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Overview of Himalayan Medicinal Plants and Phytomedicine

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Abstract:- Modern exploration of medicinal plants, used in traditional systems for curing infection and maintaining holistic health, have revealed high therapeutic value against infectious and chronic conditions. Traditional medicines which rely on multicomponent mixtures of medicinal plants and their complex interactions are finding renewed relevance in disease management. Recent understanding that majority of diseases are multi-factorial and targeting a single cause of a disease by a single drug may not deliver satisfactory treatment results has increased the acceptance of multicomponent therapies in western medicine. Such strategies have been particularly important in treating diseases such as HIV, Tuberculosis, Malaria, different Cancers, Alzheimer's, Parkinson's, Diabetes, Hypertension and Inflammation among others. The increasing popularity and acceptability of herbal medicine has raised concerns regarding the standardization, therapeutic efficiency, chemical integrity, drug-herb and herb-herb interaction and adverse reactions. Hence, coordinated research and clinical trials are necessary to study the efficacy and safety of herbal medicines as well as to determine the mechanism of actions. Moreover, it is imperative to develop delivery systems that target multiple and overlapping pathways in order to effectively deliver multiple active agents, increase bioavailability and concentration of therapeutic agents at the target. Himalayan medicinal plants from remote and virgin habitats long been regarded as sources of new therapeutic lead remain unexplored under modern technological advancement. Ethnopharmacology guided selection and high-throughput bioactivity screening can translate the potential of these medicinal plants into therapeutically significant biopharmaceuticals.

Keywords:- *Medicinal Plants; Phytotherapy; Drug Discovery; Active compounds; Disease Management; Ethnopharmacology.*

I. INTRODUCTION

Throughout the history, humans have relied on plants for food, shelter and most importantly medicines. Generations of human ancestors became part of a vast trial by error experiments aiming to decipher the medicinal and toxicological properties of several plants. Thousands of years of such research and clinical trials authenticate the safety and effectiveness of several plants against general and specific ailments. And this seasoned knowledge would be passed onto next generation through traditional healers who carried the responsibility of nurturing, developing and practicing this science of herbalism. Subsequent development in science and technology contributed better understanding of the chemical constitution and respective physiological activity thereby expediting the development of modern phytomedicine.

II. OVERVIEW ON USAGE OF MEDICINAL PLANTS

Phytomedicine often referred to as herbalism and phytotherapy in the west, is a field of medicine that uses plants and their preparations either to treat disease or as health-promoting agents. Most traditional systems of medicine throughout the world are based on phytotherapy [1]. Some of the earliest practices of traditional herbal medicine includes Ayurveda, Traditional Chinese medicine, Traditional Korean medicine, Traditional African medicine, Ancient Iranian medicine, Persian medicine, Islamic medicine, Siddha medicine, Unani, Muti and Ifa [2]. Primary drugs in these traditional systems existed in forms of powders, granules, infusions, decoctions, oils**,** tinctures, pastes, poultices and compresses of medicinal plants [3, 4].

Since ancient times, paramount civilizations all over the world consumed Harmal (*Peganum harmala*), Cannabis (*Cannabis sativa*), Nutmeg (*Myristica fragrans*), Coca (*Theobroma cacao*), magic Mushrooms (*Psilocybe sp.*), Opium (*Papaver somniferum*), Willow bark (*Salix sp.*), Indian lilac (*Azadiracta indica*), Rhubarb (*Rheum sp.*) and Ginsing (*Panax sp.*) among others as recreational and/or medicinal drugs [5]. Moreover, plants like Cinnamon (Cinnamomum tamala), Ginger (Zingiber officinale), Holy Basil (*Ocimum santrum*), Red pepper (*Zanthoxylum aromatum*), Cumin (*Cuminum cyminum*), Asparagus (*Asparagus racemosus*), Gooseberry (*Emblica officinalis*), Mugwort (*Artemisia vulgaris*), Turmeric (*Curcuma longa*), Thyme (Thymus vulgaris), Garlic (*Allium sativum*) and Fenugreek (*Trigonella foenum-graecum*) are found in kitchens all around the world and have been used as home remedies for simple ailments [6]. These herbs used in traditional systems for maintaining holistic health have high medicinal value and serve as a potential source of therapeutic new drugs [7-11].

Scientific works from Charles Derosne, Friedrich Sertürner and Joseph Louis Gay-Lussác on poppy (*P. somniferum.*) extracts led to the isolation of Morphine which became the ultimate pain medication in the 19th century [12]. Similarly, the isolation of a bitter glycoside, Salicin, by Johann Buchner as active ingredient of Willow bark (*Salix alba*) in 1828 and its subsequent translation into

ASPIRIN[13] pioneered a quest of isolating active constituents of medicinal plant extracts with greater therapeutic values. Extensive screening of medicinal plants led to the isolation of number of pure compounds or new chemical entities which have successfully developed into important drugs of the modern era.

Of all drugs produced between 1981 and 2014, it was found that only 33% antiinfective drugs (including antibacterial, antifungal, antiparasitic and antiviral) were synthetic and 67% drugs were either natural, or natural product derived or at least contained pharmacophore of natural origin. This was also true for Anticancer drugs in which 87% of all anticancer drugs were natural product derivatives and only 17% was synthetic [14]. Therefore, it is evident that plants will continue to be indispensable source for new drugs discovery in the future. Some of the important drugs discovered prom plant source are summarized in Table 1.

Compound	Effect/Activity	Plant Derived From	Reference
Artemisinin	Antimalarial	*Artemisia annua* L.	[15-17]
Berberine	Antimicrobial, Antidaibetic	*Berberis vulgaris* L.	[18-20]
Bergenin	Immunomodulatory, Antitussive	*Berginia ciliata*	[21, 22]
Capsaicin	Analgesic, Anti-inflammatory	*Capsicum frutescens* L.	[23, 24]
Catechin Catechol Epigallocatechin	Antimicrobial, Anti-inflammatory, Anticancer	*Acacia catechu* (L.f.) Willd.	[25-27]
Cucurmin	Anti-inflammatory	*Curcuma longa* L.	[28, 29]
Digitoxin Digoxin	Cardiotonic	*Digitalis purpurea* L.	[30, 31]
Paclitaxel	Antitumor	*Taxus brevifolia* Nutt.	[32, 33]
Podophyllotoxin	Anticancer	*Podophyllum peltatum* L.	[34, 35]
Quinidine	Antiarrhythmic	*Cinchona ledgeriana* (Howard) Bern.Moens ex Trimen	[36, 37]
Quinine	Antimalarial, Antipyretic		[38, 39]
Reserpine Rescinnamine	Antihypertensive, Ttranquilizer	*Rauvolfia serpentine* (L.) Benth. Ex Kurz	[40, 41]
Resveratol	Anti-inflammatory	*Veratrum album* L.	[42]
Scopolamine Atropine Hyoscyamine	Sedative	*Datura innoxia* Mill. *Duboisia myoporoides* R.Br.	[43-45]
Tetrahydro cannabinol	Antiemetic, Decreases occular tension	*Cannabis sativa* L.	[46-48]
Vinblastine	Antitumor, Antileukemia	*Catharanthus roseus* (L.) G. Don	[49-52]
Vincistrine			
Withanolide	Immunomodulatory	*Withania somnifera* (L.) Dunal	[53]

Table 1:- List of important Plant derived active compounds and their biological effect.

In general, medicinal plants and phytomedicine (preparations of medicinal plants) are used for health promotion and therapy for chronic diseases as opposed to life threatening conditions. Phytomedicine several advantages such as fewer side effects, better patient tolerance, acceptance due to long history of use and being affordable and renewable in nature. Further, positive experience with using herbal medicine in the past, including treatment successes and a positive impact on health and a failed conventional treatment effort, lack of treatment effect and adverse side effects of conventional drugs has increased the use of phytomedicine as an alternative to conventional treatment methods. It was also found that usage of traditional medicine increased when conventional medicine was ineffective and in the face of new infectious outbreak [11].

Before the advent of modern pharmaceutical industry in the 20th century, medicines were exclusively obtained from the natural sources and the preventive and curative prophylaxis were due to mixture of several plant extracts and their complex interactions. The modern pharmaceutics exclusively expedited the use of single-ingredient drugs or new chemical entities often isolated or derived from the natural source. In a highly publicized “one target - one drug” concept of modern therapy, a defined biological

function/activity is defined at a specified target through a specific therapeutic compound. These specific compounds were hypothesized by Paul Ehrlich as "magic bullets" that would specifically target diseases. Subsequently major drug development programs aimed at designing selective molecules that act on a single disease target were successful in obtaining number of highly effective and safe drugs with a low side effects in clinical trials.

However, recent understanding that majority of diseases are multi-factorial and targeting a single cause of a disease by a single drug may not deliver satisfactory treatment results has increased the acceptance of multicomponent therapies in Western medicine. Traditional medicinal systems which rely on multicomponent mixtures of medicinal plants and their complex interactions instead of mono-substances, are finding renewed relevance in disease management. Because diseases are driven by several signaling pathways, multi-targeted therapies are theoretically more efficient and could potentially evade the drug resistance that occurs when cells and pathogens acquire new mutations. Such strategies have been particularly important in treating diseases such as HIV, Tuberculosis, Malaria, different Cancers, Alzheimer's, Parkinson's, Diabetes, Hypertension and Inflammation among others.

Medicinal plants are important sources for both preventive and curative medicinal preparations in various medical systems worldwide. Till today, many medicinal plants written in historic documents/monuments and ethnopharmacology provide the integral foundation for modern medicine. They provide a tried and tested basis for selection of plants that often produce potent therapeutic leads thereby forming a bridge between traditional and modern system.

III. PHYTOMEDICINE IN THE NEPALESE HIMALAYAS

Nepalese Himalayas have been a home to a diversity of medicinal plants that have been used for millennia to treat conditions and ailments. In fact, Ayurveda the oldest science of natural healing originated in the foothills of the Himalayas and these practices still exist today. Further, geographical and climatic diversity of the Himalayas augment to a rare biodiversity and in with it a number of valuable medicinal plants. Ethnopharmacology and healing with medicinal plants is deep rooted in indigenous Nepalese societies and medical practices described by the Ayurvedic and Traditional Chinese medical system are still popular and often the only available forms of treatment.

Nepal has deeply rooted Traditional medical systems that are derived from Ayurveda, Unani and Traditional Chinese Medicine. Despite the development of modern or western medicine, people in these regions still rely on traditional medicine and practices for the prevention and cure of illnesses and often are the only measures for disease management. *Tribal Healers*, *Dhamis*, *Amchis*, *Baidhyas* and *Hakims* use plants singly or in combinatorial formulations to cure illness. The selection of plants is purely based on the ancient knowledge that is passed on from one generation to the other which is confined to and safeguarded by the practitioner.

Further, Nepal owing to its geographical and climate conditions, is one of the most biodiverse nation in the world with 807 algae, 2025 fungi, 771 lichens, 1150 bryophytes, 534 pteridophytes, 28 gymnosperms and 6653 species of angiosperms [54]. Among these at least 1600-1900 species of plants are used in traditional medical systems [55]. The fact that there are more than 36 ethnological groups in Nepal, each having distinct traditional medical treatment system highlights the vast repertoire of traditional knowledge available in the Himalayas[56]. Plants that are prominently used in traditional medical systems provide an important basis for selection of plants for bioprospecting. Such plants have a long history of use and can provide information on both therapeutic and toxicological properties.

Medicinal plants such as Jatamansi (*Nardostachys jatamansi*), Lauth Salla (*Taxus baccata*), Padamchal (*Rheum australe*), Panchaunle (*Dactylorhiza hatagirea*), Chiraito (*Swertia chairayita*), Kutki (*Picrorhiza kurroa*), Satuwa (*Paris polyphylla*), Sarpagandha (*Rauwolfia serpentina*), Pakhanbed (*Bergina ciliata*), Punarnava (*Boerhavia diffusa*), Ashwagandha (*Withania somnifera*) are prominently used in traditional medical preparations in Nepal, China and India. They also have long history of use, proven physiological benefits and thus a huge demand within the country and abroad [57-59]. Majority of the Nepalese medicinal plants are exported to India, China, Europe (Germany, France, Finland, Hungary, Switzerland, Belgium), Japan, Pakistan, USA, Canada, Singapore and Hongkong[59].

Panchaunle, Pakhanbed, Kutki, Padamchal and Satuwa are most prominently traded plants from Nepal. Various studies summarized in Table 2, highlight the bioactive potential of these plants. Kafle et. al. reported that Kutki (*Picrorhiza kurroa* syn. *Neopicrorhiza scrophulariiflora*) was found as a constituent in at least 45 herbal products marketed as ayurvedic medicines by 23 manufacturing industries. The annual demand for dry rhizomes of Kutki in Nepal alone was found to be worth NRs 8573236 (USD 83235.30) in 2015/016[60]. The demand is much higher for more potent plants such as Satuwa (*Paris polyphylla*), Pakhanbed (*Bergenia ciliata*), Ashwagandha(*Withania somnifera*) and Sarpagandha (*Rauwolfia serpentina*) which are multifaceted with wide range of bioactivities [57, 58, 61].

Reports show that Nepal exported medicinal plants worth $60.09 million in 2014 compared to US$27.49 million US in 2005. However, this growth in export amount was primarily due to increase in price rather than volume of trade[57]. This suggests a high demand for these plants and short supply leading to higher price. Such high demand for herbal raw materials and products in domestic and foreign markets presents a severe threat of overexploitation of

medicinal plants. Higher demand often leads to unsustainable overharvesting which causes loss of medicinal plants in the wild. As a result of decreased supply, the price inflates which further encourages illegal collection, smuggling and adulteration.

Plant Name	Traditional Use	Active Compounds	Reported Bio-Activity	References
Padamchal (*Rheum australe*)	- as laxative, appetizer, blood purifier and tonic to immune system - leaves used to treat oral and gum disease - root in treatment of gastric disorders and inflammation - rehabilitation of fractured bones - relieving menstrual cramps and pain [62, 63]	-Anthraquinones (Rhein, Emodin, Chrysophanol, Physcion) -Stilbenes (Picetannol, Resveratrol) -Flavonoids (Catechin, Epicatechin, Carpusin, Maesopsin) -Phenols (Gallic acid, Quercetin) β-Sitosterol	- inhibition of carrageenin induced edema demonstrating anti-inflammatory activity - prominent antimicrobial against *B. subtilis, S. aureus, E. cloacae, E. coli, K. pneumoniae, P. aeruginosa, S. typhimurium* and *Sh. flexneri* - invitro DPPH, ABTS and FRAP antioxidant activity - Antidiabetic activity - hepatoprotective effect against paracetamol induced hepatotoxicity -anticancer effect via induction of apoptosis in stomach cancer KATO III cells - immunomodulatory activity	[64] [65] [66, 67] [68] [69] [70] [71, 72]
Panchaunle (*Dactylorhiza hatagirea*)	- rhizome used as rejuvenating nervine tonic, - paste of petiole and rhizome in treatment of skin disease and as emollient, - root extracts used as aphrodisiac and antidiabetic - antimicrobial and wound healing - also useful in dysentery, chronic diarrhea, weakness and general fatigue [55, 73]	- Dactylorhin A, B, C, D and E - Dactylose A and B - Militarine - Loroglosssin - (2R)-2-β-D-glucopyranosyloxy-2-(2-methylpropyl) butanedioic acid	- Antioxidant - Antibacterial against *E. coli, S aureus, B. subtilis* and *Sh. Flexinerai* - Aphrodisiac activity in rats	[74] [75] [76]
Satuwa (*Paris polyphylla*)	- prominently used as antidote against poisonous snake and insect bites - as depurative agent and digestive stomachic - as analgesic, antipyretic and expectorant - to treat inflammation and infections [73, 77-79]	- Paris saponin I, II, III and IV - Polyphyllin II and VII, -1,5-dihydroxy-7-methoxy-3-methylanthraquinone - Formosanin C - Diosgenin	- DPPH Antioxidant activity - Antimicrobial against *E. coli, S. aureus, B. subtilis, P. aeruginosa, A. niger* and *Trichoderma reesei*. - Immunomodulatory activity through increased respiratory brust, elevated levels of nitric oxide and enhanced phagocytic activity - Anticancer activity against prostate cancer through induction of cell cycle arrest and apoptosis - Inhibition of growth of breast cancer cell lines, MCF-7 and MDA-MB-231 by inducing apoptosis via the mitochondrial dysfunction pathway - Induction of apoptosis through inhibition of Bcl-2 and enhancement of caspase-3 in gefitinib-resistant non-small cell lung cancer and anti-metastatic activity by suppression of migration, adhesion and invasion of A549 lung cancer cells via	[80-82] [83] [84] [85] [86, 87] [88]

			downregulation of MMP-2 and MMP-9 - Elevation of proapoptotic elements such as Bax,cytosolic cytochrome c, activated caspase-3 and caspase- 9 in treated SKOV3 ovarian cancer cells	
Kutki (*Picrorhiza kurroa*)	- root has bitter taste and produces cooling effect - root extracts are used as antipyretic, anthelmintic and laxative - useful in management of cold, coughs and indigestion - treatment of jaundice, hepatitis and liver disease - as a cardio tonic and regulator of high blood pressure and diabetes [89]	- Picroside I, ii, iii, iv - Vanillic acid - Kutkoside - Pikuroside - Apocyanin - Veronicoside - Picroliv - Kutkin - 6-Feruloylcatalpol	- Antibacterial activity *against P. aeruginosa and S. aureus, E. coli, B. subtilis* and *M. luteus* - Antifungal against *Candida tropicalis, C. albicans, Penecillium marneffi* and *Trichophyton rubrum* - Antioxidant and protection against oxidative damage of macromolecules such as DNA, protein and lipids - Hepatoprotective benefits in nonalcoholic fatty liver disease and provides resistance against hepatic damage and remarkable structural and architectural integrity - Anticancer activity through induction of apoptosis in MDA-MB- 435S, Hep3B and PC-3 cell lines	[90] [91] [92] [93] [94]
Pashanbed (*Berginia pacumbis*)	- well documented use as lithotrophic (breaking gall and renal stones) - as a tonic and diuretic - treat coughs and colds, - treatment of pulmonary infections, asthma and urinary problems - healing, fresh cuts, wounds and fractured bones - as a tonic in the treatment of fevers, stomach disorders like diarrhea, constipation and parasite infection [73, 95-98]	- [10]-3-O-galloylepicatechin - [10]-3-O-galloylcatechin - Berginin - Sitosterol - Stigmesterol - Afzelechin	- Inhibitory effects against *Bacillus subtilis, Escherichia coli, Staphylococcus aureus* and *Pseudomonas aeruginosa* - Inhibition of the influenza virus A and Herpes simplex virus - Inhibitory activity against rat intestinal digestive enzyme, α-glucosidase and porcine, pancreatic α-amylase -Dissolution of calcium oxalate and calcium phosphate stones	[99] [100] [101] [102]

Table 2:- Some ethnopharmacologically important Nepalese medicinal herbs and their reported bioactivity.

Adulteration through mixing or substitution of medicinal herb(s) with materials of substandard quality may lead to decreased efficacy and adverse effects. The growing concern regarding medicinal plants are the correct identification when a small amount of dried/powdered sample provided and adulteration of rare, expensive medicinal plants with easily available local plants. Hence, scientists needed a tool that provides correct identification of plant at the molecular level. Recently, DNA barcoding has been proposed as possible method for identification and authentication of medicinal plants in herbal products. DNA barcoding can be applied for the correct identification as well as in forensic determination and verification of herbal and dietary supplements[103, 104].

These barcodes primarily used for species dentification tool can also be used for biodiversity conservation. The diversity in DNA barcodes of species sampled in a specific area can provide an estimate of biological diversity in that location. Further barcode data if incorporated in trade surveillance can check illegal trading of species/commodities. Also, DNA barcoding can assist in more accurate and rapid biodiversity monitoring after implementation of conservation actions. The surveillance data can be used to evaluate the efficiency of conservation measures as well as to prioritize conservation areas based on phylogenetic diversity [105]. Nepalese medicinal plants which seek high price in local and foreign markets are often subject to illegal trade and adulteration. Implementation of DNA barcoding can effectively establish the authenticity of traded material as well as help in surveillance and conservation of endangered and threatened species.

Another effective measure in conservation of high valued Nepalese medicinal plants in the wild can be adoption of sustainable farming and harvesting methods. This ensures a continued supply of raw materials as well as conservation of the rare valuable herbs in the wild. The economy of some rural Nepalese communities in the high-altitude regions that dependent on trade of medicinal plants can be improved by engaging in cultivation. Large number of people, are engaged in the collection and trade of Medicinal and Aromatic Plants for their livelihood. Therefore, by providing training and education to farmers,

prioritizing medicinal plant cultivation and investment on processing and standardization, greater benefits can be reaped from the medicinal plant sector which ultimately contributes in uplifting the socio-economic status of local people.

IV. CURRENT TREND AND FUTURE PERSPECTIVES

Herbal medicine continues to be the major healthcare system in developing countries and its popularity has escalated in developed countries throughout the word. This popularity upsurges the global demand for medicinal herbs and herbal medicine. The WHO has stated that trade in medicinal plants, herbal raw materials, and herbal drugs is growing at annual growth rate of about 15%. A report published by Market Research Future has projected that the market for Herbal medicine is growing at a CAGR close to 7.2% during 2017-2023 and expects the market for herbal medicine to reach $ 111 billion by the end of 2023. Incorporation of cutting-edge analytical techniques and research methodologies will improve the safety, efficacy and quality of Herbal medicines and inevitably herbal medicine will be integrated into modern medical systems in the near future.

The increasing popularity and acceptability of herbal medicine has raised concerns regarding the standardization, therapeutic efficiency, chemical integrity, drug-herb and herb-herb interaction and adverse reactions. Hence, coordinated research and clinical trials are necessary to study the efficacy and safety of herbal medicines and determine the mechanism of actions. Further, the modern healthcare system has shifted from being general to what is now customized and personal medicine. In this scenario, researchers should determine the specific molecular targets of the phytochemical under study and adopt appropriate targeting and delivery methods that effectively increase bioavailability and of the drug at the target site. Moreover, delivery systems that target multiple and overlapping pathways, could effectively deliver multiple active agents, increase bioavailability and concentration of therapeutic agents at the target.

Pharmacological and therapeutic effects of plant extracts are derived from additive or synergistic effects of several compounds only measurable in the total extract. The synergistic interaction of these compounds vanishes during the isolation procedure. Using concepts of systems biology may offer new opportunities for the scientific evaluation of herbal preparations whose therapeutic efficacy is caused by the combined action of a mixture of constituents. Holistic in vivo test systems and complex functional tests such as cellular and isolated organ assays, animal experiments may be superior subcellular single target test systems (e.g. enzyme and receptor binding assays) that are usually target-driven and do not allow the detection complex effects caused by the interaction of different constituents. Moreover, using robust state of the art technology and methods can help researchers to elucidate the molecular mode of actions of phyto-therapeutics. In addition, new tools such as DNA microarrays, proteomics and metabolomics may be used for the diversity-oriented screening of herbal drugs.

Importantly, population and availability of medicinal herbs will limit the number of herbal drugs produced for therapeutic purpose. Majority of the demand for medicinal herbs is met by exporting the herbs collected by local people from the wild. However, collection from the wild is destructive and appropriate cultivation technologies must be developed and adopted to protect these valuable medicinal plants from irrational exploitation. Hence, scientific community should also be engaged conservation in vivo and development of modern, sustainable cultivation and harvesting methods apart from conducting advanced research and clinical trials that establish the safety and biological activity of herbal formulations. Investment on education and research infrastructure, vocational training on cultivation and sustainable harvesting and adoption of modern technology for qualitative and quantitative improvement of medicinal plants is important to maintain authenticity and sustain the demands for genuine Nepalese medicinal herbs.

V. CONCLUSION

Modern exploration of medicinal plants, used in traditional systems for curing infection and maintaining holistic health, have revealed high therapeutic value against infectious and chronic conditions. Himalayan medicinal plants contain great variety of medicinal properties including antimicrobial, antioxidant, antidiabetic, anticancer, hepatoprotective, neuroprotective and immunomodulatory functions. Recent understanding that majority of diseases are multi-factorial and targeting a single cause of a disease by a single drug may not deliver satisfactory treatment results has increased the acceptance of plant based multicomponent therapies in western medicine. Such strategies have been particularly important in treating diseases such as HIV, Tuberculosis, Malaria, different Cancers, Alzheimer's, Parkinson's, Diabetes, Hypertension and Inflammation among others. Traditional medicines which rely on multicomponent mixtures of medicinal plants and their complex interactions are finding renewed relevance in disease management.

As medicinal plants continue to provide new chemical entities and alternative treatment measures, Nepal has a huge possibility of deriving social and economic benefits from the commercial cultivation and industrial utilization of these magical medicinal herbs. Further, molecular validation of medicinal herbs/herbal products using DNA barcoding techniques, incorporation of high-throughput screening techniques, drug standardization and subsequent translation into biopharmaceuticals through clinical research could promote this richly biodiverse country as a hub for novel therapeutic discoveries.

➢ *Authors Contribution*

Neupane, P. wrote and shaped the manuscript. Lamichhane, J. provided critical feedback and supervised the study. Both authors discussed and approved the manuscript.

Authors state no conflict of interest.

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