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From Traditional Knowledge to Modern Medicine: *Oxalis Corniculata* as a Hepatoprotective and Antibacterial Remedy

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ABSTRACT

Oxalis corniculata, a widely used herb in traditional medicine. The review discusses the plant's rich phytochemical composition, including alkaloids, flavonoids, and phenolic compounds, which contribute to its extensive biological activities. The antibacterial potential of *Oxalis corniculata* is highlighted, with studies demonstrating its effectiveness against a broad spectrum of bacteria. The review also explores the use of nano formulations of *Oxalis corniculata*, which enhance its antibacterial activity through precise manipulation of materials at the nanoscale. Additionally, the hepatoprotective properties of *Oxalis corniculata* are discussed, including its ability to protect liver cells against oxidative stress and inflammation. The review concludes that *Oxalis corniculata* holds great promise in the development of novel therapeutic agents against bacterial infections and liver diseases.

Key words: *Antibacterial, CCL4, Hepatoprotective, Oxalis corniculata, Paracetamol, Silver nanoparticles*

INTRODUCTION

Ayurveda, a scientific practice of balanced living, has its roots in the ancient texts of Rigveda and Atharvaveda. As a traditional healthcare system in India, Ayurveda has been utilized for centuries for treating and managing a range of illnesses. Many medications derived from Ayurveda have been implemented over time, transitioning from ancient tradition to current trends. However, to enhance the efficacy of Ayurvedic medicine, it is essential to delve deeper into its potential through modern scientific validation methods, leading to more effective therapeutic advancements.[1,2]

In recent years, the prevalence of bacterial infections and liver disorders has become a major global health concern.[3] The emergence of antibiotic-resistant bacterial strains and the increasing incidence of liver diseases necessitate an urgent search for alternative therapeutic options.[4] Traditional medicines, derived from natural sources, have long been recognized for their potential medicinal applications due to their diverse chemical composition and biological activities.[5] Among these, *Oxalis corniculata* (commonly known as creeping woodsorrel has gained significant attention for its remarkable antibacterial and hepatoprotective properties.

Bacterial infections pose a significant threat to public health, leading to increased morbidity and mortality rates globally. The rapid spread of antibiotic-resistant bacteria, including methicillin-resistant Staphylococcus aureus (MRSA) and vancomycin-resistant Enterococcus

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(VRE), has further complicated the treatment of bacterial infections.[6-8] The development of new antibacterial agents to combat these resistant strains has become an urgent need. In this context, extensive research has focused on finding alternative sources of antibacterial agents, and plants have proven to be a valuable reservoir of bioactive compounds.

Nano formulation refers to the development and utilization of nanoparticles for the enhancement of antibacterial activity. In recent years, the emergence of antibiotic-resistant bacteria has become a global health concern, necessitating the development of new and effective antibacterial agents. Nanotechnology offers a promising approach in this regard, as it enables the precise manipulation of materials at the nanoscale to enhance their antibacterial properties.[9-11]

The unique properties exhibited by nanoparticles, such as their high surface area-to-volume ratio, size-dependent chemical reactivity, and ability to penetrate bacterial cell walls, make them excellent candidates for enhancing antibacterial activity.[12] Nano formulations can be designed to release antibacterial agents in a controlled manner, allowing for sustained and targeted delivery to the site of infection. This targeted release not only enhances bactericidal activity but also minimizes the potential for systemic toxicity often associated with conventional antibiotics.[13,14]

Liver diseases, including hepatitis, alcoholic liver disease, and non-alcoholic fatty liver disease, constitute a growing global burden.[15,16] Hepatoprotective agents that can prevent liver damage and promote hepatic regeneration are of paramount importance in the management of liver disorders.[17] *Oxalis corniculata* has been traditionally used as a hepatoprotective agent, and scientific studies have now validated its potential in preventing liver damage and promoting liver health.

This review aims to provide a comprehensive overview of the antibacterial and hepatoprotective activity of *Oxalis corniculata*. It will summarize and critically evaluate the existing scientific literature pertaining to its phytochemical composition, antibacterial mechanisms, and hepatoprotective effects. Additionally, this review will highlight the potential future applications of *Oxalis corniculata* in the development of novel therapeutic agents against bacterial infections and liver diseases.

METHODOLOGY

Plant profile[18]

Oxalis corniculata, a member of the Oxalidaceae family, is a perennial herb widely found in various parts of the world, including Asia, Europe, and North America. It has been used for centuries in traditional medicine systems, such as Ayurveda and Unani, to treat various ailments. The plant possesses a rich phytochemical profile, including flavonoids, alkaloids, tannins, saponins, and phenolic compounds, which contribute to its extensive biological activities.

Phytochemistry

Oxalis corniculata contains different type of secondary metabolites like alkaloids, glycosides, carbohydrates, tannin, phytosterols, phenolic compounds, flavonoids, amino acids and volatile oils.[19] β-sitosterol, betulin, 4-hydroxybenzoic acid, ethyl gallate, 5-hydroxy-7,8-dimethoxyflavone, 5-hydroxy-3', 4', 6, 7, 8-pentamethoxyflavone, 7, 5'- dimethoxy-3, 5, 2'-trihydroxyflavone, 5-hydroxy-3 , 6, 7, 4'-tetramethoxyflavone, 4', 5-hydroxy-3, 6, 7- trimethoxy flavone, 5-hydroxy-3, 6, 7, 4´-tetramethoxyflavone, apigenin 7-O-β-D glucoside and 3, 3', 5, 7-trihydroxy-4'-methoxyflavone 7-O-β-D glucopyranoside these are responsible for prevention of different disease.

It also showed the presence of calcium, fiber and tannin. Leaves contain tartaric acid and citric acids, calcium oxalate, flavones (acacetin and 7,4'- diOMe apigenin), glycoflavones (4'-OMe vitexin, 4'- OMeiso-vitexin and 3',4'-diOMe orientin), flavonols (3',4'-diOMe quercetin) and phenolic acids such as phydroxybenzoic, vanillic and syringic acids, isoorientin, isovitexin and sertisin. Phytochemistry of common phytocompounds were presented. (Figure no. 1)[20,21]

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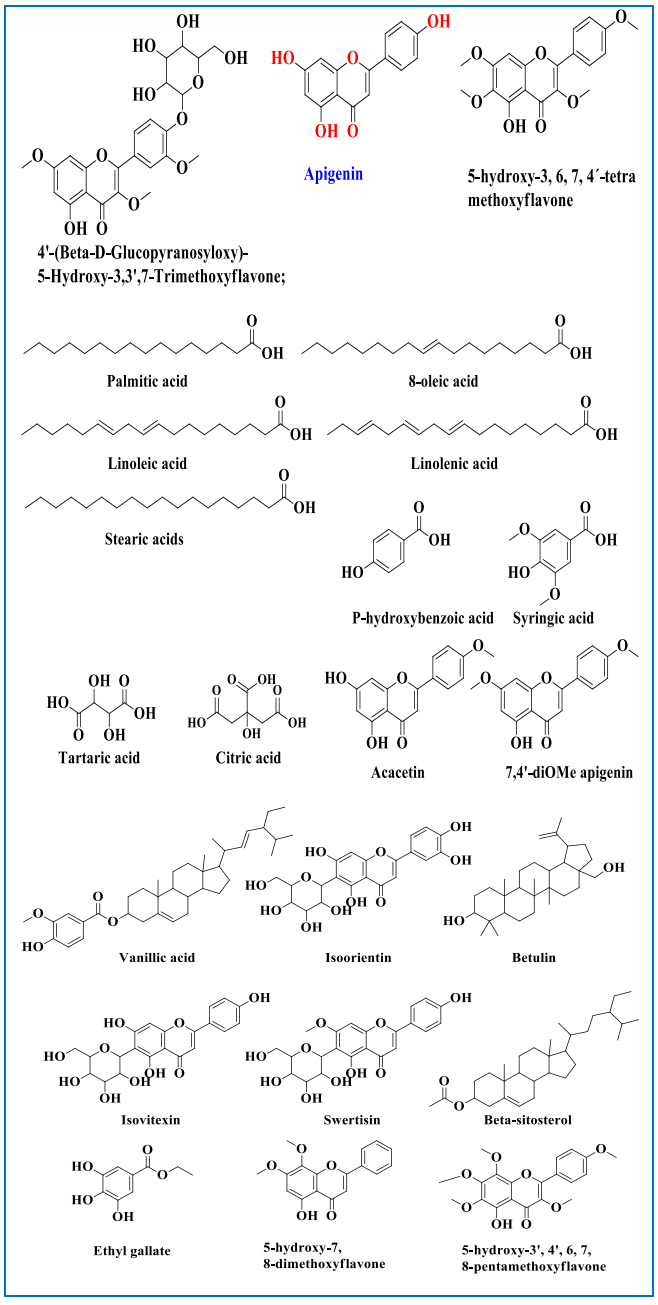
Fig. 1: Phytochemistry of selected phytocompounds of *Oxalis corniculata* Linn



Therapeutic uses[22]

The potent combination of alkaloids, flavonoids, terpenoids, cardiac glycosides, saponins, phlobatannins, and steroids found in the Oxalis plant offers a host of beneficial properties. These include protecting against various ailments, as well as displaying a range of biological activities such as fighting against fungal infections, preventing cancer, combating oxidative stress, battling bacterial infections, managing diabetes, and safeguarding the heart. Additionally, the plant's bioactive phytochemicals have shown promising capabilities in promoting wound healing.

Antibacterial activity of *Oxalis corniculata*

Various studies have reported the antibacterial potential of *Oxalis corniculata* against a broad spectrum of bacteria, including Gram-positive and Gram-negative strains. The antibacterial activity exhibited by this plant can be attributed to its bioactive constituents, such as flavonoids (quercetin and kaempferol), alkaloids (berberine and salsolinol), and phenolic compounds (gallic acid and ellagic acid). These compounds exert their antimicrobial effect through different mechanisms, including inhibition of bacterial cell wall synthesis, disruption of cellular membranes, and interference with bacterial nucleic acid synthesis.[23] Table 1 provides a comprehensive compilation of information on the antibacterial activity of *Oxalis corniculata*.

Silver nano formulation of *Oxalis corniculata*

Moreover, the small size of nanoparticles enables them to interact with bacteria at the cellular and molecular level, disrupting essential biological processes and leading to the effective elimination of bacterial pathogens. Additionally, the surface properties of nanoparticles can be engineered to specifically interact with bacterial membranes, increasing membrane permeability and inducing bacterial cell death. (Table 2)

In this review, particular attention is directed towards the evaluation of the nano formulation of *Oxalis corniculata* in order to determine its effectiveness in inhibiting bacterial growth. Understanding the mechanisms through which nano formulations exert their antibacterial activity will not only contribute to the development of new and effective therapies but also provide valuable insights into the design and optimization of future nanoparticle-based antibacterial agents.

Hepatoprotective activity of *Oxalis corniculata*

The hepatoprotective activity of *Oxalis corniculata* can be attributed to its antioxidative and anti-

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inflammatory properties. The plant's bioactive components, such as flavonoids, saponins, and phenolic compounds, play a crucial role in protecting liver cells against oxidative stress and inflammation. Additionally, *Oxalis corniculata* exhibits hepatoprotective effects by enhancing liver detoxification pathways, improving bile secretion, and reducing liver fibrosis. "Detailed information on the hepatoprotective activity of *Oxalis corniculata* and its mechanism is provided in Table 3."

CONCLUSION

Oxalis corniculata represents a promising natural source of antibacterial and hepatoprotective agents. Its diverse phytochemical profile and biological activities make it a subject of significant interest and research. Understanding the antibacterial mechanisms and hepatoprotective effects of *Oxalis corniculata* provides valuable insights for the development of novel therapeutic interventions to combat bacterial infections and liver diseases.

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Table 1: Antibacterial activity of *Oxalis corniculata*

SN	Plant part used	Solvent used for extraction	Test microorganisms	Method used	References
1.	Leaves	Methanol or acetone	Staphylococcus aureus and Streptococcus Sp.	agar well diffusion method	24
2.	*Oxalis corniculata* cream	Water	Staphylococcus aureus and Escherichia coli	Disk diffusion method	25
3.	Leaf	Ethanol, Methanol and Petroleum ether	Staphylococcus faecalis, Escherichia Coli, P. Vesicularis, Aeromonas hydrophilia, Staphylococcus cohni, Serratia ficaria and S. Typhi.	agar well diffusion method	26
4.	Whole plant	Water	*Staphylococcus aureus*, *Streptococcus pyogenes*, *Escherichia coli, Klebsiella pneumoniae*, *Salmonella typhi,* and *Pseudomonas aeruginosa*.	disk-diffusion and broth-dilution methods	27
5.	Whole plant	Methanol	*Escherichia coli, Salmonella Typhi,* MDR *Salmonella Typhi, Klebsiella pneumoniae,* and *Citrobacter koseri*	agar well diffusion method	28
6.	Leaves	Aqueous extracts	Citrobacter sp., Escherichia coli, Klebsiella sp., Proteus mirabilis, Pseudomonas aeruginosa, Salmonella typhi, Salmonella typhimurium, Salmonella paratyphi A, Salmonella paratyphi B, Shigella boydii, Shigella flexneri, Shigella sonnei, Staphylococcus aureus and Streptococcus faecalis	cup diffusion method	29

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7.	Leaves	Methanol	*Staphylococcus aureus*, *Escherichia coli*, *Shigella dysenteriae, Shigella flexneri, Shigella boydii,* and *Shigella sonnie*	A suckling mouse model	30
8.	Plant	Methanol	Staphylococcus aureus, Escherichia coli, and Candida albicans	hole diffusion method	31
9.	Leaves	Ethanol	Staphylococcus aureus	microbroth dilution method	32
10.	Leaves	Methanol	*Staphylococcus aureus*, *Escherichia coli*, *Salmonella* Typhi, *S.* Typhiimurium and *Vibrio cholera*	agar well diffusion method	33
11.	Leaves	water (W), benzene (B), and acetone	Escherichia coli (MDR), Staphylococcus aureus (MDR), Klebsiella pneumoniae, Bacillus cereus, Vibrio cholerae and Candida albicans	agar well diffusion method	34
12.	Whole Plant	Hydroethanol	Escherichia coli, Staphylococus aureus, Enterococus faecalis, Pseudomona aeruginosa, Salmonella aboni, Staphylococus aureus meticilline resisting and Staphylococus epidermidis	p-iodonitrotetrazolium microdilution method	35
13.	Leaves	Ethanol	Lactobacillus E.Coli	well diffusion method	36
14.	Leaves	Water	Staphylococcus aureus and E.coli	disc diffusion method	37

Table 2: AgNPs of *Oxalis corniculata* and its antimicrobial activity.

SN	Formulation	Solvent used for extraction	Test microorganisms	Method used	References
1.	silver nanoparticles (AgNPs)	Water	*Staphylococcus aureus*, *Streptococcus pyogenes*, *Escherichia coli,*	disc diffusion method	38
2.	silver nanoparticles (AgNPs) Leaves	Water	Staphylococcus aureus and Escherichia Coli.	agar well diffusion method	39
3.	silver nanoparticles (AgNPs) Plant	Water	*Staphylococcus aureus*, *Streptococcus pyogenes*, *Escherichia coli, Klebsiella pneumoniae*, *Salmonella typhi,* and *Pseudomonas aeruginosa*.	agar well diffusion method	40
4.	*Oxalis corniculata* leaf extract–derived silver nanoparticles	double distilled water	*Bacillus subtilis* and *Escherichia coli*	agar well diffusion method	41

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Table 3: Hepatoprotective activity of *Oxalis corniculata*

SN	Part of plant used	Solvent used for extraction	Inducing agent	Mechanism of action	Animals used	Reference
1.	Aerial parts	Methanol	CCL4	The test drug, OCME, demonstrated its mechanism of action by counteracting the effects of CCl4-induced liver damage. Specifically, CCl4 caused an increase in several biochemical markers, including AST, ALT, ALP, LDH, γ-GT, total bilirubin, cholesterol, and triglycerides, while decreasing total protein and albumin levels. Additionally, CCl4 led to a decrease in liver glutathione (GSH) content and antioxidant enzyme activities (CAT, SOD, GSH-Px, GST, GSR, QR), along with an increase in thiobarbituric acid reactive substances (TBARS) content and the development of hepatic lesions. Treatment with OCME reversed these adverse effects, bringing all parameters back to control levels.	Male Sprague-Dawley rats	42
2.	Whole plant	Ethanol	Paracetamol	Rats pre-treated with OC for 4 days showed significant reduction in the serum enzymes such as glutamate oxaloacetate transaminase, glutamate pyruvate transaminase, alkaline phosphatase, serum bilirubin and showed almost normal histological liver architecture of the treated groups compared to paracetamol induced hepatic damage group, indicating its hepatoprotective and antioxidant potential.	Wister albino male rats and male swiss albino mice	43
3.	Whole plant	Water and ethanol	Thioacetamide	the aqueous and ethanolic extracts of O. corniculata's aerial parts exerted their hepatoprotective effects by reducing liver enzyme levels (SGOT, SGPT, GGTP, ALP) and total bilirubin content, which were elevated in thioacetamide-damaged rats. The extracts also exhibited a dose-dependent reduction of liver necrosis. The exact molecular pathways or bioactive compounds responsible for these effects would require further investigation.	Wister rats	44
4.	Leaf and stem	Methanol	Isoniazid and rifampicin	Reduction of liver enzyme levels (SGOT, SGPT, GGTP, ALP) and total bilirubin content	Male wister rats	45
5.	Leaves	Water	CCL4	The mechanism of action for the aqueous extract of *Oxalis corniculata* in reducing carbon tetrachloride-induced damage in the liver. The bioactive compounds present in the extract exert hepatoprotective effects elevated levels of liver function markers such as SGOT, SGPT, SALP, and serum bilirubin, indicating a protective effect on liver function.	Female albino wister rats	46

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6.	Plant	Methanol	Ccl4/ Phenyl hydrazine	The test drug was evaluated for its impact on liver function through the analysis of key biomarkers including AST, ALT, ALP, bilirubin, cholesterol, triglyceride, and HDL-C levels in the blood. Additionally, a histopathological examination of liver tissue was conducted. In the CCl4 model, both test groups A and B demonstrated a significant reduction in serum bilirubin levels. However, the test drug did not show a significant effect on cholesterol and HDL-C levels in the PHH test. Notably, there was a significant decrease in triglyceride levels in both the standard and test group B compared to the negative control ($p<0.001$).	Wister rats	47

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