

Characteristic study on the chemical components of Korean curved ginseng products

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Dried ginseng (DG) is in fact the representing ginseng product in the worldwide market. Although it is made in various packages depending on the processing method, size and age of DG, basic scientific data reporting the chemical components are limited. In this study, 4-year-old curved ginseng (CG), one of the domestic DG products, was selected for further investigation. Eighty-six samples of 30 and 50 piece-grade CG, which are the most widely distributed in the market, were collected for 5 yr. Their major components, such as moisture, total sugar, acidic polysaccharides, total phenolic compounds, and saponins, were analyzed to figure out the standard quality characteristics. The moisture content of all CG samples was less than 15%. The total water-soluble sugar contents were 22.9% to 47.8% and 23.2% to 49.5% in the 30 and 50 piece-grade CG, respectively. The acidic polysaccharide contents were 3.6% to 6.7% and 2.9% to 6.9% in the 30 and 50 piece-grade CG, respectively. The total phenolic compound content was 0.4% to 0.5% in CG, regardless of the piece-grade. The crude saponin content, which represents the active component of ginseng, was over 2% in all samples. In 30 piece-grade CG samples, the contents of major ginsenosides, Rb1, Rf, and Rg1, were 2.2 to 4.7 mg/g, 0.4 to 1.3 mg/g, and 1.6 to 4.0 mg/g, respectively. The ginsenoside contents in 50 piece-grade CG samples were 2.1 to 3.9 mg/g (Rb1), 0.5 to 1.2 mg/g (Rf), and 1.3 to 3.4 mg/g (Rg1). Overall, since there were relatively high standard deviation and coefficient of variation in all the chemical component contents that were assessed, we found some difficulties in showing the CG standard chemical component characteristics by average, standard deviation, and other statistical analysis factors.

Keywords: *Panax ginseng*, Korean curved ginseng, Chemical components, Statistic analysis, Standardization

INTRODUCTION

Korean ginseng (*Panax ginseng* Meyer) is a perennial plant in the family *Araliaceae* and a medicinal herb cultivated primarily in the Northeast Asia, including Korea. Dried ginseng (DG) and red ginseng (RG) products have been consumed as important functional foods, constituting more than 50% of the domestic health/functional foods market. Saponin, a major component of Korean ginseng, was first highlighted as an active component of ginseng in 1957 by Brekhman of Russia, and its structure was elucidated and named as ginsenoside by the

Shibata research group of Japan [1]. Ginsenoside has been used as the primary substance for establishing the quality specifications of ginseng. Ginsenoside has also been determined to be the active ingredient that confers a wide range of beneficial health effects of ginseng, such as anticancer, antidiabetic, antineurodegenerative, anti-inflammatory actions, hepatic function improvement, and maintaining homeostasis in the body [2-6]. Korean ginseng contains various functional components, in addition to ginsenoside, such as phenolic compounds with

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anti-oxidative activity, compounds with demonstrated cytotoxicity to cancer cells, such as polyacetylene, and sesquiterpene, which is an essential oil. Meanwhile, current studies are actively investigating polysaccharides with respect to immune-related functions [7]. Studies on the functionality of major active components such as ginsenoside and on the improvement of substance content and functionality through puffing, acid treatment, and high heat treatment have been vigorously conducted. However, these studies have primarily focused on RG and its specific substances [8-10].

Currently, ginseng products distributed in the domestic market can be largely classified as fresh ginseng and processed products, RG and DG. DG is a ginseng product that has not been cooked but is dried in sunlight, by hot winds or other methods. Considering the fact that most foreign-made ginseng that is sold in the international market resembles DG, studies should be conducted on the functionality and utilization of DG. For that purpose, the standardization of quality and specification of domestic DG products were necessary. Several previous studies have reported on the quality and physicochemical properties of DG [11,12]. However, it was difficult to represent the physicochemical quality characteristics of DG products because most of them were one-time studies, or the range of sample selection and quality evaluation parameters was narrow. Presently, DG is classified based on the age (i.e., 4-, 5-, and 6-year-old root) and by shape (i.e., straight ginseng [SG], curved ginseng [CG], and half-CG). SG retains the original shape with skin, but CG is produced by peeling skin and rolling the entire length of the ginseng root into a round shape during drying. Commercial DG is also classified by the quality-grade (i.e., 1st, 2nd, and 3rd grade) depending on the morphological quality. In addition, the number of ginseng roots per package has been counted and then classified into 30 and 50 piece-grade when 30 and 50 pieces of ginseng root are counted per 300 g of package, respectively. DG is sold in packages in various pieces ranging from 5 to 75 piece-grade. Until now, studies on the chemical properties by quality-grade and piece-grade of DG are not available. Therefore, this study was conducted to provide the basic data for standardization of quality characteristics by piece-grade and for establishing new grading criteria for DG.

In summary, we selected samples of 30 and 50 piece-grade from the 1st quality-grade CG (4-year-old) products among the DG products that are the most widely distributed and sold in Korean DG markets. Eighty-six samples were collected for 5 yr, and then moisture

content, water-saturated butanol extract (crude saponin) content, ginsenoside content, total phenolic compounds, and acidic polysaccharides content were measured and statistically analyzed.

MATERIALS AND METHODS

Ginseng samples

Four-year-old CG of the 1st quality-grade in 30 and 50 piece-grade packages were selected as the target samples among major DG products. The CG was produced from 2006 to 2010. Eighty-six products (43 products for each piece-grade), with 5 to 10 products per year, were collected from major domestic DG markets, such as Gyeongdong Market (Seoul, Korea) and Geumsan Market (Geumsan, Korea) and used as samples for chemical components analysis. All of the chemical components analyses were performed every year within 1 mo after sample preparation. The samples were evenly pulverized to 60-mesh size prior to testing. All samples of CG products were finished products, and only products that passed the quality test by the inspection office of the National Agricultural Cooperative Federation (Geumsan, Korea) or manufacturer were used for our analysis.

Water content

The water content was determined according to the AOAC (Association of Official Agricultural Chemists) official method 925.45 [13].

Water soluble total sugar content

The total sugar content was quantified by a phenol-sulfuric acid method using glucose as a reference [14].

Acidic polysaccharide content

The acidic polysaccharide content was quantified by a carbazole-sulfuric acid method using β -D-galacturonic acid as a reference [15].

Phenolic compound content

The total phenolic compound content was measured according to the Folin-Ciocalteu method using gallic acid as a reference [16].

Crude saponin content

The crude saponin content was determined according to the CODEX official method [17].

HPLC analysis of ginsenosides content

The ginsenosides content was measured using HPLC

according to the previous method [18].

Statistical analysis

Basic statistical analysis was performed for the chemical analysis results between CG products and among the piece-grade for each sample. The mean, standard deviation, minimum, maximum, and coefficients of variation (CV, %) were calculated.

RESULTS AND DISCUSSION

Moisture content

The results of the moisture content analysis of CG products by piece-grade are shown in Table 1. The moisture content of 30 piece-grade CG was 7.4% to 12.9% and that of 50 piece-grade was 6.6% to 12.8%. The average moisture contents were 10.4% and 10.2% for 30 and 50 piece-grade CG, respectively. The CVs, which describe the difference among individuals within the same CG products, were 13.8% and 15.4%. Such a wide difference among individuals is thought to be associated with the differences in drying state during the manufacturing process and of natural drying during the distribution period after manufacturing. The overall moisture content of all CG products did not exceed 15%, which is within the inspection criterion that is defined in the domestic ginseng-related regulations [19].

Water soluble sugar and acidic polysaccharide contents

The total water-soluble sugar and acidic polysaccharides content analysis of CG products by piece-grade are shown in Tables 2 and 3. The total water-soluble sugar in 30 piece-grade was 22.9% to 47.8% and 50 piece-grade was 23.2% to 49.5%. Total water-soluble sugar content was not significantly different by piece-grade, as the overall mean was 36.5%. The CVs for the total water-soluble sugar were 17.2% and 16.1% for 30 and 50 piece-grade, respectively. These results demonstrate that the difference in total water-soluble sugar among products was relatively high in all CG products that were analyzed.

With regard to ginseng polysaccharides, particularly acidic polysaccharides, many studies conducted in the past revealed their positive effect on various physiological activities, such as immune function improvement, anti-tumor, anti-ulcer, and anti-diabetic activities [20,21]. For acidic polysaccharide content by piece-grade, 30 piece-grade possessed 3.6% to 6.7%, and 50 piece-grade had 2.9% to 6.9%. The mean acidic polysaccharide

Table 1. Moisture content of Korean curved ginseng products

	Moisture content (%)		
	30 Piece-grade ¹⁾ (n=43)	50 Piece-grade (n=43)	Total (n=86)
Mean	10.4	10.2	10.3
SD	1.4	1.6	1.5
Maximum	12.9	12.8	12.9
Minimum	7.4	6.6	6.6
Coefficient of variance (%) ²⁾	13.8	15.4	14.5

¹⁾Piece-grade: number of pieces per 300 g package for each curved ginseng products.

²⁾(SD/mean)×100.

Table 2. Total sugar content of Korean curved ginseng products

	Total sugar content (%)		
	30 Piece-grade ¹⁾ (n=43)	50 Piece-grade (n=43)	Total (n=86)
Mean	36.5	36.4	36.5
SD	6.3	5.9	6.0
Maximum	47.8	49.5	49.5
Minimum	22.9	23.2	22.9
Coefficient of variance (%) ²⁾	17.2	16.1	16.6

¹⁾Piece-grade: number of pieces per 300 g package for each curved ginseng products.

²⁾(SD/mean)×100.

Table 3. Acidic polysaccharide content of Korean curved ginseng products

	Acidic polysaccharide content (%)		
	30 Piece-grade ¹⁾ (n=43)	50 Piece-grade (n=43)	Total (n=86)
Mean	5.2	5.4	5.3
SD	0.9	1.0	1.0
Maximum	6.7	6.9	6.9
Minimum	3.6	2.9	2.9
Coefficient of variance (%) ²⁾	17.1	18.8	18.0

¹⁾Piece-grade: number of pieces per 300 g package for each curved ginseng products.

²⁾(SD/mean)×100.

contents of 30 and 50 piece-grade were 5.2% and 5.4%, respectively. This content was not significantly different from the previously reported value of 4.9% acidic polysaccharides in DG, as determined by Nam [22]. The CVs for 30 and 50 piece-grade were 17.1% and 18.8%, respectively.

Phenolic compound content

The result of the phenolic compound content analysis of CG products by piece-grade is shown in Table 4. The total phenolic compound content was 0.4% to 0.5% and

Table 4. Total phenolic compound content of Korean curved ginseng products

	Total phenolic compound content (%)		
	30 Piece-grade ¹⁾ (n=43)	50 Piece-grade (n=43)	Total (n=86)
Mean	0.4	0.4	0.4
SD	0.0	0.0	0.0
Maximum	0.5	0.5	0.5
Minimum	0.4	0.4	0.4
Coefficient of variance (%) ²⁾	9.3	10.4	9.8

¹⁾Piece-grade: number of pieces per 300 g package for each curved ginseng products.

²⁾(SD/mean)×100.

the mean was 0.4%, regardless of the piece-grade. The CV was approximately 10% for each piece-grade. Phenolic compounds present in ginseng are the major active components that confer its anti-oxidative activity. Choi et al. [23] reported that phenolic compounds in Korean white ginseng existed in the free, esterified and insoluble-bound form, at a relative quantity of 0.4%, 0.2%, and 0.1%, respectively.

Crude saponin and ginsenoside contents

The results of the crude saponin (water saturated n-butanol extracts) and ginsenosides content analysis of CG products by piece-grade are shown in Tables 5 and 6. The crude saponin contents in 30 and 50 piece-grade were 2.3% to 4.4% and 2.2% to 4.1%, respectively, and the mean were 3.3% and 3.0%, respectively. In general, the crude saponin content was over 2%, which is within the quality criteria for crude saponin currently defined in the domestic ginseng-related regulations [19]. The minimum value, including the experimental errors, was considered when determining our data’s compliance with the domestic regulations. Studies from Gil [12] reported crude saponin content ranging from of 2.8% to 4.3%, by piece-grade of DG in the domestic markets.

Ginsenoside, which is known as the major active component of ginseng, is mainly divided into 3 types, protopanaxadiol, protopanaxatriol, and oleanane, according to its molecular structure. To date, approximately 30 types of ginsenosides have been separated and identified from raw and processed ginsengs [7]. In the case of DG, which is a simply dried ginseng product, Rb1, Rb2, Rc, Rd, Re, Rf, and Rg1 are the primary ginsenosides components that are detected. In domestic health functional food law, over 0.8 to 34.0 mg/g of Rb1 and Rg1 contents are suggested as the quality criteria for ginseng powder [24]. Thus, the contents of Rb1, Rg1, and Rf, the unique

Table 5. Crude saponin content of Korean curved ginseng products

	Crude saponin content (%)		
	30 Piece-grade ¹⁾ (n=43)	50 Piece-grade (n=43)	Total (n=86)
Mean	3.3	3.0	3.2
SD	0.6	0.5	0.6
Maximum	4.4	4.1	4.4
Minimum	2.3	2.2	2.2
Coefficient of variance (%) ²⁾	17.2	17.0	17.5

¹⁾Piece-grade: number of pieces per 300 g package for each curved ginseng products.

²⁾(SD/mean)×100.

ginsenoside of Korean ginseng, were analyzed in this study. The mean contents of Rb1, Rf, and Rg1 in 30 piece-grade CG were 3.1, 0.8, and 2.7 mg/g, respectively, and for 50 piece-grade, the mean contents were 2.8, 0.7, and 2.4 mg/g, respectively. The CV, which represents the difference among individuals by piece-grade was 16.3% to 32.1%. Currently, the regulatory specifications for the distribution and quality control of DG are defined by visual and physical attributes, such as weight, color, and other properties. In the case of chemical composition, only moisture and the maximum content of harmful components such as arsenic, heavy metals, and foreign objects and the minimum content criteria of crude saponin are applied. The previously reported study on the quality characteristics of DG [12] and the subsequent study on the physicochemical characteristics by size and age [11] and on the changes in physicochemical characteristics of DG by processing treatment were primarily focused on the content of saponin or ginsenosides [25,26]. However, it is thought that most studies on physicochemical properties or component characteristics of DG did not use a variety of DG types and piece-grades. Thus, these studies could not reflect the considerable quality characteristics of DG samples.

In our study, we tried to present the standard component characteristics of CG products, along with the standardization study on morphological characteristics that were previously examined [27]. Eighty-six CG samples by piece-grade were collected for 5 years, and the major chemical components were analyzed and statistically compared. Overall, since there were relatively high standard deviation and CV in all the chemical component contents that were assessed, we found some difficulties in showing the CG standard chemical component characteristics by average, standard deviation, and other statistical analysis factors. In addition, the result of comparing

Table 6. Ginsenoside composition of Korean curved ginseng products

	Ginsenoside content (mg/g)								
	30 Piece-grade ¹⁾ (n=43)			50 Piece-grade (n=43)			Total (n=86)		
	Rb1	Rf	Rg1	Rb1	Rf	Rg1	Rb1	Rf	Rg1
Mean	3.1	0.8	2.7	2.8	0.7	2.4	3.0	0.8	2.5
SD	0.6	0.3	0.6	0.5	0.2	0.4	0.6	0.2	0.5
Maximum	4.7	1.3	4.0	3.9	1.2	3.4	4.7	1.3	4.0
Minimum	2.2	0.4	1.6	2.1	0.5	1.3	2.1	0.4	1.3
Coefficient of variance (%) ²⁾	20.0	32.1	20.3	16.3	27.7	18.5	19.2	30.1	20.6

¹⁾Piece-grade: number of pieces per 300 g package for each curved ginseng products.

²⁾(SD/mean)×100.

CG products by piece-grade, chemical component characteristics did not show significant differences. Also, it is difficult to use the CG chemical contents as the graded product guideline considering the previously addressed high individual difference and CV. In order to determine the exact standard quality characteristics of Korean CG, it has become necessary to collect large quantities of samples and perform constant analysis in the long term. Most of all, rather than establishing chemical products by various piece-grade, it has been considered that it is necessary to establish the standard product characteristics of all Korean CG products of all piece-grade. The results of this study are useful as a basic data set for selection of standard samples and for comparison of quality characteristics between products for the verification of the efficacy of DG.

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