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Pharmacognostic and Phytochemical Evaluation of Euphorbia neriifolia: A Therapeutic Perspective

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ABSTRACT

Based on its use in traditional medicine, *Euphorbia neriifolia* is a well-known medicinal plant with substantial therapeutic potential. The pharmacognostic traits, phytochemical profile, pharmacological activity, and quality control methods related to this adaptable species are examined in this paper. Terpenoids, flavonoids, alkaloids, and phenolics are among the many bioactive substances found in the plant that give it a variety of pharmacological qualities, including anti-inflammatory, antioxidant, antimicrobial, anticancer, antidiabetic, immunomodulatory, hepatoprotective, and wound-healing effects. Its identification and standardisation are based on pharmacognostic tests, which guarantee the use of genuine plant material. Compounds like taraxerol and euphol have been found by phytochemical studies as important contributions to its bioactivity. For extracts to be consistent from batch to batch, chromatographic fingerprinting methods such as TLC, HPLC, and GC-MS are crucial. Quality control measures, such as the assessment of physicochemical properties, toxicity testing, and conformity with regulatory standards, play a key role in insuring safety and efficacy. Even though E. neriifolia has a lot of potential for therapeutic development, issues including its inconsistent phytochemical makeup and scant clinical data call for more study. In order to effectively utilise *Euphorbia neriifolia*'s medicinal potential, this review emphasises the significance of fusing traditional knowledge with contemporary scientific methodologies. It also lays the groundwork for the plant's use in the creation of plant-based medications.

Keywords: *Euphorbia neriifolia, pharmacognostic characteristics, phytochemical profile, bioactive compounds, chromatographic fingerprinting, toxicity testing, regulatory compliance, therapeutic potential.*

1. INTRODUCTION

A prominent member of the Euphorbiaceae family, *Euphorbia neriifolia*, also referred to as Indian spurge, is highly valued in ancient Indian and Asian medicinal practices. The herb, which is indigenous to the Indian subcontinent, has long been valued for its many medicinal uses. E. neriifolia is more than simply a hardy plant; it is also a rich source of bioactive chemicals with a variety of therapeutic uses(1). It is distinguished by its thick, succulent leaves and a sturdy structure that can tolerate dry circumstances. *Euphorbia neriifolia* has a long history in folk medicine, as evidenced by its traditional usage in treating illnesses like inflammation, pain, respiratory disorders, digestive problems, and skin disorders. But as scientific studies uncover more about its pharmacognostic properties and bioactive chemicals, its function in modern medicine is becoming more widely recognised, bridging the gap between conventional wisdom and cutting-edge therapies(2,3). With an emphasis on comprehending *Euphorbia neriifolia*'s bioactive components and their therapeutic uses, this review aims to investigate the pharmacognostic and ethnopharmacological aspects of the plant. Examining plants like *E. neriifolia* methodically is made possible by pharmacognosy, the area of pharmaceutical sciences devoted to the study of medicinal plants and their active ingredients. This field enables a thorough examination of the structural, chemical, and medicinal properties of the plant, which lays the groundwork for the possible creation of novel medications or medicinal substances made from conventional plants. Given the increasing use of herbal remedies and the need for natural goods in contemporary medicine, *Euphorbia neriifolia* pharmacognostic research provides information that may help develop safer and more potent plant-based treatments(4–6). *Euphorbia neriifolia*, often known as "Snuhi," is well-documented in ancient ayurvedic

scriptures. This plant has been employed by Ayurvedic practitioners for its expectorant, carminative, and purgative qualities. The plant's latex, leaves, and roots are among the parts that are traditionally prepared in various formulations to cure a variety of illnesses(7). For instance, because of its caustic qualities, latex—which is abundant in phytochemicals—has been used to cure warts, corns, and other skin illnesses, while leaves are used to treat maladies including asthma and liver problems. Despite the plant's cultural and historical importance, there is still no scientific proof of its therapeutic benefits, which emphasises the need for thorough study to support these assertions and comprehend the underlying mechanisms of its therapeutic effects. A further crucial viewpoint for analysing *Euphorbia neriifolia* is provided by ethnopharmacology, a discipline devoted to researching the customary applications of medicinal plants in particular cultural situations. Its essential function in cultural legacy is demonstrated by the fact that many indigenous people in India and its neighbouring countries use this plant not only as medicine but also as a symbol in a variety of rituals and customs (8). According to ethnopharmacological research, *Euphorbia neriifolia* is prized for its many uses, which include healing digestive issues and serving as a general health tonic. These revelations provide a starting point for pharmacological study, assisting scientists in pinpointing particular bioactive substances that give the plant its medicinal properties and confirming its long-standing uses. Comprehending *Euphorbia neriifolia*'s traditional use and preparations offers a comprehensive perspective on its possible safety and effectiveness, which can help create standardised formulations for contemporary medical applications (7,9,10). Flavonoids, alkaloids, triterpenoids, tannins, and steroids are among the bioactive substances that have been found by phytochemical investigation of *Euphorbia neriifolia*. The plant's medicinal promise for a variety of illnesses is supported by these chemicals' varied biological actions, which include anti-inflammatory, antibacterial, antioxidant, and cytotoxic properties. Significantly, new research has demonstrated the antidepressant properties of certain of *Euphorbia neriifolia's* chemicals, generating interest in the plant's possible use in mental health therapies(11–13). The pharmacological profile of the plant is influenced by these phytochemicals, which provide a foundation for the creation of alternative remedies for ailments that traditional therapies are unable to appropriately address. However, research is still being done to discover safe and effective dosage levels for therapeutic uses as well as the bioavailability, potency, and stability of these chemicals in formulations. Notwithstanding the encouraging results, there are still obstacles in the way of *Euphorbia neriifolia's* transformation from traditional medicine to a contemporary therapeutic agent. The absence of quality control and standardisation in herbal remedies is one of the main challenges, as it can result in variations in safety and effectiveness. To provide a consistent profile of the plant's organoleptic, physicochemical, and biochemical characteristics, standardisation necessitates thorough pharmacognostic investigation, including macroscopic and microscopic assessments(14–16) Furthermore, current formulations require exact extraction methods and quality control procedures to guarantee that active compounds maintain their potency and usefulness in therapeutic applications, whereas ancient preparations frequently involve little processing. By offering a thorough analysis of *Euphorbia neriifolia's* pharmacognostic qualities and a framework for its possible incorporation into contemporary medicine, this article seeks to resolve these issues.

Figure 1: Pictorial representation of *Euphorbia neriifolia*

2. HISTORICAL SIGNIFICANCE AND CULTURAL USES OF *EUPHORBIA NERIIFOLIA*

Many communities place a great deal of historical and cultural significance on *Euphorbia neriifolia*, especially in portions of Africa and South Asia. Because of its many therapeutic uses, this perennial succulent has been used for ages in traditional medical systems. The plant has been valued by indigenous civilisations for both its symbolic meaning and its therapeutic uses. *Euphorbia neriifolia* is employed in traditional customs and ceremonies to evoke protection and healing, and it is commonly connected with strength and resilience in many tribes. In the past, the plant has been used to treat a wide range of conditions, from respiratory and skin disorders to pain alleviation and gastrointestinal concerns. Its latex, which includes a milky sap with strong medicinal qualities, has been used by traditional healers to make treatments for both mental and physical conditions(17,18). For example, it has been acknowledged for its possible antidepressant benefits in some cultures, whereas in others it is used as a purgative and to cure fevers. The centuries-old knowledge of the relationship between nature and health is reflected in the usage of *Euphorbia neriifolia* as a natural cure. Furthermore, *Euphorbia neriifolia's* cultural value goes beyond its therapeutic applications. Some cultures view the plant as sacred, and it is frequently used in customary rites, festivals, and ceremonies. It is an essential component of agricultural and communal practices since, for instance, its presence in cultural landscapes represents fertility and wealth. Because of its capacity to flourish in dry environments, the plant is also seen as a representation of resilience and adaptation, qualities that are highly valued by the communities that depend on it for healing and nutrition(19,20). Furthermore, *Euphorbia neriifolia* is frequently mentioned in regional mythology and folklore, where it is portrayed as a strong being that represents protection and healing. Communities' cultural fabric is enhanced by these stories, which also serve to emphasise the significance of this plant in their daily life. A deep regard for nature and the resources it offers is demonstrated by the incorporation of *Euphorbia neriifolia* into a variety of cultural customs, highlighting the value of traditional ecological knowledge in fostering health and wellbeing. The ethnopharmacological properties of *Euphorbia neriifolia* are gaining attention in the modern day due to the desire for natural and sustainable substitutes for manufactured medications. The cultural and historical settings in which this plant has been used provide important clues about its possible medical uses. *Euphorbia neriifolia* is a standout prospect for additional study and investigation as modern medicine increasingly acknowledges the importance of traditional knowledge, bridging the gap between traditional wisdom and current scientific inquiry (21,22). *Euphorbia neriifolia's* lasting value in historical and cultural contexts is highlighted by this harmonic fusion of ancient applications with contemporary validation, opening the door for its potential as a crucial resource in upcoming health and wellness programs.

3. BOTANICAL DESCRIPTION:

Euphorbia neriifolia is a robust, succulent plant with thick, segmented, jointed stems that typically reaches a height of 2 to 7 meters. The main defence mechanism and adaptation to lessen water loss in arid conditions are the five to seven conspicuous, ribbed ridges that run vertically along the length of the stem. The waxy, greenish-gray surface of the stem helps reduce water loss and reflects strong sunlight. Because of this waxy layer and the fact that it is a succulent plant, E. neriifolia can survive severe drought. *Euphorbia neriifolia* has a somewhat angular or columnar appearance due to the erect way its branches arise from the primary stem.The paired spines that are spaced out along the ridges give the plant a thorny, intimidating look and shield it from animals(23,24). Additionally, the spines help to shade the surface, which promotes water retention. Simple, fleshy, and oblong to elliptical in shape, *Euphorbia neriifolia* leaves are around 5–12 cm long and 2–5 cm wide. Thick and succulent, they store water to help the plant endure dry spells. The leaves form a rosette-like configuration at the end of the branches where they emerge in clusters. Its smooth surface and vivid green colour aid in maximising photosynthesis, which is crucial for its survival in the nutrient-poor soils it usually lives in. Cyathia are clusters of tiny, yellowish-green blooms that serve as the plant's reproductive organs. Male and female flowers are found on different plants in these unisexual inflorescences. Specialised bracts encircle each cyathium, shielding the flowers(25). Because the clusters are usually found towards the top of the branches, there is a greater chance that insects or the wind will pollinate them. Depending on the local climate, flowering often takes place throughout specific seasons. The fruit is a green capsule with three lobes that grows to a brown or reddish colour. One seed is found in each lobe, enabling the growth of new plants. When the fruit capsule dries and splits open, the seeds are released(26).

4. ETHNOBOTANICAL BACKGROUND

The important medicinal plant *Euphorbia neriifolia*, also referred to as the Indian Spurge Tree or Sehund, has been used for millennia in a variety of traditional medical systems. This succulent shrub, which is native to Southeast Asia and the Indian subcontinent, is a member of the Euphorbiaceae family and is well known for its medicinal properties and resilience. The plant grows in dry, rocky places and along hillsides in the wild and is well suited to arid and semi-arid environments(27). It is easily recognised by its thick, fleshy stems and spiky appearance, and its latex, a milky liquid that the plant releases when it is cut, has long been prized for its therapeutic qualities. Additionally, it has a significant role in India's ancient medical systems, especially Ayurveda, where it is regarded for its capacity to regulate the body’s doshas (the three primary energies in Ayurveda: vata, pitta, and kapha). In Ayurvedic scriptures, the plant is characterised as having “vata-shamak” (vata-balancing) characteristics, which means it is believed to settle imbalances connected with the neurological and musculoskeletal systems. As a result, it has been traditionally used to treat a wide range of maladies, including respiratory

issues such as asthma, digestive disorders including constipation, and inflammatory diseases such as arthritis. Its most notable usage, however, is its position as a nervine tonic, where it has been employed in the treatment of mental health disorders like anxiety, sleeplessness, and sadness. part from its significance within Ayurveda, *Euphorbia neriifolia* is also highly esteemed in Unani medicine, another age-old medical system that has its roots in the Greco-Arabic heritage. The latex of the plant is employed in Unani medicine as a purgative and as a component of formulations for the treatment of respiratory, neurological, and skin ailments. Because of its powerful purgative properties, the latex is used with caution and is thought to be especially potent. To lessen possible negative effects and decrease the plant's power, it is occasionally processed with other plants. Various parts of the plant, such as its leaves, roots, and latex, are used for both internal and external purposes in rural India's folk medicine(28). The plant has been used by traditional healers in Southeast Asia to treat a variety of illnesses, such as parasite infections, ulcers, and bronchitis. Because of its wide range of medicinal uses, the plant's latex is frequently administered topically to wounds, cuts, and skin disorders including eczema and warts. The plant's therapeutic adaptability is further supported by ethnobotanical studies carried out in these areas, which show that traditional healers view it as extremely beneficial, especially for diseases involving inflammation and pain. Ethnobotanical knowledge that has been passed down through the centuries is the foundation of its traditional use. This plant has a well-established reputation as a "healer" and has long been used by local populations as part of their traditional healthcare systems(29,30). In keeping with a rich ethnopharmacological legacy, healers frequently make mixtures, poultices, and powders utilising the latex or leaves of the plant to treat certain medical issues. These applications demonstrate the plant's wide range of therapeutic applications, which go beyond its usage in mental health to include the treatment of respiratory, gastrointestinal, and dermatological conditions. Because of its possible toxicity, this plant needs to be handled carefully even though it is widely used. Even though the latex has strong therapeutic properties, it can irritate and inflame skin and mucous membranes. If the plant is consumed unprepared, it may cause acute purging and other gastrointestinal problems. In order to guarantee the plant's safe use, traditional healers have created particular processing techniques. Many medicinal plants utilised in ethnobotanical techniques exhibit a balance between safety and efficacy, which is reflected in this careful management.

5. PHARMACOGNOSTIC CHARACTERISTICS

The pharmacognostic characteristics of *Euphorbia neriifolia* reveal it to be a resilient plant with distinct macroscopic and microscopic features that adapt it well to dry, arid environments. These characteristics are crucial for identifying the plant, differentiating it from similar species, and assessing its quality in a medicinal context.

a. Macroscopic Characteristics

Stem: *Euphorbia neriifolia* has a thick, segmented, succulent stem that can grow to a height of two to seven meters. Its waxy, greenish-gray surface reduces water loss and helps reflect sunlight, making it a useful adaption in arid regions. Prominent ribs that run longitudinally down the length of the stem—typically five to seven—are what define it. The spines on these ribs are paired and range in length from 5 to 12 mm. These spines, which are modified leaf structures, assist shade the stem and prevent water evaporation while providing protection from animals(5).

Leaves: Simple, thick, and meaty, the leaves are usually oblong to elliptical in shape, measuring 5–12 cm in length and 2–5 cm in breadth. These leaves are grouped in a rosette-like pattern near the tips of the branches. The smooth, waxy surface and vivid green hue of the leaves help to maximise photosynthesis and reflection. They conserve water because they are succulents, which is essential to the plant's survival in its arid natural habitat(31).

Flowers: *Euphorbia neriifolia*'s inflorescences are unique and a defining feature of the Euphorbia genus. It bears cyathia, which are clusters of tiny, yellowish-green flowers. The blooms of each unisexual cyathium are shielded by specialised bracts. These flowers, which are carried on the top branches, are designed to encourage cross-pollination, which is mostly made possible by insects or the wind(32).

Fruit: *Euphorbia neriifolia* produces a tiny, three-lobed capsule as its fruit. The fruit turns dark or reddish as it ages from its original green hue. One seed is found in each lobe, and when the capsule is completely ripe, it dries and cracks open, releasing the seeds to aid in reproduction. In the right environments, this dispersal mechanism helps the plant spread(33).

b. Microscopic Characteristics

When examined under a microscope, the stem of E. neriifolia has several layers that underpin its structural robustness and drought tolerance. The thick cuticle covering the epidermis, the outermost layer, aids in preventing water loss. The cortex, which is made up of parenchyma cells that store nutrients and water, is located directly beneath the epidermis. Both xylem and phloem tissues are found in the ring-shaped, usually collateral vascular bundles. Sclerenchymatous fibres encircle these vascular bundles, giving the stem stiffness and supporting its structure. The pith, which is made up of loosely packed parenchyma cells near the centre of the stem, aids in the storage of water(34).

Cells of Latex

The latex-producing laticiferous system of *Euphorbia neriifolia* is one of its distinctive microscopic characteristics. Specialised elongated cells called laticifers contain the milky, viscous substance known as latex. The stem and leaves are

among the components of the plant where these cells are distributed. When the plant is cut, the latex, which is abundant in several bioactive components, forms thick, white drops. Because it is poisonous, this latex serves a protective function in the plant by discouraging pests and herbivores(16,35–37)

Spines

One important defensive characteristic of E. neriifolia is its spines, which are modified leaves. The spines are made of strong, lignified tissue that protects against grazing animals, according to microscopic analysis. The spines grow from bases that resemble cushions along the stem's ribs, and when they are paired on each ridge, they form a powerful barrier(16,38)

c. Powdered Characteristics

Euphorbia neriifolia has a number of distinguishable characteristics when it is powdered that make it easier to identify, particularly for quality control in pharmaceutical applications. Parenchymatous cell fragments, xylem arteries, epidermal tissue with cuticle remains, and sporadic fragments of laticiferous cells with latex droplets are seen in the powdered stem and leaves. The powder also contains cuticle remains with waxy coatings and pieces of prickly tissue. These characteristics help identify the plant after it is powdered(39,40)

c. Organoleptic Properties(41)

Euphorbia neriifolia's organoleptic features are traits that can be determined by sensory analysis:

Colour: The latex is milky white, although the stems and leaves are typically greenish-gray from the waxy covering.

Odour: The latex has a faint, caustic fragrance, but the plant itself doesn't have a significant scent.

Taste: If a lot of the latex is consumed or used topically, it might irritate the skin due to its strong bitterness.

Texture: Firm and meaty, the stem and leaves have a faintly waxy or sticky feel.

6. PHYTOCHEMICAL CONSTITUENTS OF *EUPHORBIA NERIIFOLIA*

This plant is well known for a wide variety of phytochemical components that support its medicinal benefits. Alkaloids, flavonoids, terpenoids, phenolic compounds, and glycosides are some of the main types of bioactive compounds present in this plant; each is important for the plant's therapeutic qualities. Particularly noticeable are alkaloids, which include chemicals like neriifolin and euphol. In addition to their well-known analgesic and anti-inflammatory qualities, these nitrogen-containing chemicals may also have neuroprotective and antidepressant effects, affecting the neurotransmitter systems involved in mood regulation, according to new research. Another significant family of chemicals found in *Euphorbia neriifolia* are flavonoids, which include kaempferol and quercetin. These flavonoids are known for their potent antioxidant properties, which aid in reducing oxidative stress, a major contributor to the aetiology of many chronic illnesses. Flavonoids have been used traditionally to treat mental health conditions because they can improve mood and offer neuroprotective advantages by modifying neurotransmitter levels. Furthermore, *Euphorbia neriifolia*'s phytochemical profile is further enhanced by the presence of terpenoids such euphorbione and dihydroquercetin(28)(42). These substances are known for their analgesic and anti-inflammatory properties, which support the plant's traditional uses in inflammation and pain relief. Additionally, phenolic chemicals like ferulic acid and caffeic acid are essential for shielding brain cells from oxidative damage, which improves cognitive abilities and supports the plant's reputation for fostering mental health. Glycosides, which are substances created when sugar molecules bind to other functional groups, are also present in the plant. *Euphorbia neriifolia*'s therapeutic uses are expanded by these glycosides' diverse biological actions, which include anti-inflammatory and antioxidant properties (Figure 2).

Finally, it is recognised that *Euphorbia neriifolia* contains fatty acids and essential oils, which add to its overall pharmacological profile. Fatty acids help to promote overall health, whereas essential oils are generally known for their antibacterial and anti-inflammatory qualities. *Euphorbia neriifolia*'s diverse range of phytochemicals not only demonstrates its historical application in a number of therapeutic systems but also suggests that it may be used to provide natural solutions for modern health issues(43–47).*Euphorbia neriifolia* is a viable option for the creation of potent herbal medications, especially in the field of mental health, as research into the precise mechanisms of action and therapeutic advantages of these chemicals continues.

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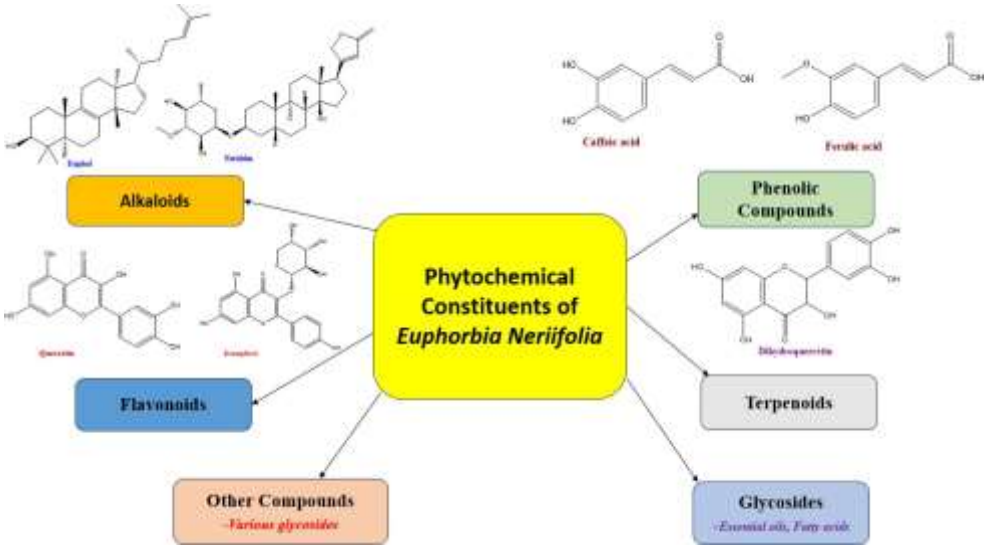

Figure 2: Graphical Representation of Phytochemical constituents of *Euphoria Neriifolia*

7. PHARMACOLOGICAL ACTIVITIES:

The pharmacological activities of *Euphorbia neriifolia* are diverse and stem from its rich phytochemical composition, including terpenoids, flavonoids, alkaloids, and phenolics. The plant exhibits potent anti-inflammatory and antioxidant properties, which are particularly effective in managing oxidative stress and inflammation-related disorders such as arthritis and atherosclerosis. Its antimicrobial and antiviral activities are notable, with studies showing effectiveness against a wide range of pathogens, including bacteria and fungi, due to compounds like euphol and taraxerol(48,49). In addition, E. neriifolia demonstrates promising anti-cancer effects, with cytotoxic activity against certain cancer cell lines through mechanisms such as apoptosis induction. The plant's anti-diabetic properties aid in lowering blood glucose levels and improving insulin sensitivity, suggesting its potential role in diabetes management(Figure 3). Its wound-healing capabilities facilitate tissue regeneration and reduce scarring, supported by its antimicrobial and anti-inflammatory effects. Other activities include immunomodulatory effects, enhancing the body's immune response, and hepatoprotective properties, protecting liver cells from toxins(8,50,51). The plant also has analgesic properties for pain relief and anti-ulcer activity, promoting gastrointestinal health by reducing gastric acid secretion and enhancing mucosal protection. Additionally, its laxative action supports its traditional use in treating constipation(52,53).

Figure 3: Pharmacological activities of *Euphorbia neriifolia*

8. TOXICOLOGICAL STUDIES AND SAFETY PROFILE

Given the historical usage of several *Euphorbia* species in traditional medicine, *Euphorbia neriifolia*'s toxicity and safety profile are crucial factors to consider when evaluating it as a possible therapeutic agent. It includes a variety of bioactive chemicals, some of which may be hazardous at specific levels or in particular populations, like many other plants in the Euphorbiaceae family(54). The plant's latex, which contains a variety of terpenoids and alkaloids, is known to irritate skin and mucous membranes when it comes into touch with them. People who handle the plant should be careful since the latex can cause allergic reactions or dermatitis in those who are sensitive. Preclinical research using animal models has used both acute and chronic toxicity evaluations to examine the safety profile of *Euphorbia neriifolia*(55). These investigations often assess variables like behavioural changes, changes in body weight, changes in organ weight, and histological analyses of important organs. These research' findings frequently show that **Euphorbia neriifolia** extracts at low to moderate dosages do not have any notable negative effects, pointing to a generally safe profile when taken within prescribed dosage ranges(56–58). The necessity for cautious dosing is highlighted by the fact that large dosages have been linked to gastrointestinal issues like vomiting and diarrhoea as well as possible hepatotoxicity and nephrotoxicity. Clinical trials have started to shed light on the safety profile of standardised extracts of **Euphorbia neriifolia** in the context of human use. These studies usually report minor and temporary side effects, such as nausea, gastrointestinal distress, and allergic reactions in certain people. These results highlight how crucial it is to set proper dosage parameters and keep an eye out for side effects in clinical settings(59–61). Even though preclinical and clinical trials have shown a positive safety profile, more investigation is required to clarify the long-term safety and possible drug interactions of *Euphorbia neriifolia*. In particular, thorough research is necessary to evaluate the long-term toxicity, developmental and reproductive toxicity, and any possible carcinogenic effects linked to extended exposure to the plant's components (Figure 4). Furthermore, care must be used because different people react differently to herbal remedies, particularly in susceptible groups including expectant mothers, young children, and those with underlying medical issues(62–64).

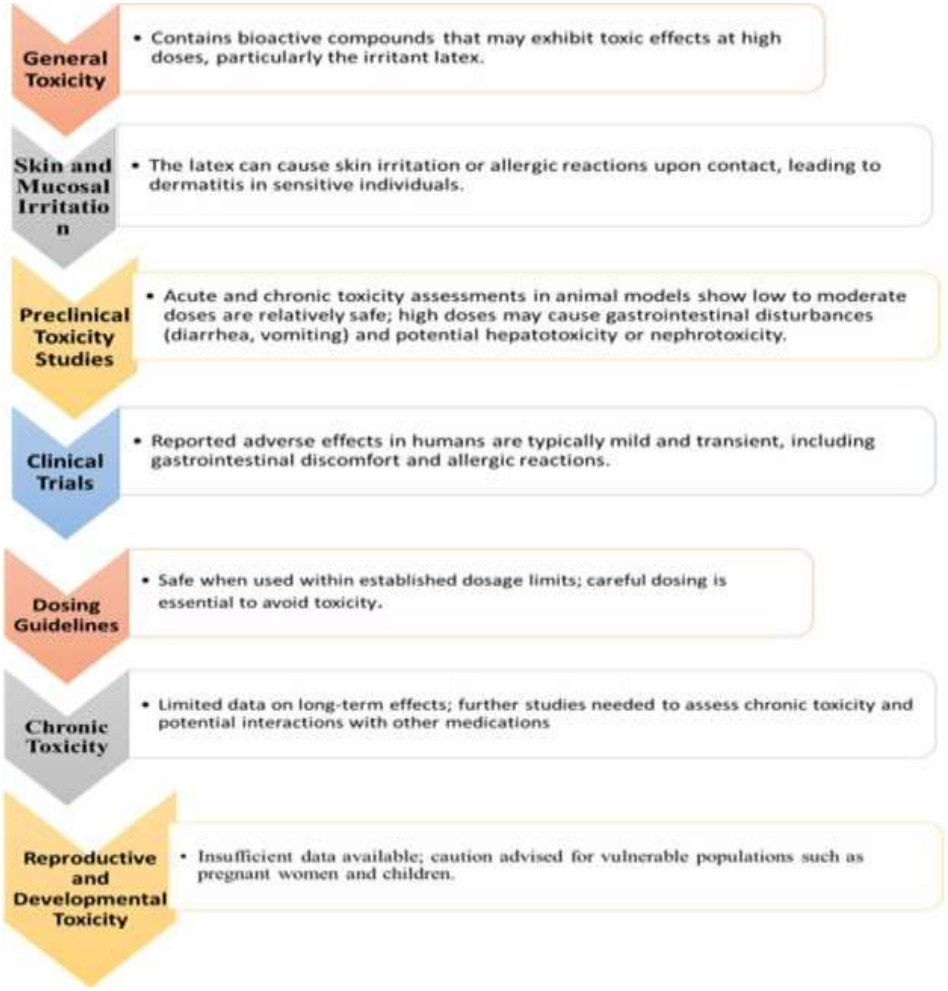

Figure 4: Toxicity and safety profile of *Euphorbia neriifolia*

9. STANDARDIZATION AND QUALITY CONTROL

To ensure *Euphorbia neriifolia*'s effectiveness, safety, and consistency as a medicinal plant, standardisation and quality control are essential. From botanical authentication to physicochemical analysis, phytochemical screening, and regulatory compliance, these procedures entail thorough evaluations. Establishing trustworthy quality guidelines is intended to guarantee that the plant material maintains its medicinal potential and complies with the established safety regulations(65–67). To properly certify *Euphorbia neriifolia*, the first stage in standardisation is botanical identification. To distinguish it from other species that might share similar physical traits, this is crucial. Both macroscopic and microscopic inspection are commonly utilised in botanical identification, and DNA barcoding can be employed for more accurate identification. A voucher specimen is kept in a herbarium for future use after identification, guaranteeing reproducibility and traceability. Because it guarantees that the right species is utilised in subsequent studies and formulations, this step is essential to quality control. The quality and purity of the plant material are next evaluated using physicochemical analysis. One of the most important tests is measuring the moisture content, which is essential for stopping microbial development and the breakdown of active ingredients. An excessive amount of moisture might cause bacterial or mould growth, which could reduce the plant's medicinal benefits. Additionally, the ash value—which comprises water-soluble, acid-insoluble, and total ash is calculated. The inorganic content and level of contamination in the plant material are indicated by these values, which makes them significant. Elevated ash levels could indicate the existence of contaminants or adulterants. The amount of active ingredients that dissolve in water, alcohol, or other solvents is measured by extractive values. This is a crucial stage since it provides an assessment of the plant's overall bioactivity, which directs the extraction process for subsequent applications. The bioactive substances found in *Euphorbia neriifolia*, including terpenoids, flavonoids, phenolics, alkaloids, and glycosides, are then found by phytochemical screening. These substances provide the plant its therapeutic qualities, such as its antibacterial, anti-inflammatory, and antioxidant capabilities. These bioactive components are separated using a variety of extraction processes, which are followed by methods like gas chromatography-mass spectrometry (GC-MS), thin-layer chromatography (TLC), and high-performance liquid chromatography (HPLC). By identifying and measuring particular active markers, these chromatographic techniques guarantee uniformity across batches of plant material and extracts. Chromatographic fingerprinting gives *Euphorbia neriifolia* a distinct chemical signature that can be utilised for verification and quality assurance(68–70). This guarantees that the desired composition of active components is present in every batch of the plant material or extract. Assessments of toxicity and safety are also essential components of the quality control procedure. For the plant material to be used safely in medicinal applications, it must be free of dangerous chemicals. To make sure they stay under allowable limits, *Euphorbia neriifolia* is tested for heavy metals like lead, arsenic, mercury, and cadmium, which are governed by pharmacopoeias. Significant health hazards can arise from heavy metal exposure, particularly when used over an extended period of time. To find any dangerous substances that might have been employed during production, testing for pesticide residue is also done. Microbial testing is also carried out to look for contamination by bacteria, fungi, or other diseases that could have a negative impact on customers. Maintaining the safety of the facility depends on making sure these contaminants are absent. In order to verify *Euphorbia neriifolia*'s pharmacological efficacy, bioassays are essential. These tests, which are carried out using in vitro or in vivo models, assess the plant extracts' therapeutic effects, validating their potency and the existence of bioactive chemicals with therapeutic significance. These tests show that the plant's use is consistent with its traditional therapeutic claims by proving its biological activity in laboratory settings. Additionally important to preserving *Euphorbia neriifolia*'s quality are storage and packaging. The active components in the plant material and its extracts can be degraded by light, moisture, and air, so they must be packaged to avoid these effects. Maintaining the plant's medicinal qualities over time requires suitable storage conditions, including temperature regulation(Figure 5). A constant product for customers is ensured by packaging that shields the plant from contamination and deterioration. Finally, the commercialisation of *Euphorbia neriifolia* as a natural remedy depends critically on regulatory compliance. It is crucial to standardise in accordance with directives from reputable organisations like the World Health Organisation (WHO), the Indian Pharmacopoeia (IP), and Good Manufacturing Practices (GMP)(71–74). These guidelines guarantee that the plant's manufacturing, processing, and packaging satisfy the necessary standards for efficacy, safety, and quality. In order to further ensure the plant's quality in the international market, manufacturers are also required to follow ISO certifications. By following these regulations, *Euphorbia neriifolia* can be confidently used as a therapeutic agent, with assurances regarding its safety and effectiveness(75).

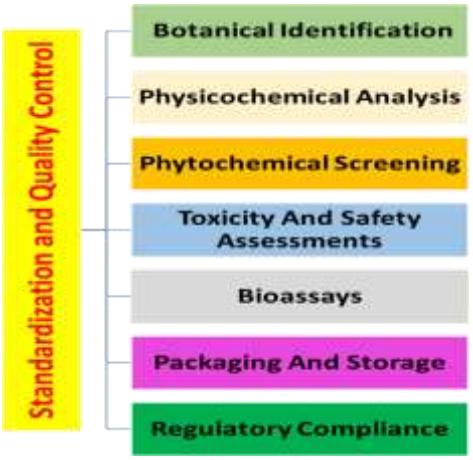

Figure 5: Flowchart of Standardization and Quality Control of *Euphorbia neriifolia*

10. CONCLUSION

The complex phytochemical makeup of *Euphorbia neriifolia*, which includes terpenoids, flavonoids, alkaloids, and phenolics, makes it a well-known medicinal plant with enormous therapeutic potential. Its wide range of bioactivities has been demonstrated by multiple pharmacological studies, which have validated its historic use in diverse ethnomedicinal practices. Among these include hepatoprotective, immunomodulatory, wound-healing, analgesic, anti-inflammatory, antioxidant, antibacterial, anticancer, antidiabetic, and gastrointestinal protective qualities. The plant is important in both traditional and modern healthcare systems because of its capacity to treat both acute and chronic illnesses. E. neriifolia's bioactive components, including taraxerol, euphol, and different glycosides, have been connected to its pharmacological properties. These compounds work through pathways such as immunological regulation, oxidative stress reduction, apoptosis induction in cancer cells, and antibacterial action. The plant's varied pharmacological profile makes it a viable option for creating natural, reasonably priced medicinal medicines. To guarantee safety, efficacy, and consistency, strict standardisation and quality control procedures are necessary for converting these qualities into clinically useful formulations. The first step in standardising *Euphorbia neriifolia* is accurate botanical identification, which guarantees that the right species is used in pharmaceutical compositions. The plant material's stability and purity are revealed by further physicochemical studies, such as extractive values, ash value, and moisture content. Advanced chromatographic procedures like as TLC, HPLC, and GC-MS create chemical fingerprints that ensure batch-to-batch uniformity, while phytochemical screening finds the bioactive chemicals that give it its therapeutic properties. Because contaminants like heavy metals, pesticide residues, and microbial load can be harmful to one's health, safety is still of utmost importance. Toxicological and safety evaluations are therefore essential to guaranteeing that the plant material stays within allowable bounds. Furthermore, bioassays validate E. neriifolia's traditional medicinal claims and strengthen its legitimacy as a therapeutic agent by confirming its pharmacological activity. The quality of the finished product is further guaranteed by the implementation of appropriate packaging and storage procedures, which stop the active ingredients from degrading. To sum up, *Euphorbia neriifolia* serves as a link between conventional wisdom and contemporary scientific discoveries. It is a useful tool for drug research and discovery due to its wide range of pharmacological actions and therapeutic potential. To fully reap its benefits, though, a comprehensive strategy that incorporates contemporary standardisation methods, thorough safety evaluations, clinical validations, and ethnopharmacological knowledge is needed. E. neriifolia has the potential to become a key player in the creation of plant-based medicinal agents and make a substantial contribution to global healthcare by filling in the gaps and overcoming the current obstacles.

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