ABC AHP NCNPR
Botanical Adulterants Prevention Program
BOTANICAL ADULTERANTS PREVENTION
BULLETIN

Botanical Adulterants Prevention Bulletin on Ginseng

(*Panax ginseng*, *Panax quinquefolius*, and *Panax notoginseng*) Root and Extracts

Panax ginseng
Photo by Steven Foster ©2026 ABC

Panax quinquefolius
Photo by Steven Foster ©2026 ABC

Panax notoginseng
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Citation (JAMA style): Orhan N. Adulteration of ginseng (*Panax ginseng*, *Panax quinquefolius*, and *Panax notoginseng*) root and extracts. Botanical Adulterants Prevention Bulletin. Austin, TX: ABC-AHP-NCNPR Botanical Adulterants Prevention Program. 2026.

Keywords: Adulteration, American ginseng, Asian ginseng, Chinese ginseng, ginseng, Korean ginseng, *Panax ginseng*, *Panax notoginseng*, *Panax quinquefolius*, tienchi ginseng

Goal: The aim of this bulletin is to provide general information on Asian ginseng (*Panax ginseng*) root and its extracts and finished products, including the available data on adulteration, mislabeling, and fraud in ingredients and finished ginseng products. It also provides information on authenticity issues with American (*P. quinquefolius*) and tienchi (*P. notoginseng*) ginseng sold for medicinal purposes commercially, their supply sources and trade, market dynamics, a summary on laboratory methods for detecting ginseng adulteration, and economic and safety implications for the consumer and industry. This bulletin may be used as an educational resource for quality control personnel, members of the international phytomedicine and botanical supplement industries, and the extended natural products community in general.

1. General Information

In the United States, according to section 10806 of the Farm Security and Rural Investment Act of 2002,[1] the use of the term "ginseng" as a common or usual name (or part thereof) for any dietary supplement or dietary ingredient is limited to those that are derived from a plant classified within the genus *Panax*. However, countries in other areas of the world do not have the same restrictions; hence, non-*Panax* species sold using "ginseng" as part of the common name may be available. The main commercially used *Panax* species include *Panax ginseng*, *P. quinquefolius*, and *P. notoginseng*. Along with the specific scientific name, Asian ginseng can be further classified by color: white, red, or black, each reflecting a distinct post-harvest drying or fresh root steaming method (processes described in Section 1.8. Plant part and form).[2-5] There are also various forms and qualities of Asian ginseng, such as wild (*shan shen*), cultivated *(yuan shen*), woods grown (*linxia shen*), processed red without sugar (*hong shen*, *hong ren shen*), and processed red with sugar (*tang ren shen*).[6,7] Additionally, there are claims of origin, most notably Korean ginseng or Korean red ginseng. In this review we provide information on the three main commercial ginseng species and describe their production methods and key differences when available.

1.1. Common names:

According to the *American Herbal Products Association's Herbs of Commerce* (HOC),[8] the standardized common name (SCN) for *Panax ginseng* is Asian ginseng, which will be used throughout this document. The plant is also known as oriental ginseng, Chinese ginseng, Korean ginseng, or simply ginseng. According to HOC, the SCN for steamed root is red Asian ginseng. The SCN for *Panax quinquefolius* is American ginseng. The SCN for *P. notoginseng* is tienchi ginseng, but it is also referred to as san-qi ginseng, sanchi, and tienchi.[8]

1.2. Common names of Asian ginseng in languages other than English:[4-6,9-11]

Bulgarian: Zhen-shen (Жен-шен)

Chinese (Mandarin): Rénshēn (人参), jin-chen

Danish: Ginseng, Koreansk ginseng, orientalsk ginseng, kraftrod

Finnish: Ginseng, ginsengjuuri

French: Ginseng, ginseng asiatique, ginseng coréen

German: Ginseng, Asiatischer Ginseng, echter Ginseng, Koreanischer Ginseng, Kraftwurzel, Samwurzel

Greek: Ginsenk panax (γίνσεγκ πάναξ)

Hungarian: ginzeng

Italian: Ginseng, ginseng asiatico, ginseng cinese, ginseng coreano

Japanese: Ninjin

Korean: Insam (인삼), sansam (산삼)*

Norwegian: Ginseng, asiatisk ginseng, kinesisk ginseng, koreansk ginseng, ekte ginseng

Polish: Żeń-szenia

Portuguese: Jinsão

Romanian: Ginseng

Spanish: Ginseng, ginseng asiático, ginseng chino, ginseng coreano

Swedish: Ginseng, asiatisk ginseng, kinesisk ginseng, koreansk ginseng

Turkish: Ginseng

1.3. Accepted Latin binomials:

Panax ginseng C.A.Mey.[12,13]

Panax quinquefolius L.[14,15]

Panax notoginseng (Burkill) F.H. Chen[16,17]

1.4. Synonyms:

Homotypic and heterotypic synonyms of selected ginseng species are given in Table 1. (In botanical nomenclature, homotypic synonyms are different scientific names that are based on the same type specimen; they represent the same taxon by definition. In contrast, heterotypic synonyms originate from different type specimens but are later determined by taxonomists to refer to the same species. Homotypic synonyms arise through changes in classification or rank, whereas heterotypic synonyms reflect taxonomic decisions that merge previously described, but not truly distinct taxa.)

1.5. Botanical family: Araliaceae[12-17]

1.6. Morphological characteristics:

The following paragraphs provide the botanical characteristics of the plants and the morphological descriptions of roots.

***Panax ginseng*:** Asian ginseng is a perennial herb that grows between 30 and 80 cm high, with characteristic

*Insam refers cultivated Asian ginseng, while sansam is Asian ginseng grown in the wild without human intervention (So-Young Park [Dankook University] written communication to S. Gafner, January 20, 2026).

branched, fleshy, persistent roots extending from the middle of the main root, which resembles the form of a human figure. Asian ginseng root consists of fusiform-cylindrical dried roots with longitudinal ridges and a transversely rugose upper portion. It measures up to 20 cm in length and approximately 2.5 cm in diameter and may be repeatedly branched below the midsection. The crown bears one or more stem scars. The bark is light yellow to pale brown, containing scattered orange-red secretory canals. The fracture is cartilaginous and brittle; the internal surface is white to yellowish.[4,18] The stem is erect, simple, and not branching. Leaves are verticillate, palmately compound with five digitate margined leaflets, with the three terminal leaflets being larger than the lateral ones. The leaflets are elliptical or slightly obovate, with an acuminate apex, a cuneate base, and a serrulate or finely bidentate margin. Leaflets are sparsely ciliate (trichomes ca. 1 mm) to glabrous; leaf margins are glabrous. Typically, one leaf forms in the first year, with an additional leaflet added annually until the sixth year. The inflorescence is a small, terminal, hemispherical umbel

Table 1. Synonyms of selected *Panax* species

P. ginseng[12,13]	**Homotypic Synonyms**
	Aralia ginseng (C.A. Mey.) Baill.
	Aralia quinquefolia var. *ginseng* (C.A. Mey.) Anon.
	Panax quinquefolius var. *ginseng* (C.A. Mey.) Regel & Maack
	Heterotypic Synonyms
	Panax schin-seng var. *coraiensis* T. Nees
	Panax verus Oken
P. quinquefolius[14,15]	**Homotypic Synonyms**
	Aralia quinquefolia (L.) Decne. & Planch.
	Ginseng quinquefolium (L.) Alph. Wood
	Heterotypic Synonyms
	Panax americanus (Raf.) Raf.
	Panax americanus var. *elatus* Raf.
	Panax americanus var. *obovatus* (Raf.) Raf.
	Panax cuneatus Raf.
	Panax quinquefolius var. *americanus* Raf.
	Panax quinquefolius var. *obovatus* Raf.
P. notoginseng[16,17]	**Heterotypic Synonyms**
	Aralia quinquefolia var. *notoginseng* Burkill
	Panax pseudoginseng var. *notoginseng* (Burkill) G. Hoo & C.J. Tseng

Asian Ginseng *Panax ginseng*
Photo by Steven Foster ©2026 ABC

appearing in early summer. The flowers are polygamous and white-green with an obscurely five-toothed calyx, five petals, and five stamens. The fruit is a small, nearly drupaceous berry that turns red when it ripens in autumn.[7,19-21]

***Panax quinquefolius*:** American ginseng is a perennial plant that typically grows between 10-50 cm tall, though under ideal conditions it can grow up to 90 cm. It has an erect stem that carries a short rhizome with a spindle-shaped, cylindrical, or conical fleshy root. The main root is 3-12 cm long and 0.8-2 cm in diameter, with a light yellow-brown to yellow-white surface, transverse annular rings, lenticel-like protuberances, fine longitudinal wrinkles, and fibrous root scars. Lateral roots are usually present on the lower portion, though often broken, and some roots retain rhizomes at the upper end with distinct round or semicircular stem scars. The dried root is dense, solid, and resistant to breaking; in the cross-section, it is pale yellow to white and slightly powdery, with yellow-brown resin canals in the cortex, a brownish-yellow cambium ring, and wood exhibiting a faint radial texture. The leaves are palmately compound with 3-5 oblong-obovate leaflets arranged in a whorl at the stem apex. Leaflets are sparsely setose on veins or glabrous adaxially, margins coarsely serrate with a few small hairs. The leaf development follows the plant age, with one 3-5-foliolate leaf in the first year, increasing annually up to four or five leaves in five-year-old plants. Inflorescences are solitary terminal umbels with 6-20 light yellow flowers appearing from June to July. The fruit is a red drupe, 1-2 cm in diameter, containing 1-4 seeds.[20,22-25]

***Panax notoginseng*:** *Panax notoginseng* grows to a height of 30-60 cm, with dark green leaves branching from a stem and a cluster of red berries in the middle. The stem is upright, simple, erect, unbranched, glabrous, and green or with many purplish longitudinal lines. The rootstock is short and the scars of the fallen stems are evident. Its main root is thick, fleshy, conical or cylindrical, 1-6 cm long, 1-3 cm in diameter, and taupe to yellow on the surface, with several wrinkles and root marks. The dried root is shiny brown, often with patches of grayish-yellow rind remaining. Tubercles, horizontal lenticels, and broken longitudinal lines are visible on the surface. The texture is hard, heavy, and resistant to breaking. When fractured, the root shows two distinct zones: a cortex that may appear grayish white, yellowish brown, or dark brown, and a xylem that is smooth, slightly cartilaginous, and marked with radiating lines. The leaves are palmately compound, three or four verticillate, and terminal to the aerial stem with slender, glabrous petioles of 5-15 cm length. The leaf is composed of 3-7 leaflets that are oblong, elliptic or oblong-ovate. The middle ones are larger, and the basal leaflets are the smallest. The leaflet apex is acuminate-caudate, oblique-rounded at the base, and the margins are finely serrate with aristate teeth. Both surfaces of the leaflets are sparsely setose on veins or glabrescent. The erect, 20-30 cm long peduncle arises from the tip of the aerial stem and bears a single terminal umbel with numerous green-pale yellow flowers. The fruits are berrylike, nearly reniform, and of scarlet color at maturity, containing 1-3 subglobose and white seeds.[7,26,27]

1.7. Distribution:

***Panax ginseng*:** Asian ginseng is native to the forests around the mountain regions of eastern Asia, specifically China, Korea, and the Russian Far East (Khabarovsk Krai and Primorye Krai). Cultivation mainly occurs in Korea, Japan, and northeastern China.[4,12,19]

***Panax quinquefolius*:** The plant grows primarily in the temperate biome found in the northern, north-central, and eastern United States, especially along the Appalachian mountains and the Ozarks, and eastern Canada, including the provinces of Ontario and Québec.[14,15] The largest producer of cultivated American ginseng is Ontario, while in the United States, Wisconsin is the most important supplier of cultivated material. Cultivation occurs outside North America, particularly in China.[4,28]

***Panax notoginseng*:** The distribution of *P. notoginseng* is very narrow due to its sensitivity to sunlight. The species is native to Vietnam but, after long evolutionary adaptation, it is mainly found in the Wenshan mountain region of Yunnan Province, China, within 23.5°N and 104°E, at elevations of 1,200–2,000 m. This area accounts for the majority of raw material production in China.[16,26,29]

1.8. Plant part and form:

Asian ginseng root is traded as red ginseng and white ginseng.[3] White ginseng is traditionally produced by sun-drying fresh Asian ginseng, while red ginseng is prepared by steaming fresh roots at 95-100 °C for two to three hours.[30] Red ginseng is translucent and cartilaginous due to post-harvest heat treatment. Black ginseng undergoes nine cycles of steaming at atmospheric pressure followed by sun-drying after each steaming. In addition to these traditional methods, other types of processed ginseng have been developed using techniques such as modified steaming, explosive puffing, or fermentation with specific microorganisms, including intestinal microbial flora.[31] Red and white ginseng are separately regulated in the Korean, Japanese, and Chinese pharmacopeias,

reflecting their distinct characteristics. Although both originate from the same plant, differences in their processing methods result in significant variations in their chemical composition and pharmacological properties.[32]

The cut root slices (discs), sachets, freeze-dried granules, and dry powdered extracts are used to prepare ginseng tea.[4,33] Additionally, ginseng root is a component of numerous tea mixtures, herbal medicinal preparations, and Chinese patent medicines (CPM) such as *Qipi*, *Renshen guipi*, *Shenlin baizu*, *Shu xiang*, or *Shen mai yin* dispensed by practitioners of traditional Chinese medicine (TCM). It is also found in certain Korean traditional formulations such as *Bak ho ga insam tag*. Other dosage forms include pills,‡ capsules, tablets, and extracts, along with tonic drinks, wines, and lozenges.[4,19,35-40]

American ginseng preparations include dry root, powdered root, and standardized or non-standardized extracts, such as dry extracts, tinctures, fluid extracts, decoctions or infusions, and their concentrates.[41,42]

Today, various prescription products that include tienchi ginseng root are also in clinical use and there are nearly 60 kinds of CPMs in the Chinese pharmacopeia that contain tienchi ginseng. While capsules and tablets are the most used forms, tienchi is also used as granules, pills, dripping pills, and powders.[26]

1.9. Key constituents and chemical markers:

Asian ginseng roots contain a number of different constituent classes, including alkaloids, amino acids, carbohydrates, fatty acids, peptidoglycans, phenolic compounds, polyacetylenes, saponins, sesquiterpenes, trace elements, and vitamins.[4,43,44] However, the primary biochemical and pharmacological effects are generally attributed to dammarane-type triterpene saponins known as ginsenosides. In *P. ginseng*, the concentrations of these ginsenosides in the root and root-hair increases with age from one to five years.[19] Analyses of Asian ginseng leaves and roots showed that there are ten major ginsenosides (Rb_1, Rb_2, Rb_3, Rc, Rd, Re, Rf, Rg_1, Rg_2, and Rh_1), with leaves typically showing higher concentrations than roots, and a different quantitative profile of these ten ginsenosides. Ginsenoside levels in leaves are highest in the first and second years of growth, while roots reach maximum levels around the fifth year.[45] Due to the higher market value of five- and six-year-old roots (30–60% more than four-year-old), adulteration with leaves or younger roots is frequently observed.[43]

Over 200 chemical constituents have been isolated from *P. notoginseng*, with saponins recognized as the major group of interest. More than 100 saponins have been identified, including ginsenosides, notoginsenosides, and gypenosides. Unlike Asian and American ginseng, tienchi ginseng does not contain oleanolic acid-type saponins. Among its saponins, ginsenoside Rb_1, ginsenoside Rg_1, and notoginsenoside R_1 (Noto-R_1) are widely used as marker compounds for quality evaluation. Ginsenoside Rb_1 is abundant in all plant parts, while ginsenoside Rg_1 is concentrated mainly in the roots and rhizomes. In addition to saponins, other primary and secondary metabolites have been reported, such as flavonoids (e.g., liquiritigenin, quercetin, kaempferol-3-*O*-α-L-rhamnoside), cyclopeptides, sterols (β-sitosterol, daucosterol, stigmasterol) and other terpenoids, polyacetylenes (panaxynol, panaxydol), amino acids, carbohydrates, and minerals.[26,35,46,47]

The primary constituents of interest in American ginseng roots are polyacetylenes, polysaccharides, and ginsenosides. Almost 100 ginsenosides have been identified in American ginseng roots, including both naturally occurring compounds and those resulting from steaming and biotransformation processes. These ginsenosides are generally classified into four groups: protopanaxadiol-type (PPD; ginsenosides Rb_1, Rc, Rb_2, Rd, Rg_3, and Rh_2), protopanaxatriol-type (PPT; ginsenosides Rg_1, Re, Rf, 20-*O*-Glc-Rf, Rg_1, Rg_2, 20(*S*)-Rg_3, and Rh_1), ocotillol-type (e.g., 24(*R*)-pseudoginsenoside F_{11} [F_{11}]) and oleanolic acid-type (ginsenoside Ro). PPD- and PPT-type ginsenosides can be found in neutral form or as their malonyl esters. These malonyl ginsenosides constitute a significant percentage (up to 45%) of the total ginsenosides in American ginseng depending on the processing.[48] Ginsenosides Rb_1, Rb_2, Rc, Rg_1, Re, and Rd and their malonyl esters account for the majority of the total ginsenoside content in American ginseng roots.[49] Furthermore, American ginseng contains amino acids, fatty acids, flavonoids, sterols and other terpenoids, and macro- and microelements.[22]

Although the three major *Panax* species share the common name "ginseng," their chemical compositions and pharmacological activities are different. While they have some common traditional uses, their unique ginsenoside profiles affect their distinct pharmacological properties.[4,50] Studies on the identification of species-specific ginsenosides revealed marker compounds that can be used to determine the authenticity of commercial ginseng products: Asian ginseng root contains ginsenoside Rf, which can be used as a chemical marker to differentiate it from American

‡ In TCM, "pill" (丸, wan) is a common pharmaceutical form used for delivering herbal medicines, including ginseng. Pills in TCM are small, round preparations made by mixing powdered herbs with a binding agent, traditionally honey or water, and forming them into spherical shapes.[34]

ginseng roots.[28,35,51-53] 24(*R*)-pseudoginsenoside F_{11} is specific to American ginseng, while tienchi ginseng root contains notoginsenoside R_1, which can be used as a means to distinguish it from Asian ginseng and American ginseng roots.[28,35,51,53] White Asian ginseng root also contains malonyl ginsenosides Rb_1, Rb_2, and Rc, which are absent in red Asian ginseng root since these compounds degrade during the steaming process.[51] Representatives of the secondary metabolites of ginseng species including marker compounds are given in Figure 1.

Additionally, the ratios of some of the ginsenosides, for example Rb_1:Rg_1, Rb_1:Rb_2, ginsenoside Rf:24(*R*)-pseudoginsenoside F_{11}, and the concentrations and ratios of other protopanaxadiol and protopanaxatriol glycosides, can help to determine the authenticity of ginseng extracts.[28,45,54] The ginsenoside Rg_1:Rb_1 ratio has been widely used to differentiate American ginseng from the other commercial species; ratios of less than 0.4 are typical of American ginseng, whereas a higher ratio is characteristic of Asian and tienchi ginseng.[4,52] Ginsenoside ratios (ginsenoside Rb_1:Rd, ginsenoside Rb_1:Re, ginsenoside Rg_1:Rb_1) are also helpful to detect the presence of undeclared Asian ginseng leaf extract in ginseng root extracts.[28]

The ratio between Rg_1 and Rb_1 is significantly different in main roots as compared to fine roots (hair) and lateral roots of *Panax ginseng*. In main roots, the Rg1:Rb1 ratio is significantly above 0.5, along with a total ginsenoside content of approximately 4% to 6%, while the Rg1:Rb1 ratio is mostly < 0.3 in fine roots. The latter, however, have a much higher total ginsenoside content of 12% or higher (Hermann Kurth [Finzelberg, Andernach, Germany], oral communication to S. Gafner, November 2025.)

According to the British Pharmacopoeia and the European Pharmacopoeia (Ph. Eur.), Asian ginseng roots[55,56] have to contain at least 0.4% of the sum of ginsenosides Rg_1 and Rb_1 while the minimum is 4% for Asian ginseng root extracts[57,58] and 3.8% for tienchi ginseng root.[59] On the other hand, the United States Pharmacopeia (USP) monograph requires that Asian ginseng root and rhizomes must contain not less than (NLT) 0.8% of total ginsenosides calculated as the sum of ginsenosides Rg_1, Re, Rf, Rb_1, Rc, Rb_2, and Rd, NLT 0.3% of the sum of ginsenosides Rg_1 and Re, and NLT 0.2% of ginsenoside Rb_1 on the dried basis.[60] While American ginseng root must contain NLT 4.0% of total ginsenosides, calculated on the dried basis, tienchi ginseng root and rhizomes has to contain NLT 5.0% of total ginsenosides calculated on a dried basis as the sum of notoginsenoside R_1, ginsenoside Rg_1, ginsenoside Re, ginsenoside Rb_1, and ginsenoside Rd.[61,62] The ginsenoside contents are also specified for ginseng extracts; NLT 10.0% of total ginsenosides for powdered American ginseng extract and NLT 3.0% total ginsenosides, calculated as the sum of ginsenosides Rg_1, Re, Rf, Rb_1, Rc, Rb_2, and Rd, for Asian ginseng dried extracts, both calculated on the anhydrous basis.[63,64]

1.10. General use[s]:

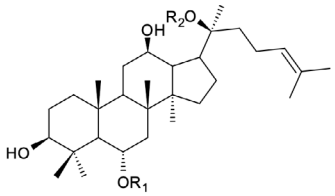
Asian ginseng is one of the most highly regarded energizing medicinal plants in the entire Chinese *materia medica*. It has also become a popular herbal tonifier in

Table 2. Differences in ginsenoside profiles of American ginseng root and leaf and roots and leaves of other medicinal *Panax* spp.[24]

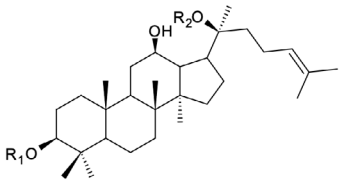
Ginsenoside	American ginseng root	American ginseng leaf	Asian ginseng root, white	Asian ginseng root, red	Asian ginseng leaf	Tienchi ginseng root
Rb_1	++++	+	++	++	+	+++++
Rb_2	tr	++	+	+	+	–
Rb_3	tr	++++	tr	+	–	–
Rc	+	+	+	+	+	–
Rd	++	++	+++	++++	++	++++
Re	++++	–	+	+(+++)	+	tr
Rf	–	–	+	+	–	–
Rg_1	+(+)	+	+++	++	+	+++++
Rg_2	tr	–	tr	–	–	–
F_{11}	+	–	–	–	–	–
Ro	+	tr	+	+	+	–
Total ginsenosides	~4-5(-9)%	~11-12%	~1-3%	~1-3%	~12%	~5-7(-20)%

Total ginsenosides are given as the percent of leaf or root mass.

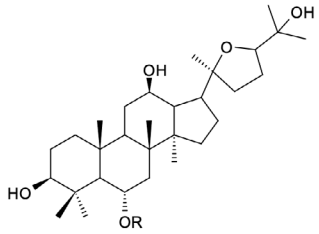
the West and has been incorporated into a wide range of products from traditional foods to dietary supplements, textiles, and cosmetics.[6,7] It is used as a tonic for invigoration and fortification in times of fatigue and debility, for declining capacity at work and concentration, and for providing strength during convalescence.[18] It is used for physical exhaustion, general weakness, chronic fatigue, irritability, insomnia (due to deficiency), and sexual problems. It is classified as an adaptogen, with benefits best achieved when used for three months or longer.[2,4,65]



Compound	R_1	R_2
Rg_1	Glc	Glc
Noto-R_1	Glc(2-1)Xyl	Glc
Rg_2	Glc(2-1)Rha	H
Re	Glc(2-1)Rha	Glc
20-*O*-Glc-Rf	Glc(2-1)Glc	Glc



Compound	R_1	R_2
20(*S*)-Rg_3	Glc(2-1)Glc	H
Rd	Glc(2-1)Glc	Glc
Rb_1	Glc(2-1)Glc	Glc(6-1)Glc
Rb_2	Glc(2-1)Glc	Glc(6-1)Ara(*p*)



Compound	R
F_{11}	Glc(2-1)Rha

Figure 1. Representatives of secondary metabolites of ginseng species[35]

Glc: β-D-glucopyranosyl; Rha: α-L-rhamnopyranosyl; Xyl:β-D-xylopyranosyl; Ara(p): α-L-arabinopyranosyl

According to Health Canada's Natural Health Product Monograph, American ginseng is used in herbal medicine as an adaptogen to support the immune system, increase energy, and improve resistance to stress. Additionally, it is used to help maintain healthy blood glucose levels.[41]

The root of tienchi ginseng is a key ingredient in several traditional remedies. *Yunnan Baiyao* is a hemostatic remedy that includes tienchi ginseng in a proprietary blend with several other herbs and is used to stop bleeding, relieve pain, and reduce infections. *Panax notoginseng* is also the main ingredient of pills used in China, Korea, and Russia for managing cardiovascular conditions such as occlusive vasculitis, coronary disease, atherosclerosis, and cerebral infarction. It is used to dissipate blood stasis, stop bleeding, promote circulation, and alleviate pain, and is applied in cases of hemoptysis (coughing up blood from lungs or airways), hematemesis (vomiting blood), epistaxis (nosebleed), hematochezia (rectal bleeding), uterine bleeding, traumatic hemorrhage, and pain due to injury.[26,66]

1.11. Historical use[s]:

The history of the use of Asian ginseng began 4,500 years ago, and its first record was written around 2,000 years ago.[42,67] In TCM, ginseng is used to restore balance between *yin* and *yang*, the opposing but complementary forces believed to govern health and vitality.[2,4,65] In folk medicine and TCM, it is used for loss of appetite, nausea, burping, vomiting, ulcers, gastric disturbances, diarrhea, cachexia (a syndrome characterized by severe weight loss, muscle wasting, and weakness), anxiety, impotence, neuralgia, insomnia, weakness of spleen, and kidney deficiency.[68,69]

American ginseng has been a key part of North American herbalism for centuries. It was traditionally used by Native American tribes throughout its very broad growing range. For the Cherokee, it was among the most highly regarded of medicinal plants.[70,71] The Cherokee used American ginseng as an aphrodisiac, tonic, expectorant, and for conditions such as chest pain, chills, fever, headaches, vertigo, convulsions, and various menstrual or reproductive disorders. Additionally, other Native American tribes including the Creek, Delaware, Houma, Iroquois, Menominee, Meskwaki, Micmac, Mohegan, Pawnee, Penobscot, Potawatomi, and Seminole used American ginseng root as a tonic and general restorative remedy for all ages, and for a wide range of conditions such as fever, pain, shortness of breath, vomiting, rheumatism, reproductive and gynecological issues, skin ailments for boils and wounds, throat, ear, and eye infections, and various systemic or severe illnesses.[71]

American ginseng was first mentioned in 1718 by French Jesuit Joseph-François Lafitau, who noted that the First Nations used it to promote bodily vigor, combat fever, and improve digestion.[72,73] By the 1750s, the trade of American ginseng to China was well-established.[70] The first mentioning of American ginseng in the Chinese literature was published in the *Běncǎo cóngxīn* (本草从新), a Chinese materia medica text from 1757, providing evidence for the long-standing use of the roots in Chinese medicine.[22] It has been used in TCM to detoxify the body, invigorate strength, nourish the spleen, relieve throat swelling, dry mouth, and cough, as well as to address dampness-heat syndromes caused by spleen deficiency.[69] On the other hand, it has also been traditionally used as a nervine or calmative to help relieve restlessness and nervousness and to aid digestion in cases of dyspepsia associated with stress or nervousness.[41]

Tienchi ginseng has long been esteemed in Chinese medicine for reducing blood viscosity, dissolving clots, and stopping bleeding. In Li Shizhen's *Compendium of Materia Medica*, it was described as stopping bleeding, removing stasis, alleviating pain, and treating wounds or bleeding disorders. Its tonic effect is recorded in later works such as the *Běncǎo cóngxīn* and the *Chinese Medicine Dictionary*.[6,26] *Panax notoginseng* has been traditionally used to relieve excruciating pain and restlessness caused by serious injury and in the management of falls, contusions, and sprains.[69]

2. Market

2.1. Importance in the trade:

The ginseng trade from China to Europe dates back as early as the 9th century, later gaining prominence through explorers such as Marco Polo in the 13th century and translations of Chinese texts in the 16th and 17th centuries.[2]

Today, ginseng products are sold in more than 190 countries. The amount of ginseng produced by individual countries worldwide is not known.[74]

In 2023, the global export value (calculated as the sum of the top 10 ginseng exporting countries) of ginseng root (fresh, chilled, frozen, dried, cut, or crushed) reached $368.6 million, while the import value totaled $321.4 million under Harmonized System (HS) code 121120 for powdered ginseng roots, constituting 8.82% and 7.56% of the total HS 1211 category.[#]

While the global market demand continues to grow, retail sales of ginseng dietary supplements in the United States have trended downwards since 2019 (Table 4). In 2023, sales increased by 12.6%, reaching $8 million in mainstream retail channels[76] but were down by 9% to $7.4 million in 2024.[77]

Up to date trade data on tienchi ginseng are limited; only Hong Kong reported an import value of US $37,000 in 2023.[75]

Table 3. Ginseng (HS 121120) export and import values in leading trade partner countries in 2023[75]

Country	Export value (USD)	Import value (USD)
Canada	98,738,000	5,704,000
South Korea	91,794,000	361,000
China	90,872,000	125,034,000
United States	78,909,000	12,759,000
Hong Kong	25,280,000	65,118,000
Japan	NA	40,222,000
Taiwan	NA	37,223,000

NA: Not available

Export value refers to the total value of goods a country ships to foreign markets, whereas import value denotes the total value of goods it acquires from foreign markets.

Table 4. Sales data for ginseng (*Panax* spp.) dietary supplements in the United States from 2019 to 2024[76-81]

Year	Mainstream channel rank	Mainstream channel sales (USD)	Natural channel rank	Natural channel sales (USD)
2024	40	7,361,814	38	3,396,758
2023	40	8,080,788	NA	NA
2022	40	7,130,572	NA	NA
2021	NA	NA	35	3,097,184
2020	NA	11,200,292	30	3,253,793
2019	30	12,572,733	30	3,291,829

NA: Not available

[#] HS codes are globally standardized six-digit identifiers developed by the World Customs Organization and used by more than 200 countries to regulate trade, set tariffs, and compile statistics, covering over 5,000 unique commodity groups. HS Code 1211 includes seven subgroups: licorice (*Glycyrrhiza* spp., Fabaceae) roots, ginseng roots, coca (*Erythroxylum coca*, Erythroxylaceae) leaves, opium poppy (*Papaver somniferum*, Papaveraceae) straw, ephedra (*Ephedra* spp., Ephedraceae) plants, the bark of pygeum (*Prunus africana*, Rosaceae), and other plants used primarily in pharmacy, perfumery, or for insecticidal and fungicidal purposes.[75]

2.2. Supply sources and conservation status:

Global ginseng production is heavily concentrated in a few countries, according to data from 2007-2009: China leads with 44,749 tons, followed by South Korea with 27,480 tons, Canada with 6,486 tons, and the United States with 1,054 tons of fresh ginseng. These four countries account for over 99% of total worldwide production (80,080 tons) and are responsible for the majority of the global ginseng supply.[67]

According to the United Nations COMTRADE database, the trade value for ginseng root (*Panax* spp.) imported by Europe in 2021 was $12.5 million for 423.78 metric tons net weight and the top suppliers were China, the Republic of Korea, the United States, India (re-export), Brazil (re-export), the UK (re-export), Canada, and Hong Kong.[82]

American ginseng is an internationally protected species by the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES) since 1975.[83] Wild American ginseng is listed as vulnerable in the United States and out of 33 states where ginseng occurs as an indigenous forest species, seven classify it as critically imperiled, four as imperiled, fourteen as vulnerable, and eight as apparently secure. In Canada, it has been listed as endangered since 1999, with all exports of wild ginseng banned.[84] Unlike American ginseng, Asian and tienchi ginseng are not internationally protected under CITES. Their commercial supply is dominated by cultivation. Wild populations of Asian ginseng are nearly gone and tienchi ginseng faces agricultural threats such as fungal diseases and soil degradation.

Nowadays, ginseng roots are mostly obtained from cultivated sources or controlled, sustainable wild harvests, while uncontrolled wild collection plays only a minor role.[24,82]

2.3. Market dynamics:

Ginseng prices vary widely by species, origin, cultivation method, and age. Wild ginseng roots, or roots that resemble wild roots, are much more valuable than cultivated roots. The 2024 prices for American and Asian ginseng were very similar, around $25-35/kg for whole roots and $30-40/kg for main roots, but tienchi ginseng was noticeably more affordable at $15-25/kg (information provided by a supplier qualified by

Panax notoginseng
Photo by Steven Foster ©2026 ABC

a reputable Swiss company specializing in ginseng products, email to S. Gafner, November 2025). In 2012 and 2013, the price of dried wild ginseng roots ranged from $400 to $1,250 per pound, while dried ginseng roots grown under artificial shade was valued at $12 to $42 per pound.[85,86] Similarly, a 2009 report showed that wild and wild-appearing American ginseng roots commanded prices up to 100 times greater than field-cultivated roots, with prices of $550-$1,300/kg (dried weight) compared with $20-$60/kg (dried weight) for cultivated material.[87] Because most traded ginseng stems from cultivation, the supply chain is relatively stable. However, the tariffs imposed by the United States in 2019 have made it more costly to import Asian ginseng, particularly from China, and to export American ginseng to China due to retaliatory tariffs from the Chinese government. This may have impacted the costs of Asian ginseng dietary supplements, possibly contributing to the decrease in ginseng dietary supplement sales in the United States (Table 4) as consumers conceivably looked for lower-cost alternatives. The impacts of the trade war on the ginseng trade are expected to continue as even higher tariffs were put on imports from China by the United States in 2025.[88,89]

Table 5 presents the average import and export prices of American ginseng in five countries in 2006 and 2016, along with the changes over this 10-year period.[90]

3. Adulteration

3.1. Known adulterants

The main adulterants in ginseng commercial products are the aerial parts or roots of other *Panax* species, most often *P. ginseng*, *P. quinquefolius*, and *P. notoginseng*, which are substituted for one another. In TCM, the term "seng" or "shen" refers to fleshy roots used to make tonics, and many plants with roots resembling ginseng have either "seng" or "shen" in their name, creating confusion and mislabeling in the herbal trade. *Codonopsis pilosula* (codonopsis or dang shen; Campanulaceae), sometimes named as "poor man's ginseng," is one such example of a ginseng adulterant, as it carries a similar name and has carrot-shaped, fusiform-cylindrical roots.[6,24,91] The Chinese market has had numerous other substitutes as well, which are summarized in Table 6. These plants represent historical adulterants, and most of these

Table 5. Comparison of American ginseng import and export prices by country over the years 2006 to 2016[90]

Country	Import Prices (USD/lb)		% Change	Export Prices (USD/lb)		% Change
	2006	2016		2006	2016	
Canada	22.48	46.01	104.69	14.18	31.17	119.78
China	18.67	25.79	38.10	7.28	29.34	303.09
Hong Kong, SAR	19.81	32.69	64.98	14.80	26.51	79.17
United States	19.34	44.35	129.37	57.94	52.36	–9.62
Republic of Korea	3.94	20.63	432.24	101.31	70.33	–30.57

Table 6. Botanicals that have been used as substitutes for ginseng in TCM

Latin name	Family	Common Name(s)
Adenophora triphylla (Thunb. ex Murray) A. DC.	Campanulaceae	Lady bells, nan sha-shen
Codonopsis pilosula Franch.	Campanulaceae	Codonopsis, dang shen
Mirabilis jalapa L.	Nyctaginaceae	Four o'clock flower, zimoli
Physochlaina infundibularis Kuang	Solanaceae	Ginseng of Mount Hua, hua shan shen
Phytolacca acinosa Roxb.	Phytolaccaceae	Indian poke, Chinese poke, shanglu
Platycodon grandiflorus (Jacq.) A. DC.	Campanulaceae	Balloon flower, jie geng
Lactuca indica L (syn. *Pterocypsela indica* L. Shih.)	Asteraceae	Indian lettuce
Rumex madaio Nakino	Polygonaceae	NA
Talinum paniculatum (Jacq.) Gaertn.	Polygonaceae	Jewels of Opar, turen shen
Vigna vexillata (L.) A, Rich.	Fabaceae	Wild cow pea

substitutions are no longer encountered in today's commercial market.

Another case of mislabeling occurred in the United States in the 1970s. Commercial products labeled as "wild red desert ginseng" were found to contain the roots of canaigre (*Rumex hymenosepalus*, Polygonaceae), a plant unrelated to *Panax* species or the Araliaceae family.[92,93] In addition, a variety of other unrelated plants are marketed as "ginseng" in different countries. In 2004, Wisconsin's American ginseng industry successfully lobbied for a law that restricted the use of the name "ginseng" in the United States to only botanicals within the genus *Panax*.[24] Table 7 lists the Latin and common names of plants promoted as ginseng.[2,6,31,42,92-97] Common examples include Siberian ginseng (eleuthero; *Eleutherococcus senticosus*, Araliaceae), Indian ginseng (ashwagandha; *Withania somnifera*, Solanaceae), and Brazilian ginseng (suma; *Pfaffia glomerata* and *P. paniculata*, Amaranthaceae).[2,31,94] Today, these plants are not adulterants of American or Asian ginseng in trade but are sometimes marketed as ginseng types through the use of the somewhat misleading common names.[24]

3.2. Sources of information supporting adulteration:

In most of the studies investigating the authenticity of ginseng products, the main adulteration issues were determined to be the undeclared addition of Asian, American, and tienchi ginseng to products that were not labeled to contain them.[28,29,33,36,46,54,98-103] A study from Brazil reported that all 30 tested samples labeled as *Panax ginseng* contained *Pfaffia* spp., as determined by using DNA barcoding, thin-layer chromatography (TLC), and high-performance liquid chromatography (HPLC).[94] In commercial samples collected from the United States, *Astragalus membranaceus* (Fabaceae) was identified in an Asian ginseng product by Molina et al.,[104] and soy (*Glycine max*, Fabaceae) was detected in two of 24 ginseng samples by Mihalov et al.[105] Additionally, *Physochlaina infundibularis, Phytolacca acinosa*, and *Platycodon grandiflorus* were identified as the adulterants of Asian ginseng commercial products purchased from China by genetic methods.[30,106]

In 1978, a study reported that one-third of 24 commercial ginseng products analyzed by quantitative TLC

Table 7. Non-*Panax* species sometimes referred to as 'ginseng'*

Latin name	Family	Common Name(s)	Other Common Name(s)
Adenophora triphylla (Thunb. ex Murray) A. DC.	Campanulaceae	Lady bells, nan sha shen	Southern sand ginseng
Aralia californica S. Watson	Araliaceae	California spikenard	California ginseng
Aralia nudicaulis L.	Araliaceae	Small spikenard	Wild ginseng, false sarsaparilla, wild sarsaparilla, American sarsaparilla
Caulophyllum thalictroides (L.) Michx.	Berberidaceae	Blue cohosh	Yellow or blue ginseng
Eleutherococcus gracilistylus (W.W.Sm.) S.Y. Hu	Araliaceae	Prickly ginseng	NA
Eleutherococcus senticosus (Rupr. & Maxim.) Maxim.	Araliaceae	Eleuthero	Siberian ginseng, eleuthero ginseng, thorny ginseng
Eurycoma longifolia Jack	Simaroubaceae	Tongkat ali	Malaysian ginseng
Gynostemma pentaphyllum (Thunb.) Makino	Cucurbitaceae	Gynostemma	Southern ginseng, blue ginseng
Hebanthe erianthos (Poir.) Pedersen (syn. *Pfaffia paniculata* (Mart.) Kuntze)	Amaranthaceae	Suma, pfaffia	Brazilian ginseng
Lepidium meyenii Walp.	Brassicaceae	Maca	Andean ginseng, Peruvian ginseng
Oplopanax horridus (Sm.) Miq.	Araliaceae	Devil's club	Alaskan ginseng, Pacific ginseng
Pfaffia glomerata (Spreng.) Pedersen	Amaranthaceae	Suma	Brazilian ginseng
Talinum paniculatum (Jacq.) Gaertn.	Polygonaceae	Jewels of Opar, turen-shen	Thai ginseng
Withania somnifera (L.) Dunal	Solanaceae	Ashwagandha	Indian ginseng, Ayurvedic ginseng

* Despite the occurrence of the name ginseng, most of the species are not found in ginseng trade.

and UV/Vis spectrophotometry contained no ginseng at all.[107]

Furthermore, high-performance thin-layer chromatography (HPTLC) and HPLC were used to calculate ginsenoside ratios in samples purchased from China, Europe, and Australia for the detection of adulteration of Asian ginseng roots with aerial parts. Six of the 17 products were adulterated with leaf or stem extracts, while one product was found to contain ginseng flower extract.[28] Liu et al also reported the adulteration of tienchi ginseng roots with flower material.[46]

Although many studies specify the adulterants detected in ginseng products, it is not always possible to identify the specific adulterant. In such cases, the analytical approach may rely on comparing the chemical fingerprint or the genetic make-up of the tested products with those of authenticated ginseng extracts, rather than directly determining the non-ginseng components. As a result, some studies report only the number or proportion of adulterated products without providing details on the specific adulterants present.[35,38,95,108-110]

Using DNA barcoding, fillers such as rice (*Oryza* spp., Poaceae), and other undeclared plant species (*Cicer* spp. [Fabaceae], *Cucurbita pepo* [Cucurbitaceae], *Melochia corchorifolia* [Malvaceae], *Moringa* spp. [Moringaceae], *Persea americana* [Lauraceae], *Trigonella foenum-graecum* [Fabaceae], and *Withania frutescens* [Solanaceae]) were identified in ginseng products. Genetic methods are highly sensitive and therefore can detect even trace amounts of plant materials and these findings are not confirmed with quantitative genetic methods. Thus, they may represent minor contaminations rather than intentional adulteration and are not reported as adulterants in ginseng products.[29]

3.3. Accidental or intentional adulteration:

Ginseng adulteration has been described since the late 18th century, driven by rising demand, overharvesting, habitat loss, and high prices. The introduction of American ginseng from Canada into trade in the 18th century created confusion with Asian ginseng, contributing to adulteration. Practices ranged from mixing wild and cultivated ginseng roots to substitution of the roots of one *Panax* species with others. One of the most hazardous forms of adulteration methods initially described in the mid-18th century involved opening holes in the roots and filling them with lead to increase their weight. The last known documentation of this practice dates to a 1905 publication and there is no evidence of this former practice's being observed in modern times.[2]

Today, both accidental and economically motivated adulteration persist due to the high demand, high costs, nomenclature confusion, and morphological similarities among *Panax* species. Authentication studies have identified several common practices, summarized in Table 9, including substitution with other plant materials or lower-cost *Panax* species, addition of undeclared aerial parts, excessive amounts of fillers or excipients, mixing previously extracted root material with unextracted roots, and blending other plant parts from ginseng or roots from similar-looking species with authentic products.[2,3,6,24,28,111-113]

In North America, both American and Asian ginseng products have been found to contain undeclared inert fillers or flow agents such as dextrose, lactose, or corn (*Zea mays*, Poaceae) syrup. These substances can be used to increase bulk and, depending on the concentration, to give the powder a different texture. Genuine ginseng root powder is fine, soft, and slightly glutinous.[24] Although small amounts of flow agents are frequently used to avoid problems during processing, undeclared excessive quantities may constitute adulteration as they increase product weight without providing consumers the declared amount of ginseng.[24] One such example is a case that occurred in the United States where a commercial sample labeled as American ginseng powder consisted of approximately 45% undeclared inorganic material, later identified as dicalcium phosphate (R. Upton e-mail to S. Gafner, October 19, 2025).

Table 8. Documented botanical adulterants in commercial ginseng products

Latin name	Family	Common Name(s)
Astragalus membranaceus Bunge	Fabaceae	Astragalus
Glycine max (L.) Merr.	Fabaceae	Soy bean
Pfaffia glomerata (Spreng.) Pedersen	Amaranthaceae	Suma, Brazilian ginseng
Physochlaina infundibularis Kuang	Solanaceae	Ginseng of Mount Hua, hua-shan-shen
Phytolacca acinosa Roxb.	Phytolaccaceae	Indian poke, Chinese poke, shanglu
Platycodon grandiflorus (Jacq.) A.DC.	Campanulaceae	Balloon flower, jie-geng

Table 9. Common adulteration methods for ginseng

Method	Examples
Plant materials that are not included in the genus *Panax* misbranded as ginseng	The use of vernacular (common) names containing the term "ginseng" for non-*Panax* species is common in many countries around the world. Some of the examples are given in Table 7.
Adulteration of one *Panax* species with another	*Panax ginseng* adulteration with *P. quinquefolius,* or vice versa
Adulteration with other plant materials or substances of lesser value	Use of pharmacologically inert bulking agents, addition of fillers such as dicalcium phosphate or sawdust
Admixing/substitution of various ginseng plant parts	Ginseng leaf extracts are added to ginseng root extracts to increase the ginsenoside content of certificates of analysis and label claims
Reduction of quality and strength	Adding waste material such as marc (leftover plant material from which most or all phytochemical constituents have been removed during commercial extraction), especially for powdered material

3.4. Frequency of occurrence:

There has been one large-scale investigation into the authenticity of commercial ginseng products as well as two review papers assessing the extent of ginseng adulteration. In 1993, the American Botanical Council launched the Ginseng Evaluation Program (GEP). The GEP was composed of two main testing phases: the Regular Phase and the Standardized Phase. The Regular Phase was aimed at investigating the quality of ginseng products on the market. Over 500 commercial samples of American ginseng, Asian ginseng, and eleuthero were examined.[114] The Standardized Phase focused exclusively on Asian ginseng products that were either standardized or made claims for total ginsenoside contents. The study evaluated 13 different products, with five separate lots analyzed for each product by HPLC-UV. The primary aim of this phase was to assess product consistency, and no pass/fail evaluation was assigned to the products.[115] The results, which were never published, indicated that about 25% of the products reviewed in the GEP were mislabeled and/or adulterated (M. Blumenthal oral communication to S. Gafner, March 6, 2025).

The authors of a 2021 review evaluated the authenticity of 507 commercial ginseng samples analyzed by various research groups up to the end of 2020. The reported adulteration rate was 24%.[3]

More recently, the ABC-AHP-NCNPR Botanical Adulterants Prevention Program reviewed global data on ginseng adulteration from studies assessing the authenticity of commercial products. Forty-eight peer-reviewed publications covering the authentication of 911 commercial ginseng products were included. Of the 853 products that were tested for botanical adulterants, 211 (24.7%) were reported to be adulterated. Eight additional studies evaluated the presence of active pharmaceutical ingredients. Conventional drugs such as sildenafil or metformin (section 3.5) were found in 28 out of 58 ginseng products (48.3%).[116]

3.5. Possible safety/therapeutic issues:

Adulteration of ginseng products is mainly related to accidental or intentional substitution of *Panax* species with each other or with other medicinal plants mistakenly named as ginseng.[3,116] Hence, the primary concern with ginseng adulteration is the potential lack of expected therapeutic effects. Although some poisonous plants such as *Mirabilis jalapa*, *Phytolacca acinosa* and *P. americana* have been reported as the adulterants of Asian ginseng,[24,30,42,97,117] this is not a common or current issue[95,118] and, to our knowledge, no cases of toxicity directly linked to adulterated ginseng commercial products have been reported. However, there are some studies reporting the presence of undisclosed active pharmaceutical ingredients, including testosterone,[47] tadalafil,[47,119-121] sildenafil,[119-122] tolbutamide,[123] glimepiride,[123] metformin,[123] caffeine,[120] and ephedrine[124] in commercial products marketed as ginseng dietary supplements. Depending on the ingested doses, these pharmaceuticals sold as dietary or food supplements may pose serious health risks to consumers.

3.6. Analytical methods to detect adulteration:

Various analytical approaches have been developed for the discovery of bioactive compounds, phytochemical characterization, quality assessment, and pharmacokinetic investigation of ginseng.[31] These analytical methods are summarized below along with their advantages and limitations.[22,31,49,111,125-127]

A study from 2014 aimed to investigate the taste characteristics of Asian ginseng that was purposefully mixed with American ginseng and to find models for predicting ginsenoside concentrations and estimat-

Table 10. Microscopic Differentiation of Three *Panax* Species[6]

Species	Powder	Starch Granules	Calcium Oxalate Crystals
Panax ginseng (unprocessed), *Panax quinquefolius*	Color is beige to white; soft texture to touch	Present	Present
Panax ginseng (processed)	Color is pale to dark reddish brown or pale yellow-brown; hard, more crystallized texture to touch	Absent; transformed into gelatinous mass due to steaming	Present
Panax notoginseng	Color is beige to yellow	Present and larger than in other *Panax* species	Infrequent or absent

ing adulteration. A taste sensing system equipped with five taste sensors representing sourness, saltiness, bitterness, astringency, and umami was used to determine the taste factors of ginseng samples with varied ratios of Asian ginseng root to American ginseng root. Data obtained from sensors were treated using three different data processing methods. In the prediction model of adulteration ratios, bitterness, astringency, and aftertaste bitterness were the most critical elements and in the prediction model of ginsenoside content, bitterness and aftertaste bitterness were the most useful parameters. Two prediction models were found to have promising performance, with R^2 values of 95.96% and 92.56%, respectively.[128] Additionally, an electronic nose system effectively distinguished between American and Asian ginseng, showing species classification accuracy comparable to gas chromatography-mass spectrometry (GC-MS) analysis. With most R^2 values reaching about 90%, this method offers a rapid and nondestructive approach for ginseng authentication.[129] However, results from these methods still need to be confirmed by chromatographic or, if applicable, genetic means.

Although microscopic characteristics of Asian, American, and tienchi ginseng roots and leaves are reported in detail in various pharmacopeial monographs,[24,55,59-62,130-132] books,[4,6] and articles,[23] differentiating them through morphological characteristics and microscopic methods is challenging. However, microscopy can be used to differentiate processed and unprocessed Asian ginseng, and the absence of calcium oxalate crystals are helpful to authenticate tienchi ginseng from two other ginseng species (Table 10). Applequist notes that Asian and American ginseng are very closely related and morphologically similar. American ginseng roots are generally smaller than Asian ginseng and have a paler yellow outer cork when unprocessed. Small rootlets are fewer in number in American ginseng, whereas Asian ginseng may be few or many. Despite these differences, root characteristics are variable and overlapping, so individual roots cannot be reliably differentiated by morphology alone.[20] Moreover, microscopy is not suitable to determine the authenticity of extracts but can help with finding excessive amounts of undeclared bulking agents and adulteration with ginseng leaves.[6,133]

DNA-based approaches are quite common to detect adulteration in commercial ginseng products, especially in Asian countries. Among them, DNA barcoding has been successfully used for the authentication of *Panax* species in numerous investigations.[33,36,39,40,99,101,103,104,106,108,109,118,134-138] However, this method is not suitable to detect adulterant DNA in highly processed plant materials, such as extracts, due to DNA degradation, limiting its application. Researchers using DNA barcoding report the absence of DNA in such highly processed products.[29,33,94,137] A study from 2014 compared the chloroplast genomes of tienchi and Asian ginseng to identify highly variable regions suitable for designing short, taxon-specific DNA mini-barcodes (DNA mini-barcoding uses primers to amplify short DNA sequences, generally 100-250 bp, that are more often taxon specific than the universal primers used for DNA barcoding). Three genomic regions, *ycf1a*, *ycf1b*, and *rps16*, were proposed as effective mini-barcodes with high discrimination power, enabling reliable identification of ginseng species even from highly processed samples with degraded DNA.[136]

Nguyen et al. (2020) determined 18 species-specific single nucleotide polymorphism (SNP) markers derived from coding DNA sequences of chloroplast genomes for the authentication of seven *Panax* species including Asian, American, and tienchi ginseng. Comparative analysis of the complete chloroplast genomes revealed 1,128 SNPs distributed among 72 of 79 protein-coding genes, providing valuable insights into the genetic diversity and evolutionary relationships of *Panax* species. The SNP markers, two or three for each species, enabled reliable discrimination among the seven species and may offer a practical tool to detect adulteration in the ginseng trade.[139]

Multiplex polymerase chain reaction (PCR) is a targeted DNA-based method that uses several species-specific primer sets and therefore can simultaneously identify multiple DNA sequences of the same species, or multiple species in a plant mixture. Multiplex PCR can detect species in degraded DNA using short genetic fragments and it is faster than conventional DNA barcoding, making it a preferred method by some authors to identify adulterants in ginseng products.[29,50,133,140-143]

In a study published in 2025, multiplex PCR and DNA barcoding with three genetic targets (*rbcL*, *matK*, and ITS2) were used to determine the authenticity of ginseng commercial products. Authors claimed that combining both methods increased the species identification rate and detection of undeclared adulterants compared to using each method individually.[29] In another study, indel variations (genetic alterations where one or more base pairs are either inserted into or deleted from a DNA sequence) have been used to distinguish *P. ginseng* from *P. quinquefolius* using high resolution melting (HRM) analysis.[40] HRM is a fast, reliable, and cost-effective method that employs a single primer set and can target short sequences such as mini-barcodes, enabling species discrimination.[33]

DNA methods are highly sensitive and require only small sample amounts, but they also have important limitations, such as the lack of amplification success in highly processed ingredients and finished products, the inability to distinguish between plant parts, the lack of quantitative information (i.e., the inability to distinguish between an adulterant and a minor contaminant), and sometimes the limited availability of good quality genetic information in reference databases.[29,106,133,144]

Chromatographic and spectroscopic methods, mainly relying on profiling the ginsenosides[35,53,145,146] and other constituents such as sugars, organic acids, and proteins,[147] are also used to authenticate *Panax* species. However, ginsenoside levels can vary with the plant part (see also section 1.9), age, environmental conditions, and processing, which needs to be taken into account when using them as chemical markers for identification.[33,35,110,148] To detect adulteration, TLC[94] and high-performance thin-layer chromatography (HPTLC)[24,28,38,141] were generally used in combination with other methods such as DNA barcoding and liquid chromatography (LC). Liquid chromatography with mass spectrometry (LC-MS),[46,102,145,149-154] ultraviolet detection (LC-UV),[24,28,38,54,155,156] or evaporative light scattering detection (LC-ELSD) are the most common methods used to quantify the ginsenosides and calculate their ratios to investigate adulteration.[157]

The Ph. Eur. recommends using a TLC method for the authentication of Asian ginseng and tienchi ginseng root. Following development, exposing the plates to

Panax quinquefolius
Photo by Steven Foster ©2026 ABC

heat after anisaldehyde treatment cause ginsenosides to visibly appear as violet zones under daylight. Arbutin and aescin serve as chemical reference standards. The method serves to distinguish *P. notoginseng* from *P. ginseng* and *P. quinquefolius* based on the absence or presence of specific zones.[59] The same method can be used to investigate Asian ginseng dry extracts in comparison to the Ph. Eur. certified ginseng dry extract herbal reference standard (HRS).[55,57,59] The USP American ginseng and Asian ginseng monographs describe an HPTLC method that specifies bands to distinguish among the three species. It can also be used for the identification of steamed Asian ginseng root and rhizome, its dry extracts, and tienchi ginseng root and rhizome products.[60-64,130-132,158] The HPTLC Association's website includes both the method described in USP38 - NF33[159-161] and the method generated by CAMAG[162-164] for Asian, American, and tienchi ginseng roots. The American Herbal Pharmacopoeia's (AHP) American ginseng monograph[24] details the same method as the one provided on HPTLC Association's website.[162] The AHP monograph also includes images of HPTLC chromatograms of cultivated and wild-grown American ginseng root samples along with American ginseng leaf, white Asian ginseng, and tienchi ginseng roots.[24]

For quantitative determination of ginsenosides, the USP provides an ultra-high performance liquid chromatography-ultraviolet spectrometry (UHPLC-UV) method[60-62] that has shorter sample preparation and run times than the HPLC method in the Ph. Eur.[55,57,59] USP also provides detailed specifications for species distinctions based on presence/absence or relative intensity of peaks and specific ginsenoside content ratios.[60-63] The American ginseng monograph of AHP features a slightly modified version of the HPLC-UV method previously included in the USP34. The method includes an additional hydrolysis step, extending the sample preparation time beyond 4 hours. The monograph provides detailed procedures for sample preparation not only for dry roots, but also for capsules, tablets, and liquid extracts. It also includes representative chromatograms for a mixed ginsenoside reference solution, hydrolyzed and unhydrolyzed American ginseng root, as well as hydrolyzed Asian and tienchi ginseng root samples.[24]

A 2025 study introduced "matrix identity cards," a novel technique that uses characteristic ion matrices derived from high-resolution MS data to generate digital fingerprints for authentic *P. ginseng* and *P. quinquefolius*. These matrices reflect the distribution and relative intensity of diagnostic ions from key ginsenosides and related metabolites. When combined with multivariate statistical modeling (e.g., PCA, PLS-DA), the method allows rapid, reliable discrimination between authentic and adulterated materials.[154]

In a study from 2020, near infrared spectroscopy (NIR) was used for authentication and geographical origin discrimination of eight Asian ginseng root samples from China. One of the samples was determined as American ginseng and three others contained roots from unrelated plant species.[30] Fourier transform infrared (FT-IR) spectroscopy with principal component analysis (PCA) was also helpful to differentiate Asian and American ginseng root samples.[165] Moreover, FT-IR was combined with PCA and partial least square (PLS) multivariate statistical analysis to verify the authenticity of Asian ginseng powder and predict the degree of adulteration with other root plants such as arrowroot (*Pueraria hirsuta*, Fabaceae), balloon flower, and lance asiabell (*Codonopsis lanceolata*, Campanulaceae).[166]

Another less commonly used approach is hyperspectral imaging combined with visible light and X-ray imaging. It was found to be an accurate, fast and non-destructive method to determine the geographical origin of Asian ginseng.[167] However, more information on its usefulness to detect ginseng adulteration is needed.

Nuclear magnetic resonance (NMR) spectroscopy coupled with PCA and cluster analysis was used to detect the cultivation ages of dried Asian ginseng roots and to investigate commercial products purchased from Taiwan. One of the six commercial products was found to be different from all clusters proving that the product did not conform to the labeled quality; however, no specific adulterant was mentioned.[110] An NMR-based metabolomics approach also successfully differentiated Asian ginseng root samples collected from different geographic locations at different ages.[147,168] Hence, NMR spectroscopy shows promise as an appropriate tool to authenticate Asian ginseng.

Finally, one research group used GC-MS to detect certain forms of ginseng adulteration. The ginsenosides have to be hydrolyzed and trimethylsilyl-derivatized to be analyzed by GC.[111] Lee et al. (2018) developed a headspace stir-bar sorptive extraction method coupled with GC-MS to identify volatile markers for detecting adulteration of red ginseng juice with lance asiabell or balloon flower. 1-Hexanol, cis-3-hexen-1-ol, and *trans*-2-hexen-1-ol were identified as specific markers indicating the presence of these adulterants.[169]

4. Conclusions

Asian, American, and tienchi ginseng are important herbs valued both in traditional medicine and in

modern health applications. Rising global demand, high market value, and the similarity of their morphological, microscopic, and chemical characteristics have contributed to ongoing adulteration, substitution, and mislabeling of these species. Various plant species improperly promoted as ginseng for economic gain, and, in some cases, undisclosed active pharmaceutical ingredients have been added to products to mimic or enhance their effects. Since using a single analytical method may not be reliable to detect all types of adulteration, a combination of orthogonal and fit-for-purpose analytical methods is recommended. Microscopy is an excellent choice to detect undeclared bulking agents. DNA-based methods can serve as a first step to confirm species identity for crude ginseng root materials, followed by chromatographic techniques such as HPTLC, LC-UV, or LC-MS to identify the plant part used and detect foreign plant species and chemical adulterants. The latter are the most commonly used methods to detect adulteration of ginseng extracts. Calculating relevant ginsenoside ratios can provide further criteria for species differentiation and help reveal adulterated materials, including adulteration with lower-cost plant parts (e.g., aerial parts) from *Panax* species.

Efforts to reduce the extent of ginseng adulteration on the global market include more prevalent use of trading materials in their whole or semi-whole form, rigorous authentication in quality control laboratories, good manufacturing practices, enhanced regulatory monitoring, and greater transparency in sourcing and labeling. Educating manufacturers, distributors, and consumers about common adulterants and trustworthy sourcing practices can further reduce the potential for purchasing adulterated ingredients and finished products.

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Revision summary

Version # , Author,	Date Revised	Section Revised	List of Changes
Version 1, N. Orhan	N/A	N/A	None