Journal of
Plant Science & Research

Open Science Publications

Volume 12, Issue 2 - 2025

www.opensciencepublications.com

Phytochemical Constituents and Pharmacological Effects of Dangshen (*Codonopsis pilosula*), an Important Traditional Chinese Medicine

Review Article

Li Yani, Wang Yulong, Yin Liming, Han Yaping, Chen Kailing, Liu Fei and Vasudeva Reddy N*

Shanxi Zhendong Genuine Regional Drug Development Co., Ltd., Zhendong Science and Technology Park, Guangming South Road, Shangdang District, Changzhi City, Shanxi Province, China

***Corresponding author:** Vasudeva Reddy N, Shanxi Zhendong Genuine Regional Drug Development Co., Ltd., Zhendong Science and Technology Park, Guangming South Road, Shangdang District, Changzhi City, Shanxi Province, China. E-mail Id: drreddy0205@qq.com

Article Information: **Submission:** 20/04/2025; **Accepted:** 20/05/2025; **Published:** 26/05/2025

Abstract

Codonopsis pilosula (Franch.) Nannf. (Dangshen), a vital medicinal herb in Traditional Chinese Medicine (TCM), is renowned for its adaptogenic, immunomodulatory, and multi-pharmacological properties. This review comprehensively examines the phytochemical composition and diverse biological activities of *C. pilosula*, highlighting its therapeutic potential in modern medicine. The plant contains bioactive compounds, including polysaccharides, alkaloids, triterpenes, polyacetylenes, and phenolic acids, which contribute to its broad-spectrum effects. Pharmacological studies reveal its antioxidant, anticancer, immunomodulatory, antidiabetic, antimicrobial, neuroprotective, hepatoprotective, cardioprotective, and antiviral activities. Key mechanisms include ROS scavenging, Nrf2/Keap1 pathway activation, apoptosis induction via signalling pathway, α-glucosidase inhibition, and immune regulation through MAPK/NF-κB signaling. Notably, *C. pilosula* polysaccharides (CPPs) demonstrate neuroprotection against Aβ-induced toxicity and enhance cognitive function in Alzheimer's models, while lobetyolin exhibits selective anticancer effects by disrupting glutamine metabolism. Additionally, *C. pilosula* shows promise in metabolic disorders, sepsis management, and myocardial repair. It is noted that *C. pilosula* compounds exhibited multiple therapeutic effects at low concentrations (IC_{50} 10-50 μg/mL). Despite its therapeutic potential, challenges in sustainable cultivation and quality control necessitate further research. This review underscores *C. pilosula*'s role as a multi-target herbal medicine, bridging traditional use and scientific validation for future drug development and functional food applications..

Keywords: *Codonopsis pilosula*; Dangshen; Polysaccharides; Immunomodulation; Neuroprotection; Anticancer; Antioxidant; Traditional Chinese Medicine

Introduction

Codonopsis pilosula (Franch.) Nannf., commonly known as Dangshen, is a perennial herbaceous plant belonging to the family Campanulaceae (bellflower family). This medicinally important species is widely distributed across East Asia, primarily in China, Korea, and Mongolia. In China, it thrives in temperate regions, particularly in the provinces of Shanxi, Gansu, Sichuan, and Shaanxi, where it grows at altitudes ranging from 1,500 to 3,100 meters in mountainous forests, shrublands, and grassy slopes [1,2].

Botanically, *C. pilosula* is characterized by its twining stems, ovate to lanceolate leaves, and bell-shaped greenish-yellow flowers with purple spots. A well growing *C. pilosula* plant was represented in (**Figure 1A).** The plant produces tuberous roots**(Figure 1B),** which are the primary medicinal part, valued in Traditional Chinese

ISSN: 2349-2805

Figure 1: (A)Well growing *C. pilosula* plant and (B) *C. pilosula* tuberous roots.

Medicine (TCM) for their adaptogenic and immunomodulatory properties. While often referred to as "poor man's ginseng," *C. pilosula* is taxonomically distinct from *Panax ginseng* (Araliaceae family), differing in growth habit (twining vs. erect), chemical composition (higher polysaccharides but lower ginsenoside content), and cultivation requirements (hardier and more adaptable to diverse climates) [3,4].

In TCM theory, it is classified as a premier Qi-tonifying herb, renowned for strengthening spleen function, nourishing lung Qi, and enhancing vitality. Though it shares therapeutic overlaps with *P. ginseng* (e.g., immunomodulation and energy-boosting effects), *C. pilosula* is milder in action, less stimulating, and more suitable for long-term use, making it a preferred substitute for patients with heat-sensitive constitutions or hypertension [5,6]. Modern pharmacological studies validate its traditional uses, demonstrating antioxidant, neuroprotective, and cardioprotective properties attributed to unique bioactive compounds like lobetyolin (a polyacetylene not found in *Panax* species) and codonopsosides (triterpenes structurally distinct from ginsenosides) [7,8]. Its sustainable cultivation remains crucial to meet growing demand in pharmaceutical and functional food industries.

Beyond medicinal applications, *C. pilosula* is deeply embedded in Asian culinary traditions. Its roots are incorporated into nourishing soups, herbal teas, medicinal wines, and congees as both a flavor enhancer and functional ingredient. The plant's cultural and economic significance is reflected in the over 160 approved health products containing *C. pilosula* extracts in China alone. Recent research has expanded its potential applications to include management of metabolic disorders, neurodegenerative diseases, and as an adjuvant in cancer therapy [9,10]. However, the rising global demand for *C. pilosula* underscores the need for sustainable cultivation, standardized quality control, and deeper pharmacological validation to ensure its long-term availability and efficacy. In this review, we comprehensively examine the phytochemical constituents, pharmacological activities, and therapeutic mechanisms of *C. pilosula*, while also addressing current challenges and future directions for maximizing its clinical and commercial potential.

Phytoconstituents of *C. pilosula*

C. pilosula is a pharmacologically rich herb containing diverse bioactive compounds that underpin its medicinal value. Key constituents include alkaloids, triterpenes, polyacetylenes, phenylpropanoids, phenolic acids, flavones, and various other unique secondary metabolites further broaden its therapeutic potential in traditional and modern medicine.

Alkaloids of *C. pilosula*

C. pilosula produces a diverse array of bioactive alkaloids, which contribute significantly to its medicinal properties. The structures of different alkaloids present in *C. pilosula* were represented in (**Figure 2**). Among these, codonopsine and codonopsinine are pyrrolidine-type alkaloids with potential neuroactive effects. The roots contain unique pyrrolidine derivatives, including codonopyrrolidium A,B, D, and E which are considered chemotaxonomic markers for *C. pilosula* and its variants (*C. pilosula*var. modesta, *C. tangshen*)[11]. Pyrrolidine alkaloid codonopsinol A, codonopsinol B, codonopsinol C, codonopyrrolidium B and radicamine A and pyrrolidine alkaloidal glycoside, codonopiloside A were reported from the roots of *C. pilosula* [12].The presence of β-carboline alkaloids like perlolyrine hints at antioxidant and neuroprotective activities [13], while simpler nitrogenous compounds such as tryptophan, nicotinic acid (vitamin B3), and adenosine may contribute to metabolic regulation and immune modulation. Notably, uracil and adenosine—key nucleosides in RNA synthesis—could play a role in the plant's adaptogenic effects[14,15].

Triterpenes of *C. pilosula*

The roots of *C. pilosula* contain a diverse array of triterpenes that contribute to its medicinal properties.Among these, codonopilates A, B, C and D are cycloartane-type triterpenes unique to this species, exhibiting potential anti-inflammatory and hepatoprotective activities [16,17]. Additionally, Pseudolarolides U and V, two new triterpenoids were reported from the roots of *C. pilosula* [18]. The roots also produce pentacyclic triterpenes such as friedelin and its oxidized form 1-friedelen-3-one, which are associated with antioxidant and cytotoxic effects. Other notable triterpenes include stigmast-7-en-3-one and stigmast-7-en-3-ol, which belong to the stigmas Tane class and may influence membrane stability and

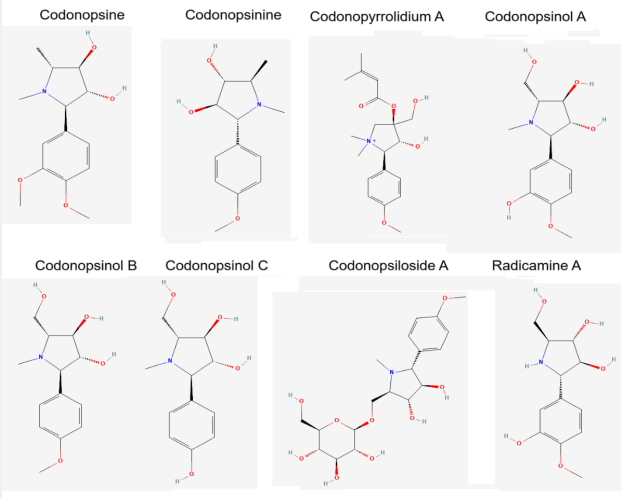

Figure 2: Structures of different alkaloids present in the *C. pilosula* extracts. Structures were retrieved from PubChem. Accessed on April 13,2025

Citation: Yani L, Yulong W, Liming Y, Yaping H, Kailing C, et al. Phytochemical Constituents and Pharmacological Effects of Dangshen (*Codonopsis pilosula*), an Important Traditional Chinese Medicine. J Plant Sci Res. 2025;12(2): 277

signaling pathways. Taraxerol, a lupane-type triterpene found in *C. pilosula* has demonstrated anti-tumor and anti-diabetic properties in preliminary studies. Furthermore, α-spinasterol, a phytosterol with structural similarities to cholesterol, exhibits anti-inflammatory and immunomodulatory effects [19]. The presence of taraxeryl acetate, an acetylated derivative of taraxerol, suggests additional bioactive potential, possibly enhancing bioavailability. Together, these triterpenes underscore the pharmacological richness of *C. pilosula* roots, with implications for developing natural therapeutics targeting metabolic disorders, inflammation, and oxidative stress[16-19].

Polyacetylenes of *C. pilosula*

The roots of *C. pilosula* contain three most active polyacetylenes, a class of compounds characterized by their conjugated acetylene bonds, which contribute significantly to the plant's pharmacological properties. The most prominent polyacetylene in *C. pilosula* is lobetyolin, a marker compound often used for quality control due to its abundance and distinctive bioactivity [20]. Lobetyolin has demonstrated anti-inflammatory, immunomodulatory, and potential anticancer effects in preclinical studies. Its structural analog, lobetyolinin, shares similar properties and may enhance the plant's therapeutic profile [21]. Another key polyacetylene, lobetyol, exhibits cytotoxic activity against certain cancer cell lines, suggesting a role in antitumor applications [20]. These polyacetylenes are considered signature compounds of Codonopsis species, and their presence underscores the plant's value in traditional and modern medicine [20,21].

Phenylpropanoids, Flavones, and Phenolic Acids in *C. pilosula*

The roots of *C. pilosula* contain a variety of phenylpropanoids, flavones, and phenolic acids that contribute to its medicinal properties. Among the phenylpropanoids, syringin (eleutheroside B) stands out as a key bioactive compound with demonstrated immunomodulatory and anti-fatigue effects. Another significant group includes the tangshenosides, particularly tangshenoside I, which shares structural similarities with ginsenosides and is associated with adaptogenic and cardioprotective activities. The plant also produces an array of flavones and phenolic acids, such as luteolin, apigenin glycosides, chlorogenic acid and caffeic acid derivatives. The presence of hesperidin, a flavanone glycoside, in the roots adds to its anti-inflammatory and vascular-protective effects. Together, these compounds underscore the multifaceted pharmacological profile of *C. pilosula* [22-24].

Polysaccharides of *C. pilosula*

C. pilosula contains a diverse array of polysaccharides that vary in molecular weight, composition, and structural characteristics. Among these, CPS-3 is a high-molecular-weight polysaccharide (1.24×10^6 Da) composed of xylose, glucose, and galactose in a 1.17:0.96 ratio, while CPS-4 exists as two distinct fractions with molecular weights of 1.96×10^6 Da and 1.51×10^6 Da [25]. Another notable polysaccharide, CPPA, has a medium molecular weight (4.2×10^4 Da) and consists of 74.6% carbohydrates and 22.3%uronic acids[26]. The roots also contain CPP1b, a pectin-like polysaccharide (1.45×10^5 Da) with a unique monosaccharide profile (Rha:Ara:Gal:GalA = 0.25:0.12:0.13:2.51) and 46.7% methyl-esterified galacturonic acid, as well as its selenized derivative, sCPP1b [27,28]. Additionally, CPP1a (1.01×10^5 Da) exhibits a branched structure with rhamnose, arabinose, galacturonic acid, galactose, and glucose in a 1:12:1:10:3 ratio, whereas CPP1c shares similarities but contains higher uronic acid content[29,30]. Further structural diversity is seen in 26 CPP variants with varying compositions, along with dCPP, a mannose-rich polysaccharide (97.2% sugars) featuring β-glycosidic bonds and a non-helical conformation. CPPS-II represents a 60-100 kDa fraction, while other unspecified CPP polysaccharides contribute to the plant's overall polysaccharide profile. This structural heterogeneity underscores the biochemical complexity of *C. pilosula* polysaccharides [29-32].

Other Bioactive Compounds in *C. pilosula*

Several organic acids are present, including succinic acid which participates in energy metabolism, 9,10,13-trihydroxy-(E)-octadec-11-enoic acid with potential anti-inflammatory effects, and shikimic acid, a key intermediate in aromatic compound biosynthesis. The sesquiterpene lactone atractylenolide III exhibits significant anti-inflammatory and gastroprotective activities.The plant also contains coumarin compounds such as angelicin and psoralen, known for their phototoxic and potential anticancer effects. Anthraquinones like emodin contribute to the plant's laxative and antimicrobial properties.Additional important constituents include geniposide (an iridoid glycoside with neuroprotective effects), various alkyl glycosides (hexyl-β-D-glucopyranoside and butyl-β-D-fructofuranoside) that may enhance bioavailability, and phytosterols (β-sitosterol and its glycoside β-daucosterol) which demonstrate cholesterol-lowering and anti-inflammatory activities[33-36].(**Table 1)** clearly represents classification of phytoconstituents, key compounds, molecular characteristics and pharmacological activities of *C. pilosula* bioactive components.

Biological Activities of *C. pilosula*

Antioxidant Properties of *C. pilosula*

C. pilosula exhibits robust antioxidant activity through a synergistic combination of its diverse phytochemical constituents. The plant's polysaccharides enhance cellular antioxidant defences by boosting the activity of key enzymes including superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GSH-Px). Flavonoids such as luteolin and apigenin glycosides, along with phenolic acids like chlorogenic and caffeic acids, act as potent free radical scavengers due to their redox-active properties. Additional antioxidant effects come from polyacetylenes (e.g., lobetyolin) and furan derivatives (5-HMF), which neutralize reactive oxygen species (ROS) and chelate metal ions. The β-carboline alkaloids perlolyrine and norharman provide neuroprotective effects against oxidative damage, while triterpenes including taraxerol and α-spinasterol reduce lipid peroxidation by lowering malondialdehyde (MDA) levels[37-40]. Pectic polysaccharides CLRP-1 and CLSP-1 further amplify antioxidant responses by activating antioxidant gene expression. Sulfated polysaccharides (SCP) demonstrate enhanced radical-scavenging capacity in standard antioxidant assays (DPPH, ABTS, FRAP), and leaf extracts show activity comparable to vitamin C due to their high flavonoid and polyphenol content. *C.*

Citation: Yani L, Yulong W, Liming Y, Yaping H, Kailing C, et al. Phytochemical Constituents and Pharmacological Effects of Dangshen (*Codonopsis pilosula*), an Important Traditional Chinese Medicine. J Plant Sci Res. 2025;12(2): 277

Table 1: Phytoconstituents of *C. pilosula* and their pharmacological effects.

Class of Compounds	Key Compounds	Molecular Characteristics	Pharmacological Activities	References
Alkaloids	Codonopsine, codonopsinine (pyrrolidine-type) Codonopyrrolidium A, B, D, E β-carboline alkaloids (e.g., perlolyrine) Nucleosides (uracil, adenosine)	Pyrrolidine derivatives as chemotaxonomic markers Simple nitrogenous compounds (e.g., tryptophan, nicotinic acid)	Neuroactive effects Antioxidant and neuroprotective Metabolic and immune modulation	[11-15]
Triterpenes	Codonopilates A–D (cycloartane-type) Friedelin, taraxerol, α-spinasterol Pseudolarolides U, V Stigmastane derivatives (e.g., stigmast-7-en-3-ol)	Unique cycloartane structures Pentacyclic and lupane-type skeletons Phytosterols (e.g., taraxeryl acetate)	Anti-inflammatory, hepatoprotective Antitumor, antidiabetic Membrane stabilization	[16-19]
Polyacetylenes	Lobetyolin (marker compound) Lobetyolinin, lobetyol	Conjugated acetylene bonds Structural analogs (e.g., lobetyolinin)	Anti-inflammatory, immunomodulatory Anticancer (cytotoxic)	[20,21]
Phenylpropanoids & Phenolics	Syringin (eleutheroside B) Tangshenoside I Luteolin, chlorogenic acid Hesperidin	Flavones, phenolic acids Structural similarity to ginsenosides (tangshenosides)	Immunomodulatory, anti-fatigue Cardioprotective, anti-inflammatory	[22-24]
Polysaccharides	CPS-3 (1.24×10⁶ Da; Xyl:Glc:Gal = 1.17:0.96) CPP1b (pectin-like; Rha:Ara:Gal:GalA = 0.25:0.12:0.13:2.51) CPPS-II (60–100 kDa) dCPP (mannose-rich, β-glycosidic)	Diverse MW (10⁴–10⁶ Da) Uronic acid content (e.g., CPPA: 22.3%) Methyl-esterified GalA (e.g., CPP1b: 46.7%)	Immunomodulation Antioxidant, antitumor Neuroprotection (e.g., Aβ toxicity)	[25-32]
Other Compounds	Atractylenolide III (sesquiterpene lactone) Emodin (anthraquinone) Geniposide (iridoid glycoside) - β-sitosterol (phytosterol)	Organic acids (e.g., shikimic acid) Coumarins (e.g., psoralen) Alkyl glycosides (e.g., hexyl-β-D-glucopyranoside)	Anti-inflammatory, gastroprotective Antimicrobial, neuroprotective Cholesterol-lowering	[33-36]

pilosula polysaccharides (CPPS) exhibit robust antioxidant activity through multiple mechanisms, including free radical scavenging and enzyme activation (SOD, CAT, GSH-Px). Two bioactive pectic polysaccharides (CLRP-1:15.9kDa; CLSP-1:26.4kDa) with distinct monosaccharide profiles but shared homogalacturonan backbones demonstrated potent antioxidant effects. Both significantly elevated SOD, CAT, and total antioxidant capacity while reducing ROS and MDA in IPEC-J2 cells and *C. elegans*, potentially via DAF-16 pathway activation. Their structural features, including arabinogalactan side chains and high GalA content (66.7-77.0%), correlate with these protective effects, suggesting their potential as natural antioxidants. These compounds activate Nrf2/Keap1 and DAF-16 pathways, upregulating antioxidant genes while reducing ROS/MDA in cells and *C. elegans*. The polysaccharides also protect gastrointestinal and hepatic systems, normalizing ALT/AST and inhibiting oxidative apoptosis. Together, these compounds work synergistically to provide comprehensive protection against oxidative stress across multiple biological systems, supporting *C. pilosula's* potential in preventing and managing oxidative stress-related disorders[40- 43].

Anticancer activities of *C. pilosula*

Lobetyolin (LBT), a characteristic polyacetylene glycoside from *C. pilosula*, exhibits broad-spectrum anticancer activity, particularly against gastric cancer. Both LBT and its aglycone lobetyol disrupt glutamine metabolism by downregulating ASCT2 transporter expression, starving cancer cells of this crucial nutrient and inducing apoptosis. The compounds demonstrate selective cytotoxicity against tumor cells while showing minimal effects on normal cells, suggesting a favorable therapeutic window. Structural analogs like lobetyolinin (bis-glucosylated form) share similar bioactivity, with their polyacetylene backbone contributing to membrane interaction and cellular uptake. LBT's mechanism extends to modulation of metabolic pathways and potential interference with oncogenic signaling cascades.The polyacetylene backbone of lobetyolin (LBT) and its analogs (lobetyol, lobetyolinin) is critical for membrane interaction and cellular uptake, while the glycoside moiety (glucose in LBT) enhances solubility and target specificity. Bis-glucosylation (lobetyolinin) retains bioactivity but may alter pharmacokinetics, whereas the aglycone lobetyol shows increased lipophilicity and cytotoxic potency. The conjugated diyne system in these compounds is essential for ASCT2 inhibition and metabolic disruption [21].

C. pilosula polysaccharide (CPP) demonstrates significant antitumor activity against NSCLC, showing concentration-dependent inhibition of A549 cell viability with optimal effects at 40 μmol/L. The compound induces dual cell death mechanisms - triggering both apoptosis through ROS accumulation/NF-κB activation and NLRP3/GSDMD-mediated pyroptosis. *In vivo* studies confirm CPP's tumor-suppressive effects, accompanied by characteristic pyroptotic morphology and elevated IL-1β/IL-18 levels. The NLRP3 inflammasome-dependent pyroptosis mechanism offers new therapeutic possibilities for NSCLC treatment[44].CPP demonstrates contrasting Wnt/β-catenin modulation, promoting proliferation in hypoxic GES-1 cells (↑Wnt-1/β-catenin/TCF-4) while inhibiting

Citation: Yani L, Yulong W, Liming Y, Yaping H, Kailing C, et al. Phytochemical Constituents and Pharmacological Effects of Dangshen (*Codonopsis pilosula*), an Important Traditional Chinese Medicine. J Plant Sci Res. 2025;12(2): 277

AGS cancer growth (↓Wnt-1/β-catenin/TCF-4). In PLGC rats, CPP alleviates gastric damage, improves serum markers, and reverses weight loss. Western blot analysis revealed CPP upregulates Wnt pathway proteins in gastric tissue while inducing apoptosis (↓Bcl-2/Bax ratio, ↑caspase-3). Metabolomics identified CPP's action on glycine/serine/threonine metabolism pathways, suggesting multi-target therapeutic potential against gastric precancerous lesions[45].

C. pilosula aqueous extract (DS) demonstrates significant efficacy against ulcerative colitis (UC) in TNBS/ethanol-induced rat models, restoring intestinal barrier function and normalizing oxidative stress/inflammatory markers. Multi-omics analysis revealed DS corrects UC-associated metabolic disorders while transcriptomics identified PI3K/Akt pathway inhibition as its primary mechanism, downregulating key inflammatory genes. Network pharmacology pinpointed glycitein as the hub bioactive compound mediating these effects. DS exhibits dual action by both suppressing pathological inflammation (via PI3K/Akt blockade) and enhancing antioxidant defenses, demonstrating concentration-dependent therapeutic effects[46].Network pharmacology analysis has identified 15 bioactive compounds in *C. pilosula* that demonstrate significant potential against osteosarcoma (OS). The active constituents include sterols (stigmasterol, stigmast-7-enol, spinasterol, poriferasta-7,22E-dien-3beta-ol, 5-α-stigmastan-3,6-dione, zinc03978781, taraxerol, and stigmasterone) inhibits cancer proliferation by modulating steroid hormone pathways; flavonoids (luteolin, glycitein, and 7-methoxy-2-methyl isoflavone) regulate apoptosis and DNA damage responses; alkaloids (11-hydroxyrankinidine and perlolyrine) targeting cell signalling and migration. These compounds collectively target 48 OS-related genes, influencing critical pathways such as DNA damage repair, apoptosis induction, cell cycle progression, and metastasis suppression. Their multi-target action disrupts cancer cell metabolism, modulates the tumor microenvironment, enhances chemosensitivity, and regulates immune responses against OS cells [47].Yang et al. (2013) purified CPP1b, a pectic polysaccharide derived from *C. pilosula*, which exhibited concentration- and duration-dependent cytotoxic effects on A549 non-small cell lung carcinoma (NSCLC) cells. The observed antineoplastic activity was attributed to its elevated galacturonate content, with the compound also demonstrating chemo sensitizing properties when combined with methotrexate, leading to augmented tumor suppression [27]. In a subsequent study, Chen et al. (2015) synthesized a selenium-modified analog (sCPP1b), which displayed enhanced oncolytic efficacy across multiple malignant cell lines (A549, BGC-823 gastric adenocarcinoma, HeLa cervical carcinoma) while preserving selective cytotoxicity toward non-transformed cells. The selenylated derivative induced more pronounced pro-apoptotic effects, stronger anti-migratory activity, and greater G2/M phase blockade (44.02% vs. 29.81%), along with elevated apoptotic indices (11.01% vs. 8.14%) compared to the native polysaccharide. Both compounds triggered mitochondrion-mediated apoptosis via Bax induction, Bcl-2 suppression, and caspase-3 activation **(Figure 3)**, with sCPP1b consistently exhibiting superior pharmacodynamic potency[28].

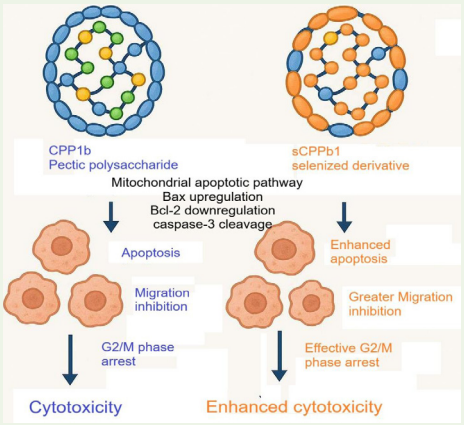

Figure 3: Anticancer effects of CPP1b and sCPP1b against A549, BGC-823, and HeLa cell lines.

Immunomodulatory Effects of *C. pilosula*

C. pilosula extract (CPE) demonstrated significant immunomodulatory effects in septic rats, with high doses increasing thymus and spleen indices while medium/high doses elevated brain indices. Treatment improved histopathology of these immune organs and enhanced CD4+ expression, indicating T-cell activation. CPE restored hematological balance by increasing RBCs, lymphocytes, and hemoglobin while reducing neutrophils, NLR, and PLR ratios. It dynamically regulated WBC and platelet counts, along with key infectious, immune, and inflammatory markers. Metabolomic and transcriptomic analyses revealed CPE modulates glycerophospholipid metabolism via the B-cell receptor (BCR) pathway, maintaining immune homeostasisparticularly humoral immunityin sepsis [48]. The glucan CPC from *C. pilosula* roots significantly stimulated RAW 264.7 macrophages, enhancing production of NO, ROS, iNOS, and cytokines (TNF-α, IL-6, IL-1β, IL-10). It upregulated mRNA expression of these immune mediators, indicating strong immunostimulatory effects[49]. *C. pilosula* oligosaccharides (CPO), with a 14.3% yield and 92.7% sugar content, consist primarily of fructose and glucose (DP 1-7, average DP=2). CPO significantly enhances immune function by stimulating RAW264.7 macrophage proliferation, phagocytosis, and secretion of TNF-α, NO, and IL-6 through MAPKs pathway activation[50]. The pectic polysaccharide CPP1c from *C. pilosula* exhibits potent immunomodulatory activity by enhancing T-cell activation through the TCR/CD28 signaling pathway**(Figure 4).**In aging mice (SAMP8), it stimulates lymphocyte proliferation and modulates T-cell subsets, increasing CD4+, CD8+, CD28+, and CD152+ populations while boosting cytokine production (IL-2, TNF-α, IFN-γ). Molecular studies confirm that CPP1c upregulates CD28, PI3K, and p38MAPK at both mRNA and protein levels, suggesting its role in T-cell co-stimulation and immune response amplification. Additionally, CPP1c promotes lymphocyte homing, further supporting its potential as an immune-enhancing therapeutic agent, particularly in aging-related immune dysfunction[51].

Antidiabetic Potential of *C. pilosula*

C. pilosula extract (CPNE) demonstrates potent α-glucosidase

Citation: Yani L, Yulong W, Liming Y, Yaping H, Kailing C, et al. Phytochemical Constituents and Pharmacological Effects of Dangshen (*Codonopsis pilosula*), an Important Traditional Chinese Medicine. J Plant Sci Res. 2025;12(2): 277

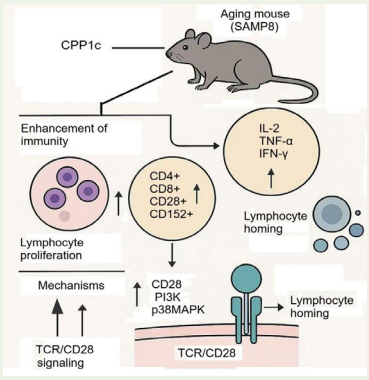

Figure 4: Schematic representation of the immunomodulatory effects of CPP1c, a pectic polysaccharide in aging SAMP8 mice. CPP1c enhances lymphocyte proliferation by activating TCR/CD28 signaling, upregulating CD4+, CD8+, and co-stimulatory molecules (CD28+, CD152+), and boosting Th1 cytokines (IL-2, TNF-α, IFN-γ). Mechanistically, it stimulates the PI3K/p38MAPK pathway and promotes lymphocyte homing, demonstrating its potential to counteract age-related immune dysfunction.

inhibitory activity, with IC_{50} values of 0.241 mg/mL (sucrase), 0.326 mg/mL (maltase), and 1.167 mg/mL (yeast α-glycosidase). In diabetic mice, CPNE significantly reduces postprandial blood glucose levels following sucrose/maltose/starch challenges. UHPLC-Triple-TOF-MS/MS analysis identified 29 bioactive compounds, including 3 alkaloids, 13 phenolic acids, 8 alcohol glycosides, and 5 alkynosides, which likely contribute to its antidiabetic effects. The extract's dual inhibition of mammalian and yeast α-glucosidases suggests broad-spectrum carbohydrate-digesting enzyme suppression. These findings position CPN as a promising functional food or adjuvant therapy for diabetes management. CPNE's ability to modulate postprandial glycemia highlights its potential for preventing diabetic complications[52].*C. pilosula* demonstrated significant plasma glucose-lowering effects in STZ-induced diabetic mice after 4 weeks of treatment. The herb effectively reduced serum aldose reductase (AR) activity, suggesting potential protection against diabetic complications. Its antidiabetic mechanism appears linked to oxidative stress modulation, as evidenced by improved SOD activity and reduced MDA levels[53].

Six purified polysaccharide fractions (WCP1-6) from *C. pilosula* demonstrated distinct bioactivities, with mannose/glucose/arabinose as primary monosaccharides. WCP3 and WCP5 exhibited potent inhibition of α-amylase (63.2%) and α-glucosidase (58.7%) respectively. Molecular docking confirmed WCP5's stable binding to digestive enzymes through multiple hydrogen bonds with catalytic residues. Molecular dynamics simulations (100ns) demonstrated excellent stability of WCP-enzyme complexes (RMSD < 0.3 nm). The triple-helix conformation and specific monosaccharide composition were identified as critical factors for both antioxidant and hypoglycemic effects[54]. The neutral polysaccharide CERP1 (4.84 kDa), composed of arabinose, glucose, and galactose (1:19.83:6.94), demonstrated significant antidiabetic potential through its unique β-linked structure (1,3- and 1,6-glucose; 1,3,6-galactose). *In vitro* studies revealed CERP1 enhances insulin secretion in INS-1 cells, while in T2DM mice it exhibited multi-target effects: reducing oxidative stress, improving lipid metabolism, and modulating glycolytic/liver enzymes. The polysaccharide's homogeneous particle size and aqueous dispersibility (confirmed by TEM) contribute to its bioactivity[55].

Antimicrobial activity of *C. pilosula*

C. pilosula leaf tea (CLT) and raw leaves (CL) exhibit significant antimicrobial activity against various bacteria and yeast strains, while the roots (CR) showed comparatively weaker effects. The antimicrobial properties are likely attributed to the higher concentration of bioactive compounds in the leaves, particularly LBT (0.68 mg/g in CLT vs 0.23 mg/g in CR), flavonoids, and polyphenols. The aqueous and ethanol extracts of CLT and CL demonstrated broad-spectrum inhibition, suggesting their potential as natural preservatives or antimicrobial agents. Interestingly, the tea processing method enhanced LBT content without compromising antimicrobial efficacy, making CLT a particularly promising antimicrobial material. These findings position *C. pilosula* leaves as valuable alternatives to the traditionally used roots for antimicrobial applications in food, cosmetic, and pharmaceutical industries. The dual antioxidant-antimicrobial activity of the leaves further increases their commercial potential as functional ingredients [39].The orthogonal experiment identified optimal desulfurization conditions for *C. pilosula* as 45°C for 50 minutes with 700W ultrasonic power and a 10:1 ethanol-to-material ratio, achieving a 55.4% desulfurization rate. Desulfurized polysaccharides demonstrated superior antibacterial activity against E. coli compared to sulfur-fumigated samples, showing a lower MIC value (35 mg/mL vs 70 mg/mL). The improved antimicrobial efficacy suggests that desulfurization effectively preserves bioactive polysaccharide structures while removing sulfur residues. This process enhances the therapeutic potential of *C. pilosula* polysaccharides for antimicrobial applications [56].

Neuroprotective Effects of *C. pilosula*

C. pilosula demonstrates significant neuroprotective potential through multiple bioactive compounds, including polysaccharides, alkaloids (e.g., codonopsine), and lobetyolin. These components reduce oxidative stress in neuronal cells by scavenging ROS and enhancing SOD/GSH-Px activity. The herb modulates neurotransmitter systems, particularly acetylcholine and dopamine, improving cognitive function in neurodegenerative models. Its polysaccharides activate Nrf2/ARE pathways, upregulating endogenous antioxidant defenses against neurotoxicity. Additionally, *C. pilosula* inhibits neuroinflammation by suppressing pro-inflammatory cytokines (TNF-α, IL-6) and microglial activation. The β-carboline alkaloids (perlolyrine, norharman) show particular promise in preventing amyloid-β aggregation and tau phosphorylation. These multi-target actions support its traditional use for cognitive enhancement and position it as a potential therapeutic candidate for Alzheimer's and Parkinson's diseases. Further research is needed to elucidate its blood-brain barrier permeability and clinical efficacy. CPP protects PC12 cells from Aβ25-35-induced oxidative damage by reducing ROS/MDA levels, enhancing SOD/GSH/CAT activity, and inhibiting apoptosis via p38MAPK pathway modulation. The polysaccharide's antioxidant and anti-apoptotic effects were reversed by p38MAPK inhibition (SB203580), confirming this signaling pathway's critical role [57]. CPPs significantly improved cognitive function and synaptic

Citation: Yani L, Yulong W, Liming Y, Yaping H, Kailing C, et al. Phytochemical Constituents and Pharmacological Effects of Dangshen (*Codonopsis pilosula*), an Important Traditional Chinese Medicine. J Plant Sci Res. 2025;12(2): 277

plasticity (increasing synaptotagmin/PSD95) in APP/PS1 mice while reducing hippocampal Aβ42/Aβ40 levels. The polysaccharides inhibited BACE1 activity both *in vivo* and *in vitro*, decreasing APPβ and Aβ42 production. These findings demonstrate CPPs' dual action against Aβ pathology through synaptic protection and amyloidogenic pathway suppression. The BACE1-targeting mechanism positions CPPs as a promising therapeutic candidate for Alzheimer's disease [58]. CPPs improved cognitive function in APP/PS1 mice by reducing Aβ plaques and hippocampal neuronal apoptosis through modulation of the PERK-ATF4-CHOP ERS pathway. Treatment downregulated GRP78, PERK, ATF4, CHOP, and Bax while increasing Bcl-2 expression, demonstrating dual action against amyloidogenesis and ER stress-induced apoptosis. Molecular docking confirmed CPPs' affinity for key ERS pathway components, supporting their targeted mechanism. These findings position CPPs as a promising multi-target therapeutic for AD by simultaneously addressing protein misfolding stress and neuronal survival pathways [59]. Hu et al. (2021) reported that CPPs exhibit neuroprotective effects in Aβ1-40-exposed PC12 cells, a model for early Alzheimer's disease (AD). CPPs counteracted Aβ-induced cytotoxicity, restoring cell viability, ATP production, and NAD+/NADH balance while mitigating oxidative stress (ROS) and mitochondrial dysfunction**(Figure 5).** Mechanistically, CPPs enhanced mitochondrial membrane potential (MMP) and preserved NAD+ levels by suppressing CD38, a key NAD+-consuming enzyme upregulated by Aβ. This NAD+ preservation activated SIRT1/SIRT3, critical for mitochondrial homeostasis and antioxidant defense, while also rescuing PGC-1α expression, a master regulator of mitochondrial biogenesis. Crucially, CD38 knockdown via siRNA abolished CPP-mediated protection, confirming that their neuroprotective effects are CD38-dependent. These findings highlight CPPs as a potential therapeutic strategy for AD by targeting NAD+ metabolism and mitochondrial function [60].

Hepatoprotective effect of *C. pilosula*

C. pilosula exhibits significant hepatoprotective properties through multiple mechanisms, demonstrating therapeutic potential for liver disorders. The herb modulates oxidative stress and inflammatory pathways by upregulating key protective genes including GDF15 and HMOX1, which play crucial roles in cellular repair and redox balance maintenance. Experimental evidence shows *C. pilosula* enhances hepatocyte proliferation and migration, promoting tissue regeneration in both hepatocellular carcinoma (HepG2, Huh7) and normal liver (L-02) cell lines. Its bioactive compounds effectively reduce liver damage markers and improve hepatic function, as demonstrated in rat models of liver injury. The herb's activity aligns with traditional qi-tonifying properties, counteracting cellular stress responses characteristic of liver pathologies. The upregulation of GDF15 indicates potential benefits in angiogenesis and liver tissue remodeling, while HMOX1 induction underscores potent antioxidant and anti-inflammatory actions within hepatocytes. The herb's multi-target approach to liver protection, addressing both cellular stress and tissue regeneration, offers a comprehensive strategy for managing liver disorders while maintaining a favourable safety profile characteristic of traditional herbal medicines[61].

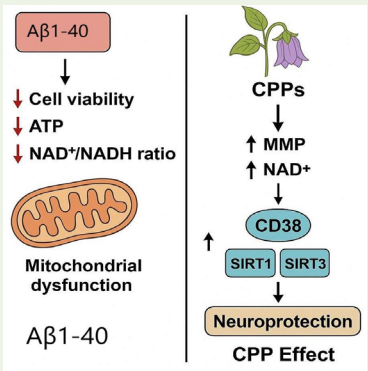

Figure 5: Neuroprotective effects of CPPs against Aβ1-40-induced toxicity in PC12 cells, a model for early AD.

Cardioprotective Effects of *C. pilosula*

The herbal extract 417W from *C. pilosula* significantly enhanced cardiogenic differentiation in mouse embryonic stem cells, as demonstrated by increased α-myosin heavy chain-driven eGFP expression. In a rat myocardial infarction model, 417W treatment improved cardiac function for at least 6 weeks post-LAD ligation. Echocardiography revealed significant enhancements in left ventricular fractional shortening (FS), fractional area contraction (FAC), and ejection fraction (EF). These findings validate the traditional use of *C. pilosula* for cardiovascular conditions. The extract demonstrates therapeutic potential for repairing infarcted myocardium through cardiomyocyte differentiation promotion [62]. Shenqi Fuzheng (SQ) is a renowned traditional Chinese medicine extracted from Radix Codonopsis and Radix Astragali. Shenqi Fuzheng (SQ) injection demonstrates multi-target cardioprotection against ischemia-reperfusion injury by activating PPARα to enhance myocardial energy metabolism. Network pharmacology revealed its dual regulation of apoptosis pathways, reducing BAX-mediated cell death while improving cardiac function. The formulation modulates inflammatory responses and prevents adverse ventricular remodeling post-injury[63].

Antiviral Activity of *C. pilosula*

C. pilosula polysaccharide (CPPS) showed antiviral efficacy against duck hepatitis A virus (DHAV).Phosphorylation modification significantly enhanced CPPS's antiviral efficacy.pCPPS reduced viral replication (TCID50) and improved survival rates in infected duck embryonic hepatocytes, unlike unmodified CPPS. The compound suppressed DHAV-induced IFN-β expression, indicating direct viral inhibition rather than immune modulation. Structural analysis confirmed successful phosphorylation, correlating with improved bioactivity. These findings position CPPS and pCPPS as a promising antiviral agent for poultry viral hepatitis prevention and treatment [64]. Multiple therapeutic effects of *C. pilosula* (Dangshen) were represented in (**Figure 6).**

Future Perspectives

Developing standardized cultivation protocols and advanced analytical methods (e.g., metabolomics, DNA barcoding) to ensure consistent bioactive compound levels. Addressing challenges like soil degradation, climate adaptability, and adulteration through

Citation: Yani L, Yulong W, Liming Y, Yaping H, Kailing C, et al. Phytochemical Constituents and Pharmacological Effects of Dangshen (*Codonopsis pilosula*), an Important Traditional Chinese Medicine. J Plant Sci Res. 2025;12(2): 277

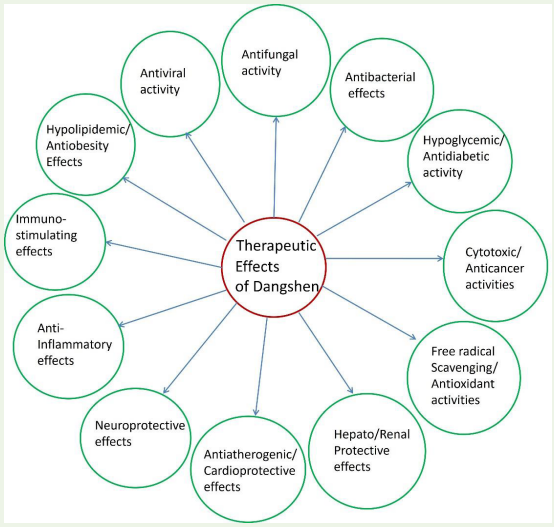

Figure 6: Multiple therapeutic effects of Dangshen.

biotechnological interventions.Elucidating molecular targets and signaling pathways of key compounds (e.g., CPPs, lobetyolin) through multi-omics approaches. Advancing preclinical studies to human trials for diabetes, neurodegenerative diseases, and cancer therapy.Exploring nano-delivery systems (e.g., polysaccharide-based nanoparticles) to enhance bioavailability and targeted action. Developing synergistic herbal combinations or synthetic analogs to amplify therapeutic efficacy.Integrating *C. pilosula* into functional foods (e.g., probiotic synergies, fortified beverages) for metabolic and immune health. Validating health claims through clinical studies to meet regulatory standards globally.Promoting agroecological practices (e.g., intercropping, organic farming) to reduce environmental impact. Expanding market potential through value-added products while ensuring fair trade and ethical sourcing.

Conclusions

This comprehensive review systematically examined the phytochemical composition and multifaceted pharmacological properties of *Codonopsis pilosula,* providing scientific validation for its traditional medicinal applications. The analysis revealed that key bioactive constituents, especially polysaccharides (CPPs) and lobetyolin, exhibit remarkable therapeutic effects including neuroprotection, immune modulation, anticancer activity, and metabolic regulation through various molecular pathways. The herb demonstrates significant potential for managing neurodegenerative conditions, diabetes, cardiovascular diseases, and immune disorders, attributable to its potent antioxidant, anti-inflammatory, and cytoprotective capabilities. However, the review also identified critical challenges that need to be addressed, particularly in standardization protocols, sustainable cultivation practices, and clinical translation of research findings. These insights collectively position *C. pilosula* as a valuable medicinal resource that warrants further in-depth investigation to fully realize its potential in pharmaceutical development and functional food applications, bridging the gap between traditional herbal medicine and evidence-based therapeutic use.

Author Contributions

WY: Writing Manuscript draft, LY: Data curation and Funding acquisition; HY and YL.: Figures and Data curation; CK and LF. Tables and References; V.R.N. Validation and Final Version Correction; All authors have read and agreed to the published version of the manuscript.

Funding

Key Laboratory of Ecological Planting and Processing of Authentic Medicinal Materials in Shanxi Province (Grant Number: 202204010931003)

Acknowledgments

We are very thankful to Key Laboratory of Ecological Planting and Processing of Authentic Medicinal Materials in Shanxi Province (Grant Number: 202204010931003) for financial support.

References

1. Tang W, Eisenbrand G (1992) *Codonopsis pilosula* (Franch.) Nannf. In: Chinese Drugs of Plant Origin. Springer, Berlin, Heidelberg Pp: 357-359.
2. Shergis JL, Liu S, Chen X, Zhang AL, Guo X, et al. (2015) Dang shen [*Codonopsis pilosula* (Franch.) Nannf] herbal formulae for chronic obstructive pulmonary disease: a systematic review and meta-analysis. Phytother Res 29:167-186.
3. Codonopsis Plants. (2023) National Collection of the Genus Codonopsis and Allied Genera.
4. Skan SA (1906) Tab. 8090. *Codonopsis tangshen*. Curtis's Botanical Magazine 2: 8090.
5. Dharmananda S (2023) Codonopsis: Medicine and Food.
6. Cai DG, Wang YZ, Han C, Zhao WW (1982) Studies on chemical constituents of Dang Shen (*Codonopsis pilosula*). II. Chin Trad Herbal Drugs 13: 442-444.
7. Shi Q, Chen Z, Yang J, Liu X, Su Y, et al. (2024) Review of Codonopsis Radix biological activities: A plant of traditional Chinese tonic. J Ethnopharmacol 332: 118334.
8. Yang D, Zhang Q, Wu Z, Chen Y, Cai Z, et al. (2024) Research status and future focus on Codonopsis pilosula: A bibliometric analysis of past and present studies. Heliyon 10: e40069. doi: 10.1016/j.heliyon.2024.e40069.
9. Liu, Q. , Zheng, H. , Jiang, R. , Wan, D. ,& Zhu, H. (2023). Exploring the Application Prospects of Aboveground Parts of Codonopsis Pilosula in Agri-Food and Other Industries Based on Chemical Composition and Pharmacological Effects: A Review. Journal of Food and Nutrition Research, 11(12), 759-771.
10. Guo H, Lou Y, Hou X, Han Q, Guo Y, et al. (2024) A systematic review of the mechanism of action and potential medicinal value of *Codonopsis pilosula* in diseases. Front Pharmacol 15: 1415147.
11. Tang X, Fan C, Zeng J, Zhao P, Wang X, et al. (2022) Targeted isolation and identification of bioactive pyrrolidine alkaloids from *Codonopsis pilosula* using characteristic fragmentation-assisted mass spectral networking. Chin J Nat Med 20:948-960.
12. Wakana D, Kawahara N, Goda Y (2013) Two new pyrrolidine alkaloids, codonopsinol C and codonopiloside A, isolated from *Codonopsis pilosula*. Chem Pharm Bull (Tokyo) 61: 1315-1317.
13. Liu T, Liang W, Tu G (1988) Perlolyrine: a beta-carboline alkaloid from *Codonopsis pilosula*. Planta Med 54: 472-473.
14. Wang ZT, Xu GJ, Hattori M (1988) Constituents of the roots of *Codonopsis pilosula*. Shoyakugaku Zasshi. 1988; 42:339.

Citation: Yani L, Yulong W, Liming Y, Yaping H, Kailing C, et al. Phytochemical Constituents and Pharmacological Effects of Dangshen (*Codonopsis pilosula*), an Important Traditional Chinese Medicine. J Plant Sci Res. 2025;12(2): 277

15. Liu XH, Liu Y, Sun XW, Liu YF (2010) Quantitative determination of adenosine in *Codonopsis pilosula* by HPLC. Pharm Today 20:13-15.

16. Wakana D, Kawahara N, Goda Y (2011) Three new triterpenyl esters, codonopilates A-C, isolated from *Codonopsis pilosula*. J Nat Med 65: 18-23.

17. Li J, Zhang J, Cao L, Ji JJ, Gao J (2021) A New Cycloartanyl Ester from the Roots of *Codonopsis pilosula* and Its Anti-Inflammatory Activity. Chem Nat Compd 57: 120-122.

18. Zheng T, Cheng LZ, Yan YM, Liu BH, Qin FY, et al. (2018) Two New Triterpenoids from the Roots of *Codonopsis pilosula*. Molecules 23: 0.

19. Chen Y, Zhu Y, Wei J, Liang N (1995) [Chemical components of *Codonopsis pilosula* (Franch.) Nannf. var. volubilis (Nannf.) L.T. Shen]. Zhongguo Zhong Yao Za Zhi 20: 611-612, 639-40.

20. Xie Q, Wang H, Guan H, Xu N, Zhao X, et al. (2023) The in vitro/in vivo metabolic pathways analysis of lobetyol, lobetyolin, and lobetyolinin, three polyacetylenes from Codonopsis Radix, by UHPLC-Q/TOF-MS and UHPLC-MS/MS. J Pharm Biomed Anal 223:115140.

21. Bailly C (2021) Anticancer Properties of Lobetyolin, an Essential Component of Radix Codonopsis (Dangshen). Nat Prod Bioprospect 11:143-153.

22. Wang RY, Su PJ, Zhang ZX, Li B, Hu FD, et al. (2021) Triterpenoids, Steroids, and Other Constituents of the Roots of *Codonopsis pilosula*. Chem Nat Compd 57: 1160-1162.

23. He JY, Zhu S, Goda Y, Cai SQ, Komatsu K (2014) Quality evaluation of medicinally-used Codonopsis species and Codonopsis Radix based on the contents of pyrrolidine alkaloids, phe nylpropanoid and polyacetylenes. J Nat Med 68: 326-339

24. Wang ZT, Xu GJ, Hattori M (1988) Constituents of the roots of Codonopsis pilosula. ShoyakugakuZasshi 42:339

25. Jian-ping G (2011) Separation and Structural Characterization and Anti-tumor Effect in vitro of Polysaccharides from Radix Codonopsis Lishizhen Medicine and Materia Medica Research

26. Xin T, Zhang F, Jiang Q, Chen C, Huang D, et al. (2012) The inhibitory effect of a polysaccharide from *Codonopsis pilosula* on tumor growth and metastasis in vitro. Int J Biol Macromol 51:788-793.

27. Yang C, Gou Y, Chen J, An J, Chen W, et al. (2013) Structural characterization and antitumor activity of a pectic polysaccharide from *Codonopsis pilosula*. Carbohydr Polym 98: 886-895.

28. Chen W, Gou Y, Li W, Zhang P, Chen J, et al. (2015) Activation of intrinsic apoptotic signaling pathway in a549 cell by a pectin polysaccharide isolated from *codonopsis pilosula* and its selenized derivative. Journal of Carbohydrate Chemistry 34: 475-489.

29. Zhang P (2016) Monosaccharide compositions of *Codonopsis pilosula* polysaccharides and their correlation analysis on cytotoxic activities against HepG2 cells[J]. Chinese Traditional and Herbal Drugs 47: 2684-2692.

30. Bai R, Li W, Li Y, Ma M, Wang Y, et al. (2018) Cytotoxicity of two water-soluble polysaccharides from *Codonopsis pilosula* Nannf. var. modesta (Nannf.) L.T.Shen against human hepatocellular carcinoma HepG2 cells and its mechanism. Int J Biol Macromol 120:1544-1550.

31. Liu H, Amakye WK, Ren J (2021)*Codonopsis pilosula* polysaccharide in synergy with dacarbazine inhibits mouse melanoma by repolarizing M2-like tumor-associated macrophages into M1-like tumor-associated macrophages. Biomed Pharmacother 142:112016.

32. Li N, Xiong YX, Ye F, Jin B, Wu JJ, et al. (2023) Isolation, Purification, and Structural Characterization of Polysaccharides from *Codonopsis pilosula* and anti-tumor bioactivity by immunomodulation. Pharmaceuticals 2023, 16: 895.

33. Yoo HH, Baek SH, Park YK, Lee SH, Kim CM, et al. (2002) Lee KS, Park MK, Park JH (2002) Quality control of dried roots of Codonopsis lanceolata. Pharmacology 33: 85-87.

34. He Q, Zhu EY, Wang ZT, Chou GX, Xu LS, et al. (2006) Study on chemical constitutes of *Codonopsis pilosula*. Chin Pharm J 41:10-12.

35. Zhu EY, He Q, Wang ZT, Xu LS, Xu GJ (2001) Chemical study on the root of *Codonopsis pilosula*. J Chin Pharm Univ 32: 94-95.

36. He JY, Ma N, Zhu S, Komatsu K, Li ZY, et al. (2015) The genus Codonopsis (Campanulaceae): a review of phytochemistry, bioactivity and quality control. J Nat Med 69:1-21.

37. Phuong PLT, Phuc NTL, Phu HL (2024) Optimization of ethanol extraction parameters for polyphenol content and antioxidant activity of *Codonopsis pilosula* root. International Journal of Food Science and Nutrition 9: 20-25.

38. Meiqi Liu, Guoqin Zhang, Kexin Zhou, Jinli Wen, Fuxiang Zheng, et al. (2023) Structural characterization, antioxidant activity, and the effects of *Codonopsis pilosula* polysaccharides on the solubility and stability of flavonoids. Journal of Pharmaceutical and Biomedical Analysis 229: 115368.

39. Doudou Yang, Yuan Chen, Fengxia Guo, Baoting Huang, Samuel Anim Okyere, et al. (2019) Comparative analysis of chemical composition, antioxidant and antimicrobial activities of leaves, leaf tea and root from *Codonopsis pilosula*, Industrial Crops and Products 142: 111844.

40. https://www.sciencedirect.com/science/article/abs/pii/S2352554123004308

41. Li LX, Chen MS, Zhang ZY, Paulsen BS, Rise F, et al. (2022) Structural features and antioxidant activities of polysaccharides from different parts of *Codonopsis pilosula* var. modesta (Nannf.) L. T. Shen. Front Pharmacol 13: 937581.

42. Liu M, Zhang G, Zhou K, Wen J, Zheng F, et al. (2023) Structural characterization, antioxidant activity, and the effects of *Codonopsis pilosula* polysaccharides on the solubility and stability of flavonoids. J Pharm Biomed Anal 229:115368.

43. Zou YF, Zhang YY, Paulsen BS, Rise F, Chen ZL, et al. (2021) New pectic polysaccharides from *Codonopsis pilosula* and Codonopsis tangshen: structural characterization and cellular antioxidant activities. J Sci Food Agric 101:6043-6052.

44. Huang S, Li Q, Song Y (2024) *Codonopsis pilosula* polysaccharide suppresses the progression of non-small cell lung cancer by triggering NLRP3/GSDMD-dependent pyroptosis. Discov Oncol 15: 510.

45. Wang ZX, Li PP, Li CN, Guo YN, Shao YZ, et al. (2024) Study on the mechanism of *Codonopsis pilosula* polysaccharide inhibiting gastric cancer precancerous lesions by regulating Wnt/β-catenin signaling pathway, Pharmacological Research - Modern Chinese Medicine 10: 100391.

46. Li F, Yang Y, Ge J, Wang C, Chen Z, et al. (2024) Multi-omics revealed the mechanisms of *Codonopsis pilosula* aqueous extract in improving UC through blocking abnormal activation of PI3K/Akt signaling pathway. J Ethnopharmacol 319: 117220.

47. Gong YB, Fu SJ, Wei ZR, Liu JG (2021) Predictive Study of the Active Ingredients and Potential Targets of *Codonopsis pilosula* for the Treatment of Osteosarcoma via Network Pharmacology. Evid Based Complement Alternat Med 2021:1480925.

48. Xia Z, Li G, Zhai Y, Tong L, Ru Y, et al. (2025) Wu M, Hu J, Wang M, Meng Y, Sun B, Wang C, Luo X, Liu Y, Zhao Y, Zheng X, Jia P. Immunomodulatory effects and multi-omics analysis of *Codonopsis Pilosula* Extract in septic rats. J Ethnopharmacol 337: 118847.

49. Li J, Wang Y, Ji J, Cao L, Bai Y, et al. (2021) Structural characterization and immunomodulatory activity of a glucan from Radix Codonopsis, Journal of Functional Foods, 83: 10453.

50. Ruibin Bai, Yajie Zhang, Xusen Jia, Jingmin Fan, Xiaohui Hou, et al. (2020) Isolation, characterization and immunomodulatory activity of oligosaccharides from *Codonopsis pilosula*, Journal of Functional Foods 72: 104070.

51. Zhang P, Hu L, Bai R, Zheng X, Ma Y, et al. (2017) Structural characterization of a pectic polysaccharide from *Codonopsis pilosula* and its immunomodulatory activities in vivo and in vitro. Int J Biol Macromol 104:1359-1369.

52. Jia W, Bi Q, Jiang S, Tao J, Liu L, et al. (2022) Hypoglycemic activity of *Codonopsis pilosula* (Franch.) Nannf. in vitro and in vivo and its chemical

Citation: Yani L, Yulong W, Liming Y, Yaping H, Kailing C, et al. Phytochemical Constituents and Pharmacological Effects of Dangshen (*Codonopsis pilosula*), an Important Traditional Chinese Medicine. J Plant Sci Res. 2025;12(2): 277

composition identification by UPLC-Triple-TOF-MS/MS. Food Funct13: 2456-2464.

53. He K, Li X, Chen X, Ye X, Huang J, et al. (2011) Evaluation of antidiabetic potential of selected traditional Chinese medicines in STZ-induced diabetic mice. J Ethnopharmacol 137:1135-1142.

54. Yang M, Wang A, Tang X, Wang X, Leng F, et al. (2024) Structure identification and activity evaluation of polysaccharide from *Codonopsis pilosula* (*C. pilosula* nannf. Var. modesta (nannf.) L. T. Shen). Food Bioscience 62: 104973.

55. Liu W, Lv X, Huang W, Yao W, et al. (2018) Characterization and hypoglycemic effect of a neutral polysaccharide extracted from the residue of *Codonopsis Pilosula*. Carbohydr Polym 197: 215-226.

56. Yuying Z, Erbing W (2016) Study on Fundamental Process of *Codonopsis pilosula* Desulfurization and In Vitro Antibacterial Activity of its Polysaccharide Extract on Escherichia coli. Pharm Chem J 49: 782-787.

57. Yang L Song S, Li X, Wang J, Bao Y, et al. (2024) Neuroprotective Effect of *Codonopsis pilosula* Polysaccharide on Aβ25-35-Induced Damage in PC12 Cells via the p38MAPK Signaling Pathways. Pharmaceuticals 17: 1231.

58. Wan L, Zhang Q, Luo H, Xu Z, Huang S, et al. (2020) *Codonopsis pilosula* polysaccharide attenuates Aβ toxicity and cognitive defects in APP/PS1 mice. Aging (Albany NY) 12: 13422-13436.

59. Cai Y, Wang X, Xiang Y, Wang Z, Long Q, et al. (2025) *Codonopsis pilosula* polysaccharides alleviate neuronal apoptosis induced by endoplasmic reticulum stress-activated PERK-ATF4-CHOP signaling in APP/PS1 mice. J Alzheimers Dis 5: 13872877251339484.

60. Hu YR, Xing SL, Chen C, Shen DZ, Chen JL (2021) *Codonopsis pilosula* polysaccharides alleviate Aβ 1-40-induced PC12 cells energy dysmetabolism via CD38/NAD+ signaling pathway. Curr Alzheimer Res 18: 208-221.

61. Ko PH, Huang CW, Chang HH, Chuang EY, Tsai MH, et al. (2019) Identifying the functions and biomarkers of *Codonopsis pilosula* and Astragalus membranaceus aqueous extracts in hepatic cells. Chin Med 14: 10.

62. Wang JN, Kan CD, Lee LT, Huang LLH, Hsiao YL, et al. (2021) Herbal Extract from *Codonopsis pilosula* (Franch.) Nannf. Enhances Cardiogenic Differentiation and Improves the Function of Infarcted Rat Hearts. Life (Basel) 11: 422.

63. Liao J, Hao C, Huang W, Shao X, Song Y, et al. (2018) Network pharmacology study reveals energy metabolism and apoptosis pathways-mediated cardioprotective effects of Shenqi Fuzheng. J Ethnopharmacol 227: 155-165.

64. Ming K, Chen Y, Yao F, Shi J, Yang J, et al. (2016) Phosphorylated *Codonopsis pilosula* polysaccharide could inhibit the virulence of duck hepatitis A virus compared with *Codonopsis pilosula* polysaccharide. Int J Biol Macromol 94: 28-35.

Citation: Yani L, Yulong W, Liming Y, Yaping H, Kailing C, et al. Phytochemical Constituents and Pharmacological Effects of Dangshen (*Codonopsis pilosula*), an Important Traditional Chinese Medicine. J Plant Sci Res. 2025;12(2): 277