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**Retrospective Studies on Phytochemistry and Therapeutic Application of
*Pueraria tuberosa***

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Abstract:

Pueraria tuberosa is widely accepted as Vidarikand and Indian kudzu. It is a valuable herb in Ayurvedic medicine. Its tubers are rich in phytochemicals like flavonoids, isoflavones, and pterocarpanoids, contributing to its diverse therapeutic properties. It has extensive pharmacological actions including antioxidant, anti-inflammatory, immunomodulatory and anticancer activities. *Pueraria tuberosa* holds promise in controlling various disorders like diabetes, inflammation and cancer. Further investigation is required to explore its mechanisms of action, pharmacological action and therapeutic applications, particularly in areas like osteoporosis and diabetes management.

Keywords: *Pueraria tuberosa*, Phytochemistry, Osteoporosis, Antioxidant, Anti-Inflammatory.

List of Abbreviation:

WHO - World Health Organization

EEPT - Ethanolic Extract of *Pueraria tuberosa*

PTTE - *Pueraria tuberosa* tuber extract

ALEPT - Alcoholic Extract of Tubers of *Pueraria tuberosa*

FRAC - Fraction rich in antioxidant compounds

1.Introduction:Traditional medicine practices such as Ayurveda, Siddha, Homeopathy, Unani and Folk medicine are commonly utilized in India to treat various diseases and disorders. According to the World Health Organization (WHO) study about 65–80% of people worldwide go for herbal remedies to treat common health issues ¹. Ayurveda encompasses numerous herbs that not only promote skin wellness but also possess properties that contribute to delaying the aging process¹. In the contemporary era, there is a growing exploration of medicinal plants as traditional therapies to address various physiological difficulties ².

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The perennial climber *Pueraria tuberosa* (Roxb. ex Willd. DC) (family: Fabaceae) is found throughout the Indian subcontinent in moist, wet places. This plant's tuberous roots, which are used in Indian Ayurvedic medicine, are becoming even more significant and are being subject of studies for their potential remedies for a various health Issues³. It is widely utilized herb in herbal medicine ¹.The species belonging to the *Pueraria* genus, particularly *Pueraria thomsonii* and *Pueraria lobata* are also find frequent use in Traditional Chinese Medicine².

Pueraria tuberosa is one of the most significant medications extensively detailed in all the traditional (Ayurveda) texts including Nighantus, Laghuttrayi, and Brihattrayi. Vidarikand, scientifically known as *Pueraria tuberosa* (Willd.) DC., is frequently referred to as Indian kudzu ⁴. It is also known as 'Vidari' according to the Ayurvedic Pharmacopoeia of India ². Vidarikand is mentioned in Guduchyadi varga of Bhavaprakash and its synonyms are listed as Krostri, Sita, Ikshugandha, Kshirvalli, Swdukanda, Kshirshukla, Ikshugandha and Payasvani ⁴.

Vidarikanda synonymously referred to as *Hedysarum tuberosum* Willd, is extensively utilized in Ayurveda's 'Rasayana' category of drugs. In Ayurvedic practices, the tuber is commonly employed for its aphrodisiac qualities, as well as its reputed benefits in promoting longevity and rejuvenation ². The term "Rasayana" is derived from Sanskrit, where "Rasa" signifies plasma and "Ayana" denotes path. Therefore, "Rasayana" refers to the path that "Rasa" takes. Drugs categorized as "Rasayana" are abundant in antioxidants and are recognized for their hepatoprotective and immunomodulating properties ⁵. In Indian traditional medicine (Ayurveda), the plant's tuberous roots find application in treating conditions such as general debility, burning sensation, intrinsic hemorrhage, nervous breakdown, spermatorrhoea, heart diseases, and tuberculosis. ³ This plant tubers are sweet in taste ⁶. The tubers of the *Pueraria tuberosa* are traditionally employed for the treatment of various conditions like inflammation, sexual weakness, as well as for its contraceptive, cardiogenic, diuretic and galactagogue, refrigerant, aphrodisiac properties². Additionally, it is used as food for both human and animal consumption².

The various formulations of this substance find application as nutritive, diuretic, and expectorants, and also in management of fever, rheumatism, and bronchitis. Some its notable biological properties include antihyperlipidaemic, antihyperglycaemic, antifertility in male rats, and hepato-protective effects⁷. The clinical application of PT root-tuber powder includes its use as a tonic, anti-aging agent, purgative, aphrodisiac, lactagogue, demulcent, and in the treatment of scorpion stings. It is also beneficial for addressing conditions such as emaciation in children, debility, and poor digestion. Some

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researchers have also highlighted its effectiveness in skin care and its potential as an anti-fertility agent. Pueraria have anti-diabetic property⁸. Numerous pharmacologically potent constituents, including puerarin, genistein, lupinose, daidzein, tuberosin, have been extracted from the Vidarikanda. In recent in vitro and in vivo studies have identified wide range of biological activities of *Pueraria Tuberosa* tuber extract and its isoflavonoids². The tuber has a various types of phyto-chemical constituents including tannins, glycosides, steroids, flavonoids, terpenoids and anthocyanidins, coumarins, alkaloids, carbohydrates⁹. The chemical constituents have been found as puerarin, daidzein, daidzin, alpha-sitosterol and stigmasterol.³

Its primary chemical constituents are flavones, including c-glycoside, isoflavones like puerarone, coumestan which include tuberostan and puerarostan, epoxychalconol also called as pueratuberosanol, and pterocarpanoids such as hydroxytuberosin, anhydroxytuberosin (3-O methylanhydrotuberosin), and tuberosin⁸.

It is significant ingredient in various Ayurvedic formulations, involving the health tonic Chyawanprash^{2,10}.

2. Taxonomical Classification: Taxonomic classification of *Pueraria tuberosa* mentioned below in Table No.-1

Table No 1: Taxonomical Classification

Kingdom	Plantae	References
Sub-kingdom	Trachebionta	1
Superdivision	Spermatophyta	
Division	Magnoliophyta	
Subclass	rosidae	
Order	Fabales	
Family	Fabaceae	
Genus	<i>Pueraria</i> DC	
Species	<i>Pueraria tuberosa</i>	

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3.Vernacular Names: Pueraria tuberosa is well known by different names in different language in India as mentioned below in Table No.-2

Table No.2: Vernacular Names

Language	Name	References
Marathi	Bhuikohala, Ghodvel	11
Hindi	Vidarikanda, Bankumara	
Sanskrit	Bhumikusmanda, Gajavajipriya, Kandapalash.	
English	Indian kudzu.	
Tamil	Nilapoosani	
Kannada	Gumadi belli, Gumadigida, Nelagumbala Gudde.	

4.Physical Characteristics:

Vidari comprises sliced and dried pieces of the tuberous root, which can grow up to 60 cm in length and 30 cm in width, derived from *Pueraria tuberosa* DC (Family: Fabaceae). This perennial climber is characterized by its extensive tuberous root and is found across the country, excluding extremely humid or arid regions, with an altitude range extending up to 1200 m¹¹.

The whole root tuber's surface is slightly undulating, with an indistinct epidermis. It includes 3 to 4 layers of cork cells followed by 5 to 7 layers of parenchymatous cells. A fibrous pericycle and couple of layers of stone cells loaded with sand crystals follow the fully developed endodermis, and the brown cork cambium measures two or three cells thick. companion cells, bast fibres, sieve tubes and phloem

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parenchyma all are found in phloem. The tracheid's, fibres, parenchyma, and vessels with scalariform pores form the xylem, which was previously pentarch. Granules of starch are present in both the phloem cells and the wide parenchymatous medullary rays on which they are formed.

These grains are polygonal in shape ranging from 2 to 5 μm in diameter are frequently complex with a central cleft and undefined hilum, lamellae are thin. In macerated samples, crystal fibres are multicellular and articulated, where each cell contains a calcium oxalate crystal. Some of these fibres are swollen at the centre resembling a bulb pipette¹².



Figure 1: Powder of vidari kand collected from SMBT Ayurved College and Hospital, Dhamangaon, Nashik.

5. Phytochemical Composition:

Phytochemical screening has revealed a variety of bioactive compounds such as carbohydrates, alkaloids, coumarins, tannins, flavonoids, steroids, terpenoids, anthocyanidins and glycosides in the tuber extract. According to recent RP-HPLC examination of the tuber extract, flavonoids including genistein (1.37%), diazene (1.70%), and puerarin (8.31%) are detected. Additional flavonoid chemicals found in the tuber include quercetin, irisolidon, tectoridin, robinin, daidzin, genistein, puerarone, tuberosin, hydroxytuberosone, 4-methoxypuerarin, biochanin A, biochanin B, quercetin, and glycoside (6-diacetyl Puerarin, C-glycoside 40). It also contains pterocarpanoids (anhydroxytuberosin, 3-O-methylanhydrotuberosin), epoxychalconol (puetuberosanol), and Coumestan (tuberostan, puerarostan). Likewise, the tuber contains organic acids (eicosanoic acid, arachidonic acid, hexadecanoic acid, tetracosanoic acid, and p-coumaric acid), phytosterols (β -sitosterol), and stigmasterol. Low amounts of anthocyanins, pterocarpintuberosin, and lupinoside (lupinoside PA4) are also present in the tuber².

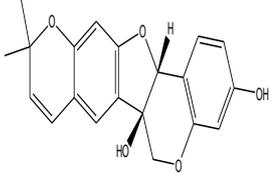
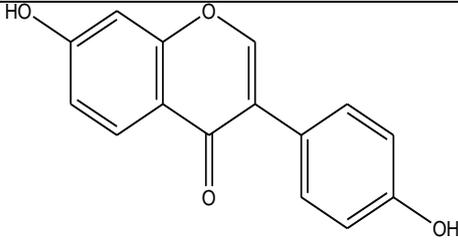
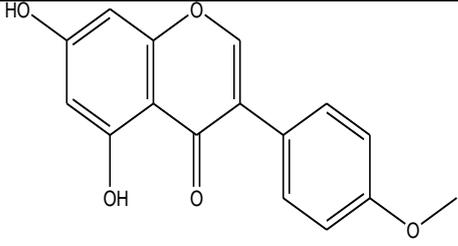
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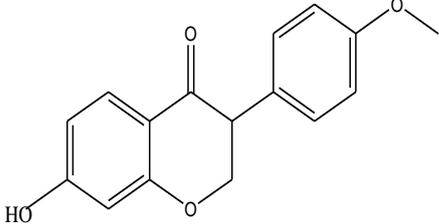
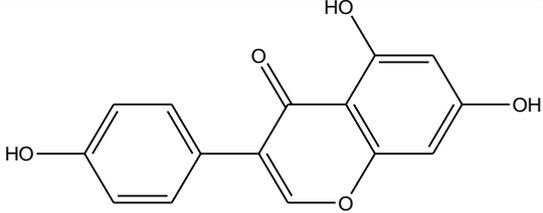
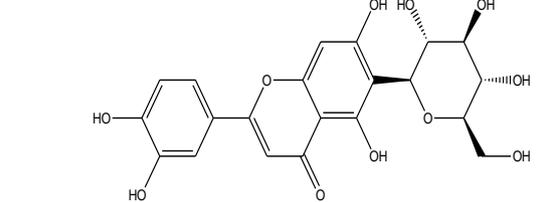
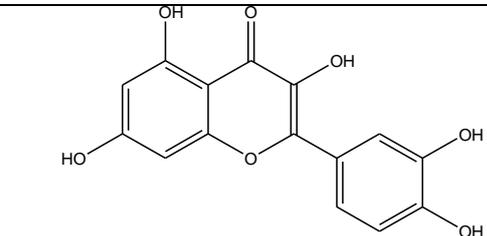
It has been revealed that the roots of Vidari contain phytoestrogen called puerarin. Its tubers contain 10.9% protein and 64.6% carbohydrates^{13,14}.

Some of the phytoconstituent and their activity are enlisted in table no. 3

Table 3: Phytoconstituent of Pueraria tuberosa and its pharmacological activity

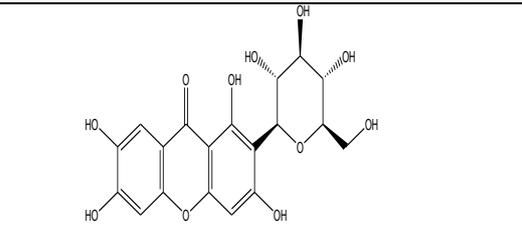
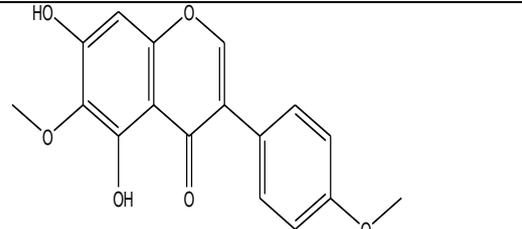
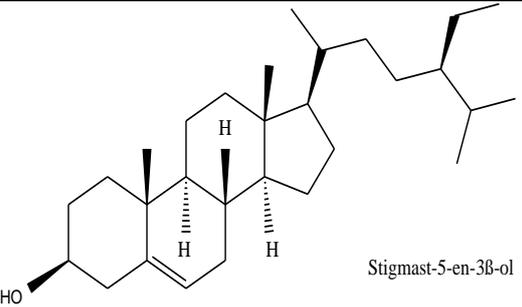
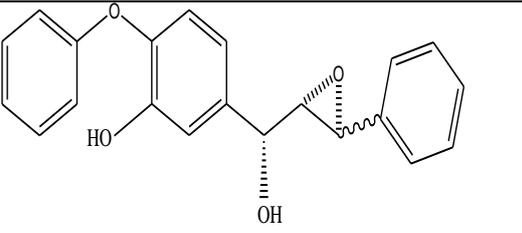
Chemical name	Structure	Activity	References
Tuberosin	 <p style="text-align: center;">(1R,13R)-7,7-Dimethyl-8,12,20-trioxapentacyclo[11.8.0.02.11.04.9.014.19]heptacosane-2(11),3,5,9,14(19),15,17-heptaene-1,17-diol</p>	Antioxidant,	15
Daidzein	 <p style="text-align: center;">7,4'-dihydroxyisoflavone</p>	Anticancer, Antidiabetic, Neuroprotective	6, 9
Biochanin A	 <p style="text-align: center;">5,7-Dihydroxy-4'-methoxyisoflavone</p>	Anti-inflammatory, Anti	1,6, 16

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		micro bial	
Biocha nin B	 <p style="text-align: center;">7-hydroxy-3-(4-methoxyphenyl)chromen-4-one</p>	Anti micro bial	6,1 7
Geniste in	 <p style="text-align: center;">5,7-dihydroxy-3-(4-hydroxyphenyl)chromen-4-one</p>	Antio xidan t, Anti- infla mmat ory	6
Isoorie ntin	 <p style="text-align: center;">2-(3,4-Dihydroxyphenyl)-5,7-dihydroxy-6-[(2S,3R,4R,5S,6R)-3,4,5-trihydroxy-6-(hydroxymethyl)oxan-2-yl]-4H-1-benzopyran-4-one</p>	Anti- Infla mmat ory	18 19
quercet in	 <p style="text-align: center;">2-(3,4-Dihydroxyphenyl)-3,5,7-trihydroxy-4H-1-benzopyran-4-one</p>	Nootr opic	17

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<p>Mangiferin</p>	 <p style="text-align: center;">1,3,6,7-Tetrahydroxy-2-[(2S,3R,4R,5S,6R)-3,4,5-trihydroxy-6-(hydroxymethyl)oxan-2-yl]-9H-xanthen-9-one</p>	<p>Anti-Inflammatory, Antioxidant</p>	<p>20 21 22</p>
<p>Irisolidone</p>	 <p style="text-align: center;">5,7-dihydroxy-6-methoxy-3-(4-methoxyphenyl)chromen-4-one</p>	<p>Anxiolytic</p>	<p>9</p>
<p>Beta-Sitosterol</p>	 <p style="text-align: center;">Stigmast-5-en-3β-ol</p>	<p>Antimicrobial</p>	<p>6,1 7</p>
<p>puetuberosanol</p>		<p>anti-implantation, Antimicrobial</p>	<p>6,2 32 4 25</p>

6. Pharmacological Actions:⁹

Pharmacological action reported are anxiolytic action³, immunostimulatory action⁵, antiapoptotic action, antioxidant activity^{26,27}, antifertility activity²⁸, antimicrobial action²⁹, antidiabetic activity¹⁴, anti-implantation activity²⁵, androgenic activity¹⁶, anticonvulsant activity, antihypertensive action²¹,

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hypolipidemic action, anti-inflammatory action^{30,19}, anticancer activity¹⁷, hepatoprotective activity³¹, fibrinolytic action, wound-healing action, fibrinolytic activity, cardiovascular activity³², neuroprotective action, nephroprotective activity³³, immunomodulatory action³⁴, nootropic action³⁵.

6.1. Antidiabetic activity:

The study suggests that water base extract of vidari has the potential to modulate DPP-IV activity, both in non-diabetic and diabetic conditions. By reducing DPP-IV activity, *Pueraria tuberosa* water extract (PTWE) may enhance the levels of incretin hormones, which could contribute to improved glucose metabolism and a better hypoglycemic state. These results indicate the potential therapeutic value of water-based extract of vidari as a natural inhibitor of DPP-IV activity, signalling further investigation into its mechanisms and clinical applications in the management of diabetes³⁶. flavonoids and polyphenols exhibit dual effects on glucose uptake, mediated partly through SGLT1 modulation, suggesting their potential as therapeutic agents for diabetes management¹⁴.

6.2. Anti-inflammatory activity:

The experimental results suggest that isoorientin, administered at doses ranging from 10mg/kg and 20mg/kg body weight, possess anti-inflammatory properties. The reduced inflammation seen in mice treated with isoorientin in contrast to those only exposed to carrageenan recommend that isoorientin could be a potential application for inflammatory conditions. Additional investigation is necessary to understand how isoorientin exerts its anti-inflammatory effects and to uncover its possible uses in treating different inflammatory ailments¹⁸.

6.3. Antioxidant activity:

The ethanolic extract of *Pueraria tuberosa* (EEPT) demonstrated significant antioxidant activity in both the reducing power assay and the hydrogen peroxide radical scavenging assay. The IC₅₀ values obtained for EEPT were comparable to those of standard ascorbic acid, indicating that the extract has potent antioxidant properties similar to or slightly lower than antioxidant ascorbic acid. The EEPT fraction indicated significant amount of flavonoid, phenolic content, and antioxidant action. These results suggest the potential of *Pueraria tuberosa* extract as an herbal source of antioxidants with possible health benefits^{37,17,38}.

6.4. Immunomodulatory activity:

The ethanolic extract of *Pueraria tuberosa* possesses immunosuppressant activity, as evidenced by its ability to reduce antibody titer values and mitigate drug-induced myelosuppression. The extract

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exhibited dose-dependent effects, with the higher dose (500 mg/kg) showing better activity compared to the lower dose (250 mg/kg) and being comparable to the standard immunosuppressant, azathioprine³⁷.

The ethanolic extract of *P. tuberosa* demonstrates immunomodulatory properties by enhancing macrophage activity and protecting against myelosuppression caused by cyclophosphamide. It appears to selectively reduce adaptive immunity while inhibiting humoral and cell-mediated immunity, leaving the innate immune system and bone marrow cell proliferation unaffected.³⁴ These findings support the potential use of *Pueraria tuberosa* extract in conditions where immunosuppression is desired, although future investigation is recommended to find out its mechanism of action and evaluate its safety and usefulness in healthcare environments³⁷.

P. tuberosa tuber extract (PTTE) enhances innate immune functions and humoral immunity in rats, suggesting its potential therapeutic use in modulating immune responses in humans. Particularly, the isoflavones PR and DZ augment various immune parameters, while GS exhibits suppressive effects. PTTE overall stimulates immune function dose-dependently. To fully understand the mechanics behind these impacts, more research is required, particularly regarding the unidentified compounds responsible for neutrophil adhesion stimulation³⁹.

6.5. Anticonvulsant activity:

The Occurrence of flavonoids, triterpenoids, glycosides, and other chemical substance in alcoholic extract of tubers of *Pueraria tuberosa* (ALEPT) suggests that these constituents may be responsible for the detected pharmacological effects of the ALEPT in experimental animal models. The study's finding suggest that plant extract exhibits anticonvulsant properties, confirming its traditional use to cure epilepsy. This provides pharmacological evidence for the efficacy of ALEPT in managing epilepsy, as per traditional knowledge⁴⁰.

6.6. Antimicrobial activity:

Extracts of *P. tuberosa*, specifically those from ethyl acetate, acetone and hexane, shown broad-spectrum inhibitory response against tests of antimicrobial susceptibility. Bacterial strains have higher susceptibility in comparison to fungi. The best solvent for removing antibacterial chemicals from *P. tuberosa* was found to be ethyl acetate. *P. tuberosa* is known to contain biologically active substances like phenols, polyphenols, alkaloids, tannins, terpenoids and flavonoids²⁹.

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6.7. Anticancer activity:¹⁷

Fraction rich in antioxidant compounds (FRAC) demonstrated promising anticancer activity specifically in ovarian and breast cancer cells. This recommends that it may have ability as a therapeutic agent in the treatment of cancer therapy. Further research and clinical trials would be essential to fully understand its effectiveness, safety profile, and potential mechanisms of action^{9,41}.

6.8. Antifertility activity:

Based on the functional toxicological experiments carried out on boar spermatozoa, Kudzu may alter cAMP, Ca²⁺ signalling, and mitochondrial function, which might have an impact on sperm motility. Kudzu includes substances that could influence ionophore-induced acrosome response (AR) and change Ca²⁺ signalling pathways. While puerarin doesn't affect motility, it inhibits other sperm functions crucial for fertilization, reducing spontaneous AR. Both compounds interact with P4 similarly to reducing agents, causing sperm decondensation. However, their mechanisms differ, possibly due to the presence of other phytoestrogenic components in kudzu^{42,28}.

7. Therapeutic Applications:

Pueraria tuberosa recognized as a 'Rasayana' herb in Ayurveda, exhibits a diverse array of therapeutic properties including refrigerant, aphrodisiac, emetic, galactagogue, emollient, laxative, diuretic, cardiogenic, rejuvenating, and expectorant effects. Its versatile nature allows it to be incorporated into various Ayurvedic formulations, where it functions as anti-aging agent, vital energy booster, restorative tonic, spermatogenic, immune booster, demulcent, cholagogue, purgative, and nutritive. With its wide-ranging applications, *Pueraria tuberosa* holds significant promise in traditional and folk medicine for addressing a multitude of health concerns and promoting overall well-being.

Ayurvedic practitioners frequently prescribe the tuber to address general weakness, fertility disorders, and alleviate symptoms related to dysmenorrhoea, menopausal syndrome, uterine bleeding.

In traditional medicine, the tuber is employed to address various health issues such as fever, chest pain, diarrhoea, abdominal pain and rheumatism. In the realm of folk medicine, the tuber is commonly utilized as a remedy for nerve-related conditions, a promoter of lactation, an anti-inflammatory agent, a tonic for the brain, a blood purifier, and to enhance sperm production. Some indigenous communities in India incorporate the tuber into their diet for nutritional supplementation, birth control, and the management of diabetes^{23,7}.

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Pueraria tuberosa has been suggested to cure three doshas (diseases caused by the three distinct energies that is Vata, Pitta, and Kapha) in the human body. *Pueraria tuberosa* tubers powder is commonly utilized with cow's milk to stimulate milk production post-childbirth and as a growth-promoting agent when combined in Piper longum L. powder to promote growth in malnourished children's. To relieve excessive menstruation, it is mixed with honey. A mixture of milk, fried wheat or barley in ghee, and powdered vidarikanda is recommended to improve sexual endurance and weakness. Furthermore, for treating spermatorrhoea, a therapeutic mixture of fresh Vidarikanda juice, cumin seeds, and sugar is employed⁶.

Its uses are mentioned in Ayurveda as Sula (Calming down pain), Kasa (useful in cough), Sula (settling down burn), mutrakricchra (helpful in dysuria), visarpa (pacifying skin disorder), visamjawar (fever), and Sukra kshya (increasing semen)¹³.

The tuberous roots are brown in colour, clinically prescribed for anti-aging, rejuvenation, as tonic, demulcent, lactagogue, aphrodisiac, purgative, cholagogue, in scorpion sting, emaciation of children, poor digestion and debility.

Vidari is recorded for its activity like antihypoglycemic, diuretic, expectorant, nutritive, glowing skin to improve complexion. and good cardio protection. It also utilised in case of fever, poor indigestion, bronchitis.

According to the reports *Pueraria tuberosa* has been proven to be effective fibrinolytic agent as it reduces fibrinogen, an individual risk factor for stroke and coronary artery disease¹.

Several important Ayurvedic formulations using Indian kudzu comprises the “Maha visagarbha taila” a traditional cure for joint diseases and sciatica, “Ashwagandharishta”, an ancient treatment of epilepsy. Other product use is “Sarasvatarista”, “Satavaryadi ghrta”, “Nityananda rasa”, “Vidaryadi ghrta”, “Marma gutika”⁶.

Pueraria tuberosa is one of the frequently utilised plants of Tdraditonal (Ayurveda) medicine. Vidari is a part of numerous highly prized Ayurvedic mixtures, including the traditional Indian food supplement Chyavanaprash. The yearly trade volume of *Pueraria tuberosa* falls between 500–1000 Metric Tonnes⁴³. Vidarikandadi Churna is crucial herbal medicine used to treat childhood malnutrition. Main ingredient of Vidarikandadi Churna is Vidarikand (*Pueraria tuberosa*), Yava (*Hordeum vulgare*) and Godhum (*Triticum sativum*)¹³.

8. Conclusion:

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Pueraria tuberosa emerges as a valuable natural resource with promising healing properties, offering avenues for further investigation and potential integration into mainstream healthcare practices. Its long-standing use in traditional medicine systems, coupled with modern scientific validation, positions it as a promising candidate for addressing various health conditions and promoting overall well-being. Future studies are required to further explore the mode of action of *Pueraria tuberosa* and its clinical applications particularly in areas like cancer treatment, microbial growth inhibition, epilepsy treatment, immunostimulatory, osteoporosis and diabetes management. Additionally, safety and efficacy evaluations in clinical settings are essential to fully understand the therapeutic application of this valuable herb. Overall, *Pueraria tuberosa* holds significant promise as a natural remedy for various health conditions, highlighting its importance in traditional and folk medicine practices.

9. Future study:

further studies are needed to evaluate its safety and efficacy in clinical settings to understand the synergistic effects of its bioactive compounds. Significant antiosteoporosis medication produced by ovariectomy was created by the FRAC of *Pueraria tuberosa*. Further it demonstrated anticancer activity in ovarian and breast cancer cells, highlighting its possible application in treatment of postmenopausal osteoporosis, osteoporotic bone degeneration and bone fractures. However, to properly assess the potential use of FRAC of *Pueraria tuberosa* in osteoporosis and bone fracture therapy more mechanistic research is required. These include research of the redox status in bone, HDL & LDL levels in serum.

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