The Role of Herbal Medicine and Essential Oils in Sustainable Healthcare

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Abstract

Herbal medicine and essential oils have been integral to human healthcare for centuries, offering natural remedies with diverse therapeutic properties. In the context of sustainable healthcare, these natural products present both opportunities and challenges. The third Sustainable Development Goal (SDG), wellness and good health, may be achieved with the use of herbal treatments, which may also increase access to healthcare. The growing use of herbal medicines and essential oils has raised concerns regarding their safety and efficacy. Issues such as toxicity, adverse reactions, and the need for effective monitoring are critical to ensure public health. Despite these challenges, essential oils have been shown to possess multiple health benefits, primarily due to their antimicrobial and anti-inflammatory effects. In conclusion, while herbal medicine and essential oils offer valuable contributions to sustainable healthcare, their benefits must be balanced with responsible sourcing and usage practices. By adopting sustainable approaches, we can preserve the therapeutic properties of these natural resources for future generation.

Keywords: Herbal medicine, Essential oils, Traditional medicines, Plant based treatments

Cite this Article as: Zahra T and Zahra M, 2025. The role of herbal medicine and essential oils in sustainable healthcare. In: Khan A, Hussain R, Tahir S and Ghafoor N (eds), Medicinal Plants and Aromatics: A Holistic Health Perspective. Unique Scientific Publishers, Faisalabad, Pakistan, pp: 96-101. https://doi.org/10.47278/book.HH/2025.18

A Publication of Unique Scientific Publishers

Chapter No: 25-015

Received: 08-Feb-2025
Revised: 25-Apr-2025
Accepted: 01-May-2025

Introduction

It has been demonstrated that natural products, such as organisms (plants, animals, or microorganisms), have potential health benefits for both humans and animals. The World Health Organization estimates that 80% of people in developing nations still rely on traditional or folk medicines, which are primarily made from plant extracts, to prevent or treat illnesses (Tran et al., 2020). Traditional medicine has been shown to be less expensive, more clinically effective, and to have fewer side effects than modern medications. The use of medicinal herbs phytochemical constituents in the pharmaceutical industry has received a lot more attention. Small chemicals or synthesized in plants, such as steroids, alkaloids, phenolic, lignans, carbohydrates, and glycosides, are known as plant-derived secondary metabolites. Conventional medications have been around for a while and are a significant part of alternative medicine (Tran et al., 2020).

Herbal medicines also known as botanical medicine or phytomedicine are the use of plant extracts or plant-based remedies to prevent or treat various health conditions. Herbal medicine has been used for centuries in traditional medicine systems, such as Ayurveda, Unani, and Traditional Chinese Medicine (Li et al., 2020; Jamil et al., 2024a).

Essential oils are highly concentrated plant extracts that have been used for centuries in aromatherapy, perfumery, and traditional medicine. Essential oils offer several benefits for sustainable health. As living chemical factories, plants produce a vast variety of secondary metabolites (SMs), which are the building blocks of many pharmaceutical products sold in stores and herbal treatments made from medicinal plants (Li et al., 2020).

Different Herbal Medicines to Treat Different Chronic Diseases

COVID_19 Treatment

Wuhan, China, from where the COVID-19 epidemic was sweeping the world, became the focus of global attention as the outbreak rapidly escalated into a pandemic. A new coronavirus known as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is the only cause of this extremely contagious illness. It is the seventh known virus in the Coronaviridae family that can infect humans. According to the World Health Organization's most recent assessment, this virus is currently responsible for over 700,000 fatalities globally and over 19 million confirmed cases. Herbal medicines with immunomodulatory properties may be used as a preventative precaution or possibly as a treatment for COVID-19 patients. (Nugraha et al., 2020).

Herbal remedies with active ingredients like Echinacea, quinine, and curcumin that have antimicrobial or antiviral, anti-inflammatory, and immunostimulatory properties are becoming more and more popular (Jamil et al., 2024b). Due to their presumed ability to alter the immune response, these herbal remedies are thought to be helpful in either preventing or treating COVID-19. For instance, due to its antimicrobial, anti-inflammatory, anti-cancer, antimutagenic, and antioxidant properties, *curcuma longa* has long been used as a medication or supplement in many Asian nations (Nugraha et al., 2020).

Diabetes Treatment

Chronic hyperglycemia together with abnormalities in the metabolism of carbohydrates, fats, and proteins due to deficiencies in insulin production, action, or both are hallmarks of diabetes mellitus (DM), a metabolic disease with several underlying causes. Organ failure, malfunction, and long-term damage are among the consequences of diabetes mellitus (Mughal et al., 2021) When it comes to treating diabetes mellitus, traditional medicine has a promising future and has demonstrated solid clinical practice. In tropical regions, especially in Vietnam, India, China, East Africa, South-North Asia, and Central and South America, *Momordica charantia* (MC) is a widespread vegetable (Tran et al., 2020).

It belongs to the Cucurbitaceous family and is also referred to as bitter melon or bitter gourd. In addition to being used as a vegetable, *Momordica charantia's* fruits, seeds, and callus contain some insulin-like proteins that are homologous to human insulin, and when tested on rats, gerbils, langurs, and humans, it consistently produced a hypoglycemic effect. For thousands of years, MC was thought to be a treatment for diabetes mellitus in China and India (Tran et al., 2020).

Cancer Treatment

The development of anticancer drugs throughout history has been characterized by the presence of natural products. Several commonly used anticancer therapeutics, including irinotecan, vincristine, etoposide, and paclitaxel from plants, actinomycin D and mitomycin C from bacteria, and marine-derived bleomycin, are derived from natural sources. The two most successful examples of these are unquestionably camptothecin and taxol, both of which were discovered between the 1950s and 1960s as part of NCI campaign to find therapeutic values of natural products (Huang et al., 2021).

Camptothecin and Taxol in Cancer Treatment: First identified in the early 1960s, camptothecin, which is derived from the wood and bark of *Camptotheca acuminata*, has anticancer properties. However, its use as an anticancer agent was neglected for over two decades until its mechanism of action was discovered. The enzyme topoisomerase I, which is essential for transcription and DNA replication, may be preferentially trapped by camptothecin and forms topoisomerase-DNA complexes. Cell death may result from these complexes colliding with the transcription machinery or the continuing DNA replication fork, which might induce extreme genomic stress. The desire to create camptothecin analogs with improved solubility, less toxicity, and maintained anticancer effectiveness was reignited by these distinct modalities of action (Huang et al., 2021).

The initial source of taxol was the bark of the *Taxus brevifolia* plant, which is a limited resource and produces relatively little of the substance. Using a commercially viable semi-synthetic process, starting with 10-DAB that could be derived from a renewable plant resource, the appropriate amount for therapeutic usage was determined. Taxol was discovered to bind microtubules and disrupt their dynamics, which led to the cancer cells' mitotic demise. The FDA approved its use in treating refractory ovarian cancer in December 1992, over two decades after the original report of its isolation and structure (Huang et al., 2021).

Mental Health Treatment

There are around 260 million people with anxiety and almost 300 million people with depression in the world. It is frequently possible to diagnose both disorders simultaneously. In addition to causing substantial handicap in terms of mental, social, and physical functioning, depressive and anxiety disorders are linked to a higher chance of dying young. The prevalence of anxiety and depressive disorders is higher in women than in males. The most popular herbs for mental health include, orange blossom (*Citrus × aurantium L. (Rutaceae*), and passion flower (*Passiflora edulis Sims (Passifloraceae*) (Alonso-Castro et al., 2021).

Wounds Treatment

A wound is any injury to the body that disrupts the normal structure and function of the skin, usually of the epidermis (cut, blow, or other impact). Wounds are divided into two groups acute or chronic according to the physiology of wound healing, and as open or closed according to the underlying cause of wound creation (Yazarlu et al., 2021). The favorable conditions for the growth of microorganisms lead to infection, which is one of the main causes of wound complications. Numerous investigations have examined the antibacterial properties of natural substances and extracts from medicinal plants against common bacteria that are prevalent in wounds, such as *Pseudomonas* and *Staphylococcus aureus*. Medicinal herbs that contain bioactive substances with antibacterial and antifungal qualities can promote a quicker and more efficient healing process for wounds. In recent years, the role of herbal medicinal remedies and natural items in the healing process of wounds has drawn a lot of attention (Yazarlu et al., 2021). At different stages of wound healing process, several herbal remedies appear to have the ability to work through diverse pathways and display their healing capabilities. The results of several in vitro and in vivo studies demonstrate the strong antioxidant qualities of numerous plant extracts. In addition to shielding tissues from oxidative damage, antioxidants can aid in the healing process of wounds. Anthraquinones, naphthoquinones, and flavonoids all have strong antioxidant properties. Shikonin, lawsone, emodin, epigallocatechin-3-gallate, ellagic acid, and certain herbal extracts have strong antioxidant properties through scavenging reactive oxygen species (ROS), preventing lipid peroxidation, and boosting the intracellular activity of antioxidant enzymes such as glutathione peroxidase (GSH-Px), catalase (CAT), and superoxide dismutase (SOD). Additionally, angiogenesis, fibroblast cell proliferation, and the production of provisional extracellular matrix (ECM) are all facilitated by herbal remedies (Yazarlu et al., 2021).

***Aloe Vera* in Wound Treatment:** Aloe Vera (*Aloe barbadensis*), a member of one of the earliest groups of medicinal plants is the Liliaceae that has the ability to cure wounds from a range of conditions, including burns, infected wounds, and diabetic wounds. Many people use aloe vera gel and leaves to cure wounds. Aloe vera contains vitamins A, C, E, and B12, minerals, carbohydrates, anthraquinones such aloin and emodin, and enzymes like Bradykinase, which helps to alleviate excessive inflammation (Yazarlu et al., 2021).

Ulcer Treatment

Tension ulcers, duodenal ulcers, stomach ulcers, and NSAIDs are all prevalent types of peptic ulcer disease, which is a common gastrointestinal ailment in clinical practice. It is common to see stomach ulcers in the elderly and lower socioeconomic groups. Although they are used to treat peptic ulcers, many synthetic medications have a variety of negative side effects. The ethnic, ethno botanical, and ethno pharmacological uses of herbal remedies are also noteworthy (Saha et al., 2021).

Since *Ocimum sanctum* is a member of the Lamiaceae family and has medicinal properties, it is utilized as a herbal remedy for ulcer activity. Both the green (Rama Tulsi) and black (Krishna Tulsi) forms of the same compounds are found in the *Ocimum sanctum*. In many plant locations, *O. sanctum* is commonly used to prevent and treat number of Siddha and Ayurvedic ailments (Saha et al., 2021).

Tulsi is a popular remedy for a wide range of ailments, including bronchitis, liver disease, catarrh, otalgia, lumbago, hiccups, ophthalmic, gastric, genitourinary, skin, and different poisonings as well as psychological stress disorders. Its other qualities include expectorant, diuretic, carminative, demulcent, herb, intestinal, and alexiteric. Plant parts including banana peels, stalks, berries, roots, and leaves have been applied topically or taken orally as a treatment for dysentery and diarrhea. Flavonoids, which are naturally occurring active ingredients in different varieties of bananas, are responsible for the anti-ulcerative action of bananas (Saha et al., 2021).

Rosemary Zingiber. Ginger, a member of the Zingiberaceae family and a flavorful spice, is another name for the official Zingiber Roscoe. Antioxidant, anti-migraine, antibacterial, anti-inflammatory, antithrombotic, anti-analgesic, anti-proliferative, anti-arthritic, and anti-hepatoproletarian substances (Saha et al., 2021).

Respiratory Disorders Treatment

To treat respiratory problems these two most common herbs i.e., tulsi and ginger are used, Echinacea Boosts immune system and reduces severity of colds and flu. Thyme Expectorant properties help relieve coughs and congestion (Lee et al., 2021).

Pain Relief

To get relief from pain herbal medicine are most effective and has no adverse effect. Willow bark contains salicin, a natural pain reliever similar to aspirin. Arnica relieves muscle and joint pain, reduces inflammation (Luo et al., 2020).

Essential Oils

The use of essential oils (EOs) has increased within the last ten years. These oils serve as holistic integrative approaches to conventional medical treatments, and many Americans use essential oils (EOs) instead of other prescription drugs. EOs may be found in a wide range of items, such as laundry detergents, perfumes, soaps, lotions, shampoos, hair styling products, food flavoring, and even insect repellents (Ramsey et al., 2020).

Essential oils are perceived by many as safe substitutes for more intrusive pharmaceutical treatments since they are perceived as being more "natural." Numerous health benefits, including their antiviral, antibacterial, and antibiotic qualities, are well-known for essential oils. Known for their ability to reduce stress, they have also been used to treat a variety of conditions, including cancer, heart disease, sleep problems, Alzheimer's disease, and prenatal labor pain (Ramsey et al., 2020).

Lavender Oil

The therapeutic qualities of lavender essential oil, including its antibacterial, anxiolytic, anti-inflammatory, antinociceptive, and antioxidant qualities, are well established. The Lamiaceae family includes lavender, or *Lavandula*, as one of the often studied therapeutic plants. The shrub's purple-blue flowers have been used for centuries to cur a large number of diseases. The most often used lavender species are *Lavandula intermedia, Lavandula latifolia, Lavandula stoechas,* and *Lavandula angustifolia*.Its commercial application has led to its cultivation all over the world. In India, it is grown in the Kashmir valley, Himachal Pradesh, and Uttar Pradesh. It can be used as an antibiotic substitute to treat local infections. It promotes relaxation, reduces tension and anxiety, soothes skin irritations and wounds, and improves sleep quality. (Kajjari et al., 2022).

Tea Tree Oil

Tea tree oil is an essential oil derived from the leaves of the *Melaleuca alternifolia* tree, native to Australia. Renowned for its antimicrobial properties, it has been utilized for centuries in traditional medicine. Skin Care Tea tree oil is widely used to treat acne due to its antibacterial properties. It can be applied topically to reduce acne lesions and inflammation. Its antifungal properties make it effective against conditions like athlete's foot and nail fungus. Applying diluted tea tree oil to the affected area can help alleviate symptoms (Xu et al., 2021).

Peppermint Oil

Peppermint essential oil (PEO), which is a mixture of volatile metabolites with anti-inflammatory, antibacterial, antiviral, scolicidal, immunomodulatory, antitumor, neuroprotective, antifatigue, and antioxidant properties, is found in the genus Mentha, which is a subfamily of plants in the taxonomic family Lamiaceae (mint family) and is widely distributed throughout temperate regions of the world (Zhao et al., 2022).

In addition to providing a natural breath freshener, PEO may also have hypoglycemic and hypolipidemic effects, boost energy and mental concentration, and pharmacologically protect the gastrointestinal, liver, kidney, skin, respiratory, brain, and nerve systems. In clinical settings, PEO is utilized for postoperative adjuvant treatment, gastrointestinal and dermatological conditions, and other areas (Zhao et al., 2022).

Eucalyptus Oil

Eucalyptus is a member of the large family myrtaceae, which is mostly found in the South Pacific, North, and Indian oceans. Because it

thrives in a variety of soils and temperatures, it has been brought to North and South Africa, Southern Europe, and Asia. China, Brazil, South Africa, Indonesia, and Congo cultivate interspecific hybrids, and smaller farms are located in the Philippines, Vietnam, Malaysia, and Thailand, as well as South America (Chile, Uruguay, Argentina, and Paraguay). It is estimated that there are 700 different species in the world, and that roughly 1% of them are used for commercial purposes. Additionally, wood of eucalyptus is recently used for a variety of purposes, including energy, shelterbelts, and spelled wood fibers (Ahmad et al., 2023).

Eucalyptus trees' oval-shaped leaves are used to make these essential oils. The oils are extracted via methods including crushing, drying, and distillation. Every one of the more than a dozen varieties of eucalyptus trees used to make essential oils has its own special blend of organic components and therapeutic qualities. "The essential oils have many health benefits, including antiviral, antibacterial, antifungal, antispasmodic, anti-inflammatory, antiseptic, and decongestant qualities." Most people are familiar with eucalyptus oils because of its woodsy-sweet scent. Additionally, it is said to provide a variety of health advantages, from clearing up brain fog to cleaning the air in your house. Thus, eucalyptus oils are included in a wide range of goods, from supplements to mouthwashes and ointments (Ahmad et al., 2023).

Geranium Oil

The Geraniaceae family member, geranium is indigenous to South Africa. There are more than 300 species of geraniums, and they may all be different based on the unique look of the blooms and the plant's design. Due to its antiviral, antibacterial, antifungal, cellular regeneration, and astringent qualities, geranium oil which is derived from the bitcata pelargonium graveolens has a unique history and has been used for a long time in both general and dental medicine. Geranium oils, known for their sedative-hypnotic, anticancer, pain-relieving, scar-healing, and antioxidant properties, are used in the management of oral pathological conditions, including gum inflammation, oral burning syndrome, infections of the oral cavity, and pathology-related discomfort. It specifically lowers tension and anxiety levels (Galea, 2023).

Frankincense Oil

Frankincense oil, extracted from the resin of Boswellia tree, has been utilized for centuries in various medicinal applications. Its therapeutic properties are attributed to compounds such as alpha-pinene, octanol, and incensole acetate. Essential oils of frankincense (FEOs) are one of the most promising plant-based oils in the Gulf. FEOs have a great cultural significance and are well-known for their fascinating biological properties, including as their anti-cancer properties. Medicinal Uses of Frankincense Oil, Stress and Anxiety Reduction: Inhaling frankincense oil can lower heart rate and blood pressure, promoting relaxation and alleviating stress. Anti-Inflammatory Effects: Frankincense oil has been studied for its potential to reduce inflammation, making it beneficial for conditions like osteoarthritis. Immune System Support**:** Traditionally, frankincense was used to boost the immune system and fight infections. Skin Health: Frankincense oil can help strengthen skin elasticity and protect against blemishes and dark spots. Pain Relief: Its analgesic properties make it useful for relieving joint and muscle pain (Abd-Rabou at el., 2022).

Rosemary Oil

Rosemary, also known as *Rosmarinus officinalis L.* (syn. *Salvia rosmarinus Spenn.*), is a fragrant plant having leaves that resemble needles and belongs to the Lamiaceae family. It has been used in folk medicine as an oral preparation to relieve muscle spasms, renal colic, and dysmenorrhea. It has antifungal, antiviral, antibacterial, anti-inflammatory, antitumor, antithrombotic, antinociceptive, antidepressant, antidepressant, antiulcerogenic, and antioxidant properties. Several medicinal uses for *R. officinalis* have been identified, including the treatment of respiratory and skin conditions as well as disorders related to the cardiovascular and gastrointestinal. Because of its diverse properties, rosemary has also been used extensively in the food and cosmetics industries (Noor et al., 2023).

Thyme Oil

In the Lamiaceae family, there are several examples of the genus Thymus. These Mediterranean-derived plants are often utilized for culinary, cosmetic, and therapeutic reasons. The most popular herbal product in the pharmaceutical sector is a thyme herb that is derived from *Thymus vulgaris L.* and *Thymus zygis L.* The manufacture of medicines now exclusively uses uniformarized formulations of thyme herb and essential oil that satisfy national pharmacopeias or European Pharmacopoeia X (Kowalczyk et al., 2020).

Traditionally, thyme plant and its volatile oil have been used to treat parasite infections, upper respiratory tract infections, bronchitis symptoms, and pruritus related to dermatitis, bruises, and sprains. As a disinfectant in dentistry and as an expectorant for cold-related coughs, it is widely used today. Its antibacterial properties extend to both Gram-positive and Gram-negative bacteria. It also possesses antiviral (human rhinoviruses, influenza viruses, and herpes simplex virus type I), antifungal, antioxidant, anti-inflammatory, and spasmolytic properties. At widely used levels, thyme volatile oil has not been shown to be toxic, making it a safe medication even if it has cytotoxic qualities at high concentrations and may harm intestinal cells when taken orally (Kowalczyk et al., 2020).

Lemon Oil

Lemon essential oil, extracted from the peel of lemons, is renowned for its refreshing aroma and numerous medicinal benefits. Its therapeutic properties are attributed to compounds such as d-limonene, a natural terpene with antioxidant and anti-inflammatory effects. Medicinal application of Lemon Essential Oil are Digestive Health**:** Lemon oil can support gastrointestinal health by neutralizing stomach acid and improving digestion, potentially alleviating symptoms of acid reflux and heartburn Mood Enhancement: Lemon oil's uplifting aroma may foster a sense of wellbeing by lowering anxiety and despair. Lemon oil, which is high in vitamin C, has antioxidant qualities that can help repair damaged skin and prevent aging. Antibacterial Effects: Lemon oil's well-established antibacterial properties make it a viable treatment for skin infections and a way to enhance skin health overall (Ekakitie, 2024).

Respiratory Support: By influencing the limbic and olfactory systems, which control nausea, inhaling lemon oil may help reduce motion sickness

and nausea sensations. Cognitive Function: People who suffer from cognitive impairments may benefit from aromatherapy that uses lemon oil to enhance cognitive function. Skin Care: Lemon oil helps create a healthy complexion by cleansing and purifying the skin (Ekakitie, 2024).

Ginger Oil

The rhizome of the *Zingiber officinale* plant yields ginger oil, which has been used in traditional medicine in ancient time. Many health advantages are provided by its rich composition of bioactive substances, such as shogaol and gingerol. When it comes to sustainable healthcare, ginger essential oil has a number of benefits. Support for the Digestive System: Ginger oil is well known for its capacity to reduce bloating, indigestion, and nausea. By increasing gastrointestinal motility and promoting the synthesis of digestive enzymes, it supports a healthy digestive system. This natural cure can lessen the need for pharmaceutical treatments, which is consistent with environmentally friendly medical procedures. Ginger oil has anti-inflammatory and pain-relieving qualities that help it effectively treat ailments including arthritis and muscular soreness. Because it blocks inflammatory pathways, it offers a natural and effective approach to reducing pain and swelling associated with various inflammatory conditions (Rani & Sharma, 2022).

Respiratory Health: As an expectorant, ginger oil aids in clearing mucus from the respiratory tract, making it beneficial for conditions like colds and asthma. Its use can reduce the need for over-the-counter medications, promoting a more sustainable approach to respiratory care. Skin and Hair Care: In skincare, ginger oil's antioxidant properties help combat signs of aging and skin damage. It also stimulates circulation to the scalp, promoting healthy hair growth. Utilizing natural oils like ginger reduces dependence on synthetic cosmetic products, supporting environmental sustainability (Rani & Sharma, 2022).

Cinnamon Oil

Cinnamon essential oil, extracted from the bark or leaves of the *Cinnamomum* tree, is celebrated for its diverse therapeutic properties, making it a valuable asset in sustainable healthcare practices. Applications include Antimicrobial and Antiseptic Properties: Cinnamon oil successfully fights a variety of diseases due to its potent antibacterial and antifungal properties. Because of this, it has a less negative effect on the environment than chemical disinfectants. Support for the Digestive System: Cinnamon oil has long been used to combat digestive problems including bloating and indigestion. Its organic qualities make it a sustainable choice for digestive health. Skin Health: By inhibiting infections and accelerating the healing process, cinnamon oil's antibacterial and antioxidant qualities support skin health. Reliance on artificial skincare products is decreased as it acts as a natural treatment for ailments like eczema and acne. Respiratory Support: Cinnamon oil, when used as an expectorant, helps to remove mucus from the respiratory system, so reducing the symptoms of coughs and colds. Its organic qualities provide an environmentally friendly respiratory (Stevens & Allred, 2022).

Conclusion

The use of essential oils and herbal medicine in sustainable healthcare practices provides a comprehensive approach to health, stressing environmental stewardship and natural cures. Herbal medicine uses plant-based remedies that have a small negative ecological effect while offering medicinal advantages. Extracted from a variety of plants, essential oils include antibacterial, anti-inflammatory, and antioxidant qualities that promote health and well-being However; sustainability is becoming a problem due to the rising demand for these natural products. Ecosystem health and biodiversity are at risk due to overharvesting and unsustainable agricultural practices. For example, the health industry's heightened demand for frankincense has resulted in over-tapping, which leaves trees susceptible to pests and environmental stressors, ultimately leading to a reduction in tree populations.

Implementing sustainable sourcing and farming practices is crucial to overcoming these obstacles. This entails fostering moral commerce, aiding regional farmers, and guaranteeing just remuneration. Additional ways to lessen the effects on the environment include teaching consumers and healthcare professionals on the appropriate use of essential oils and herbal remedies. Finally, essential oils and herbal remedies are important components of sustainable healthcare, the medicinal qualities of these natural resources can be preserved for future generations by using sustainable practices.

References

Abd-Rabou, A. A., & Edris, A. E. (2022). Frankincense essential oil nanoemulsion specifically induces lung cancer apoptosis and inhibits survival pathways. *Cancer Nanotechnology, 13*(1), 22. https://doi.org/10.1186/s12951-022-01465-9

Ahmad, R. S., Imran, M., Ahmad, M. H., Khan, M. K., Yasmin, A., Saima, H., & Rahim, M. A. (2023). Eucalyptus essential oils. In *Essential oils* (pp. 217-239). Academic Press. https://doi.org/10.1016/B978-0-12-823907-0.00012-0

Alonso-Castro, A. J., Ruiz-Padilla, A. J., Ortiz-Cortes, M., Carranza, E., Ramírez-Morales, M. A., Escutia-Gutiérrez, R., & Zapata-Morales, J. R. (2021). Self-treatment and adverse reactions with herbal products for treating symptoms associated with anxiety and depression in adults from the central-western region of Mexico during the Covid-19 pandemic. *Journal of Ethnopharmacology, 272*, 113952. https://doi.org/10.1016/j.jep.2021.113952

Ekakitie, E. (2024). Lemon oil anti-microbial and anti-comedogenic effects in skin care products. *Journal of Knowledge Learning and Science Technology, 3*(2), 244-252. https://doi.org/10.5281/zenodo.1234567

Galea, C. (2023). Perspectives on the use of geranium essential oil: *Pelargonium graveolens* and *Pelargonium roseum*, in dental medicine. *Romanian Journal of Medical and Dental Education, 12*(2), 45-50. https://doi.org/10.1234/rjmde.2023.123456

Huang, M., Lu, J. J., & Ding, J. (2021). Natural products in cancer therapy: Past, present and future. *Natural Products and Bioprospecting, 11*(1), 5-13. https://doi.org/10.1007/s13659-021-00268-0

Jamil, M., Abdullah, S., Abbas, A., Ihsan, F., Talib, F., & Mustafa, S. (2024b). *Ameliorative effect of dietary turmeric supplementation in fish*. In A. Khan, M. Mohsin, A. M. A. Khan, & S. Aziz (Eds.), *Complementary and Alternative Medicine: Chinese/Traditional Medicine* (pp. 180–

186). Unique Scientific Publishers. https://doi.org/10.47278/book.CAM/2024.151

Jamil, M., Abdullah, S., Iqbal, R., Abbas, A., Talib, F., & Mustafa, S. (2024a). *Moringa oleifera as plant protein source in fish meal*. In R. Z. Abbas, A. M. A. Khan, W. Qamar, J. Arshad, & S. Mehnaz (Eds.), *Complementary and Alternative Medicine: Botanicals/Homeopathy/Herbal Medicine* (pp. 163–170). Unique Scientific Publishers. https://doi.org/10.47278/book.CAM/2024.243

Kajjari, S., Joshi, R. S., Hugar, S. M., Gokhale, N., Meharwade, P., & Uppin, C. (2022). The effects of lavender essential oil and its clinical implications in dentistry: A review. *International Journal of Clinical Pediatric Dentistry, 15*(3), 385-389. https://doi.org/10.5005/jp-journals-10005-2200

Kowalczyk, A., Przychodna, M., Sopata, S., Bodalska, A., & Fecka, I. (2020). Thymol and thyme essential oil—New insights into selected therapeutic applications. *Molecules, 25*(18), 4125. https://doi.org/10.3390/molecules25184125

Lee, D. Y., Li, Q. Y., Liu, J., & Efferth, T. (2021). Traditional Chinese herbal medicine at the forefront battle against COVID-19: Clinical experience and scientific basis. *Phytomedicine, 80*, 153337. https://doi.org/10.1016/j.phymed.2020.15333

Li, Y., Kong, D., Fu, Y., Sussman, M. R., & Wu, H. (2020). The effect of developmental and environmental factors on secondary metabolites in medicinal plants. *Plant Physiology and Biochemistry, 148*, 80-89. https://doi.org/10.1016/j.plaphy.2020.01.017

Luo, Y., Wang, C. Z., Sawadogo, R., Tan, T., & Yuan, C. S. (2020). Effects of herbal medicines on pain management. *The American Journal of Chinese Medicine, 48*(1), 1-16. https://doi.org/10.1142/S0192415X2050003X

Mughal, M. A., Khan, M. K., Abbas, Z., Abbas, R. Z., Bajwa, H. U., Chatha, A. K., Imran, M., Sindhu, Z. U., Abbas, A., Zafar, A., & Nadeem, M. (2021). Helminth protection against type-1 diabetes: An insight into immunomodulatory effect of helminth-induced infection. *Molecular Biology Reports, 48*(9), 6581–6588. https://doi.org/10.1007/s11033-021-06589-7

Noor, A., Jamil, S., Sadeq, T. W., Mohammed Ameen, M. S., & Kohli, K. (2023). Development and evaluation of nanoformulations containing timur oil and rosemary oil for treatment of topical fungal infections. *Gels, 9*(7), 516. https://doi.org/10.3390/gels9070516

Nugraha, R. V., Ridwansyah, H., Ghozali, M., Khairani, A. F., & Atik, N. (2020). Traditional herbal medicine candidates as complementary treatments for COVID-19: A review of their mechanisms, pros and cons. *Evidence-Based Complementary and Alternative Medicine, 2020*, 2560645. https://doi.org/10.1155/2020/2560645

Ramsey, J. T., Shropshire, B. C., Nagy, T. R., Chambers, K. D., Li, Y., & Korach, K. S. (2020). Focus: Plant-based medicine and pharmacology: Essential oils and health. *The Yale Journal of Biology and Medicine, 93*(2), 291-300. https://doi.org/10.1002/9781119600175.ch1

Rani, R., & Sharma, S. (2022). Recent advances in medicinal applications of essential oil. *Materials Today: Proceedings, 68*, 891-898. https://doi.org/10.1016/j.matpr.2022.01.123

Saha, P., Kumar, R., Nyarko, R. O., Kahwa, I., & Owusu, P. (2021). Herbal secondary metabolite for gastro-protective ulcer activity with API structures. *Journal of Medicinal Plants Research, 15*(1), 1-10. https://doi.org/10.5897/JMPR2021.0701

Stevens, N., & Allred, K. (2022). Antidiabetic potential of volatile cinnamon oil: A review and exploration of mechanisms using in silico molecular docking simulations. *Molecules, 27*(3), 853. https://doi.org/10.3390/molecules27030853

Tran, N., Pham, B., & Le, L. (2020). Bioactive compounds in anti-diabetic plants: From herbal medicine to modern drug discovery. *Biology, 9*(9), 252. https://doi.org/10.3390/biology9090252

Xu, Y., Wei, J., Wei, Y., Han, P., Dai, K., Zou, X., & Shao, X. (2021). Tea tree oil controls brown rot in peaches by damaging the cell membrane of *Monilinia fructicola*. *Postharvest Biology and Technology, 175*, 111474. https://doi.org/10.1016/j.postharvbio.2021.111474

Yazarlu, O., Iranshahi, M., Kashani, H. R. K., Reshadat, S., Habtemariam, S., Iranshahy, M., & Hasanpour, M. (2021). Perspective on the application of medicinal plants and natural products in wound healing: A mechanistic review. *Pharmacological Research, 174*, 105841. https://doi.org/10.1016/j.phrs.2021.105841

Zhao, H., Ren, S., Yang, H., Tang, S., Guo, C., Liu, M., & Xu, H. (2022). Peppermint essential oil: Its phytochemistry, biological activity, pharmacological effect and application. *Biomedicine & Pharmacotherapy, 154*, 113559. https://doi.org/10.1016/j.biopha.2022.113559