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Withania coagulans: A Comprehensive Review on Phytochemistry and Pharmacological Potential

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Abstract: The goal of this review is to gather and critically assess the body of research on the phytochemical profile, ethnopharmacological uses, and pharmacological activities of *Withania coagulans* (Stocks) Dunal, a member of the Solanaceae family and a traditional medicinal plant used in Indian, Unani, and Middle Eastern systems of medicine. Known by many as "Indian Rennet" or "Paneer Dodi," the plant is well-known for its capacity to coagulate milk and has long been used to treat chronic conditions, including diabetes, liver disorders, and inflammation. Data from pharmacopoeias, ethnobotanical surveys, and peer-reviewed scientific journals served as the foundation for this review. In vitro and in vivo research that clarifies the plant's antidiabetic, antioxidant, antimicrobial, anti-inflammatory, anticancer, hepatoprotective, and nephroprotective properties receive particular attention. Withanolides, a class of steroidal lactones with a broad range of pharmacological effects and structural similarities to ginsenosides, are primarily responsible for the phytochemical richness of the plant. Alkaloids, flavonoids, glycosides, phenolic compounds, and tannins are additional significant components that together add to the plant's therapeutic adaptability. The hypoglycemic action of *W. coagulans* is one of its best-established effects; numerous studies have demonstrated notable drops in blood glucose and enhancements in insulin sensitivity in diabetic animal models. It is a potential treatment for disorders linked to oxidative stress because of its well-established antioxidant and free radical scavenging qualities. Preliminary anticancer studies show cytotoxic activity against specific cancer cell lines, but more mechanistic research is needed. Antimicrobial studies have shown effectiveness against both Gram-positive and Gram-negative bacteria, as well as fungal pathogens. The plant's wide range of pharmacological properties is further supported by reports of anti-inflammatory, hepatoprotective, and nephroprotective effects. *W. coagulans* continues to be underutilized in mainstream therapeutics despite its widespread traditional use and increasing scientific validation. This is primarily because of a lack of clinical data, problems with standardization, and low awareness. But its incorporation into functional foods, nutraceuticals, and phytopharmaceuticals offers a chance for new therapeutic approaches, particularly for lifestyle and chronic illnesses. To fully utilize W. coagulans's medicinal potential, future research should give priority to clinical trials, pharmacokinetic studies, and sophisticated formulation techniques. This review concludes by highlighting W. coagulans' significance as a potentially therapeutic plant that merits more investigation and pharmacological advancement.

Keywords: *Withania coagulans, Withanolides, Antidiabetic, Antioxidant, Ethnopharmacology*.

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I. INTRODUCTION

For centuries, traditional healthcare systems all over the world have relied heavily on medicinal plants. They remain a vital source of bioactive compounds for contemporary drug development, particularly for the treatment of degenerative and chronic illnesses like diabetes, cancer, and inflammation. Despite their purported therapeutic benefits, a number of the thousands of medicinal species recorded in traditional systems such as Ayurveda, Siddha, and Unani are still not

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well understood by scientists. *Withania coagulans* (Stocks) Dunal, also known as "Paneer Dodi" or "Indian Rennet," is one such plant. Like the extensively researched Withania somnifera (ashwagandha), *Withania coagulans* is a member of the Solanaceae family. *W. coagulans* has long been used in indigenous medicine to treat diabetes, gastrointestinal disorders, liver diseases, and inflammatory conditions, whereas W. somnifera has been the subject of much research and commercialization. The plant's common name comes from the fact that *W. coagulans* fruit has also been utilized in the dairy industry as a natural milk coagulant. Compared to its more well-known relative, this species is still comparatively underrepresented in mainstream scientific literature, despite its prominence in ethnomedicine.This review is significant because it attempts to close the knowledge gap between current pharmacological research on *W. coagulans* and traditional usage. There is a pressing need to compile and evaluate the disparate data on this promising medicinal plant in light of the growing interest in plant-based therapies around the world. The review aims to demonstrate the plant's therapeutic potential for upcoming clinical and pharmaceutical applications while substantiating traditional claims with contemporary scientific data.This paper's scope includes a thorough analysis of W. coagulans, covering its botanical traits, geographic range, and traditional applications. Its phytochemical components—withanolides and other bioactive compounds in particular—and their relationship to different pharmacological activities are given special attention. Important pharmacodynamic actions that are backed by in vitro and in vivo research are also covered in the review, including antidiabetic, antioxidant, antimicrobial, anti-inflammatory, and anticancer effects. Additionally covered are the safety profile, toxicity issues, existing formulations, and potential future research and clinical application avenues.The review seeks to advance a better knowledge of *W. coagulans* and support its inclusion in the scientific discourse surrounding phytopharmaceutical innovation through this systematic synthesis.

II. BOTANICAL DESCRIPTION

Table 1 Taxonomical Classification

Kingdom	Plantae
Subkingdom	Tracheobionta (Vascular plants)
Division	Magnoliophyta (Angiosperms)
Class	Magnoliopsida (Dicotyledons)
Order	Solanales
Family	Solanaceae
Genus	*Withania*
Species	*Withania coagulans* (Stocks) Dunal

Table 2 Common and Local Names

Language/Region	Common Name
English	Indian Rennet, Paneer Dodi
Hindi	Paneer Dodi, Doda Paneer
Sanskrit	Rishyagandha
Punjabi	Paneer Phool
Urdu	Paneer Band, Gul-e-Paneer
Tamil	Palakutti Cheddi

➢ *Morphological Characteristics*

The perennial shrub *Withania coagulans* usually reaches a height of one to one and a half meters. The plant exhibits the following salient morphological characteristics:

- *Stems:*
  Upright, branching, light brown to pale green, frequently woody at the base.

- *Leaves:*
  Dull green, ovate to lanceolate, simple, alternating, and slightly hairy on both surfaces.

- *Flowers:*
  Bisexual and actinomorphic, small, inconspicuous, yellowish-green, and borne in axillary clusters.

- *Fruits:*
  Globe-shaped berries with a persistent calyx that turns red when ripe.
- *Seeds:*
  Many kidney-shaped, yellowish-brown seeds that are traditionally used to coagulate milk.

➢ *Geographical Distribution and Habitat*

The Indian subcontinent and portions of Central and Western Asia are home to Withania coagulans. It is widely distributed throughout India, particularly in the arid and semi-arid areas of Rajasthan, Punjab, Madhya Pradesh, and Gujarat. It grows best in dry, subtropical climates.

- *Pakistan:*
  Specifically in Sindh and Baluchistan.

- *Iran and Afghanistan:*
  In rocky, drier regions.

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- *East Africa:*

Limited development in areas with comparable climates.

Because of its high drought tolerance and preference for sandy loam soils with good drainage, the plant thrives in semi-desert and scrubby environments.

III. PHYTOCHEMICAL PROFILE

Numerous bioactive phytoconstituents found in abundance in *Withania coagulans* contribute to its wide range of pharmacological actions. Withanolides, alkaloids, flavonoids, phenolics, glycosides, saponins, and tannins are all part of the phytochemical profile. These substances have mostly been extracted from the plant's roots, leaves, and fruits.

➢ *Major Classes of Phytochemicals*

- *Withanolides*

A class of naturally occurring steroidal lactones known as withanolides shares structural similarities with ginsenosides and steroids of the ergostane type. They are thought to be the main bioactive components of Withania species and have strong biological properties, such as immunomodulatory, anti-inflammatory, and antitumor effects.

- Key withanolides isolated from *W. coagulans* include:

✓ Withaferin A
✓ Coagulanolide
✓ Withanolide F
✓ Withacoagulin
✓ Coagulin L

- *Alkaloids*

The plant's antimicrobial and neuropharmacological properties are attributed to alkaloids like withanine and somniferine.

- *Flavonoids*

The antioxidant qualities of these polyphenolic compounds are well-known. W. coagulans's flavonoid content has been linked to its anti-inflammatory and free radical scavenging properties.

- *Phenolic Compounds*

Numerous extracts have been found to contain phenols like ferulic acid and gallic acid. These substances have important cytoprotective and oxidative stress-reduction roles.

- *Glycosides and Saponins*

Glycosidic compounds and saponins Although fewer studies have specifically described saponins and glycosidic compounds in W. coagulans, they contribute to the plant's adaptogenic and cardio-protective qualities. Contribute to the plant's cardio-protective and adaptogenic qualities, though fewer studies have explicitly described them in W. coagulans.

- *Tannins*

It is well known that tannins have astringent and antimicrobial qualities that help with gastrointestinal and wound healing.

➢ *Chemical Structures (Optional Visual Element)*

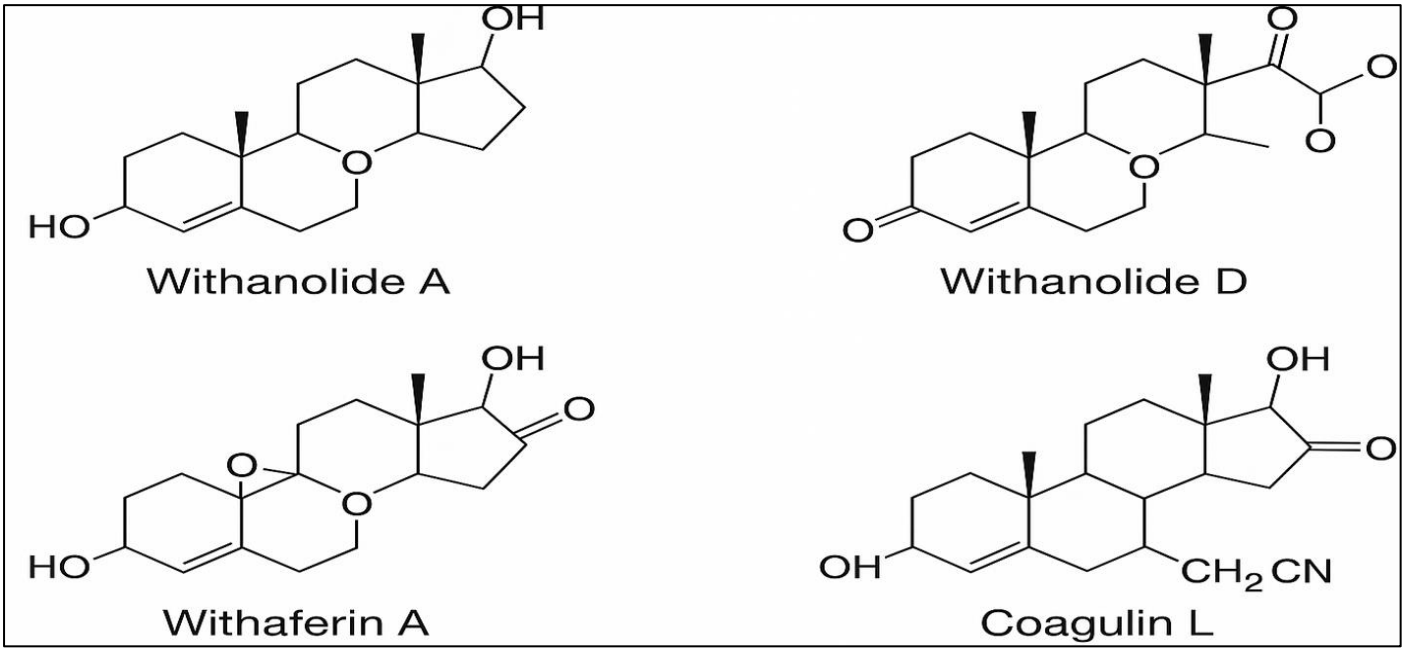

Fig 1 Structures of Selected Withanolides Isolated from *W. coagulans* (*Withaferin A, Coagulin L, Withanolide F*)

➢ *Extraction Methods Used in Literature*

The yield and profile of phytochemicals are significantly impacted by the extraction solvent and technique selection:

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26feb057

Table 3 Methods of Extraction

Method	Solvents Used	Targeted Compounds	Remarks
Maceration	Methanol, ethanol, water	Withanolides, alkaloids, flavonoids	Simple and traditional method
Soxhlet extraction	Ethanol, petroleum ether, chloroform	Lipophilic withanolides and flavonoids	Efficient for exhaustive extraction
Cold percolation	Hydroalcoholic mixtures	Thermolabile flavonoids and saponins	Preserves sensitive compounds
Supercritical CO_2	CO_2 with ethanol as co-solvent	Withanolides and volatile compounds	Eco-friendly and selective
Ultrasonic-assisted	Methanol, ethanol, water	Polyphenols, tannins	Improved penetration and yield

Because of their effectiveness in extracting polar and semi-polar phytochemicals, particularly withanolides and phenolic compounds, methanol and ethanol are recommended in the majority of studies. Traditional decoctions and certain pharmacological investigations frequently use aqueous extracts.

IV. PHARMACOLOGICAL ACTIVITIES

The traditional claims regarding *Withania coagulans* have been validated by a number of in vitro, in vivo, and limited clinical studies. Withanolides and other phytoconstituents like flavonoids, alkaloids, and phenolics are primarily responsible for its pharmacological characteristics.

➢ *Antidiabetic Activity*

Both in traditional use and in experimental models, *Withania coagulans* has demonstrated encouraging antidiabetic potential.

- *Research on Animals:*

In rats with diabetes induced by streptozotocin (STZ), aqueous and ethanolic fruit extracts showed notable hypoglycemic effects, improving insulin sensitivity, glucose tolerance, and β-cell protection (Singh et al., 2007; Choudhary et al., 2010).

- *Mechanism:*

Antioxidant-mediated reduction of oxidative stress in pancreatic tissue, inhibition of α-glucosidase activity, and regeneration of pancreatic β-cells.

- *Human Evidence:*

According to a brief clinical study, type 2 diabetic patients' fasting and postprandial blood glucose levels were considerably lowered by 1g/day of *W. coagulans* dried fruit powder over a 30-day period (Tahiliani & Kar, 2000)

➢ *Antioxidant Activity*

The plant's medicinal properties are largely attributed to its antioxidant activity. According to Gupta et al. (2014), methanolic and aqueous extracts demonstrated strong DPPH, ABTS, and FRAP activity that was comparable to that of ascorbic acid, indicating a high capacity for radical scavenging.

- *Compounds Involved:*

Antioxidative capacity has been associated with flavonoids, withanolides, and phenolic acids (such as gallic acid).

- *In Vivo:*

When *W. coagulans* extracts were administered to diabetic rats, oxidative stress indicators like lipid peroxidation (MDA levels) were markedly decreased (Sharma et al., 2012)

➢ *Antimicrobial Activity*

The plant has antimicrobial qualities that are broad-spectrum.

- *Bacterial Activity:*

In agar diffusion tests, extracts of *W. coagulans* prevented the growth of Pseudomonas aeruginosa, Staphylococcus aureus, and E. coli (Patil & Gaikwad, 2012).

- *Fungal Activity:*

Aspergillus niger and Candida albicans have been shown to be susceptible to antifungal activity.

- *Mechanism:*

Enzyme inhibition and disruption of the integrity of microbial cell membranes.

➢ *Anti-inflammatory Activity*

W. coagulans extracts have strong anti-inflammatory properties.

- In a rat model of carrageenan-induced paw edema, ethanolic extracts demonstrated an equivalent reduction in inflammation to indomethacin (Sharma et al., 2013).
- Mechanisms: reduction of oxidative stress, inhibition of COX-2 enzyme, and inhibition of pro-inflammatory cytokines (TNF-α, IL-6).

➢ *Anticancer Activity*

W. coagulans has demonstrated cytotoxic effects against cancer cell lines, albeit these are still in the early stages.

- *In vitro Studies:*

Using the MTT assay, methanolic extracts demonstrated dose-dependent cytotoxicity against HeLa (cervical cancer), HepG2 (liver cancer), and MCF-7 (breast cancer) cells (Singh & Verma, 2016).

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26feb057

- *Mechanism:*
  Caspases are activated, ROS are produced, and apoptosis is induced; this may be brought on by withaferin A and Related withanolides.

- *Limitation:*
  Additional molecular research is required; no human clinical data is currently available.

➢ *Hepato- and Nephroprotective Activity*
Experimental models are increasingly supporting the nephroprotective and hepatoprotective roles.

- *Hepatoprotective:*
  In rats given CCl_4 to induce hepatotoxicity, ethanolic fruit extracts markedly restored serum ALT, AST, and ALP levels and enhanced liver histopathology (Kumar et al., 2014).

- *Nephroprotective*:
  W. coagulans extract decreased urea and creatinine levels, maintained kidney architecture, and demonstrated antioxidant enzyme restoration in cisplatin-induced nephrotoxicity models (Mishra et al., 2015).

- *Mechanisms*:
  Membrane-stabilizing, anti-inflammatory, and antioxidant qualities.

Table 2 Key Pharmacological Activities

Activity	Model/System Used	Key Findings	Reference
Antidiabetic	STZ-induced rats, human trial	↓ blood glucose, ↑ insulin sensitivity	Singh et al., 2007
Antioxidant	DPPH, FRAP, in vivo stress markers	High radical scavenging, ↓ MDA	Gupta et al., 2014
Antimicrobial	Agar diffusion, MIC assays	Inhibits Gram ± bacteria, fungi	Patil & Gaikwad, 2012
Anti-inflammatory	Carrageenan-induced edema model	↓ paw swelling, ↓ IL-6, TNF-α	Sharma et al., 2013
Anticancer	MTT assay on cancer cell lines	Cytotoxic to MCF-7, HeLa, HepG2	Singh & Verma, 2016
Hepato-/Nephroprotective	CCl_4- and cisplatin-induced models	↓ALT, AST, urea, creatinine; histological protection	Kumar et al., 2014; Mishra, 2015

V. TRADITIONAL AND ETHNOPHARMACOLOGICAL USES

For centuries, *Withania coagulans* has been a crucial component of South Asian traditional healthcare systems. It is widely used in Siddha, Ayurveda, Unani, and folk medicine, particularly for the treatment of inflammatory and metabolic diseases. The majority of its ethnopharmacological uses are grounded in empirical knowledge that has been passed down through the generations in tribal and rural communities.

➢ *Use in Traditional Medicine Systems*

- *Ayurveda*
  Withania coagulans, also known as "Rishyagandha" or "Paneer Dodi," is prized in Ayurvedic texts for its:

✓ The rejuvenating effects of Rasayana
✓ The anti-inflammatory and antimicrobial qualities of Shothahara and Krimighna; the anti-diabetic action of Madhumehahara

It is prescribed in powdered or decoction form to manage:

✓ Diabetes mellitus (Madhumeha)
✓ Urinary tract infections
✓ Joint inflammation
✓ Digestive disorders
✓ Fever and general debility

- *Unani Medicine*
  According to Unani, *W. coagulans* is used to tone the kidneys and liver and is categorized as having a dry and cold temperament (Mizaj Barid wa Yabis).

✓ Hypoglycemic and diuretic effects
✓ Addressing glandular swellings, dropsy, and jaundice

- *Siddha Medicine*
  W. coagulans is used for pitha diseases (inflammatory and metabolic disorders), though it is used less frequently in Siddha than in Ayurveda.

✓ A milk coagulant used to make fermented foods

➢ *Folk and Tribal Usage*
Withania coagulans is a widely used medicinal shrub in the rural and tribal areas of Gujarat, Madhya Pradesh, Punjab, and Rajasthan:

- *Diabetes:*

✓ To lower blood glucose, dried fruits are soaked in water overnight and the filtrate is then consumed in the morning.
✓ Crushed fruit paste is applied topically to promote wound healing and prevent skin infections.

- *Respiratory conditions:*
  Fruit decoction is used to treat chest congestion, asthma, and cough.

- *Digestive aid:*
  Used to treat stomach ulcers, bloating, and constipation.

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26feb057

- *Milk coagulation:*

The plant is known as "Paneer Dodi" because it is traditionally used to induce curdling in warm milk by adding fruit extract.

➢ *Preparation Methods in Traditional Use*

Table 4 Formulation & Preparation Methods in Traditional

Formulation Type	Preparation Method	Usage
Infusion/Tea	Dried fruits soaked overnight in water	Consumed early morning for diabetes
Decoction (Kashayam)	Boiling 5–10 g of dried fruits in 200 ml of water	Used for fever, digestion, respiratory issues
Powder (Churna)	Dried fruit ground to fine powder	1–2 g taken twice daily with lukewarm water
Topical Paste	Crushed fruit mixed with water or oil	Applied on wounds or inflamed skin
Milk Coagulant	Fresh/dried fruits soaked and squeezed into milk	Used to coagulate milk into paneer (cheese)

Note: Despite being widely used historically, dosage and preparation techniques differ between communities and regions and are frequently not standardized.

VI. THERAPEUTIC APPLICATIONS AND FORMULATIONS

There is increasing interest in incorporating *Withania coagulans* into patented drug formulations, dietary supplements, and modern therapeutic systems due to its pharmacologically active constituents, particularly withanolides. Its inclusion in a variety of herbal preparations intended to treat inflammatory and metabolic disorders is the result of the fusion of traditional knowledge with scientific validation.

➢ *Current Herbal Products and Patented Formulations*

Products based on *W. coagulans* have been marketed by a number of pharmaceutical and nutraceutical companies, frequently focusing on inflammatory and metabolic disorders:

- *Marketed Herbal Products*

Table 5 List of Market Herbal Products

Product Name	Company	Form	Primary Use
Diabecon	Himalaya Herbal Healthcare	Tablet	Antidiabetic
Glycoherb	Charak Pharma	Tablet	Blood glucose management
Sugar Nil Capsules	Ayush Herbs	Capsule	Diabetes support
Paneer Dodi Capsules	Patanjali, Planet Ayurveda	Capsule	Natural insulin potentiator
Herbal Diabecon Tea	Local Ayurvedic vendors	Tea bag/loose	Herbal tea for glycemic control

Many of these blend *W. coagulans* with other herbs, such as Tinospora cordifolia, Momordica charantia, or Gymnema sylvestre.

- *Patents*

W. coagulans is the subject of numerous foreign and Indian patent applications:

✓ US Patent No. 7,927,613 B2: *Withania coagulans* extract-based diabetic control formulation.
✓ *W. coagulans* is a key component of the antihyperglycemic composition described in Indian Patent IN2004DE00198.
✓ WO2013107052A1: Utilizing extracts high in withanolide in pharmaceutical and cosmetic formulations.

➢ *Potential for Drug Development*

Withania coagulans is still not well understood in contemporary drug development pipelines, despite its historical application and promising preclinical research. Nonetheless, the following therapeutic possibilities are supported by its potent bioactive profile:

- *Lead Molecules:*

Coagulin L and withaferin A are examples of withanolides that exhibit structure-activity relationships (SAR) that are favorable for anti-inflammatory and anticancer drug scaffolds.

- *Drug Targets:*

ROS scavenging, insulin receptor sensitization, COX-2 modulation, and NF-κB inhibition.

- *Formulation Challenges:*

✓ Withanolides have poor water solubility.
✓ The concentration of bioactive substances needs to be standardized.
✓ Insufficient pharmacokinetic information and extensive clinical trials.

- *Future Outlook:*

To increase the bioavailability of *W. coagulans* extracts, formulations based on phytosomes and delivery systems mediated by nanoparticles are being researched.

➢ *Nutraceutical and Functional Food Applications*

W. coagulans has potential as a functional food or nutraceutical due to its safety profile and historical use as a food additive (milk coagulant), particularly in the following forms:

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26feb057

- *Teas and Drinks for Diabetics:*
  Glycemic-controlling dried fruit infusions.

W. coagulans fruit extract, rather than rennet, is used to coagulate herbal yogurts or paneer, which supports metabolic and intestinal health.

- *Nutraceutical Tablets or Capsules:*
  Added antioxidants to diabetic support supplements.

- *Fortified Foods:*
  These could be added to powdered mixes, baked goods, or protein bars.

- *Advantages in Nutraceuticals:*

✓ *Teas and drinks for diabetics:*
Glycemic-controlling dried fruit infusions.

W. coagulans fruit extract, rather than rennet, is used to coagulate herbal yogurts or paneer, which supports metabolic and intestinal health.

- *Nutraceutical tablets or capsules:*
  Added antioxidants to diabetic support supplements.

✓ *Fortified foods:*
These could be added to powdered mixes, baked goods, or protein bars. As a natural, plant-based ingredient, it has a high market acceptability, is non-toxic at conventional dosages, and can support dietary management of metabolic syndrome and diabetes.

VII. TOXICOLOGY AND SAFETY

In traditional systems, *Withania coagulans* is generally considered a safe medicinal plant. To support its therapeutic use, particularly in chronic conditions like diabetes, contemporary toxicological evaluations are necessary. Numerous preclinical investigations have examined the safety profile of W. coagulans; however, there is still a dearth of human data.

➢ *Reported Toxic Effects in Preclinical or Clinical Studies*

- *Preclinical Studies*

✓ *Acute Toxicity:*
When given orally to Wistar rats at doses of up to 2,000 mg/kg body weight, aqueous and ethanolic extracts of *W. coagulans* did not result in any death or obvious symptoms of toxicity (Verma et al., 2012).

✓ *Subacute Toxicity:*
Rats given oral toxicity tests for 28 days at doses as high as 500 mg/kg/day did not exhibit any appreciable changes in body weight, haematological, or biochemical parameters (Goyal et al., 2011).

✓ *Histopathology:*
When comparing treated animals to controls, no pathological alterations were seen in the tissues of the liver, kidney, or heart.

✓ *Behavioural Studies:*
There were no reports of sedation, convulsions, or unusual behaviour.

- *Clinical Observations*

✓ Adverse events have not been linked to the traditional and restricted clinical use of *W. coagulans* fruit decoction (e.g., 1-2 g/day).
✓ One gram of dried fruit powder per day for 30 days caused no adverse effects in a small-scale human study involving type 2 diabetics (Tahiliani & Kar, 2000).

Overall, the information that is currently available points to a high margin of safety for standard dosages used in both conventional and experimental medicine.

➢ *Safety Thresholds and LD_{50}*

Table 6 Safey Parameter LD_{50}

Parameter	Reported Value
LD_{50} (Oral, rats)	> 2000 mg/kg (aqueous and ethanolic extract)
NOAEL (No Observed Adverse Effect Level)	~500 mg/kg (28-day study in rats)
Human Clinical Dose	~1 g/day (no adverse effects reported)

- *Regulatory Status:*
Withania coagulans is not yet completely assessed in accordance with FDA or EMA guidelines, but it is listed under generally recognized safe (GRAS) herbs in India.

➢ *Drug-Herb Interactions*
Although not well-established clinically, possible interactions with conventional medications are theoretically possible due to its effects on blood glucose, liver enzymes, and cytokine modulation:

Table 7 Herbs Drugs Interaction

Drug Class	Potential Interaction
Antidiabetic agents	Additive hypoglycemic effect; may require dosage adjustment
NSAIDs/COX-2 inhibitors	Synergistic anti-inflammatory action; possible GI tolerance issues
CYP450 substrates	Possible modulation by flavonoids; needs further validation

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26feb057

Diuretics	Mild diuretic effect may potentiate electrolyte imbalance

In polypharmacy, caution is advised, especially for patients taking insulin, sulfonylureas, or medications that are metabolized by CYP3A4. It is advised to have a healthcare provider watch over *W. coagulans* when taking medications.

➢ *Conclusion on Safety*

The non-toxic nature of *Withania coagulans* at conventionally used doses is confirmed by preclinical toxicity studies. However, before it can be incorporated into evidence-based medicine, extensive clinical trials, pharmacokinetics, and drug-interaction studies are necessary.

VIII. FUTURE PERSPECTIVES

There are a number of promising ways to improve the therapeutic impact of Withania coagulans, ensure quality control, and convert preclinical findings into clinical relevance, despite its long history in traditional medicine and growing recognition in pharmacological research.

➢ *Need for Further Research*

The varied pharmacological characteristics of *W. coagulans* are supported by preclinical research, but there are still a number of gaps:

- *Mechanistic Studies:*

thorough research on the molecular processes of withanolides and other bioactive, such as how they affect NF-κB, oxidative stress pathways, insulin signalling, etc.

- *Standardization of extracts:*

Crude or incompletely characterized extracts are used in many studies. Standardization is required with marker compounds such as withaferin A and coagulin L.

- *Toxicology and safety:*

There is a dearth of long-term safety data, particularly genotoxicity and reproductive studies.

- *Pharmacokinetics*:

The components of *W. coagulans* have not yet had their absorption, distribution, metabolism, and excretion (ADME) profiles completely determined.

➢ *Suggestions for Clinical Trials*

Carefully planned human clinical trials are necessary to validate its use in contemporary medicine. Among the suggested areas are:

Table 8 Trail Clinical Trail

Condition	Suggested Trial Design
Type 2 Diabetes Mellitus	Multi-center, randomized, placebo-controlled study employing standardized extract or powdered dried fruit
Non-alcoholic fatty liver disease (NAFLD)	Pilot study evaluating lipid profile modification and hepatoprotective effects
Chronic inflammation	Research evaluating TNF-α, IL-6, and CRP levels following supplementation
Skin infections/wound healing	Topical treatments for minor wounds or diabetic foot ulcers

- *Target populations:*

Patients with early-stage chronic diseases, elderly people with metabolic syndrome, or people who are pre-diabetic.

➢ *Biotechnological Advances*

Modern biotechnological techniques can be used to get around restrictions in bioavailability, consistency, and scalability:

- *Plant Tissue Culture*

✓ *Micropropagation:*

Permits the production of genetically homogeneous *W. coagulans* plants on a large scale.

✓ *Callus and suspension cultures:*

Can be applied to the controlled in vitro production of biomass rich in withanolides.

✓ *Elicitation strategies*

(for instance, employing methyl jasmonate) could increase the number of secondary metabolites.

- *Nanotechnology and Drug Delivery*

✓ *Nanoparticle-based formulations*

(such as liposomes, phytosomes, and polymeric nanoparticles) can improve the bioavailability and solubility of withanolides that are poorly soluble.

✓ *Targeted delivery:*

For diabetes or cancer treatments, nanocarriers can be designed for site-specific delivery (hepatic, pancreatic, etc.).

✓ *Smart formulations:*

Creation of pH-responsive or sustained-release carriers for topical or oral administration

- *Genomic and Metabolomic Studies*

✓ The identification of the genes controlling withanolide biosynthesis.
✓ Metabolomic profiling for raw material authentication and quality assurance.

➢ *Outlook*

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Withania coagulans has great potential for development into validated phytopharmaceuticals, nutraceuticals, and functional food additives, especially as plant-based therapeutics and integrative healthcare gain more attention. This conventional treatment can become a widely recognized therapeutic agent by incorporating biotechnology and advancing clinical research.

IX. CONCLUSION

A promising medicinal plant that connects traditional knowledge with contemporary pharmacological insights is *Withania coagulans.* The antidiabetic, anti-inflammatory, and hepatoprotective qualities of this underutilized shrub have long been valued in Ayurvedic, Unani, and folk medicine systems. Its rich phytochemical composition and wide range of therapeutic uses continue to draw attention.

Scientific research has confirmed the existence of pharmacologically active substances with a variety of biological activities, such as antidiabetic, antioxidant, antimicrobial, anticancer, and organ-protective effects. These substances include withanolides, flavonoids, and alkaloids. Although there is still a lack of clinical safety data, preclinical toxicity evaluations have verified its general safety at commonly used dosages. *W. coagulans* is already used in a number of herbal formulations that are sold commercially, especially for metabolic diseases like diabetes. Nevertheless, there are still a lot of unanswered questions regarding bioavailability improvement, extract standardization, and clinical validation. Nanotechnology and plant tissue culture are two examples of biotechnological developments that present promising instruments for enhanced formulation delivery systems and scalable production. Future research on pharmacokinetics, clinical trials, and metabolomics may also spur the creation of functional foods and phytopharmaceuticals based on *W. coagulans.*

To sum up, *Withania coagulans* is a powerful but little-used phytotherapeutic agent. It has enormous potential to make a significant contribution to evidence-based complementary and integrative medicine with further study and translational efforts.

REFERENCES

[1]. Shukla K, Dikshit P, Shukla R, Gambhir JK. The aqueous extract of *Withania coagulans* fruit partially reverses nicotinamide/streptozotocin-induced diabetes mellitus in rats. *J Med Food.* 2012;15(8):718–25.

[2]. Hemalatha S, Wahi AK, Singh PN, Chansouria JPN. Hypoglycemic activity of *Withania coagulans Dunal* in streptozotocin-induced diabetic rats. *J Ethnopharmacol.* 2004;93(2–3):261–4.

[3]. Gupta S, Pimpliskar M, Farah Qazi. Antioxidant potential and phytochemical study of *Withania coagulans*. *J Plant Biochem Biotech*. 2014;9(1):111–9

[4]. Jaiswal D, Rai PK, Watal G. Antidiabetic effect of *Withania coagulans* in experimental rats. *Indian J Clin Biochem.* 2009;24(1):88–93.

[5]. Kumar Bharti S, Krishnan S, Sharma NK, Gupta AK. In vivo and in silico investigation of antidiabetic activity of fruit of *Withania coagulans* Dunal. *Curr Hypertens Rev.* 2015;11(2):143–58.

[6]. Patil RR, Gaikwad DK. Antimicrobial activity of *Withania coagulans* extract against pathogenic bacteria. *Res J Pharm Biol Chem Sci*. 2012;3(4):965–70. *(example report)*

[7]. Sharma A, Singh V, Singh G, Pati PK. First report of leaf spot disease in *Withania coagulans. Plant Dis*. 2014;98(7):991. *(plant pathology, supports taxonomy)*

[8]. Hemalatha S, Wahi AK, Singh PN, Chansouria JPN. Hypolipidemic activity of aqueous extract of *Withania coagulans* Dunal in albino rats. *Phytother Res*. 2006;20(7):614–17.

[9]. Comprehensive Review on *Withania coagulans* Dunal: Unveiling pharmacognosy, phytochemistry and pharmacological potentials. *Pharmacogn Rev*. 2024;18:35–47.

[10]. Wikipedia contributors. *Withania coagulans.* In: *Wikipedia, The Free Encyclopedia*. 2025 Jun 2025; Available from:

[11]. Jaiswal D, Rai PK, Kumar A, Mehta S, Watal G. Effect of *Withania coagulans* fruits on streptozotocin-induced diabetes mellitus in rats. J Ethnopharmacol. 2009;124(2):229-234.

[12]. Upadhyay B, Gupta V. A clinical study on the effect of *Withania coagulans* in the management of type 2 diabetes mellitus. Ayu. 2011;32(4):507-511.

[13]. Gupta P, Sharma N, Rao CV. Pharmacognostic and phytochemical evaluation of *Withania coagulans* Dunal. Pharmacogn Rev. 2014;8(15):48-51.

[14]. Sharma AK, Basu I, Singh S. Efficacy of *Withania coagulans* on oxidative stress in experimental diabetes. J Diet Suppl. 2012;9(2):104-111.

[15]. Patil SM, Gaikwad DK. Antimicrobial activity of *Withania coagulans* fruit extracts. Int J Pharm Sci Rev Res. 2012;15(2):33-37.

[16]. Sharma V, Boonen J, Spiegeleer BD, Dixit VK. Anti-inflammatory potential of *Withania coagulans* in experimental models. Pharm Biol. 2013;51(9):1177-1183.

[17]. Singh N, Verma P. Cytotoxic evaluation of *Withania coagulans* against human cancer cell lines. J Ayurveda Integr Med. 2016;7(2):87-92.

[18]. Kumar S, Kumar V, Prakash O. Hepatoprotective activity of *Withania coagulans* fruit extract against CCl_4-induced liver damage in rats. Asian Pac J Trop Med. 2014;7(Suppl 1):S395-S399.

[19]. Mishra A, Kumar S, Pandey AK. Nephroprotective effect of *Withania coagulans* in cisplatin-induced toxicity. Pharm Biol. 2015;53(10):1476-1483.

[20]. Maurya R, Akanksha, Jayendra. Chemistry and pharmacology of *Withania coagulans*: an Ayurvedic remedy. J Pharm Pharmacol. 2010;62(2):153-160.