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# Advances in Ethno Medicinal Plants: Diversity, Ecology and Bioactive Phytochemical Compounds

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**Abstract**

Medicinal plants are known to play an important role in tribal and rural health. However, in recent times it has been equally accepted and adopted by urban people. Around the world, medicinal plants have played an important role in traditional medicine and knowledge to treat various diseases and ailments. It has also acted as a source of natural or synthesized compounds for traditional and modern drugs. Some of these medicinal plants which were also part of daily food improved the general immune system of the people. In this review, we try to cover various aspects of medicinal plants including their diversity, ecology, and applications

## Introduction

Medicinal plants are regarded as the most popular way of medication for primary health care (65-80% of the world population relies on natural products) **(Calixto, 2005)**. This may be due to difficulty in access to modern medicine which is costly too. According to a report published by World Health Organization (WHO), medicinal plants are an important alternative medicine as they are low cost, have fewer side effects, toxic effects, fewer gastrointestinal problems, etc. **(Dey et al., 2002; Saiful Yazan et al., 2014)**. Terrestrial plants, especially member of angiosperms are known to be good sources of natural drugs. Moreover, many chemical drugs available today have their origin derived from medicinal plants **(Tag et al., 2012)**. The market of medicinal plant drugs has gone up from US $178 billion in the year 2022 to US $196.83 billion in the year 2023 and is forecasted to be US $248 billion by 2030 **(Silveira and Boylan, 2023)**. However, as per *Newsmantraa*, the estimated market potential is predicted to reach USD 600 billion by 2033.

According to WHO, approximately 21,000 medicinal plants are known to be used for therapeutic medicines. Medicinal plants contain several kinds of metabolites (primary and secondary) which have anti-microbial properties, anti-inflammatory, anti-diabetic, and other beneficial effects **(Seth and Sharma, 2004)**. The ethnobotanical studies undertaken around the world have helped to discover several plants with bioactivity and phytochemical compounds purified and isolated having pharmacological activity. Post-COVID-19, there has been an increased interest in the new pharmacologically active phyto-molecules from wild plants having increased immunological properties **(Fig. 1.)**.

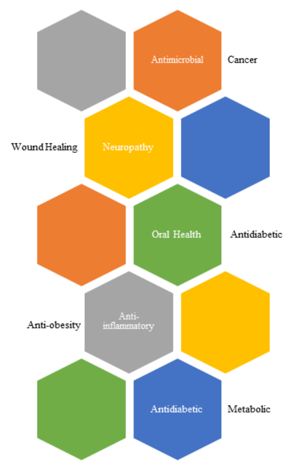


**Fig. 1** Health benefits of medicinal plants and phytochemicals produced by them

The ethnobotanical and phytochemical studies include ecological, phytochemical, pharmacological, nutritional, and other traditional and modern applications of plants. The discipline of ethnobotany serves to collect and document the traditional information of local and tribal communities and phytochemical studies help to validate the same. It also involves, the studies related to local and global markets of these medicinal plants and conservational steps taken by local communities as well as foresters. A special issue of *Plants* on Ethnobotany and Phytochemistry was published in 2023 which received a lot of manuscripts but only 13 good qualities were published **(Silviera and Boylon, 2023)**.

## Traditional Knowledge Associated with Medicinal Plants

The usage of medicinal plants in day-to-day medicines has grown around the world impacting world health. These have been in use since ancient times in almost every part of the world as local solutions to health problems, whether it is ordinary cough-cold to serious diseases like cancer **(Cunningham, 2014; Ullah et al., 2020)**. It is observed that it is more developed in regions where the plant diversity is more and less developed (in terms of modern medicine reach). There is a shift in the use of herbal medicine from modern medicine to again herbal medicine. This shift is both due to the realization of the bad effects of modern medicines and also due to the validation of ethnobotanical and ethnomedicinal properties of bioactive compounds produced by the medicinal plants. The earliest knowledge of the use of medicinal plants providing relief from diseases or illnesses dates back to the earliest civilizations like China, India, etc. **(Wanjohi et al., 2020)**.

It is observed that post-COVID-19, there is an increase in demand for herbal products and medicines based on medicinal plants. It has not only increased the cultivation of medicinal plants replacing crops but also increased the over-exploitation of medicinal plants from the forests. Due to this over-exploitation (which resulted because of fulfilling the enhanced demands), there has been degradation of habitat and unsustainable harvesting. This has affected the populations of several medicinal plants growing in the wild hence categorizing them under the endangered list **(Singh et al., 2011).** As per the available reports, about 90% of the total medicinal plant product demands are harvested from the wild, i.e. forests **(Singh and Dey, 2005).**

National and International agencies have also promoted research on ethnobotanical knowledge and the research on phytochemistry of bioactive compounds **(Fig. 2).** Traditional knowledge of medicinal plants is an important aspect of local and tribal communities of the world, whether it is from Brazil, China, Mexico, African and Australian countries, or India **(Table 1)**. Traditional knowledge is considered to be an important part of a community's social and physical welfare. The responsibility of preserving the knowledge system is crucial and lies with the senior members of the community. Many times, local businessmen and industries have tried to exploit traditional knowledge and take inappropriate commercial benefits from them. Moreover, the actual benefit is not transferred to the actual custodians. **Ullah et al. (2020)** and many other researchers have mentioned medicinal value of several plants belonging to various families *viz.*, *Asteraceae*, *Fabaceae*, *Amaranthaceae*, *Asclepiadaceae*, *Acanthaceae*, *Apiaceae*, *Poaceae*, *Zingiberaceae*, *Brassicaceae*, etc.

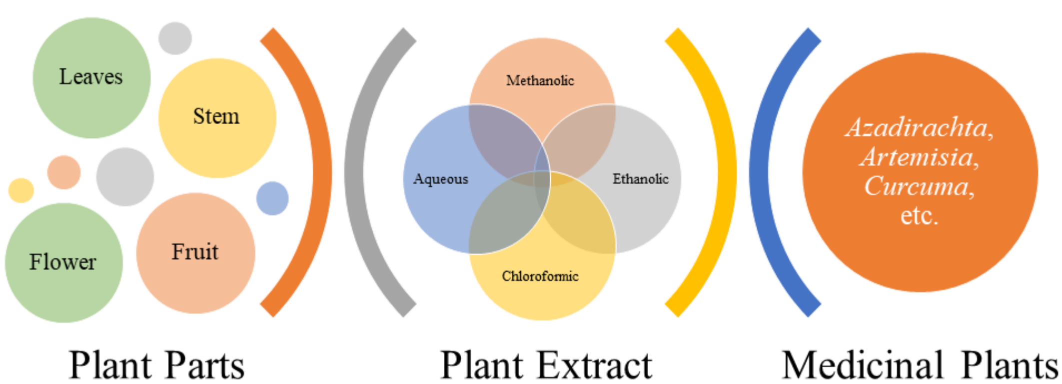


**Fig. 2** Schematic representation of medicinal plants and their extracts of various parts used against different ailments

**Table 1.** Number and percentage of medicinal species documented in different countries and regions.

| S. No. | Country of Origin | Number of Medicinal Plant Species | Total Number of Native Species | Percent of Medicinal Flora | References |
|---|---|---|---|---|---|
| 1. | Bulgaria | 750 | 3567 | 21 | Schippmann et al. 2006 |
| 2. | France | 900 | 4630 | 19 | Schippmann et al. 2006 |
| 3. | Hungary | 270 | 2214 | 12 | Schippmann et al. 2006 |
| 4. | Jordan | 363 | 2100 | 17 | Schippmann et al. 2006 |
| 5. | Korea | 1000 | 2898 | 34 | Schippmann et al. 2006 |
| 6. | Malaysia | 1200 | 15500 | 7 | Schippmann et al. 2006 |
| 7. | Nepal | 900 | 6973 | 12 | Schippmann et al. 2006 |
| 8. | Pakistan | 1500 | 4950 | 30 | Schippmann et al. 2006 |
| 9. | Philippines | 850 | 8931 | 9 | Schippmann et al. 2006 |
| 10. | Sri Lanka | 550 | 3314 | 16 | Schippmann et al. 2006 |
| 11. | Thailand | 1800 | 11625 | 15 | Schippmann et al. 2006 |
| 12. | Vietnam | 1800 | 10500 | 17 | Schippmann et al. 2006 |
| 13. | Canadian Island | 619 | 1594 | 39 | Perezde Paz and Hernandez Padron 1999 |
| 14. | Chile | 469 | 4672 | 10 | Massardo and Rozzi, 1996 |
| 15. | China | 11146 | 27100 | 41 | Shengji 2002 |
| 16. | Columbia | 5000 | 45000 | 14 | Fonnegra and Jimenez 2007 |
| 17. | India | 7500 | 17000 | 44 | Shiva et al., 1996 |
| 18. | Mexico | 2237 | 30000 | 7 | Toledo et al., 1995 |
| 19. | United States | 2572 | 20000 | 13 | Moeman et al., 1998 |
| 20. | Paraguay | 1500-3500 | 6000-7000 | 23-50 | Mereles 2009 |
| 21. | Southern African Countries | 4000 | 22000 | 18 | Arnold et al., 2000 |

**Distribution and Ecological Habitat of Medicinal Plants**

The distribution and ecology of medicinal plants is not restricted to any region but it shows high diversity in undisturbed areas. Since most of the medicinal plants are sensitive and are not hardy plants sustaining harsh environments. Generally, temperate and alpine regions show a higher degree of plants including medicinal plants. However, micro-habitat destruction and climate change have been a challenge for these medicinal plants. Construction of roads, canals, dams, anthropogenic activities, and other development projects have also resulted in endangering the habitats of most medicinal plants. In temperate climatic zones, rough terrain, altitudinal ranges, and harsh conditions make a lot of plant richness **(Chandra 2020)**.

Transformation of land, illegal practices, over-exploitation by humans, and insufficient conservation efforts of medicinal plants are additional factors that have put most of the medicinal plants on the verge of extinction **(Wani et al., 2021)**.

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Generally, the ethnobotanical knowledge is with the local people and communities. However, this knowledge remains undocumented until a researcher interacts with the tribal and local people **(Kunwar and Bussmann, 2008; Adhikari et al., 2019)**. They have complete know-how of the habitat of these plants. However, their ecological and functional roles need to be studied by scientific methods by researchers **(Khakurel et al., 2021)**. However, this information is reducing around the globe due to globalization and urbanization causing unprecedented development **(McDade et al., 2007; Díaz et al., 2006; Aswani et al., 2018)**. The role of traditional knowledge, local communities, and researchers working on ethnobotany and validation of phytochemical compounds have been recognized by the goals of Sustainable Development **(Pei et al., 2020).** The ethnobotanical studies can be used to improve healthcare facilities, understand the effects of climate change, and better conservation of biodiversity **(Peters et al., 2012; Kumar et al., 2021)**.

Climate change is a major significant factor not only affecting earth's weather but also overall climate including seasonal patterns **(Kunwar et al., 2023; Hajek and Knapp, 2022)**. The frequency and intensity of major climate change factors like heavy rains, extreme temperatures, forest fires, cyclones, etc. are increasing. Ecosystems and biodiversity of flora and fauna are impacted greatly by climate change **(Dolezal et al., 2016, Bhattacharjee et al., 2017, Shrestha et al., 2018a, Shrestha et al., 2018b)**. There is a major drift in the distribution and diversity of medicinal plants, with many entering the list of red data books of rare and endangered plants **(Kunwar et al., 2020, Charmakar et al., 2021, Shrestha et al., 2022)**.

Population modeling, demographic studies, socioeconomic impacts, and distribution modeling are helping in understanding the environmental impacts of climate change on medicinal plants **(Vincent et al., 2019, Gaisberger et al., 2020)**. It is not only impacting the availability and growth of medicinal plants but also affecting the composition and production of bioactive compounds.

**Medicinal Plants and their Active Constituents**

Human civilization has been using medicinal plants for a long time. With time, new plants have been added to the list as new properties of known plants were discovered or as and when new plants were discovered with known properties. In the initial days and even in present times, herbal drugs were used as crude extracts or tinctures or in powdered form. However, in recent times there has been an increase in formulations using pure bioactive compounds **(Kumar et al., 2015)**. Complete medicinal plants and/ or their extracts have been used by humans for various ailments which include drugs such as analgesics (morphine), antitussives (codeine), antihypertensives (reserpine), antineoplastics (vinblastine and taxol), etc. **(McRae et al., 2007)**. **Ramawat et al. (2009)** reported that at present also medicinal plants provide effective bioactive compounds against several life-threatening diseases such as cancer, malaria, cardiovascular, etc. **(Fig. 3)**. Some of the important plants used for various ailments are *Acacia arabica, Carissa edulis, Nerium oleander, Catharanthus roseus, Albizzia lebbeck, Achyranthes aspera, Amaranthus spinosus, Artemisia judaica, Lantana camara, Ocimum basilicum, Allium cepa, Allium sativum, Azadirachta indicus, Ficus indica, Syzygium aromaticum, Sesamum indicum, Ziziphus spina, Zingiber officinale, Cynadon dactylon, Cassia italic*, and *Typha domingensis*. An extensive list of medicinal plants, compounds isolated from them, and their structure is compiled in **Table 2.**

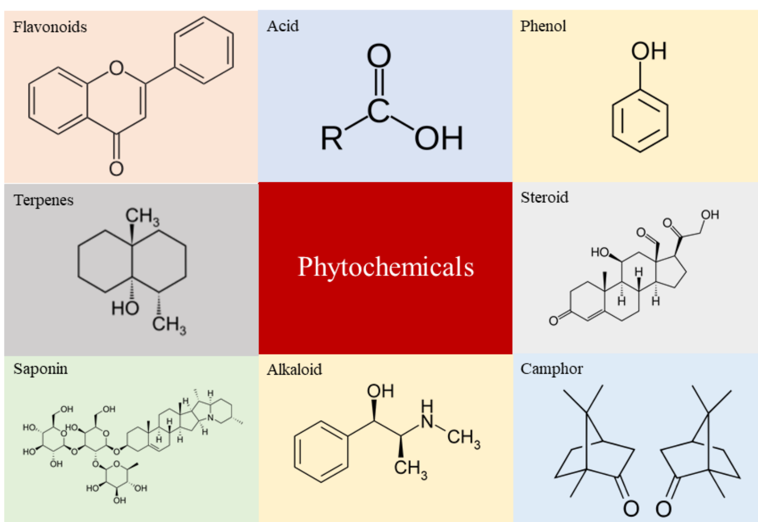
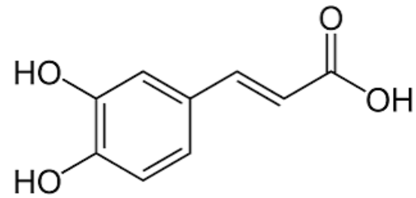
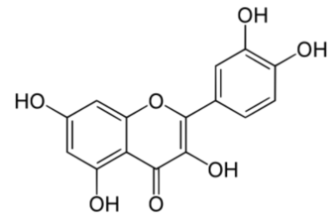
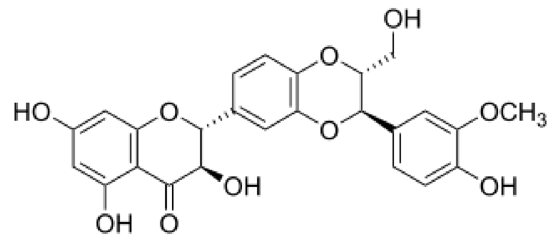
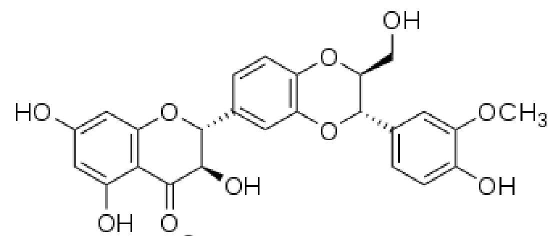
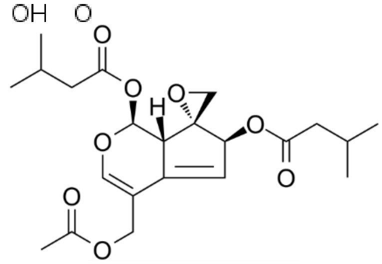
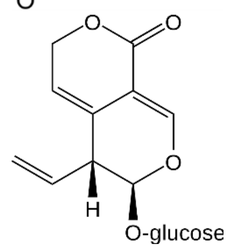



**Fig. 3** Types of phytochemicals present in different parts of plants

**Table 2.** Successful cases of plant natural products along with their structures have been isolated from their respective medicinal plant hosts and introduced into the clinic for the treatment of various human diseases.

| S. No. | Name of Plant | Compound | Structure |
|---|---|---|---|
| 1. | *Arnica montana* | Caffeic acid |  |
| 2. | *Calendula arvensis* | Quercen |  |
| 3. | *Silybummarianum* | Silibinin A |  |
| 4. | *Silybummarianum* | Silibinin A |  |
| 5. | *Valerianaofficinalis* | Valepotriate |  |
| 6. | *Genanaburseri* | Gentiopicroside |  |

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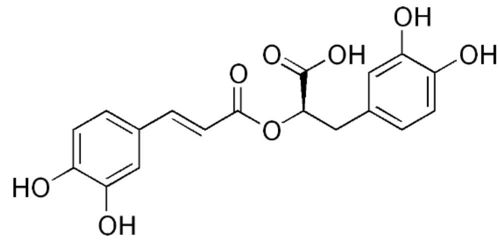
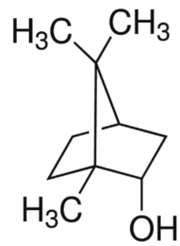
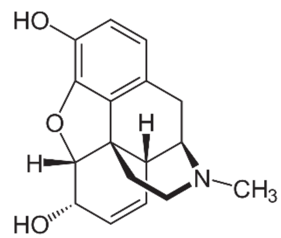
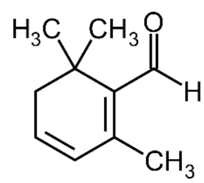
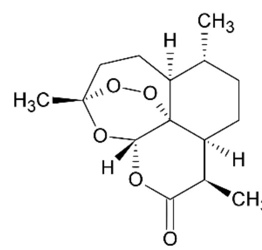
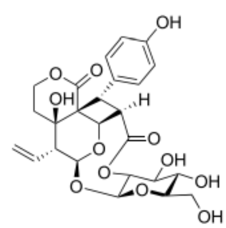
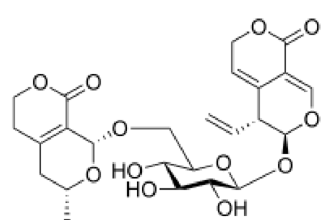
| 7. | *Rosmarinusofficinalis* | Rosmarinic acid |  |
| 8. | *Lavandulastoechas* | Borneol |  |
| 9. | *Papaver somniferum* | Morphine |  |
| 10. | *Crocus savus* | Safranal |  |
| 11. | *Artemisia annua* | Artemisinin |  |
| 12. | *Gentianarigescens* | Rigenolides A |  |
| 13. | *Gentianarigescens* | Rigenolides B |  |

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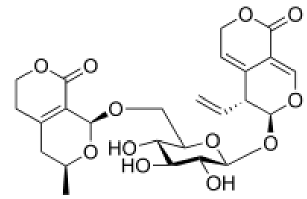
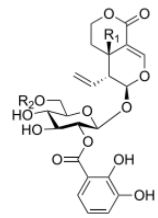
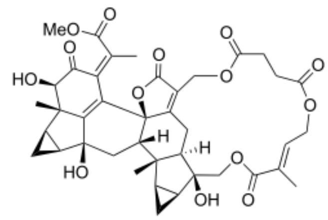
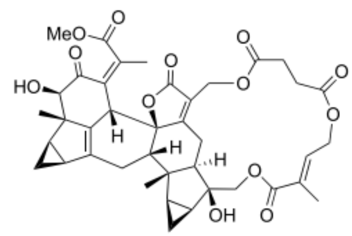
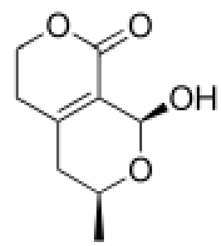
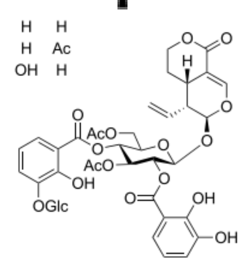
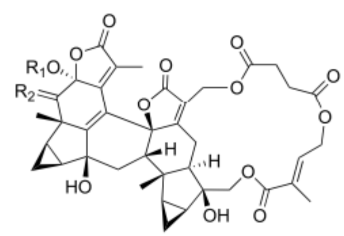
| 14. | *Gentianarigescens* | Rigenolides C |  |
| 15. | *Gentianarigescens* | Rigenolides F |  |
| 16. | *Chloranthusspicatus* | Chloramultilide A |  |
| 17. | *Chloranthusspicatus* | Shizukaol B |  |
| 24. | *Gentianarigescens* | Noriridoid |  |
| 25. | *Gentianarigescens* | Macrophylloside A |  |
| 26. | *Chloranthusspicatus* | Spicachlorantins A |  |

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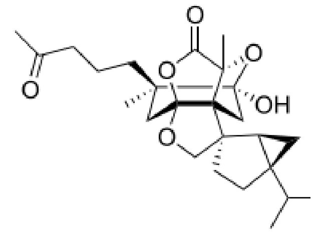
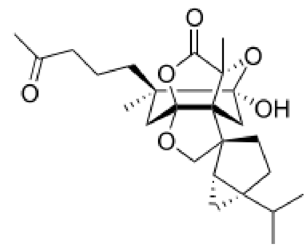
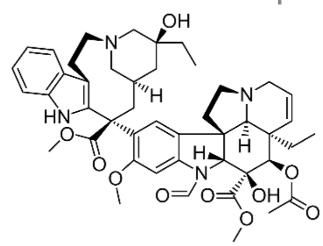
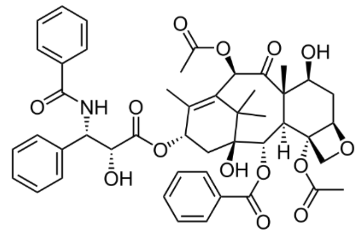
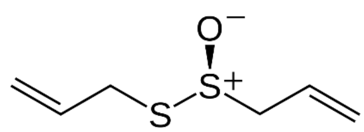
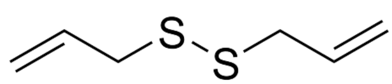
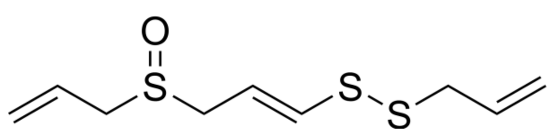
| 27. | *Chloranthusjaponicus* | Hitorins A |  |
| 28. | *Chloranthusjaponicus* | Hitorins B |  |
| 29. | *Catharanthusroseus* | Vincristine |  |
| 30. | *Taxusbrevifolia* | Paclitaxel |  |
| 31. | *Allium sativum* | Allicin |  |
| 32. | *Allium sativum* | Diallyl Disulfide |  |
| 33. | *Allium sativum* | E-Ajoene |  |

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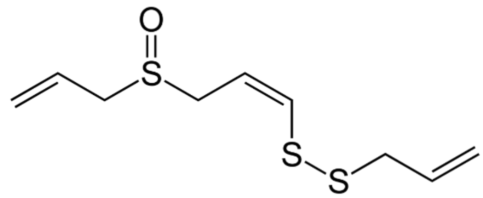
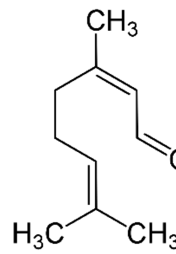
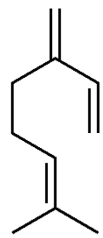
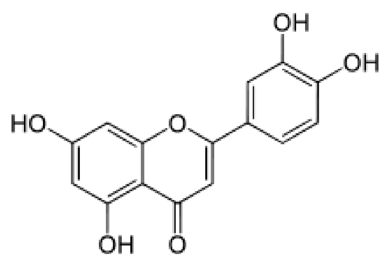
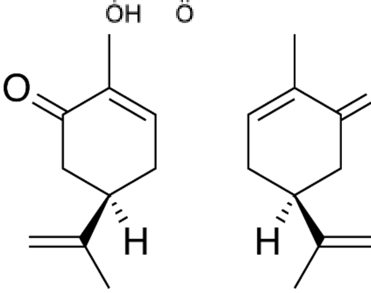
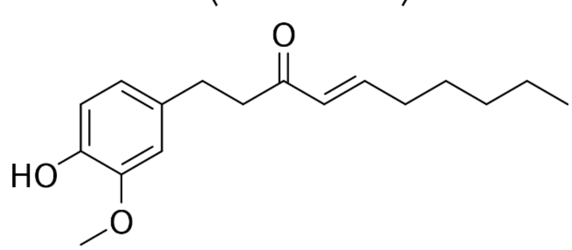
| 34. | *Allium sativum* | Z-Ajoene |  |
| 35. | *Cymbopogoncitratus* | Citral B |  |
| 36. | *Cymbopogoncitratus* | Myrcene |  |
| 37. | *Cymbopogoncitratus* | Luteolin |  |
| 38. | *Cymbopogoncitratus* | Carvone |  |
| 39. | *Zingiberofficinale* | 6-Shogal |  |

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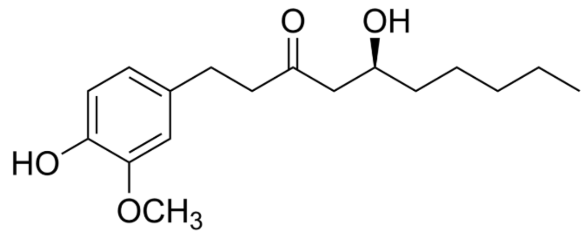
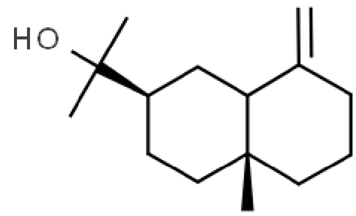
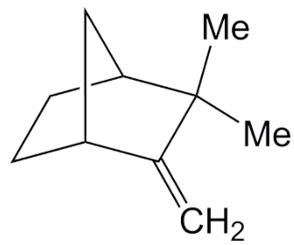
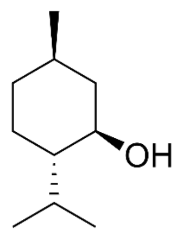
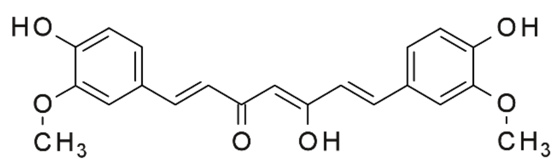
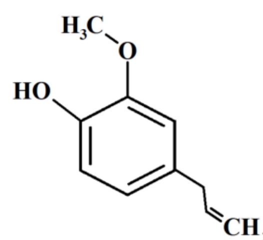
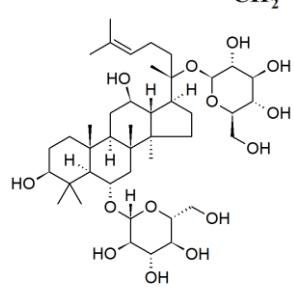
| 40. | *Zingiberofficinale* | 6-Gingerol |  |
| 41. | *Zingiberofficinale* | Zingiberol |  |
| 42. | *Zingiberofficinale* | Camphene |  |
| 43. | *Mentha*sp. | Menthol |  |
| 44. | *Curcuma longa* | Curcumin |  |
| 45. | *Ocimum sanctum* | Eugenol |  |
| 46. | *Ginseng* root | Ginsenoside |  |

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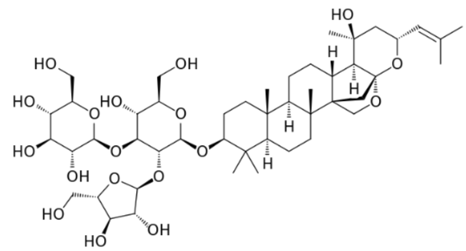
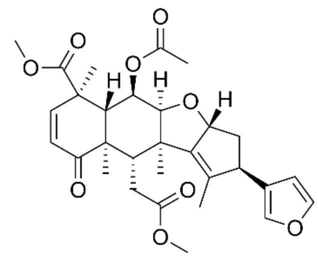
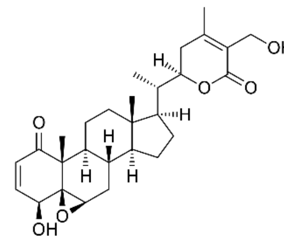
| 47. | *Bacopamonnieri* | Bacoside A |  |
| 48. | *Azadirachtaindica* | Nimbin |  |
| 49. | *Withaniasomnifera* | Withafera A |  |

According to **Cragg and Newman (2005),** very little (about 10%) of plant diversity of the world has been assessed for potential bioactive compounds. Hence, there is a challenge for chemists and biochemists to work on new natural compounds and get access to natural chemical diversity. In some countries like China and India, there is a well-established traditional system of medicine delivery. Natural bioactive compounds provide structurally diverse kinds of compounds that present opportunities for the discovery of novel compounds with low molecular weight **(Dias et al., 2012).** This has also helped chemists to artificially develop similar alternate compounds. Molecular biology and omics studies have also helped in the development of new compounds as the complete pathways are known**.**

**Mechanism of Action and Commercial Available Medicinal Plant Products**

Natural resources are an important asset for humans. The Angiosperms plants are natural sources of bioactive compounds used for treating ailments. Plant-based medicinal drugs are being used along with modern medicines such as immunotherapy. Moreover, there is a growing demand for herbal and traditional remedies for the treatment of various diseases. The future is very promising for medicinal plants. Medicinal plants as well as bioactive compounds extracted from them have played an important role in human medicines **(Dar et al., 2017)**. Many of the modern medicines are also derived from chemical compounds synthesized based on natural compounds. Post-COVID-19, there is an enhanced interest in the same. More than 125 clinically useful drugs of the known constitution have been isolated from more than 100 plant species. According to **Tantry (2009),** approximately 5000 plants have been screened for possibility of finding a novel drug.

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**References**

1. Adhikari, M., Thapa, R., Kunwar, R. M., Devkota, H. P., and Poudel, P. (2019). Ethnomedicinal uses of plant resources in the machhapuchchhre rural municipality of Kaski district, Nepal. Medicines 6, 69. doi:10.3390/medicines6020069
2. Arnold T. H., C. A. Prentice, L. C. Hawker, E. E. Snyman, M. Tomalin, N. R. Crouch & C. Pottas-Bircher. 2000. Medicinal and magical plants of Southern Africa: an annotated checklist. Strelitzia II. National Botanical Institute, South Africa.
3. Aswani, S., Lemahieu, A., and Sauer, W. H. H. (2018). Global trends of local ecological knowledge and future implications. PLoS ONE 13, 01954400–e195519. doi:10.1371/journal.pone.0195440
4. Bhattacharjee, A., Anadón, J. D., Lohman, D. J., Doleck, T., Lakhankar, T., Shrestha, B. B., ... & Krakauer, N. Y. (2017). The impact of climate change on biodiversity in Nepal: Current knowledge, lacunae, and opportunities. Climate, 5(4), 80.
5. Calixto, J. B. (2005). Twenty-five years of research on medicinal plants in Latin America: a personal view. Journal of Ethnopharmacology, 100(1-2), 131-134.
6. Chandra, P. (2020, August). The medicinal and aromatic plants business of Uttarakhand: A mini review of challenges and directions for future research. In Natural Resources Forum (Vol. 44, No. 3, pp. 274-285). Oxford, UK: Blackwell Publishing Ltd.
7. Charmakar, S., Kunwar, R. M., Sharma, H. P., Rimal, B., Baral, S., Joshi, N., ... & Oli, B. N. (2021). Production, distribution, use and trade of *Valeriana jatamansi* Jones in Nepal. Global Ecology and Conservation, 30, e01792.
8. Cragg, G. M. and Newman, D. J. (2005) Biodiversity: A continuing source of novel drug leads. Pure Appl. Chem., 77, 7–24.
9. Cunningham, A. B. (2014). Applied ethnobotany: people, wild plant use and conservation. Routledge.
10. Dar, R. A., Shahnawaz, M., & Qazi, P. H. (2017). General overview of medicinal plants: A review. The Journal of Phytopharmacology, 6(6), 349-351.
11. Dey, L., Attele, A. S., & Yuan, C. S. (2002). Alternative therapies for type 2 diabetes. Alternative Medicine Review, 7(1), 45-58.
12. Dias, D. A., Urban, S. and Roessner, U. (2012) A Historical Overview of Natural Products in Drug Discovery. Metabolites, 2, 303-336.
13. Díaz, S., Fargione, J., Chapin, F. S., and Tilman, D. (2006). Biodiversity loss threatens human well-being. PLoS Biol. 4, e277–e1305. doi:10.1371/journal.pbio.0040277
14. Dolezal, J., Dvorsky, M., Kopecky, M., Liancourt, P., Hiiesalu, I., Macek, M., ... & Schweingruber, F. (2016). Vegetation dynamics at the upper elevational limit of vascular plants in Himalaya. Scientific Reports, 6(1), 24881.

15. Fonnegra Gómez R, & S. L. Jiménez Ramírez. 2007. Plantas medicinales aprobadas en Colombia, 2da. Ed., EditorialUniversidad de Antioquia, Antioquia.
16. Gaisberger, H., Legay, S., Andre, C., Loo, J., Azimov, R., Aaliev, S., ... & Vinceti, B. (2020). Diversity under threat: connecting genetic diversity and threat mapping to set conservation priorities for *Juglans regia* L. populations in Central Asia. Frontiers in Ecology and Evolution, 8, 171.
17. Hajek, O. L., & Knapp, A. K. (2022). Shifting seasonal patterns of water availability: ecosystem responses to an unappreciated dimension of climate change. New Phytologist, 233(1), 119-125.
18. Khakurel, D., Uprety, Y., Ahn, G., Cha, J. Y., Kim, W. Y., Lee, S. H., & Rajbhandary, S. (2022). Diversity, distribution, and sustainability of traditional medicinal plants in Kaski district, western Nepal. Frontiers in Pharmacology, 13, 1076351.
19. Khakurel, D., Uprety, Y., Łuczaj, Ł., and Rajbhandary, S. (2021). Foods from the wild: Local knowledge, use pattern and distribution in Western Nepal. PLoS ONE 16, e0258905– e0258924. doi:10.1371/journal.pone.0258905
20. Kumar, A., Kumar, S., KomalRamchiary, N., and Singh, P. (2021). Role of traditional ethnobotanical knowledge and indigenous communities in achieving sustainable development goals. Sustain. Switz. 13, 3062–3114. doi:10.3390/su13063062
21. Kumar, S., Paul, S., Walia, Y. K., Kumar, A., & Singhal, P. (2015). Therapeutic potential of medicinal plants: a review. J. Biol. Chem. Chron., 1(1), 46-54.
22. Kunwar, R. M., and Bussmann, R. W. (2008). Ethnobotany in the Nepal himalaya. J. Ethnobiol. Ethnomedicine 4, 24–28. doi:10.1186/1746-4269-4-24
23. Kunwar, R. M., Thapa-Magar, K. B., Subedi, S. C., Kutal, D. H., Baral, B., Joshi, N. R., ... & Bhandari, A. R. (2023). Distribution of important medicinal plant species in Nepal under past, present, and future climatic conditions. Ecological Indicators, 146, 109879.
24. Kunwar, R.M., Adhikari, Y.P., Sharma, H.P., Rimal, B., Devkota, H.P., Charmakar S, et al. 2020. Distribution, use, trade and conservation of *Paris polyphylla* Sm. in Nepal. Glob. Ecol. Conserv. 23: e01081. https://doi.org/10.1016/j. gecco.2020.e01081.
25. Massardo F. & R. Rozzi. 1996. Usos medicinales de la flora nativa chilena. Ambiente & Desarrollo. 12: 76-81.
26. McDade, T. W., Reyes-García, V., Blackinton, P., Tanner, S., Huanca, T., and Leonard, W. R. (2007). Ethnobotanical knowledge is associated with indices of child health in the Bolivian Amazon. Proc. Natl. Acad. Sci. U. S. A. 104, 6134–6139. doi:10.1073/pnas.0609123104
27. McRae, J., Yang, Q., Crawford, R. Palombo, W. (2007) Review of the methods used for isolating pharmaceutical lead compounds from traditional medicinal plants. Environmentalist 27, 165–174.
28. Mereles M. F. 2009. La diversidad vegetal en el Paraguay, en A. Pin & G. Céspedes (eds.). 2009. Plantas Medicinales delJardín Botánico de Asunción, pp. 347-354. Asociación Etnobotánica Paraguaya, Asunción.

29. Moerman D. E. 1998. Native North American food and medicinal plants: epistemological considerations, en H. D.V.Prendergast, N. L. Etkin, D. R. Harris & P. J. Houghton (eds.). Plants for food and medicine, pp. 69-74. Proc. Joint Conference of the Society for Economic Botany and the International Society for Ethnopharmacology, Royal Botanic Gardens, Kew.
30. Pei, S., Alan, H., & Wang, Y. (2020). Vital roles for ethnobotany in conservation and sustainable development. Plant diversity, 42(6), 399.
31. Pérez de Paz P. & C. E. Hernández Padrón. 1999. Plantas Medicinales o útiles en la Flora Canaria. Aplicaciones populares. Francisco Lemus Editor, S. L., La Laguna, España.
32. Peters, C. M., Alexiades, M., and Laird, S. A. (2012). Indigenous communities: Train local experts to help conserve forests. Nature 481, 443. doi:10.1038/481443b
33. Ramawat, K.G., Dass, S. and Mathur, M. (2009) The Chemical Diversity of Bioactive Molecules and Therapeutic Potential of Medicinal Plants. In: Ramawat, K.G. (ed.) Herbal Drugs: Ethnomedicine to Modern Medicine. Springer Verlag Berlin Heidelberg.
34. Saiful Yazan, L., & Armania, N. (2014). Dillenia species: A review of the traditional uses, active constituents and pharmacological properties from pre-clinical studies. Pharmaceutical biology, 52(7), 890-897.
35. Schippmann U., D. Leaman & A. B. Cunningham. 2006. A comparison of cultivation and wild collection of medicinal andaromatic plants under sustainability aspects, en R. J. Bogers, L. E. Craker & D. Lange (eds.). Medicinal and Aromatic Plants, pp. 75-95. Springer, the Netherlands.
36. Seth, S. D.; Sharma, B. Medicinal plants in India. Indian J. Med. Res. 2004, 120, 9– 11.
37. Shengji P. 2002a. A brief review of ethnobotany and its curriculum development in China, en Z. K. Shinwari, A. Hamilton, & A.A. Khan (eds.). Proceedings Workshop on Curriculum Development in applied ethnobotany, pp. 21-33. Nathiagali. WWF-Pakistan, Lahore.
38. Shiva V. 1996. Protecting our biological and intellectual heritage in the age of biopiracy. The Research Foundation for Science, Technology and Natural Resources Policy, New Delhi.
39. Shrestha, K. K., Bhattarai, S., & Bhandari, P. (2018a). Handbook of Flowering Plants of Nepal (Vol. 1 Gymnosperms and Angiosperms: Cycadaceae-Betulaceae). Scientific publishers.
40. Shrestha, U. B., Lamsal, P., Ghimire, S. K., Shrestha, B. B., Dhakal, S., Shrestha, S., & Atreya, K. (2022). Climate change-induced distributional change of medicinal and aromatic plants in the Nepal Himalaya. Ecology and Evolution, 12(8), e9204.
41. Shrestha, U. B., Sharma, K. P., Devkota, A., Siwakoti, M., & Shrestha, B. B. (2018b). Potential impact of climate change on the distribution of six invasive alien plants in Nepal. Ecological Indicators, 95, 99-107.
42. Silveira, D., & Boylan, F. (2023). Medicinal Plants: Advances in Phytochemistry and Ethnobotany. Plants, 12(8), 1682.
43. Singh MP, Dey S: Indian medicinal plants. 2005, India: Satish Serial Publishing House, Delhi.
44. Singh, G., Rawat, G.S. (2011). Ethnomedicinal survey of Kedarnath wildlife sanctuary in western Himalaya, India. Ind J Fundam Appl Life Sci. 1, 35-36.

45. Singh, P. K., Singh, J., Medhi, T., & Kumar, A. (2022). Phytochemical screening, quantification, FT-IR analysis, and *in silico* characterization of potential bio-active compounds identified in HR-LC/MS analysis of the polyherbal formulation from Northeast India. ACS omega, 7(37), 33067-33078.
46. Tag, H., Kalita, P., Dwivedi, P., Das, A. K., & Namsa, N. D. (2012). Herbal medicines used in the treatment of diabetes mellitus in Arunachal Himalaya, northeast, India. Journal of Ethnopharmacology, 141(3), 786-795.
47. Toledo V. M. 1995. New paradigms for a new ethnobotany: reflections on the case of Mexico, en R. E. Schultes & S. von Reis(eds.). Ethnobotany: evolution of a discipline, pp. 75-88. Chapman and Hall, London.
48. Ullah, R., Alqahtani, A. S., Noman, O. M., Alqahtani, A. M., Ibenmoussa, S., & Bourhia, M. (2020). A review on ethno-medicinal plants used in traditional medicine in the Kingdom of Saudi Arabia. Saudi journal of biological sciences, 27(10), 2706-2718.
49. Ullah, R., Alqahtani, A. S., Noman, O. M., Alqahtani, A. M., Ibenmoussa, S., & Bourhia, M. (2020). A review on ethno-medicinal plants used in traditional medicine in the Kingdom of Saudi Arabia. Saudi journal of biological sciences, 27(10), 2706-2718.
50. Vincent, H., Amri, A., Castañeda-Álvarez, N. P., Dempewolf, H., Dulloo, E., Guarino, L., ... & Maxted, N. (2019). Modeling of crop wild relative species identifies areas globally for in situ conservation. Communications Biology, 2(1), 136.
51. Wani, N. A., Tantray, Y. R., Wani, M. S., & Malik, N. A. (2021). The conservation and utilization of medicinal plant resources. Medicinal and Aromatic Plants: Healthcare and Industrial Applications, 691-715.
52. Wanjohi, B. K., Sudoi, V., Njenga, E. W., & Kipkore, W. K. (2020). An ethnobotanical study of traditional knowledge and uses of medicinal wild plants among the Marakwet Community in Kenya. Evidence-Based Complementary and Alternative Medicine.