Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 9s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Nardostachys Jatamansi DC: A Medicinal Treasure in Peril (A Review)

Preethi Umanath[*1], Govindarajan Sumathy[2], Venkata Lakshmi N[3]

[1]Ph.D Scholar, Bharath Institute of Higher Education and Research, Chennai, Assistant professor, Department of Anatomy, KMCH Institute of Health Science and Research, Tamil Nadu.

[2]Professor & HOD, Department of Anatomy, Sree Balaji Dental College & Hospital, Chennai, Tamil Nadu

Email ID: ravi_sumathy@yahoo.com

[3]Associate Professor,Department of Anatomy, Meenakshi Ammal Dental College and Hospital, Maduravoyal, Chennai - 600095.

Email ID: venkatalakshmink@gmail.com

[*]Corresponding Author:

Ph.D Scholar, Bharath Institute of Higher Education and Research, Chennai, Tamil Nadu.

Email ID: preethiumanath22@gmail.com

Cite this paper as: Preethi, G. Sumathy, Venkatalakshmi, (2025) Nardostachys Jatamansi DC: A Medicinal Treasure in Peril(A Review). *Journal of Neonatal Surgery*, 14 (9s), 250-259.

ABSTRACT

The miraculous but endangered plant, Nardostachys Jatamansi DC is a highly medicinal value, primitive, and therapeutic herbal plant used in both daily self-care and professionally managed health care. It is an endangered species due to overexploitation of its rhizomes for medicinal, aromatic uses, folk medicine, overgrazing, loss of habitats, and forest degradation. All the parts of the plants are used for various therapeutic activities like Alzheimer's, anti-convulsion, antioxidants, hair growth, hepatoprotective, Parkinson's, etc.

Phytosterols, terpenoids, flavonoids, and phenolic compounds present in Nardostachys Jatamansi have strong pharmacological properties because they are bioactive molecules. The review focuses on describing the biological activities of these natural products; therefore, there is potential for their application in disease prevention and treatment. Phytosterols, consisting of beta-sterols, are cardioprotective, anti-inflammatory, antimicrobial, and anticancer agents, especially with regard to apoptosis in cancerous breast cells. Triterpenoids, including lupeol and ursolic acid, confer neuroprotection, anxiolysis, antioxidation, and anti-inflammation. Saponins are a subclass of triterpene glycosides that increase the immune response and protect against lipidemia. Furthermore, n-hexacosanol has been identified as an agent with antimicrobial, antioxidant, and hepatoprotective activities. Flavonoids and phenolic compounds are renowned for their significant antioxidant and anti-inflammatory activities. Anti-cancer and free radical scavenging capabilities make flavones, flavonols, and flavonones effective. Through antimicrobial activity and neuroprotection, gallic acid and protocatechic acid of the phenolic acids showed chemoprevention. Chlorogenic and ferulic acids have potential applications in seizure management, cardiovascular health, and protection of skin. On the other hand, syringic acid is a phenolic derivative with great antioxidant potential. These compounds are of significant interest in drug development and nutraceutical applications because of their diversified bioactivity. Their natural origin and multifaceted pharmacological properties offer a safer alternative to synthetic drugs. Further research into their mechanisms of action, bioavailability, and synergistic effects may open the doors to novel therapeutic strategies in the management of chronic diseases. This review compiles existing scientific findings, offering insight into the potential health benefits and applications of phytosterols, terpenoids, flavonoids, and phenolic compounds.

Keywords: *Phytosterols, Terpenoids, Flavonoids, Phenolic Compounds, Antioxidant Activity and Disease Prevention.*

1. INTRODUCTION

Phytochemicals, chemicals derived from Nardostachys Jatamansi , have been known for ages to be of potential health benefits and as useful therapeutic agents. These bioactive molecules are of utmost importance for the defense mechanism in plants, but they generate an array of broad biological activities, including antioxidant, anti-inflammatory, anti-cancer, antimicrobial, and cardioprotective effects upon consumption by humans [1]. In recent times, there has been a high interest witnessed in phytochemicals as functional foods and therapeutic agents, owing to its ability to control and prevent a wide number of

chronic diseases with minimal or no side effect as compared with synthetic drugs conventionally used today. Amongst the most scrutinized classes of phytochemicals are phytosterols, terpenoids, flavonoids, and phenolic compounds are the most outstanding and well noted for their diversified bioactivity. Phyosterols; these are alternatively called plant sterols. Phytosterols are structurally similar to cholesterol and are commonly found in cell membranes of plants. Due to their potential cardioprotective effects in lowering LDL cholesterol levels and having a positive influence on heart health, such compounds have recently gained much interest. Beta-sitosterol is a type of phytosterol that has shown anti-inflammatory, anti-microbial, and anticancer activity, especially within the context of breast cancer cells.

Beyond cardiovascular diseases, phytosterols have a tremendous therapeutic potential in the treatment of metabolic disorders and inflammation. This is a large and diverse group of naturally occurring compounds derived from the terpenoid biosynthetic pathway. Classes include triterpenoids, saponins, and monoterpenoids that are widely represented in the plant kingdom. These possess various pharmacological activities, such as neuroprotective, anti-inflammatory, anxiolytic, anti- cancer, and antimicrobial effects [2-4]. Notably, lupeol and ursolic acid, which are triterpenoids, are known to possess antioxidant and anti-inflammatory activity, making them promising candidates for the development of therapies aimed at combating chronic diseases such as cancer, cardiovascular diseases, and neurodegenerative conditions. Another group of terpenoids that has attracted interest is saponins, which belongs to the triterpene glycosides. These compounds have proven to have an anti-lipidemic role, enhancing the immunities and preventing long-term diseases caused by obesity and hyperlipidemia. Saponins have proved to have antibiotic properties, that may be seen in the prevention of infections and related diseases. The immense range of functions of terpenoids, coupled with their functions in enhancing immunological responses as well as providing neuroprotection, makes the compounds very fundamental in modern pharmaceuticals.

Flavonoids and phenolic compounds are the two major classes of polyphenolic compounds that have been found widely disseminated in fruits, vegetables, and herbs. These compounds have strong antioxidant properties that can neutralize harmful free radicals and reduce oxidative stress and protect cells from damage. Flavonoids and phenolic compounds have anti-inflammatory, anti-cancer, and antimicrobial properties apart from their antioxidant activity. These drugs are very effective for conditions such as cancer, cardiovascular disease, and neurodegenerative diseases. Some of these include phenolic compounds such as gallic acid, chlorogenic acid, and ferulic acid, possessing very significant therapeutic potential with their chemopreventive action, the regulation of blood pressure, and neuroprotective activities. This interaction adds to the increased bioactivity of these plant secondary metabolites. Ongoing studies include those for mechanisms of action, bioavailability, and synergism. Many treatments involving such blends yield more efficient effects with reduced adverse effects than is the case when using single pharmaceuticals. More studies are needed.As conducted, is the knowledge pertaining to the bioactive properties of these compounds and the promising therapeutic applications.

This review paper is aimed to study the pharmacological potential and therapeutic applications of phytosterols, terpenoids, flavonoids, and phenolic compounds. We will discuss the most recent research work regarding their biological activities, efficacy, and mechanisms of actions behind their health benefits. Further, we will go through an overview of their present and future scenario for drug development and give them importance in preventing and managing chronic diseases. Such emerging interest in natural bioactive compounds is opening new avenues for the development of safer and more effective therapies for cancer treatment, cardiovascular health, neuroprotection, and immune system modulation.[5-10]

2. REVIEW ABOUT PHYTOSTEROLS AND TERPENOIDS OF NARDOSTACHYS JATAMASNI:

2.1. Beta-Sterols

Beta-sterols, classified as phytosterols, possess the molecular formula $C_{29}H_{50}O$.They share structural similarity with cholesterol and are largely derived from plant roots and rhizomes. With a wide spectrum of biological activities, beta-sterols have been under intense scrutiny for their cardioprotective, anti-inflammatory, anti-microbial, and anti-cancer activities.

The activity of beta-sterols in conferring cardioprotection is due to the absorption of the compound into the intestines, thereby reducing the intestinal absorption of cholesterol and hence plasma cholesterol levels. This reduces the incidence of cardiovascular disease considerably. Beta-sterols have excellent anti-inflammatory activity as a result of the modulation of inflammatory mediators and can be potentially therapeutic against chronic inflammatory diseases.

Beta-sterols exhibit activity against several bacterial and fungal disease-causing agents because of their anti-microbial activity and hence can be a natural alternative antimicrobial agent. Beta-sterols also induce apoptosis in breast cancer cells and thus can be a potential candidate for anti-cancer treatment[11]. These studies will confirm their occurrence in natural parts of a plant structure-the rhizome and root-by ascribing beta-sterols the position as a natural phytochemical. Other avenues may then include investigating action mechanisms, processes to further extract improvements, and formulating in strategies that optimize their availability to the system for effective intervention.

Beta-sterols contain a great diversity of biological activity and show important applications in pharmaceutical and nutraceutical uses: the compounds show huge potential in the development of therapeutic agents against cardiovascular diseases, inflammation, infections, and cancers.

2.2 Triterpenoids

Triterpenoids are part of the terpenoid family and have the molecular formula $C_{29}H_{50}O_{24}$. Triterpenoids have neuroprotective, anxiolytic, cardioprotective, and anti-cancer properties and are mostly derived from the rhizomes and roots of plants. Among these, triterpenoids' neuroprotective properties are noteworthy since they shield neurones from oxidative stress and inflammation and may be useful in the management of neurodegenerative illnesses like Parkinson's and Alzheimer's. Moreover, through modulation of neurotransmitter systems in the brain,its anxiolytic activity reduces anxiety disorders[12]. Triterpenoids are highly active constituents that can be sure to be supplied for along time when obtained from roots and rhizomes. The advanced formulations techniques andextraction methods can enhance their bioavailability and therapeutic efficacy.

Triterpenoids are highly bioactive compounds whose sustainable availability is ensured by extracting them from roots and rhizomes. Modern extraction techniques combined with formulation strategies can ensure their maximum level of bioavailability and medicinal efficacy. Triterpenoids are at the center of medicinal chemistry because of their wide biological activities. This is because drugs are being formulated for cancer, heart disease, anxiety disorders, and neurodegenerative diseases. Therefore, these molecules will be the focus of drug development.

2.3 Saponins: Triterpene Glycosides

Saponins are bioactive compounds with the molecular formula $C_{55}H_{86}O_{24}$ and defined as triterpene glycosides. They have been reported to possess anti-lipidemic and immune-boosting effects, which make them valuable in the treatment of hyperlipidemia and metabolic disorders. These compounds reduce cholesterol absorption and improve lipid metabolism, thus lowering harmful cholesterol levels and promoting cardiovascular health. Besides, saponins are involved in an important role in strengthening the immune system. They not only stimulate the immune cells but also increase antibody production and possibly work as adjuvants in vaccines to promote the body's defense mechanisms. Its surfactant properties, due to its glycoside structure, permit saponins to demonstrate antimicrobial activity by disrupting microbial membranes.

Saponins occur mainly in roots and rhizomes of the plants (reference 27). These parts have been used since time immemorial in traditional medicine for their therapeutic properties. Modern techniques of extraction are now used to isolate saponins for the use in drugs, functional foods, and nutraceuticals[13-15].

With various health benefits, saponins are promising in the therapy of many diseases, including metabolic disorders, immune deficiency, and infections. Current studies seek further knowledge of their applications in the development of new therapies by specifically studying vaccine development and anti-obesity drugs. Future research efforts can be directed at increasing their bioavailability as well as their longer-term safety profiles.

2.4 Lupeol: Pentacyclic Lupane-Type Triterpenoid

Lupeol is a naturally occurring compound, pentacyclic lupane-type triterpenoid with a molecular formula $C_{30}H_{50}O$. Lupeol is believed to exhibit anti-tumor, anti-inflammatory, antioxidant, and anti-cancer properties. The considerations of these properties have made lupeol a compound of interest both in pharmaceutical and biomedical research. In the context of antitumor properties, Lupeol has shown its efficacy through cancer cell inhibition proliferation, induction of apoptosis, and suppression of metastasis. Lupeol has been considered promising against cancers like prostate, breast, and pancreatic cancers. Anti-inflammatory activities of Lupeol are primarily associated with suppression of pro-inflammatory cytokines and have applications in chronic inflammatory diseases such as arthritis. The antioxidant activity of lupeol prevents oxidative stress, which otherwise can cause damage to the cell and chronic diseases. Moreover, the modulation of signaling pathways in cancer cells further gives this compound therapeutic importance in oncology[16]. Primarily extracted from plant rhizomes (reference 10), lupeol has been one of the prime constituents in traditional medicine for curing various diseases. Modern studies do support its usage in drug development, especially in cancer therapy and inflammation-related disorders. The wide range of bioactivities that Lupeol exhibits makes it a good candidate for developing multi-target drugs. Future studies may focus on improving its bioavailability and its synergistic effects with other compounds to maximize the therapeutic outcome.

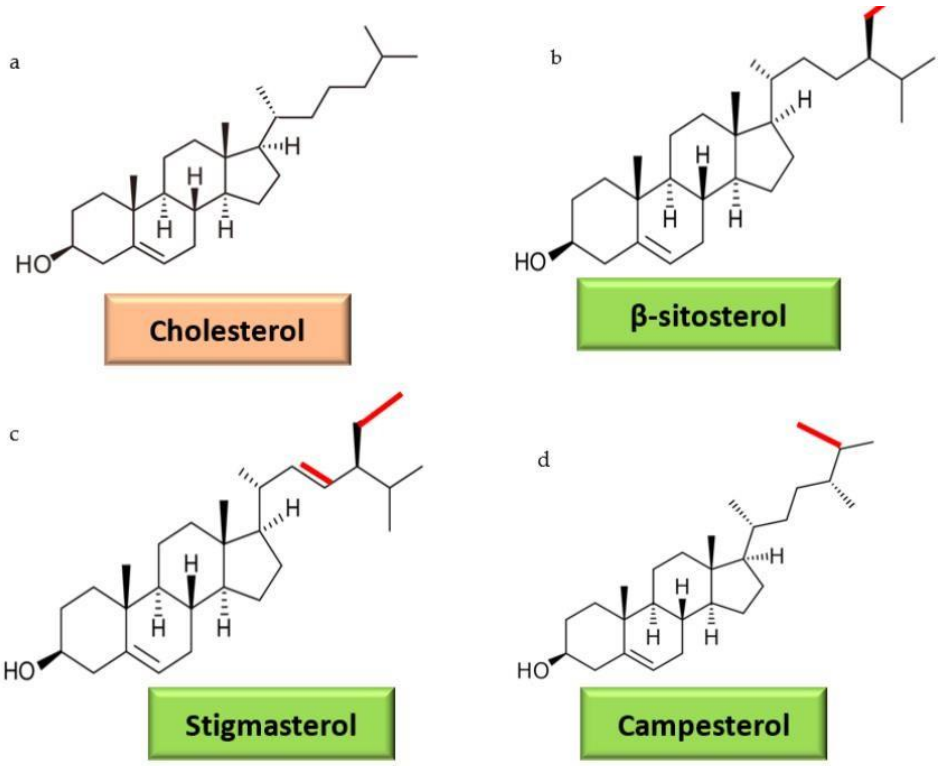

Figure 1. (a) Structure of cholesterol, (b) structure of β-sitosterol (ethyl group represents in red line), (c) structure of stigmasterol (ethyl group and double bond represented by red line), and (d) structure of campesterol (methyl group represented by red line)

2.5 Survey on Ursolic Acid

The rhizome of plants is the primary source of ursolic acid, one of the triterpenoid types (source 32). Numerous studies have been conducted on this diterpene because of its diverse biological activities, which include cardioprotection, anti-inflammatory, and antibacterial properties.Because it occurs in rhizomes, this plant part is an important reservoir of medicinalcompounds. Due to its anti-inflammatory activities, ursolic acid has become an interesting treatmentcandidate for various diseases characterized by chronic inflammation, such as inflammatorybowel disease, arthritis, and asthma. Ursolic acid is a promising candidate for anti-inflammatory drugs because it blocks pro-inflammatory cytokines and mediators, therebyreducing inflammation and the resultant pain and tissue destruction[17].

In addition to its antiinflammatory activity, ursolic acid has been found to possess strong antibacterial action, and thus, is a useful drug for the treatment of bacterial and fungal infections. This may be especially helpful in the treatment of wounds or skin infections, where microbial proliferation might impede healing. The most important therapeutic advantage of ursolic acid is cardioprotection.. Scientific research suggests that it can prevent atherosclerosis, regulate lipid profiles, and promote heart health overall. The goal of this kind of exercise is to prevent cardiovascular disorders, which are caused by plaque buildup in the arteries and can result in heart attacks and strokes.

The high concentration of ursolic acid in rhizomes highlights the importance of rhizomes as a source of bioactive compounds. This substance continues to be at the top of the list of substances being assessed for their potential medical benefits due to increased interest in the use of natural therapies.

2.6 Survey on 3-O-arabinosyl Ursolic Acid

This derivative 3-O-arabinosyl ursolic acid possesses an identical molecular formula of $C_{30}H_{48}O_3$. Apart from the activities in source 33 such as antimicrobial and antibacterial activity, and notable antioxidant activity, 3-O-arabinosyl ursolic acid also mirrors several therapeutic actions present in the therapeutic efficacy of ursolic acid itself owing to this type of arabinosylation modification. As an antimicrobial and antibacterial compound, 3-O-arabinosyl ursolic acid is highly promising against infection caused by various pathogens, particularly those with resistance to common antibiotics. Its prospect in fighting bacterial infections adds value to its therapeutic activity, particularly with the growing alarm about antibiotic resistance.

Aside from that, its antioxidant activity would be responsible for defending cells against oxidative damage, which is among the main causes leading to aging and other degenerative illnesses. The free radicals that the substance would eliminate would

consequently inhibit the oxidative stress-related diseases, such as neurodegenerative diseases, cardiovascular diseases, and cancer[18].

Isolated from rhizomes, 3-O-arabinosyl ursolic acid highlights the importance of these plant tissues as good sources of bioactive compounds with potential therapeutic uses.Its clinical utility in medicine will be contingent upon further studies of its bioavailability, mechanisms of action, and safety profiles. Overall, 3-O-arabinosyl ursolic acid is a promising natural compound that can be explored for its medicinal properties, with potential uses in infection control, aging, and oxidative stress management.

2.7 n-Hexacosanol

n-Hexacosanol is a long-chain alcohol, $C_{26}H_{54}O$, known for being pharmacological agents with antifungal properties, antimicrobial, antioxidant and as a hepatoprotective agent. Such compound is represented by the roots of plants that effectively hold back the growth of pathogenic:Fungi and bacteria and are applied in medicinal practice in order to address infections. These activities it possesses stand it out to be regarded as potent natural medicine for the treatment of severalmicrobial infections. This gives n-hexacosanol the status of an antioxidant; at such potentiality, the compound scavenges free radicals, and hence, its presence reduces oxidative stress that would lead to damage in aCellular context. Thus, in alleviating oxidative stress, n-hexacosanol helps to preserve cell health; such an approach lowers the probability of developing age-related degenerative diseases like cancer, heart diseases, and Alzheimer's.

One of the most prominent features of n-Hexacosanol is its hepatoprotective property. The compound is known to decrease oxidative stress within the liver and improve detoxification with protection from toxins or chronic conditions such as fatty liver disease. This makes n-hexacosanol a very precious compound in helping with overall function in the liver as well as in the prevention of disorder related to the liver. This compound has high versatility for its antifungal, antimicrobial, antioxidant, and hepatoprotective properties. These mechanisms of action for further research shall be used with enhanced applications of medical treatments and health supplements.

2.8 n-Hexacosanyl Arachidate

n-Hexacosanyl arachidate is a fatty acid ester $C_{46}H_{92}O_2$; it's an important compound that exhibits pretty impressive biological activity. Some properties are an antifungal compound, antistress, and antioxidant. They are produced from roots and rhizomes and have found to be great antifungals in combating fungal growth and consequently preventing infections of fungi. Thereby, these compounds can work as excellent medical and cosmetic drug preparations for infections of the fungi on the human skin.

The compound shows pronounced antistress properties andhelps in preventing anxiety and developing a state of relaxation. The drug may thus find application in toning down stress response of the body in alleviating mental issues like stress and anxiety. Just such a potential of the drug that calms nervous system may aid in promoting overall well-being and enhancing life quality of affected individuals with conditions induced by stress. In addition to its antifungal and antistress activities, n-hexacosanyl arachidate has antioxidant activity, scavenging free radicals, which would reduce oxidative damage to cells. This would be important in maintaining cellular integrity and protecting against age-related diseases, such as cardiovascular and neurodegenerative disorders.

Because of the numerous properties of n-hexacosanyl arachidate, it can be used in medicine and personal care in health, mostly concerning the skin, stress, and prevention of aging. Future research on the mechanism of action can further be optimized to make better use of this substance therapeutically.

Table 1: Summary of Phytosterols and Terpenoids with Key Biological Activities

Compound	Molecular Formula	Primary Source	Biological Activities
Beta-Sterols	$C_{69}H_{110}O$	Plant roots and rhizomes	Cardioprotective, anti-inflammatory, anti-microbial, anti-cancer, reduces cholesterol absorption
Triterpenoids	$C_{29}H_{50}O$	Plant roots and rhizomes	Neuroprotective, anxiolytic, cardioprotective, anti-cancer, reduces oxidative stress, modulates neurotransmitter systems
Saponins (Triterpene Glycosides)	$C_{55}H_{86}O_{24}$	Plant roots and rhizomes	Anti-lipidemic, immune-boosting, antimicrobial, promotes cholesterol reduction, enhances antibody

			production
Lupeol (Pentacyclic Lupane-Type Triterpenoid)	$C_{30}H_{50}O$	Plant rhizomes	Anti-tumor, anti-inflammatory, antioxidant, anti-cancer, inhibits cancer cell proliferation, induces apoptosis
Ursolic Acid	$C_{18}H_{30}O_4$	Plant rhizomes	Cardioprotective, anti-inflammatory, antibacterial, prevents atherosclerosis, regulates lipid profiles, anti-cancer properties
3-O-arabinosyl Ursolic Acid	$C_{30}H_{48}O_3$	Plant rhizomes	Antimicrobial, antibacterial, antioxidant, combats infections, reduces oxidative stress, manages neurodegenerative diseases
n-Hexacosanol	$C_{26}H_{54}O$	Plant roots	Antifungal, antimicrobial, antioxidant, hepatoprotective, protects liver function, prevents oxidative stress
n-Hexacosanyl Arachidate	$C_{46}H_{92}O_2$	Plant roots and rhizomes	Antifungal, antistress, antioxidant, reduces anxiety, promotes relaxation, prevents oxidative damage to cells, maintains cellular health

3. REVIEW ABOUT FLAVONOIDS AND PHENOLIC COMPOUNDS OF NARDOSATCHYS JATAMANSI:

3.1 Gallic Acid

Gallic acid is a phenolic compound having the molecular formula $C_7H_6O_5$ widely present in plant leaves. The chemical has multifaceted biological activities including chemoprevention, antioxidant, anti-inflammatory, and anti-microbial activities.

Being an antioxidant, gallic acid neutralizes free radicals, which are major contributors to oxidative stress, hence avoiding cellular damage. In this context, this attribute will contribute remarkably in preventing aging-related diseases as well as chronic diseases, such as cancer and cardiovascular diseases. The potential for chemoprevention is premised on protecting cells from carcinogenic changes; hence, it forms a compound worthy of interest in cancer prevention research.

Gallic acid has anti-inflammatory activity, and the effectiveness of gallic acid in the treatment of inflammatory diseases depends on its regulation of cytokines and other inflammatory mediators[19]. The majority of harmful bacteria and fungi are sensitive to this type of antibiotic action. A product obtained from the leaves, such as gallic acid, is safe, sustainable, and accessible to use in medicine. Further investigation of its bioavailability and mechanisms of action could widen the range of therapeutic use.

Gallic acid is an important chemical within medical science for the various biological activities it portrays. Its probable applications include controlling diseases caused due to oxidative stress, anticancer activity, and infection control.

3.2 Flavones

Flavones are a class of flavonoids with the molecular formula $C_{15}H_{10}O_{-2}$ and can be found mainly in the roots and rhizomes of the plant. They have been primarily known for their anti-inflammatory activity. Through the inhibition of enzymes such as cyclooxygenase (COX) and the reduction in synthesis of proinflammatory cytokines, flavones have shown to be highly potent in the inhibition of inflammatory processes. This is because they are helpful in the treatment of chronic inflammatory diseases like asthma, inflammatory bowel disorder, and arthritis. These compounds also help in cell health by protecting them from inflammation and oxidative stress. Flavones are naturally occurring bioactive compounds that are being studied in detail because they have fewer side effects than synthetic anti-inflammatory drugs. Clinical applications would be further amplified by customized administration routes and studies on bioavailability.Flavones are a major part of both medications and nutraceuticals, and they have potential as chemicals in the creation of treatments for anti-inflammatory diseases.

3.4 Flavonoids: Flavonones

As a general class of flavonoids, flavonones have the general formula $C_{15}H_{12}O_2$, known for its highly potent antioxidant and anti-cancer actions. Being natural free radical scavengers, flavonones play a crucial role in reducing the degrees of oxidative stress, which is considered one of the major contributors to chronic diseases, such as cancer, cardiovascular disorders, and neurodegenerative disorders. Neutralization of reactive oxygen species increases cellular health, and therefore, flavonones play an important role in maintaining the physiological balance.

Therefore, flavenones have particular anti-cancer activities. They inhibit proliferation of cancer cells, cause apoptosis, and suppress angiogenesis that limits tumor growth and metastasis. These actions show their involvement in cancer prevention and therapy. Their antioxidant action also helps to protect DNA against damage, reduces mutation rates, and diminishes the chance for tumor development[20]. Flavonones are largely isolated from the roots of plants (reference 24), an excellent source of these bioactive compounds. These parts of the plants have been employed for ages in traditional herbal medicine in the treatment of oxidative stress-associated diseases. Nowadays, science does validate their usage in nutraceuticals and functional foods in view of health benefits.

Since they can act both as therapeutic drugs and preventive substances, flavonones are hopeful candidates in drug discovery. Research may further study bioavailability and identify the exact mechanisms of action for these molecules at a molecular level, which may unlock the development of effective flavonone-based intervention strategies for multiple diseases.

3.5 Chlorogenic Acid

Chlorogenic acid is a bioactive compound attributed with various health-promoting properties present in the rhizomes of certain plants. Its greatest significance lies, however, in being an anti-epileptic. Chlorogenic acid has proven to be effective in managing and preventing seizures; it, therefore, poses as a promising candidate for the treatment of epilepsy and other neurological disorders.

Besides being an anti-epileptic drug, Chlorogenic acid is also a compound that has other pharmacological characteristics such as supporting blood pressure. It protects the blood pressure level due to improving endothelial functioning and reducing oxidative tension that leads the person toward avoiding cardiovascular diseases. Besides the antioxidant properties, chlorogenic acid also has further therapeutic potential as it scavenges free radicals, thus protecting cells from damage and hence overall health. Its antioxidant activity is particularly helpful in reducing the risk of chronic diseases such as cancer, heart disease, and neurodegenerative disorders.

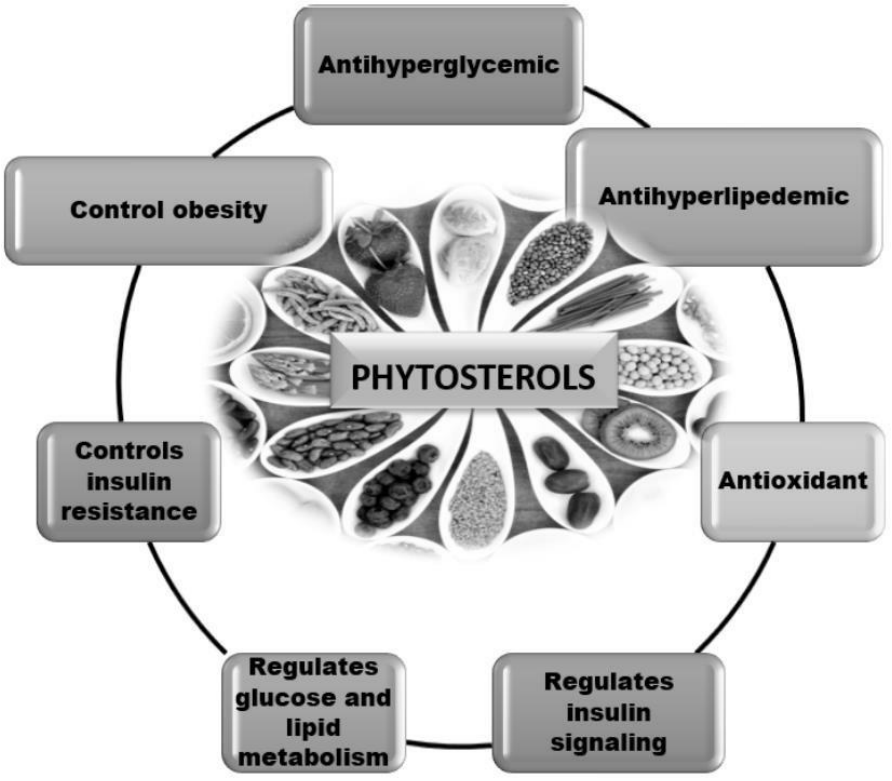

Figure 2: Overall therapeutic action of phytosterol

Chlorogenic acid has anti-epileptic, hypotensive, and antioxidant effects. Its chronic administration may also be useful for the treatment of epilepsy, hypertension, and diseases associated with oxidative stress if molecular mechanisms are investigated in the future.

3.5 Ferulic Acid

Ferulic acid is a hydroxycinnamic acid and phenolic compound that is derived from the rhizomes of specific plants. It is widely recognized for its ability to treat seizures, thus promising as a natural remedy for individuals with epilepsy. Ferulic

acid modulates neural activity, which can reduce the frequency and severity of seizures and potentially serve as a supplementary treatment for seizure management.Aside from being an antiepileptic, Ferulic acid is also said to have antioxidant and anti-inflammatory activities[21]. It accomplishes this through the neutralization of free radicals; hence, this helps protect cells from oxidative damages, which in the long run can lower the risks of diseases related to aging and inflammation.

Other than being an antioxidant, this ferulic acid is recommended as a protective agent to the skin. This is among the most common skincare products for aging, as it helps the skin prevent more damage from the sun, decreasing wrinkles and creating a better texture. Its property as an anti-inflammatory also further enhances its action to soothe irritated skin and thereby improves general health of the skin.

It is also recently gaining momentum to treat neurological diseases and inflammation. and skin conditions because of its multi-faceted benefits. Its application in supplements, skincare and therapeutic applications are being extended more and more as more research is conducted into its mechanisms of action.

3.6 Protocatechic Acid

Protocatechic acid is a phenolic acid, a compound found in the rhizomes of some plants. It has been studied for potential anti-convulsant effects, which will be useful for the treatment of seizure and epilepsyThis might also help regulate or decrease seizures in patients who suffer from epilepsy.through modulation of brain activity. Protocatechic acid has been reported to be a potential therapeutic agent for seizurbecause it influences levels of neurotransmitter and neural circuits that correspond withseizure activity[22]. As it is a natural compound, Protocatechic acid provides a very good alternative to synthetic anti-seizure drugs and has fewer side effects.

Further research eventually, this knowledge may be transferred into the mechanisms of action of Protocatechic acid to be included in modern treatments for neurological disorders, especially epilepsy. Its relatively low toxicity and natural origin also make it a promising candidate for use in long-term therapy.

3.7 Syringic Acid

Syringic acid ($C_9H_{10}O_4$) is the phenolic acid compound found in the rhizomes of certain plant species. Generally, its antioxidant property decreases free radicals from the body system by neutralizing their effects and decreasing damage through oxidative stress within cells. To sum up, Syringic acid is therefore a good reducing agent in the management of chronic diseases associated with heart disorders, cancerous diseases, and neurodegenerative disorders.

Its antioxidant activity is also involved; it reduces the inflammation further enhancesits healing potential in such conditions as arthritic, diabetes mellitus, or otherdisease conditions characterized by inflammation. Thus, its effects on modulating oxidative stressand inflammation could significantly slow the human aging process or protect cellular function. Antioxidant property also makes syringic acid potentially useful for skin application products because ofit protects the skin from environmental damage, reduces wrinkles, and maintains the health of theskin. The compound is increasingly being used in natural health products and supplements because itprovides a safe method of fighting oxidative stress[23-25].

Table 2: Summary of Flavonoids and Phenolic Compounds with Biological Activities

Compound	Molecular Formula	Primary Source	Biological Activities
Gallic Acid	$C_7H_6O_5$	Plant leaves	Antioxidant, anti-inflammatory, chemopreventive, antimicrobial, protects cells from oxidative stress, potential cancer prevention
Flavones	$C_{15}H_{10}O_2$	Plant roots and rhizomes	Anti-inflammatory, inhibits COX enzymes, reduces cytokine synthesis, useful for treating asthma, arthritis, and inflammatory disorders
Flavonols	$C_{15}H_{10}O_7$	Plant rhizomes	Antioxidant, anti-cancer, scavenges free radicals, reduces tumor growth and angiogenesis, prevents oxidative stress-related diseases
Flavonones	$C_{15}H_{12}O_2$	Plant roots	Antioxidant, anti-cancer, inhibits cell proliferation, causes apoptosis, protects DNA, reduces oxidative stress
Chlorogenic Acid	$C_9H_{10}O_{t6}$	Plant rhizomes	Anti-epileptic, hypotensive, antioxidant, protects against oxidative stress, reduces risk of cancer and cardiovascular diseases

Ferulic Acid	$C_{14}H_{10}O_4$	Plant rhizomes	Anti-epileptic, antioxidant, anti-inflammatory, reduces oxidative stress, protects skin from sun damage, reduces wrinkles
Protocatechic Acid	$C_8H_6O_4$	Plant rhizomes	Anti-convulsant, modulates neurotransmitter levels, potential treatment for epilepsy, low toxicity, natural alternative to synthetic drugs
Syringic Acid	$C_9H_{10}O_4$	Plant rhizomes	Antioxidant, anti-inflammatory, protects cells from oxidative damage, supports skincare, reduces wrinkles, useful in managing chronic diseases

4. CONCLUSION

This review provides comprehensive information about Jatamansi and its uses. Various traditional and modern uses of Nardostachys Jatamansi have been identified through modern testing procedures. Studies on the plant have revealed and supported numerous pharmacological activities such as Neuroprotective, Anti-depressant, Anti-Parkinson, Cardio protective, Hepatoprotective, Anti-fungal, Antioxidant, etc. The plant is used in the treatment of various nerve diseases in several Ayurvedic formulations. Therefore, steps should be taken to promote the use of Ayurvedic medicine and include it in more clinical trials. Different studies conducted on animals have shown significant effects of the various activities mentioned in traditional treatises. N. Jatamansi has many properties with minimum animal studies, providing researchers a platform to conduct research on those activities to scientifically validate the findings and serve humanity.

The future work, as research advances, is expected to focus on improving the bioavailability and therefore therapeutic efficacy of these compounds of Nardostachys Jatamansi in order to utilize them in new drug preparations. Current studies on these bioactive plant constituents are going to be promising in developing new treatments for many diseases and contributing to the growing field of natural medicine and healthcare innovation.

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