



## Research article

# Characteristics of Korean ginseng varieties of Gumpoong, Sunun, Sunpoong, Sunone, Cheongsun, and Sunhyang



Jang-Ho Lee<sup>1</sup>, Joon-Soo Lee<sup>1,\*</sup>, Woo-Saeng Kwon<sup>2</sup>, Je-Yong Kang<sup>1</sup>, Dong-Yun Lee<sup>1</sup>, Jun-Gyo In<sup>1</sup>, Yun-Soo Kim<sup>1</sup>, Jiho Seo<sup>1</sup>, In-Ho Baeg<sup>1</sup>, Il-Moo Chang<sup>1</sup>, Keith Grainger<sup>3</sup>

<sup>1</sup> R&D Headquarters, Korea Ginseng Corporation, Daejeon, Korea

<sup>2</sup> Korean Ginseng Center for Most Valuable Products and Ginseng Genetic Resource Bank, Kyung Hee University, Suwon, Korea

<sup>3</sup> Language Consultants to the Korea Ginseng Corporation, 2655 McDonald Drive East, Victoria, BC, Canada

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## ABSTRACT

**Background:** Ginseng (*Panax ginseng* Meyer) is an important medicinal herbs in Asia. However, ginseng varieties are less developed.

**Method:** To developed ginseng varieties, a pure line selection method was applied in this study.

**Results:** Gumpoong was testing of 4-yr-old specimens in 2002, the proportions of the below-ground roots that were rusty colored for Gumpoong was 1.29 in Daejeon and 1.45 in Eumseong, whereas the proportions for its yellow berry variant were 2.60 and 2.45 in the two regions, respectively. Thus the Gumpoong was resistant to root rust. Sunpoong has a high yielding property. Its average root weight is 70.6 g for 6-yr-old roots. Its yield is 2.9 kg/1.62m<sup>2</sup> and the rate of heaven- and earth-grade product is 20.9%, which is very high compared to 9.4% for Yunpoong. Sunone is resistance to root rot and the survival rate of 4-yr-old roots was 44.4% in 1997, whereas that of the violet-stem variant landrace was 21.7%. Sunhyang has content of arginyl-fructosyl-glucose (AFG), which produces the unique scent of red ginseng, is 95.1 μmol/g and greater than the 30.8 μmol/g of Chunpoong in 6-yr-old plants. Sunun and Cheongsun are being nurtured to protect genetic resources.

**Conclusion:** Developed ginseng varieties will be used as the basis for the protection of genetic resources and breeding.

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## 1. Introduction

The study of ginseng (*Panax ginseng* Meyer) breeding began at the Gwacheon Experimental Station of the Central Research Institute, Monopoly Bureau (Gwacheon, Korea) in 1968 [1]. Early breeding studies concentrated on the growth characteristics of the aerial and below-ground sections of violet-stem variants according to the number of stems [2], the prevalence of multi-stems according to the region and the location of ginseng cultivation, the direct and indirect effects of the number of stems on the characteristics of the below-ground section (root weight, diameter, and length), and the fact that multi-stem variants are more significantly affected by genetic factors than by environmental factors [3].

In a study of the yellow berry variant of ginseng, the characteristics of the aerial and below-ground sections of the violet-stem variant and yellow berry variant were compared, whereas the lengths of the peduncles were compared to the relative growth rates and the changes in the mineral contents of the leaves and stems (N, P, K) (N, nitrogen; P, phosphate; K, potassium). Additionally, the saponin contents were compared by age. In another study, the mineral contents, photosynthesis, respiration, and diseases of the leaves and roots of the yellow berry variant and violet-stem variant were examined based on the amounts of fertilizers used during cultivation. The seed setting rates of the breeding yellow berry variant and violet-stem variant were examined and the characteristics of the aerial and below-ground sections of F1 were studied [4]. In the F2 of the yellow

\* Corresponding author. R&D Headquarters, Korea Ginseng Corporation, 30 Gajeong-ro, Yuseong-gu, Daejeon 305-805, Korea.  
E-mail address: [cbmleejs@kgc.or.kr](mailto:cbmleejs@kgc.or.kr) (J.-S. Lee).

berry variant and violet-stem variant, the ratio of stem colors was purple (3):green (1) and the ratio of seed colors was red (3):yellow (1). It was identified that purple and red were dominant to green and yellow for both stems and seeds. There was no reciprocal effect of the yellow berry variant  $\times$  the violet-stem variant or the violet-stem variant  $\times$  the yellow berry variant F1. The aerial section characteristics of the red berry and the below-ground section characteristics of the green stem variant were first studied in 1983, and the separation of the stem colors of the two entities of the second generation offspring and 14 entities of the third generation offspring were studied in 1988. The stem color of eight third generation offspring was green, but the six entities were divided into purple and green stems, indicating that it was undergoing homogenization [5]. Superior entities were selected through a pure line selection breeding method and the five superior varieties were named KG101, 102, 103, 104, and 105 after Korean Ginseng (KG) in 1985 to initiate productivity tests and adaptation tests. It was reported that these varieties increased the yield of ginseng varieties by 15%. Among them, KG101 and KG102 were named and registered as *Panax ginseng* var. Chunpoong and var. Yunpoong, respectively, in 1998.

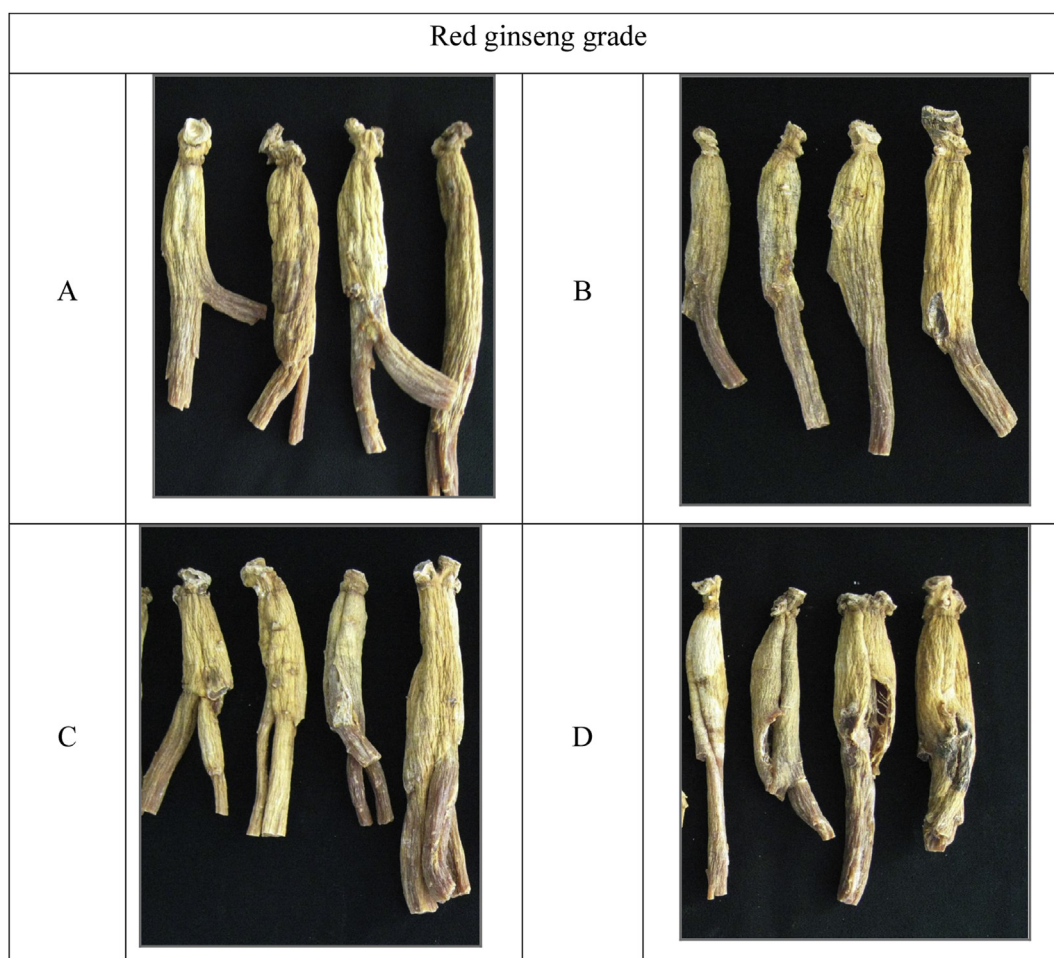
The major characteristics of the ginseng varieties that are currently grown by the Korea Ginseng Corporation (KGC)—Gumpoong, Sunun, Sunpoong, Sunone, Cheongsun, and

Sunhyang—have not yet been fully reported. This study reports on the characteristics of the aerial and below-ground sections, and the red ginseng quality characteristics of all six varieties.

## 2. Materials and methods

### 2.1. Study of the aerial section, below-ground section, and red ginseng quality

The study of the characteristics of the aerial and below-ground sections of the six varieties followed the guidelines set out by the Ginseng International Union for the protection of new varieties of plants [6]. Based on these guidelines, the anthocyanin color of the stem on the aerial section, the type of the inflorescence, the shape of the berry, and the presence of stolon roots on the below-ground section were studied among the qualitative characteristics. Among the pseudoqualitative characteristics, the anthocyanin distribution of the stem on the aerial section, the shape of the leaflet, the color of the fruit, and the color of the autumn leaves were studied, and the color of the roots was examined. Among the below-ground section characteristics, root length, root diameter, and root weight were indicated as an average based on 2–3 yr of productivity testing. The characteristics of the aerial sections of ginseng



**Fig. 1.** Red ginseng grades are divided into four grades. (A) Heaven-grade product should not have cracks and scratches. For rootlets, one or more should be well developed and the rootlet length should be three quarters or less of the main root. On the rootlet, there must be a diameter of  $\leq 0.5$  mm of whitening and pitting and an affected length of  $\leq 10$  mm. The color of the textures must be maroon, brown, or dark brown. (B) Earth-grade product has cracks and scratches on the body of the total surface area of less than a quarter. Earth-grade rootlet development is the same as that of heaven-grade. There must be a diameter of  $\leq 2.0$  mm of whitening and pitting and the affected portion length of a quarter. The earth-grade textures/colors are similar to heaven-grade. (C) The yang-grade standard is not limited to the body. Rootlets are unbalanced. Whitening of the body length is one third or less, and the pitting of the body length is one half or less. Like the other two grades, the Yang-grade color is shiny, but the color is not uniform. (D) The jab-grade has no standard and grade. The heaven-, earth-, yang-, and jab-grades are given based on the parameters provided in the Korea Ginseng Industry Act.

were investigated in 4-yr-olds. Below-ground section characteristics were investigated in 6-yr-olds. For the quality of red ginseng, the roots that could be used as ingredients for the 2- or 3-yr productivity tests were gathered to make red ginseng according to the red ginseng production process of the KGC, and an expert appraiser judged the red ginseng quality (Fig. 1). The survey items examined were 6-yr-old ginseng roots.

## 2.2. Rusty root examination

For rusty root examination, 1- to 4-yr-old ginseng fields were drenched with 10 L distilled water per 1.62 m<sup>2</sup> once a month every April–August from 1996 to artificially cause rusty roots. These entities were studied by classifying the rusty root index into four grades (degree of rusty root, 0 = noninfected, 1 = 1–10%, 2 = 11–25%, and 3 = above 26%). The reappearance testing of rusty roots was carried out in Daejeon and Punggi in 2000 using the same method.

## 2.3. Root rot resistance examination

To select the varieties that are resistant to root rot, Sunone and the violet-stem variants were transplanted to root rot-infected soil at the Daejeon Experimental Center three times using a randomized block design method on April 5, 1996, and the survival rate of the aerial sections was examined on June 4, 1996. For the reappearance test of the selected varieties, they were transplanted to root rot-infected soil at the Daejeon Experimental Centers on April 4, 1997, and the survival rates of the aerial sections were examined on July 25, 1997. They were again transplanted to root rot-infected soil at the Suwon Experimental Center on March 28, 2004 and harvested on June 15, 2004 to study the root rot infection rate. This study was performed on 2-yr-old ginseng.

## 2.4. Analysis of arginyl-fructosyl-glucose

The analysis was performed using a Dionex ion chromatography system (ICS3000; Dionex, USA). The chromatographic separation was accomplished on a CarboPac PA-1 column (4 × 250 mm; Dionex, USA) and the column temperature was 30°C. The elution was performed with water and 250mM sodium hydroxide (50:50, v/v) using isocratic elution. The flow rate was 1.0 mL/min and the injection volume was 20 µL. The arginyl-fructosyl-glucose (AFG) was detected using an electron capture detector equipped with a gold working electrode and an Ag/AgCl reference electrode operating a quadruple potential waveform.

Standard solutions were obtained from AMBO (Ambo Institute, Seoul, Korea). Stock solutions were prepared in water at a

concentration level of 1 mg/mL and stored at 4°C. Two standard stock solutions were mixed to make standard working solutions and serially diluted with water to obtain concentrations for calibration curve standards.

The red ginseng of Sunhyang and Chunpoong, 6-yr-old roots cultivated at the KGC Central Research Institute's Suwon Experimental Center were harvested in 2005, freeze-dried to make samples, and ground into powder for the 40-sieve (2.0 m/m; CISA, Barcelona, Spain). Approximately 0.1 mg of powder was weighed and dissolved in 10 mL of distilled water. The sample solutions were diluted with water to be within the standard calibration range. After sonication for 30 min without any sample clean-up, the supernatant was filtered with a 0.2-µm polyvinylidene fluoride membrane filter and injected (20 µL) into an HPAEC-PAD (High Performance Anion Exchange Chromatography-Pulsed Amperometric Detector) system.

## 3. Results and discussion

### 3.1. Breeding of *Panax ginseng* var. *Gumpoong*

A variety with green stems and yellow matured fruits was discovered in Gaepung-gun, Gyeonggi-do in 1926 and in Jangdan-gun, Gyeonggi-do in 1928. This variety has been called the yellow berry variant [4]. In order to further understand the characteristics of the yellow berry variant, continuous studies have been conducted on the aerial section characteristics of each year and at the flowering period, the relative elongation and saponin content, the chlorophyll content related to heavy and low fertilizing, and the mineral contents and photosynthetic characteristics of the leaves and roots. Substantial testing at the production site began in 1985. However, the damage of rusty roots to 5-yr-old plants was 100% in Pocheon, 60% in Icheon, and 20% in Jeollabuk-do as a result of substance testing in 1994. Therefore, the importance of the yellow berry variant was revealed as it is resistant to rusty roots. Gumpoong was selected to tolerance of rust in the Punggi region in 1979 and it was named the Punggi Yellow Berry Variant. The characteristics were examined through the growth of variants from 1979 to 1992. Productivity and substance tests were performed from 1996 through 2012 and the variant was named "KG111" and registered as Gumpoong during farm substance testing in 1996.

### 3.2. Distinction of aerial sections of *Gumpoong* and *Chunpoong* for comparison

Among the qualitative characteristics of the aerial section, Gumpoong showed no purple in the anthocyanin color of stems, whereas Chunpoong distinctively showed purple in the stems. The

**Table 1**  
Qualitative and pseudoqualitative characteristics of six varieties of ginseng













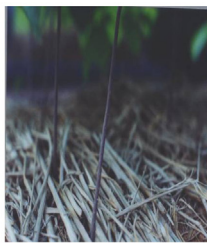



Variety	Qualitative characteristic <sup>1)</sup>				Pseudoqualitative characteristic <sup>2)</sup>				
	Aerial section <sup>3)</sup>			Below-ground section <sup>4)</sup>	Aerial section				Below-ground section
	Anthocyanin coloration of stem	Type of inflorescence	Shape of berry		Distribution of anthocyanin coloration of stem	Shape of leaflet	Color of berry	Color of autumn leaves	
Gumpoong	Absent	Simple	Round	Present	Absent	Broad elliptic	Yellow	Yellow	Cream
Sunun	Present	Simple	Round	Present	Along the whole stem	Broad elliptic	Red	Red	Cream
Sunpoong	Present	Simple	Round	Present	Along the whole stem	Broad elliptic	Red	Red	Cream
Sunone	Present	Simple	Round	Present	Along the whole stem	Broad elliptic	Red	Red	Cream
Cheongsun	Absent	Simple	Round	Present	Absent	Broad elliptic	Red	Red	Cream
Sunhyang	Present	Simple	Round	Present	On lower section only	Broad elliptic	Red	Red	Cream
Chunpoong	Present	Simple	Round	Present	On lower section only	Broad elliptic	Orange	Orange	Cream

<sup>1),2)</sup> Investigated according to the International Union for the Protection of New Varieties of Plants (UPOV) test guidelines for ginseng (*Panax ginseng* Meyer)

<sup>3)</sup> Investigated in 4-yr-old plants

<sup>4)</sup> Investigated in 6-yr-old plants



Variety	Characteristics of aerial part			
	Distribution of anthocyanin coloration of stem	Leaf shape	Color of berry	Color of autumn leaf
A				
Distinction	Absence	Broad elliptic	Yellow	Yellow
Variety	Characteristics of aerial part			
	Distribution of anthocyanin coloration of stem	Leaf shape	Color of berry	Color of autumn leaf
B				
Distinction	Along the whole stem	Strong blistering of leaf surface	Red	Red
Variety	Characteristics of aerial part			
	Distribution of anthocyanin coloration of stem	Petiole	Color of berry	Color of autumn leaf
C				
Distinction	Along the whole stem	Long petiole	Red	Red
Variety	Characteristics of aerial part			
	Distribution of anthocyanin coloration of stem	Leaf shape	Color of berry	Color of autumn leaf
D				
Distinction	Along the whole stem	Six round palmately compound leaves	Red	Red

**Fig. 2.** Characteristics of the aerial part of varieties of ginseng. (A) The distinctiveness of the aerial section of *Panax ginseng* Meyer var. Gumpoong. Anthocyanin coloration of the stem shows no purple. The leaf shape of the aerial section is broad elliptic. The color of berries is yellow. The color of autumn leaves is yellow. (B) The distinctiveness of the aerial section in *Panax ginseng* Meyer var. Sunun. The distribution of anthocyanin coloration of the stem shows purple along the whole stem. The leaf shape shows the strong development of leaflet surface blistering. The color of berries is red. The color of autumn leaves is red. (C) The distinctiveness of the aerial section in *Panax ginseng* Meyer var. Sunpoong. The distribution of anthocyanin coloration of the stem shows purple along the whole stem. The peduncle is very long. The color of berries is red. The color of autumn leaves is red. (D) The distinctiveness of the aerial section in *Panax ginseng* Meyer var. Sunone. The distribution of anthocyanin coloration of the stem shows purple along the whole stem. Four or six palmately compound leaves make circular form. The color of berries is red. The color of autumn leaves is red. (E) The distinctiveness of the aerial section in *Panax ginseng* Meyer var. Cheongsun. Cheongsun has no purple stem in the aerial section. The color of berries is red. The color of autumn leaves is red. (F) The distinctiveness of the aerial section in *Panax ginseng* Meyer var. Sunyang. The distribution of anthocyanin coloration of the stem shows purple only on the lower part. The leaf shape of the aerial section is broad elliptic. The color of berries is red. The color of autumn leaves is red. (G) The distinctiveness of the aerial section in *Panax ginseng* Meyer var. Chunpoong. The distribution of anthocyanin coloration of the stem shows purple only on the lower section. The leaf shape of the aerial section is broad elliptic. The color of berries is orange. The color of autumn leaves is orange.













Variety	Characteristics of aerial part			
	Distribution of anthocyanin coloration of stem		Color of berry	Color of autumn leaf
E				
Distinction	Absent		Red	Red
Variety	Characteristics of aerial part			
	Distribution of anthocyanin coloration of stem	Leaf shape	Color of berry	Color of autumn leaf
F				
Distinction	On lower part only	Broad elliptic	Red	Red
Variety	Characteristics of aerial part			
	Distribution of anthocyanin coloration of stem	Leaf shape	Color of berry	Color of autumn leaf
G				
Distinction	Only lower part	Broad elliptic	Orange	Orange

Fig. 2. (continued).

type of the inflorescence and berries were simple and round for both Gumpoong and Chunpoong. The existence of stolon roots on the below-ground section was found in both Gumpoong and Chunpoong. As for the distribution of the anthocyanin color of stems, which is the similar qualitative characteristic of the aerial section, the color was green for Gumpoong with no anthocyanin, whereas Chunpoong showed purple only on the basal section. The color of berries was yellow for Gumpoong and orange for Chunpoong. The color of autumn leaves was yellow for Gumpoong and orange for Chunpoong. However, the shape of the aerial section leaflets and the color of the roots on the below-ground section were broad elliptical and cream, respectively, for both Gumpoong and Chunpoong (Table 1; Fig. 2A, 2G).

### 3.3. Major characteristics of the aerial sections of Gumpoong and Chunpoong

The major characteristics of the aerial sections of Gumpoong and Chunpoong based on 3 yr of substance testing at the

production site are shown in Table 2. The average stem diameter was 7.6 mm for Gumpoong and 7.4 mm for Chunpoong. The average stem length was 35.5 cm for Gumpoong and 38.5 cm for Chunpoong; Gumpoong was 5 cm shorter than Chunpoong. The average leaflet length was 16.3 cm for Gumpoong and 15.9 cm for Chunpoong; Gumpoong was 0.6 cm longer than Chunpoong. The average leaflet width was 7.1 cm for Gumpoong and 6.3 cm for Chunpoong; Gumpoong was 0.8 cm longer than Chunpoong. The average number of palmately compound leaves was 5.5 for Gumpoong and 5.6 for Chunpoong with no distinction. The average number of leaflets was 23.6 for Gumpoong and 22.7 for Chunpoong.

### 3.4. Characteristics of below-ground sections and red ginseng of Gumpoong and Chunpoong

Table 3 shows the characteristics of the below-ground sections and the average quality of the red ginseng of Gumpoong and Chunpoong. The average yield was 2.1 kg/1.62 m<sup>2</sup> for Gumpoong and 2.0 kg/1.62 m<sup>2</sup> for Chunpoong. The average length of the main

**Table 2**  
Aerial section characteristics of six varieties in ginseng

Variety <sup>1)</sup>	Stem		Leaflet		Number of palmately compound leaves	Number of leaflets	Remarks/yr
	Diameter (mm)	Length (cm)	Length (cm)	Width (cm)			
Gumpoong	7.6 ± 0.3	35.5 ± 0.7	16.3 ± 1.7	7.1 ± 1.1	5.5 ± 1.9	23.6 ± 1.6	PDT/'91,'92
Chunpoong	7.4 ± 0.5	38.5 ± 4.1	15.9 ± 2.0	6.3 ± 0.7	5.6 ± 2.0	22.7 ± 1.5	ADT/'95-'97
Sunun	6.9 ± 11.5	29.0 ± 0.8	16.2 ± 0.0	7.0 ± 0.0	4.5 ± 0.2	24.3 ± 1.0	PDT/'96,'02
Chunpoong	7.4 ± 5.7	31.8 ± 0.4	15.6 ± 2.5	6.2 ± 0.9	4.6 ± 0.1	21.7 ± 3.7	ADT/'06,'08
Sunpoong	8.1 ± 0.4	45.0 ± 3.2	17.1 ± 1.4	10.9 ± 6.6	5.0 ± 0.2	24.8 ± 1.2	PDT/'82,'84
Chunpoong	7.6 ± 0.6	42.1 ± 4.1	16.2 ± 1.2	6.4 ± 0.7	4.8 ± 0.4	23.4 ± 2.4	ADT/'94,'02-'03
Sunone	7.5 ± 0.1	35.4 ± 2.5	15.7 ± 0.7	6.8 ± 0.3	4.5 ± 0.0	24.4 ± 0.9	PDT, ADT/'04,'08
Chunpoong	7.5 ± 0.4	33.6 ± 1.6	15.1 ± 0.8	6.3 ± 0.3	4.5 ± 0.0	23.4 ± 0.9	
Cheongsun	7.0 ± 0.7	32.2 ± 0.5	14.7 ± 0.5	6.7 ± 0.6	4.8 ± 0.4	23.8 ± 2.1	PDT/'91,'92
Chunpoong	6.8 ± 1.1	32.9 ± 0.6	14.8 ± 0.2	6.2 ± 0.7	4.9 ± 0.2	24.2 ± 1.6	ADT/'02,'08,'12
Sunhyang	6.6 ± 1.1	39.6 ± 2.5	14.9 ± 0.8	6.5 ± 0.9	4.3 ± 0.0	22.8 ± 0.1	PDT/'83,'86,'96
Chunpoong	6.4 ± 1.9	38.6 ± 1.8	14.1 ± 0.6	6.4 ± 0.2	4.5 ± 0.3	23.5 ± 2.0	ADT/'02,'06,'08

Values are expressed as mean ± standard deviation of three plants

ADT, adaptation testing; PDT, productivity testing

<sup>1)</sup> The characteristics of the aerial sections were investigated in a 4-yr-old plant

root was 7.6 cm for Gumpoong and 8.3 cm for Chunpoong. The average diameter of the main root was 26.8 cm for Gumpoong and 27.0 cm for Chunpoong with no significant difference between the two variants. By contrast, the root weight was 70.2 g for Gumpoong and 61.0 g for Chunpoong: Gumpoong was 9.2 g heavier than Chunpoong. In terms of the quality of red ginseng, the average rate of heaven-grade ginseng was 21.2% for Gumpoong and 21.8% for Chunpoong. The average rate of earth-grade ginseng was 12.8% for Gumpoong and 16.2% for Chunpoong. The average rate of yang-grade ginseng was 17.6% for Gumpoong and 20.9% for Chunpoong. Overall, for these grades, the rates of Gumpoong were lower than those of Chunpoong. The average rate of jab-grade ginseng was 48.3% for Gumpoong and 41.0% for Chunpoong; the rate of Gumpoong was higher than the rate of Chunpoong.

### 3.5. Gumpoong's prevalence of rusty roots

The average primary rate of rusty roots in 1996 was 0.8 for Gumpoong and 1.6 for the yellow-berry variant in comparison. As a result of the reappearance test in 2000, the reproductivity rates were 1.29 for Gumpoong and 2.66 for the yellow-berry variant in Daejeon. These rates were 1.45, and 2.46, respectively, in Eumseong. Fully-grown Gumpoong showed lower rates than those of the yellow-berry variant (Table 4).

### 3.6. Breeding of *Panax ginseng* var. Sunun

Ginseng is a self-fertilizing crop and its genetic resources are very limited. Therefore, the breeding of ginseng variants focused on the distinction of appearance, and the characteristics of the aerial and below-ground sections. The color of fully-ripened berries of Chunpoong is orange [7], whereas Gumpoong is green with no purple on the stems and yellow for the color of fully-ripened berries [8]. Chengsun has as green a stem as Gumpoong, but the color of fully-ripened berries is red [9]. Also, a variant whose color of fully-ripened berries are pink was recently bred, and is currently being tested for cultivation [10]. Other variants grown include Sunone whose shape of the palmately compound leaf is a bushy type [11], Yunpoong shows two or more stems from the 4th year with many stipules [12], and Gopoong shows a rich purple color across the stems, peduncle, and the length of the petiole [13]. The direction of ginseng breeding is turning to functionality, resistance to diseases/insects, and tolerance to environmental conditions such as drought and excessive moisture injury. For example, Sunhyang is a variant with a high content of unique ginseng flavor [14]. Sunil has a tolerance to damage from high temperature [15]. In order to breed these variants, however, the quality characteristics should vary by one grade and the quantitative characteristics should vary by two grades compared to the check variety for comparison when registering a new variant. Sunun was registered as a new variant because it is

**Table 3**  
Below-ground section characteristics and red ginseng quality of six varieties of ginseng

Variety	Yield/Kan (kg/1.62m <sup>2</sup> )	Below-ground section <sup>1)</sup>			Grade of red ginseng ratios <sup>2)</sup> (%)				Remarks/yr
		Main root length (cm)	Main root diameter (mm)	Main root weight (g)	Heaven	Earth	Yang	Jab	
Gumpoong	2.1 ± 0.0	7.6 ± 0.3	26.8 ± 1.0	70.2 ± 7.4	21.2 ± 20.9	12.8 ± 2.3	17.6 ± 13.4	48.3 ± 37.4	PDT/'91,'92
Chunpoong	2.0 ± 0.1	8.3 ± 0.8	27.0 ± 1.0	61.0 ± 7.8	21.8 ± 19.1	16.2 ± 7.9	20.9 ± 13.2	41.0 ± 36.0	ADT/'95-'97
Sunun	— <sup>3)</sup>	8.2 ± 0.6	26.5 ± 0.8	67.8 ± 13.8	16.4 ± 23.2	18.0 ± 14.4	24.2 ± 1.1	41.5 ± 38.7	PDT/'96,'02
Chunpoong	—	8.1 ± 1.6	26.3 ± 2.5	60.1 ± 10.1	32.3 ± 19.7	25.6 ± 5.1	27.9 ± 26.1	13.7 ± 1.2	ADT/'06,'08
Sunpoong	2.9 ± 1.3	6.5 ± 1.2	30.3 ± 3.1	70.6 ± 24.7	8.7 ± 1.1	12.2 ± 6.2	43.2 ± 11.8	42.6 ± 10.3	PDT/'82,'84
Chunpoong	3.0 ± 1.7	6.7 ± 0.1	28.3 ± 1.5	59.7 ± 7.3	17.5 ± 1.6	20.5 ± 1.7	36.9 ± 5.8	33.1 ± 8.4	ADT/'94,'02-'03
Sunone	3.3 ± 0.8	8.5 ± 0.1	29.3 ± 0.7	84.1 ± 8.4	1.9 ± 2.7	6.8 ± 4.2	32.0 ± 27.4	59.5 ± 25.7	PDT, ADT/'04,'08
Chunpoong	1.9 ± 0.1	7.3 ± 0.4	25.3 ± 1.2	52.5 ± 0.5	14.0 ± 6.2	14.9 ± 10.0	56.7 ± 11.9	15.3 ± 3.5	
Cheongsun	—	8.6 ± 1.6	25.4 ± 0.5	73.7 ± 8.6	14.6 ± 15.6	7.2 ± 10.1	34.1 ± 20.0	44.1 ± 5.8	PDT/'91,'92
Chunpoong	—	9.5 ± 0.4	26.9 ± 1.6	67.4 ± 0.3	24.9 ± 32.7	15.0 ± 21.1	28.8 ± 27.4	31.4 ± 23.8	ADT/'02,'08,'12
Sunhyang	1.8 ± 0.0	7.4 ± 0.0	29.0 ± 0.0	78.8 ± 0.4	13.3 ± 15.6	14.1 ± 10.7	15.5 ± 2.8	57.2 ± 23.6	PDT/'83,'86,'96
Chunpoong	1.8 ± 0.3	8.4 ± 1.1	27.1 ± 1.8	70.8 ± 20.6	32.3 ± 19.7	26.0 ± 5.6	28.1 ± 26.4	13.7 ± 1.2	ADT/'02,'06,'08

Values are expressed as mean ± standard deviation of three repetitions per 1.62 m<sup>2</sup>

ADT, adaptation testing; PDT, productivity testing

<sup>1),2)</sup> Investigated in 6-yr-old ginseng

<sup>3)</sup> Data was not investigated



**Table 4**  
Prevalence of rusty root in the field for “Gumpoong”

Varieties	1996		2000		Mean ± SD
	Eumseong	Daejeon	Poongki		
Gumpoong	0.8 <sup>1)</sup>	1.29	1.45		1.2 ± 0.3
Yellow berry variant	1.6	2.66	2.46		2.2 ± 0.4

SD, standard deviation

<sup>1)</sup> Degree of rusty root: 0, noninfected; 1, 1–10%; 2, 11–25%; 3, above 26%

clearly distinguished from other variants with the strong development of blistering of the surface of the leaflets compared to the genetic resources of ginseng possessed by the KGC [16].

A variant with very strongly developed blistering of the surface of the leaflets was selected at the production site, used in a purple-stem population breeding in 1985, and named “85822”. In 1989, it underwent the breeding test to name the breed “KG114”. As a result of productivity and adaptation testing from 2000, the genetic stability of the distinctively strong blistering of the surface of the leaflets was verified and the institute registered the new variant as “Sunun”.

### 3.7. Distinction of aerial sections of Sunun and Chunpoong for comparison

Among the qualitative characteristics of the aerial sections, Sunun showed purple in the anthocyanin color of stems, much the same as Chunpoong. The shapes of inflorescence and berries were simple type and round for both Sunun and Chunpoong. The existence of stolon roots in the below-ground section was found in both Sunun and Chunpoong. As for the distribution of the anthocyanin color of stems, which is the similar qualitative characteristic in the aerial section, Sunun showed purple along the whole stems, whereas Chunpoong showed purple only on the lower section. The color of berries was red for Sunun, whereas it was orange for Chunpoong. The color of autumn leaves was red for Sunun and it was distinctively orange for Chunpoong. The shape of the aerial section leaflets was broad elliptical for both Sunun and Chunpoong. The root color of the below-ground section was cream for both varieties. Among the characteristics of the aerial sections, Sunun showed strong development of the blistering of the surface of the leaflets (Table 1; Fig. 2B, 2G).

### 3.8. Major characteristics of the aerial sections of Sunun and Chunpoong

Among the characteristics of the aerial sections of Sunun and Chunpoong based on 2 yr of substance testing at the production site, the average stem diameter was 6.9 mm for Sunun and 7.4 mm for Chunpoong, revealing that Sunun was slightly smaller than Chunpoong. The average stem length was 29.0 cm for Sunun and 31.8 cm for Chunpoong; Sunun was slightly shorter than Chunpoong. The average leaflet length was 16.2 cm for Sunun and 15.6 cm for Chunpoong. The average leaflet width was 7.0 cm for Sunun and 6.2 cm for Chunpoong; Sunun was slightly longer than Chunpoong. The average number of palmately compound leaves was 4.5 for Sunun and 4.6 for Chunpoong, and the average number of leaflets was 24.3 for Sunun and 21.7 for Chunpoong. In this regard, there was no significant difference between the two varieties (Table 2).

### 3.9. Characteristics of below-ground sections and red ginseng of Sunun and Chunpoong

Table 3 shows the characteristics of below-ground sections and the average quality of red ginseng. The average length of the main root was 8.2 cm for Sunun and 8.1 cm for Chunpoong and the average

diameter of the main root was 26.5 mm for Sunun and 26.3 mm for Chunpoong with no significant difference between the two varieties. The average root weight was 67.8 g for Sunun and 60.1 g for Chunpoong and Sunun was slightly heavier than Chunpoong. In terms of the quality of red ginseng, the average rate of heaven-grade ginseng was 16.4% for Sunun and 32.3% for Chunpoong, the average rate of earth-grade ginseng was 18.0% for Sunun and 25.6% for Chunpoong, and the average rate of yang-grade ginseng was 24.2% for Sunun and 27.9% for Chunpoong. The average rate of jab-grade ginseng was 41.5% for Sunun and 13.7% for Chunpoong. Overall, in terms of the quality of red ginseng, the rates of heaven- and earth-grade ginseng were lower for Sunun than those of Chunpoong.

### 3.10. Breeding of *Panax ginseng* var. Sunpoong

The characteristics of Chunpoong include that the average rates of heaven- and earth-grade ginseng being 6–13% higher than those of the violet-stem variant when produced using grade-two fresh ginseng [17]. However, the average root weight was only 70 g when the root weight of grade-one fresh ginseng should be 75 g or heavier according to the raw ginseng quality standards [18]. It is a concern that the grade of raw ginseng may become lower when the root weight of Chunpoong is low. Sunpoong was bred as a high-yield variant because its average yield is 2.8 kg/1.62 m<sup>2</sup>, and 0.6 kg heavier than 2.2 kg/1.62 m<sup>2</sup> of the violet-stem landrace. However, the rates of heaven- and earth-grade ginseng was 9.4% and lower than the 11.7% of the violet-stem landrace. This is because the root weight is heavy and the diameter of the main root is large, thereby increasing the rate of interior vanity and the rate of undergrade ginseng when producing red ginseng [19]. For these reasons, it was necessary to develop a variant with a heavy root weight and high rates of heaven- and earth-grade ginseng. Among the high-yield populations possessed by the KGC, “7224-1-1” with a very long length of peduncle was tested for breeding and named “KG104”. As a result of performing the productivity testing from 1981, the adaptation test in 1984, and the substance testing at the farm in 1991, its average root weight was 15.4% heavier than that of Chunpoong and the new variety was registered as Sunpoong.

### 3.11. Distinction of aerial sections of Sunpoong and Chunpoong for comparison

Among the qualitative characteristics of the aerial sections, both Sunpoong and Chunpoong showed purple in the anthocyanin color of stems. The shapes of the inflorescence and berries were simple type and round for both Sunpoong and Chunpoong. The existence of stolon roots in the below-ground section was found in both Sunpoong and Chunpoong. Therefore, there was no significant distinction in the qualitative characteristics of the aerial sections. By contrast, as for the distribution of the anthocyanin color of stems, which is the similar qualitative characteristic of the aerial section, Sunpoong showed purple along the whole stem, whereas Chunpoong showed purple only on the lower section. The color of berries was red for Sunpoong, whereas it was orange for Chunpoong. The color of the autumn leaves was red for Sunpoong and it was distinctively orange for Chunpoong. The shape of aerial section leaflets was broad elliptical for both Sunpoong and Chunpoong. The root color of the below-ground section was cream for both varieties (Table 1; Fig. 1C, 1G).

### 3.12. Major characteristics of the aerial sections of Sunpoong and Chunpoong

Among the characteristics of the aerial sections of Sunpoong and Chunpoong based on 3 yr of substance testing at the production

site, the average stem diameter was 8.1 mm for Sunpoong and 7.6 mm for Chunpoong, the average stem length was 45.0 cm for Sunpoong and 42.5 cm for Chunpoong, the average leaflet length was 17.1 cm for Sunpoong and 16.2 cm for Chunpoong. There was no significant difference between the two varieties. The average leaflet width was 10.9 cm for Sunpoong and 6.4 cm for Chunpoong; Sunpoong was 4.5 cm longer. The average number of palmately compound leaves was 5.0 for Sunpoong and 4.8 for Chunpoong and the average number of leaflets was 24.8 for Sunpoong and 23.4 for Chunpoong (Table 2). In particular, the average length of the peduncle was 28.5 cm for Sunpoong and 22.9 cm for Chunpoong; Sunpoong was 5.7 cm longer (date not shown).

### 3.13. Characteristics of the below-ground sections and red ginseng of Sunpoong and Chunpoong

Table 3 shows the characteristics of the below-ground sections and the average quality of red ginseng. The average quantity of Sunpoong and Chunpoong was 2.9 kg/1.62 m<sup>2</sup> and 3.0 kg/1.62 m<sup>2</sup>, respectively. The average length of the main root was 6.5 cm for Sunpoong and 6.7 cm for Chunpoong, and the average diameter of the main root was 30.3 mm for Sunpoong and 28.3 mm for Chunpoong with no significant difference between the two varieties. The average root weight was 70.6 g for Sunpoong and 59.7 g for Chunpoong; Sunpoong was 10.9 g heavier than Chunpoong. In the study of the quality of red ginseng, the average rate of heaven-grade ginseng was 8.7% for Sunpoong and 17.5% for Chunpoong, the average rate of earth-grade ginseng was 12.2% for Sunpoong and 20.5% for Chunpoong, and the average rate of yang-grade ginseng was 43.2% for Sunpoong and 36.9% for Chunpoong. The average rate of jab-grade ginseng was 35.9% for Sunpoong and 33.1% for Chunpoong.

### 3.14. Breeding of *Panax ginseng* var. *Sunone*

Root rot (*Cylindrocarpon destructans*) is the disease that rots the roots of ginseng during cultivation. This disease is a major cause of yield reduction in ginseng cultivation areas because it is the cause of damage to continuous cropping. For the selection of a variant resistant to root rot through breeding, packaging and indoor testing of root rot began in 1982 with 50 excellent variants including 680-29-1. The selection of variants resistant to root rot continued, but most of the variants were found to be not resistant in the reappearance testing. Sunone was cultivated by population breeding to purple-stem landrace in 1978 and one entity with a broad leaf, purple stem, and six rounds, palmately compound leaves was selected among the entities packaged at the production site. It was named "78135" and the productivity testing was performed in 1992 after the breeding testing in 1982. It was the first variant selected for resistance to root rot in 1996 and its resistance was verified during the reappearance testing in 1997 and 2002. The variant was named KG112 in 2000, and an adaptation test was performed to register the new variety as Sunone.

### 3.15. Distinction of aerial sections of Sunone and Chunpoong for comparison

Among the qualitative characteristics of the aerial sections, both Sunone and Chunpoong showed purple in the anthocyanin color of stems and the shapes of inflorescence and berries were simple type and round for both Sunone and Chunpoong. The existence of stolon roots in the below-ground section was found in both Sunone and Chunpoong. Therefore, there was no significant distinction in the qualitative characteristics of the aerial sections. However, as for the distribution of anthocyanin color in the stems, which is the similar

qualitative characteristic of the aerial section, Sunone showed purple along the whole stem, whereas Chunpoong showed purple only on the lower section. The color of berries was red for Sunone, whereas it was orange for Chunpoong. It was previously reported that for Sunone the color of berries was orange-red; however, this was done in error [20]. The color of the senescence of leaves was red for Sunone and it was distinctively orange for Chunpoong. The shape of the aerial section leaflets was broad elliptical for both Sunone and Chunpoong. The root color of the below-ground section was cream for both variants (Table 1; Fig. 2D, 2G).

### 3.16. Major characteristics of aerial sections of Sunone and Chunpoong

Among the characteristics of the aerial sections of Sunone and Chunpoong based on 2 yr of substance testing at the production site, the average stem diameter was 7.5 mm for Sunone and 7.5 mm for Chunpoong. The average stem length was 35.4 cm for Sunone and 33.6 cm for Chunpoong; Sunone was 1.8 cm longer. The average leaf length was 15.7 cm for Sunone and 15.1 cm for Chunpoong and the average leaf width was 6.8 cm for Sunone and 6.3 cm for Chunpoong. The average number of palmately compound leaves was 4.5 for Sunone and 4.5 for Chunpoong, and the average number of leaflets was 24.4 for Sunone and 23.4 for Chunpoong, with no significant difference between the two varieties (Table 2).

### 3.17. Characteristics of the below-ground sections and red ginseng of Sunone and Chunpoong

Table 3 shows the characteristics of the below-ground sections and the average quality of red ginseng. The average yield of Sunone and Chunpoong was 3.3 kg/1.62 m<sup>2</sup> for Sunone and 1.9 kg/1.62 m<sup>2</sup> for Chunpoong. Sunone produced 42.4% more than Chunpoong did. The average length of the main root was 8.5 cm for Sunone and 7.3 cm for Chunpoong; Sunone was slightly longer than Chunpoong. The average diameter of the main root was 29.3 mm for Sunone and 25.3 mm for Chunpoong, and Sunone was a little thicker than Chunpoong. The average root weight was 84.1 g for Sunone and 52.5 g for Chunpoong; Sunone was 31.6 g heavier than Chunpoong. In the study of the quality of red ginseng, the average rate of heaven-grade ginseng was 1.9% for Sunone and 14.0% for Chunpoong, the average rate of earth-grade ginseng was 6.8% for Sunone and 14.9% for Chunpoong, and the average rate of yang-grade ginseng was 32.0% for Sunone and 56.7% for Chunpoong. The average rate of jab-grade ginseng was 59.5% for Sunone and 15.3% for Chunpoong.

### 3.18. Sunone's resistance to root rot

The average survival rate of the 2-yr-old aerial sections against root rot was 61.1% for Sunone and 20.5% for the violet-stem variant in testing in 1996. The average survival rate of the 4-yr-old areal section was 44.4% for Sunone and 21.7% for the violet-stem variant in 1997. Later, the average prevalence of root rot for the 2-yr-old Sunone and violet-stem variant in 2004 was 32.2% and 15.5%, respectively, to prove the reappearance of Sunone's resistance to root rot (Table 5). In 2002, the average yield of 6-yr-old ginseng per section of farmland in the package affected by root rot was 1.6 kg for Sunone and 1.3 kg for the violet-stem variant (data not shown).

### 3.19. Breeding of *Panax ginseng* var. *Cheongsun*

The green-stem variant was first discovered in Jangdan-gun, Gyeonggi-do in 1927 as a variant with green stems and red berries. The same entity was discovered at the Korea Ginseng &



**Table 5**  
Prevalence of root rot (*Cylindrocarpon destructans*) for “Sunone”

Varieties	1996	1997	2004
	2-yr-old <sup>1)</sup>	4-yr-old	2-yr-old
	Daejeon	Daejeon	Suweon
Sunone	61.1	44.4	32.2
Violet-stem variant	20.5	21.7	15.5

Values are expressed as percentages

<sup>1)</sup> Ginseng growth stage

Tobacco Research Institute’s Jeungpyeong Experimental Station in Chungcheongbuk-do in 1978. The yearly study of the characteristics of the aerial section and below-ground section of this ginseng began in 1983. In 1988, the distribution of the color of stems was studied for 14 entities of third-generation offspring and two entities of second-generation offspring. Among the third-generation offspring, eight entities showed green stems and red berries, but the remaining six entities showed a 3:1 distribution of green and purple stems. Also, the characteristics of photosynthesis and respiration according to temperature were studied for the violet-stem variant, yellow berry variant, and green stem variant. There was no significant difference among them [21]. The rusty roots, cracking, and root rot rates of the below-ground sections were studied and it was reported that there were no significant differences between the violet-stem variant and the yellow berry variant. For the green stem variant, an entity with green stems, petiole, and peduncle similar to Gumpoong, and red fully-ripened berries was selected at the Korea Ginseng & Tobacco Research Institute’s Jeungpyeong Experimental Station in 1978. After performing the breeding tests on the aerial section and below-ground section of the green stem variant, the new variety was registered as Cheongsun through productivity testing in 1991 and adaptation testing in 1999.

### 3.20. Distinction of aerial sections of Cheongsun and Chunpoong for comparison

Among the qualitative characteristics of the aerial section, Cheongsun distinctively showed no purple in the anthocyanin color of stems, unlike Chunpoong. The shapes of the inflorescence and berries were of simple type and round for both Cheongsun and Chunpoong. The existence of stolon roots in the below-ground section was found in both Cheongsun and Chunpoong. As for the distribution of the anthocyanin color of stems, which is the similar qualitative characteristic of the aerial section, Cheongsun showed green across the stems with no purple, whereas Chunpoong showed purple only on the lower sections. The color of the berries was red for Cheongsun, whereas it was orange for Chunpoong. The color of autumn leaves was red for Cheongsun and it was distinctively orange for Chunpoong. The shape of aerial section leaflets was broad elliptical for both Cheongsun and Chunpoong. The root color of the below-ground sections was cream for both variants (Table 1; Fig. 2E, 2G).

### 3.21. Major characteristics of aerial sections of Cheongsun and Chunpoong

Among the characteristics of the aerial sections of Cheongsun and Chunpoong based on 3 yr of substance testing at the production site, the average stem diameter was 7.0 mm for Cheongsun and 6.8 mm for Chunpoong, the average stem length was 32.2 cm for Cheongsun and 32.9 cm for Chunpoong, the average leaf length was 14.7 cm for Cheongsun and 14.8 cm for Chunpoong, and the average

leaf width was 6.7 cm for Cheongsun and 6.2 cm for Chunpoong. The average number of palmately compound leaves was 4.8 for Cheongsun and 4.9 for Chunpoong, and the average number of leaflets was 23.8 for Cheongsun and 24.2 for Chunpoong. There were no significant differences between the two variants in terms of the characteristics of the aerial section (Table 2).

### 3.22. Characteristics of below-ground sections and red ginseng of Cheongsun and Chunpoong

Table 3 shows the characteristics of the below-ground sections and the average quality of red ginseng. The length of the main root was 8.6 cm and 9.5 cm for Cheongsun and Chunpoong, respectively. The diameter of the main root was 25.4 mm and 26.9 mm, respectively; Cheongsun was slightly smaller than Chunpoong. The root weight was 73.7 g and 67.4 g, respectively; Cheongsun was 6.3 g heavier than Chunpoong. In the study of the quality of the red ginseng, the average rate of heaven-grade ginseng was 14.6% for Cheongsun and 24.9% for Chunpoong, the average rate of earth-grade ginseng was 7.2% for Cheongsun and 15.0% for Chunpoong, and the average rate of yang-grade ginseng was 34.1% for Cheongsun and 28.8% for Chunpoong. The average rate of jab-grade ginseng was 44.1% for Cheongsun and 31.4% for Chunpoong. For the characteristics of the below-ground section, the root weight varied between the two varieties and the quality of red ginseng was lower for Cheongsun compared to Chunpoong.

### 3.23. Breeding of *Panax ginseng* var. *Sunhyang*

The breeding of ginseng variants resulted in the creation of Chunpoong with excellent physical characteristics [17]; in this case, Yunpoong with its high-yielding properties [19], and Gopoong with its high saponin content [22]. However, more functional variants are being developed for ginseng as more people are interested in a healthy lifestyle. For the specifics of the active substances of ginseng, the content and distribution of saponin in each section and the root of ginseng [23] and the saponin content of each variant of ginseng have been reported. For the study of the red ginseng flavor, the primary identification of raw ginseng’s volatile aroma [24] and the aromatic substances of gas chromatograph/mass spectrophotometry (GC/MS) have been studied [25]. In 1978, an entity was selected and named 78093. The characteristics were studied through breeding testing from 1979 to 1981. The productivity testing was performed from 1983 through 1991 and the substance testing at the production site was performed from 1999. This variant was named KG110. During the substance testing, it was found that the quantity of the below-ground section was outstanding and the high content of Aroma-1 in red ginseng was acknowledged in 2006, which led to the registration of the new variety as Sunhyang.

### 3.24. Distinction of aerial sections of Sunhyang and Chunpoong for comparison

Among the qualitative characteristics of the aerial sections, both Sunhyang and Chunpoong showed purple in the anthocyanin color of the stems. The shapes of the inflorescence and berries were of simple type and round for both Sunhyang and Chunpoong. The existence of stolon roots in the below-ground section was found in both Sunhyang and Chunpoong. As for the distribution of anthocyanin color in the stems, which is the similar qualitative characteristic of the aerial section, both Sunhyang and Chunpoong showed purple only on the lower section. The color of berries was red for Sunhyang, whereas it was red-orange for Chunpoong. The color of the senescence of the leaves was red for Sunhyang and

orange for Chunpoong. The shape of the aerial section leaflets was broad elliptical for Sunhyang and distinctively broad elliptical for Chunpoong. The root color of the below-ground sections was cream for both variants (Table 1; Fig. 2F, G).

### 3.25. Major characteristics of the aerial sections of Sunhyang and Chunpoong

Among the characteristics of the aerial sections of Sunhyang and Chunpoong based on 2 yr of substance testing at the production site, the average stem diameter was 6.6 mm for Sunhyang and 6.4 mm for Chunpoong, the average stem length was 39.6 cm for Sunhyang and 38.6 cm for Chunpoong, the average leaf length was 14.9 cm for Sunhyang and 14.1 cm for Chunpoong, and the average leaf width was 6.5 cm for Sunhyang and 6.4 cm for Chunpoong. The average number of palmately compound leaves was 4.3 for Sunhyang and 4.5 for Chunpoong, and the average number of leaflets was 22.8 for Sunhyang and 23.5 for Chunpoong. There were no significant differences between the two varieties in the characteristics of the aerial sections (Table 2).

### 3.26. Characteristics of the below-ground sections and red ginseng of Sunhyang and Chunpoong

Table 3 shows the characteristics of the below-ground sections and the average quality of red ginseng based on 3 yr of substance testing at the production site. The average yield was 1.8 kg/1.62 m<sup>2</sup> for both Sunhyang and Chunpoong and the average length of the main root was 7.4 cm and 8.4 cm, respectively. The average diameter of the main root was 29.0 mm and 27.1 mm, respectively. There was no significant difference between the two varieties, but the root weight was 78.8 g and 70.8 g, respectively; Sunhyang was 1.0 g heavier than Chunpoong. In the study of the quality of red ginseng, the average rate of heaven-grade ginseng was 13.3% for Sunhyang and 32.3% for Chunpoong, the average rate of earth-grade ginseng was 14.1% for Sunhyang and 26.0% for Chunpoong, and the average rate of yang-grade ginseng was 15.5% for Sunhyang and 28.1% for Chunpoong. The average rate of jab-grade ginseng was 57.2% for Sunhyang and 13.7% for Chunpoong.

### 3.27. Sunhyang's unique flavor of red ginseng

As a result of harvesting the ginseng in mid-October 2005 and steaming it to compare the content of AFG, the precursor of Aroma-1, the measurements for AFG were 95.1 μmol/g for Sunhyang and 30.8 μmol/g for Chunpoong. In fresh ginseng, AFG, the precursor of Aroma-1, is produced by the combination of maltose and arginine. Comparing the arginine contents of the fresh ginseng and red ginseng of the two variants, Sunhyang showed 121.3 μmol/g in the fresh ginseng and 226.9 μmol/g in the red ginseng, whereas Chunpoong showed 101.4 μmol/g in raw ginseng and 112.4 μmol/g in red ginseng (Table 6).

As shown above, the KGC has developed the new ginseng variants of Gumpoong, Sunun, Sunpoong, Sunone, Chengsun, and

Sunhyang. Among the violet-stem variants, the yellow berry variant and the green stem variant were very weak against rusty roots. Gumpoong, which is strong against rusty roots, showed no purple stem in the characteristics of the aerial section and distinctively had yellow berries and senescence of leaves. In 2002, the rate of rusty roots in the below-ground section was 1.29 in Daejeon and 1.45 in Eumseong, whereas that of the yellow berry variant was 2.66 and 2.45, respectively, and it was proven that Gumpoong was tolerant to rusty roots (Table 4; Fig. 2A). However, there is little information on the physiological mechanism of rusty roots in ginseng, therefore studies are needed in the future. Chunpoong shows higher rates of heaven- and earth-grade, but a lower root weight than the other varieties. Therefore, it was necessary to breed a variant with heavier root weight and high rates of heaven- and earth-grade ginseng. Sunpoong distinctively has a long peduncle among the characteristics of the aerial section. It is a high-yielding variant with the average root weight of 70.6 g and yield of 2.9 kg/1.6 m<sup>2</sup>. Its rate of heaven- and earth-grade was 20.9% and very high compared to the 9.4% of Yunpoong. It is a high-yielding variant with high rates of heaven- and earth-grade ginseng (Table 3). In ginseng cultivation, root rot makes it impossible to do continuous cropping. Therefore, it was necessary to breed a variant with resistance to root rot. Sunone distinctively has bushy-type, palmately compound leaves among the characteristics of the aerial section. The survival rate of 4-yr old roots in 1997 was 44.4%, whereas only 21.7% of the violet-stem variant survived. In 2004, the prevalence of root rot in 2-yr-old roots was 61.1%, whereas it was 20.5% for the violet-stem variant (Table 5). The focus of breeding shifted from high-yield and outstanding physical properties to resistance and functionality. The purpose of breeding functional variants of ginseng was to breed a variant with high saponin content. The long storage time of red ginseng increases the more specific flavor. Also, the specific flavor of red ginseng on the market has a significant impact on sales. Sunhyang showed no clear distinction in the characteristics of the aerial section, but Sunhyang's content of AFG, the unique scent of red ginseng, was 95.1 μmol/g and greater than the 30.8 μmol/g of Chunpoong (Table 6). Ginseng does not have much genetic diversity and distinctiveness is very low when breeding new variants. In order to breed a new variant, it is necessary to develop a variant with a clearly distinctive aerial section. A clearly distinctive variant can be used as an intermediate parent. Sunun has a distinctively strongly developed blistering of the surface on the leaflets among the characteristics of the aerial section (Fig. 2B). Chengsun has no purple on the stems and distinctively red berries and senescence of leaves among the characteristics of the aerial section (Fig. 2E). Chunpoong and Chengsun have reportedly been derived from the Chunkyung landrace; also Gumpoong was derived from the Hwangsook landrace [20]. However, Cheon and Kim [21] reported that Chengsun was derived from the Jakyung landrace. Takahasi & Ousmi first reported samples of green-stems and red berry, and the green-stems and yellow berry variant was first discovered as one line of the Jakyung landrace in 1927 [26].

The saponin content of 6-yr-old red ginseng in the water extraction was Sunhyang > Sunun > Gumpoong > Sunpoong > Sunone > Cheongsun. For the different forms of ginsenoside, Sunhyang contained 2.4 mg/g of Rg1, Cheongsun contained 0.9 mg/g of Re, Sunun contained 0.9 mg/g of Rf, and Sunhyang contained 0.7, 0.6, 2.4, 0.8, 0.8, and 0.6 mg/g of Rh1, Rg2, Rb1, Rc, Rd and Rb2, respectively. However, there were no significant differences in Rd among the variants (data not shown). The saponin content of 6-yr-old red ginseng in the ethanol extraction was Sunun > Sunhyang > Sunone > Sunpoong > Gumpoong > Cheongsun and Sunun; Sunun contained 3.6 mg/g of Rg1, Cheongsun contained 1.6 mg/g of Re, Sunun contained 1.1 mg/g of Rf, Sunpoong contained 5.5 mg/g of Rb1, and Sunhyang contained 1.7 mg/g of Rc and Rb2. However,

**Table 6**  
Arginyl-fructosyl-glucose (AFG) and arginine contents of "Sunhyang"

Varieties <sup>1)</sup>	Arginine (μmol/g)	
	AFG (μmol/g) Red ginseng	Fresh ginseng Red ginseng
Sunhyang	95.1	121.3
Chunpoong	30.8	101.4

<sup>1)</sup> Analyses of AFG and arginine concentrations were performed on a 6-yr-old ginseng root

there were no differences in Rh1, Rg2, Rd, and Rg2 levels among the variants (data not shown).

The major purpose of breeding ginseng focused on the quality of red ginseng, high-yielding property, out-standing physical properties, resistance to disease, and high saponin content from 1970 through to the late 1990s. Since 2000, however, due to the increasing interest in red ginseng for its health properties, the focus has shifted to developing variants with a high content of non-saponin substances and resistance to the damage of high temperature. Ginseng is a half-shade plant and its growth is lowered by the damage of high temperature and intense light. In order to overcome these environmental conditions, a variant was selected with tolerance to the damage of high temperature and the characteristics of this variant were reported [27–29]. The genetic diversity of ginseng variants is very limited as it is a self-fertilized plant. Therefore, it is necessary to introduce cross-breeding and mutant-breeding methods to overcome this. By doing so, variants with a high content of active substances and tolerance to environmental conditions, such as drought and humidity, and resistance to diseases/insects should be developed. These are among the goals that the KGC works towards in striving to maintain the quality of plant output and improve certain characteristics to meet the realities and demands of the modern world.

#### Conflicts of interest

None of the authors have any conflicts of interest to declare.

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