

CHAPTER 7

Herbal remedies for osteoarthritis: medicinal plants that heal

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Abstract

Osteoarthritis (OA) is a prevalent degenerative joint disorder for which traditional herbal remedies continue to play an important complementary role in symptom management across various cultures. A comprehensive literature survey was conducted using different databases. Present chapter compiled and summarized medicinal plants historically and contemporarily used for OA relief, highlighting their botanical characteristics, families and traditional modes of preparation and administration. Plants such as *Boswellia serrata*, *Curcuma longa*, *Zingiber officinale*, *Vitex negundo* and *Withania somnifera* are widely recognized in traditional systems for their supportive properties in managing inflammation and joint discomfort. Present study served as a fundamental reference for future pharmacological, clinical and ethnobotanical research on plant-based methods of managing osteoarthritis by offering an organized summary of these medicinal plants and their ethnomedical uses.

Keywords: Degenerative, ethnobotanical research, future pharmacological

Introduction

Osteoarthritis (OA) is the most common chronic joint disorder worldwide, characterized by progressive degeneration of articular cartilage, subchondral bone remodelling and varying degrees of inflammation (He *et al.*, 2020; Nicola, 2020; Salman *et al.*, 2023). Its prevalence increases with age, placing a considerable burden on mobility, quality of life and healthcare systems (Singh and Kumar, 2025; Xi *et al.*, 2025). Although contemporary management strategies focus on symptom relief and functional improvement, interest in complementary and plant-based approaches has grown steadily (Seetharaman *et al.*, 2021; Jeremy *et al.*, 2023). Traditional medical systems, including Ayurveda, Traditional Chinese Medicine and various indigenous practices have long incorporated medicinal plants to support joint comfort, flexibility and the well-being in individuals experiencing OA-like symptoms (Jha *et al.*, 2024; Udayakumar *et al.*, 2025). The botanical remedies often feature preparations such as decoctions, powders, oils and infusions, each reflecting region-specific knowledge and cultural heritage (Chaachouay and Zidane, 2024). The therapeutic potential of many of these plants has attracted modern scientific investigation, with studies exploring their phytochemical constituents, anti-inflammatory actions and broader biological activities (Gandhi *et al.*, 2022; Riaz *et al.*, 2023). Species such as *Boswellia serrata*, *Curcuma longa*, *Zingiber officinale* and *Withania somnifera* exemplify the longstanding intersection between traditional knowledge and contemporary research interest (Pinzon and Wijaya, 2019; Sanchez *et al.*, 2022; Mamatha *et al.*, 2025). Despite increasing attention, the ethnomedicinal landscape of OA treatment remains vast and diverse, highlighting the value of systematically documenting plant species used across different traditions (Duche-Perez, 2024; Chashike *et al.*, 2025). Therefore, present work aims to present an organized overview of medicinal plants historically and currently employed in OA management, emphasizing their botanical identities, families and traditional modes of use. By integrating ethnobotanical documentation with emerging scientific understandings, the recent study provided a foundation for future interdisciplinary research into plant-based approaches for joint health and musculoskeletal well-being.

Methodology

An extensive literature review was conducted to document medicinal plants traditionally used by local communities for treating osteoarthritis, by utilizing databases like PubMed, Scopus, Web of Science and NCBI with key terms related to ethnomedicine and validating identified plant species through available literature (Lindler *et al.*, 2020; Kumar, 2025).

Results and discussion

The present survey of ethnobotanical and traditional medicine literature identified a diverse range of medicinal plants historically used to support individuals experiencing osteoarthritis-related symptoms. A total of 29 plant species representing 22 families were documented, highlighting the broad botanical spectrum incorporated into traditional joint-care practices across cultures (Table 1; Figure 1). The families Zingiberaceae, Burseraceae, Lamiaceae, Asteraceae and Solanaceae appeared most frequently, reflecting their longstanding prominence in herbal traditions. Modes of use varied widely among species, with decoctions, powders and topical oils emerging as the most common preparation forms (Figure 2). Several

plants such as *Curcuma longa*, *Zingiber officinale*, *Boswellia serrata* and *Withania somnifera* were reported across multiple cultural systems, suggesting a high degree of cross-traditional recognition. Topical applications were particularly noted for species such as *Arnica montana*, *Vitex negundo*, *Eucalyptus globulus* and *Symphytum officinale*, whereas internal preparations dominated reports for *Paeonia lactiflora*, *Panax notoginseng*, *Asparagus racemosus* and *Eucommia ulmoides*. The data highlighted a consistent reliance on plant parts such as roots, bark, leaves and resins, which aligns with traditional preferences for phytochemically rich tissues. Present findings demonstrated the extensive reliance on botanical resources for managing joint-related discomfort across traditional medical systems. The recurrent use of certain species across geographically distinct cultures may reflect shared empirical observations, accumulated knowledge or biochemical properties that historically aligned with symptom management needs. For example, the use of resinous species such as *Boswellia* spp., and rhizomatous plants such as *Curcuma longa* and *Zingiber officinale*, suggested that traditional practitioners may have intuitively selected plants known today to contain bioactive compounds of interest, prompting modern scientific exploration. Moreover, several plants included in the dataset have become subjects of contemporary pharmacological interest. The current research on terpenoids from *Boswellia serrata*, curcuminoids from *Curcuma longa* and alkaloids from *Withania somnifera* illustrated the ongoing convergence between ethnomedicine and modern scientific inquiry. While traditional uses do not equate to validated therapeutic effects, they provide meaningful leads for further investigation. The compilation of medicinal plants used for osteoarthritis-like symptoms provide a foundation for interdisciplinary studies spanning ethnobotany, pharmacognosy and comparative medical history. The results underscore both the cultural richness of plant-based practices and the potential relevance of traditional knowledge to ongoing research into joint health and musculoskeletal well-being.

Table: List of medicinal plants used against osteoarthritis

Botanical name	Common name	Family	Mode of use	Sources
<i>Alstonia scholaris</i> (L.) R.Br.	Scholar tree(E)	Apocynaceae	The bark decoction is consumed orally and the latex is applied topically to the affected area, sometimes mixed with oil.	Banik <i>et al.</i> , (2020)
<i>Arnica montana</i> L.	Mountain tobacco (E)	Asteraceae	A thin layer of its gel is applied topically to the affected	Smith <i>et al.</i> , (2021)

			joints 2-3 times daily.	
<i>Asparagus racemosus</i> Willd.	Shatavari (H)	Asparagaceae	The root powder is prepared as “shatavaryadi churna” for oral consumption.	Bhat <i>et al.</i> , (2013)
<i>Boswellia sacra</i> Flück.	Olibanum (E)	Burseraceae	The essential oil is diluted in a carrier oil and applied topically to the affected joints.	Al-Saban <i>et al.</i> , (2025)
<i>Boswellia serrata</i> Roxb.	Saalia (H)	Burseraceae	It is used due to its anti-inflammatory properties, with modes of use including oral consumption of extracts and less commonly topical application.	Yu <i>et al.</i> , (2020)
<i>Camellia sinensis</i> (L.) Kuntze	Tea tree (E)	Theaceae	The dried leaves are steeped in hot water to make a beverage and consumed.	Xie <i>et al.</i> , (2024)
<i>Capsicum annuum</i> L.	Red pepper (E)	Solanaceae	Warm infusions made from the capsicum fruits are used topically.	Sanati <i>et al.</i> , (2018)
<i>Cedrus deodara</i> (Roxb. ex D. Don) G. Don	Deodar cedar (E)	Pinaceae	The fine powder of the bark or wood can be consumed in doses of 1-2	Patel <i>et al.</i> , (2025)

			grams, often mixed with honey or warm milk.	
<i>Curcuma longa</i> L.	Turmeric (E)	Zingiberaceae	An oral decoction made from boiling the root is consumed & the leaves are used in massages to treat joint inflammation.	Ma <i>et al.</i> , (2025)
<i>Eucalyptus globulus</i> Labill.	Blue gum (E)	Myrtaceae	The oil from its leaves is massaged for its anti-inflammatory properties.	Sheikh <i>et al.</i> , (2025)
<i>Eucommia ulmoides</i> Oliv.	Hardy rubber tree (E)	Eucommiaceae	The bark decoction is consumed orally thrice a day after meals for one month.	Lindler <i>et al.</i> , (2020)
<i>Harpagophytum procumbens</i> (Burch.) DC.	Devil's claw (E)	Pedaliaceae	The most common way to use it by taking oral preparations like capsules, tablets or extracts.	Gxaba and Manganyi, (2022)
<i>Justicia adhatoda</i> L.	Malabar nut (E)	Acanthaceae	A decoction or a powder of the dried leaves/roots is prepared and consumed orally.	Banik <i>et al.</i> , (2020)
<i>Matricaria chamomilla</i> L.	Chamomile (E)	Asteraceae	The oil is applied topically to the affected	Shoara <i>et al.</i> , (2015)

			joint about thrice a day.	
<i>Oroxylum indicum</i> (L.) Kurz	Indian trumpet flower (E)	Bignoniaceae	A decoction is made from the root bark is consumed orally and the bark paste is applied topically.	Karnati <i>et al.</i> , (2013)
<i>Paeonia lactiflora</i> Pall.	Common garden peony (E)	Paeniaceae	The dried root decoction is administered orally.	Chen <i>et al.</i> , (2023)
<i>Panax notoginseng</i> (Burkil) F.H.Chen	Sanchi (E)	Araliaceae	It is orally administered as a raw powder or as a component in complex herbal formulations.	Chen <i>et al.</i> , (2021)
<i>Phlomis laciniata</i> (L.) Kamelin & Makhm.	Desert spike (E)	Lamiaceae	The flower and root decoctions are consumed orally.	Lindler <i>et al.</i> , (2020)
<i>Piper nigrum</i> L.	Black pepper (E)	Piperaceae	It is often combined with another medicinal herb, such as turmeric and consumed orally.	Ying <i>et al.</i> , (2013)
<i>Rosa canina</i> L.	Rosehip (E)	Rosaceae	The fruits are used as a general tonic, in syrups and teas.	Gruenwald <i>et al.</i> , (2019)
<i>Swertia chirayita</i> (Roxb.) H. Karst.	Chirayita (H)	Gentianaceae	The plant material is soaked overnight in water or boiled to create a bitter-tasting liquid	Banik <i>et al.</i> , (2020)

			is consumed orally.	
<i>Symphytum officinale</i> L.	Comfrey (E)	Boraginaceae	Traditionally, mashed fresh or dried comfrey roots and leaves are made into a paste using hot water and applied to the affected area.	Grube <i>et al.</i> , (2007)
<i>Tripterygium wilfordii</i> Hook.f.	Thunder god vine (E)	Celastraceae	The root decoction is traditionally administered orally.	Shan <i>et al.</i> , (2023)
<i>Uncaria tomentosa</i> (Willd. ex Schult.) DC.	Cat's claw (E)	Rubiaceae	Traditionally used as a decoction (tea) made from the inner bark of the root.	Marques <i>et al.</i> , (2025)
<i>Vitex negundo</i> L.	Chinese chaste tree (E)	Lamiaceae	The oil prepared from the leaves is applied topically.	Ban <i>et al.</i> , (2023)
<i>Withania somnifera</i> (L.) Dunal	Ashwagandha (H)	Solanaceae	½ teaspoon of its root powder into a glass of warm milk or water and drink it sometimes with honey or sugar, up to three times a day.	Mikulska <i>et al.</i> , (2023)
<i>Zingiber officinale</i> Roscoe	Ginger (E)	Zingiberaceae	Fresh ginger may be boiled with brown sugar to make a syrup for consumption & ginger-infused oil is	Szymczak <i>et al.</i> , (2024)

			used for massaging the affected joints to help reduce localized pain and stiffness.	
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(E: English; H: Hindi)

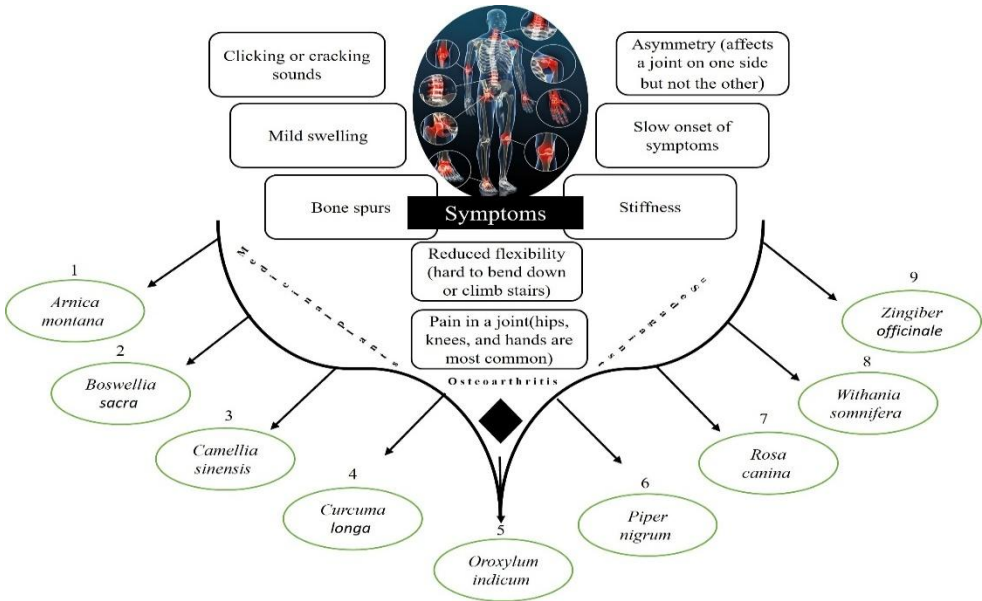


Figure 1: Some common medicinal plants effective in osteoarthritis

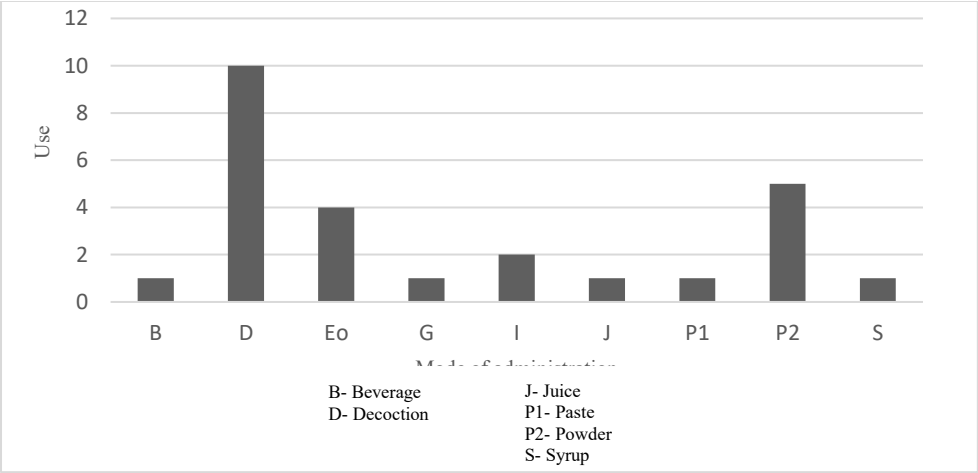


Figure 2: Medicinal plants used in different forms

Biotechnological approaches

Biotechnological strategies offer promising avenues for enhancing the therapeutic potential of medicinal plants in osteoarthritis management. Techniques such as plant tissue culture, callus and suspension cultures and micropropagation enable the large-scale production of bioactive compounds like curcuminoids, boswellic acids and withanolides under controlled conditions, ensuring consistency and quality. Metabolic engineering and elicitation approaches can further increase the yield of anti-inflammatory and cartilage-protective metabolites.

Conclusion

Present collected data highlighted the wide diversity of medicinal plants traditionally used for managing osteoarthritis-related symptoms across cultures. The documented species demonstrate rich ethnobotanical knowledge and reflect longstanding practices involving decoctions, powders, oils and topical applications. While traditional use does not confirm clinical efficacy, these plants provide valuable insights and serve as important leads for future pharmacological and interdisciplinary research on natural approaches to joint health.

References

- Al-Saban A, Maad AH, Al-Sham AS and Saad HM. (2025). Antimicrobial and antioxidant properties of *Boswellia sacra* resin: extraction, evaluation, and formulation into a topical cream for dermatological applications. *Frontiers in Medicine*. 12: 1664265. DOI: 10.3389/fmed.2025.1664265.
- Ban Y, Wang Y, Qiao L, Zhang C, Wang H, He X, Jia D and Zheng C. (2023). Total lignans from *Vitex negundo* seeds attenuate osteoarthritis and their main component vitedoin A alleviates osteoclast differentiation by suppressing ERK/NFATc1 signalling. *Phytotherapy Research*. 37(4): 1422-1434.
- Banik B, Das S and Das MK. (2020). Medicinal plants with potent anti-inflammatory and anti-arthritis properties found in eastern parts of the Himalaya: an ethnomedicinal review. *Pharmacognosy Reviews*. 14(28): 121-137.
- Bhat H, Sampath P, Pai RJ Bollor R, Baliga MS and Fayad R. (2013). Indian medicinal plants as immunomodulators: scientific validation of the ethnomedicinal beliefs. In: Watson RR and Preedy VR. *Bioactive Food as Dietary Interventions for Arthritis and Related Inflammatory Diseases*. Academic Press. Pp: 215-224.
- Chashike A, Shibru S, Gebre T and Uncha A. (2025). Ethnobotanical study of traditional medicinal plants and associated indigenous knowledge in Melokoza district, South Ethiopia. *Trees, Forests and People*. 20: 100849. DOI: 10.1016/j.tfp.2025.100849.
- Chen M, Zhou S, Liu, Wen Y and Chen L. (2021). Notoginsenoside R1 alleviates the inflammation of osteoarthritis by activating the Nrf2/HO-1 signalling pathway *in vitro* and *in vivo*. *Journal of Functional Foods*. 85: 104666. DOI: 10.1016/j.jff.2021.104666.

- Chen P, Zhou J, Ruan A, Ma Y and Wang Q. (2023). Paeoniflorin, the main monomer component of *Paeonia lactiflora*, exhibits anti-inflammatory properties in osteoarthritis synovial inflammation. Chinese Journal of Integrative Medicine. 30: 433-442.
- Di Nicola V. (2020). Degenerative osteoarthritis a reversible chronic disease. Regenerative Therapy. 15: 149-160.
- Duche-Perez A, Aguilar OAG, Castillo AS and Daza LJM. (2024). Systematic review of ethnomedicinal knowledge: documentation, evaluation, and conservation of medicinal plants and their therapeutic applications. F1000Research. DOI: f1000research.com/articles/13-1324.
- Gandhi Y, Kumar R, Grewal J, Rawat H, Mishra SK, Kumar V, Shakya SK, Jain V, Babu G, Sharma P, Singh A, Singh R and Acharya R. (2022). Advances in anti-inflammatory medicinal plants and phytochemicals in the management of arthritis: a comprehensive review. Elsevier. Food Chemistry Advances. 1: 100085. DOI: 10.1016/j.focha.2022.100085.
- Grube B, Grunwald J, Krug L and Staiger C. (2007). Efficacy of a comfrey root (*Symphyti offic. radix*) extract ointment in the treatment of patients with painful osteoarthritis of the knee: results of a double-blind, randomised, bicenter, placebo-controlled trial. Phytomedicine. 14(1): 2-10.
- Gruenwald J, Uebelhack R and Moré MI. (2019). *Rosa canina* - Rose hip pharmacological ingredients and molecular mechanisms counteracting osteoarthritis - a systematic review. Phytomedicine. 60: 152958. DOI: 10.1016/j.phymed.2019.152958.
- Gxaba N and Manganyi MC. (2022). The fight against infection and pain: Devil's Claw (*Harpagophytum procumbens*) a rich source of anti-inflammatory activity: 2011-2022. Molecules. 27(11): 3637. DOI: 10.3390/molecules27113637.
- He Y, Li Z, Alexander PG, Ocasio-Nieves BD, Yocum L, Lin H and Tuan RS. (2020). Pathogenesis of osteoarthritis: risk factors, regulatory pathways in chondrocytes, and experimental models. Biology. 9(8): 194. DOI: 10.3390/biology9080194.
- Jeremy YN, Dhawan T, Fajardo RG, Masood HA, Sunderji S, Wieland LS and Moher D. (2023). The brief history of complementary, alternative, and integrative medicine terminology and the development and creation of an operational definition. Integrative Medicine Research. 12(4): 100978. DOI: 10.1016/j.imr.2023.100978.
- Jha LA, Imran M, Shrestha J, Devkota HP, Bhattacharya K, Alsayari A, Wahab S, Jha SK, Paudel KR and Kesharwani P. (2024). Effectiveness of phytoconstituents and potential of phyto-nanomedicines combination to treat osteoarthritis. European Polymer Journal. 215: 113243. DOI: 10.1016/j.eurpolymj.2024.113243.
- Karnati M, Chandra RH, Veeresham C and Kishan B. (2013). Anti-arthritis activity of root bark of *Oroxylum indicum* (L.) vent against adjuvant-induced arthritis. Pharmacognosy Research. 5(2): 121-128.

- Kumar S. (2025). Data collection from literature for biological sciences, medicinal plants research, ethnobotany, and pharmacology: a methodological overview. *Journal of Biodiversity and Conservation*. 9(2): 167-169.
- Lindler BN, Long KE, Taylor NA and Lei W. (2020). Use of herbal medications for treatment of osteoarthritis and rheumatoid arthritis. *Medicines*. 7(11): 67. DOI: 10.3390/medicines7110067.
- Ma X, Zhao W, Yang F and Chin KY. (2025). Efficacy and mechanisms of curcumin in the treatment of osteoarthritis: A scoping review. *Biomolecules and Biomedicine*. 25(4): 761-785.
- Mamatha K, Prabhakaran P, Das SS, Aryan MK and Thomas J. (2025). A full-spectrum *Boswellia serrata* extract with enhanced bioavailability, and its co-delivered system with curcumin alleviate pain and stiffness associated with moderate spondylitis: a randomized double-blind, placebo-controlled, 3-arm study. *Frontiers in Pharmacology*. 16: 1577429. DOI: 10.3389/fphar.2025.1577429.
- Marques O, Figueirinha A, Pina ME and Batista MT. (2025). *Uncaria tomentosa* as a promising natural source of molecules with multiple activities: review of its ethnomedicinal uses, phytochemistry and pharmacology. *International Journal of Molecular Sciences*. 26(14): 6758. DOI: 10.3390/ijms26146758.
- Mikulska P, Malinowska M, Ignacyk M, Szustowski P, Nowak J, Pesta K, Szelać M, Szklanny D, Judasz E, Kaczmarek G, Ejiohuo OP, Paczkowska-Walendowska M, Gościński A and Cielecka-Piontek J. (2023). Ashwagandha (*Withania somnifera*)-current research on the health-promoting activities: a narrative review. *Pharmaceutics*. 15(4): 1057. DOI: 10.3390/pharmaceutics15041057.
- Patel H, Joshi PK, Singh RK, Kumar Y, Sahu KV and Rajwade L. (2025). A critical review on the medicinal tree Devdaru (*Cedrus deodara* (roxb) Loud.). *Journal of Ayurveda and Integrated Medical Sciences*. 10(7): 135-141.
- Pinzon RT and Wijaya VO. (2019). *Curcuma longa* and *Boswellia serrata* for improving functional status in osteoarthritis patients: from bench to bedside evidences. *Asian Journal of Medical Sciences*. 10(5): 1-5.
- Riaz M, Khalid R, Afzal M, Anjum F, Fatima H, Zia S, Rasool G, Egbuna C, Mtewa AG, Uche CZ and Aslam MA. (2023). Phytobioactive compounds as therapeutic agents for human diseases: a review. *Food Science & Nutrition*. 11(6): 2500-2529.
- Salman LA, Ahmed G, Dakin SG, Kendrick B and Price A. (2023). Osteoarthritis: a narrative review of molecular approaches to disease management. *Arthritis Research & Therapy*. 25(1): 27. DOI: 10.1186/s13075-023-03006-w.
- Sanati S, Razavi BM and Hosseinzadeh H. (2018). A review of the effects of *Capsicum annuum* L. and its constituent, capsaicin, in metabolic syndrome. *Iranian Journal of Basic Medical Sciences*. 21(5): 439-448.

- Sanchez C, Zappia J, Lambert C, Foguene J, Dierckxsens Y, Dubuc JE, Delcour JP, Gothot A and Henrotin Y. (2022). *Curcuma longa* and *Boswellia serrata* extracts modulate different and complementary pathways on human chondrocytes *in vitro*: deciphering of a transcriptomic study. *Frontiers in Pharmacology*. 13: 931914. DOI: 10.3389/fphar.2022.931914.
- Seetharaman M, Krishnan G and Schneider RH. (2021). The future of medicine: frontiers in integrative health and medicine. *Medicina*. 57(12): 1303. DOI: 10.3390/medicina57121303.
- Shan Y, Zhao J, Wei K, Jiang P, Xu L, Chang C, Xu L, Shi Y, Zheng Y, Bian Y, Zhou M, Schrodi SJ, Guo S and He D. (2023). A comprehensive review of *Tripterygium wilfordii* hook. f. in the treatment of rheumatic and autoimmune disease: bioactive compounds, mechanisms of action, and future directions. *Frontiers in Pharmacology*. 14: 1282610. DOI: 10.3389/fphar.2023.1282610.
- Shiekh RAE, Atwa AM, Elgindy AM, Mustafa AM, Senna MM, Alkabbani MA and Ibrahim KM. (2025). Therapeutic applications of Eucalyptus essential oils. *Inflammopharmacology*. 33(1): 163-182.
- Smith AG, Miles VN, Holmes DT, Chen X and Lei W. (2021). Clinical trials, potential mechanisms, and adverse effects of *Arnica* as an adjunct medication for pain management. *Medicines*. 8(10): 58. DOI: 10.3390/medicines8100058.
- Singh B and Kumar A. (2025). Ageing, multimorbidity, and quality of life: a mediation analysis using longitudinal ageing study in India. *Frontiers in Public Health*. 13: 1562479. DOI: 10.3389/fpubh.2025.1562479.
- Shoara R, Hashempur MH, Ashraf A, Salehi A, Dehshahri S and Habibagahi Z. (2015). Efficacy and safety of topical *Matricaria chamomilla* L. (chamomile) oil for knee osteoarthritis: a randomized controlled clinical trial. *Complementary Therapies in Clinical Practice*. 21(3): 181-187.
- Szymczak J, Grygiel-Górniak B and Cielecka-Piontek J. (2024). *Zingiber Officinale* Roscoe: the antiarthritic potential of a popular spice-preclinical and clinical evidence. *Nutrients*. 16(5): 741. DOI: 10.3390/nu16050741.
- Udayakumar N, Murthy VR, Reddy JP, Nagaraj S, Navya S, Ruhinaz RS, Bhavishya R and Harshitha R. (2025). A review on integration of traditional and modern medicine. *Asian Journal of Pharmaceutics*. 19(2): 365-371.
- Xi JY, Liang BH, Zhang WJ, Yan B, Dong H, Chen YY, Lin X, Gu J and Hao YT. (2025). Effects of population aging on quality of life and disease burden: a population-based study. *Global Health Research and Policy*. 10(1): 2. DOI: 10.1186/s41256-024-00393-8.
- Xie X, Fu J, Gou W, Qin Y, Wang D, Huang Z, Wang L and Li X. (2024). Potential mechanism of tea for treating osteoporosis, osteoarthritis, and rheumatoid arthritis. *Frontiers in Medicine*. 11: 1289777. DOI: 10.3389/fmed.2024.1289777.

- Ying X, Chen X, Cheng S, Shen Y, Peng L and Xu HZ. (2013). Piperine inhibits IL- β induced expression of inflammatory mediators in human osteoarthritis chondrocyte. *International Immunopharmacology*. 17(2): 293-299.
- Yu G, Xiang W, Zhang T, Zeng L, Yang K and Li J. (2020). Effectiveness of *Boswellia* and *Boswellia* extract for osteoarthritis patients: a systematic review and meta-analysis. *BMC Complementary Medicine and Therapies*. 20(1): 225. DOI: 10.1186/s12906-020-02985-6.