SCIENTIFIC CULTURE
www.sci-cult.com

SCIENTIFIC CULTURE, Vol. 12, No. 4, (2026), pp. 5846-5862
Open Access. Online & Print

DOI: 10.5281/zenodo.12426616

ARTIFICIAL INTELLIGENCE-INTEGRATED ETHNOMEDICINE OF ODISHA: CHEMOTYPES, BIOACTIVE COMPOUNDS, AND TRANSLATIONAL DRUG DISCOVERY FROM TRIBAL KNOWLEDGE SYSTEMS

Shirish Kumar Singh[1]*, Parinita Tripathy[2], Apurwa Singh[2], Sanyogita Shahi[3]*

[1] Scientist E & Project Director (I/c), Regional Science Centre, Daldal Seoni, Saddu, Raipur, Chhattisgarh 492014, India
[2] Research Scholar, Department of Science (Chemistry), Kalinga University, Raipur, Chhattisgarh 492001, India
[3] Professor, Department of Science (Chemistry), Kalinga University, Raipur, Chhattisgarh 492001, India

Received: 18/10/2025
Accepted: 21/03/2026

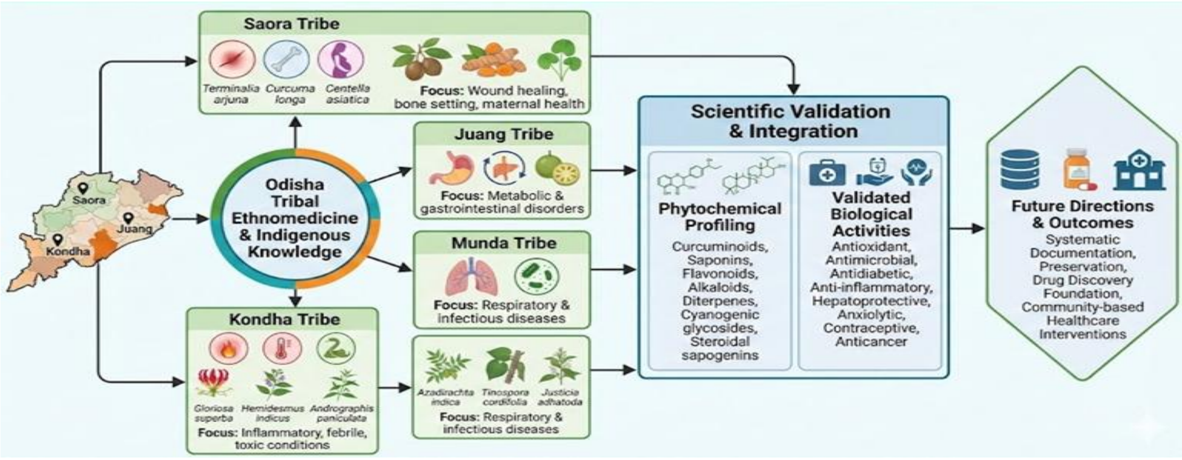
Corresponding author: Sanyogita Shahi
(drsanyogitashahi@gmail.com)

ABSTRACT

The ethnomedicinal systems of Odisha's tribal communities, including the Saora, Kondha, Juang, and Munda, represent a rich repository of traditional knowledge with significant therapeutic potential. However, the scientific validation, standardization, and translational utilization of this knowledge remain limited. This study presents an integrative approach combining ethnomedicine, phytochemistry, and Artificial Intelligence (AI) to explore the drug discovery potential of tribal medicinal plants. Ethnobotanical data were systematically compiled and correlated with phytochemical profiles, highlighting major bioactive chemotypes such as alkaloids, flavonoids, terpenoids, saponins, and glycosides. Documented medicinal species, including Curcuma longa, Tinospora cordifolia, Gloriosa superba, and Aegle marmelos, demonstrated diverse pharmacological activities such as antioxidant, anti-inflammatory, antimicrobial, antidiabetic, and anticancer effects. To enhance validation and accelerate discovery, AI-based methodologies, including machine learning models, quantitative structure–activity relationship (QSAR) analysis, and data-driven bioactivity prediction, are incorporated to establish correlations between phytochemical structures and therapeutic functions. Additionally, Natural Language Processing (NLP) tools are proposed for the systematic documentation and preservation of indigenous knowledge systems. The integration of AI with ethnopharmacology provides a predictive and scalable framework for identifying novel drug candidates while minimizing experimental cost and time. This study highlights the transformative potential of combining traditional tribal medicine with advanced computational approaches, offering new pathways for precision herbal therapeutics, sustainable drug development, and conservation of indigenous knowledge. The findings emphasize the need for interdisciplinary research integrating ethnomedicine, phytochemistry, and AI-driven technologies to unlock the full biomedical potential of tribal medicinal resources.

KEYWORDS: Artificial Intelligence (AI), Ethnomedicine, Tribal Medicinal Plants, Phytochemistry, Bioactive Compounds

GRAPHICAL ABSTRACT



1. INTRODUCTION

Odisha is home to over 62 tribal communities, four of which—Saora, Kondha, Juang, and Munda—are recognized as Particularly Vulnerable Tribal Groups (PVTGs) (Acharya, B., *et al.* 2025). Their ethnomedical systems evolved over centuries through empirical observation, spiritual belief, forest ecology, and practical healing. Despite their high dependency on medicinal plants, scientific documentation remains limited, fragmented, and in decline due to modernisation. Traditional healers (Disaris, Jani, Dehuri, Vaidhya) treat ailments ranging from infections to chronic diseases using local flora (Sahu, S. C., *et al.* 2010; Shahi, S., & Singh, S. K. 2025). Many of these medicinal plants have shown promising pharmacological activities yet remain unexploited in mainstream drug development Patra, J. K., *et al.* (2015). This research integrates tribal knowledge with phytochemistry and biological validation to build a unified scientific foundation for Odisha's unique medicinal systems (Acharya, B., *et al.* 2025; Dubey, A., *et al.* 2025).

Saora is an ancient tribe located mainly in Odisha, India, with mentions in the Ramayana and Mahabharata. They are also found in Andhra Pradesh, Jharkhand, Madhya Pradesh, and Assam. The Saora tribe speaks Sora, a Munda language with its own script, Sorang Sompeng. They exhibit Proto Australoid physical traits and practice a complex religion, worshipping various deities and spirits. Unique cultural practices include art and the traditional tattooing technique called 'Tantangbo.' Economically, they are divided into two classes: Sudha Saora, who rely on wet cultivation and wage labor, and Lanjia Saora, who engage in shifting and terraced cultivation. Their villages feature scattered houses, megaliths for commemorating the dead, and village guardian deities such as Kitungsum at entrances. Typical houses are simple, one-roomed structures with thatched roofs and mud walls.

The Kondhs, or Kui, are a significant tribal group in Odisha, primarily found in Rayagada, Kashipur, Kalyansinghpur, Bissam Cuttack, and Muniguda. Historically noted for their human sacrifices to the Earth-Goddess for good crops and health, the term 'Kondh' translates to 'mountaineer' from Telugu. They identify as a Dravidian tribe with no known origin myths, believing they have existed in Odisha since the dawn of civilization, uncolonized by foreign powers. Today's Kondhs are categorized into Desia, Dongria, and Kutia Kondhs, each residing in specific districts. Their economy is traditionally based on hunting, transitioning primarily to subsistence agriculture. The tribe celebrates three main festivals: semi jatra, mohua jatra, and chawal dhua jatra, linked to their agricultural practices. They perform various ceremonies to honour deities, especially the Earth Goddess. Marriages involve customs that prevent cousin unions, and brides are typically sourced from different villages, with arrangements made following the agreement of a bride price.

Juang is one of the 13 Particularly Vulnerable Tribal Groups (PVTGs) in Odisha, with a population of approximately 50,000 as per the 2011 census. They are primarily located in the Keonjhar and Dhenkanal districts and speak the Juang language, a member of the Munda family. Historically, the Juang relied on hunting, gathering, and limited farming until colonial forest reserves altered their customs. They adapted by excelling in basket-weaving and trading with nearby communities. Traditionally, Juang women wore leaf girdles, while men donned loincloths; however, external influences led to a shift in their clothing. Their belief system is predominantly animistic, centred on the sun god, although they also incorporate Hindu deities alongside their tribal gods.

The Munda tribe, found in Sundargarh, Sambalpur, Keonjhar, and Mayurbhanj districts of Odisha, is known for its unique language and cultural practices, sometimes referred to as 'Hul'. They share linguistic ties with the Mundari tribe and are involved in farming and traditional crafts. Their worship includes deities such as 'Marang Bonga' and 'Karam Bonga', with rituals conducted by the village priest, 'Pahan', at sacred groves known as 'Sarna'. The Munda language has its own script, 'Mundari Bani Hisira', developed by Rohidas Singh Nag. As of the 2011 Census, the Munda population is approximately 558,691, with a literacy rate of 54.92%.

2. LITERATURE REVIEW

2.1. Ethnomedicinal Systems of Odisha Tribes

2.1.1. Saora Medicine

The Saora tribe of Odisha possesses a highly developed traditional medical system deeply intertwined with their ecological knowledge and spiritual beliefs. Their healing practices emphasise wound management, bone fracture care, snakebite treatment, fever reduction, and maternal health. Saora healers, known as Kudan or Kuran, prepare remedies mainly from locally available forest plants such as Curcuma *longa* (Fuloria, S., *et al.* 2022), Aloe *barbadensis* (Gupta, V. K., *et al.* 2021), Centella *asiatica* (Ali, K., *et al.* 2025), and Terminalia *arjuna* (Jain, S., *et al.* 2009). Herbal pastes (churna), freshly squeezed gels, powdered barks, and decoctions are the most common formulations used in treating cuts, burns, swelling, and postpartum complications. Fumigation using aromatic leaves and resins is performed for respiratory ailments and to ward off evil influences, reflecting their belief in ancestral spirits guiding the healing process. Many plants, such as turmeric and arjuna bark, also hold ritual significance and are used during childbirth, purification ceremonies, and protective rites. The Saora medicinal system thus combines empirically effective herbal remedies with deeply rooted cultural practices. From an Artificial Intelligence (AI)-integrated perspective, such traditional knowledge systems represent valuable datasets for chemotype profiling, bioactivity prediction, and translational drug discovery (Orobator, E., *et al.* 2025). AI-driven tools, including machine learning and chemoinformatics approaches, can systematically analyze these plant-based formulations to establish correlations between phytochemical composition and therapeutic outcomes (Shahi, S., & Singh, S. K. 2022). Practices such as fumigation using aromatic leaves and resins for respiratory disorders and spiritual protection highlight the complex interplay between medicinal and cultural dimensions, which can be documented and preserved using Natural Language Processing (NLP) techniques (*Table 1*).

Table 1: Medicinal Plants Used by the Saora Tribe

Plant Name	Common Name	Local/Tribal Use	Preparation Method	Pharmacological Activity	Major Bioactive Groups	AI-Based Translational Potential
Curcuma *longa* 	Turmeric	Applied on fresh cuts, wounds, and infections	Paste of rhizome mixed with water/oil (Bhuyan, C., *et al.* 2024)	Wound healing, anti-inflammatory (Razavi, B. M., *et al.* 2021)	Curcuminoids, terpenoids, phenolics (Vo, T. S., *et al.* 2021)	QSAR modeling, molecular docking for anti-inflammatory drug targets
Curcuma *angustifolia* 	Tikhur	Used as cooling food and for gastrointestinal problems; given during weakness and dehydration	Rhizome processed into starch (powder) and mixed with water/milk	Digestive aid, cooling agent, anti-ulcer, energy booster (Kadam, P., & Shahi, S. 2025).	Starch polysaccharides, flavonoids, phenolics (Tripathy, P., *et al.* 2023).	AI-based formulation optimization and nutraceutical profiling
Aloe *barbadensis* 	Aloe vera	Cooling agent for burns, swelling (Yadeta, A. T. 2024).	Gel extracted from fresh leaves	Burns, skin irritation, inflammation	Anthraquinones, polysaccharides (Mitra, A., *et al.* 2023).	Machine learning for dermatological drug design and bioactivity prediction
Centella *asiatica* 	Gotu kola	Enhances healing of cuts and fractures	Leaf paste or decoction	Wound repair, bone strengthening (Dewi, R. L., & Yuniati, R. 2025).	Triterpenoids (asiaticoside), flavonoids (Singh, L. S., & Singh, W. S. 2024).	AI-driven neuroactive compound prediction and network pharmacology

Terminalia *arjuna* 	Arjuna bark	Used in childbirth and blood purification	Bark decoction or powder	Antiseptic, cardiotonic, postpartum care (Jain, S., *et al.* 2009).	Tannins, glycosides, flavones (Tahir, H., *et al.* 2025)	Drug-likeness prediction and cardiovascular pathway model ing using AI
Azadirachta *indica* 	Neem	Purification & infection control (Kashyap, K. K., *et al.* 2022).	Leaf paste or fumigation (Mohanasundaram , P., & Antoneyraj, M. 2025).	Skin infections, fever, antiseptic (Asghar, H. A., *et al.* 2022)	Limonoids, flavonoids (Sarkar, S., *et al.* 2021).	AI-based multi-target drug discovery and toxicity prediction
Ocimum *sanctum* 	Tulsi	Respiratory and fever treatment (Saila, I. Z., *et al.* 2025)	Leaf decoction or inhalation	Cough, cold, fever (Kumari, M., *et al.* 2023)	Eugenol, ursolic acid (Bhattarai, K., *et al.* 2024)	AI-assisted immune-response modeling and antiviral drug screening
Zingiber *officinale* 	Ginger	Treats digestive issues (Worasing, K., *et al.* 2023)	Rhizome paste or decoction (Mukherjee, S., & Karati, D. 2022)	Stomach pain, nausea (Aji, N., *et al.* 2022)	Gingerols, shogaols (Zhang, M., *et al.* 2021)	Predictive modeling for anti-inflammatory and gastrointestinal drugs
Justicia *adhatoda* 	Vasaka	Snakebite and respiratory relief (Kumar, P., & Singh, A. N. 2025)	Leaf juice	Anti-venom support, bronchial dilation (Jayaweera, U., *et al.* 2024)	Vasicine, vasicinone (Isha, *et al.* 2025)	AI-based respiratory drug target prediction and molecular docking
Eclipta *alba* 	Bhringra j	Liver and skin disorders	Juice or paste	Skin healing, liver tonic (Tripathy, S., *et al.* 2024).	Wedelolactone, flavonoids (Jha, U., *et al.* 2022).	AI-driven hepatoprotectiv e drug discovery and pathway analysis
Cissus *quadrangularis* 	Hadjod	Bone fracture healing	Stem paste applied externally	Bone repair, swelling reduction Patil, A. M., *et al.* 2022).	Ketosteroids, triterpenes (Hamid, H. S., & Patil, S. 2023).	Machine learning for bone regeneration drug development

2.1.2 *Kondha Medicine*

The Kondha (Dongria Kondh and Kutia Kondh) tribes of Odisha are widely recognised for their sophisticated traditional medical practices, especially in bone-setting, anti-inflammatory treatments, and detoxification therapies. Their healers, known as Jani, Bejini, or Dehuri, possess specialised knowledge of musculoskeletal injuries and are consulted for fractures, dislocations, joint pain, and swelling. One of their most notable medicinal plants is *Gloriosa superba* (Joshi, B. C., *et al.* 2024), a potent but toxic species rich in colchicine, used carefully for inflammation, pain relief, and certain poison-related conditions. Due to its narrow therapeutic index, only experienced healers handle its dosage. The Kondha also relies heavily on *Tinospora cordifolia* (Prasad, A., *et al.* 2023) for immunity boosting and fever, *Hemidesmus indicus* for blood purification and skin disorders, and *Andrographis paniculata* (Sharma, V., & Chaudhary, A. 2025) for treating infections, liver ailments, and seasonal fevers. Remedies are commonly prepared as decoctions, pastes, herbal infusions, or medicated oils, often accompanied by ritual practices that reflect the tribe's deep spiritual connection with nature. Their medical tradition not only treats physical ailments but also incorporates purification rites, detoxifying herbs, and energy-balancing therapies, making Kondha ethnomedicine a holistic healing system supported by a strong phytochemical foundation. Artificial Intelligence (AI)-integrated perspective, Kondha ethnomedicine offers a valuable framework for chemotype profiling, toxicity prediction, and bioactivity modeling (Amin, A., *et al.*). AI-driven approaches such as machine learning, QSAR analysis, and molecular docking can be employed to evaluate the therapeutic potential and safety profiles of potent plants like *Gloriosa superba* (Joshi, B. C., *et al.* 2024). while identifying novel drug candidates from less-explored species. The incorporation of Natural Language Processing (NLP) can facilitate systematic documentation and preservation of this indigenous knowledge (Table 2).

Table 2: Medicinal Plants Used by the Kondha Tribe

Plant Name	Common Name	Local/Tribal Use	Preparation Method	Therapeutic Purpose	Major Bioactive Groups	AI-based formulation optimization and nutraceutical profiling
Gloriosa *superba* 	Flame lily	Severe inflammation, bone pain, arthritis, and detoxification	Rhizome paste in extremely low dose; supervised decoction	Anti-inflammatory, analgesic, and anti-mitotic (Sanyal, R., *et al.* (2022)	Colchicine, gloriosine, alkaloids (Joshi, B. C., *et al.* 2024)	AI-based toxicity prediction, dose optimization, and anticancer drug modeling
Tinospora *cordifolia* 	Guduchi	Fever, joint pain, post-fracture healing	Stem decoction or paste	Immunomodulator, antipyretic, anti-inflammatory (Singh, A. 2024)	Tinosporaside, diterpenoids, alkaloids (Prasad, A., *et al.* 2023)	Machine learning for immune-response prediction and multi-target drug discovery
Hemidesmus *indicus* 	Indian sarsaparilla	Blood purification, skin diseases, snakebite	Root infusion or decoction	Detoxifier, hepatoprotective, antimicrobial (Kher, M. M., *et al.* -2020)	Hemidesmin, saponins, coumarins (Sai, N. M., *et al.* 2024)	AI-based metabolomic profiling and detoxification pathway analysis
Andrographis *paniculata* 	Kalmegh	Fever, infections, liver protection	Leaf decoction, powdered extract	Antibacterial, antimalarial, hepatoprotective (Sharma, V., & Chaudhary, A. 2025)	Andrographolide (diterpenoid lactone) (Vikal, A., *et al.* 2025)	QSAR modeling and antiviral drug screening using AI
Vitex *negundo* 	Nirgundi	Joint pain, swelling, rheumatism	Leaf paste or steam fomentation	Anti-inflammatory, analgesic	Flavonoids, iridoid glycosides (Bhuyan, C., *et al.* 2024)	AI-assisted prediction of anti-inflammatory pathways and drug targets
Ricinus *communis* 	Castor plant	Bone-setting and lubrication	Warm castor oil massage	Pain relief, muscle relaxation	Ricinoleic acid, fatty acids (Abdul *et al.*, 2018)	AI modeling for anti-inflammatory drug development and toxicity evaluation
Plumbago *zeylanica* 	Chitrak	Digestive disorders, toxin removal	Root paste (controlled dose)	Carminative, detoxifying, antimicrobial (Thawkar, M. M., *et al.* 2024)	Plumbagin (naphthoquinone) (Sharma, R., & Roy, A. S. 2025)	AI-based anticancer drug discovery and bioactivity prediction

Aegle *marmelos* 	Bael	Diarrhea, gut disorders	Fruit pulp decoction	Antidiarrheal, anti-inflammatory (Sharma, A., *et al.* 2025)	Marmelosin, tannins (Sahu, S. C., *et al.* 2010)	AI-driven gastrointestinal drug modeling and formulation design
Calotropis *gigantea* 	Arka	Skin infection, wound healing	Latex diluted and applied externally	Antimicrobial, wound healing (Sharma, P., *et al.* 2025)	Cardiac glycosides, terpenoids (Jamal, A., *et al.* 2025)	AI-based toxicity profiling and pharmacological pathway prediction

2.1.3 Juang Medicine

The Juang tribe of Odisha, primarily residing in the forested and hilly regions of Keonjhar, has developed a distinctive ethnomedicinal system centred on the use of forest herbs, rhizomes, and wild tubers. Their traditional healing practices primarily focus on digestive ailments, metabolic disorders, gynaecological problems, and overall vitality enhancement. The Juang healers, known locally as Dissari or Vaidya, depend heavily on plants such as Clerodendrum *viscosum* (Vo, T. S., *et al.* 2021) for gastrointestinal disturbances and fever, Costus *speciosus* (Maji *et al.*, 2020) for antidiabetic and reproductive health applications, and Aegle *marmelos* (Sahu, S. C., *et al.* 2010) for chronic diarrhoea, gut infections, and digestive improvement. Their remedies are typically prepared as fresh leaf pastes, root decoctions, or boiled rhizome infusions, often combined with dietary restrictions or ritual purification. Rich knowledge of underground plant parts—especially rhizomes and tubers—sets Juang medicine apart, making it effective against stomach disorders, menstrual irregularities, and postpartum weakness. Their pharmacological knowledge reflects a deep botanical understanding and ecological observation developed over generations, representing a valuable resource for ethnopharmacological research (Table 3).

Table 3: Medicinal Plants Used by the JuangTribe

Plant Name	**Common Name**	**Local/Tribal Use**	**Preparation Method**	**Therapeutic Purpose**	**Major Bioactive Groups**	**AI-based formulation optimization and nutraceutical profiling**
Clerodendrum *viscosum* 	Bhunimba	Stomachache, diarrhoea, fever	Leaf paste or decoction	Digestive relief, antimicrobial, febrifuge	Clerodin, flavonoids, diterpenes (Ramjan, A. H., *et al.* 2025)	AI-based antimicrobial activity prediction and gut microbiome interaction modeling
Costus *speciosus* 	Keu/ Kewda ginger	Dysentery, menstrual issues, and diabetes	Rhizome decoction or paste	Antidiabetic, anti-inflammatory, and fertility regulation	Diosgenin (steroidal saponin) (Maji *et al.*, 2020)	Machine learning for antidiabetic drug discovery and hormonal pathway analysis
Dioscorea *bulbifera* 	Wild yam/ tuber	Nutritional tonic, gynaecological disorders (Guan, X. R., *et al.* 2017)	Tuber cooked or paste applied	Energy booster, hormone regulation (Ikiriza, H., *et al.* 2019)	Diosgenin, polyphenols (Rudito *et al.*, 2021)	AI-assisted endocrine modulation studies and nutraceutical optimization
Zingiber *montanum* 	Wild ginger	Stomach pain, nausea	Rhizome paste or infusion	Carminative, digestive support (Aji, N., *et al.* 2022)	Curcuminoids, essential oils (Worasing, K., *et al.* 2023)	Predictive modeling for gastrointestinal drug targets and antiemetic compounds

Asparagus *racemosus* 	Shatavari	Women's health, lactation, and fertility	Root decoction or paste	Galactagogue, hormonal balance (Nadeem, M., *et al.* 2025)	Saponins (shatavarins) (Irakee, M. A., *et al.* 2025)	AI-driven reproductive health modeling and phytoestrogen activity prediction
Holarrhena *pubescens* 	Kutaja	Diarrhea, gut infections	Seed or bark decoction	Antimicrobial, antidiarrheal (Rani, A., & Bansal, R. 2023)	Conessine (alkaloid) (Zahara *et al.*, 2020)	QSAR modeling for antimicrobial drug development and gut pathogen targeting
Piper *longum* 	Long pepper	Respiratory and digestive issues	Fruit powder with honey	Digestive stimulant, anti-asthmatic (Huang, H., *et al.* 2010)	Piperine, essential oils (Dash, M., *et al.* 2022)	AI-based bioavailability enhancement and respiratory drug modeling
Boerhavia *diffusa* 	Punarnava	Urinary disorders, edema	Root decoction	Diuretic, anti-inflammatory	Punarnavine, rotenoids (Yadav, A., *et al.* 2025)	AI-assisted renal pathway analysis and anti-inflammatory drug prediction
Amorphophallus *paeoniifolius* 	Elephant foot yam	Digestive stimulant, piles	Cooked tuber or paste	Carminative, anti-inflammatory	Flavonoids, sterols (Angayarkanni, J., *et al.* 2010)	Machine learning for gastrointestinal therapeutics and anti-inflammatory screening

2.1.4 *Munda Medicine*

The Munda tribe, inhabiting regions of northern Odisha and adjoining Jharkhand, follows a traditional medical system that focuses strongly on the management of fever, respiratory infections, and skin diseases. Their healers, known as Ojha or Pahan, use a range of forest herbs and household medicinal plants to prepare decoctions, leaf extracts, pastes, and fumigation mixtures. Among the most important medicinal species used by the Munda are Azadirachta *indica* (also used by the Saora tribe) for skin infections, purification, and fever control; Justicia *adhatoda* (also used by the Juang tribe) for bronchial congestion, cough, and asthma; and Holarrhena *pubescens* for treating diarrhoea, dysentery, and parasitic infections. These remedies are often used in combination with ritual incantations, reflecting the tribe's belief in balancing physical and spiritual health. Additionally, the Munda utilise warming herbs, aromatic leaves, and bitter tonics to reduce fever and improve lung function. Their medicinal practices are supported by a rich knowledge of pharmacologically active plants and form an essential part of community health care in remote forest areas.

Table 4: Medicinal Plants Used by the JuangTribe

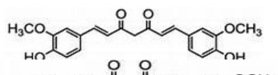
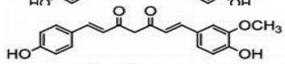
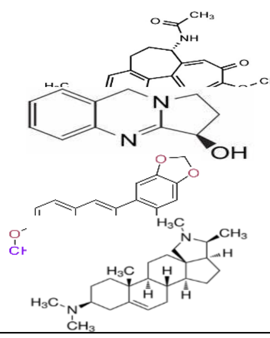
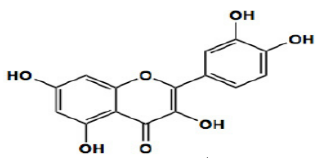
Plant Name	**Common Name**	**Local/ Tribal Use**	**Preparation Method**	**Therapeutic Purpose**	**Major Bioactive Groups**	**AI-based formulation optimization and nutraceutical profiling**
Adhatoda *vasica* 	syn. *Justicia adhatoda*	Respiratory diseases	Steam inhalation with leaves	Cough relief, airway clearance	Quinazoline alkaloids (Khandelwal, P., *et al.* 2024)	AI-based respiratory drug modeling, molecular docking for bronchodilator targets
Terminalia *chebula* 	Haritaki	Digestive issues, skin diseases	Fruit powder or decoction	Laxative, antimicrobial, detoxifier (Gupta, A. 2023)	Tannins (chebulinic acid) (Jha, A. K., & Sit, N. 2023)	Machine learning for gut health modulation and antioxidant drug discovery

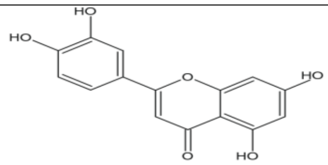
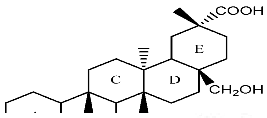
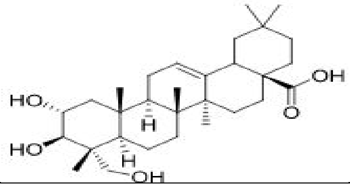
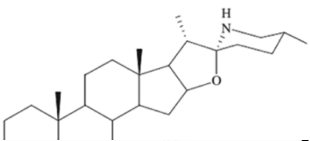
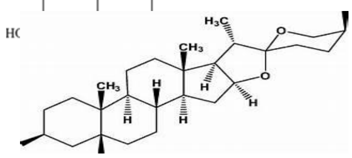
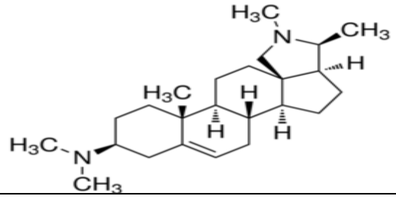
Psidium *guajava* 	Guava leaves	Diarrhea, skin infections	Leaf decoction or paste	Astringent, antibacterial (Kumar, M., *et al.* 2021)	Quercetin, tannins (Huynh, H. D., *et al.* 2025)	AI-driven antimicrobial screening and gut microbiome interaction analysis
Cassia *fistula* 	Amaltas	Constipation, skin infections	Pulp laghu-formulation or leaf paste	Laxative, antimicrobial (Jangid, T., *et al.* 2025)	Anthraquinones (Garg, R., *et al.* 2023)	QSAR modeling for laxative drug design and anti-inflammatory pathway prediction

2.2 *Phytochemistry of Commonly Used Plants*

The medicinal plants used across the Saora, Kondha, Juang, and Munda tribal systems are rich repositories of diverse phytochemicals that underpin their therapeutic potential. One of the most prominent groups is curcuminoids, found mainly in Curcuma *longa*, which possess strong antioxidant and anti-inflammatory properties essential for wound healing and tissue repair. A second major class, the alkaloids, includes powerful compounds such as colchicine from Gloriosa *superba*, vasicine from Justicia *adhatoda* (Jayaweera, U., *et al.* 2024), and berberine from species like Berberis (used regionally), all of which exhibit potent anticancer, bronchodilatory, and antimicrobial activities. Flavonoids such as quercetin and luteolin occur widely in forest herbs and contribute significantly to metabolic regulation, antioxidant defence, and anti-diabetic actions. Tribal medicinal plants also contain numerous triterpenoids, which function as hepatoprotective and immunomodulatory agents, making them vital in managing fever, inflammation, and chronic infections. Saponins, particularly diosgenin from Costus *speciosus* and wild yams, play crucial roles as anti-diabetic, anti-inflammatory, and fertility-regulating compounds frequently used in Juang remedies. Glycosides, present in plants like Terminalia *arjuna* (Rajaram, V., *et al.* 2024) and Holarrhena *pubescens* (Thawkar, M. M., *et al.* 2024), add to the cardioprotective, antimicrobial, and anti-diarrheal functions of the tribal pharmacopoeia. Collectively, this rich phytochemical diversity provides a biochemical rationale for the wide therapeutic success of Odisha's tribal ethnomedicine.

Table 5: Major Phytochemical Groups in Tribal Medicinal Plants

Phytochemical Group	Key Plant Sources	Representative Compounds	Primary Biological Activities
Curcuminoids	Curcuma *longa* (Razavi, B. M., *et al.* 2021)	Curcumin   Desmethoxycurcumin	Antioxidant, anti-inflammatory, wound healing
Alkaloids	Gloriosa *superba* (Joshi, B. C., *et al.* 2024), Justicia *adhatoda* (Jayaweera, U., *et al.* 2024), Holarrhena *pubescens* (Thawkar, M. M., *et al.* 2024)	Colchicine  Vasicine Berberine Conessine	Anticancer, bronchodilatory, antimicrobial
Flavonoids	Azadirachta *indica* (Sarkar, S., *et al.* 2021). ,Aegle *marmelos* (Sahu, S. C., *et al.* 2010) , wild herbs	Quercetin  Luteolin	Antioxidant, anti-diabetic, metabolic modulation

			
Triterpenoids	Tinospora *cordifolia* (Prasad, A., *et al.* 2023), Terminalia *arjuna* (Jain, S., *et al.* 2009)	Triterpene lactones (Joshi, R. K. 2023)  Arjunolic acid 	Hepatoprotective, immunomodulatory
Saponins	Costus *speciosus* (Maji *et al.*, 2020), Dioscorea spp., Asparagus *racemosus* (Irakee, M. A., *et al.* 2025)	Diosgenin   Shatavarins	Anti-diabetic, fertility regulation, anti-inflammatory
Glycosides	Terminalia *arjuna* (Jain, S., *et al.* 2009), Holarrhena *pubescens* (Zahara *et al.*, 2020)	Cardioactive glycosides, Conessine derivatives 	Cardioprotective, antimicrobial, anti-diarrheal

3 METHODOLOGY

3.1 *Study Design*

This study utilizes a systematic review framework to combine ethnomedicinal knowledge with modern phytochemical and pharmacological evidence. Data were sourced from ethnobotanical surveys (1990–2024) detailing the medicinal practices of Odisha's Saora, Kondha, Juang, and Munda tribes, phytochemical databases such as PubChem for identifying chemotypes and major secondary metabolites, and experimental validation studies from databases including PubMed and Scopus focused on the bioactivity of plant-derived compounds. The review aims to correlate traditional medicinal claims with bioactive compounds and their validated therapeutic potential, also considering geographical variations in phytochemical content (Kshatri *et al.*, 2025).

3.2 *Inclusion Criteria*

Studies included were based on criteria such as traditional use by the Saora, Kondha, Juang, or Munda tribes, phytochemical evidence of bioactive compounds, and pharmacological validation of at least one biological activity through lab or clinical research (Swain, n.d.). Only publications from 1990 to 2024, written in English, and fully accessible were considered, while those focusing solely on taxonomy, ecology, or general botany without medicinal relevance were excluded.

3.3 *Data Extraction*

Data extraction involved a structured four-step approach: 1) Traditional Use Documentation recorded medicinal practices for diseases from ethnobotanical surveys. 2) Administration Route and Preparation Methods categorized various application methods and formulations. 3) Phytochemical Profile documented key bioactive chemotypes and verified marker compounds. 4) Validated Biological Activities extracted pharmacological effects from studies, linking traditional uses to scientific validation.

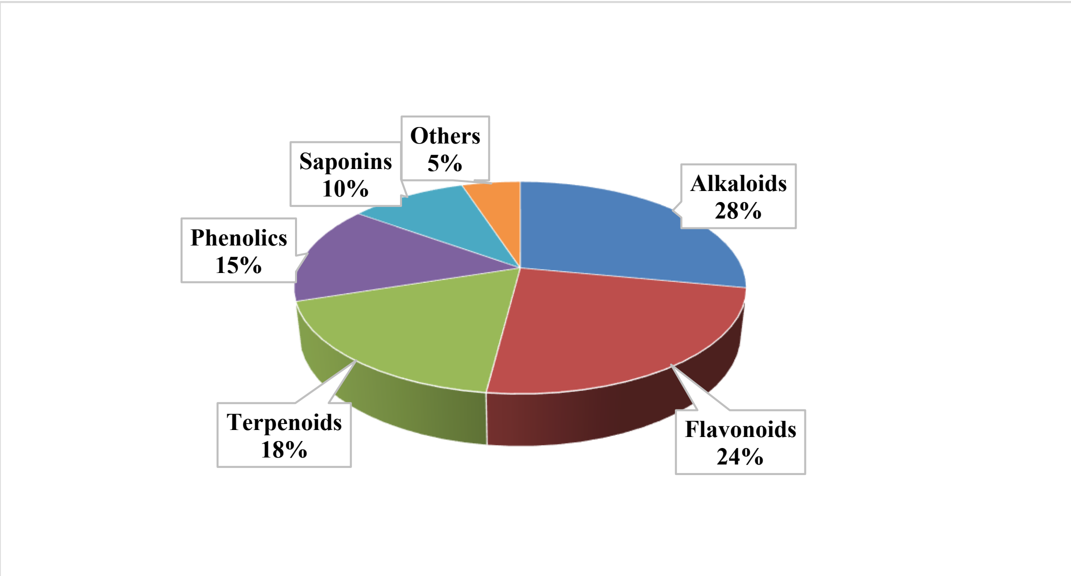
4 RESULTS

The ethnobotanical analysis of Odisha's four major tribal groups shows significant variation in medicinal plant usage. The Saora tribe uses around 45 key plants for wound care and maternal health. The Kondha tribe has the richest repository with 52 species focused on inflammation, bone setting, and detoxification. The Juang tribe employs 38 species primarily for gastrointestinal disorders and metabolic issues, while the Munda tribe utilizes 43 plants for fevers, skin infections, and respiratory illnesses. This reveals the diversity and specialization in the ethnomedicinal practices of these tribal communities. These datasets provide a structured framework for pattern recognition, clustering of therapeutic categories, and prediction of plant–disease associations, enabling data-driven validation of traditional medicinal practices.

Table 6: Tribe-Wise Medicinal Plant Inventory

Tribe	No. of Key Plants Used	Major Therapeutic Areas
Saora	45	Wound healing, maternal health, and fractures
Kondha	52	Inflammation, bone setting, poisoning
Juang	38	GI disorders, metabolic diseases
Munda	43	Fever, infections, respiratory

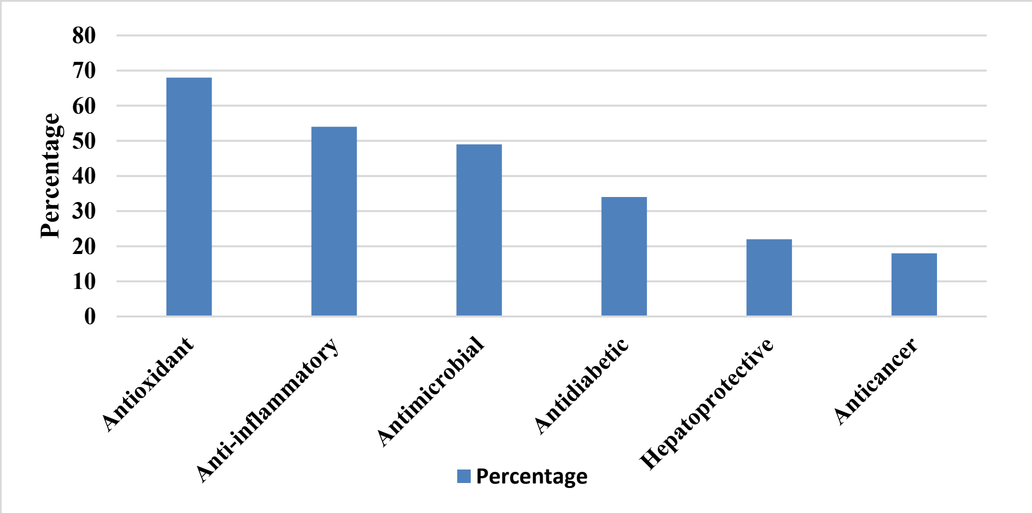
The analysis of phytochemical categories among Odisha's tribal medicinal plants revealed a diverse distribution of bioactive chemotypes. Alkaloids were the largest group at 28%, including compounds like colchicine found in Gloriosa superba. Flavonoids constituted 24%, featuring quercetin in Aloe barbadensis. Terpenoids made up 18%, with arjunolic acid present in Terminalia arjuna (Tahir, H., *et al.* 2025). Phenolic compounds accounted for 15%, dominated by curcumin from Curcuma longa (Vo, T. S., *et al.* 2021) . Saponins were 10%, mainly diosgenin from Costus speciosus. Other compounds, comprising 5%, included glycosides and sterols, contributing to the medicinal diversity essential for Odisha's tribal communities. This chemotype distribution provides a valuable dataset for machine learning-based classification, QSAR modeling, and bioactivity prediction [Graph 1]. The dominance of alkaloids and flavonoids highlights their central role in pharmacological activity and positions them as key targets for AI-assisted drug discovery pipelines.



Graph 1: Chemotype Distribution

The evaluation of pharmacological properties of plants used by Odisha's tribal communities indicates significant antioxidant (68%), anti-inflammatory (54%), antimicrobial (49%), antidiabetic (34%), hepatoprotective (22%), and anticancer (18%) activities [Graph 2]. Key species contributing to these effects include Curcuma longa, Aloe vera (Gupta, V. K., *et al.* 2021), Tinospora cordifolia (Prasad, A., *et al.* 2023), Andrographis paniculata (Sharma, V., & Chaudhary, A. 2025), and Azadirachta indica (Mohanasundaram, P., & Antoneyraj, M. 2025). These findings underscore the diverse therapeutic potential of tribal medicinal plants and their historical use in treating various ailments. AI-based predictive models can further enhance these findings by identifying multi-target drug interactions, optimizing compound selection, and accelerating virtual screening processes, thereby bridging the gap between traditional knowledge and modern pharmacological validation

(Singh, D., & Maer, M. N. D. 2026).



Graph 2: Validated Biological Activities

4.1 *Interpretation of Findings*

The chemotype profile shows a dominance of alkaloids and flavonoids, correlating strongly with the high occurrence of antioxidant, anti-inflammatory, antimicrobial, and antidiabetic activities. Plants used by the tribes demonstrate rich bioactive diversity matching therapeutic needs such as wound healing (Saora), bone disorders (Kondha), digestive ailments (Juang), and fevers/infections (Munda). This validates the relevance and scientific accuracy of tribal medical systems. AI-based analytical tools, including clustering algorithms and predictive modeling, can further validate these correlations by identifying hidden patterns between phytochemical composition and therapeutic outcomes, thereby reinforcing the scientific basis of tribal medicinal systems (Muthuraj, R., & Chandrasekaran, J. 2026).

4.2 Ethnomedicinal–Phytochemical Correlation

A strong correlation exists between traditional tribal practices and the phytochemical composition of plants used by various tribes (Sureshkumar, J., *et al.* 2017). The Saora tribe uses plants like Curcuma longa and Centella asiatica, rich in flavonoids and curcuminoids, for wounds and maternal conditions, backed by their antioxidant and anti-inflammatory properties. The Kondha tribe utilizes Gloriosa superba for bone-setting and detoxification, leveraging colchicine's anti-mitotic effects. The Juang tribe's metabolic disorder treatments involve Costus speciosus, rich in diosgenin and steroidal saponins, supporting antidiabetic effects. Further, the Munda tribe's use of Justicia adhatoda for respiratory ailments aligns with its active alkaloid vasicine. These correlations reveal significant empirical knowledge linking specific health conditions to effective phytochemicals (Mohapatra, D. D., & Pattnaik, S. 2024). AI-driven chemo-informatics approaches, such as QSAR modeling and network pharmacology, can quantitatively establish these correlations, enabling predictive validation and identification of novel therapeutic leads (Al Shami, R., & Mousa, W. K. 2026).

4.3 *Scientific Value of the Tribal Medicinal System*

The tribal medical knowledge of Odisha is a rich source of pharmacological potential, comprising plants with unique chemotypes that are under-explored in modern drug development. These plants contain compounds such as terpenoids, steroidal saponins, and alkaloids, which show promising activity against inflammation, diabetes, infections, and cancer, suggesting their utility in drug discovery. Tribal practices exhibit advanced understanding of toxicology and dosage, often exceeding contemporary preclinical knowledge. This traditional wisdom, when combined with modern analytical methods, can enhance the search for effective herbal medicines in phytopharmacology. Integration with AI technologies enables high-throughput screening of phytochemicals, prediction of pharmacokinetic properties, and identification of multi-target drug candidates. This significantly enhances the translational potential of ethnomedicine in modern drug discovery and phytopharmacology (Parmar, P., & Rathod, G. 2025).

4.4 *Threats to Knowledge Preservation*

Tribal medicinal knowledge is under threat due to rapid modernization disrupting oral tradition transmission, loss of forest biodiversity from mining and climate change, and urban migration of tribal youth, weakening traditional healer lineages. The lack of formal documentation puts this knowledge at risk of disappearing. Additionally, commercial bioprospecting often exploits tribal resources without adequate benefit-sharing, endangering the preservation of these medicinal practices. Urgent action is required to document and protect this valuable ethnopharmacological wisdom. Natural Language Processing (NLP), can play a critical role in digitizing, preserving, and organizing ethnomedicinal knowledge. However, ethical considerations such as data ownership, intellectual property rights, and equitable benefit-sharing must be addressed to ensure sustainable and respectful utilization of tribal knowledge (Muthuraj, R., & Chandrasekaran, J. 2026).

5 CONCLUSION

The traditional medicine systems of the Saora, Kondha, Juang, and Munda tribes represent a rich yet under documented heritage of Odisha. Their medicinal plants exhibit significant chemo-typic diversity with validated pharmacological activities. This integrated review bridges Indigenous knowledge with modern phytochemistry, demonstrating strong potential for drug discovery, sustainable ethnopharmacology, and community health programs. Preservation and scientific validation of tribal medicine are essential for both cultural conservation and biomedical innovation. The integration of Artificial Intelligence with ethnomedicine and phytochemistry provides a transformative approach for accelerating drug discovery, enabling predictive modeling, and validating traditional practices. This interdisciplinary framework bridges indigenous knowledge with modern scientific methodologies, paving the way for sustainable ethnopharmacology and precision herbal therapeutics. Preservation and scientific validation of tribal medicinal knowledge are essential not only for cultural conservation but also for advancing global healthcare through innovative, plant-based drug discovery.

5.1 Research Gaps and Future Directions

To effectively integrate tribal medicine into mainstream healthcare, it is essential to address several critical gaps, including the need for comprehensive metabolomic profiling to identify bioactive compounds in commonly used species. Clinical trials with authentic tribal formulations are necessary to ascertain efficacy and safety, as current studies often focus on isolated compounds. The standardization of dosage and preparation methods is complicated by variability in traditional practices. Additionally, in-vitro and in-vivo studies comparing chemotypes across regions could elucidate the impact of ecological factors on therapeutic effectiveness. There is also potential in studying microbiome–plant interactions, especially since tribal diets rich in wild tubers may influence bioactive responses. Addressing these issues will help validate traditional medical systems and promote the discovery of new therapeutic agents. AI-driven approaches offer significant opportunities to address these challenges through predictive modeling, virtual screening, and data integration. Future research should focus on developing standardized ethnomedicinal databases, integrating multi-omics data, and applying machine learning algorithms to identify novel therapeutic candidates.

REFERENCES:

Abdul, W. M., Hajrah, N. H., Sabir, J. S., Al-Garni, S. M., Sabir, M. J., Kabli, S. A., ... & Bora, R. S. (2018). Therapeutic role of Ricinus communis L. and its bioactive compounds in disease prevention and treatment. *Asian pacific journal of tropical medicine*, *11*(3), 177-185. https://doi.org/10.4103/1995-7645.228431

Acharya, B., Behera, A., Dilnawaz, F., Chowdhury, B., & Behera, S. (2025). Ethnogynecological properties of some selected local herbal plants from western Odisha: an ethnobotanical survey. *Environment, Development and Sustainability*, *27*(2), 4849-4879. https://doi.org/10.1007/s10668-023-04103-1

Aji, N., Kumala, S., Mumpuni, E., & Rahmat, D. (2022). Antibacterial activity and active fraction of Zingiber officinale Roscoe, Zingiber montanum (J. Koenig) Link ex A., and Zingiber zerumbet (L.) Roscoe ex Sm. against Propionibacterium acnes. *Pharmacognosy Journal*, *14*(1). https://doi.org/10.5530/pj.2022.14.15

Ali, K., Kumar, S., & Khan, M. F. (2025). A concise review on bioactive pentacyclic triterpenoids of Centella asiatica (Gotu Kola). *Discover Chemistry*, *2*(1), 1-21. https://doi.org/10.1007/s44371-025-00120-3

Anubhav Dubey, Sanyogita Shahi, Rajesh Mishra, Sribatsa Lanchhana Dash, Kumara Swamy Samanthula. Pharmacological screening of natural products for lung diseases: A comprehensive review, IP Indian Journal of Immunology and Respiratory Medicine, Volume 10, Issue 3, Pages: 110-121, ISSN (Print): 2581-4214, Online ISSN: 2581-4222 https://doi.org/10.18231/j.ijirm.12778.1957379553

Asghar, H. A., Abbas, S. Q., Arshad, M. K., Jabin, A., Usman, B., Aslam, M., & Asghar, A. (2022). Therapeutic potential of Azadirachta indica (Neem)-a comprehensive review. *Sch Int J Tradit Complement Med*, *5*(3), 47-64. https://doi.org/10.36348/sijtcm.2022.v05i03.001

Bhattarai, K., Bhattarai, R., Pandey, R. D., Paudel, B., & Bhattarai, H. D. (2024). A comprehensive review of the phytochemical constituents and bioactivities of Ocimum tenuiflorum. *The Scientific World Journal*, *2024*(1), 8895039. https://doi.org/10.1155/2024/8895039

Dash, M., Singh, S., Sahoo, B. C., Sahoo, S., Sahoo, R. K., Nayak, S., & Kar, B. (2022). Potential role of Indian long pepper (Piper longum L.) volatiles against free radicals and multidrug resistant isolates. *Natural product research*, *36*(16), 4271-4275. https://doi.org/10.1080/14786419.2021.1975703

Dewi, R. L., & Yuniati, R. (2025). Utiliization of Natural Compound from Pegagan (Centella asiatica (L.) Urb.) and Their Potential Role in the Health Sector. *Jurnal Penelitian Pendidikan IPA*, *11*(4), 94-103. https://doi.org/10.29303/jppipa.v11i4.10558

Fuloria, S., Mehta, J., Chandel, A., Sekar, M., Rani, N. N. I. M., Begum, M. Y., ... & Fuloria, N. K. (2022). A comprehensive review on the therapeutic potential of Curcuma longa Linn. in relation to its major active constituent curcumin. *Frontiers in Pharmacology*, *13*, 820806. https://doi.org/10.3389/fphar.2022.820806

Garg, R., Imran, M., & Sharma, V. (2023). Pharmacological and Pharmacognostical Studies of Cassia fistula Linn. https://doi.org/10.59551/IJHMP/25832069/2023.4.2.80

Guan, X. R., Zhu, L., Xiao, Z. G., Zhang, Y. L., Chen, H. B., & Yi, T. (2017). Bioactivity, toxicity and detoxification assessment of Dioscorea bulbifera L.: a comprehensive review. *Phytochemistry Reviews*, *16*(3), 573-601. https://doi.org/10.1007/s11101-017-9505-5

Gupta, V. K., Yarla, N. S., de Lourdes Pereira, M., Siddiqui, N. J., & Sharma, B. (2021). Recent advances in ethnopharmacological and toxicological properties of bioactive compounds from Aloe barbadensis (miller), Aloe vera. *Current Bioactive Compounds*, *17*(5), 2-23. https://doi.org/10.2174/1573407216999200818092937

Hamid, H. S., & Patil, S. (2023, May). A phytochemical and pharmacological review of an Indian plant: Cissus Quadrangularis. In *Medical Sciences Forum* (Vol. 21, No. 1, p. 20). MDPI. https://doi.org/10.3390/ECB2023-14557

Huang, H., Morgan, C. M., Asolkar, R. N., Koivunen, M. E., & Marrone, P. G. (2010). Phytotoxicity of sarmentine isolated from long pepper (Piper longum) fruit. *Journal of agricultural and food chemistry*, *58*(18), 9994-10000. https://doi.org/10.1021/jf102087c

Huynh, H. D., Nargotra, P., Wang, H. M. D., Shieh, C. J., Liu, Y. C., & Kuo, C. H. (2025). Bioactive Compounds from Guava Leaves (Psidium guajava L.): Characterization, Biological Activity, Synergistic Effects, and Technological Applications. *Molecules*, *30*(6), 1278. https://doi.org/10.3390/molecules30061278

Ikiriza, H., Ogwang, P. E., Peter, E. L., Hedmon, O., Tolo, C. U., Abubaker, M., & Abdalla, A. A. M. (2019). Dioscorea bulbifera, a highly threatened African medicinal plant, a review. *Cogent Biology*, *5*(1), 1631561. https://doi.org/10.1080/23312025.2019.1631561

Irakee, M. A., Saxena, S. K., & Jain, S. (2025). Recent research and uses of asparagus racemosus (Shatavari). *International Journal of Therapeutic Innovations*, *3*(2), 6-9. https://doi.org/10.55522/ijti.v3i2.0108

Isha, Kumar, P., & Singh, A. N. (2025). An Overview of Justicia adhatoda: A Medicinal Plant but Native Invader in India. *Conservation*, *5*(1), 2. https://doi.org/10.3390/conservation5010002

Jain, S., Yadav, P. P., Gill, V., Vasudeva, N., & Singla, N. (2009). *Terminalia arjuna* a sacred medicinal plant: phytochemical and pharmacological profile. *Phytochem Rev* 8, 491–502. https://doi.org/10.1007/s11101-009-9134-8

Jangid, T., Jain, A., Bhardwaj, G. S., & Jangir, R. N. (2025). A Comprehensive Review of Phytochemical and Pharmacological Appraisal of Cassia fistula Linn. *Pharmacognosy Research*, *17*(2). https://doi.org/10.5530/pres.20251970

Jayaweera, U., Shivashekaregowda, N. K. H., Herapathdeniya, S. K., & Paranagama, P. A. (2024). Ethnopharmacological uses, phytochemistry, pharmacological activities and toxicity of Justicia adhatoda L.: a review. *Discover Plants*, *1*(1), 41. https://doi.org/10.1007/s44372-024-00042-x

Jha, A. K., & Sit, N. (2023). Methods of extraction of bioactive compounds from Terminalia Chebula (Haritaki) and their application in food and pharmaceutical industry: A review. *Food Bioengineering*, *2*(2), 139-150. https://doi.org/10.1002/fbe2.12053

Jha, U., Singh, K., & Singh, A. (2022). Phytochemical and pharmacology activity of Bhringraj: A review. *International journal of health sciences*, *6*(S3), 11113-11125. https://doi.org/10.53730/ijhs.v6nS3.8560

Joshi, B. C., Durgapal, S., Mukhija, M., & Bhargava, A. (2024). An overview on the phytopharmacological insights into Gloriosa superba L.(Kalahari): a promising endangered plant species. *Discover Plants*, *1*(1), 57. https://doi.org/10.1007/s44372-024-00054-7

Joshi, R. K. (2023). Bioactive usual and unusual triterpenoids derived from natural sources used in traditional medicine. *Chemistry & Biodiversity*, *20*(2), e202200853. https://doi.org/10.1002/cbdv.202200853

Kadam, P., Shahi, S. (2025), Exploring the Medicinal Properties of Underutilized Zingiberaceae Family Plants: A Comparative Study of Thikur, Ginger, and Turmeric.International Journal of Environmental Sciences, 11(4s), 765-777, https://theaspd.com/index.php/ijes/article/view/627

Khandelwal, P., Wadhwani, B. D., Rao, R. S., Mali, D., Vyas, P., Kumar, T., & Nair, R. (2024). Exploring the pharmacological and chemical aspects of pyrrolo-quinazoline derivatives in Adhatoda vasica. *Heliyon*, *10*(4). https://doi.org/10.1016/j.heliyon. 2024.e25727

Krishna Kumar Kashyap, Manoj Kumar Ghosh, Sanyogita Shahi, Kishor Diwaker (2022), Defluoridation of Groundwater with the Help of Azadirachta indica leaves as Bioadsorbent in Korba, Chhattisgarh, India, Bioscience Biotechnology Research Communication, Vol. 15, Issue 2, Pages: 321-327, E-ISSN: 2321-4007, https://doi.org/10.21786/bbrc/15.2.9

Kumar, M., Tomar, M., Amarowicz, R., Saurabh, V., Nair, M. S., Maheshwari, C., ... & Satankar, V. (2021). Guava (Psidium guajava L.) leaves: Nutritional composition, phytochemical profile, and health-promoting bioactivities. *Foods*, *10*(4), 752. https://doi.org/10.3390/foods10040752

Kumar, P., & Singh, A. N. (2025). An Overview of Justicia adhatoda: A Medicinal Plant but Native Invader in India. *Conservation (2673-7159)*, *5*(1). https://doi.org/10.3390/conservation5010002

Saila, I. Z., Islam, M. R., Akhie, Z. K., Rahman, S. M., Islam, M. E., & Hossain, K. M. (2025). Effect of tulsi (Ocimum sanctum) and moringa (Moringa stenopetala) leaf extract of natural preservatives for raw milk: Studies on physicochemical, antioxidant, and microbial properties. *Applied Food Research*, *5*(1), 100904. https://doi.org/10.1016/j.afres.2025.100904

Kumari, M., Prasad, A., Mathur, A. K., & Mathur, A. (2023). Strategies for conservation and production of bioactive phytoconstituents in commercially important Ocimum species: a review. *Plants for Immunity and Conservation Strategies*, 57-85. https://doi.org/10.1007/978-981-99-2824-8_4

Sureshkumar, J., Silambarasan, R., & Ayyanar, M. (2017). An ethnopharmacological analysis of medicinal plants used by the Adiyan community in Wayanad district of Kerala, India. *European Journal of Integrative Medicine*, *12*, 60-73. https://doi.org/10.1016/j.eujim.2017.04.006

Maji, P., Dhar, D. G., Misra, P., & Dhar, P. (2020). Costus speciosus (Koen ex. Retz.) Sm.: Current status and future industrial prospects. *Industrial crops and products*, *152*, 112571. https://doi.org/10.1016/j.indcrop.2020.112571

Mitra, A., Singh, M., Banga, A., Pandey, J., Tripathi, S. S., & Singh, D. (2023). Bioactive compounds and therapeutic properties of Aloe vera—A review. *Plant Sci. Today*, *10*, 1-7. https://doi.org/10.14719/pst.1715

Mohanasundaram, P., & Antoneyraj, M. (2025). A systematic review of neem flower (Azadirachta indica): a promising source of bioactive compounds with pharmacological and immunomodulating properties. *Tradit Med Res*, *10*(7), 41. https://doi.org/10.53388/TMR20241025001

Mohapatra, D. D., & Pattnaik, S. (2024). Metabolic Profiling Technologies for Biomarker Discovery in Ethnomedicinal Plants for Drug Development. In *Ethnomedicinal Plants for Drug Discovery: Current Developments* (pp. 323-343). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-97-3405-4_13

Mukjerjee, S., & Karati, D. (2022). A mechanistic view on phytochemistry, pharmacognostic properties, and pharmacological activities of phytocompounds present in Zingiber officinale: A comprehensive review. *Pharmacological Research-Modern Chinese Medicine*, *5*, 100173. https://doi.org/10.1016/j.prmcm.2022.100173

Nadeem, M., Khan, M. A., Ahmad, F. J., Parvez, S., Akhtar, M., & Najmi, A. K. (2025). Exploring the neuroprotective role of Asparagus racemosus (Shatavari) in Alzheimer’s disease: mechanisms, evidence, and future directions. *3 Biotech*, *15*(7), 197. https://doi.org/10.1007/s13205-025-04355-w

Tripathy, P., Jena, P. K., Dandasena, T. K., Shahi, S. (2023), Medicinal Value about Thikur: Review, European Chemical Bulletin, 12, 1s (Part B), 143-150, https://doi.org/10.31838/ecb/2023.12.s1.0162023.21/04/2023

Gupta, A. (2023). Antibacterial screening of Terminalia chebula Retz. against certain bacterial strains. *Environment Conservation Journal*, *24*(2), 320-326. https://doi.org/10.36953/ECJ.18192546

Patil, A. M., Pawar, A. B., Purane, L. M., & Redasani, V. V. THERAPEUTIC POTENTIAL AND

PHARMACOLOGICAL INSIGHTS OF CISSUS QUADRANGULARIS LINN: A COMPREHENSIVE REVIEW. https://doi.org/10.13040/IJPSR.0975-8232.IJP.12(4).272-81

Patra, J. K., Das, S. K., & Thatoi, H. (2015). Phytochemical profiling and bioactivity of a mangrove plant, Sonneratia apetala, from Odisha Coast of India. *Chinese Journal of Integrative Medicine*, *21*(4), 274-285. https://doi.org/10.1007/s11655-014-1854-y

Prasad, A., Patel, P., Kumari, M., Saxena, G., Chakrabarty, D., & Singh, S. S. (2023). A literature update on strategies for harnessing and conserving the bioactive phytochemicals from Tinospora cordifolia: current status, challenges, and future prospects. *Plants for Immunity and Conservation Strategies*, 1-20. https://doi.org/10.1007/978-981-99-2824-8_1

Angayarkanni, J., Ramkumar, K. M., Priyadharshini, U., & Ravendran, P. (2010). Antioxidant potential of Amorphophallus paeoniifolius in relation to their phenolic content. *Pharmaceutical biology*, *48*(6), 659-665. https://doi.org/10.3109/13880200903241846

Rajaram, V., Namasivayam, A., Shanmugam, R., Mahendra, J., Sudhakar, U., Munusamy, T., & Subbiah, U. (2024). Terminalia arjuna: An overview of its magical properties. *Bioinformation*, *20*(12), 2080. https://doi.org /10.6026/9732063002002080

Bhuyan, C., Saha, D., & Rabha, B. (2024). Repellent activity of Vitex negundo and Curcuma longa herbal extract against Simulium species in India. *Journal of Vector Borne Diseases*, *61*(3), 435-443. https://doi.org/10.4103/JVBD.JVBD_181_23

Rani, A., & Bansal, R. (2023). Comparative antimicrobial study of bark extract (Aqueous, Chloroform, Ethanol) of Pum Kutaja (Holarrhena antidysenterica [Linn] Wall ex. G. Don) & Stri Kutaja (Wrightia tinctoria R. Br). *Journal of Ayurveda and Integrated Medical Sciences*, *8*(9), 46-53. https://doi.org/10.21760/jaims.8.9.8

Razavi, B. M., Ghasemzadeh Rahbardar, M., & Hosseinzadeh, H. (2021). A review of therapeutic potentials of turmeric (Curcuma longa) and its active constituent, curcumin, on inflammatory disorders, pain, and their related patents. *Phytotherapy Research*, *35*(12), 6489-6513. https://doi.org/10.1002/ptr.7224

Sahu, M., Kaushik, A., Mishra, A. U., Rout, P. K., Sundaresan, V., Shanker, K., ... & Shukla, A. K. (2025). Aegle marmelos effectively attenuates DSS-induced colitis by restoring intestinal mucosal barrier and alleviating inflammation through modulation of gut microbiota in mice. *Phytomedicine*, 157538. https://doi.org/10.1016/j.phymed.2025.157538

Sahu, S. C., Dhal, N. K., & Mohanty, R. C. (2010). Potential medicinal plants used by the tribal of Deogarh district, Orissa, India. *Studies on Ethno-Medicine*, *4*(1), 53-61. https://doi.org/10.31901/24566772.2010/04.01.07

Sai, N. M., Bodh, S., & Verma, P. (2024). A comprehensive review of the anticancer potential and other pharmaceutical effects of Hemidesmus indicus R. Br. *Ann Phytomed*, *13*(1), 1-8. http://dx.doi.org/10.54085/ap.2025.14.1.7

Sanyal, R., Nandi, S., Pandey, S., Das, T., Kaur, P., Konjengbam, M., ... & Dey, A. (2022). In vitro propagation and secondary metabolite production in Gloriosa superba L. *Applied Microbiology and Biotechnology*, *106*(17), 5399-5414. https://doi.org/10.1007/s00253-022-12094-8

Shahi, S., Singh, S. K. (2022). Medicinal Plants in Chhattisgarh State, Journal of Pharmaceutical Negative Reports, 13 (5s), 647-653. https://doi.org/10.47750/pnr.2022.13.S05.102

Sarkar, S., Singh, R. P., & Bhattacharya, G. (2021). Exploring the role of Azadirachta indica (neem) and its active compounds in the regulation of biological pathways: an update on molecular approach. *3 Biotech*, *11*(4), 178. https://doi.org/10.1007/s13205-021-02745-4

Shahi, S., Singh, S. K. (2025) Phytochemical Analysis and Characterization of Cancer-Cure Medicinal Plants: A Comprehensive Review. International Journal of Environmental Sciences, Volume 11, Issue 10s, Pages: 592-606, ISSN: 2229-7359. https://doi.org/10.64252/rg3fjw45

Sharma, P., Singh, B., Rastogi, R., Kumar, S., Nagar, G., & Rathore, P. (2025). Surveillance of importance of medicinal plant chitrak (Plumbago zeylanica) in the treatment of lifestyle disorders and in wellness tourism: an empirical approach for 21st century lifestyle. *International Journal of Indian Culture and Business Management*, *35*(3), 344-367. https://doi.org/10.1504/IJICBM.2025.147158

SHARMA, R., & Roy, A. S. (2025). A review on comparative studies of phytochemical evaluation and pharmacological activities of Calotropis species: Calotropis procera and Calotropis gigantea. *THE JOURNAL*, *14*(1), 62-69. https://doi.org/10.31254/phyto.2025.14109

Sharma, V., & Chaudhary, A. (2025). A Comprehensive Bibliometric Analysis of Global Trends on Andrographis paniculata (Burm. f.) Wall. ex Nees (Kalmegh): A multifarious Herb. *Pharmacological Research-Natural Products*, 100377. https://doi.org/10.1016/j.prenap.2025.100377

Singh, A. (2024). A Review on Traditional uses, Bioactive Chemical Constituents, Pharmacology, and Toxicity of Tinospora cordifolia (Guduchi or Giloy). *Research Journal of Pharmacognosy and Phytochemistry*, *16*(2), 107-111. https://doi.org/10.52711/0975-4385.2024.00021

Singh, L. S., & Singh, W. S. (2024). Centella asiatica and its bioactive compounds: a comprehensive approach to managing hyperglycemia and associated disorders. *Discover Plants*, *1*(1), 54. https://doi.org/10.1007/s44372-024-00070-7

Tahir, H., Akhtar, M. N., Bishoyi, A. K., Sanghvi, G., Rasheed, M., Afzaal, M., ... & Kinki, A. B. (2025). Nutritional Composition, Phytochemical Profile, Extraction Methods of Bioactive Components, and Health Benefits of Terminalia Arjuna Bark. *eFood*, *6*(2), e70038. https://doi.org/10.1002/efd2.70038

Tanwar, A. K., Chatterjee, D., Jain, N., Sharma, S., Tikoo, K., & Singh, I. P. (2025). Chemical basis of the traditional ayurvedic detoxification process of the toxic medicinal plant Plumbago zeylanica. *Journal of Natural Products*, *88*(1), 15-23. https://doi.org/10.1021/acs.jnatprod.3c00975

Thawkar, M. M., Jeurkar, M. M., Saktel, M. G., & Mohitkar, S. P. (2024). Phyto-pharmacology profile of Holarrhena antidysenterica: a review. *Journal of Advanced Zoology*, *45*(2), 1294-1299. https://l1nq.com/5Ms8i

Tripathy, S., Singh, J. P., Tripathi, A., Srivastava, S., Chaurasia, V. K., Kumar, R., ... & Pandey, S. (2024). A REVIEW ON THE PHARMACOLOGICAL, BIOLOGICAL, CHEMICAL AND THERAPEUTIC VALUE OF ECLIPTA PROSTRATE (BHRINGRAJ PLANT). *Biochemical & Cellular Archives*, *24*(2). https://doi.org/10.51470/bca.2024.24.2.3011

Ramjan, A. H., Akter, R., Hasan, M. S., Amin, M. F., Muktadir, A. M. M., Kamruzzaman, H. M., & Hasan, M. M. (2025). Phytochemical screening and evaluation of pharmacological activities of Clerodendrum viscosum methanolic leaves extract. *Journal of Pharmacognosy and Phytochemistry*, *14*(4), 209-222. https://doi.org/10.22271/phyto.2025.v14.i4c.15471

Vikal, A., Maurya, R., Patel, P., & Kurmi, B. D. (2025). Andrographis paniculata in Fatty Liver Disease: Mechanisms, Nanocarrier Approaches, and Therapeutic Potential. *Phytomedicine Plus*, 100903. https://doi.org/10.1016/j.phyplu.2025.100903

Vo, T. S., Vo, T. T. B. C., Vo, T. T. T. N., & Lai, T. N. H. (2021). Turmeric (Curcuma longa L.): Chemical components and their effective clinical applications. *Journal of the Turkish Chemical Society Section A: Chemistry*, *8*(3), 883-898. https://doi.org/10.18596/jotcsa.913136

Kher, M. M., Shekhawat, M. S., Nataraj, M., & Teixeira da Silva, J. A. (2020). Indian sarsaparilla, Hemidesmus indicus (L.) R. Br. ex Schult: tissue culture studies. *Applied Microbiology and Biotechnology*, *104*(15), 6463-6479. https://doi.org/10.1007/s00253-020-10714-9

Rudito, Suwarto, Witono, Y., Saragih, B., & Tangke Arung, E. (2021, August). Phytochemical and antioxidant analysis of fermented "Dayak" wild yam (*Dioscorea hispida* Dennst), purple yam (*Dioscorea alata*), and air potato (*Dioscorea bulbifera* L.) tuber flour. In *IOP Conference Series: Earth and Environmental Science* (Vol. 810, No. 1, p. 012005). IOP Publishing. https://doi.org/10.1088/1755-1315/810/1/012005

Worasing, K., Sungthong, B., & Phimarn, W. (2023). Effectiveness of Zingiber montanum herbal compress remedy for pain management: An updated systematic review and meta-analysis. *Scientia Pharmaceutica*, *91*(2), 24. https://doi.org/10.3390/scipharm91020024

Yadav, A., Verma, R. K., Basole, S., Tripathi, G., Das, K., Jena, N., & Kumar, S. (2025). Phytochemical analysis of leaves, stem and root of Punarnava (Boerhavia diffusa L.): a medicinal herb of Nyctaginaceae. *Plants & Secondary Metabolites*, *5*, 25. https://sl1nk.com/VzXwI

Jamal, A., Arif, A., Kiran, S., Shahid, M. N., & Hossain, M. B. (2025). Phytochemical investigations and pharmacological potential of organic extracts of Calotropis gigantea L. leaves. *Scientifica*, *2025*(1), 1669969. https://doi.org/10.1155/sci5/1669969Digital Object Identifier (DOI)

Yadeta, A. T. (2024). Chemical structures, biological activities, and medicinal potentials of amine compounds detected from Aloe species. *Frontiers in Chemistry*, *12*, 1363066. https://doi.org/10.3389/fchem.2024.1363066

Zhang, M., Zhao, R., Wang, D., Wang, L., Zhang, Q., Wei, S., ... & Wu, C. (2021). Ginger (Zingiber officinale Rosc.) and its bioactive components are potential resources for health beneficial agents. *Phytotherapy Research*, *35*(2), 711-742. https://doi.org/10.1002/ptr.6858

Parmar, P., & Rathod, G. (2025). Beyond informed consent: Toward culturally situated consent models in traditional medicine—AI integration. *Journal of Medical Society*, *39*(3), 164-167. https://doi.org/10.4103/jms.jms_90_25

Al Shami, R., & Mousa, W. K. (2026). Mining the Hidden Pharmacopeia: Fungal Endophytes, Natural Products, and the Rise of AI-Driven Drug Discovery. *International Journal of Molecular Sciences*, *27*(3), 1365.

https://doi.org/10.3390/ijms27031365

Muthuraj, R., & Chandrasekaran, J. (2026). Nature meets machine: the AI renaissance in natural product drug discovery. *Natural Products and Bioprospecting*, *16*(1), 37. https://doi.org/10.1007/s13659-025-00589-6

Orobator, E., Nnodumele, C., Tsegay, N., Onyekwelu, P., Odenigbo, A., Ugbor, M. J., ... & Elechi, K. (2025). Applications of Artificial Intelligence in Plant-Based Anticancer Drug Discovery and Development. *Journal of Pharma Insights and Research*, *3*(2), 203-210. https://doi.org/10.69613/fbzjfk64

Singh, D., & Maer, M. N. D. (2026). Ethical Marketing in Medical Tourism: Use of AI in Connecting With Conscious Healthcare Consumers in India and Indonesia. In *Marketing Mental Wellness in Medical Tourism* (pp. 301-344). IGI Global Scientific Publishing. https://doi.org/10.4018/979-8-3373-6881-8.ch011

Amin[1], A., Abyaz, R., Alom, S., Siam, S. A., Raihan, R., Imran, A., & Azad, A. K. The Journey of Industrial Revolutions and the Rise of Ai in Pharmaceutical Manufacturing. https://doi.org/10.35629/4494-100112351251

Zahara, K., Panda, S. K., Swain, S. S., & Luyten, W. (2020). Metabolic diversity and therapeutic potential of Holarrhena pubescens: an important ethnomedicinal plant. *Biomolecules*, *10*(9), 1341. https://doi.org/10.3390/biom10091341

Kshatri, J. S., Kavitha, A. K., Rehman, T., Bhattacharya, H., Bhuyan, D., Mansingh, A., ... & Pati, S. (2025). A comprehensive assessment of health indicators among tribal populations in Odisha, India (Odisha Tribal Family Health Survey): a community-based, cross-sectional study. *The Lancet Regional Health-Southeast Asia*, *38*. https://doi.org/10.1016/j.lansea.2025.100611

Swain, M. Origin, Culture And Kinship Structure Of Hill Saora. *Education*, *6*(1). https://l1nq.com/geE73