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Discrimination of ginseng cultivation regions using light stable isotope analysis

Kiwook Kim [a], Joo-Hyun Song [a], Sang-Cheol Heo [a], Jin-Hee Lee [a,b], In-Woo Jung [a], Ji-Sook Min [a,*]

[a] Chemical Analysis Division, National Forensic Service, Wonju-si 26460, Gangwon-do, Republic of Korea
[b] Department of Chemistry and Medical Chemistry, College of Science and Technology, Yonsei University, Wonju-si 26493, Gangwon-do, Republic of Korea

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ABSTRACT

Korean ginseng is considered to be a precious health food in Asia. Today, thieves frequently compromise ginseng farms by pervasive theft. Thus, studies regarding the characteristics of ginseng according to growth region are required in order to deter ginseng thieves and prevent theft. In this study, 6 regions were selected on the basis of Korea regional criteria (si, gun, gu), and two ginseng-farms were randomly selected from each of the 6 regions. Then 4–6 samples of ginseng were acquired from each ginseng farm. The stable isotopic compositions of H, O, C, and N of the collected ginseng samples were analyzed. As a result, differences in the hydrogen isotope ratios could be used to distinguish regional differences, and differences in the nitrogen isotope ratios yielded characteristic information regarding the farms from which the samples were obtained. Thus, stable isotope values could be used to differentiate samples according to regional differences. Therefore, stable isotope analysis serves as a powerful tool to discriminate the regional origin of Korean ginseng samples from across Korea.

1. Introduction

In recent decades, stable isotope ratio analysis has been utilized in product-tracking and to determine the origins of products in forensic science. The use of stable isotope analysis to trace the origin of agricultural products is a stronger discrimination tool as compared to other forensic analysis methods [1–4]. Collaborative research for the TRACE program was implemented by various research institutes and universities for five years (2005–2009) to trace the production origin of various products. The technique most frequently used in this program to identify the origin of products was stable isotope analysis. Similarly, developed countries often take advantage of stable isotope analysis to identify the origin of foods [5–9]. In the Republic of Korea, research regarding the identification of the origin of agricultural products is underdeveloped. At the end of 2008, the Ministry of Agriculture Food and Rural Affairs (MAFRA) began to provide funding for research that investigated the origin of pork and cabbage. At that time, stable isotope ratio analysis of the origin of agricultural products depended on the results obtained by other countries, because database construction was not complete in Korea. After that, the Korea Basic Science Institute (KBSI) carried out carbon, nitrogen, and oxygen stable isotope analysis to determine the origins of Korean and imported beef provided by the central customs laboratory and scientific service (CCLS) [10]. Numerous origin tracking studies for food and agricultural and livestock products are ongoing; however, studies regarding the origin identification of ginseng do not exist currently. In 2008, Choi et al. [11] first reported that origin discrimination between Korean and Chinese ginseng could be carried out using Inducted Coupled Plasma-Mass Spectroscopy (ICP-MS). In this study, significant differences in the strontium stable isotope ratio were noted between Korean and Chinese ginseng [12]. However, the results were questionable, because an unsuitable analysis was performed [13,14]. In another study, Yu et al. [15] investigated the discrimination of Korean and Chinese ginseng using liquid chromatography, but the results were not obvious. Moreover, in collaboration with the Austrian Institute of Technology [16], we conducted a study regarding discrimination of Korean and Chinese ginseng using light stable isotope analysis. Specifically, Korean and Chinese ginseng were differentiated according to their hydrogen stable isotope values. However, regional differences among samples from Korea could not be determined in this study. Since the value of ginseng has been recognized in Asia as well as

* Corresponding author. Tel.: +82 33 902 5510; fax: +82 33 902 5933.
E-mail address: minjs@korea.kr (J.-S. Min).

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throughout the world, the demand for ginseng has increased recently. Although ginseng was traditionally grown in uninhabited environments (i.e., mountains), the number of ginseng farms has increased rapidly due to the wide demand, and ginseng thieves frequently compromise the farms. Accordingly, studies regarding regional differences in the isotopic characteristics of ginseng are required in order to deter ginseng thieves and prevent theft. In this study, we carried out stable isotope analysis of ginseng collected from various regions in Korea in order to identify potential differences. The objective of this study was to obtain data regarding the H, O, C, and N stable isotope ratios in ginseng samples from different regions in Korea and conduct a statistical analysis to determine potential factors that could be used to differentiate ginseng cultivation regions and farms.

2. Materials and methods

2.1. Ginseng collection and pre-processing of ginseng roots

Fig. 1 shows the locations of the ginseng farms in the Republic of Korea. Six regions (Ganghwa-gun, Paju-si, Gimpo-si, Yeongju-si, Hwacheon-gun, and Cheolwon-gun) were selected on the basis of Korea regional criteria (si, gun, gu). These six areas are well-known ginseng cultivation regions in the Republic of Korea. Additionally, ginseng theft was prevalent in these regions just before the study was initiated. Two ginseng-farms were randomly selected from each of the 6 regions and 4–6 ginseng samples were acquired from each ginseng farm. The adhered soil was removed from the ginseng roots, and the roots were placed in an oven set to 60 °C and dried until the moisture was completely removed. Using a ball-milling machine, the samples were subsequently processed in the form of a powder using only the main root portion of the dried ginseng roots, shown in Fig. 2. The powdered ginseng roots were wrapped five times using a silver capsule for hydrogen and oxygen stable isotope analysis and were wrapped three times using a tin capsule for carbon and nitrogen stable isotope analysis.

2.2. Analysis conditions

The pretreated samples were analyzed using an elemental analyzer linked to an isotope mass spectrometer (EA-IRMS, Elemental Analysis-Isotope Ratio Mass Spectrometer; EURO EA 3000, EURO VECTOR, Italy) as well as a GV Instrument Isoprime (GV instrument Ltd., UK). Two calibration points were determined using the following standard samples in order to determine the accuracy of the measurements: hydrogen stable isotope ratios: Tibetan hair (IAEA-USGS-42, International Atomic Energy Agency, δD certified value: −78.5 ± 2.3‰ VSMOW), polyethylene (IAEA-CH-7, International Atomic Energy Agency, δD certified value: −100.3 ± 2.0‰ VSMOW), and house cellulose; oxygen stable isotope ratios:

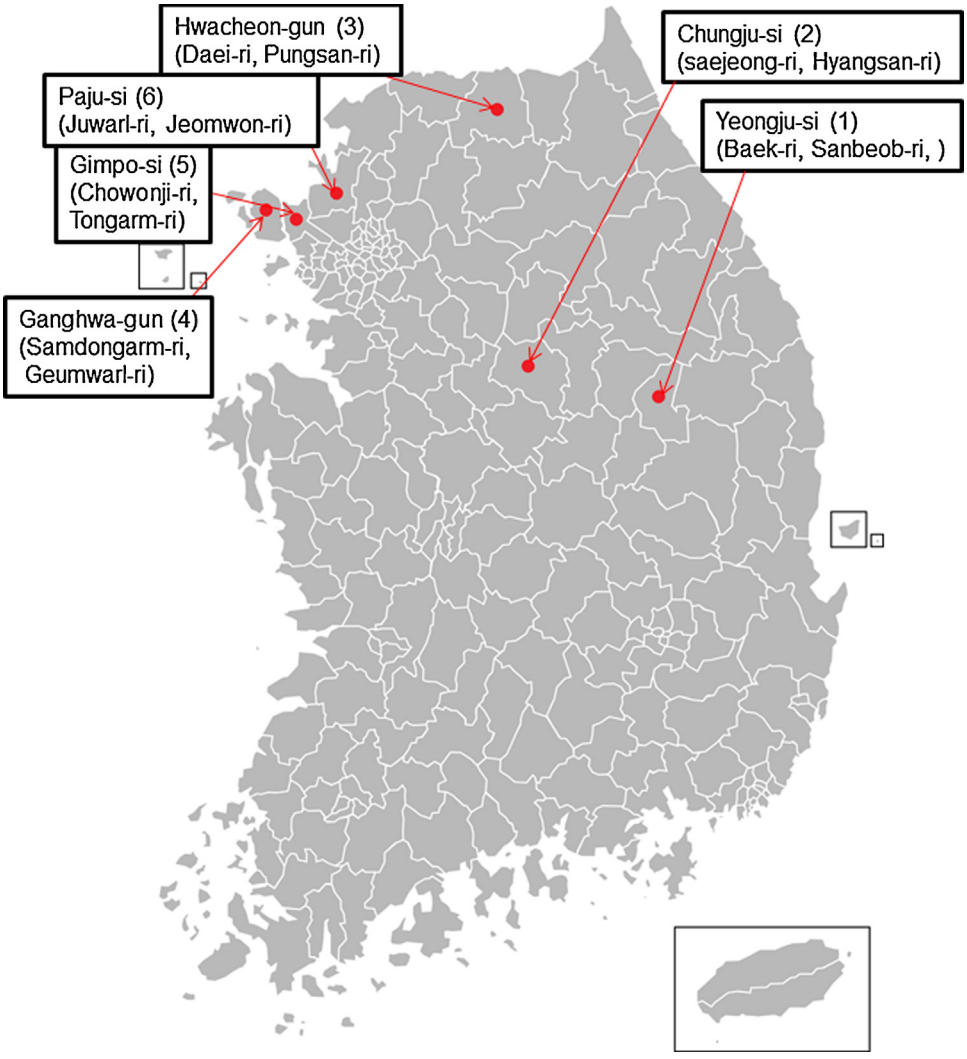

Fig. 1. Locations of ginseng farms across the Republic of Korea.