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Comparison of mineral compositions between ginseng and ginseng-alcoholic beverages

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Abstract

In this study, the composition of minerals was analyzed in ginseng, ginseng-*Yakju*, and ginseng-*Soju*. Ginseng-*Yakju* was fermented using sliced or powdered ginseng (0.2%, w/v) and steamed rice, while ginseng-*Soju* was prepared by extracting ginseng with 15 times the volume of *Soju* (35% ethanol, v/v) for 5 years. Regardless of the different forms of ginseng (sliced or powdered), the normal *Yakju*, *Yakju* fermented with slices of ginseng (*Yakju*-SG), and *Yakju* fermented with powdered ginseng (*Yakju*-PG) had similar soluble solid concentration, pH, ethanol concentration, and acidity. However, ginseng-*Yakju* and ginseng-*Soju* differed significantly with respect to all physicochemical characteristics tested ($p < 0.01$). Mineral content was found in the following order: K > P > Ca > Mg > Si > Se in ginseng, P > K > Mg > Ca > Si > Se in ginseng-*Yakju*, and K > P > Mg > Ca > Si > Se in ginseng-*Soju*. According to the mineral content determined by the recovery yield, it is not appropriate to consume ginseng-*Yakju* and ginseng-*Soju* for effective intake of minerals from ginseng. Therefore, further studies on improving the bioavailability of ginseng-derived minerals are required.

Introduction

Panax ginseng (*Panax ginseng* C.A. Mayer) belongs to the family Araliaceae and the genus *Panax*, and its root has been used in traditional pharmaceutical medicine in East Asian countries such as Korea, China, Hong Kong, Taiwan, and Japan (Jeon, 2013). Many Koreans regard ginseng products as being health enhancing foods and a part of traditional medicine. Gross production of ginseng was approximately 1.1 trillion Korean Won in 2012 and Red ginseng, a processed ginseng product, is a popular item in the functional food market (Jeon, 2013). Ginseng contains approximately 3% to 6% (v/w) saponins (approximately 24 protopanadiols and 11 protopanaxatriols), 60% to 70% (v/w) carbohydrates, 12% to 16% (v/w) nitrogen compounds, 4% to 6% (v/w) ash, 1% to 2% (v/w) hydrophobic compounds, and 0.05% (v/w) vitamins (Park *et al*., 2003).

So far, studies on health-enhancing functions of ginseng have been focused on ginsenosides, components that play important roles in suppression of platelet aggregation, vasodilation, improvement of mental stability, strengthening muscles, and possess anti-carcinogenic, anti-fatigue, anti-stress, and anti-inflammatory activities (Park *et al*., 2003; Lee *et al*., 2012; Sohn *et al*., 2012). Ginsenosides are present in Ginseng in the glycoside-form, combined with sugar compounds such as arabinose, galactose, glucose, and as aglycone-derived ginsenoside. Glycoside-derived ginsenosides are converted to aglycone-derived ginsenosides by heat/acid treatment, and the aglycone-derived ginsenosides show an improved absorption rate in addition to increased physiological function in the human body (Park *et al*., 2003; Lee *et al*., 2012; Sohn *et al*., 2012; Yang *et al*., 2006). In addition, ginsenosides are metabolized by intestinal microorganisms into other derivatives with different pharmaceutical activities in the body (Bae *et al*., 2003; Kim, 2009). Red ginseng has approximately 20 protopanaxadiol-group ginsenosides and exclusively contains the ginsenosides Rf2, Rh1 (20R), Rh4, and RS2 (20R) (Park *et al*., 2003). Ginseng comprises of major minerals such as N, P, K, Ca, and Mg, and

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minor minerals such as Na, Fe, Mn, Zn, Cu, Al, Mo, B, Se, Sr, Ba, Ce, La, and Ge (Park *et al*., 2003; Ko *et al*., 1996). Ginsengs have been used as raw material or as a water extract, *Soju*, which is a distilled from traditional rice wines in Korea. Koreans consume ginseng products in the following order: Red ginseng > Ginseng tea > Ginseng beverage, while ginseng-*Soju* comprises approximately 1.4% of total ginseng products. In addition, the purpose of purchasing raw ginseng is to use it as a medicine, a gift, or food, while ginseng-*Soju* is consumed as a snack served with alcoholic beverages (Jeon, 2013). Approximately 2.3% to 14.7% ginseng is used for the production of ginseng-*Soju* (Jeon, 2013). In this study, we compared the mineral composition of several kinds of ginseng alcohol beverages, such as ginseng, ginseng-*Yakju*, and ginseng-*Soju*.

Materials and Methods

Preparation of materials

Rice was harvested and purchased from Samcheok, Gangwon, Korea in 2011. Korean ginseng was purchased from a local agricultural cooperative outlet in October 2011. For brewing *Yakju* containing ginseng, water was obtained from Dongwon F&B Co., Ltd (Gyeonggi, Korea). BionurukR, a mixture of Saccharomyces cerevisiae and Nuruk microorganisms, was purchased from Korea Enzyme Inc. (Gyeonggi, Korea) and used as a *Yakju*-fermentation starter. *Soju*, purchased from Korea Ethanol Supplies Company (www.kasc.co.kr), was mixed with water to obtain a proportion of 35:65 (v/v) for the preparation of ginseng-*Soju*.

Pulverization of ginseng

Dried ginseng slices were pulverized by Variable Speed Rotor Mill (PULVERISETTE 14, FRITSCH GmbH Milling and Sizing, Idar-Oberstein, Germany) with a 1.0 mm sieve.

Fermentation of Yakju containing ginseng powder

Steamed rice (2 kg), yeast (40 g), and nuruk (100 g) were mixed with water to a final volume of 6.5 L in a 10 L fermentation jar in order to brew *Yakju*. Plain *Yakju*, *Yakju*-SG (containing 0.2% of 0.5 cm sliced ginseng), and *Yakju*-PG (containing 0.2% of 90 μm pulverized ginseng) were brewed for use in this study (Table 1). The fermentation jar was equipped with an air lock, and the fermentation mixture was mixed twice a day and incubated at 24°C for 7 days. After fermentation, the three varieties of brewed *Yakju* were placed at 4°C for 30 days to separate the lees and the resulting supernatant (3.25 L) was collected and used for the analysis of mineral content.

Table 1. Proportion of ginseng-Yakju

	Yakju	*Yakju*-SG[1]	*Yakju*-PG[2]
Ginseng, sliced (g)	-	13	-
Ginseng, powder (g)	-	-	13
Rice (g)	2,000	2,000	2,000
Water (mL)	4,360	4,360	4,360
Bionuruk^R (g)	100	100	100
Yeast (g)	40	40	40

[1]SG: sliced ginseng
[2]PG: powdered ginseng

Preparation of ginseng-Soju

Ginseng roots were washed twice with water, its head parts were removed, and the rest (6.25%, w/v) was added to *Soju* (water: distilled liqueur = 65:35, v/v) and stored at room temperature for 5 years.

Physicochemical characteristics of ginseng-Yakju

Measurement of pH and acidity

The pH of the fermentation mixture was measured with a pH meter (Istek Co., model 725p, Seoul, Korea). For measurement of acidity, the samples were centrifuged at 3,000 rpm and 4°C for 10 min, and the supernatant was filtered through a 0.45-μm syringe filter. Phenolphthalein (1–2 drops) was added to the supernatant (10 mL) and mixed using a stirrer (model PC-420, Corning, USA). The amount (mL) of 0.1 N NaOH required for titration until the color changed to pink and to maintain the pink color for 30 sec was measured. Total acidity was calculated using following equation:

Acidity (%) = Volume (mL) of 0.1 N NaOH consumed × Factor of N NaOH × The coefficient of tartaric acid (0.075) × 100/Volume of sample (mL)

Measurement of ethanol content

Samples were centrifuged at 3,000 rpm and 4°C for 10 min, filtered with 0.45-μm syringe filter, and quantified using an Alcolyzer (Anton Paar GmbH, Graz, Austria).

Analysis of mineral content

Mineral content was estimated in plain *Yakju*, ginseng-*Yakju*, ginseng-*Soju*, and the ingredients used to prepare them (water, rice, nuruk, yeast, and ginseng).The liquid sample was sonicated for more than 1 h to remove CO_2 gas produced during fermentation, while solid sample (0.2 g) was crushed, homogenized, and mixed with 7 mL H_2O_2 and 2 mL HNO_3. The samples were then hydrolyzed by acid

using a Microwave Digestion System (Ethos Touch Control, Milestone Inc., Italy). For measurement of mineral content, the temperature of the samples was increased to 85°C for 3 min, increased further from 85°C to 145°C for 9 min, then again increased to 180°C for 4 min, and maintained at 180°C for another 15 min. Acid-hydrolyzed samples were diluted 20 times with distilled water and injected into an inductively coupled plasma-atomic emission spectrometer (ICP-AES, Vista-Pro, Varian, Australia). Minerals were analyzed in high-temperature plasma, resulting from high-frequency waves from the ICP induction coil by argon gas flowing into a quartz tube. Wavelengths for detection of mineral ions were set for Ca, K, Mg, P, Se, and Si at 396, 766, 279, 213, 196, and 251 nm, respectively. CCD detector system was used for quantitation of minerals and the operating conditions were as follows: 1.5 L/min, auxiliary gas flow rate; 0.7 L/min, nebulizer gas flow rate; 1.5 L/min, plasma flow; and 1.2 kw, reflected power. Results were expressed as a mean, derived from results of six experiments.

Statistical analysis

All results were analyzed statistically using 1-way analysis of variance (ANOVA) (Albright *et al*., 1999).

Results and Discussion

Fermentation of Yakju and Soju containing ginseng

After fermentation for 7 days and aging for 30 days, the pH, ethanol content, and acidity of three kinds of *Yakju* containing ginseng were found to be approximately 4.4, 13.3% to 13.7%, and 0.47% to 0.57%, respectively. As the amount of ginseng supplemented in *Yakju* was very small considering the total volume, the pulverization of ginseng did not markedly affect the physicochemical characteristics of *Yakju* (Table 2), as previously reported (Yoon *et al*., 2007).

Ginseng-*Soju* showed values of approximately pH 5.6, 26.8% ethanol content, and 0.22% acidity. Generally, for preparation of ginseng-*Yakju*, approximately 0% to 2% (w/v) ginseng is added (Yoon *et al*., 2007). In this study, the amount of ginseng added in ginseng-*Soju* and ginseng-*Yakju* was approximately 6.25% (w/v), which is relatively high, and 0.2% (w/v), which is relatively low, as compared to the amounts of *Soju* and fermentation mixture, respectively. While brewing ginseng-*Yakju*, the various Nuruk microorganisms increased acidity, lowered the pH, and increased the ethanol concentration in ginseng-*Yakju* (Ann *et al*., 1996; Lee *et al*., 2011). However, due to the anti-bacterial activity of ethanol, the ethanol content of *Yakju* was limited to approximately 15% (v/v), which was conducive for survival of microorganisms in the brew (Kim *et al*., 2012). On the other hand, ginseng-*Soju* did not undergo any change in pH and acidity, as ginseng-*Soju* was prepared only by extraction of ginseng with approximately 35% ethanol and was not fermented.

Table 2. Physicochemical characteristics of Yakju with ginseng and ginseng-added Soju

Samples	pH	Ethanol (%)	Acidity (%)
Yakju	4.4[1]	13.7	0.57
Yakju-SG[2]	4.4	13.7	0.47
Yakju-PG[3]	4.4	13.3	0.47
Ginseng-*Soju*	5.6	26.8	0.22

[1] n=3
[2]SG: sliced ginseng
[3]PG: powdered ginseng

Mineral content of ginseng-Yakju and ginseng-Soju

In ginseng-*Yakju*, the major minerals present include N, K, P, Ca, and Mg, whereas Fe, Mn, Zn, Cu, and Ni exist as the minor minerals (Ko *et al*., 1996). In this study, Ca, K, Mg, P, Se, and Si were detected in ginseng-*Yakju* and ginseng-*Soju*. Mineral concentration of powdered ginseng was found as approximately 25,293 mg/kg K, 4,715 mg/kg P, 2,714 mg/kg Mg, 3,294 mg/kg Ca, 1,238 mg/kg Si, and 3.6 mg/kg Se (Figure 1A), similar to a previous report (Ko *et al*., 1996). Ko *et al*. (1996) reported that Korean, Chinese, and Japanese red ginseng and Korean/American/Canadian ginseng had approximately 1.27% to 2.17% (w/v) N, 1.10% to 1.46% (w/v) K, 0.24% to 0.37% (w/v) P, 0.16% to 0.37% (w/v) Ca, and 0.12% to 0.16% (w/v) Mg, where the mineral content of ginseng depended on area of cultivation and was related to the mineral status of cultivation soil.

Mineral content of ginseng-*Yakju* had similar levels, regardless of the supplemented amount, shape, addition of ginseng (Table 3). Mineral concentration in the three kinds of ginseng-*Yakju* was approximately 331 to 348 mg/L P, 264.7 to 276.5 mg/L K, 25.7 to 26.3 mg/L Ca, 65.4 to 68.9 mg/L Mg, 7.3 to 7.6 mg/L Si, and 2.1 to 2.2 mg/L Se. Mineral concentration in ginseng-*Yakju* showed the order P > K > Mg > Ca > Si > Se (Table 3), which was not consistent with the mineral content of ginseng. This may be due to abundant P in grains and its migration to ginseng-*Yakju* (National Rural Resources Development

Table 3. Minerals in ginseng and brewing

Samples	Major elements (mg/L)				Minor elements (mg/L)	
	P	K	Mg	Ca	Si	Se
Yakju	348.0[a]	264.7[b]	68.4[a]	25.7[a]	7.6[a]	2.2[b]
Yakju-SG[1]	337.3[a]	268.0[b]	65.4[a]	26.2[a]	7.6[a]	3.0[a]
Yakju-PG[2]	331.3[a]	276.5[b]	68.9[a]	26.3[a]	7.3[a]	3.2[a]
Ginseng-*Soju*	287.3[b]	715.6[a]	41.8[b]	10.5[b]	4.3[b]	3.3[a]
P-value	<0.001	<0.001	<0.001	<0.001	0.004	0.004

[a-b]Means with different letters are significantly different at 95% level of confidence.
[1]SG: sliced ginseng
[2]PG: powdered ginseng

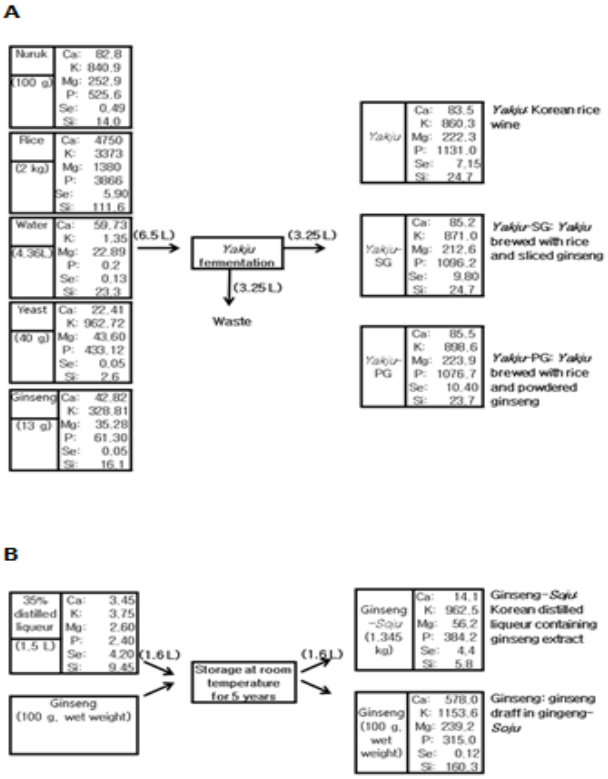

Figure 1. Change in mineral contents during lab-brewing ginseng-Yakju (top panel, A) and gingseng-Soju (bottom panel, B). *All values mean the total amounts (mg) of mineral. In top panel, for preparation of Yakju, nuruk, rice, water and yeast were used. For preparation of Yakju-SG and Yakju-PG, nuruk, rice, water, yeast and ginseng were used

Institute, 2007). In ginseng-*Soju*, the mineral content of P, K, Ca, Mg, Si, and Se was approximately 287.3 mg/L P, 715.6 mg/L K, 10.5 mg/L Ca, 41.8 mg/L Mg, 4.3 mg/L Si, and 3.3 mg/L Se (K > P > Mg > Ca > Si > Se) (Table 3).

Recovery yields of minerals in ginseng-Yakju and ginseng-Soju

In ginseng-*Yakju*, ginseng-*Soju*, and their ingredients, the recovery yield of K, Ca, Mg, P, Si, and Se was investigated, as shown in Figure 1. Mineral contents were measured in 0.1 kg Nuruk, 2 kg rice, 4.36 L water, 0.04 kg yeast, 0.013 kg dried ginseng, and the lees (3.25 L)/supernatant (3.25 L) after fermentation, aging, and clarification (Figure 1A).

Content of Ca in fermentation ingredients of *Yakju* was approximately 82.8 mg/100 g in Nuruk, 4,750 mg/2 kg in rice, 59.7 mg/4.36 L in water, 22.4 mg/0.04 kg in yeast, and 42.8 mg/0.013 kg in dried ginseng. Total amount of Ca in ginseng-*Yakju* and plain *Yakju* was approximately 4,957.8 mg and 4,914.9 mg, respectively. After removal of lees, *Yakju*, *Yakju*-SG, and *Yakju*-PG had approximately 83.5, 85.2, and 85.5 mg/3.25 L Ca, respectively, and the recovery yield of Ca ranged from approximately 1.70% to 1.73% (w/w).

Level of K in Nuruk, rice, water, yeast, and ginseng was approximately 840.9 mg/100 g, 3,373 mg/2 kg, 1.4 mg/4.36 L, 962.7 mg/0.04 kg, and 328.8 mg/0.013 kg, respectively, and the total K content of ingredients in ginseng-*Yakju* and plain *Yakju* was approximately 5,506.8 mg and 5,178 mg, respectively. After fermentation, plain *Yakju*, *Yakju*-SG, and *Yakju*-PG contained approximately 860.3, 871.0, and 898.6 mg/3.25 L of K, respectively, and the recovery yield of K in plain *Yakju*, *Yakju*-SG, and *Yakju*-PG was approximately 16.6%, 15.8%, and 16.3%, respectively. In addition, the recovery yield of Mg in plain *Yakju*, *Yakju*-SG, and *Yakju*-PG was approximately 13.1%, 12.3%, and 12.9%, respectively. P, Si, and Se in plain *Yakju*, *Yakju*-SG, and *Yakju*-PG was approximately 23.4%, 22.4%, and 22.0%; 16.3%, 14.7%, and 14.2%; and 109.0%, 103.4%, and 109.8% of recovery yields, respectively. Low recovery yields of minerals, except for Se, result from precipitation of lees, which contains several minerals from the ingredients of fermentation (Kim *et al*., 2009). Therefore, sufficient shaking is required for effective intake of minerals into *Yakju* containing ginseng.

For preparation of ginseng-*Soju*, ginseng and 35% (v/v) *Soju* (1.5 L) were mixed and extracted

Table 4. Minerals intake through ginseng consumption in Koreans

Minerals	Intakes (mg/1.26 g ginseng/day)	Korean RDA (mg/day)	% of RDA
Ca	4.150	700	0.57
K	31.869	3,500	0.91
Mg	3.420	280~350	0.98~1.22
P	5.941	700	0.85
Se	0.045	55	8.18
Si	1.560	No data	No data

for 5 years at room temperature. After termination of extraction, ginseng-*Soju* (supernatant) and ginseng was separated, as shown in Figure 1B. *Soju* contained approximately 2.5, 2.3, 1.7, 1.6, 6.3, and 2.8 mg/L of K, Ca, Mg, P, Si, and Se, respectively. This result was similar with the previous report (Lee *et al*., 2013), in which the content of Mg, P, Si, and Se was approximately 4.1, 0.9, 4.0, and 2.2 mg/L in Korean domestic *Soju*. Extracted ginseng-dregs and ginseng-*Soju* contained approximately 578 and 14.1 mg Ca, 1153.6 and 962.5 mg K, 315 and 384.2 mg P, 0.12 and 4.4 mg Se, and 160.3 and 5.8 mg Si, respectively. Mineral K, P, and Se in ginseng were taken up more effectively into *Soju* than Ca and Si. Although the mixture ratio of ginseng in *Soju* was high, at 15:1, this may be attributed to the fact that whole ginseng was used for ginseng-*Soju* (Table 3). Ca, Mg, P, and Si were known to be related closely with bone metabolism and regeneration of skin (Lee *et al*., 2013, Kim *et al*., 2009). Mineral recovery yield of ginseng-*Soju* was lower than two ginseng-*Yakju*s (Figure 1). For *Yakju*-SG and *Yakju*-PG, the sliced or pulverized ginseng were used, whilst full size of ginseng was used for gingseng-*Soju* preparation. Therefore, there was difference in the surface area of gingeng. Sufficient shaking and increase in surface area of ginseng by slicing prior to fermentation or aging process may help to improve the recovery yields of minerals in ginseng.

Evaluation of mineral intake through ginseng-soju

In Korea, the gross production of ginseng was 26,507 tons in 2012. Additionally, the consumption of ginseng was approximately 23,318 tons in total and 460 g/person in 2012 (Jeon, 2013). Based on these data, the daily intake of ginseng was approximately 1.26 g/day per person, which means approximately 0.57% (w/w), 0.91% (w/w), 0.98%–1.22% (w/w), 0.85% (w/w), and 8.18% (w/w) of the Recommend Daily Allowance (RDA) of Ca, K, Mg, P, and Se for a Korean adult (Table 4) (KNS, 2010).

Se is a component of antioxidative glutathione peroxidase for the prevention of oxidative cell damage, and the reference intake of Se for a Korean adult is 55 μg (Rotruck *et al*., 1973). Daily Si intake for American is known to be 20–50 mg/day, but that for a Korean adult is not established so far (Sripanyakorn *et al*., 2004). Beer and banana supplement Si in American diets. If the intake amount of Si in Korea is similar to that in America, the intake amount of Si through ginseng is calculated to be approximately 3.1%–7.8% of the estimated daily amount of Si intake in Korea. It is assumed that intake of Si through consumption of ginseng for Korean is very high. Recently Si was reported to help improve Alzheimer`s disease (Bellés *et al*., 1998) and osteoporosis (Price *et al*., 2013). Si is absorbed by humans and is found in bones, aorta, kidney, liver tendons, etc (Sripanyakorn *et al*., 2004; Spector *et al*., 2008). However, the consumption of ginseng and ginseng products such as Red ginseng, ginseng tea, and ginseng beverage, according to sex and age, has not been reported. Additionally, it is valuable to study the relation between the consumption of ginseng and disease.

Conclusions

Taken together, it is anticipated that the intake of ginseng minerals present in *Yakju* or *Soju* is not appropriate for supplement of minerals to human body. Development of processing techniques that increase the absorbability of ginseng minerals in the body may help to improve the bioavailability of ginseng.

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