

Feature Article

Current Status and Problem-Solving Strategies for Ginseng Industry*

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ABSTRACT Ginseng is a plant in the family *Araliaceae* and the genus *Panax* with the formal name of *Panax ginseng* C. A. Meyer and the treasure of traditional herbal medicine resources as the "king of herbs". Ginseng has been traditionally used for over 2,000 years in Asian countries, especially in China and Republic of Korea. During the ginseng industry chain, the cultivation in farmland and seed breeding are important for sustainable development of ginseng resources. Active components in ginseng including ginsenosides, polysaccharides, phenolic compound and their therapeutic benefits for multiple diseases are being studied. This paper aimed to review current research status and problem-solving strategies for each step of ginseng industry, including ginseng growing cultivation and seed resources, basic and clinical studies as well as comparison of ginseng industry between China and Republic of

Korea, hoping to provide a reference for research direction and future development of ginseng industry.

KEYWORDS ginseng, cultivation in farmland, functional mechanism, review

Ginseng is a plant in the family *Araliaceae* and the genus *Panax* with the formal name of *Panax ginseng* C. A. Meyer and the treasure of traditional herbal medicine resources as the "king of herbs".⁽¹⁾ Ginseng has been traditionally used for over 2,000 years in Asian countries, not only as a nourishing and tonifying agent but also a therapeutic agent for a variety of diseases including cardiovascular disease, neurological disease, diabetes, cancer, etc.⁽²⁻⁴⁾ Generally, ginseng typically grows in cooler climate like Northeast China, Korea peninsula, and Russia⁽⁵⁾ and includes 3 categories of cultivated ginseng, forested ginseng and wild ginseng, based on the growing environment.⁽⁶⁾ After growing for 4–6 years, fresh, white and red ginseng have been widely used in food, medicine, health products, cosmetics and other production, which is one of the most important and potential trade goods for market expansion.⁽⁷⁾ This paper aimed to review current research status and problem-solving strategies for ginseng industry, including ginseng growing cultivation and seed resources, basic and clinical studies and comparison of ginseng industry between China and Republic of Korea, hoping to provide a reference for research direction and future development of ginseng industry.

Ginseng Growing Cultivation and Seed Resources

According to the distribution, ginseng is mainly distributed in China, Republic of Korea, Japan and other countries. Chinese ginseng mainly distributed in the three provinces of northeast, among which Jilin's ginseng output accounts for about 85% of the whole country, and 70% of the whole world.⁽⁵⁾ The main planting mode of ginseng in the deforestation land for 400 years has caused serious damage for forest resource and ecological environment, which has been prohibited by the Chinese government,

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according to the limitation of available forest land. At present, a pollution-free planting technology system as a main planting mode in China for cultivating ginseng needs to improve and modify, which has been established in the Republic of Korea and Japan since 1940s.⁽⁸⁾ Global Geographic Information System for Medicinal Plant (GMPGIS) was used to select the most optimum regions of farmland cultivation in the world for the high quality ginseng production.⁽⁹⁾ Current researches mainly focus on soil remediation and improvement, planting and field management, disease and pest control to cultivate ginseng with maximum residue limit of pesticide residue, heavy metal contents and harmful elements.^(8,10-12)

Meanwhile, ginseng varieties and seed breeding are very important to guarantee ginseng sustainable development. In 2014, the International Organization for Standardization (ISO 17127-1: 2014) specifies minimum requirements and test methods for ginseng seeds and seedlings for quality assurance of ginseng cultivators. Currently, more than 20 varieties of ginseng, such as Gumpoong, Sunun, Sunpoong, Jilin Ginseng, Damaya, Kangmei ginseng were cultivated and extended planting in Japan, Republic of Korea and China.^(13,14) At present, systematic-, group-, cross-breeding and molecular labelling techniques were used to establish ginseng breeding system to gain new varieties with high stress resistance. Key disease resistance genes, such as nucleotide binding site (NBS)-encoding gene family have been identified to underly the function for facilitating disease resistance genetic improvement and breeding in ginseng.^(15,16) In addition, the entire genome sequences of ginseng line IR826, a high quality strain with low heterozygosity in 2017⁽¹⁷⁾ and Korean ginseng cultivar, Chunppoong in 2018⁽¹⁸⁾ provide valuable resource for improving the breeding and cultivation. Therefore, it is necessary to establish pollution-free ginseng cultivation and high-quality seeds breeding for the healthy and sustainable development of ginseng resources.

Active Components and Functional Mechanism of Ginseng in Basic and Clinical Studies

Recent phytochemistry and pharmacological studies have discovered a variety of active components in ginseng, including ginsenosides, polysaccharides, phenolic compound, protein, peptides, and alkaloids.⁽¹⁹⁾ Ginseng contains 38 types of ginsenosides as the major bioactive ingredients, including protopanaxadiol-type ginsenosides, Rb1, Rb2, Rc, and Rd; protopanaxatriol-type ginsenosides, Re, Rf, and Rg1; and oleanane-

type ginsenoside, Ro.⁽²⁰⁾ Many studies indicated that ginsenoside metabolites, such as Rh2, compound K, PT, and PD exerted better biological effects than naturally occurring ginsenoside.⁽²¹⁾ Polysaccharides as the largest numbers of components in ginseng are a diverse group of sugars with molecular masses ranging from 1,200–260,000 Da and composed of 3 types of glycosidic bonds (e.g., beta-1,3, beta-1,6, and 3,6-brancing).⁽²²⁾ In addition, protein, peptides and phenolic compounds from ginseng are studied to evaluate functional roles of neuroprotective and anti-oxidative activities.⁽²³⁻²⁵⁾

Currently, the therapeutic benefits of ginseng are mainly attributable to ginsenosides for the prevention or treatment of multiple diseases through overcoming various types of stress and restoring homeostasis. Ginsenosides as main active components were widely studied and showed cardiovascular and neurological protection,^(26,27) anti-cancer,⁽²⁸⁾ anti-diabetes,⁽²⁹⁾ and anti-aging⁽³⁰⁾ activities, and other functions as dietary supplements or medical applications. Recently, it was reported that ginseng polysaccharides restored the homeostasis of gut microbiota and consequently promoted absorption of certain ginsenosides to show the immune-enhancing and anti-cancer activity.^(22,31,32) Importantly, other active components from ginseng need to identify their structure and compound profiles, as well as explain their molecular mechanism for multiple functions in future.

Clinical trials on ginseng have been conducted in the worldwide and increased steadily over recent years, particularly in Republic of Korea and China. A total of 134 ginseng clinical trials (GCTs) were registered in the WHO International Clinical Trials Registry Platform (ChiCTR, 9 trials, clinicalTrials.gov, 85 trials), of which 60.4% were completed and 23.1% are recruiting participants.⁽³³⁾ The primary purpose of GCTs was disease treatment, followed by supportive care, prevention, and safety/efficacy evaluation.⁽³⁴⁾ The most common conditions in clinical trials were diabetes, metabolic syndrome, fatigue, cognitive disorders, erectile dysfunction, and cancer-related symptoms.^(35,36) Despite the wide application of ginseng products as complementary and alternative medicine, ginseng has only been studied in a limited number of clinical trials with a lower number of healthy subjects or patients with various symptoms. In the future, we need to demonstrate the efficacy and safety of ginseng through stricter and suitable researches.

Comparison of Ginseng Cultivation, Standards and Trade Competition between China and Republic of Korea

China and Republic of Korea are main countries in the world for ginseng cultivation, production and trade export. For the resource limitation of forest land in Republic of Korea and Japan, the techniques of cultivated ginseng in the farmland had been established since 1940s. The ginseng planting model has been changed from deforestation to cultivation in the farmland of China. A series of standards, including planting, product, determination methods, and pesticide limit standards are formed to guarantee the yield and quality of ginseng (Table 1). However, ginseng processing and product standards are still lack in China, which is a possible reason for the inferiority in ginseng production and trade competition. Korean ginsengs are processed by the factories with good manufacturing practice to develop 600 types of products with high-technological and added-value characteristics, which are applied in the industries of food, medicine, and cosmetics. In China, the processing techniques and product development are not mature and difficult to produce more competitive and famous products. The analysis for ginseng trade from 2007 to 2015 showed that the average price and ginseng export amount of the Republic of Korea was 5- and 6.3-fold of China, respectively. Compared with China, Korea only had 15% total amount of ginseng exports with the same total export values, suggesting that ginseng export competition of Korea was more competitive than China (Table 1).⁽⁷⁾ Based on the current experiences and technologies in Korean ginseng industry, researchers need to improve each step of Chinese ginseng industry, particularly ginseng processing and product development.

Future Perspective for Ginseng Industry in China

Cultivated ginseng in farmland had been approved as a new resource food in 2012, and put into the list of medicinal and food origin in 2014 by the China Food and Drug Administration. In 2016, fresh ginseng output in China was 28,900 tons, ranking at the first position, which produced the output value of \$7,500 million in Jilin's ginseng industry. However, the total value of ginseng industry is not compatible with ginseng yield in China. Moreover, the molecular mechanism of ginseng for clinical application remains unclear. To further improve and promote the development of the ginseng industry chain, we need to establish a pollution-free ginseng planting technology system in farmland and explore molecular

Table 1. Comparison of Ginseng Cultivation, Standards and Trade Competitiveness between China and Republic of Korea

Items	China	Republic of Korea
Planting model	Deforestation model to cultivation in farmland, planting in forest	Cultivation in farmland
Ginseng varieties	Jilin Ginseng, Damaya, Kangmei Ginseng, etc.	Gumpoong, Sunnun, Sunpoong, Sunone, etc.
Quality standard measurement	Rb1, total saponins, Re+Rg1	Rb1, Rf, Rg1
Ginseng industry standard		
National standard age	<5, 5–10, >15 years	5–10 years
Planting standard	3 standards for ginseng seeds and seedlings and cultivating operation rules, ISO standard (17127-1:2014) for ginseng seeds and seedlings	0
Product standard	10 standards for grade quality of fresh ginseng, 1 standard for products of geographical indications (GB/T 19506-2009)	4 standards for ginseng extract, dried ginseng, ginseng tea, ginseng chicken soup, 1 standard for ginseng product specification
Determination method standard	1 standard for quality standard method of ginseng	2 standards for ginseng tea test method and determination of Rb1 and Rg1 contents in ginseng and related product
Pesticide limit standard	1 standard for the limit of the pesticide residue, heavy metal contents and harmful elements in pollution-free ginseng (T/CATCM 001-2018)	1 standard for pesticide residues in red ginseng
Ginseng trade (2007–2015)		
Total export value (\$)	92.41 million	\$84.88 million
Export amount (ton)	2453	389
Export price (\$)	42.77/kg	215.49/kg
Market share (%)	21.15	21.06
Trade competitiveness	0.556	0.985

mechanisms for tonifying frailty-related disorders, and optimizing processing procedures as well as developing healthy products with the widespread commercial value.

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