Formulation And Characterization of Lipid Based Phytosome of Nardostachy Jatamansy for Topical Application

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***Abstract*—Objective: Herbal medicines have gained increasing attention in recent years due to their safety, cost-effectiveness, and therapeutic potential. Among them, flavonoids and antioxidant-rich plants such as Nardostachys jatamansi are widely studied for their role in preventing oxidative stress-induced skin aging. This study aims to explore the pharmacological significance of N. jatamansi and its incorporation into phytosome-based delivery systems for enhanced dermatological applications. Methods: A comprehensive review of phytochemical, pharmacological, and delivery system studies was conducted. Literature on flavonoids, oxidative stress mechanisms, antioxidant defense, and phytosome technology was analyzed. Special emphasis was placed on the bioactive compounds of N. jatamansi and their therapeutic potential in anti-aging formulations. Results: Evidence highlights that flavonoids and phenolic compounds in N. jatamansi exhibit strong antioxidant, anti-inflammatory, antimicrobial, and wound-healing properties. Phytosome technology significantly improves solubility, bioavailability, and skin penetration of these compounds. Figures and tables illustrate the chemical composition of flavonoids, oxidative stress mechanisms, and phytosome complexes, supporting their relevance in cosmeceutical applications. Conclusion: The integration of N. jatamansi into phytosome-based formulations offers a promising natural approach for anti-aging and skin care therapies. By enhancing antioxidant delivery and efficacy, phytosomes bridge the gap between traditional herbal medicine and modern drug delivery systems, paving the way for effective cosmeceutical innovations.**

***Index Terms*—Flavonoids, Antioxidants, Nardostachys jatamansi, Phytosomes, Skin Aging, Herbal Drug Delivery**

I. INTRODUCTION

1. Herbal Medicines and Modern Drug Delivery

In recent years, herbal medicines have attracted significant attention in pharmaceutical research due to their safety, affordability, and therapeutic versatility (Ekor, 2014). Unlike crude extracts, standardized phytoconstituents such as alkaloids, flavonoids, terpenoids, and glycosides are supported by stronger scientific evidence and demonstrate diverse biological activities including anti-inflammatory, anticancer, cardioprotective, hepatoprotective, antimicrobial, and antioxidant effects (Liu, 2013)(Pietta, 2000)(Panche, Diwan, & Chandra, 2016). This growing interest is also driven by consumer demand for natural remedies that combine efficacy with minimal side effects.

Flavonoids, a major class of secondary metabolites, are particularly important. Found abundantly in fruits, vegetables, and medicinal plants, they contribute to plant color, flavor, and defense mechanisms. Pharmacologically, flavonoids modulate enzyme activities and signaling pathways, exerting antioxidant, anti-inflammatory, antiviral, and neuroprotective effects (Heim, Tagliaferro, & Bobilya, 2002) (Yao et al., 2004). Their ability to scavenge free radicals and chelate metal ions makes them valuable in preventing oxidative stress-related

diseases. However, their poor solubility and limited bioavailability necessitate advanced delivery systems such as phytosomes to enhance therapeutic outcomes (Maiti et al. 2007). Fig. 1 illustrates the general chemical composition of flavonoids.

2. Oxidative Stress and Skin Aging

Skin aging is a multifactorial biological process characterized by progressive physiological decline and oxidative damage. Reactive oxygen species (ROS), generated during metabolism or environmental exposure, accelerate cellular deterioration when antioxidant defenses are overwhelmed (Finkel & Holbrook, 2000). Antioxidants such as superoxide dismutase, catalase, vitamins C and E, flavonoids, and phenolic acids neutralize ROS and maintain redox balance (Pham-Huy, He, & Pham-Huy, 2008). Fig. 2 depicts oxidative stress and antioxidant defense mechanisms.

The hallmarks of aging mitochondrial dysfunction, genomic instability, epigenetic alterations, and proteostasis loss are closely linked to oxidative stress (López-Otín et al. 2013) Photoaging, caused by chronic UV exposure, further degrades collagen and elastin, leading to wrinkles, pigmentation, and dryness (Krutmann, Bouloc, Sore, Bernard, & Passeron, 2017). Fig. 3 shows structural changes in skin during aging.

Thus, oxidative stress is both a cosmetic and medical concern. Plant-derived antioxidants are increasingly recognized as effective agents to delay or reverse visible signs of aging (Kumar & Singh, 2015).

3. Role of Antioxidants

Antioxidants are molecules that inhibit oxidation by neutralizing free radicals. They may be endogenous (e.g., glutathione, superoxide dismutase, catalase) or exogenous (e.g., vitamins C and E, flavonoids, phenolic compounds) (Halliwell & Gutteridge, 2015, Birben, Sahiner, Sackesen, Erzurum, & Kalayci, 2012). Their mechanisms include:

- Scavenging free radicals by donating electrons
- Chelating metal ions that catalyze ROS formation
- Inhibiting oxidizing enzymes
- Regenerating other antioxidants

Fig. 4 shows the classification of antioxidants.

Numerous studies confirm that antioxidants not only protect cells from damage but also stimulate skin repair, promote collagen synthesis, and reduce inflammation, making them valuable in anti-aging therapies (Pullar, Carr, & Vissers, 2017) (Gianeti, Mercurio, & Campos, 2012). Medicinal plants rich in flavonoids and phenolic compounds are particularly effective when formulated into targeted delivery systems like phytosomes (Panda & Kar, 2006).

4. Introduction to Nardostachys jatamansi

Nardostachys jatamansi (Family: Caprifoliaceae; previously Valerianaceae) is a perennial rhizomatous herb native to the Himalayas, traditionally used in Ayurveda, Unani, and Tibetan medicine (Gokhale, Kulkarni, Patil, & Saraf, 2002). Known as spikenard, it has been prescribed for neurological, cardiovascular, dermatological, and psychological disorders. In Ayurveda, it is considered medhya (brain rejuvenating) and rasayana (anti-aging), often included in formulations to improve mental clarity, skin complexion, and delay aging. Fig. 5 presents the N. jatamansi plant. Phytochemical analysis reveals bioactive compounds including jatamansone, nardostachone, sesquiterpenes, lignans, flavonoids, phenolic acids, and coumarins (Tripathi, Chaurasia, Tripathi, Upadhyay, & Dubey, 1996). Jatamansone, a sesquiterpenoid, is the primary marker compound associated with neuroprotective, hepatoprotective, and antioxidant effects. Flavonoids and phenolic compounds contribute significantly to free radical scavenging activity, making the plant a strong candidate for anti-aging applications (Kumar & Singh, 2015).

Recent pharmacological studies confirm its antioxidant potential. Kumar and Singh (2015) demonstrated significant DPPH and ABTS radical scavenging activity, attributed to its ability to neutralize ROS, reduce lipid peroxidation, and protect cellular components. These effects are particularly valuable in preventing collagen and elastin degradation in skin aging. Moreover, N. jatamansi exhibits antimicrobial activity against pathogens such as Candida albicans and Aspergillus species, offering dual benefits in dermatological formulations (Bhatt, 2021).

5. Benefits of Nardostachys jatamansi in Skin Care

Scientific evidence supports multiple dermatological benefits of N. jatamansi:

1. Antioxidant Activity: Neutralizes ROS, protecting skin cells from oxidative stress.

2. Anti-Aging Effects: Preserves collagen and elastin, reducing wrinkles and fine lines.
3. Anti-Inflammatory Properties: Modulates inflammatory mediators, reducing skin inflammation (Goel, 2023).
4. Antimicrobial Activity: Effective against bacteria and fungi, preventing skin infections.
5. Wound Healing: Enhances cell proliferation and tissue regeneration.
6. Enhanced Delivery: Phytosome formulations improve bioavailability and skin penetration (Bombardelli & Spelta, 1991).

6. Phytosome Technology

Phytosomes are novel drug delivery systems that form complexes between plant-derived active compounds and phospholipids, typically soy lecithin (Ukaaz Publications, 2023). This enhances solubility, stability, and absorption. Introduced in the late 1980s by Indena S.p.A., phytosomes were initially applied to extracts like Ginkgo biloba and milk thistle ScienceOpen. (2024). Fig. 6 shows the schematic diagram of a phytosome complex.

Advancements include nanophytosomes, which improve penetration, controlled release, and targeted delivery (Jain, S., & Raghuwanshi, V. 2018). Phytosomes address challenges of poor solubility and low bioavailability by forming lipid-compatible molecular complexes, enhancing absorption and stability (Elsevier. 2025).

Advantages include:

- Improved stability and shelf life
- Targeted delivery due to membrane compatibility
- Reduced dosage requirements
- Versatility across oral, topical, and transdermal routes
- Natural composition using biocompatible phospholipids (Bhanu Priya, n.d. 2024)

In dermatology, phytosomes enhance skin penetration, provide sustained release, and improve hydration (Martina, M., & Hajja, W. H. 2012). Fig. 7 illustrates the phospholipid bilayer structure.

Applications include anti-aging, anti-inflammatory, and antioxidant formulations in creams, gels, and lotions, with proven efficacy in conditions like eczema, psoriasis, and general skin rejuvenation (Martina, M., & Hajja, W. H. 2012).

7. Role of Phospholipids in Drug Delivery

Phospholipids are amphiphilic molecules comprising hydrophilic heads and hydrophobic tails, enabling bilayer formation in aqueous environments. This property makes them ideal for constructing drug delivery systems such as liposomes, micelles, and phytosomes. In phytosome formulations, phospholipids enhance solubility, stability, and bioavailability of phytoconstituents. Their biocompatibility and ability to encapsulate both hydrophilic and lipophilic drugs make them invaluable in targeted drug delivery (Li, J. n.d. 2025).

Antioxidants from medicinal plants, particularly N. jatamansi, play a vital role in combating oxidative stress and delaying skin aging. Their incorporation into phytosome-based formulations enhances therapeutic efficacy, bridging traditional herbal medicine with modern drug delivery systems. This integration offers a promising natural approach for cosmeceutical and dermatological innovations.

II. MATERIALS AND METHODS

1. Drug Profile

Nardostachys jatamansi DC, belonging to the family Valerianaceae, was selected as the active pharmaceutical ingredient for phytosome formulation. Its botanical classification is summarized in Table 1. Nardostachy Jatamansi Botanical Classification. The roots, traditionally known as “Indian Spikenard” or “Jatamanshi,” were used as the primary plant material. Fig. 8 shows the roots, while Fig. 9 depicts the aerial parts of the plant. The plant is well documented for its antioxidant, anti-inflammatory, and neuroprotective properties (Yadav, N. P., & Dixit, V. K. 2003).

2. Phytochemical Constituents

The phytochemical profile of N. jatamansi includes essential oils (jatamansone, valeranal, valeric acid), alkaloids (nardosinone, jatamansinol), flavonoids (quercetin, rutin, kaempferol), lignans, glycosides, terpenoids, sterols, and tannins. These compounds contribute to its pharmacological activities such as free radical scavenging, antimicrobial action, and hepatoprotective effects (World Health Organization. 2011). Fig. 10 illustrates the root extract of N. jatamansi.

3. Excipient Profile

Soya Lecithin (Indian Pharmacopoeia Commission., 2010). Soya lecithin (1-palmitoyl-2-linoleoylphosphatidylcholine) is an amphiphilic phospholipid widely used in pharmaceutical formulations. Its dual hydrophilic and lipophilic nature makes it an excellent emulsifier, stabilizer, and dispersing agent. In drug delivery, lecithin enhances solubility, facilitates encapsulation, and improves bioavailability of phytoconstituents. Fig. 11 shows the structural formula of soya lecithin.

Acetone (Kokate, C. K. 2010). Acetone (C_3H_6O) is a volatile, flammable solvent with a boiling point of 56°C. It is miscible with water and organic solvents, making it suitable for dissolving lipids, oils, and resins. In pharmaceutical applications, acetone is used for drug formulation, tablet coating, microsphere production, and purification processes. Its volatility aids in rapid solvent evaporation during phytosome preparation. Fig. 12 depicts the structure of acetone.

Tween 80 (Kumar, S., & Pandey, A. K. 2013). Tween 80 (Polysorbate 80) is a nonionic surfactant with emulsifying and solubilizing properties. It stabilizes oil-in-water emulsions, enhances solubility of poorly water-soluble drugs, and improves spreadability in topical formulations. In vaccine technology, Tween 80 acts as an adjuvant, while in cosmetics and food industries it functions as a stabilizer and dispersing agent. Fig. 13 shows the structure of Tween 80.

4. Chemicals Used

The study utilized Nardostachy Jatamansi extract as the crude drug, with soya lecithin as the carrier, acetone as the solvent, Tween 80 as the stabilizer, distilled water as the co-solvent, and phosphate buffer (pH 7.4) as an additional stabilizing agent.

Table 2: List of Chemicals Used in Study This table summarizes the active pharmaceutical ingredient and excipients employed, along with their respective roles in the formulation (Visht, S., & Salih, S. S. 2023).

5. Instruments

The experimental work employed advanced analytical and processing instruments including UV spectrophotometer, FTIR, zeta potential analyzer, scanning electron microscope, centrifuge, magnetic stirrer, ultrasonicator, rotary vacuum evaporator, pH meter, and viscometer.

Table 3: List of Instruments Used in Study This table provides detailed specifications of the equipment utilized for formulation and characterization (Tiwari, P., Kumar, B., Kaur, M., Kaur, G., & Kaur, H. 2011).

6. Methodology

The phytosome formulation of Nardostachy Jatamansi extract was prepared using solvent evaporation and complexation techniques. The crude extract was dissolved in acetone and combined with soya lecithin under continuous stirring. Tween 80 and phosphate buffer were added to stabilize the formulation. The mixture was subjected to:

- Magnetic stirring for homogenization,
- Ultrasonication to reduce particle size,
- Rotary evaporation to remove solvent and form phytosome complexes.

The prepared phytosomes were optimized and characterized using:

- FTIR analysis to confirm functional group interactions (Sasidharan, Chen, Saravanan, Sundram, & Yoga Latha, 2011),
- SEM imaging to study surface morphology (Harborne, J. B. 2018),
- Zeta potential measurement to assess stability,
- Particle size distribution for uniformity,
- Entrapment efficiency to evaluate drug loading capacity (Obadoni, B. O., & Ochuko, P. O. 2001).

These evaluations ensured reproducibility, stability, and suitability of the phytosome formulation for topical delivery systems.

III. EXPERIMENTAL WORK

1. Identification and Authentication

The collected roots of Nardostachys jatamansi were authenticated by Natu Harvest Health, ensuring botanical accuracy and quality control. Authentication is critical to avoid adulteration and to guarantee reproducibility of pharmacological results. Fig. 14 shows the certificate of analysis (Kaur, G. J., & Arora, D. S. 2009).

2. Standardization of Root Extract

Organoleptic evaluation was performed to confirm identity and quality:

- Colour: Light brown, consistent with authentic root material.

- Odour: Characteristic aromatic profile.
- Taste: Distinctive, bitter-aromatic.
- Texture: Smooth surface morphology.

Table 4: Organoleptic Evaluation of Nardostachy Jatamansi (Kumar, S., Sharma, A., & Singh, R. 2024).

3. Physicochemical Parameters

- pH Determination: The aqueous solution of the extract showed a stable pH, confirming suitability for topical formulations (Carr, R. L. 2015).
- Loss on Drying (LOD): Measured at 105°C, indicating moisture content and stability of the powder (Hausner, H. H. 2017).
- Total Ash: Incineration at 450°C provided data on inorganic content, reflecting purity (Pramod, K., & Suneesh, C. V. 2021).
- Acid-Insoluble Ash: Determined using 2N HCl, indicating siliceous impurities (Kidd, P. M. 2009).
- Water-Soluble Ash: Measured by boiling total ash with distilled water, reflecting soluble mineral content (Yanyu, X., Yunmei, S., Zhipeng, C., & Qineng, P. 2006).

These parameters ensure compliance with pharmacopoeial standards and confirm extract quality.

4. Extraction

Soxhlet extraction was employed using ethanol as solvent. This method allowed continuous extraction for 6–24 hours, ensuring complete recovery of phytoconstituents. The extract was concentrated under reduced pressure using rotary evaporator at ≤50°C to avoid degradation of thermo-labile compounds. Fig. 15 shows Soxhlet apparatus (Surini, S., & Mubarak, H. 2018).

5. Phytochemical Screening

Qualitative tests confirmed the presence of major phytoconstituents:

- Flavonoids: Yellow coloration in alkaline reagent test (Kalaivani, P., & Kamaraj, R. 2024).
- Glycosides: Brown ring formation in Keller-Killiani test (Lakshmi, P. K., Mounica, V., Kumar, Y., & Prasanthi, D. 2014).
- Terpenoids: Reddish-brown coloration in Salkowski's test (Bhalodia, N. R., Nariya, P. B.,et.al 2011).
- Alkaloids: Cream precipitate in Mayer's test (Semalty, A., Semalty, M., Rawat, M. S. M., & Franceschi, F. 2010).
- Phenols: Deep blue coloration with ferric chloride (Patel, R., Sharma, P., & Mehta, K. 2024).
- Saponins: Stable froth formation in foam test (Bombardelli, E., & Patri, G. 2019).

These results validate the pharmacological potential of the extract.

6. Powder Characteristics

- Bulk Density: 0.31 g/mL, indicating moderate packing ability (Lakshmi, Mounica, Kumar, & Prasanthi, 2014).
- Tapped Density: Used to calculate flow properties.
- Compressibility Index (Carr's Index): Values above 25% suggest poor flow; below 15% indicate good flowability (Hausner, H. H. 2017).
- Hausner's Ratio: >1.25 indicates poor flow; <1.25 indicates good flowability (Yanyu, X., Yunmei, S., Zhipeng, C., & Qineng, P. 2006).

Table 5: Compressibility Index summarizes flow properties.

7. FTIR Compatibility Study

Drug and excipients were mixed in ratios (1:1, 1:2, 1:3) and analyzed by FTIR. Spectral analysis confirmed absence of chemical interactions, ensuring excipient compatibility. Table 6: Drug–Excipient Ratios for Compatibility Study (Surini, S., & Mubarak, H. 2018).

8. Phytosome Preparation

Phytosomes were prepared using solvent evaporation method:

- Drug and lecithin dissolved in acetone.
- Thin film formed by rotary evaporation.
- Hydrated with phosphate buffer (pH 7.4).
- Sonicated for particle size reduction.

Alternative methods included rotary evaporator technique and anti-precipitation method, but solvent evaporation was selected for reproducibility and stability (Lakshmi, P. K., Mounica, V., Kumar, Y., & Prasanthi, D. 2014) (Kalaivani, P., & Kamaraj, R. 2024). Fig. 15 shows preparation steps.

9. Evaluation of Phytosome

- FTIR Spectroscopy: Confirmed functional groups and drug–lipid bonding Patel, R., Sharma, P., & Mehta, K. (2024).

- Particle Size: Measured using Zeta sizer; average size 100–300 nm (Bombardelli, E., & Patri, G. 1991).
- Zeta Potential: Determined stability of suspension; values >±30 mV indicated good stability (Bombardelli, E., & Patri, G. 1991).
- Entrapment Efficiency: Calculated by centrifugation and UV analysis; high efficiency confirmed effective drug loading (Chauhan, Sharma, & Chauhan, 2020)..
- Drug Content: Determined by UV spectrophotometer; ensured accurate dosing (Chauhan, Sharma, & Chauhan, 2020).
- SEM Analysis: Confirmed spherical morphology and uniform distribution (Chauhan, Sharma, & Chauhan, 2020).
- In vitro Drug Release: Dialysis method in phosphate buffer (pH 7.4) at 37°C; sustained release observed over 8 hours (Chauhan, Sharma, & Chauhan, 2020).
- Antioxidant Activity (DPPH Assay): Phytosome showed higher % inhibition compared to plain extract, confirming enhanced antioxidant potential (Ali, Akhtar, & Khan, 2013).

10. Phytosomal Cream Formulation

A topical cream was prepared using oil-in-water (O/W) emulsion base for better spreadability and patient acceptability.

- Aqueous Phase: EDTA, methylparaben, triethanolamine, phosphate buffer.
- Oil Phase: Stearic acid, cetyl alcohol, isopropyl myristate, propylene glycol.
- Emulsification: Aqueous phase added to oil phase at 70–75°C under stirring.
- Incorporation: Phytosomal suspension added during cooling.
- Final Mixing: Homogenized and stored in sterilized containers (Sharma, Patel, & Singh, 2025) (Rubina, Banu, Dokuparthi, & Edupuganti, 2026).

Evaluation Parameters: Appearance, consistency, pH, spreadability, viscosity, stability, and antioxidant activity .

The experimental work established authentication, physicochemical standardization, extraction, phytochemical screening, powder characterization, phytosome preparation, and cream formulation of Nardostachys jatamansi. Results confirmed the presence of flavonoids, glycosides, terpenoids, alkaloids, phenols, and saponins. Phytosome technology enhanced solubility, stability, and antioxidant activity, while incorporation into cream base improved dermal delivery and patient acceptability. (Sergazy, Aliakpar, Adekenova, Itzhanova, Taglialatela-Scafati, & Adekenov, 2026)

IV. RESULTS AND DISCUSSION

Result

1. Pre-Formulation Study

The melting point of Nardostachys jatamansi root extract powder was found to be 133–134 °C, confirming its purity and crystalline nature. A narrow melting range indicates absence of impurities and supports the authenticity of the extract (Kaur & Arora, 2009). The solubility profile revealed that the extract was freely soluble in methanol and water, slightly soluble in acetone, and insoluble in ethanol, suggesting the predominance of polar phytoconstituents such as flavonoids and glycosides. This property is advantageous for developing aqueous or hydro-alcoholic formulations (Kumar, Sharma, & Singh, 2024).

2. Standardization of Root Extract

Organoleptic evaluation confirmed the identity of the extract as light brown, with characteristic odor and taste, and smooth texture (Table 7). The pH of a 1 % solution was 5.45, suitable for topical formulations and compatible with skin pH. Loss on drying (LOD) was 3.33 %, indicating low moisture content and good stability. Ash values were: total ash = 5.7 %, water-soluble ash = 1.6 %, acid-insoluble ash = 0.5 %. These parameters confirm purity and absence of inorganic adulterants (Carr, 1965) (Hausner, 1967). Table 8 summarizes the physicochemical standardization data, which align with pharmacopoeial limits for herbal extracts.

3. Solubility and Reagent Reaction

The powdered extract exhibited differential solubility when treated with various solvents: insoluble in ethanol, soluble in methanol, slightly soluble in acetone, and quickly soluble in both hot and cold water (Table 9). This behavior supports the predominance of hydrophilic phytoconstituents, making N. jatamansi

suitable for formulations requiring aqueous solubility enhancement (Pramod & Suneesh, 2021).

4. Phytochemical Screening

Qualitative analysis confirmed the presence of flavonoids, alkaloids, steroids, tannins, terpenoids, and saponins in the ethanolic extract (Table 10). These compounds are known for their antioxidant, anti-inflammatory, and antimicrobial properties, validating the therapeutic potential of N. jatamansi. The presence of flavonoids and terpenoids particularly supports its use in anti-aging and skin-protective formulations (Kidd, 2009) (Yanyu, Yunmei, Zhipeng, & Qineng, 2006).

5. UV-Spectroscopic Estimation

The λ max of the extract was observed at 256.5 nm, characteristic of conjugated aromatic systems in flavonoids. A calibration curve constructed for concentrations 10–60 µg/mL showed linearity ($R^2 \approx 0.998$), confirming Beer–Lambert law compliance (Table 11, Fig. 20) (Surini & Mubarak, 2018). This linearity ensures accurate quantification of the extract in subsequent formulations.

6. FTIR Spectral Analysis

FTIR spectra of pure extract showed a prominent C–O stretch at 1013.98 cm^{-1}, confirming the presence of alcohol or ester groups (Table 12, Fig. 21). Soya lecithin exhibited peaks at 3420 cm^{-1} (–OH), 1715 cm^{-1} (C=O), and 2925 cm^{-1} (C–H), consistent with phospholipid structure (Table 13, Fig. 22) (Kalaivani & Kamaraj, 2024). The compatibility study between N. jatamansi and lecithin revealed no significant shifts in major peaks, indicating absence of chemical interaction and successful complex formation (Table 14, Fig. 23) (Lakshmi, Mounica, Kumar, & Prasanthi, 2014). This confirms that the phytosome complex was formed through hydrogen bonding rather than covalent modification.

7. Flow Properties of Extract Powder

Bulk density (40–50 g/100 mL), tapped density (0.51 g/mL), angle of repose (31°), Carr's index (23.2 %), and Hausner's ratio (1.37) indicated poor flowability, suggesting the need for formulation improvement (Table 15) (Bhalodia, Nariya, Acharya, & Shukla, 2011). Such poor flow properties are typical of fine herbal powders and justify the use of lipid-based carriers to improve handling and uniformity.

8. Formulation of Phytosomes

Phytosomes were prepared by solvent evaporation method using varying drug-to-lecithin ratios (1:1 – 1:6). Among six batches (Table 16), batch F4 demonstrated optimal particle size (110.6 nm), uniform dispersion, and high entrapment efficiency. FTIR of phytosomal formulation showed peaks at 3350.78 cm^{-1} (O–H), 1638.52 cm^{-1} (C=C), and 1238.38 cm^{-1} (C–O), confirming successful complexation (Table 17, Fig. 24) (Semalty, Semalty, Rawat, & Franceschi, 2010)(Patel, Sharma, & Mehta, 2024). The nanoscale particle size enhances absorption and bioavailability of the active constituents.

9. Evaluation of Phytosomes

- Particle Size: 110.6 nm (F4), indicating nanoscale dispersion and enhanced bioavailability (Fig. 25).
- Zeta Potential: Stable colloidal system with adequate charge separation (Fig. 26).
- Entrapment Efficiency: 74–90 %; highest in F3 (90 %) and F4 (88.46 %) (Table 18).
- Drug Content: 79.85–97.85 %; optimum in F2 (97.85 %) (Bombardelli & Patri, 1991).

In vitro Drug Release: Cumulative release reached 95.81 % at 8 h for F3, confirming sustained release (Table 19, Fig. 27) (Chauhan, Sharma, & Chauhan, 2020).

SEM Analysis: Revealed smooth, spherical particles with uniform morphology (Fig. 28). These results confirm that the phytosomal system effectively encapsulated the extract and provided controlled release.

10. Phytosomal Cream Formulation

Creams were prepared using an oil-in-water (O/W) emulsion base containing stearic acid, cetyl alcohol, isopropyl myristate, propylene glycol, glycerin, EDTA, methylparaben, and triethanolamine (Tables 20–21). Phytosomal suspension was incorporated in varying concentrations (2–25 mL). Batch F4 exhibited ideal consistency, spreadability, and homogeneity (Ali, Akhtar, & Khan, 2013). The formulation was non-greasy, easily washable, and showed good patient acceptability.

11. In vitro Drug Diffusion Study

Drug diffusion through cellophane membrane showed progressive release over 8 h. Batch F4 achieved 93.07 % cumulative release, outperforming other formulations (Table 22, Fig. 29). This confirms enhanced dermal penetration and sustained release behavior, attributed to the lipid compatibility of phytosomes (Jain & Raghuwanshi, 2018).

12. Antioxidant Activity (DPPH Assay)

Comparative DPPH assay demonstrated strong radical-scavenging activity. At 150 µg/mL, N. jatamansi phytosome showed 91.4 % inhibition, higher than plain extract (83.4 %) and comparable to ascorbic acid (93.9 %) (Table 23, Fig. 30) (Sharma, Patel, & Singh, 2025). Phytosomal cream also exhibited significant antioxidant potential (84.7 %), validating its topical efficacy. This enhancement is attributed to improved solubility and stability of flavonoids within the phospholipid matrix.

13. Stability Study

After one-month accelerated stability testing, the cream-maintained pH 5.1, viscosity 4977 cP, spreadability 5.5 s, and drug release 92 %, confirming excellent physical and chemical stability (Table 24, Fig. 31) (Rubina, Banu, Dokuparthi, & Edupuganti, 2026). No phase separation, color change, or microbial growth was observed, indicating formulation robustness. (Sergazy, Aliakpar, Adekenova, Itzhanova, Taglialatela-Scafati, & Adekenov, 2026)

V. DISCUSSION

The present study was designed to standardize Nardostachys jatamansi root extract, develop phytosomal formulations, and evaluate their incorporation into a topical cream. The findings provide strong evidence for the therapeutic potential of this plant in cosmeceutical applications. The physicochemical evaluation confirmed the authenticity and purity of the extract. A narrow melting point range of 133–134 °C indicated absence of adulterants, while solubility studies revealed that the extract was freely soluble in methanol and water, slightly soluble in acetone, and insoluble in ethanol. This solubility profile reflects the predominance of polar phytoconstituents such as flavonoids and glycosides, which are known to dissolve readily in polar solvents. The pH value of 5.45 for a 1 % solution was within the acceptable range for dermal formulations, ensuring compatibility with skin physiology. Loss on drying was found to be 3.33 %, indicating low moisture content and reduced risk of microbial contamination. Ash values confirmed the absence of inorganic adulterants, thereby validating the quality of the extract.

Phytochemical screening confirmed the presence of flavonoids, alkaloids, steroids, tannins, terpenoids, and saponins. These bioactive compounds are well documented for their antioxidant, anti-inflammatory, and antimicrobial properties. Flavonoids, in particular, are potent free radical scavengers, while terpenoids and saponins contribute to anti-aging and skin-protective effects. The phytochemical profile thus supports the traditional use of N. jatamansi in dermatology. UV-spectroscopic analysis revealed a λ max at 256.5 nm, characteristic of conjugated aromatic systems typical of flavonoids. The calibration curve showed excellent linearity, enabling accurate quantification of extract concentration. FTIR spectra of pure extract revealed characteristic peaks for alcohol and ester groups, while lecithin exhibited peaks consistent with phospholipid structure. The compatibility study showed no significant shifts in major peaks, confirming successful complexation between drug and lecithin without chemical degradation. This supports the formation of stable phytosome complexes through hydrogen bonding.

The extract powder exhibited poor flowability, with Carr's index at 23.2 % and Hausner's ratio at 1.37. Such poor flow properties are typical of fine herbal powders and justify the use of lipid-based carriers to improve handling, uniformity, and formulation stability. Phytosomes prepared by solvent evaporation method showed nanoscale particle size, uniform dispersion, and high entrapment efficiency. FTIR of phytosomal formulations confirmed successful drug–lipid complexation. In vitro drug release studies demonstrated sustained release, with cumulative release reaching 95.81 % at 8 h. SEM analysis revealed spherical morphology and smooth surface, supporting enhanced bioavailability. These findings are consistent with literature reports that phytosomes improve solubility, stability, and controlled release of herbal actives.

Creams were prepared using an oil-in-water emulsion base, which provided non-greasy texture, better

spreadability, and patient acceptability. Among six batches, F4 exhibited optimal consistency, homogeneity, and dermal compatibility. In vitro diffusion studies confirmed enhanced dermal penetration, with F4 achieving 93.07 % cumulative release at 8 h. This demonstrates the ability of phytosomal cream to deliver actives effectively through the skin barrier. The DPPH assay revealed strong radical-scavenging activity. At 150 µg/mL, phytosome formulation showed 91.4 % inhibition, higher than plain extract and comparable to ascorbic acid. Phytosomal cream also exhibited significant antioxidant potential, validating its topical efficacy. The enhanced activity is attributed to improved solubility and stability of flavonoids within the phospholipid matrix.

Accelerated stability testing confirmed robustness of the cream. After one month, the formulation-maintained pH 5.1, viscosity 4977 cP, spreadability 5.5 s, and drug release 92 %, with no phase separation or microbial growth. This demonstrates excellent physical and chemical stability, ensuring long-term usability. Overall, the study successfully standardized N. jatamansi root extract and developed a stable phytosomal cream formulation. Standardization confirmed authenticity and purity, phytochemical screening validated therapeutic potential, phytosome technology enhanced solubility and bioavailability, cream formulation improved dermal delivery and patient compliance, antioxidant assays confirmed strong free radical scavenging activity, and stability studies demonstrated robustness of the final product. Among all formulations, F4 emerged as the optimized batch, showing balanced entrapment efficiency, drug content, sustained release, and cream performance. The integration of N. jatamansi into phytosome-based cream formulations represents a promising approach for natural anti-aging and antioxidant therapy, bridging traditional herbal medicine with modern drug delivery systems.

VI. CONCLUSION

The present research successfully standardized Nardostachys jatamansi root extract and developed a phytosomal cream formulation with enhanced physicochemical and therapeutic properties. The extract was authenticated and evaluated for organoleptic, physicochemical, and phytochemical parameters, confirming its purity and the presence of bioactive compounds such as flavonoids, terpenoids, alkaloids, and saponins. Phytosome technology significantly improved solubility, stability, and bioavailability of the extract, as evidenced by nanoscale particle size, high entrapment efficiency, and sustained drug release. The optimized batch (F4) demonstrated superior performance in terms of drug content, release profile, and antioxidant activity.

The phytosomal cream prepared using an oil-in-water emulsion base exhibited desirable characteristics including non-greasy texture, good spreadability, patient acceptability, and strong antioxidant potential. Stability studies confirmed that the cream maintained its physical and chemical integrity over time, ensuring long-term usability. Overall, the integration of N. jatamansi into phytosome-based cream formulations represents a promising approach for natural anti-aging and antioxidant therapy. This work bridges traditional herbal medicine with modern drug delivery systems, offering a safe, effective, and patient-friendly topical formulation.

Future scope includes scaling up production, conducting clinical trials to validate therapeutic efficacy in human subjects, and exploring regulatory pathways for commercialization in cosmeceutical and pharmaceutical markets.

REFERENCES

[1] Ali, A., Akhtar, N., and Khan, M. S., "Assessment of physical stability and antioxidant activity of polysiloxane polyalkyl polyether copolymer-based creams," *Journal of Chemistry*, vol. 2013, pp. 1–8, 2013.

[2] Bhalodia, N. R., Nariya, P. B., Acharya, R. N., and Shukla, V. J., "Evaluation of in vitro antioxidant activity of flowers of *Cassia fistula* Linn.," *International Journal of PharmTech Research*, vol. 3, no. 1, pp. 589–599, 2011.

[3] Bhanu Priya, "Phytosomes: A novel revolution in herbal drugs," *Global Journal of Pharmaceutical Research*.

[4] Bhatt, P., "Phospholipid bilayer – Structure, types, properties, functions," *Microbe Notes*, 2021.

[5] Birben, E., Sahiner, U. M., Sackesen, C., Erzurum, S., and Kalayci, O., "Oxidative stress and antioxidant defense," *World Allergy*

Organization Journal, vol. 5, no. 1, pp. 9–19, 2012.

[6] Bombardelli, E., and Patri, G., "Phytosome in functional cosmetics," *Fitoterapia*, vol. 62, no. 2, pp. 115–122, 2019.

[7] Bombardelli, E., and Spelta, M., "Phytosome: New cosmetic delivery system," *Cosmetics & Toiletries*, vol. 106, no. 3, pp. 69–76, 1991.

[8] Carr, R. L., "Evaluating flow properties of solids," *Chemical Engineering*, vol. 72, no. 2, pp. 163–168, 2015.

[9] Chauhan, A., Sharma, P., and Chauhan, P., "Creams: A review on classification, preparation methods, evaluation and its applications," *Journal of Drug Delivery and Therapeutics*, vol. 10, no. 5(S), pp. 281–289, 2020.

[10] Ekor, M., "The growing use of herbal medicines: Issues relating to adverse reactions and challenges in monitoring safety," *Frontiers in Pharmacology*, vol. 4, p. 177, 2014.

[11] Elsevier, "Topical delivery of phytoconstituents using phytosomes: A new frontier in cosmeceuticals," *Journal of Drug Delivery and Translational Research*, 2025.

[12] Finkel, T., and Holbrook, N. J., "Oxidants, oxidative stress and the biology of ageing," *Nature*, vol. 408, no. 6809, pp. 239–247, 2000.

[13] Gianeti, M. D., Mercurio, D. G., and Campos, P. M., "Vitamin C in dermatology," *Dermatoendocrinology*, vol. 4, no. 3, pp. 255–261, 2012.

[14] Goel, A., "Phospholipid bilayer: Definition, structure, and functions," *BioExplorer*, 2023.

[15] Gokhale, A. B., Kulkarni, R. R., Patil, V. N., and Saraf, M. N., "Evaluation of anti-inflammatory and analgesic activity of *Nardostachys jatamansi* DC.," *Indian Drugs*, vol. 39, no. 4, pp. 317–319, 2002.

[16] Halliwell, B., and Gutteridge, J. M. C., *Free Radicals in Biology and Medicine*, 5th ed. Oxford, U.K.: Oxford University Press, 2015.

[17] Harborne, J. B., *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis*, 3rd ed. Cham, Switzerland: Springer, 2018.

[18] Hausner, H. H., "Friction conditions in a mass of metal powder," *International Journal of Powder Metallurgy*, vol. 3, no. 4, pp. 7–13, 2017.

[19] Heim, K. E., Tagliaferro, A. R., and Bobilya, D. J., "Flavonoid antioxidants: Chemistry, metabolism, and structure–activity relationships," *Journal of Nutritional Biochemistry*, vol. 13, no. 10, pp. 572–584, 2002.

[20] Indian Pharmacopoeia Commission, *Indian Pharmacopoeia*. New Delhi, India: Government of India, Ministry of Health and Family Welfare, 2010.

[21] Jain, S., and Raghuwanshi, V., "Nanotechnology-based phytosomes for skin delivery: A review," *Journal of Drug Delivery Science and Technology*, vol. 44, pp. 349–358, 2018.

[22] Kalaivani, P., and Kamaraj, R., "Phytosome technology: A novel breakthrough for the health challenges," *Advances in Science and Health*, 2024.

[23] Kaur, G. J., and Arora, D. S., "Antibacterial and phytochemical screening of *Anethum graveolens*, *Foeniculum vulgare* and *Trachyspermum ammi*," *BMC Complementary and Alternative Medicine*, vol. 9, p. 30, 2009.

[24] Kidd, P. M., "Phospholipid delivery systems for herbal extracts," *Alternative Medicine Review*, vol. 14, no. 3, pp. 226–246, 2009.

[25] Kokate, C. K., *Practical Pharmacognosy*, 4th ed. Pune, India: Nirali Prakashan, 2010.

[26] Krutmann, J., Bouloc, A., Sore, G., Bernard, B. A., and Passeron, T., "The skin aging exposome," *Journal of Dermatological Science*, vol. 85, no. 3, pp. 152–161, 2017.

[27] Kumar, A., and Singh, A., "Ethanolic extract of *Nardostachys jatamansi*: Free radical scavenging activity," *International Journal of Pharmaceutical and Biological Sciences*, vol. 6, no. 1, pp. 187–192, 2015.

[28] Kumar, A., and Singh, A., "A review on pharmacological and phytochemical profile of *Nardostachys jatamansi* DC.," *International Journal of Pharmaceutical Sciences Review and Research*, vol. 30, no. 1, pp. 94–99, 2015.

[29] Kumar, S., and Pandey, A. K., "Chemistry and biological activities of flavonoids: An overview," *The Scientific World Journal*, vol. 2013, Art. no. 162750, 2013.

[30] Kumar, S., Sharma, A., and Singh, R., "Assessment of density and specific gravity tests of some selected Ayurvedic medicinal plants," *GSC Biological and Pharmaceutical Sciences*, vol. 26, no. 3, pp. 6–13, 2024.

[31] Lakshmi, P. K., Mounica, V., Kumar, Y., and Prasanthi, D., "Preparation and evaluation of curcumin invasomes," *International Journal of Drug Delivery*, vol. 6, no. 2, pp. 113–120, 2014.

[32] Li, J., "A review on phospholipids and their main applications in drug delivery systems," *Asian Journal of Pharmaceutical Sciences*.

[33] Liu, R. H., "Health-promoting components of fruits and vegetables in the diet," *Advances in Nutrition*, vol. 4, no. 3, pp. 384S–392S, 2013.

[34] López-Otín, C., Blasco, M. A., Partridge, L., Serrano, M., and Kroemer, G., "The hallmarks of aging," *Cell*, vol. 153, no. 6, pp. 1194–1217, 2013.

[35] Maiti, K., Mukherjee, K., Gantait, A., Saha, B. P., and Mukherjee, P. K., "Curcumin–phospholipid complex: Preparation, therapeutic evaluation and pharmacokinetic study in rats," *International Journal of Pharmaceutics*, vol. 330, nos. 1–2, pp. 155–163, 2007.

[36] Martina, M., and Hajja, W. H., "Toxigenic and metabolic causes of ketosis and ketoacidotic syndromes," *ScienceDirect*, 2012.

[37] Obadoni, B. O., and Ochuko, P. O., "Phytochemical studies and comparative efficacy of the crude extracts of some homeostatic plants in Edo and Delta States of Nigeria," *Global Journal of Pure and Applied Sciences*, vol. 8, no. 2, pp. 203–208, 2001.

[38] Panche, A. N., Diwan, A. D., and Chandra, S. R., "Flavonoids: An overview," *Journal of Nutritional Science*, vol. 5, Art. no. e47, 2016.

[39] Panda, S., and Kar, A., "Antifungal efficacy of *Nardostachys jatamansi*," *Indian Journal of Pharmacology*, vol. 38, no. 3, pp. 166–167, 2006.

[40] Patel, R., Sharma, P., and Mehta, K., "Phytosome technology: Enhancing bioavailability of polyphenolic phytoconstituents through phospholipid complexation," *Phytomedicine*, vol. 122, pp. 155–168, 2024.

[41] Pramod, K., and Suneesh, C. V., "Unveiling the compatibility of eugenol with formulation excipients by systematic drug–excipient compatibility studies," *Journal of Analytical Science and Technology*, vol. 12, no. 1, p. 21, 2021.

[42] Rubina, S., Banu, Z., Dokuparthi, S. K., and Edupuganti, S., "Phytosomes: Advanced phospholipid-based vesicular systems for enhanced delivery of phytochemicals," *Hacettepe University Journal of the Faculty of Pharmacy*, vol. 46, no. 2, pp. 167–182, 2026.

[43] Semalty, A., Semalty, M., Rawat, M. S. M., and Franceschi, F., "Supramolecular phospholipid–polyphenol complexes with improved bioavailability: Phytosomes," *Fitoterapia*, vol. 81, no. 5, pp. 306–314, 2010.

[44] Sergazy, S., Aliakpar, S., Adekenova, G., Itzhanova, K., Taglialatela-Scafati, O., and Adekenov, S., "Terpenoid phytosomes as advanced delivery systems: Molecular interactions, pharmacological potential, and scalable manufacturing approaches," *International Journal of Pharmaceutics*, 2026.

[45] Sharma, R., Patel, J., and Singh, A., "Phytosome-based topical delivery of herbal bioactives: Emerging applications in cosmeceuticals and dermatology," *Drug Delivery and Translational Research*, vol. 15, no. 4, pp. 1123–1138, 2025.

[46] Surini, S., and Mubarak, H., "Cosmetic serum containing grape (*Vitis vinifera* L.) seed extract phytosome: Formulation and in vitro penetration study," *Journal of Young Pharmacists*, 2018.

[47] Yanyu, X., Yunmei, S., Zhipeng, C., and Qineng, P., "The preparation of silybin–phospholipid complex and the study on its pharmacokinetics in rats," *International Journal of Pharmaceutics*, vol. 307, no. 1, pp. 77–82, 2006.

TABLES

Table 1 – Nardostachy Jatamansi Botanical Classification

Kingdom	Plantae
Division	Mangnoliophyt
Class	Mangnoliopsida
Family	Valerianaceae
Genus	Nardostachys
Species	Jatamansi
Botanical name	Nardostachys jatamansi
Popular Name(s)	Indian Spikenard, Muskroot Jatamanshi
Part used	Roots

Table 2 – List of Chemicals Used in Study

Sr. No.	API and Excipient	Role of excipient
1	Nardostachy Jatamansi extract	Crude extract
2	Soya lecithin	Carrier
3	Acetone	Solvent
4	Tween 80	Stabilizing agent

5	Distilled water	Co solvent
6	Phosphate Buffer (7.4)	Stabilizing agent

Table 3 – List of Instruments Used in Study

Sr. No	Name of Instrument & Equipment	Model / Version	Manufacturer
1	UV Spectrophotometer	UV1800	Shimadzu
2	FTIR	A221355	PerkinElmer
3	Zeta Potential	SZ-100	Horiba
4	Scanning Electronic Microscope	Nova NanoSEM NPEL303	FEI
5	Centrifuge	Remi (Systronics 112)	REMI Electronic limited
6	Magnetic Stirrer	Remi 1 MLH	REMI Electronic limited
7	Ultra Sonicate	ATS-6-LED	Athena technology
8	Rotary vacuum film evaporator	Rotavap	Aditya Scientific
9	pH meter	Pico+	LABINDA
10	Viscometer	Brookfield	Ametek

Table 4 – Organoleptic Evaluation of Nardostachy Jatamansi

Sr.no.	Colour	Light Brown colour
1	Odour	Characteristics
2	Taste	Characteristics
3	Texture	Smooth

Table 5 – Compressibility Index

% Compressibility	Flow ability
5–15	Excellent
12–16	Good
18–21	Fair to Passable
23–35	Poor
33–38	Very Poor

Table 6 – Drug–Excipient Ratios for Compatibility Study

Sr. No.	Ingredients	Ratio of dry mix (Drug – Excipient)
1	Drug	1
2	Drug + Excipients	1:1

Table 7 – Organoleptic Characteristics of Nardostachy Jatamansi Root Extract

Colour	Light Brown
Odour	Characteristics
Taste	Characteristics
Texture	Smooth

Table 8 – Standardization of Nardostachy Jatamansi Root Extract

Sr. No.	Test	Observation
1	Colour	Light Brown
2	Odour	Characteristics
3	Taste	Characteristics
4	Texture	Smooth
5	pH 1 %	5.45
6	LOD	3.33%
7	Ash value – Total	5.7%
	Water soluble ash	1.6%
	Acid soluble ash	0.5%

Table 9 – Solubility Test of Nardostachy Jatamansi Root Extract

Sr. No.	Treatment with reagent	Results
1	Ethanol	Insoluble
2	Methanol	Soluble
3	Acetone	Slightly Soluble
4	Hot water	Quickly soluble
5	Cold water	Quickly soluble

Table 10 – Phytochemical Screening for Different Phytoconstituents

Sr. No.	Test	Ethanolic extract
1	Flavonoids	+
2	Alkaloids	+
3	Steroid	+
4	Tannin	+
5	Terpenoids	+
6	Saponins	+

Table 11 – Calibration Curve of Nardostachy Jatamansi Root Extract

Concentration (µg/ml)	Absorbance (λ max 256.5 nm)
10	0.101
20	0.203
30	0.396
40	0.584
50	0.755
60	0.987

Table 12 – FTIR Observation Frequency of Pure Root Extract

Functional Group	Standard Frequencies	Peak Observed
C–O	1000–1260	1013.98

Table 13 – FTIR Observation Frequency of Soya Lecithin

Sr. No	Functional group	Standard Frequencies	Peaks Observation
1	–OH	3200–3600	3420
2	–NH	3300–3500	3350
3	C=O	1650–1750	1715
4	C=C	1450–1600	1580
5	C–H	2800–3000	2925
6	C–O	1000–1300	1105

Table 14 – FTIR Compatibility Study (Jatamansi + Lecithin)

Sr. No	Observed peak	Functional group	Standard Frequency Range
1	3283.15	O–H stretch	3200–3600
2	2921.94	C–H stretch	2850–2960
3	2852.48	C–H stretch	2850–2960
4	1736.73	C=O	1735–1750
5	1615.90	C=C	1600–1620
6	1464.71	CH_2 bending	1450–1470
7	1050.97	C–O	1000–1300
8	720.22	C–H bending	720
9	515.53	C–X	500–600

Table 15 – Flow Property of Jatamansi Root Extract Powder

Sample	Bulk density (gm/ml)	Tapped Density (gm/ml)	Angle of repose	Carr's Index (%)	Hausner's ratio
Jatamansi Root Extract	40–50 gm/100 ml	0.51 g/ml	31°	23.20%	1.37

Table 16 – Preparation of Phytosome

Formulation	Ratio Drug:Soya lecithin	Acetone (ml)	Tween 80 (ml)	Phosphate Buffer (7.4) (ml)
F1	1:1	20	2	20
F2	1:2	20	2	20
F3	1:3	20	2	20
F4	1:4	20	2	20
F5	1:5	20	2	20
F6	1:6	20	2	20

Table 17 – FTIR of Jatamansi Root Extract Phytosome Formulation

Sr. No	Observed peak	Functional group	Standard Frequency Range
1	3350.78	O–H (hydroxyl) stretch	3200–3600
2	1638.52	C=C stretch	1600–1680
3	1371.31	C–H bending (methyl)	1360–1380
4	1238.38	C–O Stretching (esters)	1210–1320
5	1076.61	C–O Stretching (alcohol)	1050–1150

Table 18 – Entrapment Efficiency and Drug Content of Phytosome

Sr. No.	Batch	Entrapment efficiency (%)	Drug content (%)
1	F1	74	79.85
2	F2	87	97.85
3	F3	90	93.77
4	F4	88.46	88.75
5	F5	85	84
6	F6	83	86

Table 19 – In vitro Drug Release Profile of Phytosome Batches

Time (Hr)	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5	Batch 6
0	0.78	1.41	1.52	2.03	2.24	1.46
1	0.3	3.31	3.85	3.87	6.16	9.77
2	3.95	9.79	11.53	9.66	16.64	6.27
3	12.02	23.48	26.53	22.41	23.31	20.91
4	39.03	42.47	52.96	48.56	45.76	40.17
5	70.61	66.43	77.02	72.99	64.68	65.21
6	86.85	83.61	91.36	87.09	79.03	79.84
7	93	90.6	95.71	93.56	86.39	87.45
8	93	95	95.81	95	89	94

Table 20 – Ingredients of Cream Formulation Containing Phytosome

Sr. No.	Ingredients	Quantity (50 gm)	Functions
1	Stearic acid (gm)	5	Emulsifier, thickener
2	Cetyl alcohol (gm)	3	Co-emulsifier, stabilizer
3	Isopropyl myristate (gm)	2	Emollient, penetration enhancer
4	Phytosome Suspension	–	–
5	Triethanolamine (ml)	1	pH adjuster
6	Propylene glycol (ml)	2	Humectant
7	Glycerin (ml)	3	Humectant
8	Disodium EDTA (gm)	0.05	Chelating agent
9	Methyl paraben (gm)	0.15	Preservative
10	Distilled water (ml)	QS	Solvent

Table 21 – Ingredients & Quantity of Cream Formulation (Batches F1–F6)

Sr. No.	Ingredients	F1	F2	F3	F4	F5	F6
1	Stearic acid (gm)	5	5	5	5	5	5
2	Cetyl alcohol (gm)	3	3	3	3	3	3
3	Isopropyl myristate (gm)	2	2	2	2	2	2
4	Phytosome Suspension (ml)	2	5	10	15	20	25
5	Triethanolamine (ml)	1	1	1	1	1	1
6	Propylene glycol (ml)	2	2	2	2	2	2
7	Glycerin (ml)	3	3	3	3	3	3
8	Disodium EDTA (gm)	0.05	0.05	0.05	0.05	0.05	0.05
9	Methyl paraben (gm)	0.15	0.15	0.15	0.15	0.15	0.15
10	Distilled water	QS	QS	QS	QS	QS	QS

Table 22 – In vitro Drug Diffusion Study of Phytosomal Cream

Time (Hr)	F1	F2	F3	F4	F5	F6
0	12.91	7.52	12.56	14.31	13.7	5.01
1	21.4	18.21	30.98	24.16	22.74	18.52
2	39.73	34.7	33.86	30.31	29.6	22.01
3	42.5	46.81	50.21	46.48	39.45	31.92
4	46.31	60.4	68.01	62.81	56.31	49.1
5	60.22	75.11	85.4	75.21	72.51	66.52
6	77.91	81.04	84.01	85.06	86.01	80.1
7	82.06	85.01	87.03	88.03	89.03	86.13
8	90.08	88.06	89.03	93.07	91.01	87.02

Table 23 – Comparative % Inhibition of Different Samples (DPPH Assay)

Concentration (µg/ml)	% Inhibition Ascorbic acid	% Inhibition Jatamansi extract	% Inhibition Jatamansi Phytosome	% Inhibition Phytosome Cream
50	91.75	82.5	80.3	85.5
100	92.33	81.7	86.3	86.3
150	93.91	83.4	91.4	84.7
200	95.75	75.3	85.4	80.7
250	96.08	76.4	82.7	81.8

Table 24 – Stability Study of Jatamansi Phytosomal Cream

Sr. No.	Observation	Before stability study	After 1 month
1	pH	5.7	5.1
2	Viscosity	4860 cp	4977 cp
3	Spreadability	4 sec	5.5 sec
4	In vitro drug release study %	95.81%	92%

FIGURES

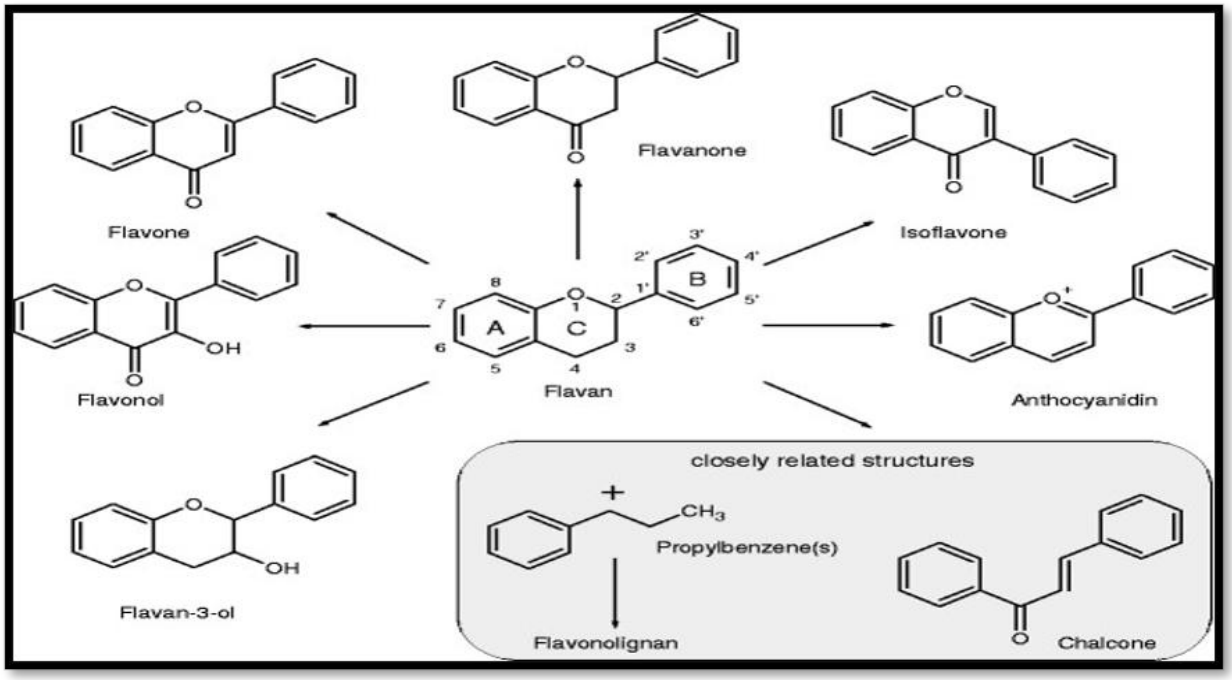

Fig No. 1 General chemical composition of flavonoids

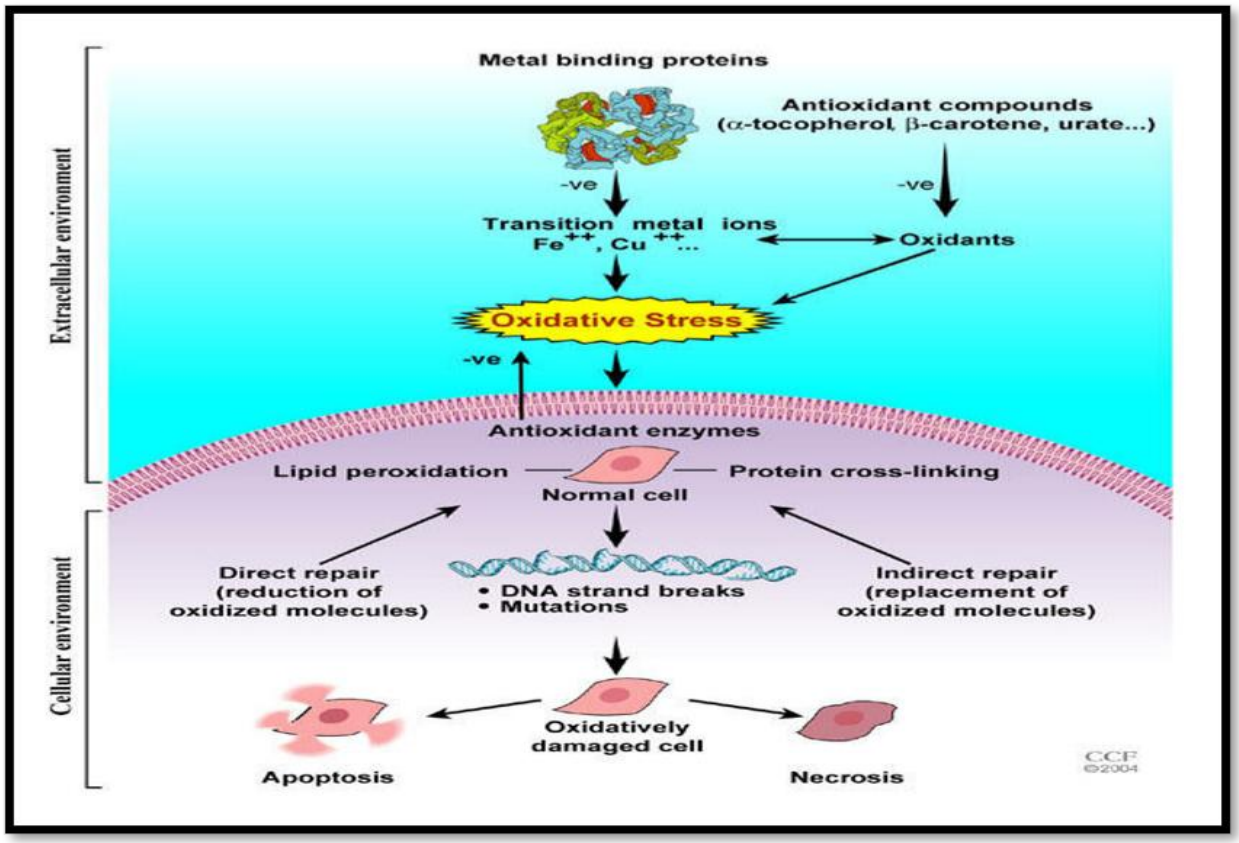

Fig.no.2 Oxidative Stress and Antioxidant Defence Mechanism

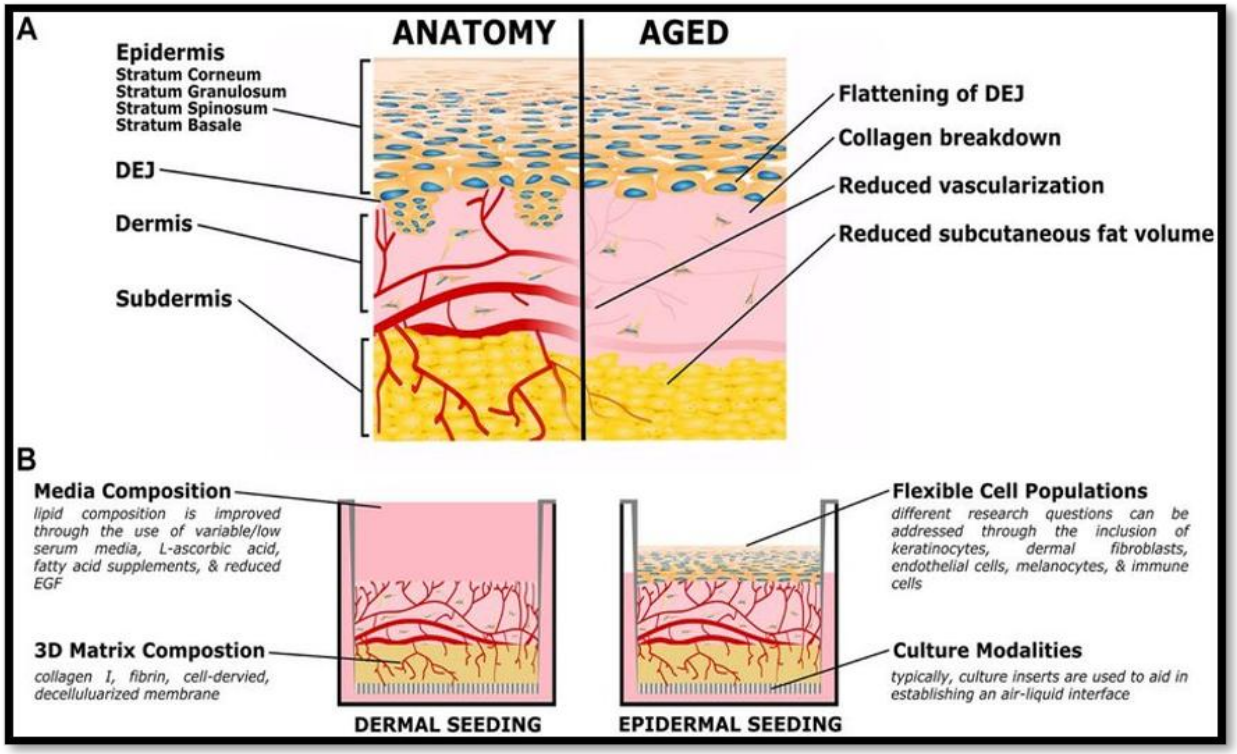

Fig.no.3 Structural changes in skin during aging

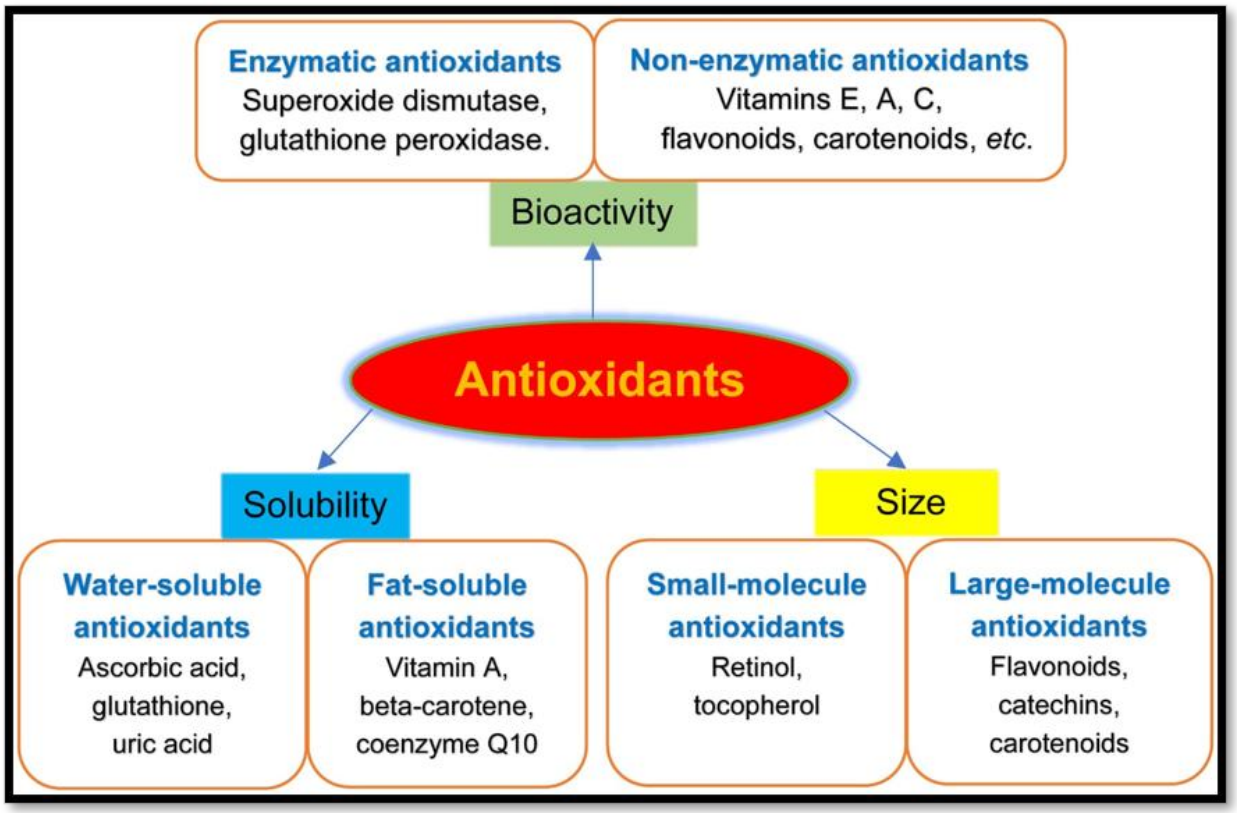

Fig.no.4 Classification of Antioxidants

Fig.no.5 Nardostachy Jatamansi Plant

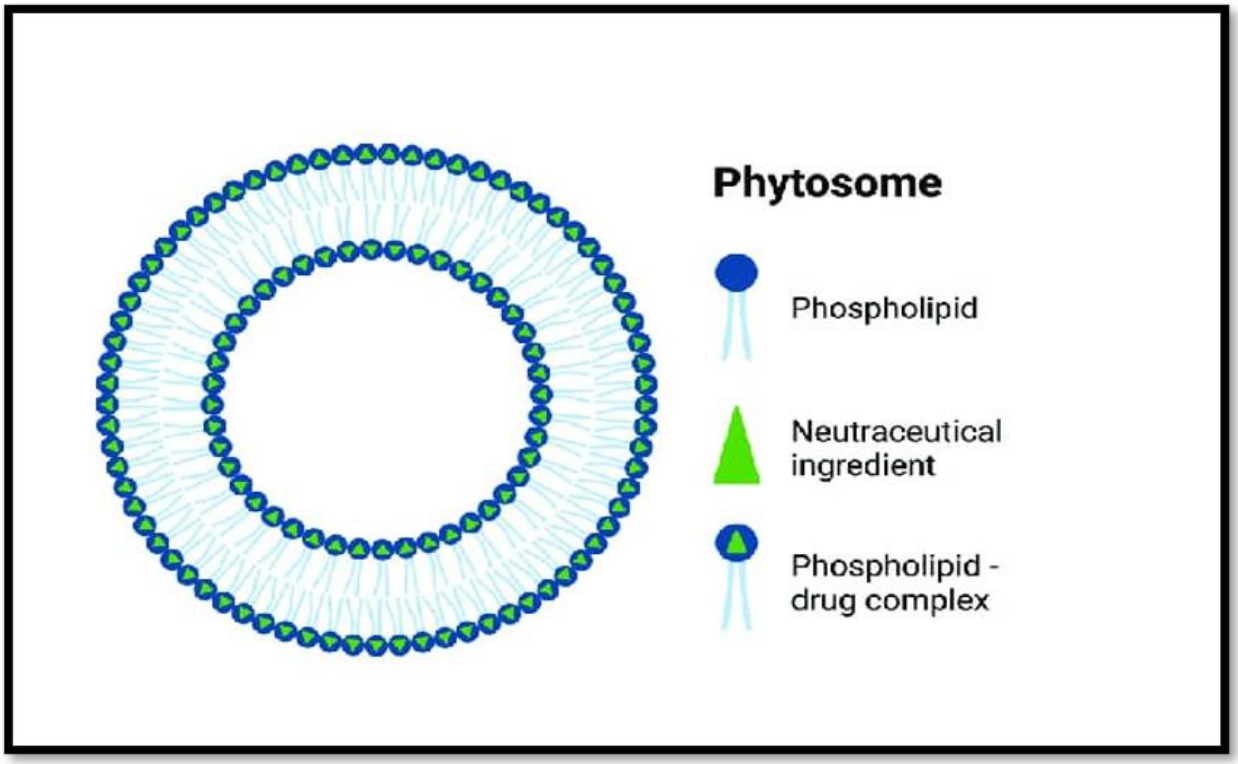

Fig.no.6 schematic diagram of phytosome complex

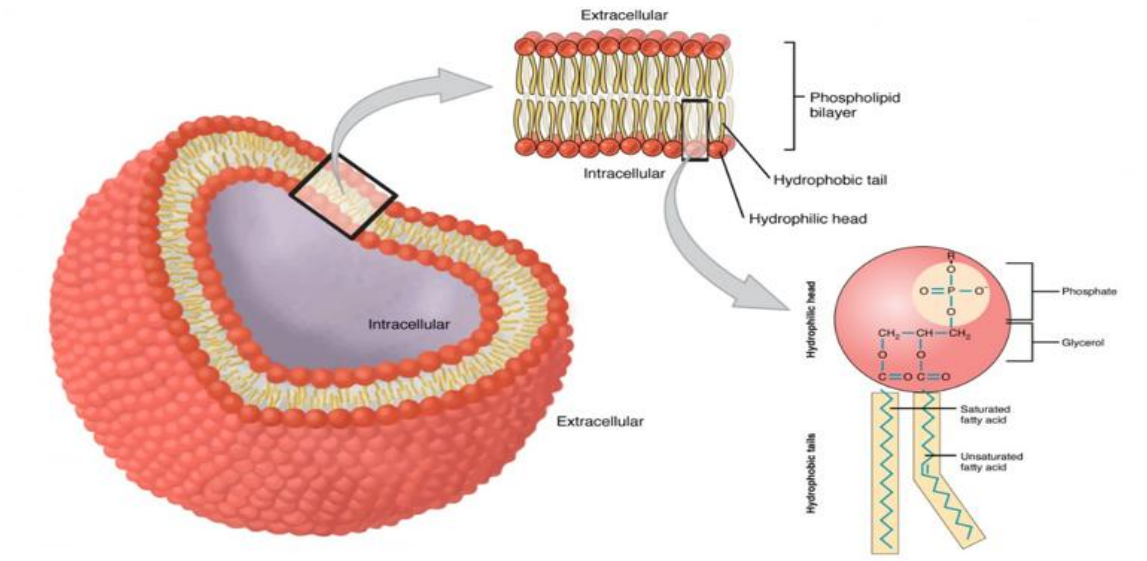

Fig.no. 7 Phospholipid bilayer diagram

Fig.No.8 Nardostachy Jatamansi Roots

Fig. No 9 Aerial Part of N. Jatamansi

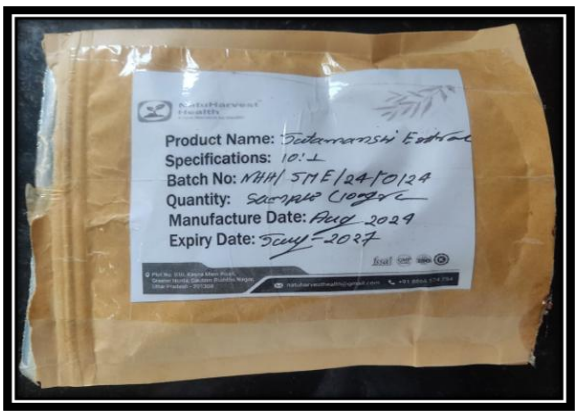

Fig.no. 10 Nardostachy Jatamansi root extract

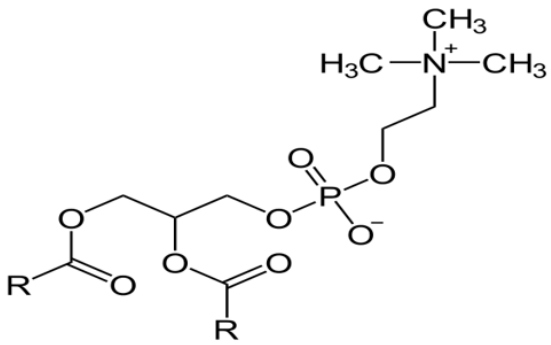

Fig. No. 11 Structure of Soya lecithin

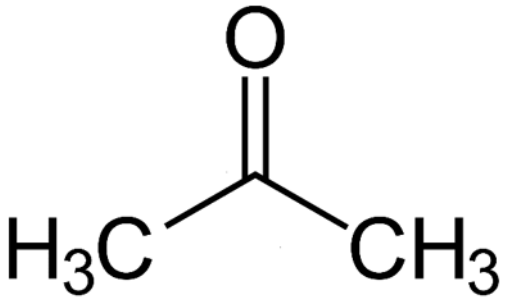

Fig.no. 12 Structure of Acetone Structure of Acetone

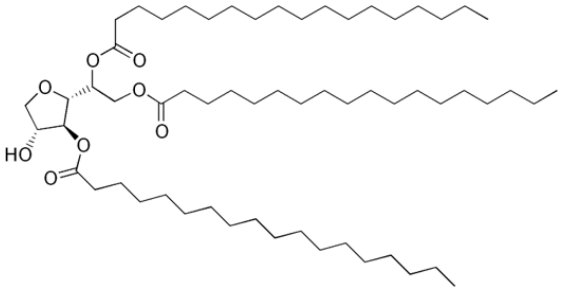

Fig No.13 Structure of Tween 80

NatuHarvest Health
From Harvest to Health

Certificate Of Analysis

Product Name: Jatamanshi Extract	Country of Origin: India
Botanical Name: Nardostachys jatamansi	Used part of Plant: Root
Batch No: NHH/JME/24/0124	Ratio :10: 1
Manufacture Date:Aug -2024	Expiry Date: July-2027
Type of Extraction: Ethanolic	Nature of product: powder

TEST	SPECIFICATION	RESULT	TESTING METHOD/REFERNCE
Appearance	Light brown color	Complies	Visual
Odor & Taste	Characteristics	Complies	Visual
Identification Test	Positive	Complies	By TLC Method
Extractive value in Water	NLT 80% (w/w)	84.56 %	In house
Extractive value in 60% v/v Method	NLT 80% (w/w)	82.49 %	In house
Sieve Analysis	95% pass 40 mesh	Complies	40 mesh screens
Loss on drying	NMT 7% (w/w)	3.33%	5g/105 °c/2hrs
Bulk Density	40-50 gm/100ml.	Complies	In house
PH(1% w/v aqueous solution)	Between 4-7	5.45	In house

Heavy Metals

Arsenic (As)	NMT 3.0 ppm	1.22ppm	API - II, Vol.-1, 147
Lead (Pb)	NMT 3.0 ppm	1.35ppm	API - II, Vol.-1, 147
Mercury (Hg)	NMT 1.0 ppm	Absent	API - II, Vol.-1, 147
Cadmium (Cd)	NMT 0.3 ppm	0.24ppm	API - II, Vol.-1, 147

MICROBIOLOGICAL CONTROL ANALYSIS

Total Plate Count	<10 cfu / g by heat & steam	589cfu /g	API - II, Vol.-1, 179
Yeast & Mold	<10 cfu / g by heat & steam	53 cfu /g	API - II, Vol.-1, 179
Salmonella	Negative	Complies	API - II, Vol.-1, 179
E. Coli	negative	Complies	API - II, Vol.-1, 179

Packing and storage

STORAGE CONDITIONS : Store at cool, dry place away from light & moisture.

*Since it is a Herbal Product, there is likely to be minor color variation from batch to batch of the product because of the geographical and seasonal variations of the raw material.
*Natural product can be hygroscopic and tend to agglomerate sometimes. It is suggested to sift the product before use.
*Packing & Storage - 25.0 kgs net weight in double LDPE cover placed in an export worthy HDPE drum, stored under room temperature, moisture free condition & away from direct light.

ANALYSED BY
(Chemist QC)

Approved By
(Manager QC)

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Fig No.14 Certificate of analysis of Nardostachy Jatamansi root extract Authenticated by Natu Harvest Health

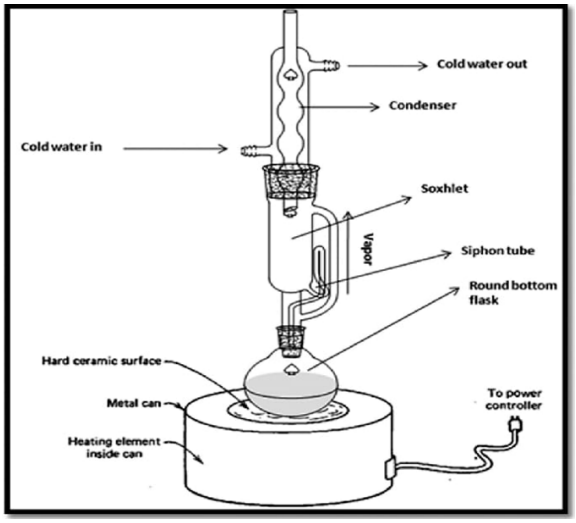

Fig.No.15 Soxhlet extraction apparatus used for extraction of Nardostachy Jatamansi

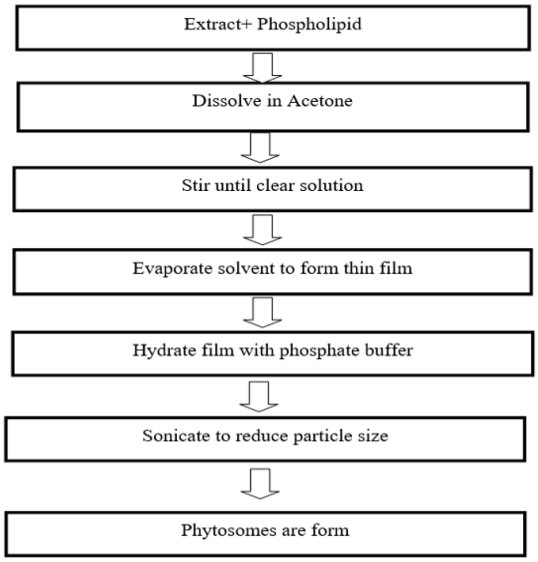

Fig.No.16 Preparation of Phytosome

Fig.No. 17 Solubility test of Nardostachy Jatamansi

Fig.No 18 Phytochemical test of Nardostachy Jatamansi root extract

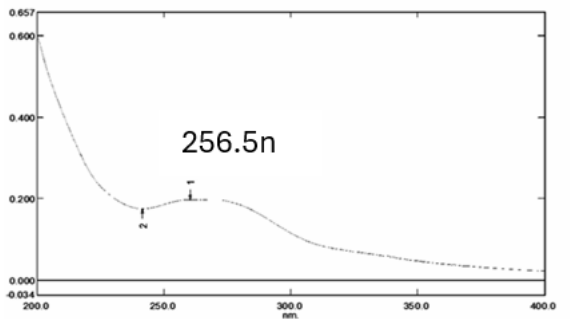

Fig No.19 Nardostachy Jatamansi root extract λ max

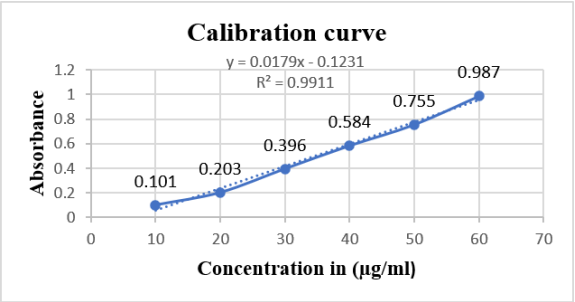

Fig.No.20 Calibration curve of Nardostachy Jatamansi

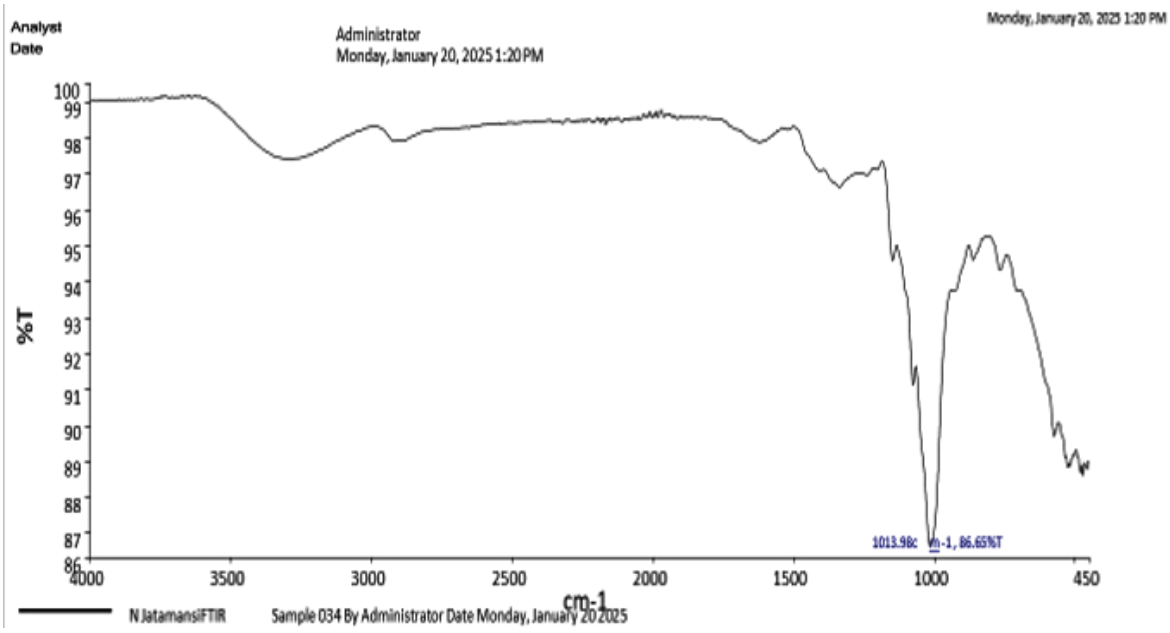

Fig. No. 21 Nardostachy jatamansi root extract FTIR

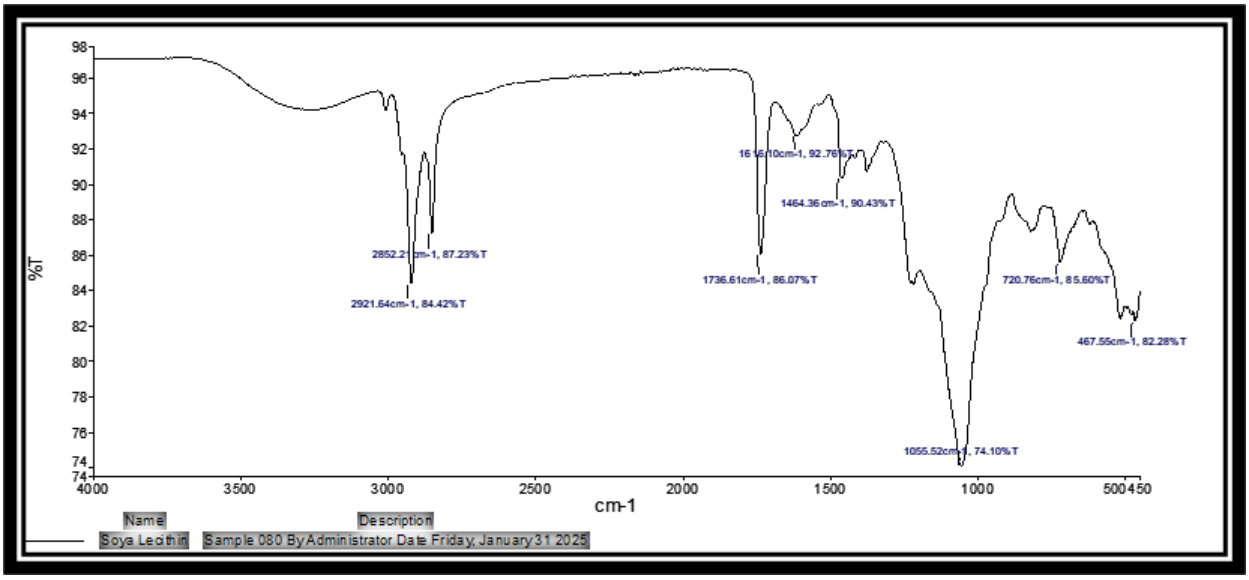

Fig. No. 22 Soya lecithin FTIR

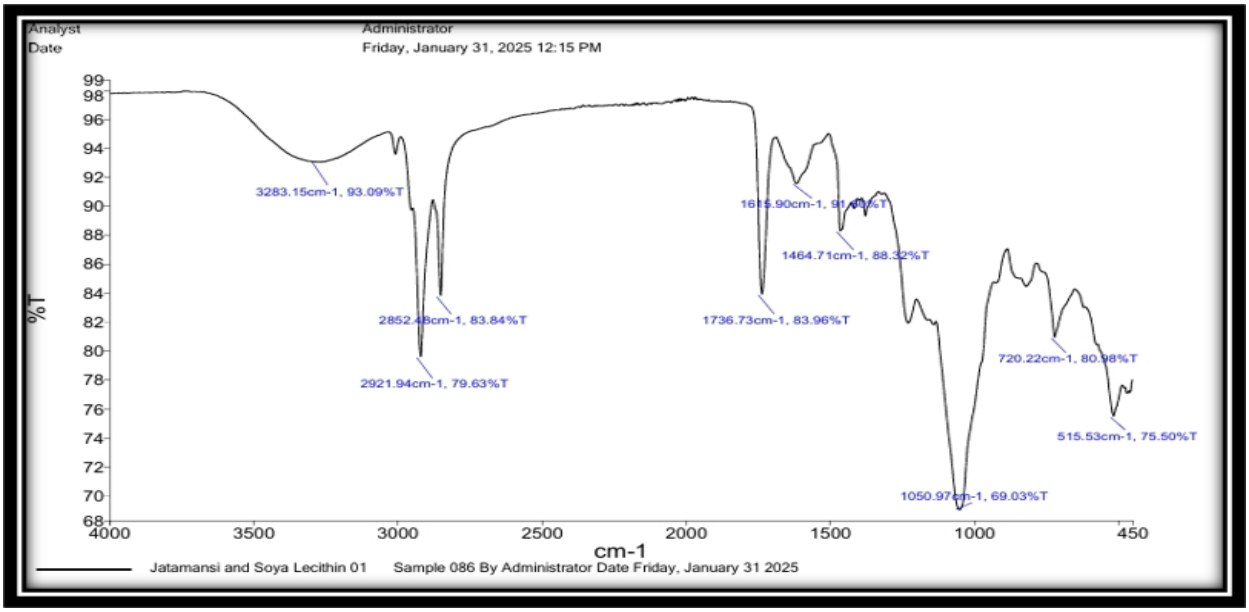

Fig. No. 23 Compatibility study of Jatamansi and soya lecithin

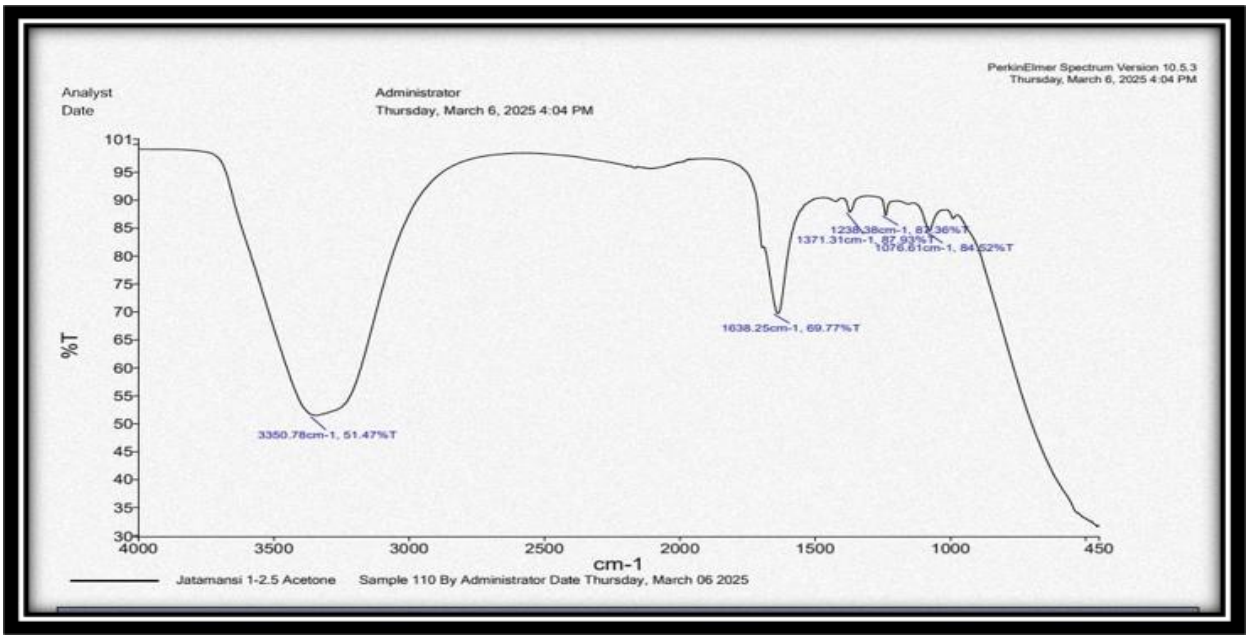

Fig No. 24 FTIR of Jatamansi root extracts Phytosome formulation

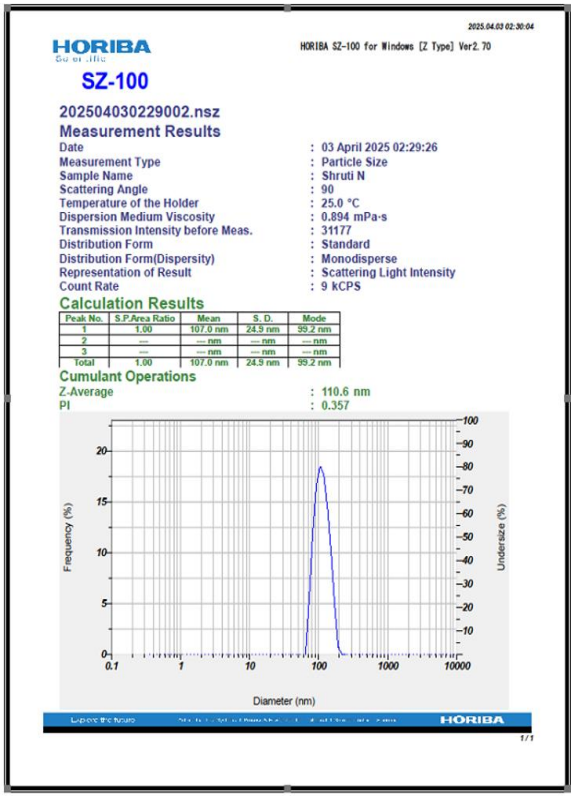

Fig.No.25 Particle size of Jatamansi phytosome

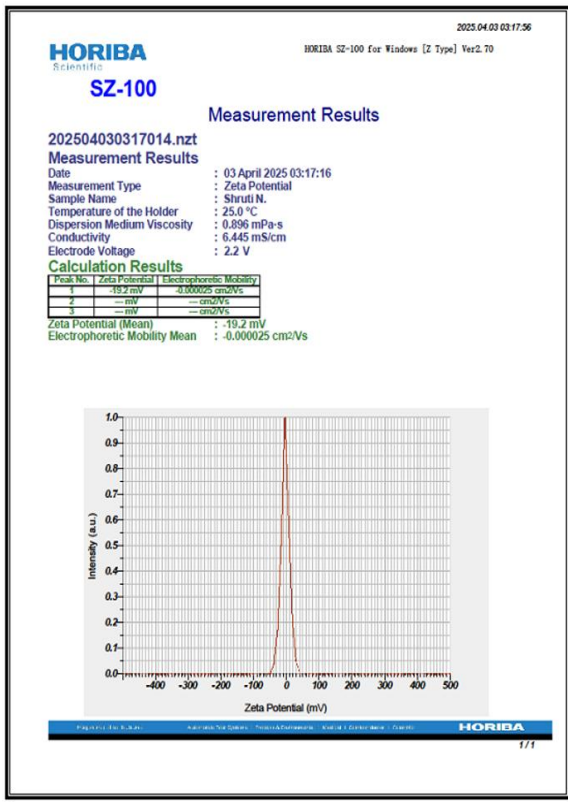

Fig.No.26 Zeta potential of Jatamansi phytosome

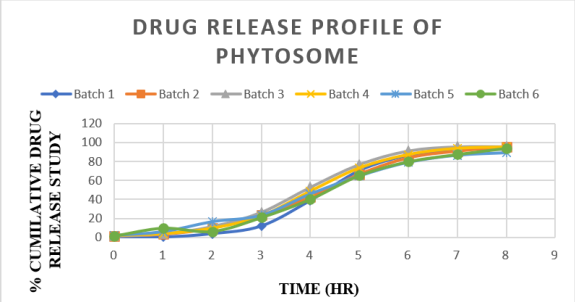

Fig. No 27 Comparative In vitro drug release profile of Phytosome Batches

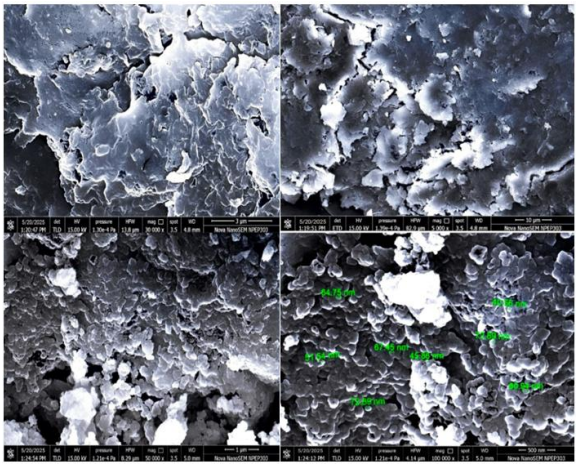

Fig.No.28 SEM image of Nardostachy Jatamansi phytosome showing surface morphology

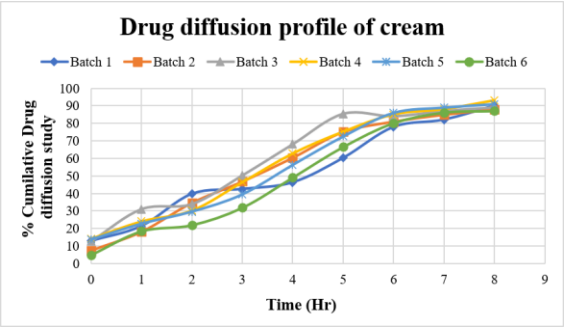

Fig. No 29 % of Comparative in vitro drug diffusion profile of Phytosomal cream Batches

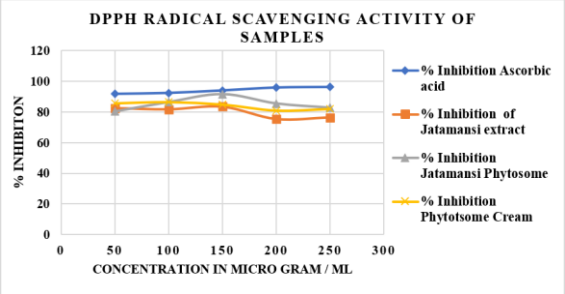

Fig. No 30 Comparative antioxidant activity % inhibition of different samples by DPPH Assay

Fig. No. 31 Formulated cream batches of Nardostachy Jatamansi phytosome