

A Review on Extraction of *Hyptis Suaveolens* Leaves and Study the Antistress Activity

Neha Bhati¹, Sarika Chaturvedi^{1*}

¹HIMT College of Pharmacy, Greater Noida, India

***Correspondence Author**

Sarika Chaturvedi

Associate Professor

HIMT College of Pharmacy, Greater Noida, India, 201310

Abstract

Stress is a global health concern known to contribute to the pathogenesis of various physical and psychological disorders, including anxiety, depression, cardiovascular diseases, and immunosuppression. The increasing limitations associated with synthetic anti-stress medications, such as dependence and side effects, have shifted research focus toward natural, plant-based remedies. *Hyptis suaveolens*, a traditionally used medicinal plant, is rich in phytoconstituents with potential adaptogenic and antioxidant properties. This study was undertaken to evaluate the antistress activity of *Hyptis suaveolens* in Swiss albino mice using standardized models of stress-induced behavior and biochemical alterations. The plant extract was administered orally, and its effects were assessed against both acute and chronic stress paradigms. Behavioral changes were monitored using validated stress models, while biochemical markers, including corticosterone levels, lipid peroxidation, and antioxidant enzyme activity, were measured to understand the physiological response. The findings suggest that *Hyptis suaveolens* exhibits significant antistress potential by modulating both behavioral and biochemical parameters, comparable to standard adaptogenic agents. The promising results from this study highlight the therapeutic potential of *Hyptis suaveolens* as a natural adaptogen. Future research should focus on the isolation and structural characterization of active phytoconstituents responsible for its antistress effects. Additionally, long-term toxicity studies and clinical trials are crucial to ensure the safety and efficacy of this product in humans. Exploring its mechanism of action at the molecular level may also pave the way for the development of novel phytopharmaceuticals for managing stress-related disorders. The integration of such herbal formulations into mainstream medicine could offer a safer and holistic approach to stress management.

Keywords: *Hyptis suaveolens*, Lamiaceae, antimicrobial, anti-inflammatory, and antioxidant properties.

INTRODUCTION:

Stress is defined as a disruption to the body's internal balance, or homeostasis, and it can stem from both psychological and physical factors [1]. In response to stress, several physiological systems become activated, prompting complex neural processes to help the body adapt to various internal and external demands [12]. It plays a significant role in mental health disorders, including their onset, persistence, and recurrence, with conditions such as schizophrenia, depression, and substance dependence being closely linked [3].

To counter stress, the body initiates a process called allostasis—an adaptive mechanism aimed at maintaining internal stability amid changing conditions. However, chronic or poorly managed stress can lead to what's known as allostatic load, contributing to the development of several diseases [4]. Over the past decade, substantial research has explored how stressful life experiences contribute to disease causation. Stress triggers changes in the autonomic nervous system and the Hypothalamus-Pituitary-Adrenal (HPA) axis, leading to significant physiological, behavioral, and neurochemical shifts [5].

The HPA axis initiates the stress response via the hypothalamus, which secretes corticotropin-releasing factor (CRF) [6]. This hormone stimulates the pituitary gland to release adrenocorticotrophic hormone (ACTH), which then acts on the adrenal cortex to produce glucocorticoids [7]. These glucocorticoids serve as the final effectors of the HPA axis and regulate numerous body functions during stress [8]. They also modulate the baseline activity and shutdown of the stress response through feedback to the pituitary gland, hypothalamus, and other brain regions such as the frontal cortex and hippocampus [9].

CRF, ACTH, and glucocorticoids serve as the central components of the HPA axis, integrating the brain and endocrine systems to manage the stress response [10-11]. In addition, neurotransmitters like dopamine (DA), noradrenaline (NA), and serotonin (5-HT) play key roles during stress [12-13].

Regions like the frontal cortex and striatum are rich in dopamine (Miyazaki & Asanuma, 2008), while the hippocampus contains many glucocorticoid receptors [14]. These brain areas are interconnected and communicate via various neurotransmitter systems [15-16].

Prolonged or repeated stress exposure can result in several chronic conditions that don't fit traditional disease categories, such as cardiovascular disease, hypertension, gastric ulcers, and other systemic disorders [17-19]. Benzodiazepines are often prescribed to manage stress-related symptoms, but their long-term use can lead to sedation and dependency issues [20]. Therefore, there is a growing need for safer and more effective alternatives for stress management [21].

One such approach involves the use of "adaptogens," a term introduced by Lazarev (1947) to describe substances that enhance an organism's nonspecific resistance to stress. Herbal and plant-based remedies have long held an important role in traditional and integrative healthcare systems [22]. Modern scientific research is increasingly focused on identifying, isolating, and characterizing active compounds from these natural sources [23-24].

Studies have demonstrated that plants such as *Panax ginseng*, *Eleutherococcus senticosus*, and *Rhodiola rosea* significantly enhance the body's overall resistance to stress [25]. The use of herbal adaptogens as a strategy to treat stress-related ailments is a well-known concept in many traditional medical systems worldwide [26]. Further in-depth investigations have explored the anti-stress properties of various plants, including *Ocimum sanctum* [27], *Emblica officinalis* [28], *Bacopa monnieri* [29], *Ginkgo biloba* [30], and *Withania somnifera* [31], among many others.

The primary goal of the present research was to investigate the physiological mechanisms associated with stress and to assess the therapeutic potential of plant-based remedies, particularly *Hyptis suaveolens*, in alleviating stress-induced alterations [32]. To fulfill this objective, various stress paradigms with differing levels of intensity, duration, and predictability were developed using Swiss albino mice. These experimental models were instrumental in distinguishing the behavioral and systemic effects of stress and in determining the adaptogenic efficacy of *Hyptis suaveolens* in mitigating or reversing stress-triggered disturbances [33-34].

To evaluate peripheral markers of stress, several physiological indicators were recorded, including adrenal gland enlargement, severity of gastric ulcers, plasma glucose concentration, creatine kinase activity, and serum corticosterone levels [35]. Simultaneously, the study concentrated on the central nervous system, particularly focusing on neurotransmitter systems and antioxidant activity, which are integrally involved in the regulation of stress through the Hypothalamic-Pituitary-Adrenal (HPA) axis [36-37].

For a detailed insight into the adaptogenic action of *Hyptis suaveolens*, neurochemical evaluations were performed to monitor changes in neurotransmitters like dopamine, noradrenaline, and serotonin, along with their respective metabolites [38]. Oxidative stress was assessed through both enzymatic antioxidants—such as superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GSH-Px)—and non-enzymatic antioxidants like reduced glutathione (GSH) [39-40]. Lipid peroxidation was quantified by measuring malondialdehyde (MDA) concentrations across critical brain regions, including the hippocampus, striatum, and frontal cortex [41]. Additionally, to explore the molecular interactions underlying the protective influence of *Hyptis suaveolens* during both short- and long-term stress exposures, the expression patterns of stress-regulatory biomolecules were examined [42]. These included corticotropin-releasing factor (CRF), pro-opiomelanocortin (POMC), glucocorticoid receptors (GR), heat shock protein-70 (HSP-70), and tyrosine hydroxylase (TH) in selected neural regions [43]. Overall, the findings aim to decode the mechanisms by which this medicinal plant exerts its antistress effects, supporting its future development as a natural alternative in the management of stress-related conditions [44].

Botanical and Phytochemical Overview of *Hyptis Suaveolens*:

Hyptis suaveolens, commonly referred to as "Vilayati Tulsi" or "Bush Mint," is a fast-growing aromatic shrub belonging to the Lamiaceae family with the genus *Hyptis* [45]. It is native to tropical regions of the Americas but has become naturalized in various parts of Asia, Africa, and Australia [46-47]. The plant typically reaches heights of 1 to 3 meters and is characterized by its square stems, oppositely arranged ovate leaves with serrated margins, and clusters of small purple or pink flowers [50]. Extensive phytochemical investigations have revealed that *H. suaveolens* is rich in a variety of bioactive compounds [51]. The plant contains essential oils, flavonoids, alkaloids, tannins, saponins,

terpenoids, and phenolic compounds. Notably, the essential oil extracted from the leaves is composed of constituents such as 1, 8-cineole, β -caryophyllene, and sabinene, which contribute to its distinctive aroma and therapeutic properties [52]. There are some common traditional uses, like Ayurveda and traditional medicine for stress, anxiety, and digestive issues, known for their antimicrobial, anti-inflammatory, and antioxidant properties [53].



Figure no. 1. Flower of Hyptis suaveolens.

Major Bioactive Compounds:

Hyptis suaveolens, a member of the Lamiaceae family, is known to possess a wide array of phytochemicals responsible for its diverse pharmacological activities [54-55]. Various studies have confirmed the presence of essential oils, flavonoids, terpenoids, phenolic compounds, saponins, tannins, and alkaloids in different parts of the plant. The essential oil extracted from the aerial parts is particularly rich in 1,8-cineole, sabinene, limonene, β -caryophyllene, and spathulenol, which contribute its antimicrobial, antioxidant and adaptogenic effects. Flavonoids such as quercetin and kaempferol exhibit strong antioxidant and neuroprotective properties, potentially counteracting oxidative stress induced by chronic stress exposure [61]. Terpenoids and phenolic acids may enhance stress resilience by modulating neurotransmitters and the hypothalamic–pituitary–adrenal (HPA) axis [62]. These constituents support the rationale for using Hyptis suaveolens in traditional medicine as an antistress agent [55].

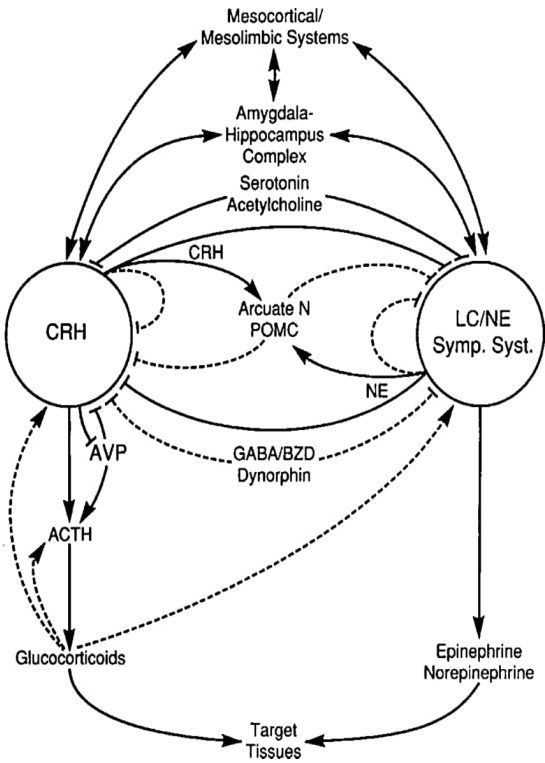


Figure no. 2 A simplified schematic representation of the central and peripheral components of the

Table 1. Phytochemical Compounds and Their Pharmacological Activities of *Hyptis suaveolens*

Compound	Class	Part of Plant	Activity
Sabinene	Monoterpene	Essential oil	Antioxidant, antimicrobial
β -Caryophyllene	Sesquiterpene	Essential oil	Anxiolytic, anti-inflammatory
Spathulenol	Sesquiterpene	Essential oil	Antioxidant, immunomodulatory
Quercetin	Flavonoid	Leaves	Antioxidant, neuroprotective
Kaempferol	Flavonoid	Leaves	Stress modulator, anti-inflammatory
Tannins	Polyphenols	Whole plant	Adaptogenic, hepatoprotective
Saponins	Glycosides	Roots, leaves	Immunomodulatory, adaptogenic

Literature survey has revealed that the plant contains phytoconstituents such as flavonoids, terpenoids, and essential oils like β -caryophyllene and 1,8-cineole. These compounds have been associated with diverse biological activities including antioxidant, anxiolytic, neuroprotective, anti-inflammatory, and adaptogenic effects. Such properties are closely linked with the ability to resist stress and to restore physiological balance during stressful conditions. However, despite its traditional usage, the claim of therapeutic efficacy of *Hyptis suaveolens* as an antistress agent has not yet been scientifically scrutinized in validated experimental models. At present, synthetic drugs such as benzodiazepines are widely prescribed to reduce stress and associated symptoms. While effective, these drugs have limitations including sedative effects, risk of dependence, tolerance, and withdrawal symptoms, which restrict their long-term use. In contrast, herbal formulations are often claimed to enhance physical endurance, improve mental function, and increase non-specific resistance to stress, without causing marked alterations in normal physiological functions.

PREPARATION OF EXTRACT:

Fresh *Hyptis suaveolens* leaves were collected and washed under running tap water and rinsed with distilled water to remove dust and debris. The leaves were crushed in a mortar and pestle to a coarser particle size. The crushed leaves (50gm) added with 40ml of distilled water and boiled till the volume reduces to 20 ml. Decoction was passed through muslin cloth and allowed to cool down at room temperature. The prepared decoction was passed through muslin cloth and filtrate used for further research study.

Aqueous extract: The collected *Hyptis suaveolens* leaves were washed under running tap water and rinsed with sterile distilled water to remove a dust and debris. The leaves were separated out from each after wash, segregated and shed dried. The shed dried leaves were powdered using a dry mechanical grinder. The dried powder was passed through the mesh sieve to obtain the fine powder. The fifty gram of leaves powder was added with 250 ml of distilled water. This conical flask was stopper tightly and was kept at room temperature for maceration of 48 hours and during maceration period the content of conical flask was shaken at interval of two hours. Content of the conical flask was filtered through a muslin cloth. The content left in the flask was rinsed timely by taking the little quantity of the filtrate so obtained was once again filtered through Whatman number 1 filter paper. The filtrate was transferred to sterilized evaporating bowl and kept under fan for evaporation of the

solvent. After complete evaporation of the solvent the extract left in the bowl was taken in the airtight screw cap vials and stored in refrigerator for use as per the requirement in experimental investigation. [56]

Conclusion:

This review consolidates evidence supporting the antistress potential of *Hyptis suaveolens*, demonstrated through both behavioral and biochemical parameters in Swiss albino mice. The plant extract significantly reduced immobility in the forced swim test and improved exploratory behavior, indicating a reduction in stress-induced anxiety and depressive-like responses. Biochemically, it enhanced antioxidant defense by increasing levels of superoxide dismutase (SOD), catalase (CAT), and glutathione (GSH), while reducing malondialdehyde (MDA) levels—a key marker of oxidative stress. Additionally, its ability to lower corticosterone levels suggests beneficial modulation of the hypothalamic-pituitary-adrenal (HPA) axis. Importantly, acute and sub-chronic toxicity studies confirmed that *H. suaveolens* is well tolerated, with no significant adverse effects even at high doses. This favorable safety profile, combined with its adaptogenic and antioxidant effects, highlights its promise as a natural therapeutic agent for managing stress-related disorders. Comparisons with standard agents such as diazepam and ashwagandha further strengthen its relevance in the field of herbal medicine. To move from preclinical promise to clinical application, future studies should include well-designed human trials to validate efficacy, determine appropriate dosing, and ensure long-term safety. Standardization of active constituents and in-depth mechanistic studies are also needed to support its development as a scientifically backed, plant-based adaptogen. Overall, *Hyptis suaveolens* represents a promising candidate for natural antistress therapy, meriting further exploration in both research and clinical settings.

Conflicts of Interest The authors declare that they have no conflicts of interest

Acknowledgments: The authors thank Dr. Anuj Mittal, Director, from HIMT College of Pharmacy for their technical assistance.

References:

1. Mishra P, Sohrab S, Mishra SK. A review on the phytochemical and pharmacological properties of *Hyptis suaveolens* (L.) Poit. *Future journal of pharmaceutical sciences*. 2021 Mar 12;7(1):65.
2. Jagannath n, sheela d, dixit r. evaluation of antidiabetic activity of *hyptis suaveolens* instreptozytocin induced diabetic rats. *cahiers magellanes-ns*. 2024 jul 15;6(2):256-65.
3. Ghaffari H, Ghassam BJ, Chandra Nayaka S, Ramachandra Kini K, Prakash HS. Antioxidant and neuroprotective activities of *Hyptis suaveolens* (L.) Poit. against oxidative stress-induced neurotoxicity. *Cellular and Molecular Neurobiology*. 2014 Apr; 34(3):323-31.
4. Parbat AY, Malode GP, Shaikh AR, Panchale WA, Manwar JV, Bakal RL. Ethnopharmacological review of traditional medicinal plants as immunomodulator. *World Journal of Biology Pharmacy and Health Sciences*. 2021;6(2):043-55.
5. Prajapati KK, Pandey G, Pandey R. A Review on some Medicinal Plants of North Eastern Terai Region of Uttar Pradesh. *PhytoTalks*. 2024;1(1):46-62.
6. Maity P, Mahakur b. studies on some american exotic weeds of paschim medinipur district of west bengal, india, and their medicinal uses. *Exploratory Animal & Medical Research*. 2023 Jun 2;13.
7. Kandhare AD, Alam J, Patil MV, Sinha A, Bodhankar SL. Wound healing potential of naringin ointment formulation via regulating the expression of inflammatory, apoptotic and growth mediators in experimental rats. *Pharmaceutical biology*. 2016 Mar 3;54(3):419-32.
8. Majumdar A, Sangole P. Alternative approaches to wound healing. *Alexandrescu VA. Wound Healing: New insights into Ancient Challenges.*, IntechOpen. 2016 Oct 12:459.
9. Arsenijević J, Sisto F, Drobac M, Šoštarić I, Maksimović Z, Kovačević N. In vitro anti-*Helicobacter pylori* activity of extracts and essential oil of *Thymus pannonicus* All. (Lamiaceae).

10. Selvaraj C, Yogeswari C, Singh SK. Molecular features of potential herbal products in enhancing human immune system. In *Traditional Herbal Therapy for the Human Immune System* 2021 Oct 28 (pp. 301-362). CRC Press.
11. Joon S, Tjoa E, Singla RK, Bhatnagar R, Shen B. Plant-Based Antimicrobials for Sepsis Management: What Progress Have We Made. In *Antimicrobials in Pharmaceutical and Medicinal Research* 2023 Apr 3 (pp. 49-68). CRC Press.
12. Kumar A. A systemic review of tulsi (*Ocimum tenuiflorum* or *Ocimum sanctum*): Phytoconstituents, ethnobotanical and pharmacological profile. *Research Journal of Pharmacognosy and Phytochemistry*. 2023;15(2):179-88.
13. Hussain A, Abidi SH, Syed Q, Saeed A, Alim-Un-Nisa, Naib N, Bano A, Sunaina, Malik M, Nadeem AA. A supernatural multipurpose plant Sea buckthorn (*Hippophae rhamnoides* L.): An updated overview of its folk traditional uses, phytochemical profile and biological activities. *Journal of Berry Research*. 2023 Mar 28;13(1):21-66.
14. Spinozzi E. Medicinal and food plants as sources of biopesticides and biologically active compounds: a focus on *Carlina acaulis* and *Acmella oleracea*.
15. Alam MS. fifteen major medicinal trees of bangladesh.
16. Pateiro M, Domínguez R, Putnik P, Kovačević DB, Barba FJ, Munekata PS, Fierro EM, Lorenzo JM. Herbal product development and characteristics. In *Herbal Product Development* 2020 Nov 24 (pp. 205-240). Apple Academic Press.
17. Aragão kk. atividade anticoagulante e antiagregante do óleo essencial de *rosmarinus officinalis* l. e ação vasorrelaxante do monoterpene γ -terpinene em artéria mesentérica de ratos (doctoral dissertation).
18. Ngozi LU, Ugochukwu N, Ifeoma PU, Charity EA, Chinyelu IE. The efficacy of *hyptis suaveolens*: a review of its nutritional and medicinal applications.
19. Li R, Tang G, Liu X, Li J, Wang D, Ji S. An ethnopharmacological review of *Hyptis suaveolens* (L.) Poit. *Tropical journal of pharmaceutical research*. 2020 Nov 18;19(7):1541-50.
20. de Kloet ER. Stress and the hippocampus. *The Clinical Neurobiology of the Hippocampus*. 2012 Jul 26:77-104.
21. Newman ML, Pennebaker JW, Berry DS, Richards JM. Lying words: Predicting deception from linguistic styles. *Personality and social psychology bulletin*. 2003 May;29(5):665-75.
22. Cooper M. Essential research findings in counselling and psychotherapy: The facts are friendly.
23. Pandey DK, Tripathi NN, Tripathi RD, Dixit SN. Fungitoxic and phytotoxic properties of the essential oil of *Hyptis suaveolens*/Fungitoxische und phytotoxische Eigenschaften des ätherischen Öls von *Hyptis suaveolens*. *Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz/Journal of Plant Diseases and Protection*. 1982 Jun 1:344-9.
24. Brekhman II, Dardymov IV. New substances of plant origin that increase nonspecific resistance. *Annual review of pharmacology*. 1969 Apr;9(1):419-30.
25. Brekhman II, Dardymov IV. Pharmacological investigation of glycosides from Ginseng and *Eleutherococcus*.
26. Bhargava KP, Singh N. Anti-stress activity of *Ocimum sanctum* Linn. *Indian Journal of Medical Research*. 2013 Mar 1;137(3).
27. Sairam KC, Rao CV, Babu MD, Kumar KV, Agrawal VK, Goel RK. Antiulcerogenic effect of methanolic extract of *Emblica officinalis*: an experimental study. *Journal of Ethnopharmacology*. 2002 Sep 1;82(1):1-9.
28. Rai D, Bhatia G, Palit G, Pal R, Singh S, Singh HK. Adaptogenic effect of *Bacopa monnieri* (Brahmi). *Pharmacology Biochemistry and Behavior*. 2003 Jul 1;75(4):823-30.
29. Bhattacharya SK, Muruganandam AV. Adaptogenic activity of *Withania somnifera*: an experimental study using a rat model of chronic stress. *Pharmacology Biochemistry and Behavior*. 2003 Jun 1;75(3):547-55.
30. Arsenijević J, Sisto F, Drobac M, Šoštarić I, Maksimović Z, Kovačević N. In vitro anti-*Helicobacter pylori* activity of extracts and essential oil of *Thymus pannonicus* All.(Lamiaceae).

31. Worku LA, Bachheti RK, Bisht SS, Bachheti A, Alemu WK. Exploring the Medicinal Potential of *Hyptis suaveolens* (Lamiaceae): A Comprehensive Review of Phytochemicals, Pharmacological Properties, and Drug Development Prospects. *Natural Product Communications*. 2024 Nov;19(11):1934578X241298919.
32. Matafora V, Gorb A, Noble W, Bachi A, Perez-Nievas BG, Jimenez-Sanchez M. Proteomics of the astrocyte secretome reveals changes in their response to soluble oligomeric A β . *bioRxiv*. 2023 Jan 20:2023-01.
33. Molfino A, De Luca S, Muscaritoli M, Citro G, Fazi L, Mari A, Ramaccini C, Rossi Fanelli F, Laviano A. Timing of antioxidant supplementation is critical in improving anorexia in an experimental model of cancer. *International Journal of Food Sciences and Nutrition*. 2013 Aug 1;64(5):570-4.
34. Martín-Hernández D, Bris ÁG, MacDowell KS, García-Bueno B, Madrigal JL, Leza JC, Caso JR. Modulation of the antioxidant nuclear factor (erythroid 2-derived)-like 2 pathway by antidepressants in rats. *Neuropharmacology*. 2016 Apr 1;103:79-91.
35. Ghaffari H, Ghassam BJ, Chandra Nayaka S, Ramachandra Kini K, Prakash HS. Antioxidant and neuroprotective activities of *Hyptis suaveolens* (L.) Poit. against oxidative stress-induced neurotoxicity. *Cellular and Molecular Neurobiology*. 2014 Apr;34(3):323-31.
36. Mallick K, Banerjee S. Plants Affecting Serotonergic Neurotransmission. In *Role of Herbal Medicines: Management of Lifestyle Diseases 2024 Feb 27* (pp. 211-229). Singapore: Springer Nature Singapore.
37. Kalita JK, Das PJ, Mandal S, Sen S, Path SM, Nagar G. Herbal Remedies for Mental Health Disorders: A Focus on Adaptogenic Plants and Their Mechanisms of Action.
38. Mythri RB, Venkateshappa C, Harish G, Mahadevan A, Muthane UB, Yasha TC, Srinivas Bharath MM, Shankar SK. Evaluation of markers of oxidative stress, antioxidant function and astrocytic proliferation in the striatum and frontal cortex of Parkinson's disease brains. *Neurochemical research*. 2011 Aug;36(8):1452-63.
39. Şahin E, Gümüslü S. Alterations in brain antioxidant status, protein oxidation and lipid peroxidation in response to different stress models. *Behavioural brain research*. 2004 Dec 6;155(2):241-8.
40. Shetty GA, Hattiangady B, Upadhyay D, Bates A, Attaluri S, Shuai B, Kodali M, Shetty AK. Chronic oxidative stress, mitochondrial dysfunction, Nrf2 activation and inflammation in the hippocampus accompany heightened systemic inflammation and oxidative stress in an animal model of Gulf War illness. *Frontiers in Molecular Neuroscience*. 2017 Jun 14;10:182.
41. Sharma MK. Exploring the biochemical profiles of medicinal plants cultivated under stressful environmental conditions. *Current Agriculture Research Journal*. 2024 Apr 1;12(1):81-103.
42. Kumar M, Padalia H, Nandy S, Singh H, Khaite P, Kalra N. Does spatial heterogeneity of the landscape explain the process of plant invasion? A case study of *Hyptis suaveolens* from the Indian Western Himalaya. *Environmental Monitoring and Assessment*. 2019 Dec;191(Suppl 3):794.
43. Hartz L. The founding of new societies: studies in the history of the United States, Latin America, South Africa, Canada, and Australia. Houghton Mifflin Harcourt; 1969 Oct 22.
44. ES S.. preliminary analysis of floristic diversity in selected wards of cheranelloor panchayat (doctoral dissertation, st teresa's (autonomous), ernakulam).
45. da Costa SP, Schuenck-Rodrigues RA, Cardoso VD, Valverde SS, Vermelho AB, Ricci-Júnior E. Therapeutic Potential of Bioactive Compounds from *Brugmansia suaveolens* Bercht. & J. Presl. *Nutrients*. 2023 Jun 27;15(13):2912.
46. Naz T, Packer J, Yin P, Brophy JJ, Wohlmuth H, Renshaw DE, Smith J, Elders YC, Vemulapad SR, Jamie JF. Bioactivity and chemical characterisation of *Lophostemon suaveolens*—an endemic Australian Aboriginal traditional medicinal plant. *Natural product research*. 2016 Mar 18;30(6):693-6.
47. Jayakumar SV, Ganesh SK. New enolic type bioactive constituents from *Hyptis suaveolens* (L.) Poit. *Asian J. Plant Sci. Res*. 2012;2(4):403-8.
48. Awuchi CG. The biochemistry, toxicology, and Uses of the ecologically active phytochemicals: Alkaloids, terpenes, polyphenols, and glycosides. *Merit Research Journals*. 2020;5(1):6-21.

49. Mir MA, Parihar K, Tabasum U, Kumari EJ. Estimation of alkaloid, saponin and flavonoid, content in various extracts of *Crocus sativa*. *Journal of Medicinal Plants Studies*. 2016;4(5):171-4.
50. Estell RE, Fredrickson EL, Anderson DM, Remmenga MD. Effects of cis- β -ocimene, cis-sabinene hydrate, and monoterpene and sesquiterpene mixtures on alfalfa pellet intake by lambs. *Journal of Animal Science*. 2008 Jun 1;86(6):1478-84.
51. Sabulal B, Dan M, Kurup R, Pradeep NS, Valsamma RK, George V. Caryophyllene-rich rhizome oil of *Zingiber nimmonii* from South India: Chemical characterization and antimicrobial activity. *Phytochemistry*. 2006 Nov 1;67(22):2469-73.
52. Martins AP, Salgueiro L, Vila R, Tomi F, Canigual S, Casanova J, Da Cunha AP, Adzet T. Essential oils from four *Piper* species. *Phytochemistry*. 1998 Dec 5;49(7):2019-23.
53. Garodia P, Ichikawa H, Malani N, Sethi G, Aggarwal BB. From ancient medicine to modern medicine: Ayurvedic concepts of health and their role in inflammation and cancer. *J Soc Integr Oncol*. 2007 Mar 21;5(1):25-37.
54. Ashalatha B. Exploring the Role of Medicinal Plants in Ayurveda: A Comprehensive Review. *Medicinal plants and Their uses: Basic to Field*. 2025 May 2:122.
55. Govindarajan R, Vijayakumar M, Pushpangadan P. Antioxidant approach to disease management and the role of 'Rasayana' herbs of Ayurveda. *Journal of ethnopharmacology*. 2005 Jun 3;99(2):165-78.
56. S V Maragathavalli , S Brindha, N. S Kaviyarasi, B. Annadurai, S.K Gangwar, Antimicrobial activity in leaf extract of neem, *International journal of science and nature*.