IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 5, Issue 2, January 2025

Evaluation of Medicinal Importance of Nothapodytes Nimmoniana

Mr. Shivam Sureshrao Mehkar[1], Mrs. Sneha K. Salve[2], Dr. Manisha D. Kitukale[3]
Student, Department of Pharmacognosy[1]
Assistant Professor[2]
Principal[3]
Pataldhamal Wadhwani College of Pharmacy, Yavatmal, Maharashtra, India

Abstract: *Nothapodytes nimmoniana (Amruta), also known as durvasanemara, kodsa, ghenera (Hindi), narcya and kalgur (Marathi), is a medicinal herb distributed immensely in India, especially in Maharashtra, Goa, Kerala, Assam and Jammu. The feature that distinguishes this plant the most is the production of camptothecin (CPT) which is a known anticancer agent.Camptothecin is a quinoline derivative and is referred to as a topoisomerase I inhibitor.Topoisomerase I is an enzyme that facilitates the unwinding of DNA during replication and transcription, hence it is vital in the duplication of genetic material.*

Apart from this, camptothec inpossesses anticancer, antibacterial, anti-inflammation and also antioxidant activity. Pharmacological activities of the plant include cytotoxic, antimicrobial, antifungal, anti-inflammatory and antioxidant among others. Camptothecin obtained from N. nimmoniana has been widely explained for its Use for the treatment of cancer.

In addition, the plant also possesses other bioactive compounds including quercetin and gallic and ellagic acids that enhance its medicinal value. The distribution of camptothecin in the leaves and stems of the plant varies; therefore, the population of N. nimmoniana must be assessed in order to achieve maximum efficiency in drug extraction.To put it concisely, Nothapodytesnimmoniana, a traditional herb also called as Amruta or Narkya, is considered significant because it yields camptothecin, an efficient cancer treatment drug. It also has several other names and is predominantly located within the Indian subcontinent. The plant also offers a broad range of therapeutic effects such as anticancer, antimicrobial, antifungal, anti-inflammatory, and antioxidant..

Keywords: Nothapodytes

I. INTRODUCTION

Medicinal plants have been an integral part of traditional medicine systems and serve as a crucial source of novel drug discovery. Nothapodytes nimmoniana holds a unique position in this realm, being one of the richest natural sources of camptothecin, which is widely used in synthesizing chemotherapeutic drugs like topotecan and irinotecan

These drugs are vital for treating cancers such as ovarian, colorectal, and lung cancers.However, overharvesting and habitat destruction have made this plant vulnerable,necessitating efforts to sustainably utilize and conserve it.

This study integrates ethnobotanical knowledge, modern phytochemistry, and pharmacology to provide a comprehensive evaluation of the medicinal value of Nothapodytes nimmoniana. It also highlights the need for conservation strategies and emphasizes the importance of this species in modern medicine.

By bridging the gap between traditional knowledge and scientific research, the project aims to contribute to the sustainable use of this endangered medicinal plant while maximizing its; therapeutic potential

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 5, Issue 2, January 2025

II. LITRATURE REVIEW

Karwasara & Dixit, 2013 Research indicates that N. nimmoniana possesses substantial antioxidant properties, which are closely linked to its phenolic and flavonoid content. The seasonal variation in these compounds suggests that the plant's medicinal efficacy may fluctuate throughout the year, with peak antioxidant activity noted in summer .

Shivaprakash et al., 2014 Ethnobotanical studies have documented the antimicrobial activity of N. nimmoniana against various pathogens, reinforcing its potential therapeutic applications in traditional medicine .

Khan et al., 2013; Rather et al., 2019 The role of camptothecin as a key therapeutic agent in cancer treatment has been extensively studied. Investigations reveal that different plant parts exhibit varying concentrations of camptothecin, with roots and seeds showing the highest levels .

Isah & Mujib, 2015 Significant geographical differences in camptothecin yield highlight the importance of targeted conservation efforts, particularly in regions where high concentrations are found .

Vasanthakumari et al., 2015 The establishment of endophytic fungi capable of producing camptothecin presents an alternative source for this valuable compound, thereby reducing reliance on wild populations of N. nimmoniana .Restoration of camptothecine production in attenuated endophytic fungus on re-inoculation into host plant and treatment with DNA methyltransferase inhibitor.

Dhar et al., 2019 Ethnopharmacological Applications Beyond CPT, traditional uses of this plant highlight its broader therapeutic potential. The bark, leaves, and roots have been traditionally used for their anti-inflammatory, antimicrobial, and hepatoprotective effects. These uses have spurred interest in identifying additional bioactive compounds.

Pai SR. Kolhapur, Maharashtra, India: Department of Botany, Shivaji University; 2010. Studies in medicinal plants: Ancistrocladus heyneanus Wall. Ex Grah. And Nothapodytes Nimmoniana (Grah.) Mabb. Ph.D. Thesis

Padmanabha BV, Chandrashekar M, Ramesha BT, Gowda HC, Gunaga RP, Suhas S, et al. Patterns of accumulation of camptothecin, an anti-cancer alkaloid in Nothapodytes Nimmoniana Graham, in the Western Ghats, India: Implications for identifying high yielding Sources of the alkaloid.

Qadri M, Johri S, Shah BA, et al.It describes Identification and bioactive potential of endophytic fungi Isolated from selected plants of the Western Himalayas. Springerplus. 2013 Dec;2(1):8. DOI: 10.1186/2193-1801-2-8.

Swamy, M. K.., Nath, Shreya., Paul, Subhabrata., Jha, N.., Purushotham, B.., Rohit, Komdur Channabasavaraju., & Dey, A.(2021). Biotechnology of camptothecin production in Nothapodytes nimmoniana, Ophiorrhiza sp. And Camptotheca acuminata.

AIM:

"Evaluation of Medicinal Importance of Nothapodytes nimmoniana":

OBJECTIVES:

To investigate its phytochemical composition, focusing on camptothecin and other bioactivecompounds. Assessing its pharmacological activities, including anticancer, antimicrobial, and antioxidant properties.

Exploring sustainable harvesting methods and potential biotechnological approaches forcamptothecin production to reduce pressure on natural populations.

To evaluate the pharmacological activities of its extracts or isolated compounds, such as anticancer, antimicrobial, antiviral, anti-inflammatory, and antioxidant properties.

To scientifically validate the traditional uses of Nothapodytes nimmoniana in indigenous systems of medicine for treating various ailments.

To evaluate the toxicity and safety profile of the plant extracts and isolated compounds to ensure their safe therapeutic use.

To explore its bioactive compounds as potential leads for the development of novel drugs targeting cancer, viral infections, or other diseases

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 5, Issue 2, January 2025

PLAN OF WORK:

Project Objective: To evaluate the medicinal properties of Nothapodytes nimmoniana, particularly focusing on its pharmacological activities, chemical constituents, and potential therapeutic applications.(2-3 Week).

Literature Review.: To gather existing knowledge about Nothapodytes nimmoniana, including its botanical properties, traditional uses, chemical composition, and previous studies on its medicinal properties.(1-2 Week).

Collection of Plant Samples: To collect plant materials (leaves, bark, roots, etc.) from a reputable source or field collection.(2-3Week).

Phytochemical Analysis: To identify and quantify the chemical constituents present in different parts of the plant.(3-4Week).

Evaluation of Pharmacological Properties:To evaluate the medicinal effects of the plant, including antimicrobial, anti-inflammatory, antidiabetic, anticancer, and antioxidant properties.(4-5Week).

Toxicological Studies: To assess the safety of Nothapodytes nimmoniana extracts.(6- 7Week).

Preparation of Herbal Formulations:To develop potential medicinal formulations from the plant, such as extracts, ointments, or teas, based on its active constituents.(1-2Week).

Data Analysis and Interpretation: To analyze and interpret the results from the various experiments.(3-4Week)

Report Writing and Documentation: To compile the findings into a comprehensive research report.(1 Week).

Conclusion and Recommendations: To summarize the findings and suggest Practical applications.(1Week)

NOTHAPODYTES NIMMONIANA AND ITS SIGNIFICANCE

The plant Nothapodytes nimmoniana is an endangered medicinal plant which is largely available in the regions of Western Ghats in India. Camptothecin (CPT) is present in the plant and is famous for its anticancer drug properties. Although, CPT is present in various

plant species but largest quantity of CPT has been found in N. nimmoniana. Because of its very high source of CPT, this plant has been studied in all possible Phytochemical, Biotechnological, and Pharmacological terms.

However due to the high global demand for CPT, the overharvesting of N. nimmoniana, uncontrolled timber extraction, and low yield of CPT from wild collected plants, the decline of seed viability, high retail price and lack of an economical approach for the substance industrial cultivation has encouraged us to research this plant in an ordered manner.

It may also serve as a way to optimize the extraction and quantitative determination ofCPT. Also, Bioreactors production of CPT using high yielding cell line of N. nimmoniana. The pharmacological data will be applicable for new Drug discovery and development for safe and effective novel compounds.

Nothapodytes nimmoniana is an endangered medicinal plant which is found largely in Western Ghats of India. The plant is rich in camptothecin (CPT) which is famous for it's anticancer drug properties. Although, CPT is found in many plant species but the highest yield of CPT is provided by N. nimmoniana. Because of its very high source of CPT, this plant has been studied in all possible Phytochemical, Biotechnological and Pharmacologicalterms.

While considering the fact that there is a tremendous demand for CPT across the world, the rampant destruction of N. nimmoniana, risks of deforestation, and the least amount of usable synthesis from wild-grown plants deployed at restoration, falling levels of seed viability, high reproductive cost and not having an affordable method of production has encouraged us to tudy the plant in a systematic way.The medicinal properties of several herbal plants have been documented in ancient Indian literature and the preparations have been found to be effective in the treatment of diseases.

In developing countries the basic health care needs are met through the traditional healing practices and use of herbal medicinal - plants and over the last few decades there has been a similar trend where the use of herbal medicine has increased in the developed countries. With growing concerns over the efficacy of chemotherapeutics and the growing threat posed by pathogenic microbiological infectious agents antibiotic resistance screening many medicinal plants for antimicrobial activities has begun.

Out of the above, plants remain one of the richest sources of therapeutic agents. Many drugs are derived from plants or plant secondary metabolites are incorporated into drug synthesis. The production and, use of large number of ethnopharmacological and, biological investigations done around the globe explains the great contribution of plants to the drug manufacturing sector. [1,2,3]

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 5, Issue 2, January 2025

IMPORTANCE OF CAMPTOTHECIN AND ITS APPLICATION IN CANCER TREATMENT:

Camptothecin is a naturally occurring compound considered a potent chemotherapeutic drug used in the treatment of cancer and particularly leukemia (Jones et al. 1997). Camptothecin interacts with the enzyme type I DNA topologies target structures preventing DNA replication by inhibiting both cuts and rejoining processes. Thisinhibits the in vitro growth of L. donovanipromastigotes.

Unfortunately, camptothecin would seem to possess a significant disadvantage because it is unstable in human plasma and is very toxic. Hence, developed diazole membranes with light steric stabilization by using dipalmitoylphosphatidyl choline, dipalmitoylphosphatidyl glycerol, and distearoylphosphatidyl ethanolamine-N-PEG 2000.

Dipalmitoylphosphatidylcholine lipids exposed to hydrating conditions usually below the phase transition temperature were hydrated in the presence of camptothecin suspended in DMSO and phosphate buffer to yield liposomes of sizes 160 and 200 nm.

Also, sterically stabilized liposomes exhibited in vitro inhibition of L. donovanipromastigotes growth in a dose dependent manner. Intraperitoneal injection of liposomal camptothecin achieved high concentrations of the drug in the liver and spleen after treatment, and parasite loads in the liver were reduced by 55% as compared to untreated controls.[1,2,3]

II. BOTANICAL DESCRIPTION OF NOTHAPODYTES NIMMONIANA

TAXONOMY AND CLASSIFICATION ;

The taxonomy of the Nothapodytes nimmoniana plant is as follows:

Kingdom:	Plantae
Phylum:	Tracheophyta
Class:	Magnoliopsida
Order:	Icacinales
Family:	Icacinaceae
Genus:	Nothapodytes Blume

Nothapodytes nimmoniana is a shrub or small tree that is native to the Western Ghats and Himalayan regions of India. It is also known as Amruta, kalgur, or Narkya. [1,4,5]

Features:

1. Leaves	Dark green, simple, alternate, spiral, and clustered at twig ends.
2. Flowers	Yellowish, in terminal cymes, and emit an unpleasant odor.
3. Fruit	Purplish red, smooth, oblong, and 1.5-1.8 cm
4. Bark.	Brownish and lenticellate
5. Blaze	Light orange, Young branchlets, Subterete, lenticellate, and puberulous.

MORPHOLOGICAL CHARACTERSTICS (HABITAT, DISTRIBUTION, PHYSICAL FEATURES):

Nothapodytes nimmoniana, also referred to as the fetid tree or tinking plant, is an evergreen tree that belongs to the Icacinaceae family. It is best known for its medicinal applications due its high content of the potent alkaloids such as camptothecin.

Morphological characteristics :

Habitat- The tree mainly grows in the moist evergreen forests of the southern WesternGhats in India and in Sri Lanka. The tress flourishes in warm moist tropical climate.

Distribution; the southern Western Ghats of India down to Sri Lanka mainly in the rain forests, mostly but not always, high rainfall areas.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 5, Issue 2, January 2025

Physical features:

Size: Nothapodytes nimmoniana is an example of a medium tree species reachingmaximum height growth of 20 meters.

Bark: The bark has a rough texture and is grayish brown in color with longitudinalfurrows that are usually present.

Leaves: The leaves are simple, alternate, leathery, and tippet tipped elliptical or ovateshaped leaves, which are pointed at the apex.

Flowers: Few yellowish Green Flowers rise in Clusters on the Tree

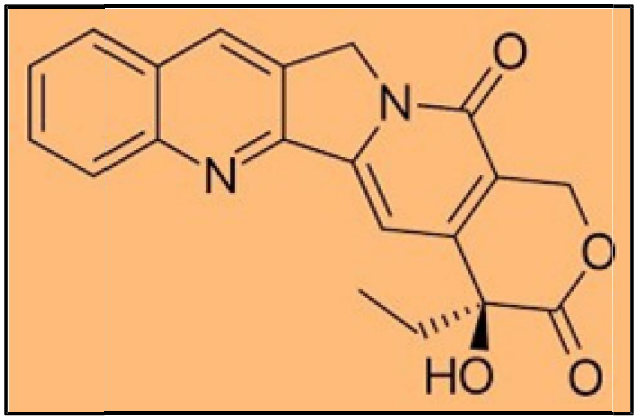
Fruits: At this point small fleshy, dark purple or blue fruits are formed after the blossoming stage. [4,8]

Medicinal significance:

The main alkaloid components of Nothapodytes nimmoniana are extracted, which is used in the treatment of various cancers like colon, ovarian, and lung; Camptothecin is a carcinogenic alkaloid and plant extract.

Although Nothapodytes nimmoniana is one of the amazing medicinal plants. It is essential to seek medical advice prior to taking any products produced from it. This plant is increasingly being used owing to its medicinal value and this is causing the concern on its conservation status. [3,4,5]

PHYTOCHEMICAL COMPOSITION AND UNIQUE FEATURES :



Medicare requirements of more than 80% of the Indian population are satisfied by the enormous diversity of medicinal plants (1/4 of the globe) present in India. Of the entire plant wealth, 25 % is distributed in Western Ghats, a hot-spot of mega biodiversity and an important area of collection.

Exports of herbal medicines, both in quantity and value, rank India as the second largest in the world. Due to these newly identified and recently discovered pharmacological and curative properties, some tree species from Western Ghat have begun to draw the attention of the world audience. But this has encouraged their unregulated exploitation and as a result intense pressure is being exerted on very existence of these species.

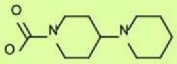
One such species is Nothapodytesnimmoniana [earlier included in MappiafoetidaMiers], which is an excellent source of potent alkaloids such as camptothecin (CPT) [(S)-4-ethyl- 4-hydroxy- indolizino[1,2-b] quinoline-3,14(4H, 12H)-dione] , 9-methoxy camptothecin and mappicine.

CPT is generally extracted from leafy parts, stem wood, stem bark, root bark, root wood and seeds of the N. nimmoniana plant. For the very first time, CPT was isolated from the Chinese tree Campothecia acuminata [6], and subsequently its analogs were traced in a number of plant species such as Merriliodendron megacarpum, N. nimmoniana, Ophiorrhiza mungos, O. pumila (Rubiaceae), Eravatamia heyneana (Apocynaceae) and Mostuea brunonis (Loganiaceae).

Of these species studied so far, N. nimmoniana was the one that had the highest N. nimmoniana harvested the highest camptothecin (0.3% w/w) content. [7]

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 5, Issue 2, January 2025

MAJOR CHEMICAL CONSTITUENTS REPORTED FROM NOTHAPODYTES NIMMONIANA:

Camptothecin	H	H	H
9-Aminocamptothecin	H	NH_2	H
Topotecan	OH	$CH_2N(CH_3)_2$	H
Irinotecin		H	CH_2CH_3
SN38	OH	H	CH_2CH_3

CAMPTOTHECIN : A VALUABLE ALKALOID :

STRUCTURE, PROPERTIES AND BIOSYNTHESIS OF CAMPTOTHECIN:

Camptothecin is a component that has the six rings connected in a planar pentacyclic way.It has the following characteristics:

Ring structure: A planar pentacyclic ring system composed with a moiety of pyrrolo[3,4- beta]-quinoline spends three rings marked as A, B, C and then a pyridone ring attached conjugatively as ring D, with a 20th position being a chiralcenter within the alpha hydroxy lactone ring

Substitutions: Oxford comma in both 3 and 14 positions along with elements Sand C attached at 4th position

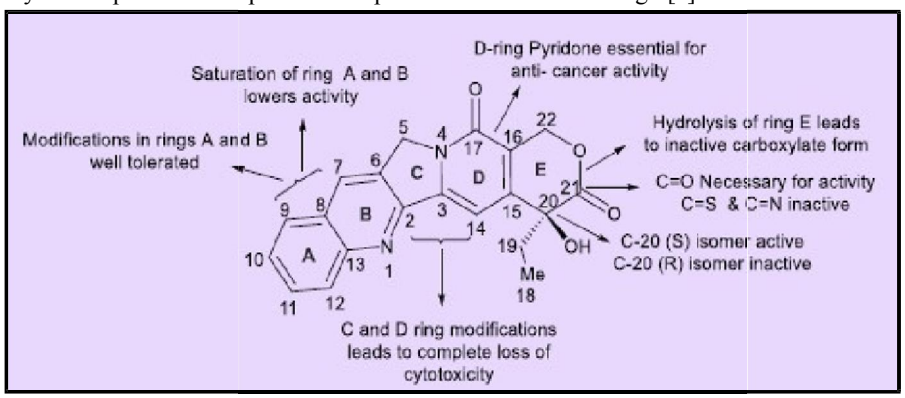
Chemical formula: C20H16N2O4

The anticancer activity of camptothecin is contributed by the same compound in its lactoneand carboxylate forms. Several investigations established that:

E-ring in the lactone form is more active adhered than carboxylate E-ring adhered

E-ring located at the position 20 with S-configuration at the chiral center is criticalfor the activity of CPT compound

Antitumor activity of the patented camptothecin depends on the A and B rings [9]



[10]

PROPERTIES:

Anticancer activity:

CPT is a potent inhibitor of nuclear enzyme topoisomerase I that participates in DNA replication. As a result of inhibiting the re-ligation of DNA by the topoisomerase I- DNAcomplex, CPT leads to DNA damage and ultimately to cell death. CPT is used in treatment of a number of cancers such as lung cancer, breast cancer, brain cancer, colorectal cancer and ovarian cancer.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 5, Issue 2, January 2025

pH-dependent:

CPT has two different stable forms namely lactone and carboxylate forms which exist at different levels of pH. The lactone form is stable in pH less than 5.5 and is considered the active form where as carboxylate form is stable in pH more than 9 and is considered aninactive conformer.

Poor solubility:

CPT is known to be poorly soluble and not stable.

Adverse effects

The administration of CPT may result in the adverse effects of neutropenia, diarrhea and cholinergic syndrome.

Source:

CPT was first discovered some 60 od years ago in the course of investigations into steroidal precursors of cortisone. It is obtained from the Chinese tree Camptotheca acuminata, but also produced by endophyte Nothapodytes foetida and fungus Fusarium solani. [13,14,15]

BIOSYNTHESIS OF CAMPTOTHECIN:

Pre-strictosamine pathway:

The first step in tryptophan synthesis is via the shikimate pathway from chorismate. Anthranilate synthase enzyme departs synthesizing chorismate and incited anthranilate which later attaches to 5-phosphoribosyl pyrophosphate giving rise to indole glycerol phosphate. The indole TSA α-subunit is attached into the growing IPA chain of indole- glycerol phosphate, which is done by condensation of tryptophan with TSB. Due to the action of tryptophan decarboxylase enzyme, tryptophan is decarboxylated to tryptamine. In addition to this, secologanin is prepared from IPP and its isomer DMAPP both of which are 2 C-methyl-D-erythritol-4-phosphate (MEP) and mevalonate (MVA) pathwayprecursors.The two intermediates IPP and DMAPP react to give Geranyl pyrophosphate (GPP) and the GPP undergoes reaction with GPP geraniol-synthase enzyme to give geraniol. Geraniol undergoes hydroxylation at the 10 position to give 10-hydroxy geraniol and is transformed into loganin. Loganin is a precursor to secologanin, which is formed by the action of secologanin synthase on loganin .

Strictosidine synthesis:

A complete molecule of tryptamine and a complete molecule of secologanin are bothcombined together which leads to the production of strictosidine.This is Pictet- Spengler reaction between tryptamine and secologanin which is facilitated by the enzyme known as strictosidine synthases (STR).

Post-strictosidine pathway:

In the present situation, all steps involving CPT are carried out in a single or multistep sequence. Internal cyclization transforms strictosidin into strictosamide. Subsequently, strictosamide is transformed to pulmioside and deoxypulmioside andeventually gives camptothecin. When converting strictosamide to camptothecin, a B ring and a C ring undergo oxidation and rearrangement, and the D ring undergoes elongation while C is omitted

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 5, Issue 2, January 2025

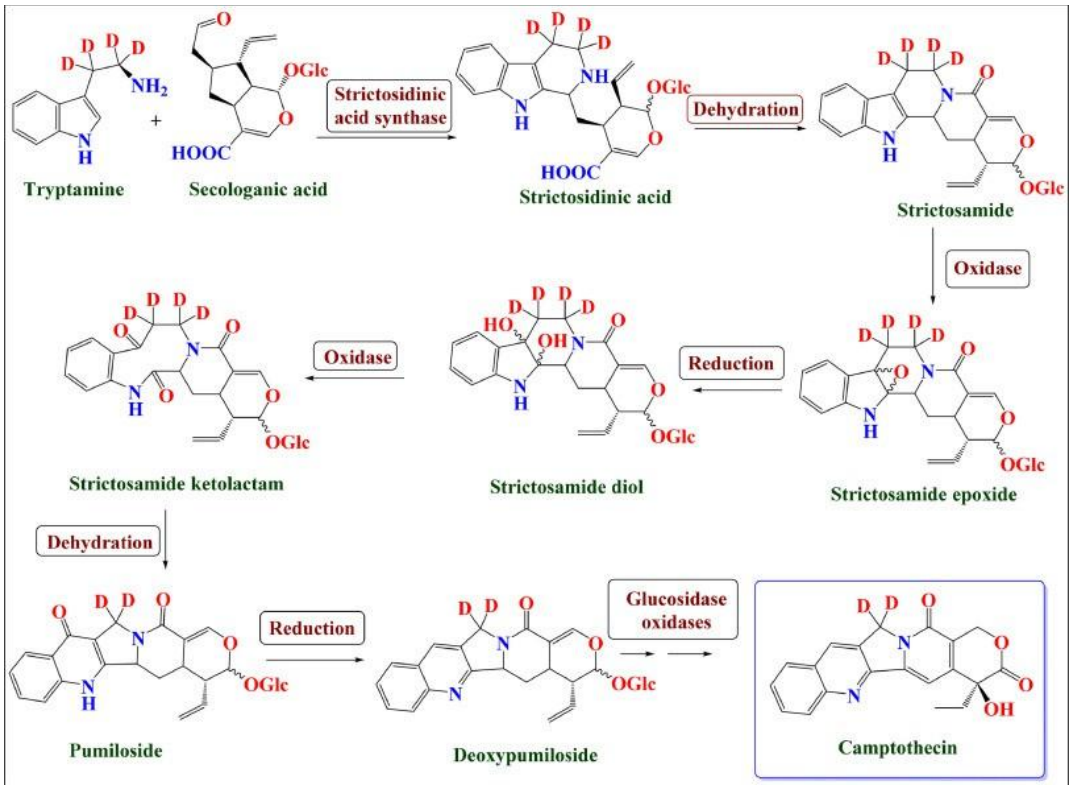


Fig : BIOSYNTHESIS OF CAMPTOTHECIN [7,16]

ACCUMULATION AND LOCALISATION IN NOTHAPODYTES NIMMONIANA:
By using Blue-coloured fluorescence:

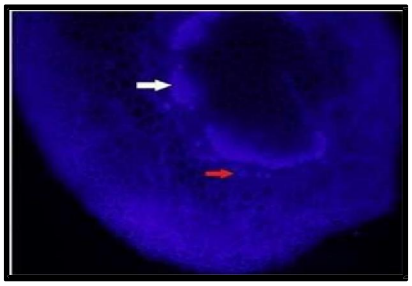


Figure 1

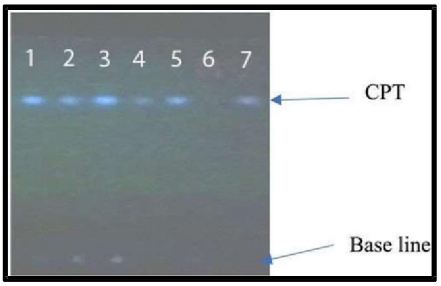


Figure 2 [17,18]

Fig1.Blue-coloured fluorescence in the xylem elements and isolated strands of fibres in the phloem layer suggest the accumulation of CPT in *N. nimmoniana* petiole.

Fig.2 The TLC of chloroform–methanol (4:1 v/v) extracts of various parts of *Nothapodytes nimmoniana* visualised under UV 366 nm. Lane 1: CPT standard, lane 2:stembark extract, lane 3: root extract, lane 4: leaf extract, lane 5: twig extract, lane 6: *Centella asiatica* leaf extract (negative control) and lane 7: CPT standard.

Observations made through fluorescence microscopy showed that vascular based tissues mainly the xylem is the site where most of the CPT is stored within all the plant parts of N. nimmoniana. Camptotheca acuminata, it was shown that the vascular tissues of the shoots and the outer cortical regions of the roots contained the greatest levels of tryptophan synthase beta subunit (TSB).

This specific TSB is needed for the production of an important precursor called tryptophan, which is then used for producing CPT.This indicated that, CPT, or more likely a soluble form of it, may also be transportedthrough the

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 5, Issue 2, January 2025

xylem from where it is made to where it is kept.Moreover, in Chonemorpha fragrans, the places identified for the storage of CPT in leaf,root and twig were trichomes, epidermis and vascular tissues respectively.In the case of cellular localization of CPT in N. nimmoniana Similar trend was seen inthis study.
[9,11]

By using TLC method:
The TLC technique illustrated the presence of CPT in the CM extracts of all the tested plant parts (Figure 8). For Rf 0.66, the CPT reference exhibited distinct blue fluorescence.
Likewise, the CM extracts of the leaf, stembark, and root tissues revealed an impressive blue fluorescence spot at the same Rf 0.66. On the other hand, this spot was absent in the CM extract of the leaves of Centella asiatica, which does not produce CPT.Hence, these findings clearly indicate a qualitative presence of CPT in N. nimmoniana.
[12]

PHARMACOLOGICAL ACTIVITIES AND MECHANISM OF ACTION:
Antimalarial activity:
In vitro effects of a topoisomerase I selective and potent inhibitor, CPT, on the erythrocytic stages of malaria parasites. Camptothecin, in Plasmodium falciparum, caused protein-DNA complex trapping, inhibited nucleic acid production and had a cytotoxic effect.These observations proved the hypothesis that new antimalarial strategies would benefit om targeting topoisomerase I.

Anti-inflammatory activity:
Evaluation of the anti-inflammatory property of the N. nimmoniana by the carrageenan- induced hind paw edema method in rats. The activities of the extracts were compared with control and standard ibuprofen.All the drugs were used through oral administration. It was dose-dependent when compared to the petroleum ether extract, yastimi capsule, which contains the ethanol extract of 200 mg/kg (p less than 0.01) considerably reduced the inflammation and the result was appreciably equal to that of the standard, ibuprofen .

Immunomodulatory activity:
An extract of the newly found fungal endophyteEntrophosporainfrequens isolated from N. nimmoniana has exhibited immunomodulatory activity.The evaluation was done on the bioactivities of chloroform and methanolextracts of Entrophosporainfrequens in vitro and in Balb/c mice in vivo concerning their potential as immunomodulatory agents.In endophyte E. infrequens, the synthesis of CPT was found to be comfortable when tested with chloroform.For the first time, the presented work showed the immunomodulatory potential of a newly discovered mobile CPT producing endophyte within neearchic N. nimmoniana.

Antitumor/cytotoxic activity:
The efficient antitumor activity of 10-methoxy-9-nitrocamptothecin. Paralleling the high cytotoxic potency of 10-methoxy-9-nitrocamptothecin was its capacity to promote entrapment of DNA damage within cells.Because of these results, the possibility that development of the anticancer properties of 10-methoxy-9-nitrocamptothecin is associated with regulation of the cell cycle was postulated, which created a firm basis for further anticancer efforts with 10-methoxy-9- nitro-camptothecin.It was also demonstrated thatS or G2-M arrest as well as homologous recombination repair were activated by CPT in tumor cells. It was shown that the plant alkaloid CPT caused DNA damage by acute interaction with DNA topoisomerase and exerts antitumor activity against various types of tumors.A broad spectrum of biologically active agents was also found, namely, a novel alkaloid hitacetylcamptothecin with 17 other standard compounds.These include, but are not limited to, scopoletin, camptothecin, 9-O- methoxycamptothecin and O-acetyl camptothecin which displayed moderate cytotoxic activity. [7,11,12]

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 5, Issue 2, January 2025

MEDICINAL PROPERTIES OF NOTHAPODYTES NIMMONIANA:

TRADITIONAL USES AND FOLKLORE:

The common names for Nothapodytes nimmoniana include Ghanera, Durvasanemara, Kalgur, Kalagaura. This species occurs inthe Western Ghats - Southern, Central and Southern WesternGhat of Maharashtra, parts of Assam, Himalayan region,Ceylon, Burma and Thailand.

The plant is a tree reaching a height of 3-8m growing on the smooth and grey wrinkled bark of about5 mm thickness. Branchlets are slightly angled corky with prominent leaf scars6. Leaves are borne in whorls and aredistichous, slightly leathery texture, broadly ovate to oblong elliptic caulicule 1-25cm in length and 4- 12cm in breadth. The base of the leaf is often unequal; the tip is tapered to longsharp. Leaves areclustered at the apices of branches. Leafstalks 3 to 6 centimetres long. Flowers are hermaphrodite,creamy yellow, fetid, approximately 5 mm in diameter, in flat-toppedracemes at the terminal ends of the branches.The surfacesof the petals are pubescent. The seeds are 2 x 1 cm, smooth,bearing a single seed, purple-black when matured and elongatedcylindrical to ellipsoidal in shape.

Nothapodytes nimmoniana has been reported to possess camptothecin as its active ingredient which has an anticancer potential. Camptothecin (CPT), which is a monoterpene indole alkaloid, is the appropriate- proposed anticancer compound of the twenty first century. DNA topoisomerase I, the cellular target of camptothecin, has led to the synthesis of many analogues as therapeutic agents.In vitro, CPT also has been shown to inhibit the replication of Human Immuno Deficiency Virus (HIV) and it is also effective in managing lung, breast, uterine and cervical cancers to a complete remission.

Topotecan and irinotecan are some of the several water-soluble derivatives of camptothecin that are already in practice against patients suffering from colorectal and ovarian cancer. Camptothecin shows a molecular and cytotoxic effect against Plasmodium falciparum and this makes CPT an appealing compound for the development of new antimalarial drugs. The Chinese deciduous tree Camptotheca acuminata was the first to contain camptothecin. [19,20]

CULTIVATION , EXTRACTION AND ANALYSIS OF OF CAMPTOTHECIN:

CULTIVATION AND HARVESTING OF NOTHAPODYTES NIMMONIANA:

Planting practices:

This tree crop does well in moist and deciduous tropical forests with good drainable andfertile soils with an acceptable soil pH of 5.0-6.0.

The temperature recommended for sown seeds is between 12-35 degrees centigrade.Seeds are planted within the windows of winter and early spring seasons.

The average gestation period for the crop is said to be between seven and eight years.

Crop structure:

Collection of the crop should mostly be done during summer. The highest content ofcamptothecin is found in the root wood whereas the least is found in the leaves.

The content of camptothecin is directly proportional with the age of the plant.

Cultivation of Endophytes:

Endophytes can also be exploited for bioactive cytochalasins from Nothapodytesnimmoniana. For instance, endophytic culture medium can also be formulated using detergents partially gone off industrial materials such as corn steep liquor, molasses and sour whey.

The endophytes can be grown through submerged fermentation or solid statefermentation techniques. [23]

EXTRACTION METHODS (SOLVENT EXTRACTION) AND OPTIMIZATIONOF NOTHAPODYTE

The extraction of natural products derived from plants is one of the most complex area of research for both pharmaceutical and chemical industries. In the past, extraction was performed by methods like maseration, percolation,

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 5, Issue 2, January 2025

soxhlet, stirring e.t.c. Most of these old extraction methods are labor intensive, take a lot of time, consume a lot of organic solvents with low extraction efficiencies resulting to low yields.

Infatuation with drugs derived from plants and a focus on process improvement has driven Ultrasound, Microwave, and Pressure Assisted Extraction innovative technologies for extraction.

For CPT, literature does report on maceration and its related methods of extraction but the methods are slow and take as much as five days with treatment; that is three treatment cycles and use of up to twenty to two hundred times the amount of organic solvents. In order to compensate for these limitations and improve the process, we thought of employing ultrasound as a means to aid in extraction. The findings and analysis of the investigations such as the effects of different process parameters, and kinetic mechanisms, mathematical modelling are discussed in this paper.

Ultrasound Assisted Extraction (UAE) process is characterized by several features that make it simple to execute, offers quick application, low-energy consumption and turns out to be remarkably effective. Upon application of ultrasound, bubbles within the liquid tend to grow creating the effect of cavitation. When asymmetric implosion occurs with such bubbles near the cell or that of solid surface under saturated conditions, high shear force generates due to enhanced mass transfer causing cell damage. Furthermore, the transmission of ultrasound increases the solvent's ability to penetrate the plant material, promotes solid-liquid interactions, and facilitates the rapid transfer of solute from the solid phase to the liquid phase. UAE is a technique that has found its scope in the extraction of various biological materials such as oils, flavonoids and alkaloids as well. Due to limited availability of the plant species, and given the high content of CPT in the stem we used commercially the ethylene plant without damaging roots structure

In designing a process, it is also useful to analyse the cause of slow extraction and how this can be avoided by employing better extraction techniques. Therefore we intended to examine the plant stem cellular sites of occurrence. It can provide valuable insight into location of the compound within plant matrix.

Fluorescence microscopy was carried out first to locate the place where CPT was foundand what barriers were preventing the diffusion of CPT. This included formation of tissues and prepared a dovetail for application of ultrasound waves for enhanced disruption of cells. Correlating the site of compound and the process of extraction is a new development thatis expected to provide a deep understanding of how the extraction process behaves. [24]

ANALYTICAL TECHNIQUES FOR CAMPTOTHECIN QUANTIFICATION:

Preparation of Extract and Isolation of Camptothecin

The microwave-assisted extraction and isolation of CPT from the leaves of Nothapodytes nimmoniana employed the synthetically surfactant emulgen as an emulsifying agent.

An accurately weighed quantity of 5 g of leaf powder was taken in a clean dry 250 mlconical flask along with 200 ml of emulgen solution of pH 8.

The resultant mixture was microwave irradiated for about 1 minute at 350 Voltage andallowed to cool for 2 Minutes.

The resultant solution was adjusted to pH 3-4 using Sulfuric acid after which CPT wasprecipitated by the addition of Mayer's Reagent.

Fourier transform infrared spectroscopy (FTIR) study

FTIR (Perkin Elmer FTIR model-1615) is a contemporary analytical technique which affirms the disease-different peaks of CPT which makes clear the special groups in it, and the CPT sample was measured within the range of 4000 to 400 cm−1 with 4 cm−1 resolution

Mass spectrometry

As far as mass spectrometry is concerned, the LC ion trap method was employed to determine both positively and negatively charged ions in the mass spectra. For the positive ion mode and negative ion mode, capillary voltages of -3800 V and + 4500 V were applied, while the final voltages in both ion modes were ±500 volts in the positive and negative ion modes, respectively.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 5, Issue 2, January 2025

Also, a miniature tofit-q was attached with an Apollo ESI ion source through which a CPT sample was injected. The conclusion of structural elucidation was supported by the evaluation of isotope and mass precision patterns .

Cytotoxicity study

Cells were plated in 96 well microtiter plates and were allowed to pre-incubate at 37

Cin 95% humidity and 5% CO2 atmosphere overnight.

Cells were treated untill one day prior to assay with the given concentrations from 20 to0.625 ug/mL samples. The cells were incubated for 48 additional hours.

The wells were washed with phosphate buffer solution and every well was filled with 20µL of MTT solution and incubated at 37 °C.

After 4 h incubation, DMSO was added in each well to dissolve formazan crystal andabsorbance was quantified at 570 nm using micro plate reader.

Preparation of standard stock solution

In prepared 10 mg of camptothecin accurately weighed, and put into 10 mL of organicsolvent, methanol, then diluted to 100 mL with the same solvent.

The prepared solution was termed as standard stock solution and contained camptothecin of concentration 1000 µg/ml. From this standard stock solution, 10 ml was taken out and a concentration solution of 100 µg/ml was prepared by an appropriate dilution which was then filtered within Whatman filter paper before analysis.

Development of Calibration Curve

At room temperature, primary stock solution was adjusted appropriately to obtain aworking solution.

The working solution was then diluted serially at varying concentrations, and scanned within the range of 200 - 400 nm (Shimadzu-UV-1900).Using this working solution, the linearity of calibration curve was determined between 1- 100 µg/ml by dilution. [25,26]

CHALLENGES AND FUTURE PERSPECTIVE:

SUSTAINABILITY AND CONSERVATION OF NOTHAPODYTES NIMMONIANA:

N. nimmoniana is a threatened species. There is a tough work ahead of every conservation biologist, because they have to come up with the solutions, in which wild population can be exploited commercially without high harvest pressure. This is to encourage the cultivation of the species in quantifiable measures, as they in a way eliminate unnecessary harvest from the wild . The studies presented here have shown positive progress towards achieving that objective.

The background screening collected ‘plus individuals’ of wild populations with exceedingly high CPT content. Some individuals exhibited CPT contents that were over three times higher than the CPT range (0.14-0.24 %). These individuals come from regions which have lower rainfall and temperate deciduousforests. Hence to begin with, it will be an important for the scale up of existing nursery facilitiesfor multi-location field trials in raising plantations over different agroclimatic zones. This will help in determining the feasibility of the region for commercial cropping of N.nimmoniana.

Increase of stem bark’s CPT content is directly related to the maturity of that particular plant. From the earlier experiments carried out by us and also, did not show any effect onCPT content with respect to plants with GBH more than 16 cm. The specimens which we collected were young specimens with less than 15 cm GBH. The specimens of these age classes showed considerably increased CPT content as theage of plant increased.

Further experiments on the plantings from different sites with increasing age (1 yr, 2 yr, 3yr etc.) for assessing the CPT content would give a more decisive outcome and wouldalso result in the establishment of the ideal harvestable age of the stem after the plant has been cultivated. Such growth and CPT content studies will contribute in increasing the yield of CPT perbiomass. [26,27]

BIOSYNTHETIC AND BIOTECHNOLOGICAL APPROACHES FOR CAMPTOTHECIN PRODUCTION:

In recent years there have been significant developments in the area of Biosynthesis and Bioproduction of CPT. Metabolic engineering is one of the methods which focuses on the production of CPT. It is a special field of biotechnology which involves alteration of the genetic material of the enzymes which are part of the biosynthetic pathways. There has been partial resolution and identification of the biosynthetic genes responsible for

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 5, Issue 2, January 2025

strictosidinic acid and some of its derivatives. These are designated CaG10H, Ca10HGO, CaIS, CaSLAS, CaTDC, CaSTRAS, andCa10OMT.

The knowledge of the function of these genes makes it possible for the research to control the biosynthetic pathway in order to increase the production of CPT (Fan et al.2022). In metabolic engineering, the enhancement of CPT production may be achieved by the overexpression of the genes which encode enzymes responsible for the biosynthesis of CPT or by the inhibition of the competing pathways which in turn increase the metabolicflux of the biosynthetic pathways of interest.

In the previous ten years, numerous studies of metabolic engineering for the enhancement of CPT production have been carried out. Plant tissue culture Techniques such as hairy root culture, cell suspension culture, and adventitious root culture can be used to produce CPT. Endophytic fungi Endophytic fungi like Entrophosporainfrequens can be used to produceCPT.

Precursor supplementation Adding precursors like tryptamine, loganin, and secologanin to the plant can increase CPT production. Metabolic engineering Gene editing tools can be used to engineer the biosynthetic pathway of CPT. Omics-based approaches Transcriptomics, proteomics, and metabolomics can be used to study the CPT biosynthesis pathway. Computational biotechnology Computational BGC identification can be used to selectcandidate genes and for functional characterization.

The current main source of CPT is from C. acuminata's fruits and barks, which leads to excessive felling of the tree. The growing need for CPT can also be satisfied by biotechnological measures so as to protect the source tree from further harm. [26,29]

FUTURE RESEARCH DIRECTION (IMPROVING YEILD, UNDERSTANDING MECHANISM):

At the moment, there is a huge demand for camptothecin in the global market because synthetic derivatives are not available.In recent years, there has been heavy reliance on N. nimmonina populations for camptothecin production, owing to the ever-increasing worldwide appetite for these alkaloids.

Due to such essentials at last decade alone over 20% of the population of this species has been lost from the western ghats, rendering the species as endangered.More so, these plants need great conservation attention, as their range is gradually diminishing, mainly due to destruction of their habitat and excessive utilization.

The growth of the tree is slow and the propagation is predominantly through seeds. The seeds are recalcitrant, having great degree of sensitivity to desiccation andfreezing, and also have a very short viability period. Up to now, there has been limited success in developing in vitro techniques for the propagation of this species.

The seeds of N. nimmoniana are large and intermediate. The seed receptacle, which is orange in color, turns black upon the completion of drying.This species can be distinguished by its very unpleasant smell that is characteristic during the flowering stage. The fruits (drupes) are obliquely ovoid in shape and measuring greater than 1 cm in girth and ranging from 1.5-2.5 cm in length including the nut/seeds attached.

Some study has shown that cryopreservation of zygotic embryos led to the germination of 87.67% , when maintained under specific environmental conditions.Holt and co-workers showed that embryonic axes with cotyledons having moisture content of 55.7% which were thought to be intermediate in nature lost viability for prolonged storage within a short time after maturity.However it is still accepted as a viable solution in the long term preservation ofsuch plant species which produce large/recalcitrant seeds

Hence, the primary goals of this research are to work out a simple, efficient, and affordable technique for vegetative propagation and germination of the critically endangered herbal plant N. nimmoniana J. Graham. located in the Western Ghats of the state of Maharashtra, India. [30,31,32]

SUMMARY :

Nothapodytes nimmoniana (J. Graham) Mabb., which is known as Narkya in the local parlance, is an extremely useful medicinal plant with a variety of pharmacological activities.

This paper presents a detailed description of the techniques for obtaining active compounds from various parts of the plant followed by the description of their pharmacological properties.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 5, Issue 2, January 2025

The relevance of the plant is associated with the fact that it contains high levels of camptothecin (CPT), a well-known anti-cancer agent. Also, we study the plant's anti-microbial, antioxidant, anti-cancer, anti-helminth, anti-malarial, and anti-inflammatory effects.

In addition, the threats posed to N. nimmoniana (J. Graham) Mabb. Such situations have aroused concerns over the potential overexploitation of the genus and its current status in the wild as an endangered species.

To that end, the review draws attention to the need for sustainable conservation practices and the use of modern approaches such as tissue culture technology and cultivation of endophytes to enhance production of camptothecin.

This comprehensive review encourages better understanding about the various usesof the plant, and the need to utilize it in a responsible way.

SCOPE OF WORK:

This is the comprehensive review on the project titled as 'Evaluation of medicinal importance of Nothapodytesnimmoniana, focusing on its medicinal properties, phytochemical constituents and therapeutic uses

Apart from this, I also have documented traditional and folk medicinal application of plant along with its key Bioactive compounds isolated from Nothapodytesnimmoniana.

Afterwards I will work on following mentioned tasks such as, Survey and identification of regions and sources for sustainable collection ofplant by verifying its authenticity through Botanical identification.

Extraction and isolation of Bioactive compounds by preliminary phytochemical screening of Nothapodytesnimmoniana.

Evaluation on the safety profile of Nothapodytesnimmoniana by monitoringtoxicity studies and adverse effects of Nothapodytesnimmoniana.

Evaluation on potential medicinal formulation by analysing stability studies anddelivery methods for optimal therapeutic effects.

To conduct Ethnobotanical survey for investigation of traditional knowledge of Nothapodytesnimmonianaby interviewing local individual healers.

So, The above mentioned tasks is next scope of work of mine on this project, which I will draft by preparing comprehensive report on it.

REFFERENCES

[1]. Shrivastava V, Sharma N, Shrivastava V, Sharma A. Review on Camptothecin Producing Medicinal Plant: Nothapodytesnimmoniana. Biomed Pharmacology J 2021;14(4).

[2]. The isolation and structure of camptothecin, a novel alkaloidal leukemia and tumor inhibitor from *Camptothecaacuminata*. *J Am Chem Soc.* 1966;88:3888–3890. [Google Scholar]

[3]. Cancer Therapies Utilizing the Camptothecins: A Review of *in Vivo* Literature Vincent J.Venditto and Eric E. SimanekMol Pharm. Author manuscript; available in PMC 2013Aug 5.*Published in final edited form as:* doi: 10.1021/mp900243b

[4]. Gowda, H.C.H., Vasudeva, R., Mathachen, P.G., Shanker, R.U. and Ganeshaiah, K.N. 2002. Breeding types in Nothapodytesnimmoniana Graham: An important medicinal tree.Current Science 83:1077–1078.

[5]. Roja G and Heble M. R. The quinoline alkaloids camptothecin and 9- methoxycamptothecin from tissue cultures and mature trees of Nothapodytesfoetida. Phytochem., 1994; 36: 65-66. CrossRef

[6]. https://www.researchgate.net/profile/Nazeerullah-Khan/publication/269476898/figure/fig2/AS:669104792928279@1536538422549/figurefig2.png

[7]. G.A., Sharma, A., Jeelani, S.M. et al. Metabolic and transcriptional analyses in response to potent inhibitors establish MEP pathway as major route for camptothecin biosynthesis in Nothapodytesnimmoniana (Graham) Mabb. BMC Plant Biol 19, 301 (2019). https://doi.org/10.1186/s12870-019-1912-x

[8]. Khan N., Tamboli E. T., Sharma V. K., & Kumar S. (2013). Phytochemical and pharmacological aspects of Nothapodytesnimmoniana. An overview. Herba Polonica, 59(1), 53–66.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 5, Issue 2, January 2025

[9]. Namdeo A. G., Sharma A., Fulzele D. P., & Mahadik K. R. (2010). Influence of geographical and climatic conditions on camptothecin content of Nothapodytesnimmoniana. Records of Natural Products, 4(1), 64.

[10]. https://www.biochempeg.com/usr/uploads/3/202210/Camptothecin-STRUCTURE.png

[11]. National Center for Biotechnology Information (2024). PubChem Compound Summary for CID 24360, Camptothecin. Retrieved October 15, 2024 from https://pubchem.ncbi.nlm.nih.gov/compound/Camptothecin.

[12]. National Center for Biotechnology Information. PubChem Compound Summary for CID 24360, Camptothecin.https://pubchem.ncbi.nlm.nih.gov/compound/Camptothecin. Accessed Oct. 15, 2024.

[13]. PubChem [Internet]. Bethesda (MD): National Library of Medicine (US), National Center for Biotechnology Information; 2004-. PubChem Compound Summary for CID 24360, Camptothecin; [cited 2024 Oct. 15]. Available from: https://pubchem.ncbi.nlm.nih.gov/compound/Camptothecin

[14]. https://www.researchgate.net/publication/381549115/figure/fig3/AS:1143128125337257@1718848466425/The-biosynthetic-pathway-of-camptothecin-involves-the-pre- strictosidine-strictosidine.png

[15]. Dhiraj M. Patil, Basavaraj S. Hunasagi, Anjanapura V. Raghu, Raghavendra V. Kulkarni, Krishnacharya G. Akamanchi, Optimisation of enzyme□assisted extraction of camptothecin from Nothapodytesnimmoniana and its characterisation, Phytochemical Analysis, 10.1002/pca.3331, 35, 4, (825-839), (2024).

[16]. https://analyticalsciencejournals.onlinelibrary.wiley.com/cms/asset/dc223dc2-ceb3-42af-b643-aa85506855be/pca3226-fig-0007-m.png

[17]. https://analyticalsciencejournals.onlinelibrary.wiley.com/cms/asset/c734fde2-13d2-4cdc-8eba-24878797ae45/pca3226-fig-0008-m.png

[18]. https://analyticalsciencejournals.onlinelibrary.wiley.com/cms/asset/3af99798-5196-4dbd-916d-2d9c2654229d/pca3226-fig-0006-m.png

[19]. Li F, Jiang T, Li Q, Ling X. Camptothecin (CPT) and its derivatives are known to target topoisomerase I (Top1) as their mechanism of action: did we miss something inCPT analogue molecular targets for treating human disease such as cancer? Am J Cancer Res. 2017; 7(12): 2350-2394.

[20]. Ramesha BT, Amna T, Ravikanth G, Gunaga RP, Vasudeva R, Ganeshaiah KN, et al. Prospecting for camptothecines from Nothapodytesnimmoniana in the WesternGhats, South India: Identification of high-yielding sources of camptothecin and new families of camptothecines. J Chromatogr Sci. 2008;46:362–8. [PubMed] [Google Scholar]

[21]. IIT Madras researchers metabolically engineer plant cells to increase production of Anti-Cancer Drug Camptothecinhttps://www.iitm.ac.in/happenings/press-releases- and- coverages/iit-madras-researchers-metabolically-engineer-plant-cells

[22]. IIT Madras researchers metabolically engineer plant cells to increase production of Anti- Cancer Drug Camptothecin Posted On: 28 DEC 2023 7:14PM by PIBhttps://pib.gov.in/PressReleasePage.aspx?PRID=1991321

[23]. https://ruffordorg.s3.amazonaws.com/media/project_reports/2-20.09.06%20Detailed%20Final%20Report.pdf

[24]. Mohinudeen, I.A.H.K., Kanumuri, R., Soujanya, K.N. et al. Sustainable production of camptothecin from an Alternaria sp. isolated from Nothapodytesnimmoniana. Sci Rep 11, 1478 (2021).https://doi.org/10.1038/s41598-020-79239-5

[25]. Dixit A., Gayakwad S., Shirolkar A., Warkad S., Devlae A., Murthy S. N., & Pawar S. (2015). Phytochemical characterization and cells based analysis of bioactive components of Nothapodytesnimmoniana (J. Graham). International Journal of Current Microbiology and Applied Sciences, 2, 18–37.

[26]. Fulzele D. P., &Satdive R. K. (2005). Comparison of techniques for the extraction of the anti-cancer drug camptothecin from Nothapodytesfoetida. Journal of Chromatography A, 1063(1-2), 9–13.https://doi.org/10.1016/j.chroma.2004.11.020

[27]. Isah T., & Mujib A. (2015). Camptothecin from Nothapodytesnimmoniana: Reviewon biotechnology applications. ActaPhysiologiaePlantarum, 37, 1–14.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 5, Issue 2, January 2025

[28]. Kavitha P., Kumar T. V., Rajasekharan P. E., Kareem V. A., & Rao V. K. (2010). Camptothecin and 9-methoxy camptothecin, anticancer alkaloids in Nothapodytesnimmoniana from Western Ghats, India. Journal of Medicinal and Aromatic Plant Sciences, 32, 129–132.

[29]. Luo P., He Q., He X., Hu Y., Lu W., Cheng Y., & Yang B. (2006). Potent antitumor activity of 10-methoxy-9-nitrocamptothecin. Molecular Cancer Therapeutics, 5(4), 962–968.https://doi.org/10.1158/1535-7163.MCT-05-0385

[30]. Padmanabha B. V., Chandrashekar M., Ramesha B. T., Gowda H. H., Gunaga R. P., Suhas S., Vasudeva R., Ganeshaiah K. N., &Shaanker R. U. (2006). Patterns of accumulation of camptothecin, an anticancer alkaloid in Nothapodytesnimmoniana Graham., in the Western Ghats, India: Implications for identifying high-yielding sources of the alkaloid. Current Science, 90, 95–100.

[31]. Patwardhan A. (2006). Domestication of Nothapodytesnimmoniana (grah.) Mabb. An endangered medicinal tree from Western Ghats of India (pp. 7–15) The Rufford Small Grants Foundation.

[32]. Sharma S., Kumar A., &Namdeo A. (2012). Pharmacognostical and phytochemical analysis of Nothapodytesnimmoniana stem. International Journal of Pharmacy and Pharmaceutical Sciences, 4(4), 455–459.