

PROFILES OF *PANAX VIETNAMENSIS* CULTIVATED IN SON LA MOUNTAIN, VIETNAM

Nguyen Thi Minh Tu 

Received on July 31, 2025

Presented by D. Ivanov, Corresponding Member of BAS, on October 28, 2025

Abstract

This study examined the phytochemical composition and environmental adaptation of *Panax vietnamensis* cultivated in Son La, a non-native high-land region. Roots aged 3–5 years were analyzed for saponins and amino acids. Grown above 1600 m in humus-rich soils under > 70% forest canopy, the plants showed high levels of majonoside R2 (6.10%), Rg1 (2.85%), and Rb1 (0.74%), with total saponins of 6.61–9.82% (w/w). Amino acid content increased with age, reaching ~ 3.424 mg/100 g in 5-year-old roots. These results indicate that forest-based cultivation in Son La preserves the phytochemical quality of *P. vietnamensis* and supports its sustainable expansion beyond native habitats.

Key words: Vietnamese ginseng, saponins, amino acids, traditional cultivation, Son La

Introduction. *Panax vietnamensis* Ha and Grushv., (Vietnamese ginseng), is a rare and endemic species of the *Panax* genus (Araliaceae), naturally occurring in the moist, shaded highlands of Central Vietnam at elevations between 1500 and 1800 m. Traditionally used by the Sedang people, *P. vietnamensis* has attracted scientific interest for its potential in treating neurological, cardiovascular, oncological, and age-related disorders [1]. Due to slow growth and overharvesting, it

This research was supported by grants T2024-PC-082 from Hanoi University of Science and Technology, Vietnam.

<https://doi.org/10.7546/CRABS.2025.12.04>

is listed as endangered in the Vietnam Red Data Book (2007). Its pharmacological activity is largely attributed to ginsenosides – glycosylated triterpenoid saponins (Rb1, Rd, Rg1, Re, and the unique majonoside R2) with proven anti-inflammatory, antioxidant, neuroprotective, and hepatoprotective effects [2–5]. Multiple ginsenosides have shown anti-inflammatory and metabolic benefits in preclinical studies, reinforcing interest in their therapeutic potential [6,7]. Recent reviews highlight an expanding catalogue of ginsenosides and substantial chemical variation across *Panax* species and processed products [8,9]. Ginsenoside profiling is a key indicator of ginseng quality and maturity, while amino acids further contribute to its adaptogenic and immunomodulatory properties [10–12], making their combined analysis a valuable tool for pharmacological assessment.

Son La, a highland province in Northern Vietnam outside the native ginseng range, is emerging as a new area for *P. vietnamensis* cultivation. To support Vietnam's national strategy (1604/VPCP-NN/2022) on sustainable ginseng development, this study analyzed the saponin and amino acid composition of Son La ginseng in relation to altitude, soil, and irrigation water quality.

Materials and methods. Plant material collection and preparation. Samples of 3 to 5-year-old *P. vietnamensis* were collected from Sam Ta village, Son La province. The cultivar, certified by Vietnam's Ministry of Agriculture and Rural Development was authenticated, and voucher specimens (KTTP_SAM 052022, 052023 and 052024) were deposited at Hanoi University of Science and Technology. Main roots were cleaned, longitudinally sliced, shade-dried to prevent thermal degradation, and ground to fine powder for analysis.

Survey for *P. vietnamensis*'s cultivation practice. A field survey was conducted in Sam Ta village to document traditional cultivation practices. The study employed semi-structured interviews and direct field observations, involving 15 ginseng-growing households. The survey focused on core themes, including traditional farming techniques (site selection, seed sourcing, land preparation, planting methods, routine care) and role of indigenous knowledge.

Saponin determination. High-performance liquid chromatography with a PDA detector at 196 nm was performed on a C18 column (150 × 4.6 mm, 3 μm). The mobile phase ran at 1.0 mL/min with a 10 μL injection. Standard ginsenosides (G-Rg1, M-R2, G-Rb1, G-Rd, with purity ≥ 98%, obtained from University of Medicine and Pharmacy at Ho Chi Minh City, Vietnam) were dissolved in methanol. Samples were extracted in methanol and filtered through a 0.22 μm membrane. Saponin content was calculated by comparing peak areas of samples and standards [13,14].

Determination of amino acid content. Amino acids in *P. vietnamensis* roots were determined following the method of NAVAL et al. [15] with minor modifications. Root powders were extracted, centrifuged, filtered, and the supernatant analyzed by HPLC with pre-column derivatization. Quantification was performed using external calibration with amino acid standards from Sigma-Aldrich, USA.

Soil and irrigation water analysis. Soil samples were collected alongside the sample's harvest, according to the Vietnam's National standard (TCVN) method of TCVN 7538-6:2010. pH (KCl), organic carbon (OC), total nitrogen (N), total phosphorus (P), and total potassium (K) were analyzed according to TCVN 5979:2007, TCVN 8941:2011, TCVN 6498:1999, TCVN 4052:1985, and TCVN 8660:2011, respectively. The pH of the irrigation water was measured following QCVN 39:2011/BTNMT.

Determination of humic and fulvic acids in soil samples. Humic and fulvic acids were quantified using a gravimetric method adapted from LAMAR et al. [16]. Soil samples were extracted with 0.1 M NaOH under nitrogen for 16–18 h. After centrifugation (30 min), humic acids (HA) were precipitated at pH 1.0, dried at 90 °C, and ashed at 600 °C to determine ash-free HA. Fulvic acids (FA) were isolated from the supernatant using DAX-8 resin, and the content was calculated from the ash-free mass.

Statistical analysis. The experiments on physicochemical properties and saponin composition as well as soil and water parameters were conducted with three replicates, the data were analyzed using one-way ANOVA, followed by the Tukey test. The significance level was set at $p < 0.05$. Data are expressed as the mean $\pm$ standard deviation.

Results and discussion. Traditional cultivation of *P. vietnamensis* in Son La, Vietnam. Soil and irrigation water of planting areas. Table 1 summarizes the key characteristics of the climate, soil and water sources of ginseng's cultivation area.

Located in Northwest Vietnam, Son La has a temperate climate with dry, cool winters and hot, wet summers with medium temperature (~ 23 °C), 78.8% average humidity and 2115.7 annual sunshine hours. Sam Ta Mountain (~ 1700 m) maintains a cool microclimate (< 25 °C year-round). Soils are humus-rich, slightly acidic (pH 4.0–6.4), and nutrient-dense with essential elements. Neutral irrigation water (pH of 7.3–7.5) and high TDS (1650–1700 ppm) favour ginseng cultivation.

Cultivation practice of *P. vietnamensis*. Agricultural production in Son La represents a unique forest system, at an altitude of over 1600 m with 70% forest canopy cover, which relies on humus-rich soils and rainwater irrigation (Fig. 1). Practices are non-mechanized, orally transmitted, unlike Korea's breeding programs for *P. ginseng*, or China's intensive farming of *P. notoginseng* under shade nets [17]. Seeds for germination are from mature plants (> 5 years), some dispersed by birds, and they are applied in forest mulch with moisture and microbial diversity.

Saponin composition and accumulation in *P. vietnamensis* root. The saponin composition of *P. vietnamensis* roots varied with cultivation age, with both the root yield and total content of ginsenosides increasing markedly in older roots. This pattern coincided with a progressive rise in root biomass, as root thickening and metabolite deposition intensify after the 3rd year. VU-HUYNH et

T a b l e 1

P. vietnamensis cultivation's condition in Son La (2024)

Geographical***	Northwest Vietnam (20°39′–22°02′ N, 103°11′–105°02′ E)	
Season***	Dry, cold winter (October – March); Hot, rainy summer (April – September)	
Temperature***	Average: 23 °C (Max: 28.4 °C (May), Min: 15.5 °C (January))	
Air humidity***	Average: 78.80% (Highest: 85% (December); Lowest: 69.0% (May))	
Rainfall***	Annual rainfall: 1434 mm (> 215 rainy days), 69% in June to September	
Sunshine***	Number of sunny hours: 2115.7 h, concentrated in April, May, June	
Wind***	Hot winds occur 15–18 days per year, with speeds of 0.8–1.9 m/s	
In Sam Ta***	Altitude > 1700 m; Cool climate all year round, < 25 °C	

Soil	Cold winter + Dry season			Hot summer + Rainy season				
	loose humus soil			loose humus soil				
	HA	FA	HA:FA	HA	FA	HA:FA	FA	HA:FA
Soil characteristic	6.2	3.8	1.63	5.9	4.0	1.48		
	pH	OC (g/kg)	N (g/kg)	P ₂ O ₅ (g/kg)	K ₂ O (g/kg)	pH	OC (g/kg)	N (g/kg)
	KCl							
Trace elements*	4.0±0.0	6.4±0.2	0.3±0.0	18.2±0.8	25.9±1.3	3.8±0.0	5.8±0.2	0.3±0.0
Irrigation water	0.02±0.0	0.02±0.0	0.01±0.0	0.02±0.0	0.02±0.0	0.01±0.0	0.01±0.0	0.02±0.0
pH		TDS ppm		pH		TDS ppm		
7.3±0.1		1650±11		7.5±0.1		1700±13		

*Biological trace elements; ** : nd: not detected; ***: analyzed from dubaothoitiet.info

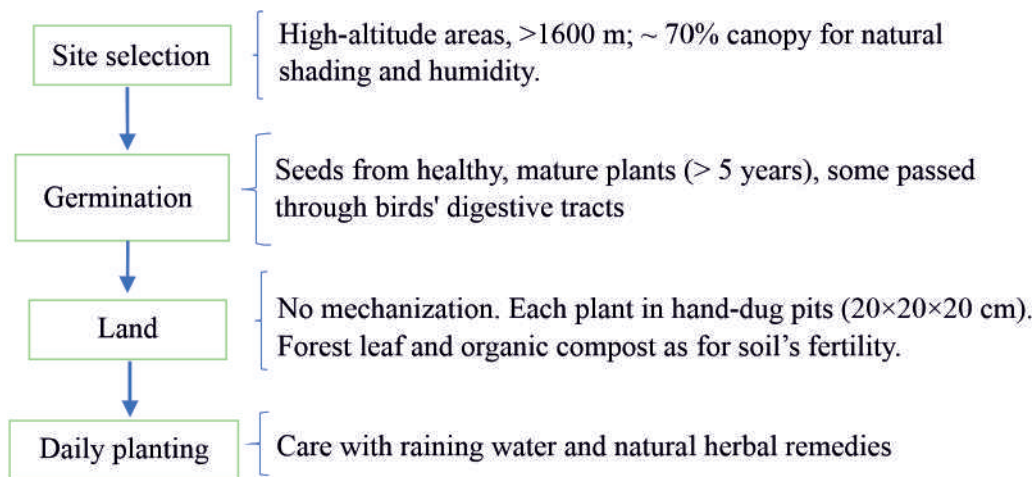


Fig. 1. “Slow cultivation practice” of *P. vietnamensis* in Sam Ta Mountain

T a b l e 2

Physicochemical and saponin profile of *P. vietnamensis* root compared with other cultivated *Panax* species

	<i>P. vietnamensis</i>			<i>P. gin-</i>	<i>P. noto-</i>	<i>P. quinque-</i>
	3 years	4 years	5 years	<i>seng</i> *	<i>ginseng</i> *	<i>folius</i> *
Physicochemical properties						
Moisture (%)	85.68 ^a ±1.21	82.06 ^b ±1.07	69.02 ^c ±1.34	N/A	N/A	N/A
Carbohydrate (% dw)	28.97 ^a ±1.07	30.14 ^b ±1.08	30.17 ^b ±1.06	N/A	N/A	N/A
Ash (% dw)	6.60 ^a ±0.72	6.54 ^a ±0.65	6.40 ^a ±0.52	N/A	N/A	N/A
Cellulose (% dw)	7.69 ^a ±0.96	9.42 ^b ±0.80	9.64 ^b ±0.88	N/A	N/A	N/A
Saponin composition (%w/dw)						
Ginsenoside Rg1	1.98 ^a ±0.12	2.50 ^b ±0.13	2.85 ^c ±0.11	0.21–0.29	1.9	0.15
Majonoside R2	4.12 ^a ±0.23	5.21 ^b ±0.20	6.10 ^c ±0.27	N/A	N/A	N/A
Ginsenoside Rb1	0.44 ^a ±0.05	0.71 ^b ±0.07	0.74 ^b ±0.06	0.38–0.47	1.8	1.84
Ginsenoside Rd	0.07 ^a ±0.00	0.10 ^b ±0.00	0.13 ^b ±0.01	0.036–0.15	0.20	0.45
Total	6.61	8.52	9.82			

*Choi [19] (Samples of 6 years old)

Different letters within the same independent variable in the same row indicate statistical differences at a 95% confidence

al. [18] reported that fresh root weight nearly doubled between the third and 5th years of cultivation, with both yield and total ginsenoside content reaching maximal levels at ≥ 5 years. As shown in Table 2, *P. vietnamensis* is distinguished by its high content of majonoside R2, a unique ocotillol-type saponin absent in other *Panax* species, which reached 6.10% at 5 years. Ginsenosides Rg1 and Rb1 also increased with age, and their levels in 5-year-old roots are similar to those reported in *P. quinquefolius* and *P. notoginseng* [19]. Although ginsenoside Rd was

Table 3

Amino acid profile of *P. vietnamensis* roots compared with mountain cultivated and cultivated ginseng

	Amino acids (AA), mg/100g dw			Mountain cultivated ginseng*	Cultivated ginseng*
	3 years	<i>P. vietnamensis</i> 4 years	5 years		
<i>Non-essential amino acids (NEAA)</i>					
Aspartic acid	300.12 ^a ±10.29	353.34 ^b ±15.64	400.73 ^c ±18.91	nd	36.31±1.82
Serine	58.74 ^a ±2.09	72.01 ^b ±3.18	78.17 ^c ±5.07	14.24±0.71	26.97±1.35
Glutamic acid	342.25 ^a ±12.37	419.78 ^b ±19.39	469.64 ^c ±19.88	27.48±1.37	13.46±0.67
Glycine	96.34 ^a ±3.58	113.34 ^b ±4.02	131.71 ^c ±5.07	6.15±0.31	6.51±0.33
Arginine	189.76 ^a ±6.25	249.15 ^b ±7.89	284.73 ^c ±11.25	305.23±15.26	90.59±4.53
Alanine	121.89 ^a ±4.97	156.23 ^b ±5.29	175.35 ^c ±6.01	40.35±2.02	51.33±2.57
Cystein	nd	nd	nd	16.96±0.85	20.99±1.05
Tyrosine	124.23 ^a ±3.84	145.45 ^b ±4.19	158.15 ^c ±4.76	10.28±0.51	16.69±0.83
Proline	84.25 ^a ±4.83	98.48 ^b ±4.75	117.05 ^c ±3.01	22.01±1.10	18.93±0.95
<i>Essential amino acids (EAA)</i>					
Histidine	42.80 ^a ±1.34	50.93 ^b ±1.89	62.52 ^c ±1.93	8.36±0.42	7.15±0.36
Threonine	133.61 ^a ±5.25	149.79 ^b ±5.72	181.26 ^c ±5.50	11.60±0.58	21.06±1.05
Valine	126.73 ^a ±3.55	151.28 ^b ±5.63	172.79 ^c ±5.91	15.31±0.77	30.27±1.51
Methionine	6.87 ^a ±0.22	8.53 ^b ±0.44	9.97 ^c ±0.52	7.30±0.37	4.36±0.22
Lysine	172.55 ^a ±5.97	202.64 ^b ±6.03	219.64 ^c ±5.91	16.56±0.83	28.32±1.42
Isoleucine	116.03 ^a ±4.02	130.79 ^b ±3.53	156.48 ^c ±4.05	13.65±0.68	25.50±1.28
Leucine	221.80 ^a ±6.74	280.27 ^b ±6.53	310.02 ^c ±6.82	20.53±1.03	35.97±1.80
Phenylalanine	156.31 ^a ±4.37	183.97 ^b ±5.62	202.28 ^c ±5.93	12.33±0.62	24.56±1.23
Total AA	2625.72	3404.96	3424.54	568.24	457.07
EAA	961.95	1256.68	1632.01	105.04	177.19

*Lee et al. [21] (Samples of 5 years old); ** nd: Not detected, (LOD = 0.06 mg/kg)

Different letters within the same independent variable in the same row indicate statistical differences at a 95% confidence

in smaller amounts, it remained within the expected range of related species. Besides conventional cultivation, recent advances have explored in vitro tissue culture systems for *P. vietnamensis*. Adventitious root and cell suspension cultures can rapidly accumulate biomass, reaching up to 22 g DW L⁻¹ within 25–35 days, and produce a range of ginsenosides under controlled conditions [20]. Thirteen major ginsenosides and their isomers were identified, including chikusetsusaponin IV isomers newly reported in *P. vietnamensis* cell cultures, while protopanaxatriol-type ginsenosides were absent. The total yield and diversity of ginsenosides remain lower than in mature field-grown roots, underscoring the continued importance of cultivation for maximizing yield and phytochemical diversity.

Amino acid composition in *P. vietnamensis* root. Table 3 presents the amino acid profile of *P. vietnamensis* roots, compared with mountain-cultivated

and cultivated ginseng [21]. Aspartic acid, glutamic acid, and arginine were the most abundant NEAA, particularly in 5-year-old roots (400.73, 469.64, and 284.73 mg/100 g dw, respectively). Among EAA, leucine, lysine, and phenylalanine were dominant, with leucine peaking at 310.02 mg/100 g dw in 5-year-old roots. Total essential amino acids rose from 961.95 mg/100 g (3 years) to 1632.01 mg/100 g (5 years), indicating improved nutritional value with maturation.

Conclusion. This study presents the first comprehensive biochemical and environmental analysis of *Panax vietnamensis* cultivated in Son La province, Vietnam. Results show that traditional under-canopy agroforestry practices in this non-native highland region support the growth of *P. vietnamensis*, producing roots with high levels of majonoside R2 and a rich amino acid profile. Five-year-old roots exhibited superior saponin and amino acid contents compared to other *Panax* species. The findings underscore the potential of community-based, ecologically sustainable cultivation for conserving and commercializing Vietnamese ginseng.

REFERENCES

- [1] LE Q. U., H. L. LAY, M. C. WU et al. (2018) Phytoconstituents and biological activities of *Panax vietnamensis* (Vietnamese Ginseng): A precious ginseng and call for further research – A systematic review, Nat. Prod. Commun., **13**(10), 1381–1384, <https://doi.org/10.1177/1934578X1801301036>.
- [2] CHRISTENSEN L. P. (2009) Ginsenosides chemistry, biosynthesis, analysis, and potential health effects, Adv. Food Nutr. Res., **55**, 1–99, [https://doi.org/10.1016/S1043-4526\(08\)00401-4](https://doi.org/10.1016/S1043-4526(08)00401-4).
- [3] QI L. W., C. Z. WANG, C. S. YUAN (2011) Ginsenosides from American ginseng: chemical and pharmacological diversity, Phytochemistry, **72**(8), 689–699, <https://doi.org/10.1016/j.phytochem.2011.02.012>.
- [4] NGUYEN M. D., T. N. NGUYEN, R. KASAI et al. (1993) Saponins from Vietnamese ginseng, *Panax vietnamensis* Ha et Grushv. collected in central Vietnam. I, Chem. Pharm. Bull. (Tokyo), **41**(11), 2010–2014, <https://doi.org/10.1248/cpb.41.2010>.
- [5] SHIN H. R., J. Y. KIM, T. K. YUN et al. (2000) The cancer-preventive potential of *Panax ginseng*: a review of human and experimental evidence, Cancer Causes Control, **11**(6), 565–576, <https://doi.org/10.1023/a:1008980200583>.
- [6] YI Y. S. (2024) Pharmacological potential of ginseng and ginsenosides in non-alcoholic fatty liver disease and nonalcoholic steatohepatitis, J. Ginseng Res., **48**(2), 122–128, <https://doi.org/10.1016/j.jgr.2023.11.003>.
- [7] JANG W. Y., J. Y. HWANG, J. Y. CHO (2023) Ginsenosides from *Panax ginseng* as key modulators of NF- κ B signaling are powerful anti-inflammatory and anticancer agents, Int. J. Mol. Sci., **24**, 6119, <https://doi.org/10.3390/ijms24076119>.
- [8] GENG X., J. WANG, Y. LIU et al. (2024) Research progress on chemical diversity of saponins in *Panax ginseng*, Chinese Herbal Medicines, **16**(4), 529–547, <https://doi.org/10.1016/j.chmed.2024.08.005>.

- [9] HOU M., R. WANG, S. ZHAO et al. (2021) Ginsenosides in *Panax* genus and their biosynthesis, *Acta Pharm. Sin. B*, **11**(7), 1813–1834, <https://doi.org/10.1016/j.apsb.2020.12.017>.
- [10] RADAD K., G. GILLE, L. LIU et al. (2006) Use of ginseng in medicine with emphasis on neurodegenerative disorders, *J. Pharmacol. Sci.*, **100**(3), 175–186, <https://doi.org/10.1254/jphs.crj05010x>.
- [11] TRAN Q. L., I. K. ADNYANA, Y. TEZUKA et al. (2002) Hepatoprotective effect of majonoside R2, the major saponin from Vietnamese ginseng (*Panax vietnamensis*), *Planta Med.* **68**, 402–406, <https://doi.org/10.1055/s-2002-32069>.
- [12] LIU Z., X. WEN, C. Z. WANG et al. (2020) Remarkable impact of amino acids on ginsenoside transformation from fresh ginseng to red ginseng, *J. Ginseng Res.*, **44**(3), 424–434, <https://doi.org/10.1016/j.jgr.2019.04.001>.
- [13] ANGELOVA N., H. W. KONG, R. V. D. HEIJDE et al. (2007) Recent methodology in the phytochemical analysis of ginseng, *Phytochem. Anal.*, **19**(1), 2–16, <https://doi.org/10.1002/pca.1049>.
- [14] KOKANOVA-NEDIALKOVA Z., P. NEDIALKOV (2022) UHPLC-HRMS based saponin and flavonoid profiling of *Chenopodium bonus-henricus* L. roots and prolipase activity of the main saponins, *C. R. Acad. Bulg. Sci.*, **75**(7), 982–991, <https://doi.org/10.7546/CRABS.2022.07.06>.
- [15] NAVAL M. V., M. P. GÓMEZ-SERRANILLOS, M. E. CARRETERO et al. (2006) Value of high-performance liquid chromatographic analysis of amino acids in the determination of *Panax ginseng* radix extract effect in cultured neurons, *J. Chromatogr. A*, **1121**(2), 242–247, <https://doi.org/10.1016/j.chroma.2006.04.051>.
- [16] LAMAR R. T., D. C. OLK, L. MAYHEW et al. (2014) A new standardized method for quantification of humic and fulvic acids in humic ores and commercial products, *J. AOAC Int.*, **97**(3), 721–730, <https://doi.org/10.5740/jaoacint.13-393>.
- [17] ZHANG H., S. ABID, J. C. AHN et al. (2020) Characteristics of *Panax ginseng* cultivars in Korea and China, *Molecules*, **25**(11), 2635, <https://doi.org/10.3390/molecules25112635>.
- [18] VU-HUYNH K. L., H. T. NGUYEN, T. H. VAN LE et al. (2020) Accumulation of saponins in underground parts of *Panax vietnamensis* at different ages analyzed by HPLC-UV/ELSD, *Molecules*, **25**(13), 3086, <https://doi.org/10.3390/molecules25133086>.
- [19] CHOI K. T. (2008) Botanical characteristics, pharmacological effects and medicinal components of Korean *Panax ginseng* C A Meyer, *Acta Pharmacol. Sin.*, **29**(9), 1109–1118, <https://doi.org/10.1111/j.1745-7254.2008.00869.x>.
- [20] TITOVA M. V., M. K. LUNKOVA, T. M. TYURINA et al. (2024) Suspension cell cultures of *Panax vietnamensis* as a biotechnological source of ginsenosides: growth, cytology, and ginsenoside profile assessment, *Front. Plant Sci.*, **15**, 1349494, <https://doi.org/10.3389/fpls.2024.1349494>.
- [21] LEE H. Y., J. G. JUNG, S. C. KIM et al. (2021) Comprehensive comparison of nutritional constituents and antioxidant activity of cultivated ginseng, mountain-cultivated ginseng, and whole plant parts of mountain-cultivated ginseng, *J. Appl. Biol. Chem.*, **64**(4), 453–463, <http://dx.doi.org/10.3839/jabc.2021.064>.

Department of Food Engineering, Hanoi University of Science and Technology,

1 Dai Co Viet St, Hanoi, Vietnam

e-mail: tu.nguyenthiminh@hust.edu.vn (<https://orcid.org/0000-0002-4985-9751>)