

Scientific Insights into Ginseng

SIMON MING YUEN LEE*, AI-HUA LIN**

ABSTRACT: The global ginseng market, including *Panax ginseng* (Asian ginseng), *Panax quinquefolium* L. (American ginseng) and *Panax notoginseng* (Sanqi ginseng), was estimated to be worth over 2000 million US Dollars. Although these three ginseng species have very close phylogenetic relationships, interestingly, their biological functions and therapeutic uses are quite different. Unlike Asian ginseng and American ginseng, the root of *P. notoginseng*, named *Sanqi* or *Tienchi* in Chinese, can only be cultivated in a highly specific mountainous area constituting about 8300 hectares in Wenshan Prefecture, Yunnan Province, China, and thus is less well known worldwide. Nevertheless, Sanqi ginseng is very popular in China and is commonly used in foods and pharmaceutical products for management of trauma and ischaemic cardiovascular health problems. A recent biomedical research on Sanqi ginseng provides a strong scientific rationale supporting the historical uses of Sanqi ginseng in the prevention and treatment of cardiovascular diseases. Moreover, the discovery of a family of major bioactive ingredients, named ginsenosides, present in these ginseng species which have diverse biological activities, provides insight into why these ginsengs exhibit very different therapeutic effects. However, long-term domestic cultivation has rendered Sanqi ginseng highly vulnerable to diseases and pathogen infections. The issue of ensuring a sustainable supply of Sanqi ginseng and preserving this unique medicinal plant urgently requires our attention.

KEYWORDS: Ginseng; *Panax notoginseng*; *Sanqi*; Cardiovascular disease; Yunnan.

* Simon Ming Yuen Lee is currently the deputy director and distinguished professor at the Institute of Chinese Medical Sciences of the University of Macau. He received his Ph.D. from the Chinese University of Hong Kong.

Simon Ming Yuen Lee é actualmente director-adjunto e distinguido professor no Instituto de Ciências Médicas Chinesas da Universidade de Macau. Obteve o doutoramento pela Universidade Chinesa de Hong Kong.

** Ai-Hua Lin is currently a master's student at Institute of Chinese Medical Sciences of the University of Macau. She obtained her bachelor's degree in Pharmaceutical Science from Xiamen University.

Ai-Hua Lin é actualmente mestranda no Instituto de Ciências Médicas Chinesas da Universidade de Macau. Obteve a licenciatura em Ciências Farmacêuticas pela Universidade de Xiamen.



Fig. 1: Morphology of *Panax notoginseng* collected from a cultivated field in Wenshan (文山), Yunnan Province, China. *Panax notoginseng* is called *Sanqi* (三七) in Chinese, which refers to its unique appearance of ‘seven leaves and three branches’. Photo by the authors.

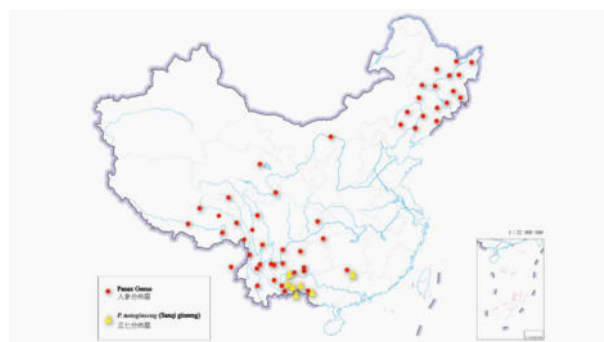


Fig. 2: Geographical distribution of *Panax* genus and *Panax notoginseng* in China. The inset map is modified by the authors based on a map numbered GS(2016)2884 from the *Biaozhun ditu fuwu xitong* (標準地圖服務系統 System of Standard Map Service) of the National Administration of Surveying, Mapping and Geoinformation of China. Source: <http://bzdt.ch.mnr.gov.cn/>

1. PANAX NOTOGINSENG: FOLK TALES IN CHINA

1.1 A BRIEF COMPARISON OF PANAX NOTOGINSENG WITH OTHER COMMON PANAX GINSENG SPECIES

Panax notoginseng is a highly valued ginseng species in the genus *Panax*, the family of Araliaceae.¹ The root and rhizome of *P. notoginseng* are famous *Chinese materia medica*, named *Sanqi* (三七) or *Tienchi* (田七) in Chinese, which is commonly used in the treatment of trauma and ischaemic cardiovascular diseases. *Panax notoginseng*, together with *Panax ginseng* C. A. Meyer (*P. ginseng*) and *Panax quinquefolius* L. (*P. quinquefolius*) which are commonly called Asian ginseng and American ginseng, respectively, constitute an important medicinal genus in East Asia. The global ginseng market, including *P. ginseng*, *P. quinquefolius* and *P. notoginseng*, was estimated to be worth over 2000 million US Dollars.²

Among these three ginseng species, *P. ginseng* is the most well known and popular worldwide. *P. ginseng* has been consumed for over 1600 years and is widely distributed in China, Russia, Korea and Japan. The flesh and dried root of ginseng are strong tonic and adaptogen that have beneficial effects on blood pressure and heart function. Besides, they can

alleviate neurasthenia, physical weakness, stomachic, diuretic and euphoric problems. It is believed that wild *P. notoginseng* has been consumed for over 3000 years in Asia and cultivation of it has been practised for about 400 years in China. Many Chinese physicians have hailed *P. notoginseng* as ‘the sacred plant of the South’ and ‘the golden immortal’. Unlike *P. ginseng* and *P. quinquefolius*, which are widely distributed across continents in the Northern Hemisphere, *P. notoginseng* is mainly cultivated in mountainous areas at an altitude of 1200–2000 metre around 23.5°N and 104°E; about 8300 hectares of the cultivated area is present in Wenshan Prefecture, Yunnan Province, China (Fig. 1 and Fig. 2).³ Yunnan is located in southwestern China and has been well preserved due to its famous cultural diversity (25 ethnic minority groups) as well as unique biodiversity and natural geography where some sites are classified as UNESCO cultural heritage.

P. ginseng (Asian ginseng), *P. quinquefolium* L. (American ginseng) and *P. notoginseng* (Sanqi ginseng) are all herbaceous plants belonging to the same genus according to taxonomic classification, and their flowers and stems have a very similar appearance; interestingly, however, their biological functions and therapeutic uses are quite different (Table 1). *P. ginseng* is commonly used to promote vitality and aid recovery from weakness

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after illness. According to traditional Chinese medicine philosophy, *P. quinquefolium L.* is mainly used to nourish *yin* energy, clear away heat and also replenish vital energy; however, it seems to be less effective than *P. ginseng*. The dried root of *P. notoginseng* is mainly used as food and in Chinese medicine to resolve blood stasis, promote blood circulation and stop wound

bleeding. For example, *P. notoginseng*-based *Xuesaitong* injection is one of the most popular Chinese medicines prescribed in China for the prevention and treatment of ischaemic cardiovascular diseases.⁴ The scientific basis for the differential biological effects of these three phylogenetically closely related ginseng species will be elaborated upon in this article.

Table 1: Comparison of *P. notoginseng* with two major ginseng species

English Name	Chinese Name	Traditional Indication
<i>Panax ginseng</i> (Asian Ginseng)	人參 (<i>ren shen</i>)	Revitalise and aid recovery from weakness after illness.
<i>Panax quinquefolium L.</i> (American ginseng)	西洋參 (<i>xi yang shen</i>)	Nourish <i>yin</i> energy and clear away heat; replenish vital energy (but less effective than Asian ginseng).
<i>Panax notoginseng</i> (Sanqi ginseng)	三七 (<i>san qi</i>)	Stop bleeding, dissolve blood stasis, and relieve pain.

Source: Wan et al., *Journal of Pharmaceutical and Biomedical Analysis*, Volume 41, April 2006, 274–279.

1.2 *P. NOTOGINSENG* HAS LONG BEEN USED AS A TRADITIONAL FOOD AND MEDICINAL CUISINE IN CHINA

P. notoginseng is ubiquitous in daily life in China. In Chinese herbal pharmacies in Macao, the raw dried root of *P. notoginseng* can be easily found and purchased, it is commonly used for preparing soup or decoctions in the home (Fig. 3). A soup containing with chicken stew or steamed pigeon has traditionally been prepared as a tonic remedy in Yunnan Province and Guangxi Zhuang Autonomous Region of China.⁵ ‘*P. notoginseng* steam pot chicken’ has long been a popular tonic in Yanshan, Yunnan Province, China. This delicious meal is prepared by stuffing the *P. notoginseng* roots inside a cleaned chicken, followed by soaking it in water and steaming it for a few hours. The natural flavour and fresh scent of the stewed chicken remain and the soup is light

and sweet. In addition, many varieties of over-the-counter (OTC) pharmaceutical products containing *P. notoginseng* as the major active ingredient, such as atypical medicinal oils for bruises and injuries, can be found in pharmacies (Western drug stores) in Macao (Fig. 4), while some *P. notoginseng* pharmaceutical products can only be prescribed by a physician or obtained in hospital.

1.3 USE OF *P. NOTOGINSENG* IN REGISTERED PHARMACEUTICAL PRODUCTS

P. notoginseng is the main active ingredient in several hundred proprietary Chinese medicine and pharmaceutical products in China. A search on the official website of the National Medical Products Administration by using the keyword ‘*Panax notoginseng*’ yielded 596 hits in the prescription drug category, 19 in the non-prescription Chinese medicinal

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Fig. 3: Raw dried roots of *P. notoginseng* in Chinese herbal pharmacies in Macao, China. Photo by the authors.



Fig. 4: Different OTC medicinal oil and pharmaceutical products of *P. notoginseng* available in pharmacies in Macao, China. Photo by the authors.

Table 2: The number of different registered ginseng products according to the National Medical Products Administration

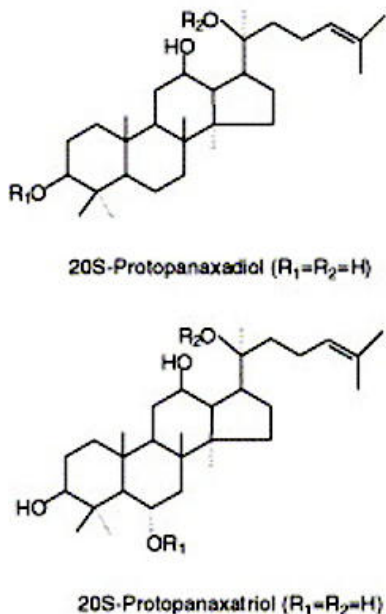
Search keywords	Number of registered products		
	<i>P. notoginseng</i> (Sanqi)	<i>P. ginseng</i>	<i>P. quinquefolium</i> L.
Domestic drugs	596	791	17
Non-prescription Chinese medicine products	19	36	5
Health foods	171	468	811

Source: Data retrieved and collated from the official website of the National Medical Products Administration. <https://www.nmpa.gov.cn/>

product category, and 171 in the registered health dietary supplement category (Table 2). Notable examples of registered *P. notoginseng* pharmaceutical products in China include *Panax notoginseng* tablets, *Panax notoginseng* Dangshen tablets, *Panax notoginseng* honey essence oral liquid, *Panax notoginseng* hemostasis tablets, *Panax notoginseng* hemostasis capsules, *Panax notoginseng* medicinal tablets, *Panax notoginseng* triol saponin, *Panax notoginseng* flower granules,

Panax notoginseng honey essence, *Panax notoginseng* capsules, *Panax notoginseng* Ning San for blood disorders, indomethacin *Panax notoginseng* ice tablets, etc. Pharmaceutical products containing *P. notoginseng* are mostly used to improve blood circulation, resolve blood stasis, or relieve swelling and pain. *P. notoginseng* is often used in combination with other Chinese medicinal plants to enhance the therapeutic effect. In addition to typical bulk tablets,

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Saponin	R1	R2	M.W.
Rb1	-glc(2-1)glc	-glc(6-1)glc	1108
Rb2	-glc(2-1)glc	-glc(6-1)arap	1078
Rb3	-glc(2-1)glc	-glc(6-1)xyl	1078
Rc	-glc(2-1)glc	-glc(6-1)araf	1078
Rd	-glc(2-1)glc	-glc	946

Saponin	R ₁	R ₂	M.W.
Re	-glc(2-1)rha	-glc	946
Rg1	-glc	-glc	800
Rf	-glc(2-1)glc	-H	800
R1	-glc(2-1)xyl	-glc	932

Glc= β-D-glucose
 Arap= α-L-arabinose (pyranose)
 Araf= α-L-arabinose (furanose)
 Xyl= β-D-xylose
 Rha= α-L-rhamnose
 M.W. = Molecular Weight

Fig. 5: Comparison of anti-vascular inflammatory effects of PDS-ginsenosides and PTS-ginsenosides by measuring the expressions of adhesion molecules, including ICAM-1 and VCAM-1, on TNF-activated human coronary artery endothelial cells (HCAECs) at which PDS was more potent than PTS. *Chinese Medicine*, Volume 6, 2011, Article 37. Figure created by the authors.

other forms of products containing *P. notoginseng* as the principal component include granules, delayed-release capsules and suppositories. Although *P. notoginseng* is less well known than *P. ginseng* and *P. quinquefolius* worldwide, it has a comparable market share to *P. ginseng* in China.

1.4 A FEW EXAMPLES OF PHARMACEUTICAL PRODUCTS CONTAINING *P. NOTOGINSENG* WITH OVER A CENTURY OF DOCUMENTED USE

1.4.1 YUNNAN BAIYAO (雲南白藥)

Yunnan Baiyao (雲南白藥) can relieve pain and reduce oedema. It was created in 1902 by Dr. Qu Huanzhang, a Yunnanese folk doctor, and was originally known as *Qu Huanzhang Baibao Dan* (曲煥章百寶丹). *Yunnan Baiyao* was referred to as a ‘Chinese treasure and sacred remedy for injuries’ over a century ago. Yunnan Baiyao Group Co., Ltd. was established on May 3, 1993; its predecessor

was Yunnan Baiyao Factory, established in June 1971. Initially, *Yunnan Baiyao* was only offered in powder form but in recent years, with developments in pharmaceutical technology, other forms of *Yunnan Baiyao* have become available, including capsule, tincture, ointment and aerosol forms. In addition, *Yunnan Baiyao* has been listed as a class A drug in China, whereby the prescription, dosage and manufacturing methods are classified and protected as state secrets.

1.4.2 PIEN TZE HUANG (片仔癀 PIAN ZI HUANG)

Since the Ming Dynasty (A.D. 1522–1566), a Chinese medicine formula called *Pien Tze Huang* (片仔癀 *Pian Zi Huang*) has been widely used to treat blood diseases. *Pien Tze Huang* can be used to treat viral hepatitis, carbuncles and furuncles, swelling and poisoning, bruising and injuries, and a variety of inflammatory conditions. Similar to *Yunnan Baiyao*,

The abundance of representative PTS- and PDS-ginsenosides

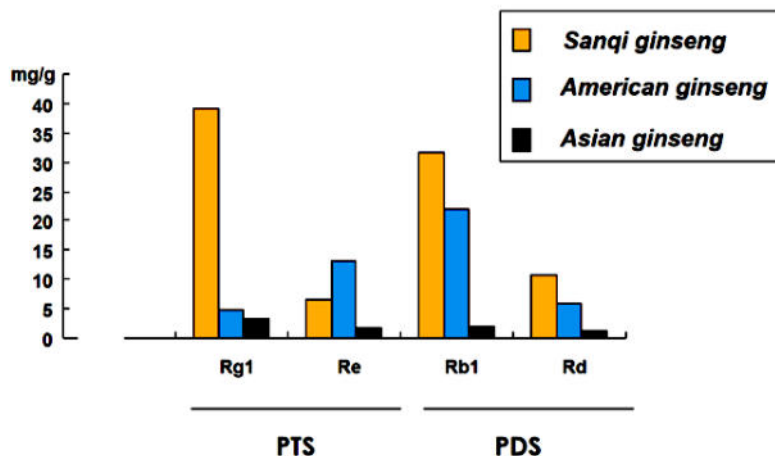


Fig. 6: Comparison of abundance of representative saponins (ginsenosides), PTS (Rg1 and Re) and PDS (Rb1 and Rd), in different ginseng species. *Journal of Pharmaceutical and Biomedical Analysis*, Volume 41, April 2006.

Pien Tze Huang is one of the four Chinese medicinal formulas listed as class A drugs.

2. IDENTIFICATION OF BIOACTIVE COMPONENTS AND PHARMACOLOGICAL EFFECTS OF *P. NOTOGINSENG*

2.1 GINSENOIDES EXHIBITED HIGH DIVERSITY IN VASCULAR REACTIVITY AMONG DIFFERENT CARDIOVASCULAR DISEASE CONDITIONS IN RECENT PHARMACOLOGICAL STUDIES

Historically, Chinese healers have highly regarded *P. notoginseng* for promoting health and treating many different human diseases. *P. notoginseng* can stop bleeding, promote blood circulation, and relieve pain. According to Li Shizhen's *Ben Cao Gang Mu* (《本草綱目》 *Compendium of Materia Medica*) from the Ming Dynasty (A.D. 1590s). From a contemporary biomedical perspective, questions arise such as does 'stopping bleeding' imply that *P. notoginseng* can accelerate wound hemostasis? Does 'dispersing blood' suggest that *P. notoginseng* can dissolve blood clots? Does 'relieving pain' refer

to anti-pain or anti-inflammation effects? And what is the bioactive constituent and mechanism of pharmacological activity of *P. notoginseng* according to recent biomedical studies?

The main active ingredient of *P. notoginseng* and other ginseng species is a group of small molecules called ginsenosides, which consist of a triterpenoid skeleton and a glycosyl group.⁶ Our group has optimised a methodology for the extraction and isolation of a dozen ginsenosides from *P. notoginseng*, and has also successfully developed pressurised liquid extraction and high-performance liquid chromatography methods for simultaneous determination of nine saponins in different ginseng species. The ginsenosides isolated from *P. notoginseng* and other ginseng species can be divided into two main types according to their skeleton structure: 20-S protopanaxadiol saponin (PDS) and 20S-protopanaxatriol saponin (PTS). Examples of PDS include Rb1 and Rd, while PTS include notoginsenoside R1, ginsenoside Rg1 and Re.

In general, these ginsenosides have shown very different vascular reactivity among different

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cardiovascular disease conditions such as atherosclerosis, hypertension, platelet aggregation, angiogenesis imbalance, and vascular ageing. Interestingly, PTS and PDS, as two different major structural skeletons of ginsenoside, exhibit major differences in potency (e.g., weak to strong anti-inflammatory effect) (Fig. 5) and even exert opposing effects (e.g., anti-angiogenesis vs. pro-angiogenesis) based on many published scientific investigations.

2.2 RECENT SCIENTIFIC EVIDENCE OF THE EFFECTS OF *P. NOTOGINSENG* ON CARDIOVASCULAR DISEASES

Cardiovascular diseases are the leading cause of death worldwide, killing 17.9 million people each year.⁷ Cardiovascular diseases include coronary heart disease, atherosclerosis (AS),⁸ cerebrovascular illness, and rheumatic heart disease, among other disorders. AS is a chronic vascular inflammatory condition of the blood arteries which is the major cause of heart diseases and acute myocardial infarction worldwide. In addition, AS is a multifactorial illness characterised by the accumulation of lipid and fibrous elements in the inner wall of the aorta. By recruiting inflammatory cells and releasing cytokines, inflammatory processes play a critical role in the pathological development of AS, leading to plaque rupture, thrombosis and, ultimately, acute cardiovascular events. High saturated fat diets, smoking, hypertension and hyperglycaemia are all common risk factors for coronary artery endothelial diastole, loss of anti-thrombotic properties, and activation of endothelial cells, resulting in chronic vascular inflammation and eventually AS.

Moreover, in our previous study, the anti-atherogenic effect of *P. notoginseng* saponins (PNS) was examined in an atherogenic model of transgenic animals, specifically apolipoprotein E (apo-E)-deficient mice.⁹ PNS dissolved in drinking water was administered orally to two treatment groups at doses of 4.0 and 12.0 mg/day/mouse, respectively.

After eight weeks, atherosclerosis in the entire aortic area was assessed by using an enface method. Compared with the control group, both the low and high-dose PNS-treated groups showed a significant decrease in atherosclerotic lesions, by 61.4% and 66.2%, respectively ($P < 0.01$). In brief, PNS exerts antiatherogenic activity, at least in part through its lipid-lowering and anti-vascular inflammatory effects. We further investigated the effects of three different saponin fractions (e.g., total saponins, PNS; PDS; and PTS), and two major representative individual ginsenosides, from *P. notoginseng* on the endothelial inflammatory response in vitro and in vivo. Our data demonstrated potential anti-atherogenic effects of the saponin fractions (e.g., PNS, PDS and PTS) and selected individual ginsenosides (e.g., Rg1 and Rb1) in multiple experimental models (Fig. 5).

The initiation of vascular inflammation and rupture of the natural barrier occurs at the vascular endothelium and represents a key pathological phase of atherosclerosis. Inflammatory monocytes migrate from the circulation into the sub-endothelium and take up lipids and produce foam cells in the early phases of vascular inflammation. Adhesion molecules expressed in the vascular endothelial surface, such as intercellular adhesion molecule-1 and vascular cell adhesion molecule-1, play a key role in attracting and mediating monocytes and neutrophils, prompting them to roll along the vascular surface and stick to activated endothelium cells.¹⁰ Monocyte chemoattractant protein-1 (MCP-1) promotes the infiltration of monocytes into the subintima of the aorta wall and the differentiation of the adherent monocytes into macrophages, resulting in an innate immunological response associated with endothelial activation. A phenotypic shift in vascular smooth muscle cells caused by a persistent chronic inflammatory response in the artery wall leads to plaque growth, increased vascular stress and, eventually, an increase in the risk of blood vessel rupture and plaque dissociation.

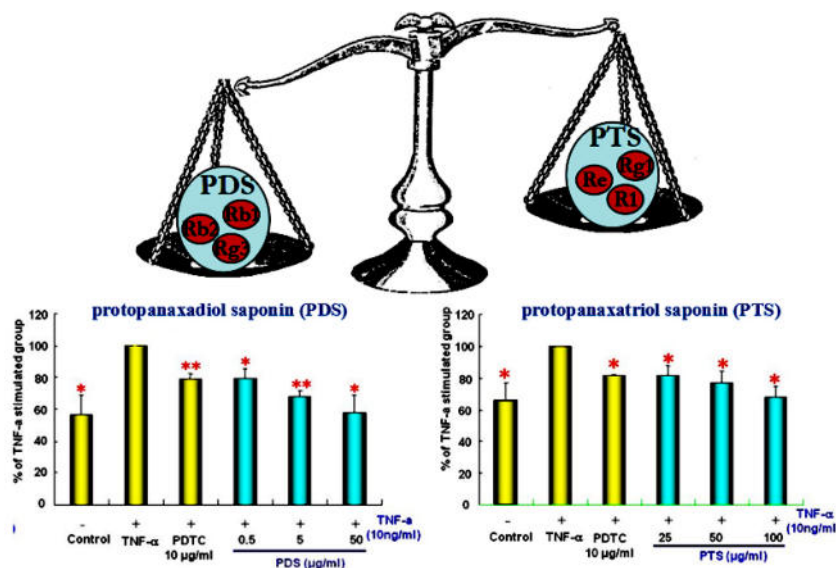


Fig. 7: Opposite angiogenesis effects of PTS-ginsenosides and PDS-ginsenosides. Data from *Phytotherapy Research*, Volume 23, 2009, 677–686 and *Chinese Journal of Integrative Medicine*, Volume 22, June 2016, 420–429. Figure created by the authors.

As mentioned above, three saponin fractions (PNS, PDS and PTS) and two representative components (Rg1 and Rb1) were systematically evaluated and compared in our previous study, in terms of their ability to inhibit monocyte adherence in vitro and the expression of adhesion molecules. PNS, PDS and PTS exhibited differential potencies concerning the inhibition of monocyte adherence to activated endothelial cells in vitro, as well as the mRNA and cell membrane expression of adhesion molecules, including ICAM-1 and VCAM-1, on TNF-activated human coronary artery endothelial cells (HCAECs) in vitro.¹¹ One of the most important findings was that, among all tested components, PDS was the most effective ginsenoside against TNF-induced monocyte adherence and the expression of adhesion molecules (Fig. 5). The findings provide a scientific rationale for the use of *P. notoginseng* to prevent and treat cardiovascular diseases. Moreover, they provide insight into the potentially unique therapeutic effects of *P. notoginseng* on blood vessels and circulation, which

are not obvious in other ginseng species. The different therapeutic effects of *P. notoginseng*, *P. ginseng* and *P. quinquefolius L.* could be attributed to their different chemical compositions (e.g., the ratio of PDS to PTS and abundance of individual ginsenosides) (Fig. 7).

3. GREEN SOLUTIONS FOR A SUSTAINABLE SUPPLY OF *P. NOTOGINSENG*

P. ginseng and *P. quinquefolius L.* are widely distributed across continents in the Northern Hemisphere, while *P. notoginseng* is only cultivated in restricted mountainous areas, in Wenshan Prefecture, Yunnan Province, China. Long-term domestication has made the *P. notoginseng* population highly genetically homogeneous in a small growing area, resulting in susceptibility to environmental stress and diseases. The entire worldwide supply of commercial *P. notoginseng* is derived solely from cultivation in this small growth area which produces a limited amount of *P. notoginseng* (e.g., about 7.03 million kg of fresh *P. notoginseng* was harvested in late 2005).¹²

The mass cultivation of *P. notoginseng* is severely

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Fig. 8: Representative beautiful landscape of Yunnan Province. Source: She Tu Wang (攝圖網): *Dongchuan Hong Tudi* (東川紅土地). <https://699pic.com/tupian-500195991.html>

hindered by root-rot diseases, which impact both crop yields and farmers. To understand why *P. notoginseng* is vulnerable to pathogen attack, we generated a whole-genome map of *P. notoginseng* and performed data mining on the genome.¹³ Approximately 88.89% of the 2.25 Gb of assembled sequences could be unambiguously assigned to 12 chromosomes with a contig N50 of 220.89 kb, thus providing a superior genome assembly. This may shed light on the decrease of disease-resistance genes, which may underlie the poor disease resistance of most *P. notoginseng* cultivars. This study provides insight into the disease resistance of *P. notoginseng*, which could be improved or enhanced by incorporating lost disease-resistance genes into the plant genome using various genetic engineering tools.

The recent advances in synthetic biology technology have rendered the biosynthesis of selected plant secondary metabolites in different microorganisms feasible, by fabricating all the biosynthetic genes involved in the biosynthesis of the target metabolite molecule into a host organism, such as algae or yeast. Synthetic biology is a promising alternative solution for sustainable production and supply of valuable chemicals. Understanding the genes encoding the biosynthesis enzymes involved in the

biosynthesis pathway of the various ginsenosides in *P. notoginseng* is crucial for the design and implementation of engineered biosynthesis. Thus, we established a global transcriptome dataset on *P. notoginseng* via RNA-seq analysis.¹⁴ A family of dammarenediol synthase genes encoding the enzymes responsible for the biosynthesis of dammarane group saponins, which are the major bioactive ingredients, was annotated. These biosynthesis gene sequences will serve as important reference genetic markers for improving the breeding and cultivation of *P. notoginseng*.

The root of *P. notoginseng* is the major vegetative part consumed. The flower of *P. notoginseng* (FS) is also commonly consumed as a tea in China. To fully utilise the other vegetative parts of *P. notoginseng*, we studied the chemical composition and biological activities of its flower.¹⁵ Surprisingly, FS was found to be a rich source of ginsenosides and contain a higher level of saponins, particularly PDS-type ginsenosides, than the root. However, detailed pharmacological studies have rarely been conducted on the flower of *P. notoginseng*. Therefore, we performed a study on ginsenosides extracted from the FS and then examined them in the context of a rat myocardial infarction (MI) model. Our results demonstrated that compared to the MI group, FS (25–50 mg/kg/day) induced an approximately 3-fold upregulation of VEGF mRNA expression, and a concomitant increase in blood vessel density in the peri-infarct area of the heart, at 2 weeks post-treatment. Moreover, TUNEL analysis indicated a reduction in the mean apoptotic nuclei per field of the peri-infarct myocardium upon FS treatment. In vitro experiments showed that FS can enhance VEGF-induced migration of HUVECs and activate VEGF-A mRNA transcription, resulting in pro-angiogenic effects. FS administration partially restored vascular insufficiency in zebrafish and enhanced vascular density in myocardial infarction rat heart tissue, suggesting that it is a potent pro-angiogenic agent for ischaemic heart diseases. Overall, our results suggest

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Fig. 9: Collection of cultivated coffee beans by Yunnan ethnic minorities. Source: Maja Wallengren, *Spilling the Beans*. <http://www.spilling-the-beans.net/coffee-of-the-day-medium-roast-from-chinas-yunnan-province/>

that the purified ginsenoside preparation from the flowers of *P. notoginseng* may serve as an alternative preventive and therapeutic agent for cardiovascular diseases.

To identify alternative plant species to *P. notoginseng*, we reviewed the historical uses and cultivation of *P. notoginseng* and analysed the traditional uses, major chemical components, modern pharmacological studies, distribution and morphological characteristics of phylogenetic hemostatic herbs in the *Panax* genus. *Panax japonicus* C. A. Meyer (*Zhujiashen*) and *P. japonicus* var. *major* (*Zhuzishen*), which are phylogenetically related Chinese materia medica with similar chemical and pharmacological properties to *P. notoginseng*, have been identified as candidate hemostatic species (based on traditional Chinese medicine theory) and potential substitutes for *P. notoginseng*. In addition, another possible solution is to identify alternative geographical locations to grow *P. notoginseng*, which is currently only cultivated in restricted areas in Yunnan Province, China. Yunnan has a unique red soil enriched in iron oxide, which is also suitable for growing coffee plants (Fig. 8). These unique soil conditions have made Yunnan the dominant coffee production area in China since a trial plantation project of imported

coffee started two decades ago (Fig. 9). The feasibility of growing *P. notoginseng* in other countries has not been studied before and merits exploration.

CONCLUSION

P. notoginseng, as a blood-invigorating medicinal plant, plays an important role in traditional Chinese medicine treatment protocols. *P. notoginseng* has been widely used as a medicine by households in China and is a major ingredient in several hundred proprietary Chinese medicine and pharmaceutical products, particularly for the management of cardiovascular diseases. The traditional uses, major chemical components, and results of modern pharmacological studies of *P. notoginseng* have been reviewed in this article. Current scientific evidence strongly echoes the ancient wisdom of our ancestors and supports the use of *P. notoginseng* for treating cardiovascular diseases. Compared to other famous ginseng species like *P. ginseng* and *P. quinquefolius*, *P. notoginseng* is relatively less well known outside China. Although *P. notoginseng* has many valuable properties, for more extensive use of this plant, worldwide additional research on sustainable production and supply is required to improve pathogen resistance in agriculture, utilising the whole plant (flower and leaves), identifying other potential cultivation sites (e.g., Brazil) and substitute *Panax* species like *Zhujiashen* (竹節參) and *Zhuzishen* (珠子參). **RG**



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