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Review Article

Therapeutic Potential of Medicinal Plants Grown in the Bundelkhand Region of India for Addressing Severe Non-communicable Diseases

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Abstract: Herbal Medicines (HMs) have experienced exponential development in the past few years. Consequently, their natural origins and minimal side effects, the popularity of these medications is gradually growing across the globe. Ancient text Rigveda has well documented the remedial application of medicinal herbs for the management of a spectrum of disorders. Phytometabolites derived from plants are rich in bioactive agents, crucial in regulating dysfunctional biochemical pathways that arise due various diseases. Fortunately, India is recognized for its vast reserves of herbal medicinal flora and has been considered the world's significant region regarding phytomedicinal diversity. The cultivation of an array of Herbal Plants (HPs) amid the hot and arid territory of Bundelkhand has made it the epicenter of biodiversity and played a crucial role in the region's agricultural economy. Urbanization and lifestyle shifts have become defining characteristics of modern society, driving both economic growth and health challenges. Among the most pressing of these health challenges are Noncommunicable Diseases (NCDs), which account for approximately 74% of deaths worldwide, amounting to nearly 41 million deaths annually (Noncommunicable Diseases). The review delves into the variety of medicinal herbs cultivated in the Bundelkhand area, highlighting their potential to prevent non-communicable diseases.

Keywords: Herbal Medicines, Phytometabolites, NCDs, Bundelkhand Biodiversity, Medicinal Plants

Introduction

Since the onset of civilization, herbal medicines have been used for improving human health. The growing health consciousness of people and the shortfalls of allopathic therapies have made traditional medicine more prominent worldwide because of its diversity, adaptability, accessibility, social and religious acceptance, few side effects and affordability (Payyappallimana, 2009). Plant derived medicine are complementary medicine which cure spectrum of diseases. Medicinal herbs offer an extensive variety of bioactive chemicals with an enormous number of therapeutic advantages, such as anti-microbic, neoplastic, inflammation reducing, antimalarial and analgesic outcomes (Parham *et al.*, 2020), cancer eradication, diabetes management and heart conditions. Around 2,500 medicinal plants continue to be employed by traditional herbalists in rural regions of India to cure common illnesses, making them a very efficient therapy (Panmeiet al., 2019).

Phytometabolites are broadly classified into two main categories: primary and secondary metabolites. Primary metabolites, i.e., amino acids, nucleic acids and polysaccharides, are essential components necessary for the growth and functioning of all living cells and secondary metabolites (extensively utilized in traditional medicines) are synthesized from basic metabolic pathways and do not contribute directly to growth (Hussein and El-Anssary, 2019). The primary classes of secondary metabolites are alkaloids, terpenoids and

phenols; among them, terpenoids are the most abundant category of plant metabolites, followed by phenolic molecules (Mazid *et al.*, 2011).

India ranks second in global export of a wide range of plant derived medicines, offering unmatched quality and quantity. It is one among the 12 significant hotspots of biodiversity globally, characterized by 16 distinct agroclimatic zones and an extensive collection of over 45,000 plant species. Around 7,000 species are recognized for their medicinal properties (Chakraborty, 2018). Numerous surveys and case studies have substantiated the significance of folk medicine in the fundamental health maintenance system in India. An investigation conducted in a country side of West Bengal revealed the efficacy of traditional remedies in preventing prevalent ailments like skin disorders, pyrexia, dehydration, hyperglycemia, increased blood pressure, hepatic malfunction and minor injuries (Khatib *et al.*, 2021). A separate examination indicated the potential of Ayurvedic remedies as an alternative of non-steroid anti-inflammatory medicine in addressing chronic diseases. Furthermore, this study showcased the efficacy of Ayurvedic multimodal therapy Albert and Porter (2015).

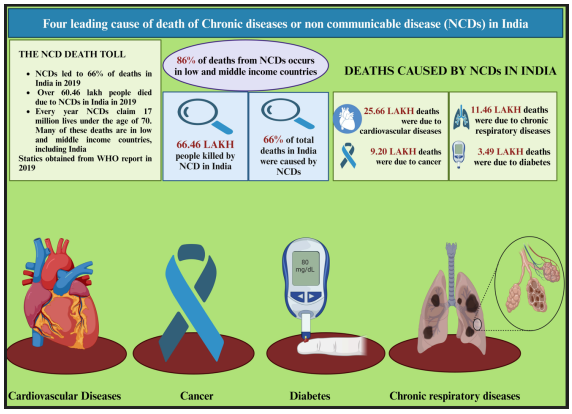

Fig. 1: Statistical illustration of NCDs (CVDs, diabetes mellitus, cancer, CRDs) in India

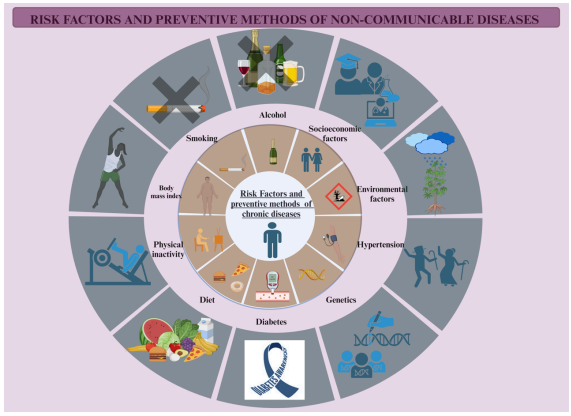

Fig. 2: The pictorial representation demonstrating the probable causes and remedies of chronic diseases or non-communicable diseases (NCDs)

Chronic diseases are enduring conditions that can be managed but not cured. Individuals with chronic diseases often face daily symptoms that impact their quality of life and experience acute health issues and complications that can decrease their life expectancy. The global prevalence of chronic or Non-Communicable Diseases (NCDs) is on the rise, accounting for 74% of all fatalities and causing 80% of mortality in developing nations (Ouyang *et al.*, 2022). Over half of all deaths worldwide are caused by chronic diseases, with a significant focus on Cardiovascular Disorders (CVDs), diabetes mellitus, cancer and Chronic Respiratory Diseases (CRDs) Khaltaev and Axelrod (2019) (Figs. 1-2).

The hot and humid weather conditions, low rainfall, desert-like topographical conditions and pesticide-free stony soil of the Bundelkhand region tender fabulous opportunities for cultivating medicinal and aromatic plants (Mishra and Shankar 2019). Many studies have high lightened the therapeutic potential of medicinal plants native to this region for treating the spectrum of disease conditions (Uniyal *et al.*, 2011;Sachan *et al.*, 2023;Sengaret al., 2023; Sengar and Sachan, 2025;Sachan *et al.*, 2025). However, there is currently a lack of discussion regarding using these plants to treat Non-Communicable Diseases (NCDs). This review paper aims to identify, analyze and document specific medicinal plants that are endemically found in the Bundelkhand region (Figure 3) and are unexplored in terms of their therapeutic potential to alleviate NCDs.

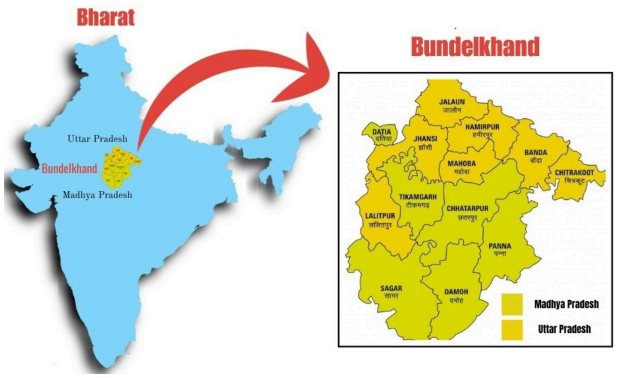

Fig. 3: Map of India showing districts of Bundelkhand region

Methods

The review article presents a comprehensive and methodical exploration of secondary electronic databases collected from various sources, including published research papers, proceedings, ethnobotanical surveys, review articles and books. These materials were sourced from databases i.e. Google Scholar, ResearchGate, PubMed, Scopus and science direct. The primary inclusion criterion encompassed published research articles that discussed medicinal plants native to or grown in the Bundelkhand region. Addressed the application of phytomedicines in healing/management of Non-Communicable Disorders (NCDs), covering the

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timeframe from January 1, 1999, to November 26, 2024. The exclusion criteria included published articles that were unrelated to Non-Communicable Diseases (NCDs) or the Bundelkhand Region, did not pertain to medicinal plants or were not written in English. Titles, abstracts and full texts of the retrieved articles were examined to identify pertinent studies. Additionally, the articles referred in the reference section, were examined to ensure that all significant sources were included. The search terms utilized for this review included "medicinal plants," "Non-Communicable Diseases (NCDs)," "Bundelkhand region," "World Health Organization (WHO)," and "Sustainable Development Goals (SDGs)." For data extraction various combinations of these terms to identify pertinent studies that link medicinal plants with NCDs in the context of the Bundelkhand region and related to WHO's health reports and SDG targets. Data categorization based on endemic medicinal plants to the Bundelkhand region and their therapeutic potential to target NCDs

Phytomedicines for the Amelioration of Cardiovascular Diseases (CVDs)

CVDs killed around 19.05 million people worldwide in 2020. In 2021, the death toll jumped to 20.5 million people. Heart related dysfunctions account for 85% of all mortalities. Furthermore, it is predicted that CVDs will be the primary cause of mortality for 22.2 million individuals by 2030. Metabolic, behavioral, environmental, socioeconomic and environmental variables may exacerbate CVDs.

CVDs, encompassing disorders associated with the malfunctioning of heart and blood vascular channels, are on the rise right now all over the world. This comprised of Coronary Artery Disease (CAD), Congenital Heart Defects (CHDs), venous thrombosis, arthritis, myocardial ischemia and stroke related illness (Vaduganathan *et al.*, 2022). The potential factors contributing to an increased susceptibility to the development of CVDs encompass hypertension, obesity, elevated cholesterol levels, diabetes, renal disease and various risk factors associated with CVDs. Unhealthy lifestyle choices such as a poor diet, exposure to air pollution, smoking, insufficient physical activity, excessive alcohol consumption and insomnia further compound the risk

The findings of the World Health Organization revealed that in 2018, 91% of people from Southeast Asia, which includes the Indian subcontinent, 87% from Africa, 80% from the Americas and 89% from Europe rely on traditional and conventional medicines (T & CM) to treat their medical conditions (Mishra *et al.*, 2022). Developing nations like India experienced a tremendous rise in CVDs over a very short period during the shift from an agricultural to an industrial culture in the post-independence phase. Compared to rural areas, the disease is much more prevalent in urban shelters. Expensive drugs, lifelong medication and costly surgical procedures to prevent CVDs place a significant economic burden on the poor. In such circumstances, plant-derived natural products (traditional medicines) become very useful in controlling cardiac ailments.

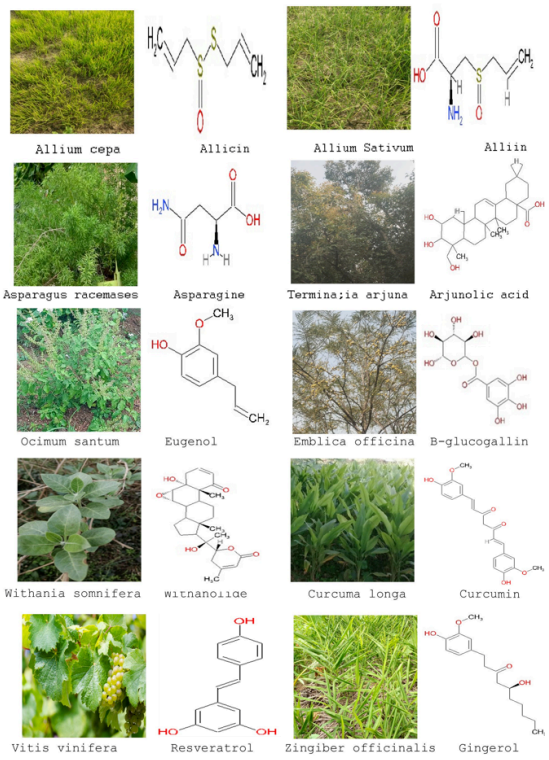

Fig. 4: Medicinal plants along with their chemical structure of active constituents, highlighting their diverse chemical constituent's structural arrangements. The plant images are taken from our own repository and images obtained from the eflora of India website (https://efloraofindia.com/2011/04/05/vitis-vinifera/)

There is a growing focus on preventing cardiovascular diseases through risk factor modification, such as adopting a healthy diet with high levels of antioxidants, engaging in regular physical exercise and refraining from smoking. Evidence indicates that implementing lifestyle modifications can significantly contribute to reducing both the occurrence and severity of cardiovascular events. Multiple studies consistently indicate a strong link between physical fitness and the prevalence of heart disease, additionally various general risk factors (Rippe, 2018).

Several medicinal plants, endemic to the Bundelkhand region have potential antioxidant properties, contributing to their cardioprotective and cardiotonic nature to administrate the CVDs such as Onion (*A. cepa*), Shatavari (*Asparagus racemosus*), Garlic (*Allium sativum*), Arjuna (*T. arjuna*), Ashwagandha (W. somnifera), Turmeric (*Curcumalonga*), Amla (*E. Officinalis*), Tulsi (*O. sanctum*), Ashwagandha (*W. somnifera*) and Ginger (*Z. officinale*), etc. are enumerated with active constituents in Fig. (4) and Table (1).

Table 1: Specialized medicinal plants cultivated in the Bundelkhand region for managing cardiovascular diseases

Family	Botanical Name	Common name	Plant part used	Cardioprotective effect	Method of herbal material preparation	Active constituents	Other therapeutic effects	References
Amaryllidaceae	*Allium sativum L*	Garlic	Cloves Bulb	Antithrombotic, Cardioprotective, Hypolipidemic	The cold-pressed extract is used as a decoction	Allicin (allyl 2-propenethiosulfinate or diallyl thiosulfate)	Anticancer, Antimicrobial, Anti-inflammatory	(Drobiova *et al*., 2010)
Amaryllidaceae	*Allium cepa L*	Onion	Bulbs	Cardioprotective effect, hypolipidemic, antithrombotic	The various plant components are utilized to prepare a decoction that is ingested orally	Anthocyanins, polyphenols, flavonoids	Antimicrobial, Antitumor, Hypoglycemic, Antiarthritic	(Akash *et al*., 2014)
Asparagaceae	*Asparagus Racemasus* (Wild)	Shatavari	Roots	Cardioprotective effect	Root powder is used in decoctions	Steroidal saponins, mucilage, alkaloids. shatavarosideA, shatavarosideB, filiasparosideC, shatavarins	Immunomodulator, Anti-stress agent, Antihepatotoxic	(Goyal *et al*., 2003)
Combretaceae	*Terminalia arjuna*	Arjuna	Bark	Cardioprotective, spasmogenic, hepatoprotective and anti-angina	Bark powder can be used to make a decoction	Triterpenoids (arjunolic acid, Arjun glucoside), tannins (ellagic acid and gallic acid), flavonoids and minerals	Antimicrobial, Hypoglycemic, Antiarthritic, Antitumor	(Gauthaman *et al*., 2005)
Lamiaceae	*Ocimum sanctum* L.	Tulsi	Whole part	Cardioprotective and anticoagulant	Leaves extract used as decoction	Eugenol, borneol, camphene, oleanolic acid, rosmarinicacid, cubebene	Antithyroid, chemoprotectant, radioprotective, neruro-protective, anti-ulcerogenic	Cohen (2014)
Phyllanthaceae	*Emblica officinalis Gaertn*.	Amla	Fruits	Cardiovascular effect	Fruit extract used as decoction	Ascorbic acid, catechol Gallic acid, ellagic acid, rutin and quercetin	Antiinflammatory, antiulcer, antipyretic, anti-tumor and analgesic, hepatoprotective, anticandidal, cytoprotective,	(Bhattacharya *et al*., 1999)
Solanaceae	*Withania somnifera L.*	Ashwagandha	Roots	Cardioprotective and anticoagulant	Roots powder is orally used for decoction	Withanolide, withaferin A, Withanolide A, Withanone, physagulin-d	Immunomodulatory, antiinflammatory, antiaging, anti-sensor, anticarcinogenic and thyroid stimulator	(Dhuley, 2000)
Vitaceae	*Vitis vinifera L.*	Grapes	Fruits	Antioxidant activity, cardioprotective	Grape's juice is used for CVDs	Isoflavin, anthocyanidins	Anticarcinogenic, anti-inflammatory, radioprotective, hepatoprotective	(Hung *et al*., 2000)
Zingiberaceae	*Curcuma longa*	Turmeric	Roots	Cardioprotective and anticoagulant	Powder of rhizome used as a decoction	Curcuminoides, curcumin, cyclocurcumin	Anti-inflammatory, chemopreventive, anti-mutagenic	(Fu *et al*., 2021)
Zingiberaceae	*Zingiber officinalis*	Ginger	Roots	Cardiotonic, Cardioprotective and anticoagulant	Powder of rhizome used as a decoction	Gingerol, zingiberene, zingerone	antibacterial, Carminative, general tonic, blood purifier, anti-inflammatory	(Ahmed *et al*., 2000)

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Traditional Herbal Plants Utilized for Managing Diabetes Mellitus (DM)

Diabetes Mellitus (DM) is presently a significant public health concern, often a hidden epidemic of the twenty-first century (Wild *et al.*, 2004) enumerated that Asia and Africa are experiencing most new diabetes cases due to changing lifestyles. DM is highly prevalent as a chronic disorder in India, affecting a large portion of the population. An estimated 74 million individuals in India were diagnosed with diabetes in 2021 and this number is projected to surpass 124 million by the year 2045 (Pradeepa and Mohan, 2021).

DM is a disorder related to the dysfunctional metabolism of insulin hormones. Type I diabetes occurs due to the malfunctioning of beta cells of the pancreas and insulin must be supplemented externally. However, type II diabetes is nonresponsive to insulin and can be regulated by dietary discipline, physical activity and meditation (Modak *et al.*, 2007). The mechanism of occurrence of DM is yet to be fully revealed but it is suggestive that non-enzymatic glycation of nonglucose molecules and, oxidation of glucose generates the free radicals. The free radicals (synthesized during the process of oxidative metabolism held in mitochondria) are responsive to the etiology of diabetes by onsetting oxidative stress (the consequence of hyperglycemia), causing damage on a molecular and cellular scale (Asmat *et al.*, 2015).

Long-term diabetes causes malfunctioning and loss of multiple organs associated with various comorbidities, including cancer, heart disease, rheumatoid arthritis, erectile dysfunction, poor wound healing, neuropathy, nephropathy and retinopathy (Jebari *et al.*, 2019). Multiple drugs and therapies are applied to check hyperglycemic conditions and to enhance glucose uptake by peripheral cells, but having certain limitations due to high cost, ill effects, weight gain and gastrointestinal tract-related disorders (Dey *et al.*, 2002). To sublime oxidative stress, attempts are being made to develop cheaper and more friendly natural anti-diabetic and antioxidant therapies.

Ethnobotanical records reveal that 800 medicinal flora might contain hypoglycemic attributes. Various plant-derived active compounds with diverse chemical compositions have exhibited therapeutic potential in the context of diabetes treatment (Tran *et al.*, 2020). These include amino acids, carbohydrates, glycosidic compounds, galactomannan, hypoglycans, guanidine, steroids, terpenoids, polysaccharides, peptidoglycans and inorganic ions (Patil *et al.*, 2011) (Figure 5).

Antidiabetic medicinal plants which are native to the Bundelkhand region are widely recognized for their effectiveness, including *A. cepa* (Onion), *A. sativum* (Garlic), *E. jambolana* (Black plum), *Fagopyrum esculentum* (Buckwheat), *Aegle marmelose* (Bael), Peepal tree (*Ficus religiosa*), *Momordica charantia* (Karela), Babul (*Acacia arabica*), Tulsi (*Ocimum sanctum*) (Table 2). The secondary metabolites of these plants have strong antioxidant activity and hyperglycemic activity to combat oxidative stress (Odeyemi and Afolayan, 2018).

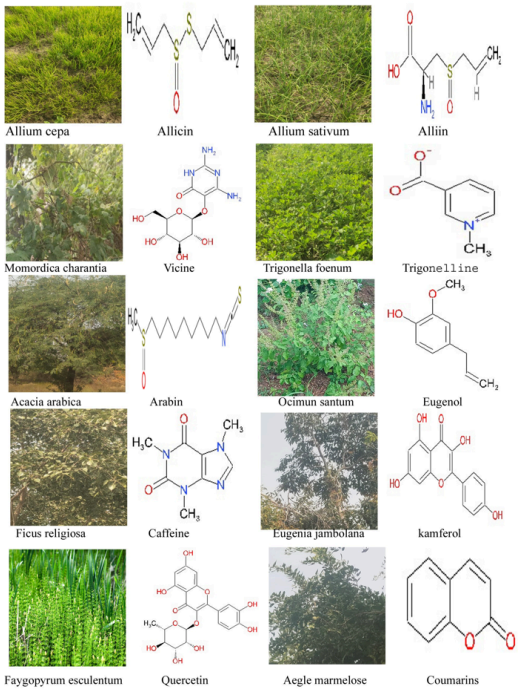

Fig. 5: Medicinal plants along with their chemical structure of active constituents, highlighting their diverse chemical constituents' structural arrangements. The plant images were taken from our own repository and the eflora of India website

Application of Herbal Plants for the Cancer Therapy

Cancer stands as the world' seconds most common cause of mortality, following CVDs and remains one of the prominent causes of deaths across the globe (WHO, 2005). In 2020, cancer accounted for around 10 million deaths worldwide, representing one in six fatalities. By 2030, the global death toll from the diseases is projected to exceed 13.1 million. In the development of cancer, normal cells transform into tumor cells, often following a progression from pre-cancerous lesions to malignant tumors. The pathophysiology of cancer involves the misexpression of genes, aberrant gene function, disruption of the cell cycle, deregulated apoptosis, the start of ontogenesis and metastasis to other normal cells and tissue (Almalki 2023). The most prevalent cancers include lung, colon, rectum, prostate, gastric and hepatic cancers in men and mammary carcinoma, colon, alveolar, uterine cervix and stomach carcinoma in women (Mattiuzziand Lippi, 2019). Cancer occurrence rises considerably with age, likely because aging increases the chance of developing certain types of cancer. In addition to the general build-up of danger, aging tends to reduce the effectiveness of cellular repair processes (Siegel *et al.*, 2021).

Table 2: Family, botanical name, common name, plant part used, active constituents, method of herbal preparation and therapeutic properties of selective medicinal plants used in the management of Diabetes Mellitus in Bundelkhand Region

Family	Botanical Name	Local Name	Plant part used	Antidiabetic Effect	Method of herbal remedies preparation	Other therapeutic properties	Active constituents	Reference
Amaryllidaceae	*Allium cepa L.*	Onion	Bulb, leaves	Hypoglycemic effect, lowering of cholesterol and glucose.	Oral administration used as a decoction for the hypoglycemic effect	Cardiac diseases, cancer, parasitic, fungal diseases	Allicin, Quercetin Onionin A (ONA)	(Akash *et al*., 2014)
Amaryllidacea	*Allium sativum L.*	Garlic	Bulb and leaves	Hypoglycemic, hypolipidemic, reduce proteinuria	The different parts are used to make a decoction which is taken orally	Hypolipidemic, Antioxidants, Antithrombotic, Anticancer, Antimicrobial	Allicin, Allixin, Organo sulphur compounds	(Drobiova *et al*., 2010)
Cucurbitaceae	*Momordica charantia L*	Bitter gourd	Whole fruit	Hypoglycemic, lipid-lowering properties	Fruits and seeds are used to make an infusion which is taken orally	Antibacterial, Antiviral, Anticancer, Antidiabetic activities	Vicine, charantin, and triterpenoids	Grover and Yadav (2004)
Fabaceae	*Trigonella foenum-graecum L.*	Fenugreek, methi	Seeds leaves	Antihyperglycemic effect	Fenugreek seed powder is used as a decoction	Antiulcer, Antioxidant Anti-inflammatory and antipyretic	Saponins, Steroids Hydroxy Isoleucine, and Trigonelline, and Alkaloid	(Geberemeskel *et al*., 2019)
Fabaceae	*Acacia arabica (Lam.) Wild.*	Babul Indian Gum Arabic tree	Seed leaves	Hypoglycemic effect	Powdered seeds of Acacia arabica administered in hypoglycemic	Antimutagenic Antidiabetic Nematicidal: Antioxidant	Arabin, L-arabinose, D-galactose, D-glucuronic acid Cyanogenic Glycosides, Flavonoids, Alkaloids, Seed oils, Cyclitols, Fluoroacetate	(Maslin *et al*., 2003)
Lamiaceae	*Ocimum sanctum L.*	Holy basil or tulsi	Seed Leaves Stem	Antidiabetic properties	Holy basil leaf oil used as a decoction	Antifertility, Anticancer, Antidiabetic, Antifungal, Antimicrobial, Hepatoprotective	Eugenol triterpenoids, isothymusin, orientin, and vicenin, rosmarinic acid apigenin	(Pattanayak *et al*., 2010)
Moraceae	*Ficusreligiosa L.*	Peepal	Bark Leaves	Reduce blood glucose (Hypoglycemic)	Bark decoction is utilized for treating diabetes.	Anti-inflammatory, Analgesic, Antimicrobial, Antioxidant, Antitumor, Antiulcer, Antianxiety, Antihelmintic	saponins, flavonoids sterols, tannins	(Singh *et al*., 2011)
Myrtaceae	*Eugenia jambolana Lam.*	Black plum jamun	Seeds Leave, fruits, and bark	Anti-diabetic	Fruits and seed powder are used as an antidiabetic effect	Hypolipidemic, Antiinflammatory, Antiulcer, Antibacterial, Anti-Hiv, Antidiarrheal and Antihypertensive Activities	Jambosine, Anthocyanins, Glucoside, Ellagic Acid, Isoquercetin Kaempferol, Myricetin, and Hydrolysable Tannins	Rizvi and Mishra (2013)
Polygonaceae	*Fagopyrum esculentum*	Buck Wheat	Whole plant	Anti-Diabetic	Whole plant used for anti-diabeic effect	Reducing Plasma and Cholesterol Level, Anti-Cancer	Flavonoids, Quercetin (Orientin), Tannis (Fagopyritol) Triterpenoides (Ursolic Acid, Glutinone),Steroids	(Jing *et al*., 2016)
Rutaceae	*Aegle marmelos L.*	Bael or Sirphal Golden apple	Bark, leaves fruits	Hypoglycemic effect	Leaf extract used against the anti-diabetic properties	Antidiarrheal Antidysentery, Antipyretic, Anti-Inflammatory, Anticancerous,	Terpenoids, Flavonoids Alkaloids (Aegline, Marmesin, Marmelosin) Coumarins, Luvangetin	(Maity *et al*., 2009)

Table 3: Anticancer activity of selective medicinal plants grown in Bundelkhand region

Family	Botanical name	Local name	Parts used	Anticancer activity	Method of herbal preparation	Other therapeutic uses	Active constituents	Reference
Annonaceae	*Annona squamosa* L.	Custard apple, Seetapalam	Aerial part, seeds	Colon and breast cancer	Seeds used for anti-cancerous properties	Antimicrobial, Antitumor, Anticonvulsant, Antidiarrhea, Antimalarial, Anti-Inflammatory, Antioxidant, Antileishmanial	Borneol, Farnesol, Tannins, Polyphenols, Geraniol, Annoteamoyin-1, Annonaceousacetogenins, Linalool	Al-Ghazzawi (2019)
Apiaceae	*Centella asiatica* L.	Indian pennywort, Gotu kola, Brahmi	Leaves	Lung cancer	The leaves are orally ingested after being infused	Antioxidant, Anti-inflammatory, Anticancer, Anti-Allergic Neuroprotective, Cardioprotective	Asiatic Acid, Asiaticoside and Madecassic Acid	(Aizad *et al*., 2020)
Asparagaceae	*Asparagus racemosus* (Wild)	Shatavari, satavar	Roots	Anti-cancer	The Root is used to make a decoction that is taken orally	Antioxidant, Hormonal Imbalance(PCOD), Infertility	Shatavarin I to X (shatavarins), terpenoids, lignans	(Hayes *et al*., 2008)
Apocynaceae	*Asclepias Curassavica L.*	Scarlet Milkweed, Kage Tundi	leaves	Anti-nasopharynx human carcinoma	Leaves used as infusion those used orally	Hemostatic disorders, Inflammation, Antipyretic, Analgesic, Antimicrobial, Cardiovascular	Calotropin, Coroglaucigenin, Asclepin, Cardenolide	(Regassa *et al*., 2022)
Apocynaceae	*Catharanthus roseus* (L.) G. Don	Nayantara rose periwinkle	Roots	Breast cancer	Root decoction is used for various illness	Anti-diabetic, Anti-pyretic, Anti-oxidant, Anti-bacterial, Anti-fungal	Bisindole Alkaloids, Vinblastine, and Vincristine	(Saha *et al*., 2022)
Asclepiadaceae	*Calotropis gigantea* L.	Crown flower, Giant Indian milkweed, Madar or aak	flower petals	Anti-Ehrlich ascites carcinoma (EAC)	Flowers are used for anti-cancer properties	Antidepressant, Sedative-Hypnotic, Antianxiety, Anticonvulsants, Analgesic, and Neuritogenesis	Gigantin, Cardenolide Calotropin, Calcium oxalate, alpha and beta-calotropeolhydrocarbons	(Choudhary *et al*. 2017)
Asteraceae	*Inula racemose* Hook F.	Pushkar Mula	Roots	Colon, Prostate, CNS, Ovary, Leukemia, and Lung cancer	Pushkarmula powder is used as a decoction with milk	Alantolactone, isoalantolactone used as a anticancer properties	Inulin, alantolactone, isoalantolactone	(Kalachaveedu *et al*., 2018)
Asteraceae	*Mikania micrantha* L.	Maotamgui	Leaves	Anti-esophageal adenocarcinoma	Leaves used as infusion those used orally	Antioxidant,Antiinflammatory, Anti-microbial, Anti-dermatophytic, Antiprotozoal, Anthelmintic, Cytotoxic, Anxiolytic, Anti-diabetic, Lipid-lowering	Milkaloids, glycoside flavonoids, triterpenoids, tannins, sterols, and saponin	(Das *et al*., 2023)
Asteraceae	*Cyanthillium cinereum* L	Little ironweed	plant	Anti-matrix metallopeptidases	The plant is used to make an infusion taken orally	Asthma, Cancer, Cholera, Colic Pain, Cough, Diarrhea, Dysentery, Impotency, And Night Blindness	Glycosides, Phenols, Flavonoids, Steroids, Tannins, Lupeol Saponins, and Phlorotannins	(Regassa *et al*., 2022)
Boraginaceae	*Arnebia euchroma* I. M. Johnst	Johnst, Ratan jot.	Roots leaves	Anti-tumor	Roots used as decoction	Anti-microbial, Anti-Inflammatory, Emitting, chronic diseases, Burnt Limbs, Cough, and Cold	Isobutyl-shikonin, Arabinose, β-Sitosterol, Alkannin, Flavonoids, Triterpenoids	(Kumar *et al*., 2021)

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During the last decades, ongoing research on novel synthetic anticancer strategies could not attain success in combating cancer as it was anticipated that synthetic chemotherapeutic drugs would be used to treat carcinoma but pose a negative impact on normal cells. The toxicities in blood channels and kidneys are observed because of the application of anticancer drugs. Therefore, it is pertinent to formulate innovative, low-toxic and cheaper anticancer remedies from alternative sources.

Phytometabolites are a natural and harmless therapeutic method for treating cancer and metastases (Gupta *et al.*, 2021). Prior to clinical investigation, phytometabolites has demonstrated encouraging anticancer potential. These have the potential to regulate the biochemical cascade responsible for the genesis of oncogenic cells, differentiation of stem cells and death of cancerous cells (Yang *et al.*, 2020). The herbal remedies target the treatment noncompliance ability of cancer cells and significantly curtail the menace of metastatic recurrence Anticancerous properties of numerous phytometabolites like phytoalexin, curcumin (Ramasamy *et al.*, 2015), quercetin (Wang *et al.*, 2018) and (-)-epigallocatechin-3-O gallate (Namiki *et al.*, 2020) have been broadly investigated in several in vivo mouse models, targeting biochemical cascade of metastatic cells (Liaoet al., 2023).

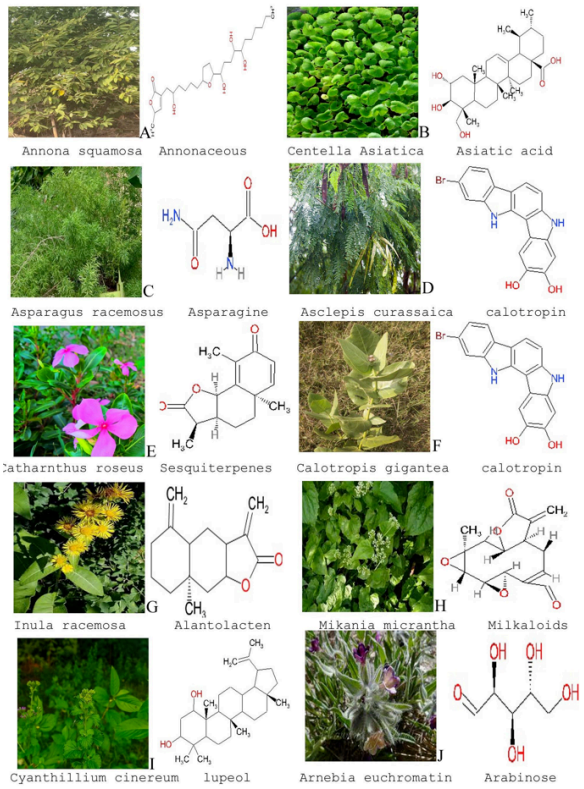

Fig. 6: Medicinal plants and their active constituent's, highlighting their diverse chemical constituents' structural arrangements. The plant images were taken from our own repository and the eflora of India website

Many important phytometabolites derived from medicinal plants grown in the Bundelkhand region have immense anticancerous properties such as annonaceous, Asiatic acid, asparagine, calotropin, milkaloids and arabinose, obtained from *Annona squamosa* (Custard apple), *Centella asiatica* (Indian pennywort), *Asparagus racemosus* (Shatavari), *Catharanthus roseus* (Rose periwinkle), *Calotropis gigantea* (Crown flower), *Inula racemose* (Pushkar mula), *Mikania micrantha* (Maotamgui), *Cyanthillium cinereum* (Little ironweed), *Arnebia euchromatin* (Johnst Ratan jot.) (Fig. 6 and Table 3) (Uniyal *et al.*, 2011)

Utilization of Medicinal Plants in Managing Chronic Respiratory Disorders (CRDs)

Respiratory disorders are a very threatening global health concern, leading to a very high death toll. According to the WHO, NCDs comprise 74% of all global deaths. Among these, CRDs and Chronic Obstructive Pulmonary Disease (COPD) are responsible for causing 4.1 million deaths (According to WHO, 2023 report). Respiratory disorders, both acute and chronic, are a frequent cause of health issues. CRDs significantly impact bronchial tubes and other respiratory organs. They include some of the most common and debilitating conditions, such as COPD, asthma, lungailments, hypertension, lung carcinoma, tuberculosis and pneumonia, which are the most observed respiratory diseases. Inhaling irritants and toxins for a prolonged period can lead to CRDs, causing chronic airway inflammation by neutrophils, macrophages, cytotoxic ($CD8^+$) and T lymphocytes, damaging the lungs' alveolar structures. This results in the development of conditions like chronic bronchitis and emphysema. The occurrence of bronchitis is linked to the enlargement and multiplication of glands that secrete mucus in the larger airways, infiltration of inflammatory cells in the submucosa, swelling, fibrosis around the bronchioles and an increase in smooth muscle (Ram *et al.*, 2010).

Asthma is another respiratory ailment characterized by inflammation. The inflammatory process begins with the activation of T helper-2 (T_H2) and immunocompetent cells like Dendritic Cells (DCs), which activate the eosinophilic cells (ECs) and the immunosensitivity of mast cells. This, in turn, triggers the release of different types of immune response regulators like prostaglandins, histamine and leukotrienes (Kuruvilla *et al.*, 2018).

Herbal Plants are a valuable resource for the remediation of respiratory ailments. The anti-inflammatory, bronchodilatory, cholinergic antagonist, spasmolytic antitussive and airway cleansing function of phytometabolites significantly reduces the degradation of lung tissues and maintains proper alveolar functionality. Asperuloside obtained from *H.Paederiae* lessens pulmonary congestion and lipopolysaccharide mediates lung dysfunction by controlling mitogen-activated protein kinase pathway and NF-kB pathways (Qiu *et al.*,

2016). Carnosic acid obtained from Chili induces cell death and suppresses neoplastic progression in the lungs and Curcumin obtained from *C. longa* regulates the adaptor proteins of Shc family and curtails alveolar lining disruption in COPD (Boukhatem *et al.*, 2020). The bioactive compound Nimbolide, derived from *A. indica* has shown promising therapeutic potential. Researchers suggest that it effectively reduces the nitrosative-oxidative stress, controls cytokines involved in immune responses and checks the iNOS and nitrotyrosine concentration. Hence, it actively regulates Pooladanda syndrome (ARDS) (Pooladanda *et al.*, 2019).

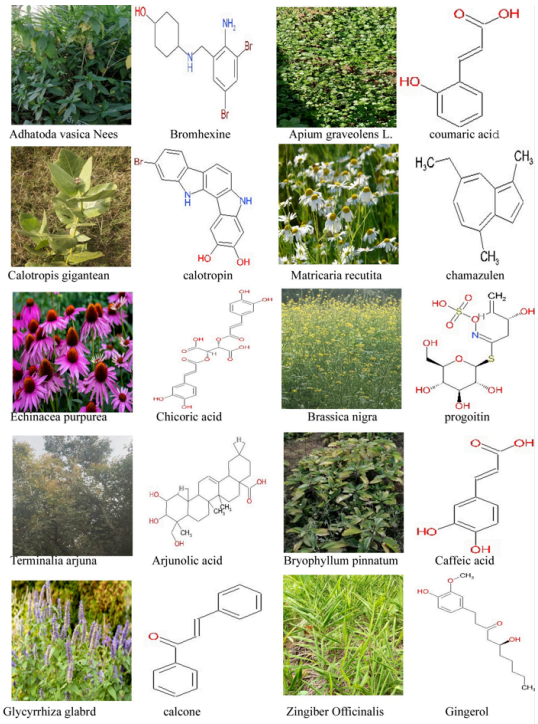

Fig. 7: Medicinal plants along with their active constituent's;, highlighting their diverse chemical constituents' structural arrangements. The plant images were taken from our own repository and the eflora of India website

To treat respiratory conditions, healthcare professionals employ various pharmacological approaches, including the use of anti-inflammatory agents, bronchodilators, antibiotics, anti-allergics, mucolytics and antineoplastics (Figure 7). Apart from the aforementioned methods, traditional medicinal plants like Malabar nut, Adusa, Celery, Crown flower, Ammonicum, Fennel, Elephant yam Corn, German chamomile, Purple coneflower, Mustard, Arjun, Bryophyllum pinnatum and ginger have been utilized since ancient times for the treatment of respiratory disorders (Table 4).

Toxicological Impact of Phytomedicines

The toxicological impact of herbal plants refers to the potential adverse effects that these plants can have on human health when misused or consumed in excessive amounts. The toxic nature of herbal plants depends on their chemical constituents. The substantial toxic impact of traditional medicines may be due to short term or long-term exposer, even when the extracts involved have relatively low toxicity. The plant extracts can produce deleterious carcinogenic and mutagenic consequences (Ferreira-Machado *et al.*, 2004). Cytotoxic compounds hamper cell-cell interaction and rate of replication and bring change in morphology. Some medicinal plants like *Digitalis purpurea* leaf have a narrow therapeutic index and need expert supervision for harmless use. Daily doses of digoxin are 0.125 to 0.25 mg. Every part of plant has toxic potential. A minuscule dose of Digitalis is deleterious for humans and toxicity has ranged between 5-25% (Jadhav *et al.*, 2018). Acute toxicity causes adverse cardiac reactions. Ingestion of 10 bays of *Atropa belladonna* is quite harmful to humans. The oral LD_{50} in rats is around 750 mg/kg. Muscarinic acetylcholine receptor sites are competitively inhibited by Atropine, leading to various toxic effects. These effects include asphyxia, tachycardia, Congestive Heart Failure (CHF), blockage of sweat glands, dyslexia, blurred vision and decreased milk production. (Berdai *et al.*, 2012).*R. communis* (local name Castor, family Euphorbiaceae) is prevalent in the tropical climate of the Bundelkhand region and possesses significant nutritional and medicinal properties. The fermented methanol extract of *R. communis* exhibits low toxicity at lower concentration as indicated by its acute toxicity assessment and median Lethal Dose (LD50), but it becomes deleterious at higher doses, specifically at 5000 mg/kg of body weight. Death was observed at concentrations exceeding this amount (Joshua *et al.*, 2020). *C. autumnale* (Wild saffron), contains the alkaloid colchicine, which is toxic in nature and disrupts mitosis, inhibits replication and prevents tubulin polymerization. As a result, exposure can lead to severe health issues, including cardiac failure, dysrhythmia, renal insufficiency, liver dysfunction, breathing ailment, coagulation disorders, myelosuppression and myodystrophy. Gastrointestinal symptoms typically occur at doses below 500 µg/kg, while quantities exceeding 800 µg/kg are quite lethal. Consequently, a range of effects can be anticipated, from gastroenterocolitis to multiple organ dysfunction, ultimately succumbed (Brvaret al., 2004).*Aconitum* (Ranunculaceae) contains a prolific amount of the highly poisonous aconitine which is neurotoxin and cardiotoxin in nature. Even very small dose of aconitine may cause death due to respiratory or cardiac failure. Hypotension, sinus bradycardia and ventricular arrhythmias are further consequences of aconitine toxicity. Other features may include illusion, dilemma, sweating, breathing ailment headache and confusion. The leading factors behind fatalities are asystole and disorders ventricular rhythms or degeneration of the cardiac and breathing center (Chan, 2009). The toxicity of curcumin (derived from *C. longa*) has potential detrimental effects. Curcumin in combination with Copper (Cu) and p450 system enzymes, causes DNA disintegration of genetic material. observed that curcumin bound to copper, in a rat model of hepatic cancer, failed to prevent tumor development. Approximately 150mg of curcumin powder/day has no harmful impact (Sharma *et al.*, 2007).

Table 4: List of selective medicinal plants and their chronic respiratory diseases activity along with their local name, family, plant part used, method of herbal preparation, therapeutic properties

Family	Botanical name	Local Name	Parts Used	Medical conditions	Method of herbal preparation	Mode of action	Active constituents	Reference
Acanthaceae	*Adhatodavasica Nees*	Malabarnut and adusha	Aerial parts	Asthma Bronchitis and Tuberculosis	Leaves decoction used a kada in India	Bromhexine, also called vascinone, has expectorant and mucus-liquefying properties.	Bromhexine, also called vascinone, has expectorant and mucus liquefying properties.Vasicine is an alkaloid and has antioxidant, anti-inflammatory, and bronchodilatory activities	(Nikhitha *et al*., 2021)
Apiaceae	*Apium graveolens L.*	Celery	Leaves	Bronchitis and asthma	Leaves used as infusion those used orally	Chemical constituents like limonene, selinene, furocoumarin glycosides, flavonoids, and vitamins A and C have beneficial effects on chronic respiratory diseases.	Coumaric acid, Tannin, Saponin, Caffeic acid Kaempferol, Apigenin Ferulic acid and Luteolin	Kooti and Daraei (2017)
Apocyanaceae	*Calotropis gigantean R.Br.*	Crown flower	Whole plant	Bronchitis and asthma	The plant is prepared as an oral infusion for consumption.	Infusion of flowers and leaves was used for the prevention of various chronic conditions of traditional healers of India	Calotropin, proceraside, Beta-sitosterol, Lupeol, Quercetin-3-O- rutinoside, 9-methaoxypinoresinol	(Murti *et al*., 2010)
Asteraceae	*Matricaria recutita L*	German chamomile	Leaves Flower	Head Bronchitis	The leaves are utilized to create an oral decoction for consumption.	Methanol extracts of chamomile exhibit inhibitory effects on histamine release from mast cells in individuals.	terpenoids, flavonoids, and lactones, including matricin and apigenin.	Kolanos and Stice (2021)
Asteraceae	*Echinacea purpurea L.*	Purple coneflower	Root shoot	Bronchitis and pulmonary disorders	The roots are utilized to prepare an oral decoction for consumption.	The release of inflammatory mediators, including cytokines and tumor necrosis factor,	Chicoric acid, Glycoproteins, Volatile oils, Flavonoids, Caftaric acid, chlorogenic acid, caffeic acid, echinacoside	(Manayi *et al*., 2015)
Brassicaceae	*Brassica nigra L.*	Mustard	Seeds foliage	Prolonged bronchial inflammation	The seeds are utilized to prepare an oral decoction for consumption.	Bioactive compounds in Brassica nigra reduce respiratory tract inflammation by inhibiting inflammatory mediators and limiting oxidative stress.	Glucosinolates, Phenolic compounds, flavonoids, Brassinosteroids	(Chaachouay *et al*., 2019)
Combretaceae	*Terminalia arjuna*	Arjun	bark	Anti-asthmatic effect	Bark extract used for the management of asthma	The fresh bark extract of Brassica nigra exhibits a potent anti-asthmatic effect when combined with specific medicinal plants.	Arjunic acid, Arjungenin, Arjunetin Arjun glucoside, and oleanane-type triterpene glycosides	(Kapoor *et al*., 2014)
Crassulaceae	*Bryophyllumpinnatum or Kalanchoe integra*	Mother of thousands, miracle leaf	Leaves	Anti-asthmatic effect	The utilization of boiled leaf extracts from the plant offers effective management of respiratory disease.	K. integra leaves contain flavonoids and tannins, which demonstrate promising effects in the treatment of bronchial asthma	Alkaloids, Calcium, Flavonoids, Sodium, Saponin, Tannin, Phenol, Phosphorous, Potassium and Magnesium	(Yadav *et al*., 2016)
Fabaceae	*Glycyrrhiza glabra L.*	licorice	Roots	Bronchitis and asthma	Root decoction using it as a remedy for cough, cold, and asthma symptoms.	Glycyrrhetinic acid and liquiritigenin on asthma which can reduce inflammation	Flavonoids, Glycyrrhizin, glycyrrhizin, isoflavonoids, chalcones. and glycyrrhetinic acid	(Ram *et al*., 2010)
Zingiberaceae	*Zingiber Officinale*	Ginger	Roots	Bronchitis, cold, and asthma	Powder of rhizome is used as a decoction.	Ginger contains gingerols, which inhibit macrophage and neutrophil activation and negatively affect monocyte and leukocyte migration which can reduce inflammation in respiratory conditions	Gingerol, shogol, zingiberene, zingerone	(Ahmed *et al*., 2000)

Conservation of Medicinal Plants and the Sustainable Development Goals (SDGs): Challenges and Further Prospects

While the therapeutic significance of herbal plants in the Bundelkhand area is promising, many challenges need to be addressed. Conservation efforts for these endemic plants are crucial due to increasing habitat destruction, overexploitation and nonscientific collection procedures. These plants also tend to have a short shelf life and need specific storage conditions to retain their potency and safety. Significant research gaps exist in the pharmacokinetics and pharmaco dynamics of many medicinal plants, which complicate their incorporation into mainstream medicine (Brantley *et al.*, 2014).

It is essential to formulate concrete collaborative strategies that integrate traditional healing systems with innovative applications of high-throughput techniques to enhance the efficient processing of medicinal plant materials. Policymakers should solicit input from local communities to formulate accurate conservation policies and implement responsive, long-term harvesting measures, aligning with SDGs framed by the United Nations General Assembly. Traditional medicinal plants are integral to achieving sustainable development with their diverse range of applications (Sharma and Kumari, 2023). Furthermore, the adoption of folk herbal practices is pivot in promoting biodiversity conservation by safeguarding natural habitats and employing optimal cultivation methods to preserve rare, threatened, or endangered species, thus maintaining ecological stability.

Discussion

The review paper analyzes existing research investigation, focusing on the therapeutic importance of medicinal herbs cultivated in the Bundelkhand region (Uniyal *et al.*, 2011). It explores each plant's botanical classification and features, presenting an overview of their bioactive compounds that enhance their therapeutic properties in combating chronic health conditions, including CVDs, DM, cancer and CRDs. Each plant's effectiveness, mode of action and scientific evidence supporting its therapeutic claims are thoroughly examined and discussed. It highlighted areas where further investigation is needed, such as dosage optimization, potential synergistic effects when combining specific plants, standardization of herbal preparations and clinical trials to validate the traditional uses. Furthermore, the discussion may touch upon the sustainability and conservation of these medicinal plants, addressing the need for responsible cultivation practices and the preservation of their natural habitats. It acts as a thorough reference for researchers, healthcare practitioners and policy makers seeking to leverage the therapeutic potential of these plants.

Conclusion

The Bundelkhand region's land offers a conducive environment for growing specific lifesaving medicinal plants. This review paper represents an initial effort to discuss the applications of phytomedicine in the prevention/management of Non-Communicable Disorders (NCDs), highlighting their accessibility, affordability and reduced side effects. It emphasizes the need for further research, preservation and responsive use of these natural remedies to develop evidence-based therapeutic interventions that can contribute to public health initiatives to combat NCDs locally and globally.

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Author's Contribution

Manvendra Sengar: Conceptualizing the manuscript.

Neelam Kashyap: Participated in organizing the study.

Abha Sachan: Data curation and conceptualization.

Prakash Chandra: Supervision.

Shailendra Kumar: Conceived and designed the analysis.

Dev Brat Mishra: Analysis of the review.

Ashutosh Tiwari: Writing review and editing.

Ethics

This review paper includes secondary information and has been verified by the corresponding author and co-authors. They have confirmed that no ethical issues were involved in the preparation of the manuscript. All sources have been duly acknowledged and cited in the reference section.

Conflict of Interest

Authors declares that there is no conflict of interest.

Abbreviations

CD - Chronic diseases; CAD - Coronary artery disease; CRDs-Chronic respiratory diseases; CHDs - Congenital heart defects medicinal and aromatic plants; COPD - Chronic obstructive pulmonary disease; CRDs,

Chronic respiratory diseases; CVD - Cardiovascular diseases; DALY - Disability-adjusted life-years lost; DCs - Dendritic cells; DM-Diabetes mellitus; ECs - Eosinophilic cells; HM - Herbal medicine; LD - Lethal Dose; MAPs - Medicinal and aromatic plants; NCD - Non-communicable diseases; NSAIDs - Non-steroidal anti-inflammatory drugs; SDGs - Sustainable development goals; T &CM - Traditional and conventional medicines; TH_2 - T helper-2; TM - Traditional medicines; UNGA - United Nations General Assembly.

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