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Ginseng: History, Cultivation, Industry and Future Prospects

Y. Zhan, H.Z. Xie, N. Yan, Q. Li* and T. Zhang*
Postal Address: No. 1035, Boshuo Road, Jingyue National High-tech Industrial Development Zone, Jilin Ginseng Academy, Changchun University of Chinese Medicine, Changchun, 130117, China.
E. Mail: zhangtaoccucmedu@163.com,wode17k@163.com

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CONTENTS

ABSTRACT

This paper summarized the Ginseng origin, species, morphological characteristics, cultivation history and industrial status. Three main planting patterns of cultivated ginseng [(i). Forest and (ii). Farmland and (iii). Flat land planted] were compared. Factors restricting ginseng's production were discussed. The important roles of regulating ginseng planting, developing deep processing and strengthening scientific and technological support in ginseng cultivation and industrial development were discussed. This study laid a foundation for further study to improve the ginseng yield and quality worldwide.

Key words: *Panax ginseng*, origin, species, morphological characteristics, cultivation history, ginseng industry, planting pattern, cultivation

1. INTRODUCTION

Ginseng (*Panax ginseng* C.A. Mey.) is a perennial herb of genus *Panax* (21,55), which has rich nutritional values and medicinal efficacy, in traditional Chinese medicine and

*Correspondence author, Qiong. Li and Tao. Zhang

the health industry (12,13). Ginseng has numerous uses: food, medicine and health care products. Its stem, leaf, fruit and its processing byproducts are the raw material to prepare the tea, wine, ointment etc. Hence, Ginseng is called “king of hundreds of herbs”. For the continuous development of ginseng food industry, in-depth research is needed on ginseng. It is not only leader in the field of traditional Chinese medicine, but also opens up a vast world in food industry. In addition, during the COVID-19 outbreak, ginseng has played an active and very important role in treating serious patients, which further indicates its future application prospects in safeguarding people's health and even life safety.

The total economic value of ginseng > US $ 2.0 billion and is steadily growing (38). However, the soil sickness problem in ginseng cultivation is major bottleneck restricting its sustainable production. Re-planting of ginseng in previously planted soil, drastically reduces its yields. Earlier researches have shown that ginseng soil sickness is caused by the interactions of ginseng plants-and soil-microorganisms and this problem still exists in ginseng cultivation. Therefore, we need to study the ginseng (i). Cultivation conditions, (ii). Cultivation methods and (iii). Cultivation patterns used. The modern science and technology should be applied to develop new technology to overcome the soil sickness and expand the planting scope of ginseng. Thus, we have reviewed the ginseng origin, species, morphological characteristics, cultivation techniques and industrial status and prospects of its future development.

2. GINSENG ORIGIN

Ginseng (genus *Panax*) is a precious medicinal plant. The genus *Panax*, was first used by Carl A Meyer a Russian botanist (28), the term ‘Panax’ is derived from two Greek words, Pan meaning “all”, and axos, meaning “medicine”, indicating that ginseng is a cure for all diseases (7). Ginseng originated in Palaeozoic Tertiary period about 60 million years ago. According to *the Dictionary of World History*, ginseng was first used in China, with a history of its medicinal use dating back 7,000 - 10,000 years. A Chinese ancient book called *Oracle Bone Inscriptions Collection*, in its sixth volume recorded that the vivid character “Shen” indicating ‘Ginseng’ was created 3,500 years ago in Yin and Shang dynasties (Fig. 1). It is said that in prehistoric times in China, there was a famous pharmacist named Shen Nong. He tested hundreds of plants on himself, to discover the power of herbs to treat people illness (56). In Han Dynasty (202-220 BC), ginseng was used to treat diseases. According to old literature, Taihang Mountains and Changbai Mountains are the birthplace of ginseng. During the Southern and Northern Dynasties (420-589 AD) the morphological characteristics and ecological habits of ginseng were described in the Book '*Famous Doctors*' written by Tao Hongjing. Ginseng has been regarded as the best food since ancient times. It has many nicknames, such as “god grass”, “stick hammer” and “goblin”. Ginseng uses have been described in medical books such as *Compendium of Materia Medica*, *Xinxiu Materia Medica* and *Compendium of Materia Medica*. Due to the resemblance between the ginseng root and the human shape (Fig. 1), the English name “ginseng” was introduced from the Chinese word “renshen” (6). Ginseng is widely used as medicine in China, in ethnic medicine in Korea, Japan and other Far Eastern countries. The medicinal aspects of ginseng

have been detailed in the famous Book "*Eastern Medicine*" written by the Korean writer and the "*Medicine Micro*" written by Yoshi-tong-dong in Japan.

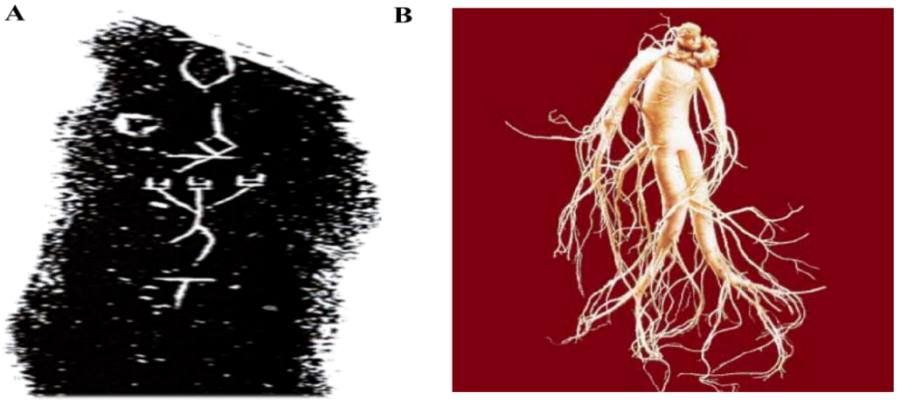

Figure 1. The origin of ginseng. (A is the character "Shen" recorded in the ancient Chinese book Anthology of Oracles and Bone; B is humanoid ginseng)

3. GINSENG SPECIES DISTRIBUTION

Ginseng is mainly distributed in China, Russia and Korea, and cultivated in Jilin and Liaoning provinces of China (3,50) (Fig. 2). According to its origin, ginseng can be divided into 4 categories: (i). Jilin ginseng, (ii). Liaoning ginseng, (iii). Korean ginseng and (iv). Japanese ginseng. Jilin ginseng is the ginseng produced in Jilin Province, China. Liaoning ginseng is a kind of ginseng produced in Liaoning Province of China, and "Kuandian ginseng" and "Shizhu ginseng" from Dandong City are the best. Korean ginseng, also known as "Korean ginseng", is divided into Korean red ginseng and Korean white ginseng according to different processing methods (16,29). Japanese ginseng is also called "East American Ginseng". It cuts from Chinese ginseng seed in Japan. Because of its unique processing methods, there are also white ginseng and red ginseng. In addition, there are many plants similar to ginseng. For example, *Panax trifolius* was first discovered in Nova

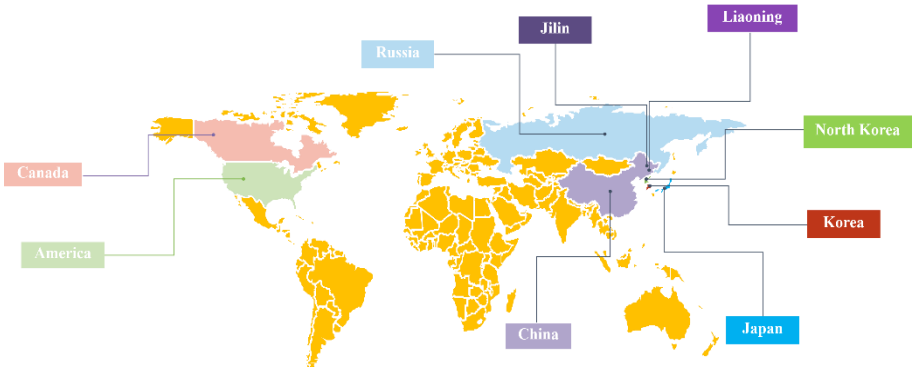

Figure 2. Distribution map of main producing areas of ginseng.

Scotia and the south. American ginseng (*Panacis Quinquefolii*) is grown chiefly in southern Canada and the United States (from south to Florida, west to Oklahoma, Maine to Minnesota) (4, 47). And Siberian ginseng without ginsenosides, the main active ingredient of ginseng (Table 1). There are many varieties of ginseng and we summarized the species and common names of ginseng (19) (Table 2).

Table 1. Ginseng classification based on area of origin.

#	Ginseng spp. Name	Botanical name	Growing area	Reference
1.	Jilin ginseng	*Panax ginseng* C. A. Mey	Jilin Province	-
2.	Liaoning ginseng	*Panax ginseng* C. A. Mey	Liaoning Province	-
	(i). Kuandian ginseng*	*Panax ginseng* C. A. Mey	Dandong City	-
	(ii). Shizu ginseng*	*Panax ginseng* C. A. Mey	Dandong City	-
3.	Korean ginseng	*Panax ginseng* C. A. Mey	Korea	16, 29
4.	Japanese ginseng**	*Panax ginseng* C. A. Mey	Japan	-
5.	Panax stipuleanatus	*Panax trifolius*	Nova Scotia, Canada	-
6.	American ginseng	*P. quinquefolius*	South Canada, USA (Florida, Oklahoma, Maine, Minnesota)	4,47
7.	Siberian ginseng***	*Eleutherococcus Senticosus*	Siberia	19

*Donong city Ginseng best quality, **2-Colours (White, Red, the colours depends on method of Proceesing), *** Without ginsensosides

Table 2. List of ginseng species.

#	Ginseng Species	Trivial Name	References
1	*P. notoginseng*	Chinese ginseng	10,41,67
2	*P. quinquefolius*	American ginseng	4,30,45
3	*P. trifolius*	Dwarf ginseng	25,35
4	*P. japonicas*	Japanese ginseng	49,54,61
5	*P. zingiberensis*	Ginger ginseng	2,8,9,39
6	*P. ginseng*	Korean ginseng	1,12,15,29,35,59
7	*P.pseudoginseng*	Himalayan ginseng	11,51
8	*P. bipinnatifidus*	Feather-leaf bamboo ginseng	4,46
9	*P. stipuleanatus*	Pingpien ginseng	8,9,67
10	*P. vietnamensis*	Vietnamese ginseng	2,39,53
11	*P. omeiensis*	Omei ginseng	8
12	*P. wangianus*	Narrow-leaved	2,8
13	*P. sinensis*	N/A	2,8
14	*P. sokpayensis*	N/A	4, 46
15	*P. assamicus*	N/A	10,42
16	*P. variabilis*	N/A	2,9
17	*P. shangianus*	N/A	2,39

4. MORPHOLOGICAL CHARACTERISTICS OF GINSENG

Ginseng is mainly divided into two classes: (i). Garden ginseng and (ii). Mountain ginseng (grown in the forest).

(i) Garden Ginseng: The cultivated ginseng is called "Garden Ginseng" and is marketed. Its taproots are fusiform or cylindrical, 3-15 cm in long and 1-2 cm in diameter. The surface is grayish yellow, the upper part has longitudinal wrinkles, the lower part has 2-3 lateral roots. Its rhizomes are short, 1-4cm long, with adventitious roots and in sparsely concave stem marks. The quality is hard, the cross section is yellowish white, showing pink, there is a prominent yellow brownish ring, the skin part has yellowish brown points and radial cracks. Its taste is slightly bitter, sweet (18,26,64).

(ii). Mountain ginseng (grown in forest): This ginseng grows naturally in the forest in wild state. Its appearance characteristics are different from garden ginseng, because it grows in nature. Its main root is short and thick. The rhizomes may be long or short, with more than two branch roots, shaped like human body, and the upper part has fine and deep ring lines. The fibrous roots are white or yellowish and may be as long as the main root. Thus "garden ginseng" and "mountain ginseng" can be distinguished by the length of the root and stem.

5. GINSENG CULTIVATION

To meet the increasing demand of ginseng, Modern cultivation has started in many Chinese provinces (28).

5.1 Ginseng Cultivation

(I). Ancient cultivation Methods: Ginseng is being cultivated in China since ancient times and continued in the Western Jin Dynasty, Tang, Song, Yuan, Ming and Qing Dynasties. The history of ginseng cultivation in China can be divided into two methods.

(i). Transplanted Ginseng (Western Jin Dynasty to the Yuan Dynasty): It mainly collects the wild ginseng and transplant them in wild forests/shady places near their homes (57). The transplanting increases the plant weight and not the number of plants. It is the primary method of ginseng cultivation.

(ii). Seed sown Ginseng (Ming Dynasty to Qing Dynasty): It greatly increased the area of ginseng cultivation. Its fresh seeds are collected at maturity and used for sowing. During Xianfeng Dynasty (1851-1861), ginseng cultivation developed rapidly.

Furthermore, American ginseng is important in the international ginseng market, cultivation is closely related to China. After two years of effort, Farther Lafitau, a North American Indian, proved that the Chinese ginseng was same species found in Canadian forests (27). The Ginseng plant was also found in eastern United States forests and after 1716 was named *Panacis Quinquefolii* Radix. However, due to the extensive cutting of forests, ginseng optimal growth conditions were destroyed, hence, the area of wild ginseng decreased sharply. During the 3-decades from 1900 to the outbreak of World War II, the ginseng industry expanded rapidly in the United States.

(II) Modern Cultivation Methods: Modern ginseng cultivation is mainly done by (i). Seed sowing and (ii). Seedlings transplanting. Seed sown Ginseng plants are more robust, have strong resistance to adversity, no pests and diseases, good growth for 5-years. Ginseng seeds have dormancy period, hence, takes more time to germinate. Therefore, ginseng seed should before sowing should be treated to hasten germination. The ginseng seed needs to be disinfected. Seed is soaked in 1% formalin solution for 10 min or soak in Bordeaux liquid for 15 min. After disinfection, seed is rinsed few times with water before sowing. Seed can be planted 3-times (i). Spring, (ii). Summer and (iii). Autumn, because winter is too cold (Table 3). Spring sowing is done mainly in mid-April to early June. Summer sowing is done mainly between July and August (sowing of the year's collected or stored seeds and the next spring seedlings). Autumn sowing is mainly between September and October (to sow the seeds after accelerating germination and the seedlings will emerge in about half a month).

Table 3. Ginseng sowing/transplanting time.

Seed sown crop			Transplanted crop*		
Sowing season	**Months**	**Days for seedlings emergence**	**Transplant Time**	**Months**	**Remarks**
Spring	Mid-April to early June	10-15	Autumn	Sept-October	To avoid high temperatures
Summer	July-August	Next spring	-	-	-
Autumn	Sept-October	15	-	-	-

*2-3 years old seedlings are transplanted and harvested after 6- Years.

Furthermore, ginseng seedling transplanting is mainly done in autumn, to avoid high temperatures. General 2-3-years-old seedlings are selected for transplanting, and 6-year-old seedlings are harvested (31,52). No matter what kind of cultivation, good crop management is necessary for the normal growth of ginseng (14).

5.2 Growth requirements

In nature, ginseng had been growing in deciduous broad-leaved forest or mixed coniferous broad-leaved forest hundreds of meters above sea level. Loose porous soil with water drainage, fertile sandy soil, and cool humid climate are suitable for its growth and development (23). Therefore, attention should be paid to select the ideal growing environment during ginseng cultivation.

(i). Soil. Ginseng should be planted in irrigated, loose porous, well drained and fertile soil, rich in nutrients and organic matter, with large aggregate structure. The slope should not exceed 25 degrees. Ideal soil pH: 5.5-6.5 not > 7. Before ginseng is planted, *Perilla frutescens* Britt., *Zea mays* L. or other Legume sp. should be planted in soil. Recommended dose of organic fertilizer should be added to soil to facilitate microbial reproduction, improve soil physical and chemical properties and increase the organic matter (43). However, before ginseng is planted, do not grow unsuitable crops (*Beta vulgaris* L., *Helianthus annuus* L., *Brassica oleracea* L. and *Raphanus sativus* L.). In

addition, reductive soil disinfestation technology based on ecological principle as pre-planting treatment effectively reduces the problems of soil sickness (33). This technology has been applied to *P. notoginseng* Burkill (65), *Citrullus lanatus* Thunb (66), *Solanum lycopersicum* (26) and *Cucumis sativus* L (65) and has achieved good results.

(ii). Moisture. The optimal moisture content in ginseng soil should be maintained at 40-50 %. When the soil moisture content is < 30 % or > 60 %, it will damage the ginseng root system and decreased the yield.

(iii). Temperature. When the temperature is below 10 ^{0}C or over 30 ^{0}C, ginseng becomes dormant. Ginseng resists the cold weather and survives in the winter at minus 30 ^{0}C. The suitable temperature for ginseng is 15-25 ^{0}C. When the temperature is below -6 ^{0}C, the ginseng stem will stop growing. The suitable temperature for ginseng germination and seedlings growth is > 10 ^{0}C.

(iv). Light intensity. Ginseng is shade loving plant, hence, grows better under weak sun light conditions than under strong light. But the light should not be lower than photosynthetic compensation point. It likes scattered sun light and avoids direct light. Ginseng can grow normally under the conditions of 52 % - 54 % daily illumination. If the illumination intensity exceeds 75 % of full sunshine, or the strong light at noon shines for > 2.0 h, the growth is inhibited, leaf tissue is damaged, photosynthesis is reduced, causes sunburn and even the plant dies. While the insufficient light, leads to poor growth, stunted plants, weak leaves and reduced photosynthesis. Therefore, in ginseng cultivation, partial shading is necessary. The scattered light can be used to provide illumination and avoid the direct irradiation of strong light to ensure the normal growth of ginseng.

5.3 Ginseng Planting

To prevent the damage to ecological environment during ginseng cultivation and get higher yield, it is necessary to improve the ginseng cultivation techniques.

(i). Ginseng Beds planting: For the healthy growth and good quality of ginseng, its field selection, land preparation, tillage, sowing, transplanting, field management are important. The land should be well drained, rich in organic matter, is porous and fertile. Plough the land at least once before freezing, and plough again after spring thawing and manure. The ploughing controls the weeds, loosen the soil and increases the aeration necessary for roots growth. The large fields should be divided into small plots to prepare ginseng beds.

The ginseng beds are 130-150 cm wide, 25-35 cm high and spaced 30-50 cm. The ginseng is sown or transplanted on the beds. Before sowing, break the seeds dormancy and disinfect them. For transplanting, healthy ginseng seedlings should be selected for oblique planting (Angle of 30-45 °). Anti-freezing measures should be taken in autumn planting. It is desirable to build shed for shade on ginseng plants and do regular weeding, watering and fertilization etc.

(ii). Ginseng planting methods: Ginseng is mainly cultivated in the field or forest.

(a). Forest cultivation: The ginseng cultivation in forest in natural environment is called forest cultivation. It can replace the wild ginseng to a certain extent. The forest

planting ginseng is an effective way to produce environmentally friendly ginseng with higher quality. However, due to the limited forest resources, long cultivation cycle and low yield of understory ginseng, it cannot meet the market demand. The soil should be rich in humus, loose and with good water holding capacity for its growth. Dense herbaceous plants should not interfere with ginseng growth. Therefore, it is very important to choose suitable soil conditions in the forest before planting the ginseng. The natural and secondary forest are mainly interlaced with broad-leaved and coniferous forest, these form natural protective layer to avoid direct sunlight and damage from heavy rain. It is necessary to clear the dense weeds, dead branches and rotten leaves to ensure normal sowing. To improve and hasten the seeds germination, it is necessary to break dormancy before sowing.

To avoid the damage to the ecological environment for ginseng planting, most ginseng growers cultivate on the flat land and have made some achievements. Plots with flat terrain, good drainage and relatively high organic matter content are mainly selected. It is best to plant soybean, corn as previous crop to make full use of nutrients in the soil. To improve the yield and quality of ginseng, it is necessary to apply manure before planting. Ginseng is susceptible to diseases and insect pests, due to its long growth cycle. Therefore, it is necessary to strengthen the field management and to immediately remove the diseased plants and disinfect them with lime.

(b). Field planting: It is relatively advanced technology in ginseng production (32,63). In the field ginseng cultivation, field crops are used as fore crops. However, the previous crop should not be root or stem and crops like corn and soybean are preferred. Before planting, the content of agricultural residues, heavy metals, nutrients, organic matter and pH value of soil should be determined. If their content exceeds the standard, field should not be selected. At the same time, the soil should be well prepared, with multiple rotary and deep tillage, add organic fertilizer such as animal manure and pesticides to control pests and diseases. The selection and treatment of seeds, nursery bed disinfection, sowing time and cultivation management are similar to those under forest cultivation. Now it has become the main cultivation method.

(c). New Methods: Due to the continuous development of ginseng industry and the continuous expansion of ginseng market, some new cultivation techniques have attracted greater attention, such as (i). Soil-less culture (24) and (ii). *in-vitro* culture (37,48) and other techniques.

(i). Soil-less culture: It uses nutrients solution instead of soil for culture. By artificially controlling the plant's absorption of nutrients, the incidence of diseases can be reduced. It saves water resources, fertilizer, labour, high yield and excellent production.

(ii). *In-vitro* culture: This technique is used to obtain new intact plants or other product organs of economic value by isolating some tissues from plants, artificially regulating the culture environment and inducing culture under aseptic conditions. *In-vitro* culture can reproduce plants rapidly, which has great effect on the protection

of rare plants and large-scale cultivation of many cash crops. The two new methods have broad application prospects in ginseng cultivation.

5.4 Existing Problems

Soil sickness (34) and ginseng diseases (15,58) are the two major obstacles, leading to the frequent occurrence of ginseng infectious and non-infectious diseases. At the same time, the deterioration of soil physical and chemical properties, the accumulation of allelopathic autotoxic substances, the increase of agricultural residues and heavy metals, the imbalance of nutrients and the imbalance of rhizosphere microecosystem occurs with the increase of ginseng planting years (17,60). In addition, the occurrence of diseases and insect pests is also a key factor restricting the development of ginseng. In ginseng cultivation, there are many types of diseases and pests and > 40 kinds of diseases have been reported, which reduces the ginseng yield and quality (20,44,36).

6. GINSENG INDUSTRY ECONOMIC STATUS QUO

Ginseng is a rare Chinese medicine. Modern pharmacological studies have shown its anti-aging, anti-depression, anti-senile dementia, anti-osteoarthritis, anti-tumor etc. properties. Many countries and regions of world are producing and selling ginseng and its products with annual international trade of 6500 tons. Its head, bud, stems and leaf all have certain medicinal value. During COVID-19 pandemic, ginseng enhanced the body's immunity against harmful viruses and bacteria and attracted wide attention (68). China is major producer and consumer of ginseng, accounting for 70 % of world's total production (19,62) (Fig. 3). The main importing countries of Chinese ginseng are America, Korea and Canada, among which American ginseng occupies a large part of market (32). In 2019, China imported 1,304.22 tons of ginseng from America, which is more than half of total imports (Fig. 4). Mainland China's exports ginseng mainly to Hong Kong, Taiwan and Japan (Fig. 5).

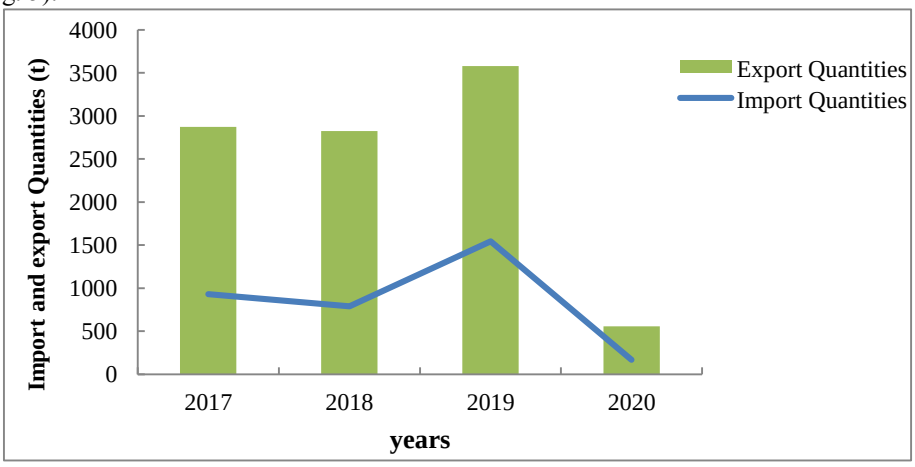

Figure 3. The quantities of import and export of ginseng industry in China during 2017-2020. (The quantities of imports and exports for 2020 are only available for the first quarter).

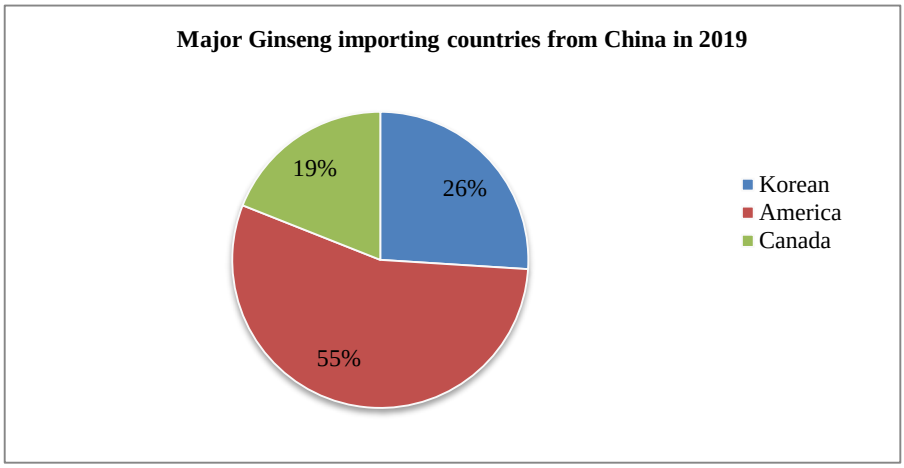

Figure 4. Major Ginseng importing countries from China in 2019.

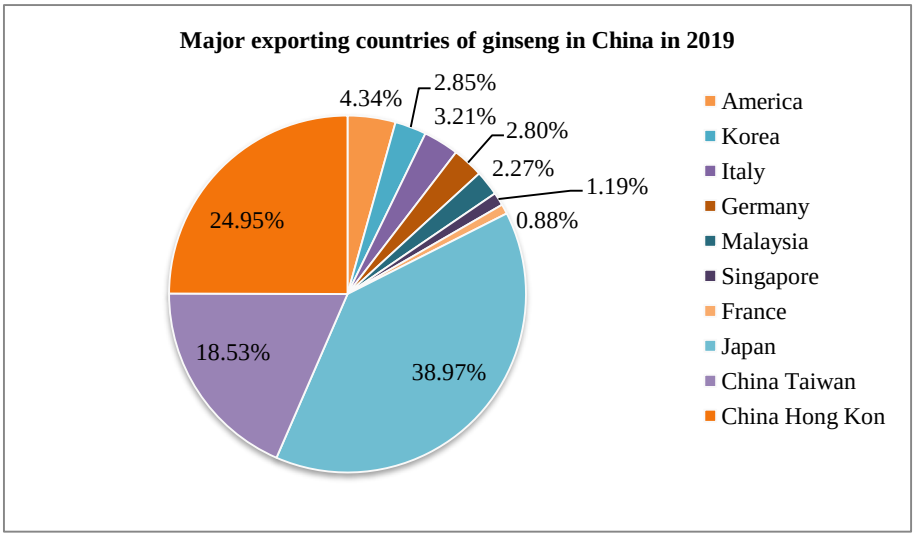

Figure 5. Major exporting countries and areas of ginseng in China in 2019.

The ginseng industry has some problems. Ginseng trade is mainly based on raw material, and the market share of additional products (Drugs, functional health products, food and articles for daily use) is low. The soil sickness of ginseng severely limits the development of ginseng industry, resulting in the decline of ginseng yield and quality year by year. Therefore, we need to further explore the causes of ginseng soil disease and the ways to alleviate the ginseng soil sickness.

7. FUTURE RESEARCH AREAS

We need to further explore the causes of ginseng soil sickness and develop technology to overcome it.

(i). Regulating ginseng cultivation. The greater demand for ginseng has resulted in excessive use of ginseng fields, serious pesticide residues in soil. Therefore, ginseng planting should be limited to most suitable growing regions.

(ii). Develop fine and deep processing. In recent years, many ginseng products (ginseng wine, ginseng honey tablets, ginseng soap, ginseng facial mask and other products) have gradually entered the market, their marketing needs to be improved.

(iii). Strengthen scientific and technological support. Strengthen the cooperation and exchange between the domestic and foreign scientific research institutes, introducr advanced equipment, adopting advanced technology, improvr yield and quality, develo ginseng varieties tolerant to soil sickness, scientific research to use land more efficiently and avoid environmental pollution.

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COMPLIANCE WITH ETHICAL STANDARDS

Conflict of Interest : The Authors declare no conflict of Interest.

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