Comprehensive Crop Reports

Siberian Ginseng

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ADDITIONAL INDEX WORDS. **cultivation, eleuthero root, ginseng, propagation, wujia**

SUMMARY. **Siberian ginseng** [*Eleutherococcus senticosus* (Rupr. ex. Maxim.) Maxim.] is currently a popular medicinal plant in Eurasia and North America. It has been used by the Chinese for over 2000 years. Recently, imported products of this plant have become available in North America, with a market share of 3.1% of the medicinal herbal industry. Siberian ginseng is harvested from its natural habitat in Russia and northeast China. Overharvesting has resulted in this popular herb approaching endangered species status. Cultivation is the only way to avoid its extinction, and to ensure the correct identity. Siberian ginseng is not a true ginseng (*Panax quinquefolium* L. or *P. ginseng* C.A. Meyer), but it has its own bioactive ingredients with unique and proven medicinal values. However, standardization and quality control of the active ingredients in the marketed products, which are mainly imported from China, are needed to avoid mislabeling or adulteration with other herbs.

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Contribution no. 2062. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

Siberian ginseng grows in thickets, small groups, or clumps, at the borders of broad-leaved and evergreen forests mainly in northeast China (Chen et al., 1997) and Russia. Its long, round, woody and pliable roots spread horizontally at a shallow depth and produce abundant suckers (Halstead and Hood, 1984). It has been used for medicinal purposes for centuries by the Chinese. It was listed in the Chinese "Shen Nong Ben Cao Jing" (The Divine Husbandman's Classic of the Materia Medica) over 2000 years ago (Foster, 1991).

The market demand for siberian ginseng has been steady over the years. Its products were listed No. 9 and 10 on the top ten bestselling list for health remedies in the United States in 1996 and 1997, with an estimated market share of 3.1% of the \$12 billion medicinal herbal industry (Rawls, 1996; Richman and Witkowski, 1997; Yat et al., 1998). Imported products, usually in the form of capsules (400 to 500 mg), are available in the pharmacies and health food stores at the price tag between \$5 to 8 per bottle of 100 capsules.

Botany and description

Siberian ginseng, *Eleutherococcus senticosus* [syn. *Acanthopanax senticosus* (Rupr. & Maxim. ex. Maxim.) Harms.], belongs to the family Araliaceae. It is a native shrub in northeast China, Korea, Japan, and the Khabarovsk and Primorsk Districts of Russia (Foster, 1991). It is also known as wujia, eleuthero root, touch-me-not, and devil's shrub (Farnsworth et al., 1985; Halstead and Hood, 1984). It is a winter hardy perennial

deciduous shrub with erect, scarcely branched and slender prickly stems up to 8 to 15 ft (2.4 to 4.5 m) in height (Fig. 1). Its dark green leaves have hairy veins and 3 or 5 oval to oblong fine toothed leaflets 3 inches (7.6 cm) long on a bristly short stalk 3 to 5 inches (7.6 to 12.7 cm) long. It has one or more globose umbels 1.5 inches (3.8 cm) wide with purplish male and yellow female flowers terminating the shoots. Each individual plant produces three types of flowers, male, female and bisexual, which bloom in early July (Halstead and Hood, 1984; Liu et al., 1997). Siberian ginseng flowers are cross-pollinated mainly by bees such as *Bombus*, *Haliplus*, and *Megachile* (Liu et al., 1998). Pollinated flowers develop into oval and berry-like black fruits 0.5 inches (1.3 cm) in diameter when mature (Bailey and Bailey, 1977; Chittenden, 1974).

Cultivation

Over the years, heavy harvesting in the natural habitat has resulted in siberian ginseng approaching endangered status in China (Chen et al., 1997). In order to protect its existence, it is recommended that some roots be left in the soil during harvesting for future regeneration (Chen et al., 1997). In order to meet increasing market demand, farmers are interested in cultivating this potentially lucrative crop. Recently, experimental cultivation started in Japan (Isoda and Shoji, 1989; 1994) and Canada (unpublished data) and it was demonstrated that siberian ginseng can be cultivated without any difficulties.

Growing siberian ginseng commercially requires consideration of its soil and environmental requirements, the reliability of seed sources or of proper propagation methods and cultural techniques. Information is scarce, therefore, the best method of understanding how to cultivate siberian ginseng is to grow it in soil and conditions resembling its natural habitat (i.e., shady, rich and moist sandy loam soil within northern temperate zone).

Experiments with the culture of siberian ginseng have been conducted at the Pacific Agri-Food Research Centre, Summerland, British Columbia under semiarid climatic conditions. Siberian ginseng seedlings and green wood cuttings were planted in the spring under full sun in sandy loamy soil (pH 7.2) at 1.6 ft (0.5 m) apart

within the row. Irrigation was provided as needed during the growing season. Plants grew vigorously until the middle of July, then started to show signs of sunburn with purplish-brown coloration on the leaf surface. To avoid this physiological disorder, experiments are underway to grow it under artificial shade and in the forest. The plants need 3 to 4 years of growth from seed emergence to flowering and seed setting. A shorter period is required (2 to 3 years) from cuttings and suckers (unpublished data). In our studies, mature fruits contained large numbers of shriveled and insect-damaged seeds, with plump seeds making up about 40% of the total seed produced. The plump seeds were mainly endosperm with a very small embryo (Liu et al., 1998). There were variations in seed set among plants in each year; a similar observation was reported by Liu et al. (1997). It has also been reported that seed set varies among habitats (Zhu and Guo, 1998), and is affected by air temperature and photoperiod (Park et al., 1995). Soil moisture has no marked effect on seed quality (Gorokhova, 1986).

Siberian ginseng depletes soil nutrients and requires supplementary fertilizer even in the forest (Chen et al., 1998). Our unpublished data indicated that an annual application of 13N-7P-8.3K at 0.07 lb (30 g) per tree in the early spring enhanced growth and flowering. Under our semiarid climate, with a total yearly precipitation of 11.8 inches (300 mm), irrigation was applied during the growing season.

In siberian ginseng, probably due to the lack of cultivation and observation, very few diseases and pests have been reported and no control recommendations are available. Two diseases were reported in the past, leaf spot and root rot, caused by *Alternaria panax* Whet. and *Alternaria* sp. and *Phymatotrichopsis omnivorum* (Shear) Dug., respectively (USDA. Agriculture Res. Service. Crop Res. Div. 1970). Only one pest, leaf-miner, *Phytomyza* Fallen, was found on siberian ginseng in Japan (Iwasaki, 1996). No disease or pests were observed in our research plot.

Propagation

There are many ways to propagate siberian ginseng: from seeds, cuttings, and suckers, or by micropropa-

gation. Chen et al. (1997) indicated that vegetative propagation, either by cuttings or rhizomes, was better than seed propagation.

SEEDS. Seed propagation is the simplest and least expensive method of propagating siberian ginseng if there is a reliable source of fully developed seeds. Seedlings grow rapidly after emergence, with three oval to oblong leaflets during the first growing season (Fig. 2). Seed weight and aeration during the stratification period affect seed germination (Isoda and Shoji, 1994), and 50 to 59 °F (10 to 15 °C) is the optimum temperature for germination (Isoda and Shoji, 1989). Our unpublished data indicate that the embryo of freshly harvested siberian ginseng seeds is not fully developed and needs a warm environment to continue embryo development before it is able to germinate. This observa-

tion supports the report by Vorob'eva (1965a). He claimed that seed germination can be greatly improved by presowing stratification for 4 to 5 months at 64.4 to 68 °F (18 to 20 °C) followed by 2 to 3 months at 33.8 to 35.6 °F (1 to 2 °C). On the other hand, Isoda and Shoji (1989) claimed a suitable temperature of 59 °F (15 °C) for after-ripening and 41 °F (5 °C) for breaking the dormancy of the seeds. They also reported that soaking seeds in 100 ppm (mg·L⁻¹) gibberellic acid solution for 24 h and 200 ppm kinetin solution for 25 h will promote germination and break dormancy. A recently developed ginseng stratification method (Li, 2000) can also be applied to siberian ginseng with good results. Seeds are available from herb seed companies in the U.S. at \$15 to 20/oz

Fig. 1. Mature siberian ginseng plant.

(\$0.53 to 0.70/g) with about 1000 to 1200 seeds/oz (35 to 42 seeds/g).

CUTTINGS. Siberian ginseng can be propagated from both hardwood and softwood cuttings. Plants from cuttings have two main advantages. First, they have identical genetic characteristics to the plant from which they are taken, and secondly, cuttings can often flower and produce fruit in less time than a plant started from seed. In our experience, siberian ginseng propagated by softwood cuttings gave the best results, compared to hardwood cuttings in the winter or seed propagation. Semi-lignified two-node softwood cuttings, 6 inches (15.2 cm) long, were collected in late June and dipped into 4000 ppm indolebutyric acid (IBA) solution before planting in perlite and placed in a mist chamber.

Fig. 2. Siberian ginseng seedling.

This method resulted in over 90% rooting in 2 to 3 weeks with leaves within a month (Fig. 3). Similar results were reported by Vorob'eva (1965b), who claimed 70% to 94% rooting was obtained with single-node softwood cuttings rooted in cold frames in July. We had poor results with hardwood cuttings collected in late January. Rooted cuttings are available in some of the nurseries.

SUCKERS. A sucker is a shoot that arises from below-ground rhizomes. Propagation using suckers is a form of dividing plants. Suckers are dug out and cut from the parent plant. In some cases part of the old root may be retained, although new roots arise from the base of the sucker. Suckers are best dug in early spring while still dormant. This is a reliable way of propagating siberian ginseng. Under natural conditions, siberian ginseng propagates itself mainly

by suckers and only very rarely by seed.

MICROPROPAGATION. Recently, success with micropropagation, such as shoot tip culture (Zhang et al., 1996) and somatic embryogenesis (Choi et al., 1999; Gui et al., 1991) of siberian ginseng, has been achieved. It was reported that the rate of plant conversion produced was 97% from embryos produced in solid culture and 76% from embryos produced from cell suspensions; regenerated plants were successfully acclimatized in the greenhouse (Choi et al., 1999), and 62% of the plantlets survived in soil (Gui et al., 1991).

Harvest and usage

Siberian ginseng roots in the wild are normally dug in the fall or early spring. The disadvantage of this practice is that some plants are destroyed when the roots are dug. This ecologically damaging practice was lessened after stem bark (Kurkin et al., 1992; Nishibe et al., 1990) and leaves (Shao et al., 1989; Sui et al., 1994) were also found to contain major chemical components. It was reported that commercial production of siberian ginseng root, varied with the environment and location in Russia, from 268 to 536 lb/acre (300 to 600 kg·ha⁻¹) (Dyukarev and Komarova, 1986).

Siberian ginseng roots have been a major folk medicine in the past and more recently there have been chemical components identified and clinical studies conducted (Kurkin et al., 1991; Segiet and Kaloga, 1991). In China, fresh flowers are used to make tea, fresh and sliced dried roots are used after decoction and infusion processing. Dried roots can also be made into tincture and powder. In the North America, siberian ginseng products on the market, such as tincture and powder are mainly imported from China. However, consumers have to be aware that adulteration, mislabeling, and misidentification during harvesting exist among these imported products. To avoid these problems, material should only be collected from field-grown plants with proper identification. Standardization of siberian ginseng products is also urgently needed (Tyler, 1993).

Medicinal value

Traditionally, siberian ginseng has been used as an adaptogen, which increases resistance to stress and has a

balancing effect on body function (Halstead and Hood, 1984; Rege et al., 1999), as a folk remedy for rheumatic complaints, weak liver and kidney energy (Bown, 1995), bronchitis, heart ailments, and hypertension. It is also used to restore vigor, improve general health, and increase longevity (Duke, 1985). Extensive laboratory and clinical research around the world on siberian ginseng in the last 3 decades has confirmed its medicinal benefit to humans (Brekhman and Dardymov, 1969; Farnsworth et al., 1985; McLeod, 1993; McRae, 1996; Rege et al., 1999; Singh et al., 1991; Thom and Wollan, 1997; Zhekalov, 1995) and animals (Hou et al., 1998; Khetagurova et al., 1991).

In Russia, it has been reported that the major functions of siberian ginseng are its carcinostatic (Baranov, 1982) and antitoxic effects (Gol'dberg et al., 1971). A thorough literature review was conducted by Farnsworth et al. (1985), of the adaptogenic effects of siberian ginseng in humans. These studies, most of them conducted in Russia, were to determine the ability of humans to withstand adverse conditions (heat, noise, motion, work load

increase, exercise, or decompression); to improve auditory disturbances; to increase mental alertness and work output; to improve the quality of work under stressful conditions and to improve athletic performance. The studies concluded that the evidence to support the adaptogenic nature of siberian ginseng in humans is extensive. However, pharmacological explanations of the mechanism of activity of the adaptogenic nature of siberian ginseng are not clear. Farnsworth et al. (1985) found the weight of evidence unconvincing in light of modern pharmacological concepts. Most recently, Rege et al. (1999) reported that siberian ginseng has not been successfully introduced as an adaptogen in the clinic due to problems in evaluation of adaptogens.

Siberian ginseng is generally considered by most herbalists in the U.S. to be milder in activity than the more stimulating root of asian ginseng (*Panax ginseng*). There are no reported side effects from consuming siberian ginseng (Blumenthal, 1998), however, it is contraindicated for hypertension (Farnsworth et al., 1985). On the other hand, Hung (1993) stated that the

glycosides contained in siberian ginseng have the function of lowering the blood pressure and a tranquilizing effect on the central nervous system. The main medicinal values of siberian ginseng, as indicated in The Complete German Commission E Monographs (Blumenthal, 1998), are "a tonic for invigoration and fortification in times of fatigue and debility or declining capacity for work and concentration, also during convalescence." Tyler (1993) indicated that siberian ginseng has the same stimulant and tonic effects as ginseng. Its adaptogenic or antistress activities are brought about by the combination of sterols, coumarins, flavonoids and polysaccharides.

The results from recent clinical studies in many countries indicate that siberian ginseng has antiviral (Hou et al., 1998), antitumor (Tong et al., 1994) and anticarcinogenic activities (Bespalov et al., 1992). It can improve lipid metabolism in hyperlipemic patients so that it might play an important role in preventing or alleviating arteriosclerosis (Shi et al., 1990). Sibe-

Fig. 3. Siberian ginseng plant from cutting.

rian ginseng can also treat uncomplicated upper respiratory tract infections (Thom and Wollan, 1997), stress (Flynn, 1996), and impotence (McLeod, 1993). It has been used as an antiemetic remedy (Loniewski et al., 1998), and for strengthening the immune system (Fang et al., 1985; Keville, 1985; Shen et al., 1991; Wan, 1989) especially for cancer patients (Kupin et al., 1986).

Siberian ginseng has been used to improve human physical working capacity in Japan (Asano et al., 1986), and in the U.S. it is used to improve exercise and athlete performance including more rapid recovery from exercise (Azizov, 1997; Dowling et al., 1996; Kelly, 1997). In Mongolia, siberian ginseng has been used to accelerate adaptation of newly arrived people to the harsh environment in mountain and desert areas (Zhekalov, 1995).

Chemical components

The constituents in siberian ginseng that have received the most attention are the eleutherosides (Collisson, 1991). Seven eleutherosides, A to G, have been identified (Baranov, 1982; Farnsworth et al., 1985; Hikino et al., 1986), and six more eleutherosides, H to M, were recently added by Tyler (1993). Among these 13 eleutherosides, A (β -sitosterol glycoside), B (syringin) and E (syringaresinol) have received the most research attention for their medicinal values (Farnsworth et al., 1985; Lawson and Bauer, 1998; Tyler, 1993).

Other major constituents in siberian ginseng include polysaccharides (Hikino et al., 1986; Shen et al., 1991), triterpenoid saponins (Cui et al., 1999; Segiet and Kaloga, 1991), lignans and flavonoids (Nishibe et al., 1995), isofraxin, wax, carotenoids, pectins and resins (Duke, 1985), stearic acid, betulic acid, and amygdalin (Zhao et al., 1993), isofraxidin, eleutheroside B₁, coniferin, and syringin (Kurkin et al., 1992; Nishibe et al., 1990), chlorogenic acid and ethyl caffeate (Kurkin et al., 1991) and coumarins (Baranov, 1982). Bioactive phenolic compounds isolated from the root and bark: (+)-syringaresinol di-O- β -D-glucoside (Nishibe and Atta, 1994), sinapyl alcohol 4-O-(2'-O- α -L-apioxy)- β -D-glucopyranoside, scopoletin, protocatechuic acid, and protocatechuic acid 3'-O- β -D-glucopyranoside (Kurkin et al., 1992). Duke (1985)

reported that 0.8, 0.5, 0.31 and 0.26% essential oil were extracted from roots, fruit, leaves, and stems, respectively.

Accurate extraction methods for identification of major chemical constituents are critical in medicinal herbs. Over the years, extraction procedures for identifying and quantifying the active ingredients from siberian ginseng have progressed rapidly. The major chemical constituents, eleutherosides, have been extracted with aqueous methanol and analyzed by reversed-phase high-performance liquid chromatography (HPLC) on a C-18 column. The recovery was >80% for eleutheroside B within the range 0.5 to 10 mg, and similar for eleutheroside E in the range 0.5 to 2.5 mg (Yat et al., 1998). Rotary thin-layer chromatography (TLC) has been used to separate a mixture of eleutherosides I and II (Segiet, 1994). Characteristic fragmentation of triterpenoid saponins has been made possible by multistage mass spectrometry (MSn) combined with electrospray ionization (ESI) (Cui et al., 1999). Centrifugal partition chromatography techniques have been developed (Marston et al., 1990).

Conclusion

Both siberian ginseng and ginseng belong to the Araliaceae family, but not to the same genus. In China, siberian ginseng and ginseng have different names and there is no confusion. On the other hand, in the North American and European markets, consumers sometimes confuse these two names and mistakenly purchase siberian ginseng products instead of ginseng, which does not meet their expectations. In the past, Chinese referred to siberian ginseng as poor man's ginseng, meaning that it is for the poor man and could be used as a substitute for the much higher priced ginseng. However, siberian ginseng has its own unique chemical components which contribute to claimed medicinal values. In North America, siberian ginseng is available widely and sold as a health remedy. Because of the excessive harvesting in its natural habitat, cultivation is the only alternative to prevent the extinction of siberian ginseng, to ensure proper identity, and to satisfy high market demand. Standardization and quality control of the products are also important to avoid adulteration and mislabeling.

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