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Review Article

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A COMPREHENSIVE REVIEW ON ETHNOMEDICINAL PLANTS OF LOWER HIMALAYAN REGIONS WITH ANTI-INFLAMMATORY, ANTI-OXIDANT, AND ANTI-DIABETIC POTENTIAL

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ABSTRACT

Background: The Himalayan region is globally recognized as a biodiversity hotspot, harboring a broad spectrum of medicinal plant species with significant therapeutic potential. Ethnomedicinal practices in this region have long guided traditional healthcare systems, yet many indigenous species remain underexplored for their pharmacological properties and bioactive compounds. **Objective:** This review aims to provide a comprehensive analysis of ethnomedicinal plants from the lower Himalayan regions with reported anti-inflammatory, antioxidant, and antidiabetic properties, highlighting their phytochemical composition and therapeutic relevance. **Methodology:** An ethnopharmacological survey was conducted involving 133 informants, including 20 traditional healers, through semi-structured interviews, participatory group discussions, and in-field observations. Plant identification was confirmed using photographic records and, when possible, direct verification in natural habitats. Relevant literature was also synthesised to contextualise traditional claims within existing pharmacological evidence. **Results and Discussion:** A total of 90 plant species were documented, many of which are traditionally used to manage chronic inflammatory conditions, oxidative stress, and diabetes. These species are rich in pharmacologically active constituents, including flavonoids, alkaloids, polyphenols, terpenoids, and proanthocyanidins, which modulate key biochemical pathways associated with inflammation, oxidative damage, and glucose regulation. Despite consistent ethnomedicinal use, scientific validation of most species remains limited, underscoring the need for bioactivity-guided isolation, phytochemical standardization, and preclinical-to-clinical evaluation. **Conclusion**: Lower Himalayan ethnoflora represents a valuable reservoir of pharmacologically significant plants with promising therapeutic applications. Bridging traditional knowledge with modern pharmacological research can enable drug discovery and development of novel phytotherapeutics targeting prevalent chronic diseases.

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INTRODUCTION

The study of how indigenous people use plants is known as ethnobotany [1]. It is crucial to comprehend the dynamic interactions between cultural systems and biological variety [2]. Traditional knowledge can be preserved for future generations & other communities through ethnobotanical surveys of conventional knowledge [2,3]. In particular, the therapeutic properties of plant species serve as a source of essential medicines [1,4].

The Lower Himalayas, spanning northern India, Nepal, Bhutan, and parts of the Tibetan Plateau, are recognized not only for their rich biodiversity but also for the ethnomedicinal heritage conserved by local communities [5]. Because of their close linkages between local and indigenous communities and the environment, and their often living in natural habitats, they possess extensive traditional knowledge about the importance and uses of living resources [6]. Indigenous knowledge of medicinal plant use has evolved since ancient times and is an essential component of traditional healthcare practices for managing human ailments [7,8]. In healthcare, approximately 85% of the world's population in developing countries relies on traditional medicinal plants. Because of their recognized negligible side effects and low cost, the use of medicinal plants in health care systems is becoming increasingly popular worldwide [9-12]. The lower Himalayan or sub-Himalayan range comprises the southernmost part of the Himalayas, located on the Indian subcontinent, with altitudes ranging from 600 to 1200m above sea level. Compared to the higher Himalayas, these mountain ranges have lower altitudes [13,14].

Therapeutic use of herbs has a long tradition in India. Ancient Hindu texts such as the Charak Samhita [1000–800 BCE], the Rigveda [4500–1600 BCE], and others record the earliest known use of plants. 800–700 BCE Sushrut Samhita, among others. Although more than 2,000 plant species are known to be used medicinally in the Indian subcontinent, 500 are frequently used in the many indigenous medical systems practiced there. More than 54 million tribal people live on the Indian subcontinent, accounting for 15% of the nation's land area. They live in roughly 5000 communities that are dominated by forests [15]. For their primary medical care, the majority of tribal groups continue to rely on regional traditional healing systems [16]. Data from conventional indigenous medicine have contributed significantly to the development of new plant-derived compounds used as chemotherapeutic agents. One of the most geographically and culturally diverse states in India is West Bengal, which is also home to numerous ethnic groups, including the Oraons, Mundas, Lodhas, Mahalis, Bhutias, Bedias, etc [17]. The sub-Himalayan region of West Bengal is also known for its home gardens, as in other humid areas, owing to its high rainfall, rich ethnic diversity, and biodiversity [18]. These ethnic populations support vegetative diversity by relying primarily on home gardens for their livelihood. These home gardens have a wide variety of ethnomedicinal plants [14,19]. There are four distinct physiographic zones in the North Western Himalayan state of Himachal Pradesh: dry temperate-alpine, moist temperate, sub-temperate, and sub-tropical. The state has a high plant diversity, including rare and unique species, due to its diverse climate and altitudinal gradients [20].

The state forest department has identified 57 endangered wild medicinal plants and 91 non-timber forest products used for economic purposes. Tribal groups like the Gaddis and Gujjars reside in the Himachal Pradesh districts of Kangra and Chamba. These individuals are the custodians of ancient indigenous knowledge regarding the ecological assets in their immediate environment. They have traditionally used these resources in their daily lives for various reasons [4]. The Lepchas are the oldest documented tribe in Sikkim, India; the majority live in the Dzongu Valley, a Lepcha community reserve that is formally designated and borders the Khangchendzonga Biosphere Reserve in the northern district. The Dzongu Lepchas are renowned for preserving a strong cultural legacy. Given the ongoing cultural and economic shifts brought about by globalization, it was urgently necessary to thoroughly document the little-known ethnomedical practices of the Lepchas of the Dzongu Valley.

According to the survey, 118 species from 71 families and 108 genera are used ethnomedically by Lepchas to treat approximately 66 illnesses, which can be divided into 14 major categories [21]. 51 Asteraceae species, representing 38 genera and 12 tribes, were collected and found to be beneficial in Tharu daily life for the treatment of various illnesses [22]. The Sherpa tribes of Nepal and Sikkim, known worldwide for their extraordinary mountain-climbing skills, have also maintained distinctive ethnomedicinal knowledge for treating numerous diseases [23]. Because of the mutually beneficial relationship between plant and cultural diversity, as well as the support

provided by social norms, ecological awareness, and cultural memory, traditional knowledge and biodiversity are closely linked in the Himalayas. Every ethnic group used plants extensively for ethnomedical purposes, and information originally passed down orally is now available in writing for reference. This might open the door to offering incentives to nearby communities to celebrate and showcase their abilities and benefit from future development projects [24].

Antioxidant

There are several reasons our bodies produce hydroxyl radicals. Because of its extreme instability, this radical is extremely reactive. Lipid peroxidation begins when radicals attack membranes and lipoproteins, leading to the formation of vascular lesions. It is thought that antioxidants are crucial to the body's defensive mechanism against ROS. An antioxidant is defined as "any substance that significantly delays or inhibits oxidation when present at low concentrations compared with that of an oxidizable substrate." As radical scavengers, antioxidants in plant material help convert radicals into less reactive species. Fruits, vegetables, tea, and other foods include a range of antioxidants that scavenge free radicals. Regular consumption of fruits and vegetables rich in antioxidants has been shown to reduce the risk of chronic diseases. Antioxidants have garnered significant interest recently in relation to oxidative stress & radicals, as well as cancer prevention & treatment [25].

When the equilibrium between the production of reactive oxygen species [ROS] and detoxification favors an increase in ROS levels, oxidative stress takes place, disrupting cellular function. ROS damages cellular macromolecules, altering proteins, nucleic acids, and lipids. Their production is thought to be a pathobiochemical mechanism that contributes to the development or progression of several diseases, including diabetes, ischemic heart disease, atherosclerosis, initiation of carcinogenesis, and liver diseases [26].

Anti-inflammatory

Numerous things, including damaged cells, pathogens [viruses, bacterial or fungal infections], and dangerous chemicals, can trigger inflammation, a complicated biochemical loop of the immune system. The process of inflammation is marked by swelling, redness, heat, pain, and loss of tissue function. It is driven by the local immune response, vascular dilatation, leukocyte recruitment, and the release of inflammatory mediators, which are responsible for the development, persistence, and eventual resolution of the acute phase of inflammation. India's health faces major challenges from inflammatory diseases, which incur substantial economic costs [27]. The world's highest number of cardiovascular disease cases exists in India because more than 54 million people have coronary artery disease, which develops through atherosclerosis and leads to strokes. The population of India includes 15 million people with rheumatoid arthritis, representing 0.28-0.7% of the total population [28,29].

The lower Himalayan region of Northeast India maintains one of Earth's most diverse ecosystems, which indigenous people have used medicinal plants for centuries to treat various medical conditions. The Northeast Himalayan tribal communities have safeguarded vital plant-medicine knowledge through traditional knowledge systems, which scientists now use for drug development and pharmacological research [30]. Traditional healers recognized swelling, redness, heat, and pain as signs of inflammation, but lacked contemporary scientific understanding of these symptoms. Traditional healing practices of Northeast Himalayan indigenous communities have evolved over thousands of years to treat modern inflammatory diseases using specific plant-based remedies [31]. The healthcare system in this region integrates physical symptom management with spiritual and social care to achieve comprehensive patient well-being. Even though there are many drugs available to treat pain and inflammation, these conditions are still uncontrollable, and the current treatments have limitations.

The most widely used medications for treating pain and inflammation are non-steroidal anti-inflammatory drugs, NSAIDs. These medications prevent prostaglandin formation by blocking the cyclo-oxygenase [COX] enzyme. The preferred medication for severe or persistent pain, especially cancerous pain that acts via central pathways, is an opioid analgesic. Inflammatory crises are also controlled and suppressed by a variety of additional medications, such as immunosuppressive medications and steroids. The main disadvantages of the synthetic NSAIDs now on the market are their toxicity, side effects, and recurrence of symptoms after stopping use [31]. Indigenous knowledge of plant harvesting times and processing techniques, and of medication amounts, stems from extensive practical experience and continuous improvement over many

centuries. Tribal communities use anti-inflammatory plants in their daily practices. The tribes maintain detailed rules for plant collection, which include specific techniques and quantity limits and growth period management to show their natural ability to maintain ecological stability and preserve resources There are various tribal communities found, such as Kaski, Garo, Khasi, Mampo, Lohit, etc., that use ethnomedicinal plants as a source of medication for various joint pains, inflammation, gum swelling analgesic activities. Ayurvedic formulations are derived from these ethnomedicinal plants, such as the Triphala decoction. [*Terminalia bellarica*], paste, Chavanaprasha, Dasamoolarishta, Vyaghriharitaki avaleha, Vyaghri tailam, Vyaghriyadi kwatha, Vyaghri ghrtam [*Solanum xanthocarpum*] [32, 33].

Antidiabetic

The definition of diabetes mellitus varies by perspective and is not a single condition. From a medical standpoint, it refers to a group of metabolic disorders characterized by partial or complete insulin deficiency and associated with hyperglycemia. Chronic exposure to hyperglycemia can cause microvascular problems in the peripheral, renal, or retinal vasculature. Although these symptoms are indicative of diabetes, they are too late to be used for diagnosis. Myocardial infarction, stroke, and peripheral artery disease, the so-called macrovascular consequences of diabetes, occur more frequently because they are often present in the prediabetic state. To highlight the clinical issues that the majority of patients face, it has been proposed that diabetes be described as "premature atherosclerosis with associated hyperglycemia." From a societal standpoint, diabetes is defined as the financial burden the condition places on economies due to its expensive treatment and related early morbidity and death.

According to each patient, diabetes is a chronic illness that necessitates daily dietary and lifestyle changes, blood glucose self-monitoring, and frequent prescription delivery. It may be linked to different levels of anxiety, depression, and repeated trips to the doctor [34]. Chronic high blood sugar caused by improper insulin action due to insulin resistance, deficiency, or both is the primary characteristic of diabetes mellitus. Persistent hyperglycemia, caused by disruptions in glucose homeostasis, impairs the metabolism of proteins, fats, and carbohydrates [35]. It results in long-term harm to the heart, blood vessels, kidneys, nerves, and eyes, as well as failure and dysfunction. Premature mortality is caused by these comorbidities [36]. The length of diabetes and the presence of hyperglycemia are linked to the severity of the impairment. Reactive oxygen species and advanced glycation products are produced inside cells in conjunction with hyperglycemia. This metabolic disruption triggers inflammation, which, in turn, leads to a range of micro- and macrovascular problems [37].

Factors such as advanced age, smoking, sedentary lifestyle, poor diet, obesity, overweight, gestational diabetes, family history, and ethnicity all raise the chance of developing diabetes [38]. Five to ten percent of diabetics have type 1 diabetes, which is autoimmune in nature and requires exogenous insulin consumption due to T-cell-mediated loss of pancreatic β-cells 2] [38]. It is primarily seen in children and adolescents. Over 90% of diabetics have type 2 diabetes mellitus [T2DM], which is caused by the body's incapacity or deficiency to use the insulin that is produced. The inability of the insulin target organs, liver, adipose tissue, and skeletal muscles to respond to insulin results in insulin resistance [39]. Insulin action is blocked when oxidative stress and inflammation trigger signalling pathways such as c-Jun Amino Terminal Kinase and IkappaB kinase nuclear kappa B [NF-KB] pathways.

Biguanides, thiazolidinediones, sulfonylureas, dipeptidyl peptidase-4 inhibitors, sodium-glucose transport protein 2 inhibitors, α-glucosidase inhibitors, and non-sulfonylurea secretagogues are among the commonly used oral diabetes drugs [40]. Achieving a euglycemic index with insulin or oral anti-diabetic drugs alone leads to intermittent hypoglycemia, elevated lipid reserves, and digestive issues. Therefore, this underscores the need to identify new sources with antidiabetic properties [41,42].

There is a strong correlation between antioxidant, antidiabetic, and anti-inflammatory activity. The exact mechanisms by which oxidative stress speeds up the development of diabetic complications are only partially understood, despite a substantial body of evidence demonstrating that oxidative stress is primarily caused by hyperglycemia and is linked to a crucial process in the initiation and progression of diabetic complications. Hyperglycemia-induced oxidative stress produces free radical species, which, in turn, stimulate the production of inflammatory mediators. Unstable molecules known as free radicals attack healthy cells and pair up their unpaired electrons, resulting in a

loss of cell structure and/or function. Degenerative diseases like cancer, inflammation, immune system deterioration, liver disease, brain dysfunction, cardiovascular disorders, diabetic renal failure, and others are significantly exacerbated by these damaged cells. The harmful effects of these unstable species on the human body can be controlled by plant antioxidants, which scavenge free radicals. They may also help treat some complications of diabetes. The objective of this work was to conduct a large-scale screening of plant extracts for low side effects and for both α-amylase inhibitory and free radical-scavenging activities [25,26,43].

MATERIALS AND METHODS

Details of the study area

In a recent study of the lower Himalayan region, including Uttarakhand, Nepal, Assam, Meghalaya, Sikkim, Darjeeling, Kashmir, Bhutan, Arunachal Pradesh, and Mizoram, we observed significant biodiversity and unique ecosystems. This is home to a wide array of plant species, ranging from medicinal herbs such as *Tinospora cordifolia* [Gudhuchi] and *Costus speciosus* [Betlouri] to many edible wild fruits, leafy greens, and shoots, which play important cultural and ecological roles [44].

Additionally, in these regions, we observe that these communities have a strong relationship with their flora, which they use for food, medicine, and spiritual practices; many of their activities are grounded in the traditional knowledge systems they have developed over generations. A survey of different tribes and some plants from the lower Himalayas has revealed diverse species with extracts from leaves, roots, rhizomes, whole plants, seeds, fruits, and bark. The traditional preparation of various plant species includes decoction, juice, paste, and fermentation. For example, 'Paris polyphylla', found in the Kaski tribe of western Nepal, exhibits significant anti-inflammatory activity and is used as a fermented preparation and in pickles for consumption. Similarly, Chariata [*Swertia chirayita*] exhibits multi-potential activity, including antioxidant, antidiabetic, and anti-inflammatory effects. The traditional preparation of fresh juice of shoots includes antidiabetic activity [45,46]

Data collection and analysis

A study of over 900 scientific papers that merged articles from Semantic Scholar, PubMed, Google Scholar, and ScienceDirect databases. Specific search strings were applied in the research strategy to fetch ethnomedicinal plants from the lower Himalayan region with antioxidant, antidiabetic, and anti-inflammatory potential. The research journey began with 979 papers, which were reduced to 554 eligible studies, then to 443 after an additional layer of assessment, and finally to 86 pertinent documents for this review.

RESULT AND DISCUSSION

The native people, together with local healers in the Lower Himalayan region, have documented rich ethnomedical practices that use plants to manage chronic diseases such as diabetes, oxidative stress, and inflammation. In this region, we summarize the therapeutic uses of these species based on findings from indigenous wisdom.

Table 1: Ethnomedicinal plants with Anti-inflammatory Activity

SNo	Scientific name	Family	Vernicular name	Part used	Traditional preparation
1	*Coptis teeta walls*	Ranunculaceae	Mishimi teetay	Rhizome	Rhizome decoction, Fresh rhizome pastes [47, 48]
2	*Aconitum heterophyllum*	Ranunculaceae	Ativisha, Patrees	Roots [Tuber], leaf	Decoction churna [49]
3	*Paris polyphylla*	Liliaceae	Herb peris, Love Apple, Satuwa	Rhizomes [dried], leaf, stem	Paste, fermented preparation, churna [44, 45]
4	*Tinospora cordifolia*	Menispermaceae	Guduchi, Giloy, Amrita	Stem, leaf, roots	Paste, boiling [44, 45]
5	*Ealeocarpus floribundus*	Elaeocarpaceae	Jalpai, Indian olive	Fruit, leaf, bark	Fruits are boiled with mustard oil, bark by paste [33,50]
6	*Clerodendrum wallichii*	Verbenaceae	Sampulis	Leaf	Leaf paste, Decoction [48]
7	*Terminalia bellarica*	Combretacea	Barro	Fruit, bark	Triphala, decoction [33]
8	*Achyranthes aspera*	Amaranthaceae	Prickly Chaff Flower, Devil's Horsewhip	Whole plant, roots, seed, leaf	Not as such a specific procedure [49]
9	*Acalypha indica*	Euphorbiacea	Kuppi, Indian nettle	Whole plant, roots, leaf	Leaf paste, Decoction [51]

SNo	Scientific name	Family	Vernicular name	Part used	Traditional preparation
10	*Parkia timoriana*	Fabaceae	Yongchak [Manipur], Zawngtah [Mizoram], Tree Bean	Tender pod, flower, capitulum, seeds, fruit skin, bark	Consumed raw as salad, or boiled as a vegetable; decoctions and extracts are used for inflammation and related ailments [52,53]
11	*Inula cappa*	Compositae	Gai-tihare	Leaf or flower, or root	Not as such a specific procedure [49]
12	*Debregenasia longifolia*	Urticaceae	Khajing [Manipuri]	Leaf or roots	Decoction, juice, raw consumption [54]
13	*Dalbergia sisso*	Leguminaceae	Sessau	Bark	Boiling and filtrate [44]
14	*Polygonum plebejum*	Polygonaceae	Bethe	Plant	Cuts, wounds, and inflammation are covered with plant paste [44]
15	*Colocassia gigantea*	Araceae	Kochu, Yendem [Manipur]	Leaf	Fresh juice [54]
16	*Allium hookeri*	Amarylidacea	Maroi napakpi [Manipur]	Whole plant	Dried powder [54,55]
17	*Houttuynia cordata*	Saururaceae	Jamyrdoh [khasi, jaintia]	Plant, leaf, rhizome	Use rhizomes as a paste applied to inflammation from a snake bite [27, 56]
18	*Oenanthe javanica*	Apiceae	*komprek* [methei], water dropwort	Whole plant	Raw, cooked, fermented organic extracts are used traditionally in the diet [57, 58]
19	*Solanum xanthocarpum*	Solanacea	Yellow Berried Nightshade	Herb	Several formulations contain it, including Chavanaprasha, Dasamoolarishta, Vyaghriharitaki avaleha, Vyaghri tailam, Vyaghriyadi kwatha, Vyaghri ghrtam [32]
20	*Osbeckia crinita*	Melasto-mataceae	Builukhampa[Mizo]	Leaf	Fresh juice [59]
21	*Myrica esculenta*	Myricaceae	Nagatenga, Soh-phi[khasi]	Leaf	Paste, oil of nagatenga, is used for joint pains and inflammation [60]
22	*Zanthoxylum acanthopodium*	Rutaceae	Andaliman	Fruit, leaf	Fresh or dried form [61]
23	*Aeschynanthus parviflorus Spreng*	Gesneriaceae	Bawltehlantai [Lushai]	Roots, leaf, seed, flower	Crushed/grounded, externally applied [46]
24	*Entada phasioloides*	Leguminosae	LekPangro	Fruit	The fruit paste is used to cure arthritis, swelling due to coldness [44]
25	*Hemerocallis fulva Linn.*	Liliaceae	Kuanki [Khamti tribe]	Rhizhome	Rhizome paste is applied to fire-burn skin, mixed with cooled water, and taken during chest and stomach hotness [62]
26	*Ricinus communis*	Euphorbiaceae	kunkaw	Leaf or seed	To ease body discomfort, inflammation, and localized swelling, the fresh leaves are warmed on the flame applied all over the body. Raw seed paste is administered to the swelling feet [62]
27	*Ficus hispidia*	Moraceae	khohotadimoru	Fruit or leaf	Fruit paste by decoction is used in inflammatory disorders [31]
28	*Physalis minima*	Solanaceae	Pokmou	Whole plant	Paste of the whole plant or roots used to treat menstrual pain [31]
29	*Mimosa pudica*	Leguminaceae	Lajuki lota	Leaf or root	Dried, boiled and filtrate is taken [31]
30	*Curcuma aromatic salisb.*	Zingiberaceae	Bon halodi	Rhizhome	Paste of rhizome is used to treat body pain [31]

Table 2: Ethnomedicinal plants with antioxidant activity

SNo	Scientific Name	Family	Vernacular Name	Part used	Traditional preparation
1	*Alternanthera sessilis*	Amaranthaceae	Bhiringi jhar	Whole plant	The whole plant is used as a green vegetable [63]
2	*Cassia tora*	Leguminosaesss	Sano tapre	Leaf and seed	Paste of the leaves with lime juice is used externally [46]
3	*Leucas cephalotes*	Lamiaceae	Drona puspi	Leaf, flower, aerial parts, fruit	Decoction of aerial parts, juice of unripe fruits, paste of flowers and leaves are applied externally [64,65]
4	*Haematocarpus validus*	Menispermaceae	Sohsnam	Fruit, leaf	Ripe fruits are used in dessert [66]
5	*Myrica nagi*	Elaeagnaceae	Sohphienam	Fruit, bark	Fresh fruits are consumed at all stages during growth,bark powder is used [66]
6	*Prunus nepalensis*	Rosaceae	Sohiong	Fruit	Fresh fruits are consumed [66]
7	*Berberis aristata*	Berberidaceae	Indian barberry	Roots, bark, leaf, stem, fruit	Juice or decoction of bark [67]
8	*Allium wallichi*	Amaryllidaceae	Himalayan onion	Bulb, leaf, shoot, roots, flower or whole plant	Bulbs are boiled and fried with ghee, or raw bulbs are chewed. Leaves and shoots are boiled with water and the soup is taken orally [68]
9	*Momordica cochinchinensis*	Cucurbitaceae	Gulkakra	Fruit	Fruits are incorporated in a dietary supplement [69]
10	*Cordia dichotoma*	Boraginaceae	lashuda	Fruit, leaf, bark, kernels, flower, roots	Leaves juice, decoction of the bark [70]
11	*Anaphalis contorta*	Asteraceae	Bukiphul	Whole plant	Decoction of the plant is consumed 4 teaspoons once a day with a pinch of black pepper [71]
12	*Angelica archangelica*	Apiaceae	Gundang	Leaf	Decoction of the leaf is taken about 5-6 teaspoons three times a day [72]
13	*Centella asiatica*	Apiaceae	Ghortapare,	Whole plant	Decoction of the plant is taken 5 teaspoons three times a day [72]
14	*Desmodium heterocarpon*	Fabaceae	Bangahat	Leaf, roots	Juice of the root is consumed 4 teaspoons twice a day with jaggery powder [72]
15	*Isodon coesta*	Lamiaceae	Jwahane jhar, Mirre	Leaf, roots	Juice of the leaves or roots [72]
16	*Angelica cyclocarpa*	Apiaceae		Rhizome	Dried rhizome is boiled and taken before bed [73]
17	*Saussurea costus*	Asteraceae	Putchuk	Rhizome	Dried rhizome powder [73]
18	*Habenari latilabris*	Orchidaceae	Nar Madi	Tuber	Decoction of tuber [74]
19	*Artemisia maritima*	Asteraceae	Afsanthene	Leaf, stem	Powder or paste of leaves and stem [74]
20	*Cynodon dactylon*	Poaceae	Khabal	Leaf	Decoction of leaves [74]
21	*Randia dumetorum*	Rubiaceae	Mainphal	Leaf, bark	Infusion of leaves, decoction of bark [75,76]
22	*Aquilaria agallocha*	Thymelaeaceae	Agaru	Whole plant	Plant oil extraction is used as an ointment [77]
23	*Lycopersicon esculentum*	Solanaceae	Bilahi	Fruit	The extracted juice is combined with coconut oil and applied [77]
24	*Murraya koenigii*	Rutaceae	Narasingha/ Nwrsingh	Leaf	Raw or cooked leaf [77]
25	*Houttuynia cordata*	Piperaceae	Machandari	Whole plant	It is mixed *with Centella asiatica*, and a little salt is given [77]
26	*Cassia fistula*	Fabaceae	Sonaru	Leaf and bark	The paste of the leaves and bark is ground and mixed with oil [77]
27	*Justicia adhatoda*	Acanthaceae	Bhaka-tita	Leaf	The Leaf extract is mixed with honey [77]
28	*Spondias pinnata*	Anacardiaceae	Hog-Plum	Fruit	Fruit juice is used [78]
29	*Euphorbia helioscopia*	Euphorbiace	sun spurge	Leaf	Decoction of leaves [43]
30	*Fagopyrum dibotrys*	Polygonaceae	Kathu	Leaf	Decoction of leaves [79]

Table 3: Ethnomedicinal plants with Antidiabetic Activity

SNo	Scientific Name	Family	Vernacular Name	Part Used	Traditional Preparation
1	*Abelmoschus esculentus [L.] Moench*	Malvaceae	Bhindi	Fruit	Fruits are cut and soaked in water for a few hours and then consumed [42]
2	*Anona squamosa L.*	Magnoliaceae	Seetaphal	Leaf	Leaves are chewed on an empty stomach [42]
3	*Artemisia annua L.*	Asteraceae	Dudh-kandij	Leaf	Infusion of leaves [80]
4	*EquisetumarvenseL*	Equisetaceae	Bandakey	Whole plant	Infusion of whole plant [80]
5	*Origanum vulgare L.*	Lamiaceae	Wanbaber	Leaf	Infusion of leaves [80]
6	*Cynodon dactylon [L.]*	Poaceae	Dramun	Leaf	Juice of leaves [80]
7	*Malus domestica Borkh.*	Rosaceae	Treil	Fruit	Fruit juice [80]
8	*Lycopersicum esculuntum Mill.*	Solanaceae	Tamatar	Fruit	Powder, paste extract [74]
9	*Urtica dioica L.*	Urticaceae	Bichhu buti	Leaf	Leaves cooked as a vegetable [42]
10	*Zizyphus jejuba Mill.*	Rhamnaceae	Ber	Leaf, seed, fruit	Ripened fruits are eaten [42]
11	*Ajuga parviflora Benth*	Lamiaceae	Neelkanthi	Aerial parts	Fresh leaves are chewed [81]
12	*Cassia fistula L.*	Fabaceae	Amaltash	Fruit	Fruit is eaten [82]
13	*Agave americana L.*	Asparagaceae	Rambaan	Sap	Infusion of sap [82]
14	*Butea monosperma [Lam.]Taub.*	Fabaceae	Palash	Leaf	Leaf powder is combined with water and consumed [82]
15	*Barleria cristata L.*	Acanthaceae	-	Whole plant	Infusion of the entire herb is utilized [82]
16	*Swertia chirayita [Roxb.]H.Karst.*	Gentianaceae	Charaita	Shoot	Fresh juice of young shoots is consumed [83]
17	*Anethum graveolens L.*	Apiaceae	Shatapushpa	Seed	Infusion of seeds [84]
18	*Allium stracheyi Baker*	Amaryllidaceae	Jimbu pharan/Keer	Herb or whole plant	Crude bulbs or juice are orally taken [84]
19	*Vitex negundo L*	Lamiaceae	Nirgundi	Shrub or whole plant	Decoction of the whole plant [84]
20	*Urtica dioica L.*	Urticaceae	Vrscikali	Herb or whole plant	Juice or tea is prepared from leaves [84]
21	*Abroma augustaa [L.] L.f.*	Sterculiaceae	Ulatkamal	Stem bark and leaf	Decoction [85]
22	*Costus speciosus*	Costaceae	Betlouri	Rhizome	Decoction [85]
23	*Picrorhiza kurrooad Royle ex Benth.,*	Scrophulariaceae	Putse sel	Rhizome	Dry rhizome powder [0.5g] taken with two tablespoons of curd and a pinch of pepper powder [84]
24	*Quercus lanatad Sm.,*	Fagaceae	Banj	Stem and bark	Decoction of stem and bark [85]
25	*Nardostachysjatamansia DC.,*	Valerianaceae,	Jatamansi	Rhizome	Dry rhizome powder [0.5g] taken with two tablespoons of curd and a pinch of pepper powder [85]
26	*Chonemorphafragrans [Moon]AlstonBM*	Apocynaceae	Ranipani	Leaf	Leaf juice [72]
27	*Herminiumlanceum*	Orchidaceae	Kath Jhakri	Leaf, stem	Decoction of leaf or stem [72]
28	*Syzygium cumini [L.] Skeels*	Myrtaceae	Kola Jamuk	Bark	About 20 g of bark powder is mixed with cow milk [100 ml] and sugar. [86]
29	*Garcinia pedunculata*	Clusiaceae	Borthekera	Fruits	A paste of fleshy fruit pulps [50 g] is soaked overnight in water [86]
30	*Ficus hispida L*	Moraceae	Dimoru	Sap	Two to 3 teaspoonfuls of sap extracted from the root is mixed with 50 ml cow milk[86]

CONCLUSION

The wide genetic diversity of the flora and wildlife of India's lower Himalayan region is well known. Numerous wild floras in these areas have not yet been investigated for their potential medical and therapeutic benefits. It is crucial to identify wild medicinal plants using ethnobotanical methods to isolate bioactive compounds with therapeutic potential. Herbal plant therapy is primarily based on its antioxidative properties, which are linked to anti-inflammatory and antidiabetic effects. The primary mechanisms underlying its antioxidant, antidiabetic, and anti-inflammatory actions are attributed to proanthocyanins, flavonoids, and phenolic compounds. Therefore, a chemical analysis of the plant with therapeutic qualities is necessary to accurately identify the bioactive components that can be used to create new medications. The pharmaceutical and herbal businesses will benefit greatly from this. To protect the medicinal biodiversity, proper conservation planning is crucial. Establishing medicinal gardens for ex situ conservation by mobilizing local ethnic communities is essential for maintaining plant populations in their natural habitats. It is necessary to thoroughly screen reported medicinal plants for potential bioactive chemicals using pharmacological and phytochemical methods. Validation of these results through experimentation could aid the development of novel medications to treat unavoidable illnesses.

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The authors declare no conflict of interest.

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