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REVIEW ARTICLE

A review on therapeutic potential of *Swertia chirayita*

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ABSTRACT
Herbal therapeutic plants are vital for about 80% of the world's inhabitants in developed as well as emergent countries for their vital and primary health care along with minor side effects. Phytochemical ingredients such as alkaloids, flavonoids, xanthones, saponins, glycosides etc are reported to found unboundedly in herbal plants. Swertia chirayita (Gentianaceae), is a popular therapeutic herb which is indigenous to the temperate Himalayas and is used in conventional medicine for the treatment of various ailments and are reported to encompass a wide range of pharmacological properties. This medicinal herb is recognized typically for its bitter taste which is caused by the occurrence of diverse phytochemical compounds that are directly associated with regards to human health benefits. The aim of the present review is focused on the discussion over the taxonomy, botanical description, distribution, phytochemistry, biological activity and medicinal activity of Swertia chirayita along with its possible application in pharmaceutical industries and gap identification. At present, very less information are available in the scientific platform about the medicinal importance of Swertia chirayita. Thus the present article would be an endeavor to amass and document information on diverse aspects of Swertia chirayita and emphasize the requirement for research and development.
Key words: *Swertia chirayita, antimicrobial, antioxidant, phytochemistry, anticancer.*

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INTRODUCTION

Ayurveda, the essence of life, dates back to the era of Charaka Samhita and Sushruta Samhita (1,200 AD). It states that the body and mind should be strong and balance among the two is the returning theme of Ayurveda. For achieving this conclusion, drug plants and drug yielding herbs, has been accredited all through the centuries [1]. Ayurveda is one of the ancient therapeutic systems in the world, providing immeasurable leads to discover vigorous and therapeutically valuable compounds for drug development from plants. At present, the utilization of herbal medicines is broad spread across the globe due to its natural basis and less unfavorable effects [2]. Herbs have always been the chief form of medication in India and currently they are becoming admired throughout the world, as community endeavor to stay healthy in the face of chronic stress and pollution, and to treat sickness with medicines that work in add up with the body's own defense. There is a extensive conviction that herbal medicines are healthier and more undamaging or safer than synthetic medicines [3]. The World Health Organization (WHO) anticipated that about an 80% population of developing countries depends on traditional medicines, typically plant drugs, for their primary wellbeing care necessities [4]. The utilization of herbs and therapeutic plant as the primary medicines is a universal phenomenon. India a country of massive biotic prosperity has more than 7000 plant species reportedly used for medicinal purposes the bulk of which are being used for the extraction of drugs. The age old traditional principles attached with the range of forest products (i.e., medicinal plants) have gained incredible significance in the current century [5, 6, 7].

Therapeutic plant drug continues to offer novel and imperative leads against a variety of disease including cancer, diabetes, malaria, cardiovascular and neurological disorders [8]. During the last few decades there has been an escalating curiosity in the study of therapeutic plants and their conventional use in various geographic locations of India such as Himalayan zones, Desert areas, Western Ghats, North-East India etc. There are numerous information regarding the use of plants in traditional remedies by either tribal populace or native communities of India [9, 10, 11, 12]. Uttarakhand is one of the states in India which is recognized for its enormous diversity in terms of flora and fauna and as well its prosperous plant based traditional approaches. *Swertia chirayita* is one among the 32 extremely prioritized therapeutic herbs in the rich biodiversity of Uttarakhand (India) as acknowledged by National Medicinal Plant Board, Government of India. *Swertia chirayita* belongs to Gentianaceae family consisting of 84 genera and about 970 species in the world and treated the family under order Gentianales [13]. Members of the family are extensively dispersed but mainly diverse in subtropical and temperate regions and in the montane tropics. *Swertia chirayita* has been reported consisting of various active secondary metabolites which are responsible for immense bioactivities and important medicinal properties such as antibacterial, wound healing, anti-inflammatory, antiviral, anti-diabetic, antipyretic as well as antioxidant activities [14]. The present review discusses about the botanical description, medicinal, in pharmaceutical industries and gap identification of *Swertia chirayita* summing up the research efforts about its clinical properties and its characterization.

SWERTIA CHIRAYITA

Swertia, a genus in the family Gentianaceae including a huge assemblage of annual and perennial herb representing around 135 species. *Swertia* species are commonly used in various herbal remedies. About 40 species of *Swertia* are recorded in India [15, 16]. *Swertia chirayita* is considered as the most imperative for its therapeutic properties. It was initially described by Roxburgh under the name of *Gentianachyrayta* in 1814 [17]. Chirayata has vertical stems which grow about 2 to 3 ft long. These are orange brown or purplish in color containing large yellow colored pith. It has simple and short root which is about 7 cm long and typically half an inch broad. It has small flowers which are green yellow in color (Figure 1). The fruits are small in size with one celled capsule bearing transparent yellow colored pericarp. Its leaves are about 10cms in length and in opposite pairs having no stalk [18].

Common names and botanical classification

Swertia chirayita (Gentianaceae) is known numerous names in Indian tertiary which suggesting its widespread uses amongst Indian population. The common names and botanical classification of *Swertia chirayita* are tabulated in Table 1 and Table 2, respectively [19, 18].

Distribution and Habitat

The plant is an inhabitant of temperate Himalayas, and is found at an altitude of 1200-3000 m (4000-10,000 ft), commencing from Kashmir to Bhutan and in the Khasi hills at 1200-1500 m (4000-500 ft) It can be developed in sub temperate regions between 1500 and 2100 m altitudes [20]. It occurs intermittently in subtropical and temperate forests in open forest precincts, as well as cool and humid place or in shaded damp slopes amid tall grasses. *Chirayita* prefers to develop in acidic soil condition with pH of 4.7 to 5.5. The foremost threats to the wild populace of this plant species are loss of habitat and its harvesting for therapeutic uses [21, 22].

Substitute of *Swertia chirayita*

In the deficiency of a preferred primary option medicinal herb, traditional Ayurveda recommends utilization of a functionally alike substitute [23, 24], which has been mentioned in Table 3.

TRADITIONAL USES

The traditional Ayurvedic herb *S. chirayita* has been used for several medicinal purposes by different indigenous Indian population. It cures the nutritional disorders occurring in the body and helps in bringing regularity into the system. It has the properties to reduce cough, bronchial infections, malaria and asthma, inflammation, and digestive diseases. The plant is wholly used in medicines for more than centuries [25]**.** The traditional use of *S. chirayita* is mentioned in the following Table 4 [19, 26, 27].

PHYTOCHEMISTRY

Phytochemicals are natural substances and might be acquired equally in primary and secondary metabolic pathway. They are synthesized naturally in all parts of plant such as bark, stem, root, flower, fruits, seeds, leaves etc. The most imperative bioactive elements present in plant are flavonoids, alkaloids, steroids, terpenoids, tannins, glycosides, and so forth [28]. The extensive spread uses of *Swertia chirayita* in conventional drugs have resulted in substantial chemical investigation of the plant along with vigorous

principles by which the medicinal properties are attributed to the plants [14]. Sayyed *et al.,* investigated that the methanolic extract of *Swertia chirayita* shows the existence of phytoconstituents alkaloids, carbohydrates, glycosides, flavonoids, tannins, terpenes and phenolic compounds whereas saponins not present [29]. Phoboo *et al.,* studied through HPLC analysis quantity of mangiferin was estimated to be maximum in aqueous extract as well as 12% ethanolic extract of IL (mixture of inflorescence and leaf) for all plant samples of *Swertia chirayita*. In general, the extracts of stem had higher amount of mangiferin as compared to the root extracts for all collected samples. The highest quantity of mangiferin was 0.46 mg/g DW in aqueous and 0.4 mg/g DW in ethanolic extracts of IL from Rasuwa. The quantities of mangiferin along with its derivatives were observed to be 0.003 mg/g DW in aqueous and 0.001mg/g DW in ethanolic extracts of roots from Dolakha which was the lowest amount [30]. Mahmood *et al.,* investigated that results of phytochemical tests discovered the presence of alkaloids, flavonoids, saponins, ascorbic acid, glycosides, steroids and triterpenoids in the methanolic extracts of all three species Nepali *chirayita* Multan, Nepali *chirayita* Karachi and Indian *chirayita* Multan. Tannins and polyphenols were entirely absent in all, but anthraquinones existed in Nepali *chirayita* Karachi, and absent in Nepali *chirayita* Multan and Indian *chirayita* Multan [31]. As the presence of secondary metabolites and foremost phytoconstituents in other species of *Swertia* in substantial amounts is well known so these species ought to be conceived for analysis to discover the potential of bioactive compounds as well as its authentication and determination regarding in future their characteristics, purity and quality.

MEDICINAL ACTIVITIES

The extensive uses of *S. chirayita* in traditional drugs have resulted in substantial chemical analysis of the herb and lively principles which attribute the plant its remedial properties (Figure 2). The entire plant is utilized in conventional remedies. It is reported that root of this herb is the most bioactive component[16]. Research analysis demonstrates that the extracts of *S. chirayita* extracts possess an extensive range of pharmacological activities such as antibacterial, antioxidant, antifungal, anticancer, antiviral, anti-inflammatory and antidiabetic activities [32, 33].

Antioxidant Activity

Reactive oxygen species (ROS), such as superoxide anion, hydrogen peroxide, and hydroxyl radicals are generated in living organisms during various metabolic pathways. ROS causes oxidative damage and generate a variety of diseases in the human being such as aging, cancer, inflammation, arthritis, and heart diseases. Antioxidants are that chemical compound which reacts with reactive free radicals to demolish them by accepting or donating electron(s) to eradicate the radical or reduce the formation of free radicals thereby preventing the oxidation of lipids, sugars and proteins and DNA damage [34]. Antioxidant compounds consists of enzymes such as Superoxide dismutase, catalase etc. Vitamins such as vitamin A, C and E and also the phytochemicals present in plants like flavonoids (flavanols, flavones, catchins, isoflavones) etc. Many investigations have been done regarding the antioxidant activity of herbal plants [35]. Chen *et al.,* investigated antioxidant activity of 70% ethanolic extract of *S.chirayita* by performing reducing power and beta carotene assay. High DPPH scavenging activity of about 267.80 µg/mL was shown by 70% ethanolic extracts of *S.chirayita* as per the results [36]. *In vitro* antioxidant capacity of methanolic extracts of *Swertia chirayita* exhibited effective results as compared to the standard compounds such as BHT gallic acid [37]. Kshirsagar *et al.,* investigated the antioxidant activity of different solvents ethanol, methanol, acetone and aqueous extracts of entire plant of *Swertia chirayita* comparing with Gallic acid as control. The results showed that the antioxidant activity (DPPH) for the ethanolic extract was much more effectual than methanolic extract of *S. chirayita* whereas the antioxidant activity of water extract of *S.chirayita* was much better than the acetone extract [38]. Kumar *et al.,* analyzed the antioxidant activity of leaf samples of *Swertia chirayita* and *Punica granatum* and it was revealed that *Punica granatum* showed higher antioxidant activity than *Swertia chirayita.* Further studies are considered necessary for the identification and validation of compounds for better approach [39].

Antimicrobial Activity

The number of multidrug resistant microbial strains with reduced susceptibility to antibiotics is constantly escalating. Screening of a number of therapeutic plants to evaluate their potential for antimicrobial activity is being done. Medicinal plants signify a prosperous source of antimicrobial agents having the capability of inhibiting the growth of pathogens and to heal many infectious diseases [40]. Ahirwal *et al.,* investigated the antimicrobial activity of the methanolic extract of *S. chirayita* which showed most noteworthy activity against *B. subtilis* (5 mm at 800 µg/ml) whereas against *E. coli* and *S. typhi* (4 mm at 800 µg/ml) the activity was moderate. No activity was shown against *S. aureus, V. cholerae, P. alkalifaciens,* and *P. aeruginosa, S. pyogenes.* Moderate activity was shown by aqueous extract against *E. coli, P. alkalifaciens, S. typhi,* and *V. cholera* (2 mm at 800 µg/ml) and was inactive against *S. aureus, B.*

subtilis, S. pyogenes, P. mirabilis, B. polymyxa and *P. aeruginosa*. The antimicrobial activity of methanolic extract was found to be more effective than aqueous extract [41]. Nyein *et al.,* investigated the antibacterial property of ethanolic extracts of both stem and leaves of *Swertia chirayita* against several gram positive and gram negative microorganisms by means of disc diffusion method. It was revealed that ethanolic crude extract of both leaves and stem of *S. chirayita* showed effective inhibition against test organisms. For gram positive bacteria *S. aureus* and *B. cereus*, zone of inhibition for was observed 10 mm 6 mm, respectively. For gram negative bacteria, *E. coli* and *S. Arizonae* showed inhibition zone of 9 mm and 7 mm, respectively. The ethanolic extract of the medicinal plant *S. chirayita* both stem and leaves demonstrate appreciable antibacterial property [42]. Nayak *et al.,* revealed the antibacterial activity of ethanolic and methanolic extracts of *Swertia chirayita* on different pathogenic strains using agar well diffusion method. Significant activity of the ethanol extract of leaves was observed against *Bacillus sp*. and *Pseudomonas aeruginosa* with zone of inhibition having a range of 14-19 mm for *Bacillus* sp. whereas for *Pseudomonas aeruginosa* it was 10-18 mm. Moderate activity was shown by methanol extract of stem against *Bacillus* sp. with zone of inhibition ranging from 10-12 mm and *S. aureus* 9-10mm. Ethanol extract showed more effective activity against the bacteria compared to methanol extract. More research work is needed to find the mechanism of bioactive compounds against microorganisms [43].

Anti-Inflammatory Activity

Inflammation is considered as chief physiologic defense mechanisms of body that helps to defend itself against infections, toxic, burn, chemicals etc. An uninhibited and continual inflammation may act as feature for numerous of chronic illness. Anti-inflammatory drugs possess rigorous side effects therefore development of effective anti-inflammatory drugs consisting less side effects is compulsory from herbal plants [44]. Hossain *et al.,* investigated that mild to moderate anti-inflammatory activity was possessed by ethanolic extract of *S. chirayita*. Significant activity against acute, sub-acute, and chronic models of inflammation has been observed for the benzene extract of *S. chirayita* (whole plant).Effective anti-inflammatory activities was known to be possessed by the phytoconstituents such as Xanthone, glucosides and prenylated xanthones, mangiferin, mangostin, mangostin triacetate, and isomangostin [45]. Further investigations are still needed to pin point the exact compound and its mechanism for better understanding of actions.

Antidiabetic Activity

The term Diabetes mellitus is referred as cluster of common metabolic disorders which shares the phenotype of hyperglycemia. The factors responsible for it are reduced insulin secretion, decreased glucose consumption and increased glucose production. These factors are due to increase in oxidative stress occurred by higher production of reactive oxygen species and declination of antioxidant resistance. Following investigations have been done regarding antidiabetic activity to find the probable solution of this problem [46]. Grover *et al.,* investigated the *in vitro* antidiabetic activity of 95% of ethanolic and hexane extract of whole plant of *Swertia chirayita* in STZ-NAD (streptozotocnnicotinamide) induced diabetic albino mice. The plant came to possess antidiabetic activity [47]. Kumar *et al.,* revealed that aqueous extracts of leaves of *S. chirayita* and *Punica granatum* showed significant antidiabetic activity as it reduced the increased blood glucose level in the induced diabetic rats. The blood glucose level in *S. chirayita* treated diabetic rats decreased from 250.62 ± 2.03 mg/dl to 86.5 ± 2.85 mg/dl whereas the blood glucose level in *Punica granatum* treated rats decreased from 265.58 ± 3 .00 mg/dl to 90.23 ± 2.03 mg/dl. Both the plants showed antidiabetic activity [48].

Anticarcinogenic Activity

Cancer has been a continuous trouble worldwide for humankind. This ailment is characterized by continually multiplying and uncontrolled cells in the human body. Treatments like chemotherapy, radiotherapy are harmful to patients as it damages more of their health. Herbal medicines have been used and are being used as the chief source regarding the treatment and prevention of development of cancer in developing countries. Multiple researches are going on plant species to evaluate its anticarcinogenic properties [49]. Saha *et al.,* investigated that the hexane extract of whole plant of *Swertia chirayita* consisted *In vivo* anticarcinogenic activity [50]. Subedi and Karki investigated that the methanolic extract of *Swertia chirayita* exhibited the potential of anti-cancer activity against human cancer cell lines which were evaluated by the examining the effect on cell viability by MTT assay and fluorescence microscopy. The observation was done KELLY, MCF-7 and CACO-2 cells [51].

Antipyretic Activity

Antipyretic are a drug which reduce elevated body temperature and maintains the body temperature. Antipyretic activity is usually mentioned as characteristics of drugs which have inhibitory effects on prostaglandin biosynthesis [52]. Bhargava *et al.,* observed that significant *In vitro* antipyretic activity was shown by water extract of root of *Swertia chirayita* plant in Brewer's yeast induced pyrexia Typhoid-

Paratyphoid A, B vaccine induced Hyperexia [53]. Sharma and Kumar found that major antipyretic activity of methanolic extract of *Swertia chirayita* possessed against rectal elevated temperature induced by yeast suspension in rats. Furthermore investigations are required for characterization of bioactive principles needed for antipyretic activity [54].

Antiviral Activity

Viral infections are disseminated all over the world and causes various mild as well as acute diseases which are life threatening in some cases. There is a need of innovation of novel drugs for treatment of increasing viral resistance to antiviral drugs. The screening of many traditional plants has been done for antiviral activity in order to find some novel drugs regarding the treatment of viral diseases [55]. Verma *et al.,* investigated that significant *In vitro* antiviral activity was possessed by water extract of leaves/stem of *Swertia chirayita* against Herpes simplex virus type-1by using plaque reduction assay, cytotoxicity assay, virus infectivity and antigen expression assay alongwith PCR based approach [56]. Further developments of novel antiviral products with different mechanism of action are mandatory in order to evade the difficulty of viral resistance.

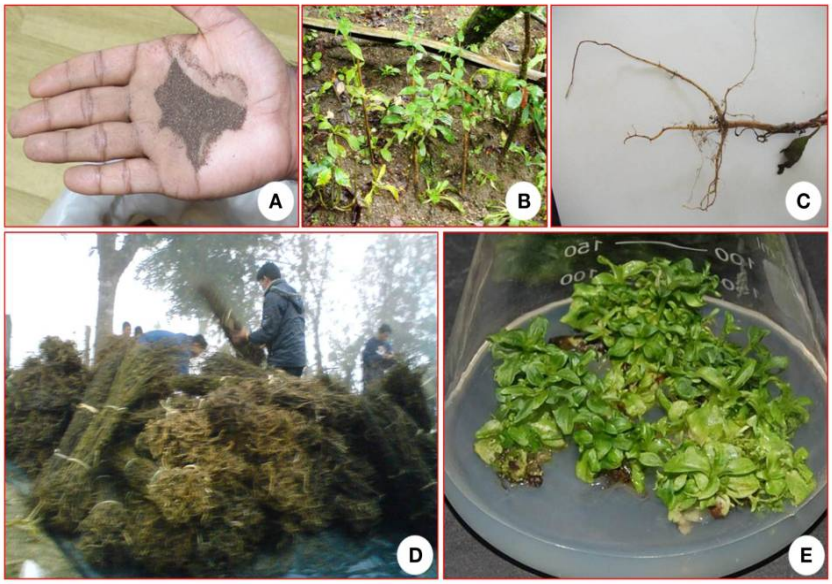

Figure 1. *Swertia chirayita.* (A) Seeds, (B) Plant in nature,(C) Root of a mature plant, (D) Dry plant material, (E) High shoot multiplication in a plant tissue culture system [14]. (Reproduced from permission of Frontiers in Pharmacology, Kumar and Staden, 2016)

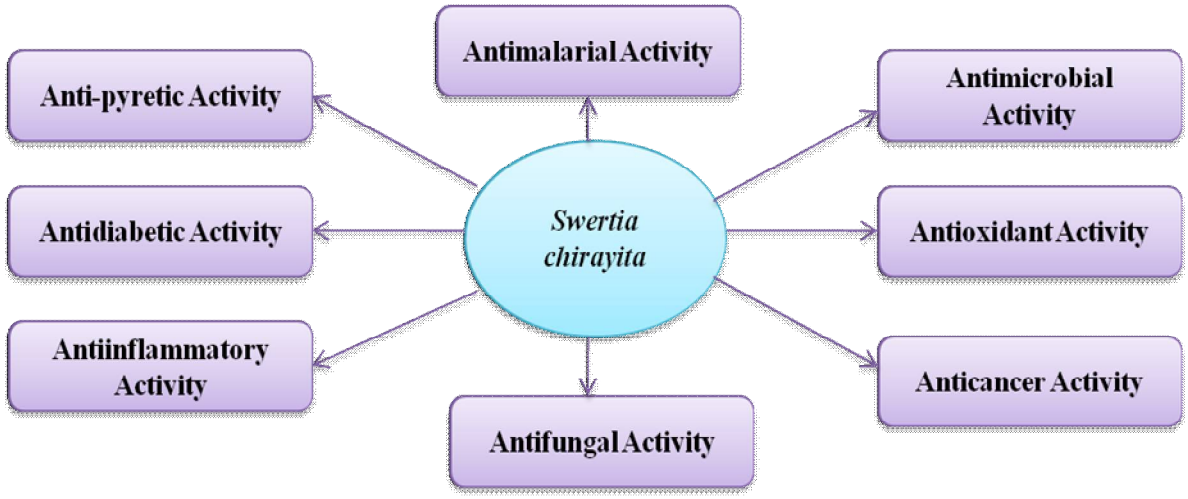

Figure 2. Different medicinal properties of *Swertia chirayita* due to which it is used for treatment of various diseases.

Table:-1 Common names of *Swertia chirayita* in India

Common Names	Different languages	States of India
Bhunimba, Anaryatika	Sanskrit	--
Chirrato	Nepali	Northern region of Uttarakhand
Chiraita and Kiraita	Marathi	Maharashtra
Chirayatin	Guajarati	Gujarat
Chireta	Bengali	West Bengal
Nilavembu	Tamil	Tamil Nadu
Charaita	Punjabi	Punjab
Nilavippa	Malayalam	Kerala

Table:-2 Botanical classification of *Swertia chirayita*.

Botanical Classification	
Kingdom	Plantae
Phylum	Tracheophyta
Class	Magnoliopsida
Order	Gentianales
Family	Gentianaceae
Genus	Swertia
Species	chirata

Table 3: Name of plants that have been used as substitutes of Swertia Chirayita

S. No.	Substitute of *Swertia chirayita*
1	*Swertia purpurascens* Wall
2	*Swertia perennis* Linn.
3	*Swertia lawii* Burkill
4	*Swertia chinensis* Franchet
5	*Swertia decussata* Nimmo
6	*Swertia chinensis* Franchet
7	*Swertia paniculata* Wall
8	*Swertia affinis* C. B. Clarke

Table 4. Traditional uses of *Swertia chirayita* in India

Parts of *S. chirayita*	Traditional uses
Whole plant	Headaches, blood pressure, malaria, skin diseases, dyspepsia, intestinal worms, liver and stomach disorders, kidney diseases, vaginal discharge, gastrointestinal infections, scanty urine, hypertension melancholia and certain types of mental disorders
Root	Root Serves as a drug effective tonic for general weakness, fever, joint pain, cough, asthma and common cold

FUTURE PERSPECTIVES

S. chirayita offers numerous promising prospects mutually for conventional and current medicine. *S. chirayita* is in fact a possible herbal remedy form any ailments. Commercial products such as Ayush-64, Diabecon and Menstrual syrup containing the extract of *chirayita* are used for antifungal, antipyretic and antibacterial properties [57]. Some phytochemicals like Swertiamarin, Mangiferin, Amarogentin etc exhibit a unique significance in scientific society as they consists of remedial properties such as antibacterial, antiviral, antiinflammatory activity etc. Further research work is required for analysis of phytochemicals along with their identification, purification as well as quantification which is also the need of time. The investigation regarding the mode of action of phytoconstituents is necessary to treat various diseases such as viral fever eg. dengue, cancer, along with treatment of a range of pathogens. Search for new drugs are in demand so these studies will be helpful in discovering novel therapeutic drugs beneficial for humankind. Due to multiple uses of *S. chirayita* its demand in both national as well as international markets is continuously on the rise. Medicinal plants should go through proper standardization mandatorily to be in market on the worldwide scale. Keeping in view the enormous medicinal and pharmaceutical value along with high demand of *Swertia chirayita*, conservation of this valuable and endangered therapeutic plant should be promoted. Herbal drugs are safer having fewer or no side effects as compare to allopathic medicines. Different bioactive constituents extracted from *Swertia chirayita* improve frequently occurring diseases like cough, cold, fever diarrhea, pain, etc. On the other hand utilization of expensive allopathic medicines might cause infinite side effects. So increasing

manufacture of *Swertia chirayita* active compounds can further be made accessible for the preparation of drugs which will also be cost effective.

CONCLUSION

Therapeutic plants are utilized by bulk of the Indian population. The reasons for this comprise accurate improvement of disease conditions after herbal treatment, detrimental side effects and the high cost of the other forms of treatment. *Swertia chirayita* comprises of a tremendous potential against various ailments. Further significant studies are essential for the determination of the mechanism by which *Swertia chirayita* exhibit medicinal potential properties and its effects are required to be confirmed by means of clinical trials for its effectual utilization as therapeutic agents in future which would be significant for humankind.

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