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Phytochemical constituents, extraction and pharmacological activity of vitex agnus-Castus nanoparticle

RA. Devaakshayah shreenithee, J.P. Shanmadi * and A.B. Hariharasudhan

Department of pharmacy practice, Vinayaka Mission's College of Pharmacy, Vinayaka Mission's research foundation (deemed to be university), Yercaud main road, Kondappanackenpatty, Salem, Tamil Nadu, India.

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Abstract

As a participant of the Verbenaceae family, Vitex agnus-castus comprises a wide range of chemical machineries, including flavonoids, phenolic compounds, iridoid glycosides, and essential oils. Because of its hormonal effects, it is primarily used to treat PMS, menstrual disorders, and menopausal difficulties. Green synthesis, which services plant extracts convert into metal ions into nanoparticles, its process used to make Vitex negundo nanoparticles, also denoted as nano formulations or nanoscale versions of Vitex negundo extract. This process comprises heating or ultrasonicating the plant extract after it has been jointing with a solution containing metal ions, such as silver, gold, copper oxide, or zinc oxide. This allows the phytochemicals in the extract to reduce metal ions into nanoparticles. The green synthesis experiments are both environmentally kind and sustainable. Vitex linn leaf extract is the starting point for silver and gold nanoparticles, which has some indication in pharmacological properties because of their nanoscale features, which gives antimicrobial, anti-inflammatory property, antitumor, and wound-healing abilities.

Keywords: Vitex Agnus; Nanoparticle; Silver Nanoparticle; Extraction; Composition

1. Introduction

Emerging new drug molecules from variety of botanical features which evaluating plant products from their medicinal and therapeutic potentials. Vitex negundo is one of the wider plants that have been focus of wide education since antiquity. One member of the Verbenaceae family is Vitex agnus-castus (1). Under common name of nirundi (Hindi) and five leaved chaste trees (English). It is distributed across Central Asia, the Mediterranean region, and Southern Europe, and is harvested in various geographical areas(2).

Vitex negundo L. is a fragrant, typically characterized by its five-angled branches. The fruits of V.agnus-castus contain a diverse array of chemical constituents, including essential oils, flavonoids, iridoid glycosides, and diterpenoids like agnuside, isoflavonoids, and phenolic compounds . Employed in traditional and folk medicine to address a broad array of health ailments. The primary use of V. agnus-castus is in treating PMS, menstruation disorders, and menopausal problems, leveraging its hormonal effects(1,3).

Nanoparticles are entities that vary in size from 1 to 100 nano meters and, because of their dimensions, Nanotechnology is utilized across various domains including medicine (30%), advanced materials (29%), information technology (21%), energy (10%), automotive industries (5%), aerospace (2%), textiles (2%), and several other emerging hybrid fields. Producing nanoparticles from Vitex negundo involves a method termed green synthesis whereas Vitex negundo nanoparticles display multiple pharmacological effects owing to their improved characteristics at the nanoscale that includes antimicrobial, anti-inflammatory, and antitumor activities. Vitex negundo nanoparticles are alternatively referred to as nano formulations or nanoscale versions of Vitex negundo extract(4,5).

* Corresponding author: J.P. Shanmadi

wider studies have observed into effects of plants that have archaeologically been used by herbalists and native healers to treat liver diseases. By descriptive the mechanisms& actions of these plants and restating their healing worth through clinical studies, this research has often validated traditional data.(1,3).

2. Description

- **Habit:** A branched shrub reaching up to 5 meters in height, or a small, slender tree.
- **Duration:** long -lasting.
- **Medicinal Parts Used:** Roots, fruits, flowers, leaves, bark(4).

Leaves: Palmately compound with petioles measuring 2.5-3.8 cm long; typically trifoliate, occasionally penta-foliate. In trifoliate leaves, the leaflets are lanceolate or narrowly lanceolate, with the middle leaflet being 5-10 cm long and 1.6-3.2 cm wide, and petioles about 1-1.3 cm long. The other two leaflets are nearly sessile. (fig 1.2) In penta-foliate leaves, the inner three leaflets have petioles, while the remaining two are almost stalkless. The upper surface of the leaves is smooth (glabrous), and the underside is hairy (tomentose); the texture is leathery and typically pungent odor(6).

Roots: Cylindrical, hard, and tough with irregular fractures. The external surface is rough with longitudinal narrow cracks and small rootlets. The cut surface reveals a greyish-brown cork region, a greyish-white middle region, and a cream-colored xylem region (fig 1.1). The bark is thin and easily separates from the wood, which is hard and forms the major part of the root(7).

Flowers: Small, bluish-purple flowers form large, terminal, often compound pyramidal panicles. (fig 1.3)

Seeds: 5-6 mm in diameter.in (fig 1.5).

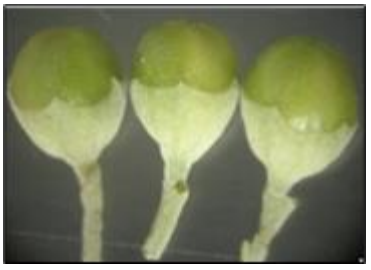
Fruit: Rounded drupe, 1 to 3 mm in diameter, with 1/3rd to 3/4th of its size surrounded by a dull grey, cup-like, persistent calyx and pedicel (fig 1.5). The calyx cup may have one or two vertical splits. The fruit is light brown to black in colour, with two locules, each containing two seeds. The texture is smooth, and the taste and Odor are not distinctive(7).

Vitex root (fig 1.1)

Vitex leaves (fig1.2)

Vitex flowers (fig1.3)

Vitex negundo L (fig1.4)



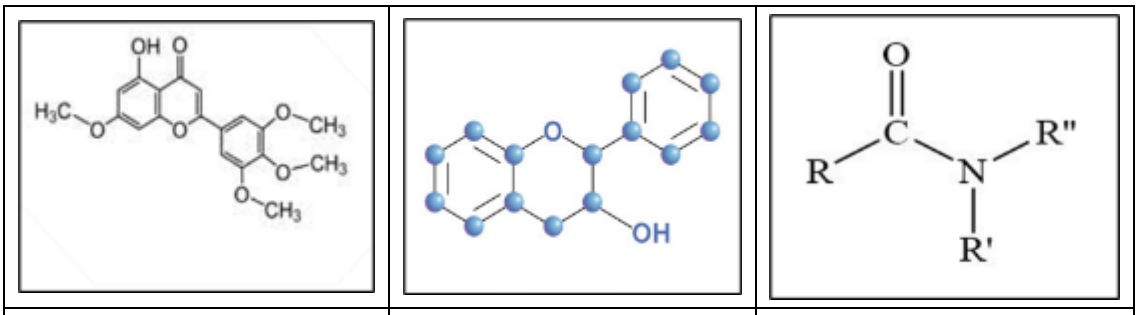
Vitex negundo seeds and fruits (fig 1.5)

Figure 1 Morphology of Vitex negundo

3. Chemical composition of vitex negundo nanoparticles

- **Zinc oxide (ZnONPs) nanoparticles phytochemical:** The bioactive substance corymbosin, which originates from Vitex negundo, is vital part of production of ZnO nanoparticles (8)

- **Copper oxide (CUO NPs) nanoparticle Phytochemicals:** The chief components of cap and stabilize CuO nanoparticles are proteins, amides, flavonoids, and tannins found in the leaves of Vitex agnus castus(8,9).
- **Magnesium Oxide (MgO NPs) Nanoparticles Phytochemicals:** Magnesium oxide synthesis is assisted by the flavonoids and phenolics found in Vitex leaf extract (9).
- **Gold (Au NPs) nanoparticles Phytochemicals:** Gold nanoparticle formation is assisted by flavonoids and other dropping agents found in Vitex extracts.
- **Silver (Ag NPs) nanoparticles Phytochemicals:** The Vitex negundo extract's flavonoids and polyphenols aid to stabilize and diminish silver nanoparticles (10).



(Corymbosin,)	*(flavonoids)*	*(amides)*

Figure 2 Structure of components of vitex negundo

4. Pharmacological actions

The mechanisms of action for Vitex negundo are complex and involve multiple pathways, but some of the key pharmacological activities are

4.1. Analgesic Activity

Administering certain leaf and root extracts intraperitoneally with various solvents exhibited pain-relieving effects(11).

4.2. Anti arthritic Activity

The anti-arthritic properties of the ethanolic extract from Vitex negundo Linn leaves were evaluated. Arthritis was induced using FCA, and the anti-arthritic activity of the leaf extract was analysed through liver function tests and radiological examinations.

4.3. Central nervous system activity

The central nervous system (CNS) and anticonvulsant effects of petroleum ether and methanolic extracts from Vitex negundo were studied in mice.

The mechanisms of action for Vitex negundo nanoparticle are complex and involve multiple pathways, but some of the key pharmacological activities are

4.4. Antitumor effects

Researchers investigated the antitumor effects of the ethanolic extract from Vitex negundo leaves against Dalton's ascitic lymphoma in Swiss albino mice. longer lifespan, cancer cell count, cancer volume and mean survival period among parameters measured in the study. Linking the ethanolic leaf extract of Vitex to the qualified medication, the results exhibited that the former had greater antitumor activity (12,13).

4.5. Anti Inflammatory Effects

Via carrageenan-induced paw oedema models for acute inflammation and carrageenan-induced granuloma copies for sub-acute inflammation, the anti-inflammatory abilities of Vitex Linn leaf extract were studied. To inspect the part prostaglandins plays in the extract anti-inflammatory properties, a rat uterus was remoted (14).

4.6. Antimicrobial effects

The antimicrobial properties of essential oil mined from Vitex Linn leaves were evaluated against a series of pathogenic microorganisms, including Candida albicans, S. aureus, E. coli, K. pneumoniae, B. subtilis, and M. luteus. Linking the essential oil to the standard, the results displayed that it had strong antimicrobial activity (7).

5. Traditional use of vitex negundo nanoparticle

- **Root :** known for their tonic, febrifuge, antirheumatic, diuretic, and expectorant properties, the roots are also demulcent and used in the treatment of dysentery, cephalalgia, otalgia, colic, uropathy, wounds, and ulcers.
- **Bark:** useful in treating odontalgia, erminois, and ophthalmopathy.
- **Leaves :** the leaves are bitter, aromatic, acrid, astringent, anti-inflammatory, antipyretic, bronchial smooth muscle relaxant, anti-arthritic, anthelmintic, and vermifuge.
- **Flower :** the flowers have cool, astringent, carminative, hepatoprotective, digestive, febrifuge, and vermifuge properties, and they are useful in treating hemorrhage and cardiac disorders.
- **Fruits:** acts as a nervine, cephalic, aphrodisiac, emmenagogue, and vermifuge.
- **Additional use :** some villagers use vitex negundo to clean their teeth. the leaves are also used to protect grains from insects and are used in bathing water to treat skin diseases (5,13).

6. Extraction

Vitex linn nanoparticles are formed using a method acknowledged as green synthesis, which customs plant extracts to convert metal ions into nanocrystals. The plant extract is assorted with a solution containing metal ions (such as silver, gold, copper oxide, and zinc oxide). The mixture is then subjected to heat or ultrasonication to aid the reduction of metal ions into nanoparticles by the phytochemicals present in the extract (6,15).

7. Extraction silver nanoparticle

7.1. Preparation of leaf extract

fresh leaves of Vitex negundo were harvested and cleaned meticulously using both tap water and distilled water to eliminate any contaminants. Subsequently, they were air-dried at room temperature over a span of two weeks. Once dried, the leaves were finely chopped into small fragments and ground into a fine powder (16).

A quantity of 5 grams of this powdered Vitex negundo leaf material was then immersed in 100 millilitres of distilled water and heated to 80° C. Afterward boiling for 10 minutes, the assort was extracted through Whatman No. 1 filter paper to eliminate any solid residues. Then finally extract was then cooled to 4° C and conserved for later use in the synthesis of nanocrystals (4).

7.2. Synthesis of silver nanoparticle

A 1 mm aqueous solution of silver nitrate (AgNO3) was made in order to generate silver nanocrystal. A volume of 100 millilitres of vitex leaf extract was measured in a contrast conical flask. The vitex leaf extract was assorted with the manufacture 1 mm AgNO3 solution after a 20-minute hold back. After that, the blend was warmed up until there was a discernible color transfer, going carried out by pale green-yellow to a dark or golden-brown tint, which would advise the creation of silver nanoparticles (Ag NPs). One container was preserved as a control and the silver nitrate solution was not attached. (12).

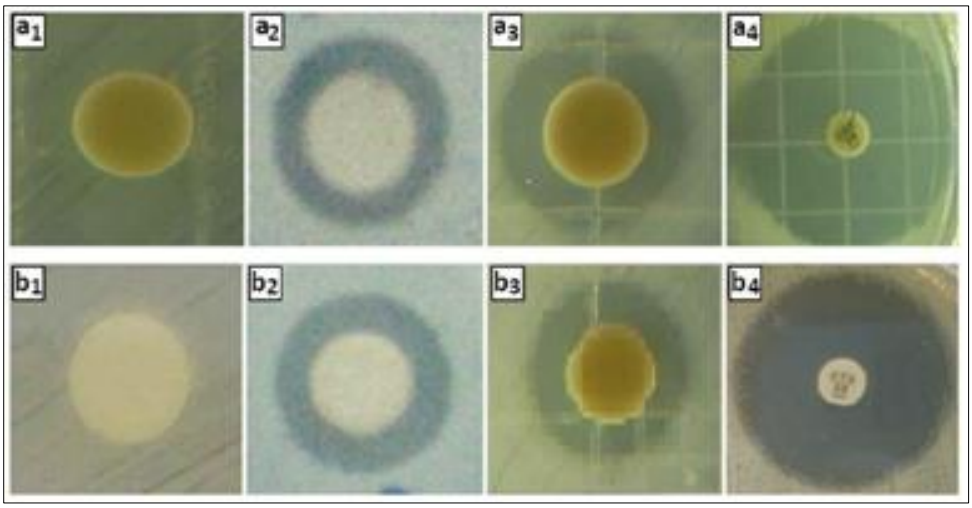


Figure 4 Silver nanoparticle synthesis

8. Extraction gold nanoparticle

8.1. Root extract of vitex negundo

We buy the dried root of Vitex linn from M/s United Chemical and Allied objects, an Indian company with its main office pinpointed in Kolkata. Twenty millilitres of double-distilled water were used to liquefy two grams of dry root powder, which was then injected for 48 hours at a temp between 2 to 8° C. Following this incubation period, the solution underwent centrifugation, and the supernatant was carefully collected. The dry weight of the collected supernatant was then measured. The concentration of the extract was expressed in terms of dry weight (mg/ml, w/v)(10).

8.2. Preparation of vitex negundo gold nanoparticle

A volume of 45 millilitres of ultrapure water was heated to 80° C and stirred at a speed of 550 rpm. following, while thrilling continuously, 1.25 millilitres of a 10 mm HAuCl4 solution was progressively added to the water. After that, the solution was attach to 5 millilitres of Vitex linn extract, which contained 17 milligrams of dry weight. The assort was then continuously upset for 30 minutes. After gold nanocrystal (VN-GNP) set up , the assort was centrifuged for 30 min at 30,000 rpm. The nanocrystals were re- abstain in ultrapure water for extra use after centrifugation. (2,16).

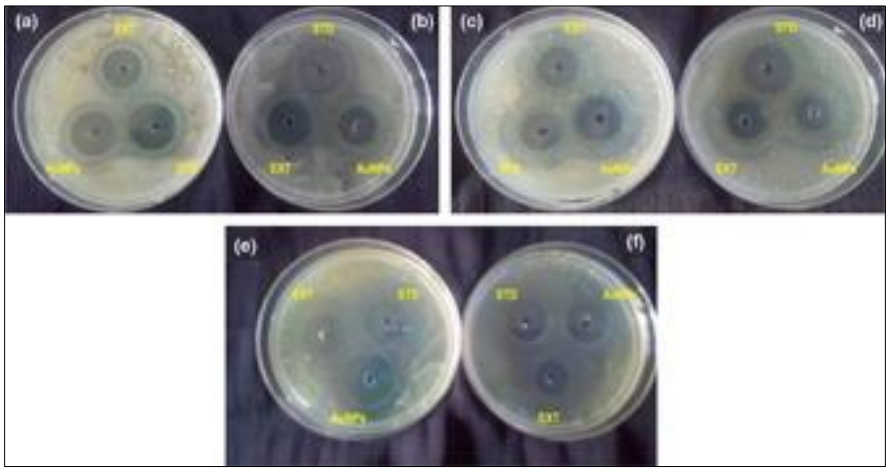


Figure 5 Gold nanoparticle synthesis

9. Techniques used

- **UV-Visible Spectroscopy**: Confirms the formation of nanoparticles by detecting surface plasmon resonance peaks.

- **Fourier Transform Infrared Spectroscopy (FTIR):** Identifies functional groups involved in nanoparticle capping and stabilization.
- **X-Ray Diffraction (XRD):** Determines the crystalline nature and usual size of the nanoparticles.
- **Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM):** Reveal the shape, size, and morphology of the nanoparticles.
- **Dynamic Light Scattering (DLS) and Zeta Potential Analysis:** Measure the size distribution and stability of the nanoparticles (15,17).
- **Energy Dispersive X-Ray Spectroscopy (EDX)**: Confirms the elemental composition of the nanoparticles (7,10).

10. Nanoparticle synthesis and modern applications

10.1. Antibacterial Properties

- Siver Nanoparticles (AgNPs): Green synthesis of silver nanoparticles utilizing Vitex negundo extracts has demonstrated significant antibacterial activity against various pathogenic strains, making them promising candidates for antimicrobial treatments (10,17).
- Gold Nanoparticles (AuNPs): gold nanoparticles produced using Vitex negundo extract exhibited potent antibacterial effects, especially against wound pathogens.

10.2. Anticancer Activity

- Zinc Oxide Nanoparticles (ZnO NPs): The bioactivity of ZnO nanoparticles synthesized using Vitex negundo against cancer cell lines, showing potential in cancer therapy (12).

10.3. Wound Healing

- Iron Oxide Nanoparticles (FeNPs): The synthesized iron oxide nanoparticles using Vitex negundo leaf extracts, demonstrating their effectiveness in enhancing wound healing due to their antimicrobial properties (12,13).

10.4. Antioxidant And Anti-Inflammatory

- Tungsten Nanoparticles: Tungsten nanoparticles stabilized by Vitex negundo extracts exhibited strong antioxidant and anti-inflammatory activities, which can be utilized in various therapeutic applications (13,18).

11. Interactions

Interactions involving Vitex negundo nanoparticles (VN-NPs) are multifaceted, spanning biological, chemical, and physical realms:

- Biological Interactions: VN-NPs engage with biological entities like cells, tissues, and biomolecules, influencing processes like cellular uptake and intracellular trafficking. These interactions can impact cell signalling pathways and elicit cellular responses, potentially affecting biological functions(19).
- Chemical Interactions: VN-NPs undergo chemical reactions with molecules or surfaces, encompassing adsorption, desorption, and surface modification. Surface chemistry dictates stability, reactivity, and compatibility with diverse environments, influencing VN-NPs' behaviour and performance(20).
- Interactions with Biomolecules: VN-NPs interact with biomolecules such as proteins, nucleic acids, and lipids, involving adsorption and conformational changes. They can modulate biological functions and serve as carriers for drug delivery or imaging, targeting specific biomolecular sites(10,14).

12. Advantages

- **Biocompatibility:** VN-NPs created from natural extracts such as Vitex negundo typically exhibit biocompatibility, minimizing the likelihood of adverse reactions in biomedical applications like drug delivery and tissue engineering. This quality makes them appropriate for in vivo use without inducing notable toxicity or immune responses (21).
- **Targeted Drug Delivery**: VN-NPs can be functionalized or coated to achieve targeted drug delivery, allowing for the controlled release of therapeutic compounds at specific sites in the body. This enhances the efficacy of treatments while minimizing side effects and systemic toxicity (18).

- **Environmental Sustainability**: The use of natural extracts like Vitex negundo for nanoparticle synthesis reduces the reliance on synthetic chemicals and minimizes environmental impact. Additionally, VN-NPs may find applications in environmental remediation, such as wastewater treatment or pollutant removal, leveraging their antimicrobial and adsorption properties (10,15,19).

13. Recommended dose

Doses recommended, in adults are:

- Juice10-20 ml;
- Decoction, 50-100 ml;
- leaves powder, 1.5-3 g;
- Dry leaves extract, 300-600 mg (13).

13.1. Toxicity

- Ethanol (50%) extract (whole plant): LD50, >1,000 mg/kg (mice, i.e.).
- Ethanol (70%) extract (leaves): LD50, 7.58 g/kg (rats, oral).
- Flavonoid-rich fraction (ex-seeds): No toxic effect on any vital organs at a dose of 15 mg/rat/day for 15 days(1).

14. Conclusion

The green synthesis of nanoparticles using Vitex negundo represents a sustainable and environmentally friendly method of nanoparticle production. By employing the plant's inherent compounds, this approach reduces the need for harmful chemicals and lowers environmental impact. To produce silver nanoparticles from Vitex negundo, researchers typically extract bioactive compounds from the plant. These mixtures are used to decrease silver ions and stabilize nanocrystals. This dual role foils the nanocrystal from clip-clop and keeps them stable. The green synthesis of gold nanoparticles from Vitex linn has unique assets and potential applications in biomedicine, catalysis, and detection. The nanoparticles produced exhibit significant biological activities, including antimicrobial, antioxidant, and antitumor effects, making them highly beneficial for various medical applications. In summary, green synthesis using Vitex negundo demonstrates the potential to merge traditional botanical knowledge with modern nanotechnology, offering innovative and sustainable solutions.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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