



## A Review of the Phytochemical Composition and Therapeutic Uses of *Artemisia* spp.

Fadwa Abdelkader Almiar

Department of Botany, Faculty of Sciences, University of Derna, Derna, Libya.

f.elmeiar@uod.edu.ly

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**Abstract**—Species of the genus *Artemisia* are rich sources of biologically active phytochemicals, including terpenoids, flavonoids, phenolic acids, and essential oils, contributing to their diverse therapeutic applications. These species have been extensively studied and demonstrated a wide range of pharmacological activities such as antimalarial (e.g., artemisinin), antioxidant (e.g., quercetin), antimicrobial (e.g., camphor), and anticancer (e.g., artemisinin and its derivatives) effects, highlighting their importance in both traditional and modern medicine. Artemisinin, a key sesquiterpene lactone, has revolutionized malaria treatment globally. However, research on *Artemisia* faces challenges regarding standardization of extraction methods (such as ethanol, methanol, and aqueous extracts being common) and analytical protocols, as well as the need for comprehensive clinical trials to validate efficacy and safety. This narrative review provides a comprehensive summary of the phytochemical composition and therapeutic uses of various *Artemisia* spp., emphasizing major bioactive compounds and potential mechanisms of action. The findings highlight the significant potential of *Artemisia* spp. as sources for novel natural drug development, calling for further clinical studies and standardization efforts to ensure the quality and efficacy of herbal products.

**Keywords**—*Artemisia*; Phytochemicals; Therapeutic uses; Natural drugs.

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### 1. Introduction

Medicinal plants have long been recognized as vital resources for human health, contributing significantly to the development of modern pharmaceutical agents and providing accessible therapeutic alternatives, particularly in developing countries. The World Health Organization estimates that approximately 80% of the world's population relies on traditional plant-based medicines for primary healthcare, highlighting the global importance of medicinal plants in healthcare systems [1].

Within this context, the genus *Artemisia* (family Asteraceae) comprises over 500 species widely distributed across Asia, Europe, North America, and Africa [2-4]. Species of *Artemisia* are well-adapted to diverse ecological conditions and are economically significant due to their applications in traditional medicine, agriculture, and the pharmaceutical industry [5]. Among these species, *Artemisia annua* is renowned for its production of artemisinin, a sesquiterpene lactone that has revolutionized malaria treatment worldwide [6,7]. Other species, such as *A. absinthium*, *A. afra*, and

*A. vulgaris*, have been traditionally used to manage various ailments, including digestive disorders, infections, inflammation, and parasitic diseases [8, 9].

Despite the recognized medicinal potential of *Artemisia* spp., the diversity of their phytochemicals—particularly terpenoids, flavonoids, phenolic acids, coumarins, and volatile essential oil constituents—and the full spectrum of their therapeutic applications have not yet been systematically consolidated in a single up-to-date review. Although several studies have examined selected compounds such as artemisinin or focused on specific pharmacological activities, comprehensive analyses that integrate the broader phytochemical diversity with emerging therapeutic fields (e.g., anticancer, antidiabetic, immunomodulatory, and hepatoprotective activities) remain limited. Given the growing global interest in natural products as safer alternatives for drug discovery and the increasing demand for evidence-based evaluation of medicinal plants a detailed synthesis of these aspects is urgently needed.



**Figure 1.** Morphological characteristics of *Artemisia* commonly used in traditional and modern medicine [10]

This review therefore aims to provide an updated and integrative overview of the major phytochemicals identified in *Artemisia* species and their diverse pharmacological activities. Unlike previous reviews that focused on specific species, regions, or compound classes, this manuscript offers a comprehensive cross-species comparison, highlights newly reported bioactive metabolites, and critically evaluates recent advances (2020–2025) in the therapeutic applications of *Artemisia*. Additionally, it identifies key research gaps related to phytochemical standardization, variability across species and extraction methods, and the scarcity of large-scale clinical evidence, thereby outlining priorities for future research.

## 2. Methodology

A narrative review approach was adopted in this study, aiming to synthesize and critically analyze current evidence on the phytochemical composition and therapeutic uses of *Artemisia* species. This type of review was selected because it allows for a broad and integrative examination of diverse study designs and outcomes, which is essential given the wide variability in phytochemical analyses and pharmacological assays across the existing literature. A comprehensive literature search was conducted using PubMed, Scopus, and Web of Science to ensure wide and high-quality coverage of peer-reviewed publications relevant to the topic [11].

The search strategy utilized the following keywords in various combinations: *Artemisia*, phytochemicals, therapeutic uses, pharmacological activities, essential oils, and medicinal plants. Boolean operators (“AND”, “OR”) were used to refine the search, ensuring that articles discussing both the phytochemical profiles and pharmacological or therapeutic properties of *Artemisia* spp. were captured. A total of approximately 120 articles were initially retrieved, of which 70 met the inclusion criteria after screening titles, abstracts, and full texts for relevance and methodological rigor.

The inclusion criteria for studies were:

- Original research articles or reviews published in English between 2020 and 2025. This period was selected to ensure the inclusion of the most recent and relevant studies, reflecting advancements in analytical techniques and therapeutic applications. Earlier studies were reviewed in previous comprehensive reviews, and this review aims to build upon and update the existing knowledge base.
- Studies investigating the phytochemical composition of *Artemisia* species.
- Articles evaluating pharmacological or therapeutic activities of *Artemisia* extracts or isolated compounds.
- Studies with clear methodological approaches and measurable outcomes. Measurable outcomes included, but were not limited to, antioxidant activity (e.g., DPPH or ABTS radical scavenging assays), extraction yields, concentration values such as IC<sub>50</sub> for bioactivity, and pharmacological efficacy in in vitro or in vivo models.

The exclusion criteria were:

- Articles focusing solely on agricultural, ecological, or non-medicinal uses of *Artemisia* spp.
- Studies lacking sufficient methodological details or clear, measurable results.
- Conference abstracts without full-text availability.

By applying these criteria, this review provides a focused and high-quality synthesis of the phytochemical diversity and therapeutic potential of *Artemisia* spp., while highlighting gaps in the current literature to guide future research. Titles and abstracts of the retrieved articles were screened for relevance, followed by a detailed full-text review of eligible studies. Additionally, reference lists of relevant articles were examined to identify any additional studies not captured during the initial database search, ensuring a comprehensive and thorough review process. Extracted data from the included studies covered the *Artemisia* species investigated, identified phytochemicals, extraction and analysis methods, as well as reported pharmacological activities [12].

### 3. Results and Discussion

#### 3.1. Phytochemical composition

The genus *Artemisia* is known for its diverse and rich phytochemical profile, which underpins its wide range of therapeutic applications. Several classes of bioactive compounds have been identified in *Artemisia* spp., with significant variation among species, plant parts, and extraction methods [13, 14]. Comparative findings from recent studies show that *A. annua* typically exhibits higher concentrations of sesquiterpene lactones (e.g., artemisinin), whereas species such as *A. absinthium* and *A. vulgaris* are richer in flavonoids and phenolic acids, which account for their strong antioxidant activities. Similarly, essential oil composition differs markedly between species: *A. herba-alba* is dominated by  $\alpha$ - and  $\beta$ -thujone, while *A. afra* contains higher levels of 1,8-cineole, explaining differences in their antimicrobial potency (see Figure 2).

### 3.1.1. Terpenoids

Terpenoids are among the most abundant and therapeutically significant compounds in *Artemisia* spp. Artemisinin, a key sesquiterpene lactone isolated from *A. annua*, remains the most well-studied example [4, 15]. Comparative analyses indicate that *A. annua* contains significantly higher artemisinin concentrations than other species, while *A. japonica* and *A. scoparia* exhibit distinct monoterpene and sesquiterpene profiles with strong antimicrobial and anti-inflammatory properties [3, 16, 17].

### 3.1.2. Flavonoids

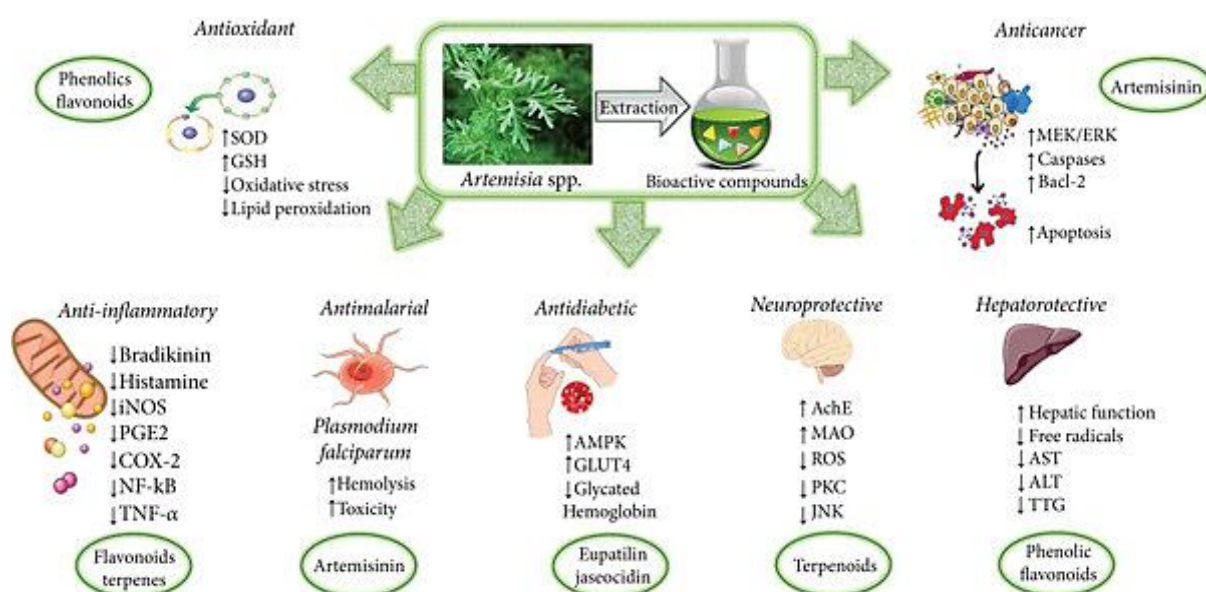
Flavonoids such as quercetin, rutin, luteolin, and kaempferol are widely distributed across various *Artemisia* species and are responsible for their antioxidant and hepatoprotective activities [3, 17, 18]. For instance, *A. absinthium* and *A. dracunculus* have been shown to contain higher total flavonoid content compared with *A. annua*, correlating with stronger free-radical scavenging activities in DPPH and ABTS assays [17-21].

### 3.1.3. Phenolic acids

Phenolic acids—including caffeic, chlorogenic, ferulic, and p-coumaric acids—are present in many *Artemisia*-based extracts. Their concentrations vary substantially among species; *A. annua* tends to be richer in chlorogenic acid, while *A. abrotanum* and *A. vulgaris* often contain higher levels of ferulic acid, contributing to stronger anti-inflammatory effects [2, 22]. Their concentration and bioactivity may vary significantly depending on the species and extraction conditions [15, 23].

### 3.1.4. Essential oils

Essential oils derived from *Artemisia* spp. are complex mixtures containing constituents such as camphor, 1,8-cineole,  $\alpha$ -thujone,  $\beta$ -thujone, and borneol [24-26]. Their relative proportions differ markedly across species and geographic origins. For example, *A. herba-alba* oils are dominated by thujones, while *A. afra* contains cineole-rich oils, explaining variations in antimicrobial and insecticidal efficacy [27-29].



**Figure 2.** *Artemisia* spp.: An update on its chemical composition, pharmacological, and toxicological profiles. Adapted from [20]

### 3.2. Factors affecting phytochemical composition

The phytochemical composition of *Artemisia* spp. is influenced by several factors that directly affect the concentration and diversity of bioactive compounds, and consequently their therapeutic potency.

#### 3.2.1. Geographical location

Climatic conditions, soil type, and altitude significantly influence the biosynthesis and accumulation of phytochemicals [30, 31]. Studies have shown that *A. vulgaris* grown at higher altitudes produces higher phenolic content, while *A. argyi* displays increased essential-oil yield in warmer regions.

#### 3.2.2. Plant part used

Leaves generally contain higher concentrations of terpenoids and flavonoids compared with stems and roots, while flowers often exhibit elevated essential-oil content [32-34]. For example, artemisinin is mainly concentrated in the glandular trichomes of *A. annua* leaves and inflorescences.

#### 3.2.3. Extraction methods

Extraction solvents and techniques significantly impact phytochemical yield. Methanolic extracts typically show higher flavonoid and phenolic acid recovery, whereas hydrodistillation yields essential oils rich in volatile monoterpenes [23, 35, 36]. These differences explain variations in reported biological activity among studies.

Understanding these factors is crucial for the standardization of *Artemisia*-based products and for optimizing the extraction of bioactive compounds for therapeutic applications.

### 3.3. Therapeutic uses

Species of *Artemisia* have demonstrated a wide range of therapeutic properties attributed to their rich phytochemical profiles. Below are the main pharmacological activities of *Artemisia* spp., supported by recent in vitro, in vivo, and clinical studies.

#### 3.3.1. Antimalarial activity

The most notable therapeutic use of *Artemisia* is its antimalarial activity, primarily due to artemisinin, a sesquiterpene lactone isolated from *Artemisia annua* [4, 37, 38]. Artemisinin and its derivatives (artemether and artesunate) are highly effective against *Plasmodium* species and have become the cornerstone of artemisinin-based combination therapies (ACTs) for malaria treatment globally [39-41]. The mechanism involves the cleavage of its endoperoxide bridge by iron in the parasite, generating free radicals that damage vital parasite proteins, leading to cell death [42-44].

#### 3.3.2. Antioxidant activity

Various *Artemisia* species exhibit significant antioxidant properties due to the presence of flavonoids (quercetin, rutin) and phenolic acids (caffeic acid and chlorogenic acid) that scavenge reactive oxygen species (ROS) and reduce oxidative stress [23, 45, 46]. For example, *A. absinthium* and *A. vulgaris* extracts have shown high DPPH and ABTS radical scavenging activities, which may contribute to their protective effects against oxidative damage-related diseases [47].

### 3.3.3. Antimicrobial activity

Essential oils and extracts from *Artemisia* spp. have demonstrated antimicrobial activity against a range of Gram-positive and Gram-negative bacteria and fungi [48-50]. Compounds such as camphor, 1,8-cineole, and  $\alpha$ -thujone are responsible for these activities by disrupting microbial cell membranes and interfering with microbial metabolism [26, 51, 52]. Species such as *A. herba-alba* and *A. afra* have shown activity against *Staphylococcus aureus*, *Escherichia coli*, and *Candida albicans* [53-55].

### 3.3.4. Anticancer activity

Several *Artemisia* species have demonstrated anticancer potential in preclinical studies. Artemisinin and its derivatives exhibit selective cytotoxicity towards cancer cells by inducing apoptosis, inhibiting angiogenesis, and generating ROS in cancer cells [56-58]. Additionally, flavonoids and terpenoids in *Artemisia* extracts have shown antiproliferative effects against various cancer cell lines, including breast, liver, and lung cancers [59-61].

### 3.3.5. Other uses

Beyond their traditional uses, *Artemisia* species have demonstrated a range of pharmacological properties in modern studies. Notably, they exhibit anti-inflammatory activity by inhibiting pro-inflammatory cytokines and mediators [62]. In addition, *Artemisia* spp. have shown promising antidiabetic effects, primarily through the modulation of glucose metabolism and improvement of insulin sensitivity [63, 64]. Furthermore, certain species such as *A. absinthium* and *A. capillaris* possess hepatoprotective properties, effectively reducing oxidative stress and inflammation in liver tissues [20, 65].

**Table 1.** Summary of major phytochemical classes in selected *Artemisia* species and key factors influencing their concentrations.

Species	Dominant Phytochemicals	Highest in (plant part)	Influential Factors
<i>A. annua</i>	Artemisinin, arteannuin B	Leaves & flowers	Temperature, light intensity
<i>A. absinthium</i>	Flavonoids, phenolic acids	Leaves	Soil nutrients, extraction solvent
<i>A. herba-alba</i>	Thujone-rich essential oils	Aerial parts	Geographical region
<i>A. afra</i>	1,8-cineole, camphor	Leaves	Altitude, season

## 3.4. Mechanisms of action

The therapeutic activities of *Artemisia* spp. are attributed to the diverse bioactive compounds that exert their effects through various mechanisms, depending on the target condition.

### 3.4.1. Antimalarial mechanism of artemisinin

Artemisinin, a sesquiterpene lactone from *Artemisia annua*, exerts its antimalarial activity through interaction with iron in the parasite's digestive vacuole, leading to the cleavage of its endoperoxide bridge and the generation of reactive oxygen species (ROS) [7, 66]. These ROS cause damage to essential proteins and membranes within *Plasmodium* spp., leading to parasite death [20, 66, 67].

### 3.4.2. Anticancer mechanism of artemisinin

Artemisinin has shown selective cytotoxicity towards cancer cells due to their high iron uptake, which enhances the cleavage of the endoperoxide bridge, producing ROS that induce apoptosis and

cell cycle arrest in cancer cells [56, 68, 69]. Artemisinin also inhibits angiogenesis and metastasis by downregulating VEGF and MMP expression, contributing to its anticancer potential [56, 57, 70].

### 3.4.3. Antioxidant activity

The antioxidant activity of *Artemisia* spp. is primarily attributed to flavonoids and phenolic acids, which scavenge free radicals, reduce lipid peroxidation, and enhance cellular antioxidant enzyme activities [46, 71, 72]. By neutralizing ROS, these compounds protect against oxidative stress-associated cellular damage, inflammation, and chronic diseases [73, 74].

### 3.4.4. Antimicrobial activity

Essential oils and terpenoids in *Artemisia* spp. exhibit antimicrobial activity through disruption of microbial cell membrane integrity, increasing membrane permeability and causing leakage of cellular contents, leading to microbial cell death [48, 75]. Additionally, these compounds can interfere with bacterial enzyme systems, inhibiting essential metabolic pathways [52, 76].

## 3.5. Challenges and future prospects

Despite the wide array of pharmacological benefits associated with *Artemisia* species, several challenges hinder their broader adoption in modern therapeutics. Addressing these limitations is essential for fully realizing the medicinal potential of this genus.

### 3.5.1. Need for expanded clinical studies

While numerous *in vitro* and *in vivo* studies have demonstrated the efficacy of *Artemisia* extracts and compounds, there remains a significant gap in robust clinical trials. Most existing clinical data are limited in scope, scale, and geographic representation. Large-scale, placebo-controlled human studies are urgently needed to validate safety, dosage, and efficacy, particularly for artemisinin derivatives in non-malarial contexts, such as cancer, diabetes, and inflammatory disorders [20, 37, 41].

### 3.5.2. Standardization of extraction methods and phytochemical composition

One of the key limitations in the therapeutic use of *Artemisia* lies in the variability of phytochemical content due to factors such as geographic origin, plant part used, and extraction technique. This heterogeneity affects reproducibility and complicates pharmacological evaluation. Thus, developing standardized protocols for extraction and quality control of phytochemical composition is essential for ensuring consistent therapeutic outcomes and regulatory approval of *Artemisia*-based products [23, 30, 36].

### 3.5.3. Opportunities for new natural drug development

The rich phytochemical profile of *Artemisia* spp. offers significant opportunities for the discovery and development of novel natural drugs. Bioactive compounds such as artemisinin, flavonoids, and terpenoids exhibit multi-target activities and favorable safety profiles, making them attractive candidates for pharmaceutical development. Advances in biotechnology, such as metabolic engineering and nanoformulations, can enhance the bioavailability and therapeutic targeting of these compounds, opening new avenues for drug innovation based on *Artemisia* [56, 63, 70].

### 3.5.4. Limitations of the review

This review has several limitations that should be acknowledged. The search strategy was restricted to articles published in English and to studies indexed in three major scientific databases (PubMed, Scopus, and Web of Science). As a result, relevant research published in other languages or indexed in regional or specialized databases may have been unintentionally excluded, potentially introducing a language and database-selection bias. Furthermore, the review focused on literature published between 2020 and 2025 to highlight recent scientific advances; however, this temporal restriction may have led to the omission of earlier foundational studies that offer important historical and methodological context for research on *Artemisia* spp. In addition, variability in methodological quality among the included studies—such as differences in extraction protocols, analytical techniques, and experimental models—may limit the comparability of results and contribute to heterogeneity in the synthesized evidence. These limitations underscore the need for broader, multilingual, and more inclusive future reviews to provide a more comprehensive understanding of the phytochemical diversity and therapeutic potential of *Artemisia* species.

## 4. Conclusions

*Artemisia* species were rich sources of biologically active phytochemicals, including terpenoids, flavonoids, phenolic acids, and essential oils. Their diverse chemical composition underpinned a wide range of experimentally validated therapeutic uses, such as antimalarial, antioxidant, antimicrobial, and anticancer activities. Despite challenges related to standardization and clinical validation, *Artemisia* spp. showed great promise as valuable natural resources for the development of novel phytopharmaceuticals. Future research focusing on rigorous clinical trials and standardized extraction methods remained essential to fully realize their potential in modern medicine.

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## References

- [1] World Health Organization, WHO traditional medicine strategy 2025–2034, Geneva, 2023.
- [2] M. Hussain, R.K. Thakur, J. Khazir, S. Ahmed, M.I. Khan, P. Rahi, L.A. Peer, P. Vppalayam Shanmugam, S. Kaur, S.N. Raina, “Traditional uses, phytochemistry, pharmacology, and toxicology of the genus *Artemisia* L.(Asteraceae): A high-value medicinal plant,” *J Current Topics in Medicinal Chemistry*, Vol. 24(4), 301-342, 2024.
- [3] A. Nurlybekova, A. Kudaibergen, A. Kazymbetova, M. Amangeldi, A. Baiseitova, M. Ospanov, H.A. Aisa, Y. Ye, M.A. Ibrahim, J. Jenis, “Traditional use, phytochemical profiles and pharmacological properties of *Artemisia* genus from Central Asia,” *J Molecules*, Vol. 27(16), 5128, 2022.
- [4] L.M. Shinyuy, G.E. Loe, O. Jansen, L. Mamede, A. Ledoux, S.F. Noukimi, S.N. Abenwie, S.M. Ghogomu, J. Souopgui, A. Robert, K. Demeyer, M. Frederich, “Secondary metabolites isolated from *Artemisia afra* and *Artemisia annua* and their anti-malarial, anti-inflammatory and Immunomodulating properties—pharmacokinetics and pharmacodynamics: a review,” *J Metabolites*, Vol. 13(5), 613, 2023.

- [5] O. S. Abduraimov, W. Li, H.F. Shomurodov, Y. Feng, "The main medicinal plants in arid regions of Uzbekistan and their traditional use in folk medicine," *J Plants*, Vol. 12(16), 2950, 2023.
- [6] B.J. Lee, M. Weyers, R.K. Haynes, F. van der Kooy, "Discovery of artemisinin in *Artemisia annua*, its current production, and relevance to sub-Saharan Africa," *J South African Journal of Botany*, Vol. 153, 21-27, 2023.
- [7] S.K. Rai, K.K. Rai, S. Pandey-Rai, "New perspectives of the *Artemisia annua* bioactive compounds as an affordable cure in treatment of malaria and cancer," *Natural bioactive compounds*, Academic Press, 299-315, 2021.
- [8] H. K. Pazhouh, S. Hamed, S.M.A.R. Hosseini, A. Taghipour, B. Javadi, M. Noras, "Gastrointestinal effects of *Artemisia absinthium* Linn. based on traditional Persian medicine and new studies," *J Traditional Medicine Research*, Vol. 5(6), 498-506, 2020.
- [9] A. Szopa, J. Pajor, P. Klin, A. Rzepiela, H.O. Elansary, F.A. Al-Mana, M.A. Mattar, H. Ekiert, "Artemisia absinthium L. Importance in the History of Medicine, the Latest Advances in Phytochemistry and Therapeutical, Cosmetological and Culinary Uses," *Plants (Basel)*, Vol. 9(9), Aug 19, 2020.
- [10] F.E. Köhler, "Camellia sinensis. Köhler's Medizinal-Pflanzen," 1897.
- [11] M.J. Page, J.E. McKenzie, P.M. Bossuyt, I. Boutron, T.C. Hoffmann, C.D. Mulrow, L. Shamseer, J.M. Tetzlaff, D. Moher, "Updating guidance for reporting systematic reviews: development of the PRISMA 2020 statement," *J Journal of clinical epidemiology*, Vol. 134, 103-112, 2021.
- [12] T. Greenhalgh, S. Thorne, K. Malterud, "Time to challenge the spurious hierarchy of systematic over narrative reviews?," *J European journal of clinical investigation*, Vol. 48(6), e12931, 2018.
- [13] M.K. Diab, A.M. Abu-Elsaoud, M.G. Salama, E.M. Ghareeb, "Phytochemical treasure troves—insights into bioactivities, phytochemistry, and uses of *Artemisia* species," *J Phytochemistry Reviews*, 1-38, 2025.
- [14] A. Hussain, "The genus *artemisia* (Asteraceae): a review on its ethnomedicinal prominence and taxonomy with emphasis on foliar anatomy, morphology, and molecular phylogeny: ethnomedicinal prominence and taxonomy of *artemisia*," *J Proceedings of the Pakistan Academy of Sciences: B. Life Environmental Sciences*, Vol. 57(1) 1, 1-28, 2020.
- [15] R. Anibogwu, K.D. Jesus, S. Pradhan, S. Pashikanti, S. Mateen, K. Sharma, "Extraction, isolation and characterization of bioactive compounds from *Artemisia* and their biological significance: A review," *J Molecules*, Vol. 26(22), 6995, 2021.
- [16] N.S. Al-Sowayan, F. Al-Harbi, S.A. Alrobaish, "Artemisia: A Comprehensive Review of Phytochemistry, Medicinal Properties, and Biological Activities," *J Journal of Biosciences Medicines*, Vol. 12(11), 524-537, 2024.
- [17] D. Bisht, D. Kumar, D. Kumar, K. Dua, D.K. Chellappan, "Phytochemistry and pharmacological activity of the genus *artemisia*," *J Archives of pharmacal research*, Vol. 44(5), 439-474, 2021.
- [18] H.H. Kim, P. Vetrivel, S.E. Ha, P.B. Bhosale, H.J. Lee, J.A. Kim, K.I. Park, S.M. Kim, G.S. Kim, "Functions of flavonoids in three Korean native varieties of *Artemisia* species," *J Journal of Biomedical Translational Research*, Vol. 21(2), 39-49, 2020.
- [19] S. Chib, B.J. Dutta, R. Chalotra, M. Abubakar, P. Kumar, T.G. Singh, R. Singh, "Role of Flavonoids in Mitigating the Pathological Complexities and Treatment Hurdles in Alzheimer's Disease," *Phytother Res*, Vol. 39(2), 747-775, 2025.

- [20] J. Sharifi-Rad, J. Herrera-Bravo, P. Semwal, S. Painuli, H. Badoni, S.M. Ezzat, M.M. Farid, R.M. Merghany, N.M. Aborehab, M.A. Salem, "Artemisia spp.: an update on its chemical composition, pharmacological and toxicological profiles," *J Oxidative Medicine Cellular Longevity*, Vol. 2022(1), 5628601, 2022.
- [21] S. Singh, R. Verma, "Exploring the Therapeutic Potential of Flavonoids in the Management of Cancer," *Curr Pharm Biotechnol*, Vol. 26(1), 17-47, 2025.
- [22] N. Gavarić, M. Aćimović, N. Kladar, M. Hitl, J. Drljača Lero, N. Milić, K. Radovanović, "Unlocking the Bioactivity of Sweet Wormwood (*Artemisia annua* L., Asteraceae) Ethanolic Extract: Phenolics, Antioxidants, and Cytotoxic Effects," *J Pharmaceutics*, Vol. 17(7), 890, 2025.
- [23] A. Trifan, G. Zengin, K.I. Sinan, E. Sieniawska, R. Sawicki, M. Maciejewska-Turska, K. Skalikca-Woźniak, S.V. Luca, "Unveiling the phytochemical profile and biological potential of five *Artemisia* species," *J Antioxidants*, Vol. 11(5), 1017, 2022.
- [24] S. Shanoo, J.B. Sharmeen, M. Fawzi, "Artemisia Species," *J Wild Plants*, 308, 2021.
- [25] S. Shanoo, J.B. Sharmeen, M.M. Fawzi, "Artemisia species: medicinal values with potential therapeutic uses," *Wild Plants*, 308-325: CRC Press, 2020.
- [26] P.T.N. Trinh, L.X. Tien, T.T. Danh, D.T. Le Hang, N.V. Hoa, T.T.B. Yen, L.T. Dung, "Antioxidant, anti-inflammatory, and anti-bacterial activities of *Artemisia vulgaris* L. essential oil in Vietnam," *J Natural Product Communications*, Vol. 19(8), 1934578X241275782, 2024.
- [27] K.H. Can Baser, I.C. Haskologlu, E. Erdag, "An Updated Review of Research into Carvacrol and Its Biological Activities," *J Records of Natural Products*, Vol. 19, 2025.
- [28] F. Larit, F. Leon, "Therapeutics to Treat Psychiatric and Neurological Disorders: A Promising Perspective from Algerian Traditional Medicine," *Plants (Basel)*, Vol. 12(22), 3860, 2023.
- [29] B.S. Olayem, O.B. Olaitan, A.B. Akinola, "Immunomodulatory plant based foods, it's chemical, biochemical and pharmacological approaches," *J Medicinal plants-chemical, biochemical, pharmacological approaches*, 2024.
- [30] K.R. Sharma, S. Adhikari, "Phytochemical analysis and biological activities of *Artemisia vulgaris* grown in different altitudes of Nepal," *J International Journal of Food Properties*, Vol. 26(1), 414-427, 2023.
- [31] D. Yang, X. Liu, X. Xu, T. Niu, X. Ma, G. Fu, C. Song, X. Hou, "Effect of soil and community factors on the yield and medicinal quality of *Artemisia argyi* growth at different altitudes of the Funiu mountain," *J Frontiers in Plant Science*, Vol. 15, 1430758, 2024.
- [32] S. Dogra, B. Koul, J. Singh, M. Mishra, D. Yadav, "Phytochemical Analysis, Antimicrobial Screening and In Vitro Pharmacological Activity of *Artemisia vestita* Leaf Extract," *J Molecules*, Vol. 29(8), 1829, 2024.
- [33] S. Dogra, J. Singh, B. Koul, D. Yadav, "Artemisia vestita: A folk medicine with hidden herbal fortune," *J Molecules*, Vol. 28(6), 2788, 2023.
- [34] G. Tiwari, T. Chaturvedi, N. Singh, "Integration of Omics Tools for Enhancing Secondary Metabolite Content in Medicinal and Aromatic Plants," *Medicinal and Aromatic Plants: Current Research Status, Value-Addition to Their Waste, and Agro-Industrial Potential*, Vol. II, 161-172, 2024.
- [35] G. Abate, L. Zhang, M. Pucci, G. Morbini, E. Mac Sweeney, G. Maccarinelli, G. Ribaud, A. Gianoncelli, D. Uberti, M. Memo, L. Lucini, A. Mastinu, "Phytochemical Analysis and Anti-Inflammatory Activity of Different Ethanolic Phyto-Extracts of *Artemisia annua* L.," *Biomolecules*, Vol. 11(7), 975, 2021.

- [36] R. Metoui, H. Mighri, J. Bouajila, M. Znati, H. El-Jani, A. Akrou, "Artemisia campestris dried leaf extracts: Effects of different extraction methods and solvents on phenolic composition and biological activities," *J South African Journal of Botany*, Vol. 151, 288-294, 2022.
- [37] H. Ekiert, J. Świątkowska, P. Klin, A. Rzepiela, A. Szopa, "Artemisia annua—importance in traditional medicine and current state of knowledge on the chemistry, biological activity and possible applications," *J Planta Medica*, Vol. 87(8), 584-599, 2021.
- [38] P. Weathers, "Artemisinin as a therapeutic vs. its more complex Artemisia source material," *J Natural Product Reports*, Vol. 40(7), 1158-1169, 2023.
- [39] J. M. Alghamdi, A.A. Al-Qahtani, F.S. Alhamlan, A.A. Al-Qahtani, "Recent advances in the treatment of malaria," *J Pharmaceutics*, Vol. 16(11), 1416, 2024.
- [40] Y. Lai, H. Zhang, X. Chen, "Emerging trends and new developments in global research on artemisinin and its derivatives," *J Heliyon*, Vol. 11(1), 2025.
- [41] A. Sanyaolu, A. Marinkovic, S. Prakash, V. Balendra, O. Shazley, T. Gardellini, A. Jan, K. Younis, C. Okorie, R. Izurieta, "Emerging Molecular Mechanisms in Malaria Pathogenesis and Novel Therapeutic Approaches: A Focus on *P. falciparum* Malaria," *J Biomolecules*, Vol. 15(7), 1038, 2025.
- [42] G. Das, H.S. Shin, J.K. Patra, "The Antiviral and Antimalarial Prodrug Artemisinin from the Artemisia Species: A Review," *J Current Issues in Molecular Biology*, Vol. 46(11), 12099-12118, 2024.
- [43] S.A. Virendra, C. Sahu, A. Kumar, P.A. Chawla, "Natural antioxidants as additional weapons in the fight against malarial parasite," *J Current Topics in Medicinal Chemistry*, Vol. 22(24), 2045-2067, 2022.
- [44] L. Zhang, J. Song, L. Kong, T. Yuan, W. Li, W. Zhang, B. Hou, Y. Lu, G. Du, "The strategies and techniques of drug discovery from natural products," *J Pharmacology Therapeutics*, Vol. 216, 107686, 2020.
- [45] S. Suroowan, E.J. Llorent-Martínez, G. Zengin, S. Dall'Acqua, S. Sut, K. Buskaran, S. Fakurazi, M.F. Mahomoodally, "Phytochemical characterization, anti-oxidant, anti-enzymatic and cytotoxic effects of Artemisia verlotiorum Lamotte extracts: A new source of bioactive agents," *J Molecules*, Vol. 27(18), 5886, 2022.
- [46] S.V. Zhigzhitzhapova, E.P. Dylenova, D.B. Goncharova, B.V. Zhigzhitzhapov, E.A. Emelyanova, A.V. Polonova, Z.A. Tykheev, S.V. Bazarsadueva, A.S. Taraskina, E.T. Pintaeva, "Functional activity of the antioxidant system of Artemisia genus plants in the republic of Buryatia (Russia) and its significance in plant adaptation," *J Plants*, Vol. 13(18), 2630, 2024.
- [47] M. Nikoosokhan, "Treatment of Various Skin Diseases, Including Psoriasis, Skin Cancer, Ultraviolet Protection, Skin Dryness, Allergic Reactions," *Medicinal Plants used in Traditional Persian Medicine*, 352-378, 2023.
- [48] S. Das, B. Vörös-Horváth, T. Bencsik, G. Micalizzi, L. Mondello, G. Horváth, T. Kőszegi, A. Széchenyi, "Antimicrobial activity of different Artemisia essential oil formulations," *J Molecules*, Vol. 25(10), 2390, 2020.
- [49] R. A. Hrytsyk, R.V. Kutsyk, O.I. Yurchyshyn, O.A.A. Struk, I.V. Kireev, A.R. Grytsyk, "The investigation of antimicrobial and antifungal activity of some Artemisia L. species," *J Pharmacia*, Vol. 68, 93-100, 2021.
- [50] S. Mohammed, A. Dekabo, T. Hailu, "Phytochemical analysis and anti-microbial activities of Artemisia spp. and rapid isolation methods of artemisinin," *J AMB Express*, Vol. 12(1), 17, 2022.

- [51] B. Baranová, D. Gruřová, F. Polito, V. Sedlák, M. Konečná, M.M. Blařčáková, I. Amri, V. De Feo, J. Poráčová, "Artemisia herba-alba Essential Oil: Chemical Composition, Phytotoxic Activity and Environmental Safety," *J Plants*, Vol. 14(2), 242, 2025.
- [52] K. Umam, C.S. Feng, G. Yang, P.C. Tu, C.Y. Lin, M.T. Yang, T.F. Kuo, W.C. Yang, H. Tran Nguyen Minh, "Phytochemistry, pharmacology and mode of action of the anti-bacterial artemisia plants," *J Bioengineering*, Vol. 10(6), 633, 2023.
- [53] R.D. Alghonmeen, S.M. Dmour, S.A. Saghir, S. Abushattal, S. Alnaimat, M. Al-Zharani, F.A. Nasr, O.Y. Althunibat, "Anti-MRSA and cytotoxic activities of different solvent extracts from Artemisia herba-alba grown in Shubak, Jordan," *J Open Veterinary Journal*, Vol. 14(4), 990, 2024.
- [54] F. EL-Hajli, M.R. Kachmar, A. Assouguem, R. Ullah, A. Bari, K. Hammani, S. Chakir, R. Lahlali, E.A. Barka, G. Echchgadda, "Phytochemical analysis, in vitro antioxidant and antifungal activities of extracts and essential oil derived from Artemisia herba-alba Asso," *J Open Chemistry*, Vol. 22(1), 20230200, 2024.
- [55] N. Ouguirti, F. Bahri, A. Bouyahyaoui, J. Wanner, "Chemical characterization and bioactivities assessment of Artemisia herba-alba Asso essential oil from South-western Algeria," *J Natural Volatiles Essential Oils*, Vol. 8(2), 27-36, 2021.
- [56] B.H. Kiani, W.K. Kayani, A.U. Khayam, E. Dilshad, H. Ismail, B. Mirza, "Artemisinin and its derivatives: A promising cancer therapy," *J Molecular Biology Reports*, Vol. 47(8), 6321-6336, 2020.
- [57] Y. Li, X. Zhou, J.Liu, X. Yuan, Q. He, "Therapeutic potentials and mechanisms of artemisinin and its derivatives for tumorigenesis and metastasis," *J Anti-Cancer Agents in Medicinal Chemistry*, Vol. 20(5), 520-535, 2020.
- [58] K.I. Wani, A. Zehra, S. Choudhary, M. Naeem, M.M.A. Khan, R. Khan, T. Aftab, "Artemisia annua L.: Traditional Uses, Phytochemistry, and Pharmacological Activities," *Medicinal Plants of the Asteraceae Family: Traditional Uses, Phytochemistry and Pharmacological Activities*, 17-42, 2022.
- [59] S. Javid, "A Comprehensive Study of Antiproliferative Effects of Artemisia carvifolia Buch against Liver Cancer," *CAPITAL UNIVERSITY*, 2024.
- [60] Z. Keshtmand, S.N. Naimi, Z.K. Piran, P.P. Jafroodi, M.T. Yaraki, "Enhanced anticancer effect of Artemisia turcomanica extract in niosomal formulation on breast cancer cells: In-vitro study," *J Nano-Structures Nano-Objects*, Vol. 35, 101030, 2023.
- [61] R.K. Tiwari, A. Ahmad, A.F. Khan, L.A. Al-Keridis, M. Saeed, N. Alshammari, N.M. Alabdallah, I.A. Ansari, F. Mujeeb, "Ethanollic extract of Artemisia vulgaris leaf promotes apoptotic cell death in non-small-cell lung carcinoma A549 cells through inhibition of the wnt signaling pathway," *J Metabolites*, Vol. 13(4), 480, 2023.
- [62] M. Bottoni, F. Milani, L. Colombo, K. Nallio, P.S. Colombo, C. Giuliani, P. Bruschi, G. Fico, "Using medicinal plants in Valmalenco (Italian Alps): from tradition to scientific approaches," *J Molecules*, Vol. 25(18), 4144, 2020.
- [63] M. Ghanbari, M.S. Lamuki, E. Habibi, F. Sadeghimahalli, "Artemisia annua L. extracts improved insulin resistance via changing adiponectin, leptin and resistin production in HFD/STZ diabetic mice," *J Journal of Pharmacopuncture*, Vol. 25(2), 130, 2022.
- [64] R. Sharafati-Chaleshtori, A. Nickdasti, E. Mortezapour, M.H. Pourhanifeh, M. Ghazanfari, A. Movahedpour, A. Khatami, M. Ashrafzadeh, A. Zarrabi, M.K. Mahabady, "Artemisia species as a new candidate for diabetes therapy: a comprehensive review," *J Current Molecular Medicine*, Vol. 21(10), 832-849, 2021.

- [65] E. Karami, Z. Goodarzi, S.J. Shahtaheri, M. Kiani, M. Faridan, M. Ghazi-Khansari, "The aqueous extract of *Artemisia Absinthium* L. stimulates HO-1/MT-1/Cyp450 signaling pathway via oxidative stress regulation induced by aluminium oxide nanoparticles ( $\alpha$  and  $\gamma$ ) animal model," *J BMC Complementary Medicine Therapies*, Vol. 23(1), 310, 2023.
- [66] T.A. Addissouky, "Artemisinin and its derivatives throughout the therapeutic mechanisms and clinical potential," *J Discover Chemistry*, Vol. 2(1), 10, 2025.
- [67] H.P. Hou, G.P. Zhang, L.N. Ma, P. Su, Z.X. Zhang, B.Q. Dai, Z.G. Ye, "Effects and mechanism of action of artemisinin on mitochondria of *Plasmodium berghei*," *J Chinese Journal of Integrative Medicine*, Vol. 26(4), 277-282, 2020.
- [68] G.Q. Chen, F.A. Benthani, J. Wu, D. Liang, Z.X. Bian, X. Jiang, "Artemisinin compounds sensitize cancer cells to ferroptosis by regulating iron homeostasis," *J Cell Death Differentiation*, Vol. 27(1), 242-254, 2020.
- [69] Q. Zhang, H. Yi, H. Yao, L. Lu, G. He, M. Wu, C. Zheng, Y. Li, S. Chen, L. Li, "Artemisinin derivatives inhibit non-small cell lung cancer cells through induction of ROS-dependent apoptosis/ferroptosis," *J Journal of Cancer*, Vol. 12(13), 4075, 2021.
- [70] J. Sun, J. Xufeng, Z. Qiu, Q. Gao, Z. Zhu, J. He, S. Gao, X. Sui, "Artemisiae Annuae Herba: from anti-malarial legacy to emerging anti-cancer potential," *J Theranostics*, Vol. 15(15), 7346, 2025.
- [71] M. Țicolea, R.M. Pop, M. Pârvu, L.O. Usatiuc, A. Uifălean, D.D. Pop, E. Fischer-Fodor, F. Ranga, C.C. Rusu, A.F. Cătoi, "Flowers and Leaves of *Artemisia absinthium* and *Artemisia annua* Phytochemical Characterization, Anti-Inflammatory, Antioxidant, and Anti-Proliferative Activities Evaluation," *J Plants*, Vol. 14(7), 1029, 2025.
- [72] M. Țicolea, R.M. Pop, M. Pârvu, L.O. Usatiuc, A. Uifălean, F. Ranga, A.E. Pârvu, "Phytochemical composition antioxidant and anti-inflammatory activity of *Artemisia dracunculoides* and *Artemisia abrotanum*," *J Antioxidants*, Vol. 13(8), 1016, 2024.
- [73] M.V. Ashraf, S. Khan, S. Misri, K.S. Gaira, S. Rawat, B. Rawat, M.H. Khan, A.A. Shah, M. Asgher, S. Ahmad, "High-altitude medicinal plants as promising source of phytochemical antioxidants to combat lifestyle-associated oxidative stress-induced disorders," *J Pharmaceuticals*, Vol. 17(8), 975, 2024.
- [74] K.D. Patel, Z. Keskin-Erdogan, P. Sawadkar, N.S.A.N. Sharifulden, M.R. Shannon, M. Patel, L.B. Silva, R. Patel, D.Y. Chau, J.C. Knowles, "Oxidative stress modulating nanomaterials and their biochemical roles in nanomedicine," *J Nanoscale horizons*, Vol. 9(10), 1630-1682, 2024.
- [75] D. Li, R. Wang, M. You, N. Chen, L. Sun, N. Chen, "The antimicrobial effect and mechanism of the *Artemisia argyi* essential oil against bacteria and fungus," *J Brazilian Journal of Microbiology*, Vol. 55(1), 727-735, 2024.
- [76] N. Jaradat, "Phytochemical profile and in vitro antioxidant, antimicrobial, vital physiological enzymes inhibitory and cytotoxic effects of *Artemisia jordanica* leaves essential oil from Palestine," *J Molecules*, Vol. 26(9), 2831, 2021.