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## Chemical constituents and bio-pharmacological activities of *Swertia chirata*: A review

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### ABSTRACT

*Swertia chirata* (Chirayata) is a traditional Ayurvedic herb with strongly bitter taste. The whole plant promotes digestion and lowers fevers of various types. It is the main ingredient in sudarshana churna, a formula containing more than 50 herbs. Chirayata contains xanthenes, which are reportedly effective against malaria and tuberculosis; and amarogentin, a glycoside that may protect the liver against carbon tetrachloride poisoning. It promotes the flow of bile in liver and also has anticarcinogenic activity. The detoxification enzymes studied viz, reduced glutathione, glutathione peroxidase, superoxide dismutase and catalase were found to be activated to different degrees after the treatment with crude extract and a purified 'amarogentin' from chirayata. The effect of chirayata extract on apoptosis and cell proliferation has been studied in mice skin exposed to dimethylbenz (a) anthracene. Both the crude and purified extracts significantly inhibited cell proliferation and induced apoptosis. It may cure infectious diseases, tonsillitis, bronchitis, pneumonia, whooping cough, acute enteritis, gastritis, urethritis, nephritis, tuberculosis, gall bladder infection, influenza and high blood pressure. Besides, the anti-helminthic, hypoglycemic and antipyretic antifungal and antibacterial properties there are amarogentin (most bitter compound), swerchirin, swertiamarin and other active principles of the herb.

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### KEYWORDS

Amarogentin;  
Chirayata extract;  
Swerchirin;  
Swertiamarin;  
Detoxification enzymes.

### INTRODUCTION

Chirayata (*Swertia chirata*) belongs to family gentianaceae. It is known by different names, suggesting its widespread use. It is called Anaryatikta, Ardhatikta, Bhunimba, Bhuchiretta, Chiratika, Charayatah, Chiratitka, Chiraita, Haima, Jvarantaka, Kairata, Kandatikta, Kiranta, Kirataka, Naditikta, Naipala, Nepalanimba,

Nidrari, Ramasenka, Sannipatha, Sutiktaka, Trinanimba, and Viktaka in Sanskrit. The herb is called cherayata in Patna, Chirrato and Chiraita in Nepal, Chiraita and Kiraita in Mumbai, Chirayatin in Gujarat, Chireta in Bengal, Nilaveppa in Kerala, Nenilawandi, Nilavembu, Shirattakuchi (Tamil) and Sekhagi in Burma. It is also called Chiaravata (Urdu); Qasabuzzarirah (Arab, Farsi); Charayatah (Deccan); Nelabevu (Kannada). Its

medicinal uses are reported in different traditional systems of medicines such as the Ayurveda, Unani and Siddha. *Swertia chirata* is a medicinal plant indigenous to temperate Himalaya and grows abundantly in Himalayan regions of India between 1200-1500 meter altitudes<sup>[1]</sup>. It is also cultivated in Kashmir, Meghalaya, Khasi hills and Madhya Pradesh. Sudarshan Churna is very potent Ayurvedic formulation, which possess anti-malarial, antipyretic, hepatoprotective, antiviral, antihelminthic, antioxidant and antidiabetic activity and used in the treatment of all types of fever including bone fever, fever due to common cold, viral fever etc<sup>[2]</sup>. In Sudarshan Churna, *Swertia Chirata* is present in 50% of total quantity, remaining other 42 ingredients is in equal proportion in remaining 50% of total churna. The whole plant, aerial parts as well as root are used for traditional medicinal remedies. The extract of the plant is used for curing various diseases<sup>[3]</sup>. Externally, it is beneficial for cleaning the wounds and in the cases of skin rash, with the help of its decoction. The plant also responds well in case of skin diseases with oozing, burning sensation and itching. Internally, it is commonly used for fevers – acute, chronic as well as recurrent. It can be effectively used in epidemics of malaria as a preventive medicine. The herb is used in the form of an infusion or tincture. The infusion is prepared in hot water with aromatics like cloves and cinnamon. It is generally taken in doses of 15 to 30 ml or 1 to 2 tablespoons. The plant has an interesting chemistry, similar in many respects to *Gentiana lutea*, a widely used restorative tonic of the digestive system. The extract of *S. chirata* is used in the treatment of various disorder related to digestive, hepatic, regulating blood sugar levels<sup>[4,5]</sup>. Manjunath et al.<sup>[6]</sup> showed that the *Swertia chirata* possess strong wound healing activity.

### Taxonomy

<b>Domain</b>	:Eukaryota
<b>Kingdom</b>	:Plantae
<b>Subkingdom</b>	:Viridaeplantae
<b>Phylum</b>	:Tracheophyta
<b>Subphylum</b>	:Euphyllophytina
<b>Infraphylum</b>	:Radiatopses
<b>Class</b>	:Magnoliopsida
<b>Subclass</b>	:Lamiidae

<b>Superorder</b>	:Gentiananae
<b>Order</b>	:Gentiales
<b>Family</b>	:Gentianaceae
<b>Genus</b>	: <i>Swertia</i>
<b>Specific epithet</b>	: <i>chirata</i> .
<b>Botanical name</b>	: <i>Swertia chirata</i> Buch.-Ham. ex Wall.

The plant is an erect, annual, herb and grows 0.5-1.5 meters in height Figure 1. Roots are fibrous or woody; primary roots with few secondary rootlets or rhizomes short and with few fleshy adventitious rootlets. Stems are absent, scapiform or well developed, ascending or erect, terete, striate or angled, simple or branched. Leaves are opposite and rarely alternate or whorled, margin entire. The flowers are very small, numerous and greenish yellow in color.



(a) : Plant at early stage



(b) : Mature plant with flowers

Figure 1 : *Swertia chirata* plant

## Review

Inflorescences are cymose type, usually grouped into simple or paniculate thyrses, rarely strictly dichotomous, sometimes reduced to single flowers and inflorescence appears racemelike. Flowers are tetra or pentamerous. Calyx and corolla are rotate, lobe like structure are present at the base, tubes less than 3 mm. Nectaries are present one or two per corolla lobe, with fimbriate margin or represented by naked spotlike gland patches. Stamens inserted at base of corolla tube. Ovary is one celled. Style is either short or elongate. Capsules are two-valved, few to many seeded. Seeds are small in size. The fruits are minute capsules, 6 mm in diameter and with many angled seeds inside. About 150 species of *S. chirata* are present worldwide, mainly in Asia and Africa, few in North America and Europe. Among them nearly 75 species are present only in China<sup>[7]</sup>.

### Chemical constituents

The plant contains the two bitter compound, *ophelic acid* (C<sub>13</sub>H<sub>20</sub>O<sub>10</sub>), and *chiratin* (C<sub>26</sub>H<sub>48</sub>O<sub>15</sub>). The ash of *S. chirata* yields carbonates and phosphates of calcium, potassium, and magnesium. Tannin is almost entirely absent. *Ophelic acid* is a hygroscopic, soluble (in water, ether, and alcohol), non-crystalline, yellow, viscid body, having an odor faintly suggestive of gentian, and an acidulous, bitter taste which is persistent in nature. Basic lead acetate precipitates it yellow. Chiratin forms an insoluble compound with tannic acid (*ophelic acid* does not), and may be removed by means of that acid. It is a pale-yellow, though hygroscopic, soluble (in alcohol, ether, warm water and hardly soluble in cold water) indistinctly crystalline powder. Its taste is extremely bitter, and its behavior to litmus is neutral. Boiled with hydrochloric acid it splits into *ophelic acid*, water, and *chiratogenin* (C<sub>13</sub>H<sub>24</sub>O<sub>3</sub>), a bitter, amorphous, brown body, not soluble in water, but freely soluble in alcohol<sup>[4,8]</sup>. It is also reported that plant also contains glucosides; amarogentin, a xanthone and iridoid<sup>[9,10]</sup>. Amarogentin Figure 2A is one of the bitterest substances known in *Swertia chirata*. The herb contains, gentiopicrin Figure 2B, swertenol, episwertinol, chiratenol, gammacer-16-en-3 $\beta$ -ol, 21-a-H-hop-22 (29)-en-3 $\beta$ -ol, taraxerol, oleanolic acid Figure 2C, ursolic acid Figure 2D, swerta-7, 9(11)-dien-3 $\beta$ -

ol, pichierenol, besides  $\beta$ -amyrin,  $\gamma$ -taraxasterol, lupeol and erythrodiol. It also contain, 1, 3, 6,7-tetrahydroxyxanthone-C-2- $\beta$ -D-glucoside (mangiferin) having a significant immunomodulatory potential. A new xanthone; 1, 5-dihydroxy-3, 8-dimethoxyxanthone (chiratol) besides swertichirin Figure 2E, 7-O-Me swertiarin, monohydroxy terephthalic acid and 2, 5-dihydroxy terephthalic acid were isolated from the herb. Ghosal et al<sup>[11]</sup> reported that the herb also yields nine tetraoxygenated xanthenes:

- 1, 5, 8-trihydroxy-3-methoxyxanthone (I),
- 1-hydroxy-3, 5, 8-trimethoxyxanthone (II),
- 1-hydroxy-3, 7, 8-trimethoxyxanthone (III),
- 1, 8-dihydroxy-3, 5-dimethoxyxanthone (IV),
- 1, 8-dihydroxy-3, 7-dimethoxyxanthone (V),
- 1, 3, 6, 7-tetrahydroxyxanthone-C<sub>2</sub> $\beta$ -D-glucoside (mangiferin, VI),
- 1, 3, 8-trihydroxy-5-methoxyxanthone (VII),
- 1, 3, 5, 8-tetrahydroxyxanthone (VIII),
- 1, 3, 7, 8-tetrahydroxyxanthone (IX)

and the alkaloids gentianine, gentiocrucine, enicoflavine, swertinin, swertianin, decussatin, isobellidifoli swertiamarin Figure 2F, friedelin, sitosterol, arginine, leucine, methionine, threonine, tryptophan, aspartic acid and glutamic acid were isolated from root and aerial part of *S. chirata*.

Among these xanthenes, II was not encountered before in nature and VI was found for the first time in the genus *Swertia*. In addition to the tetraoxygenated xanthenes (I-IX), a number of heterosides, triterpenes and monoterpene alkaloids were isolated from this plant. Preliminary pharmacological screening of the total xanthenes of *S. chirata* indicated that the medicinal properties ascribed to the plant extracts were due to these constituents<sup>[11]</sup>. Wang et al<sup>[12]</sup> showed that 1,3,5,8-Tetrahydroxyxanthone is produced during growing of root cultures of *Swertia chirata* where as Keil et al<sup>[13]</sup> reported the presence of amarogentin from the root culture of *S. chirata*. The plant contains, a dimeric xanthone chiratanin<sup>[14]</sup> swertia lactone – C, swertain – D<sup>[15]</sup> and triterpene swertanone, swertiamarin, seco-hopene lactones<sup>[16]</sup>. Suryawanshi et al<sup>[17]</sup> reported that *Swertia chirata* contain bioactive constituents including the xanthone and secoiridoid glycosides consists of mangiferin, amarogentin, amaroswerin, sweroside Figure 2I and swertiamarin. Koul et

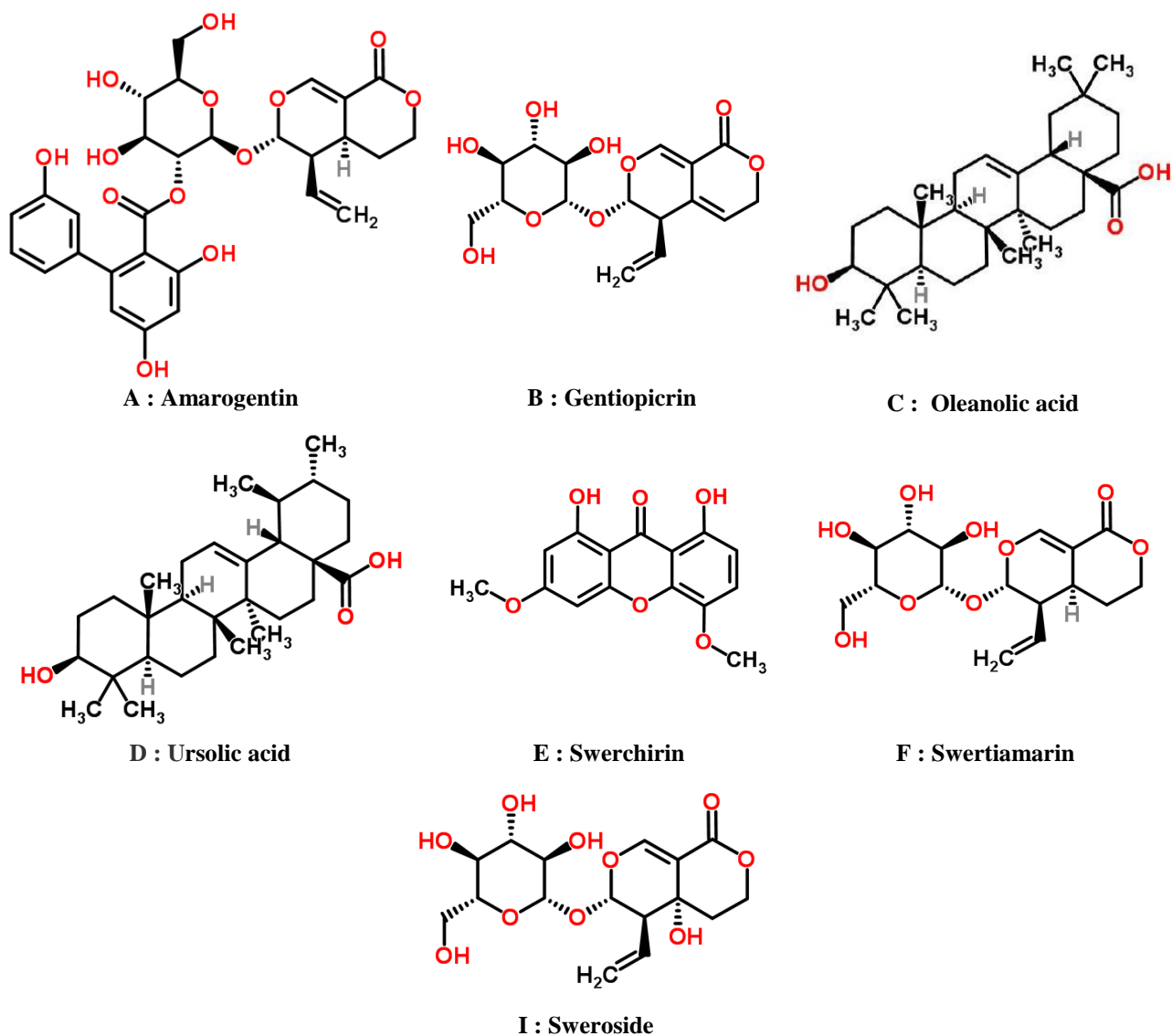


Figure 2 : Chemical structures of compounds A-I.

al.<sup>[18]</sup> isolated amarogentin and amaroswerin from callus, roots, multiple shoots, regenerated plants, and mother plant.

### Bio-pharmacological activity of Chirayata

The plant have many clinical application such as, in the control of diabetes, liver disease, weak stomach, indigestion, malaria, tuberculosis, skin disease, bronchial asthma, burning sensation of the body and vomiting.

### Hypoglycemic effect

Malhotra et al.<sup>[14]</sup> attributed the beneficial action of the natural compound present in the methanolic extracts of aerial part of *Swertia chi-*

*rata* to prevent the hyperglycemic condition and hypothesized that it is largely due to the presence of flavonoids and secoiridoids. A xanthone was isolated from the hexane fraction of the *Swertia chirata* plant, identified as 1, 8-dihydroxy-3, 5-dimethoxyxanthone (swerchirin). It has a very significant blood sugar lowering effect in fasted, fed, glucose loaded and tolbutamide pretreated albino rat models. The ED<sub>50</sub> for 40% blood sugar lowering in male albino rats (body weight 140-165 g) is 23.1 mg/kg/oral<sup>[19-23]</sup>. It is also reported that the whole plant of *Swertia chirata* extract shows hypoglycemic activity<sup>[10,17,24-26]</sup>. Researchers have analysed the effects of mode of action of three structurally different hypoglycemic agents, tolbutamide, centpiperalon and a swerchirin con-

## Review

taining fraction (SW1) from the plant *Swertia chirata*, in normal and streptozotocin induced mild and severe diabetes in rats. It was found that except in rats with severe pancreatic damage, SW1 showed better blood glucose lowering effect compared to tolbutamide<sup>[27,28]</sup>. Kohli et al.<sup>[29]</sup> reported that hypoglycemic activity of Diabecon is due to the antioxidant activity of *Swertia chirata*<sup>[30]</sup>. It has been also found that the ethanolic extract of *Swertia chirata* plant potentially lowered the blood sugar level in fasted, glucose fed and tolbutamide pretreated animals when the animals were administered with 250mg/kg plant extract<sup>[31,32]</sup>. Chandrasekhar et al.<sup>[33]</sup> has been also reported that the hexane fraction (250mg/kg, b.w. orally for 28 days) of plant, lowered blood sugar of albino rats with increased glycogen content of liver and insulin released from pancreatic  $\beta$ -cells. Swerchirin (50mg/kg, b.w. orally) isolated from crude extract of *Swertia chirata* showed a strong potential to lower blood glucose (up to 60%) after 7 hour post-treatment<sup>[34]</sup>. Suryawanshi et al.<sup>[35]</sup> studied that methanolic extracts of *S. chirata* possess strong antidiabetic activities.

### Hepatoprotective activity

Extracts of *S. chirata* and a few other plants in combination are marketed commercially in the traditional Indian system of medicine (known as Ayurveda) as hepatoprotectants<sup>[22,36]</sup>. The extracts of *Swertia chirata* were evaluated for hepatoprotective activity against paracetamol and galactosamine models. Karan et al.<sup>[37]</sup> reported that methanolic extract of the whole plant showed overall protection of 81% and 78% against paracetamol and galactosamine, respectively, when animals were administered with a dose of 100 mg/kg body weight. They found that the protective effect of plant extract against these two hepatotoxins, suggests broader and non-specific protection of the liver due to difference in their mechanisms of inducing hepatotoxicity. The butanol soluble fraction, rich in secoiridoids, showed significant protection against hepatotoxic compounds<sup>[38]</sup>. Balasundari et al.<sup>[39]</sup> suggested that the extract of *Swertia chirata*, has a potent hepatoprotective activity under *in vivo* conditions. The plant extracts also showed hepatoprotective activity against carbon tetrachloride ( $\text{CCl}_4$ ) and paracetamol

[acetaminophen (AAP)] toxicity in primary monolayer cultures of rat hepatocytes<sup>[40]</sup>. Researchers found that the hepatoprotective activity of the plant extract is due to the presence of amarogentin, a glycoside, which is reputedly effective compound against carbon tetrachloride poisoning to protect the liver<sup>[41,42]</sup>. Study also showed that the water extract of the whole plant is also used to treat liver disorders<sup>[43]</sup>. Mukherjee et al.<sup>[44]</sup> reported that treatments with *S. Chirata* (in different doses, viz, 20, 50 and 100 mg/kg body wt daily) to albino rats improved both biochemical and histopathological parameters as compared to that of  $\text{CCl}_4$  treatment alone. Chaudhuri et al.<sup>[10]</sup> reported that the extracts of *S. chirata* are used to protect the liver against liver toxicant.

### Antioxidant activity

Suryawanshi et al.<sup>[26]</sup> reported that the methanolic extracts of *Swertia chirata* from aerial part shows antioxidant activity and hypothesized that it is largely due to the presence of flavonoids and secoiridoids. The drugs which prevent the toxic effects of free radicals are called free radical scavengers or antioxidants substrates. The ethanolic extract of *S. chirata* is rich in xanthenes. It reduces the free radical formation as well as free radical induced lipo-peroxidation. Balasundari et al.<sup>[39]</sup> suggested that the xanthenes present in the extract of *S. chirata* decreased the lethal cell injury against  $\text{CCl}_4$  which causes elevation in the formation of lipid peroxidation products due to impairment in antioxidant enzyme activities. The antioxidative properties of extract could be attributed to their radical scavenging ability with superoxide, hydroxyl radicals and singlet oxygen species. The high scavenging ability of the extracts may be due to presence of high phenolic contents, flavonoid constituents and considerable reducing equivalents. The reaction of the extracts of *S. chirata* with dimethyl p-phenylene diamine dihydrochloride (DMPD), one of the important stable synthetic radicals showed strong radical scavenging ability with more than 30% inhibition. In view of these observations, termination of the free radical reaction and quenching of reactive oxygen are suggested to be, in part, responsible for the antioxidant activity of *Swertia chirata* extracts. *Swertia chirata* extracts may act as effective antioxi-

tive agents, protecting cells from pathophysiological oxidants, generated during UV-Vis photosensitization/radiation-induced injury and may be useful in the food industry as effective synthetic antioxidants<sup>[45-47]</sup>.

### Anti-inflammatory effects

Banerjee *et al.*<sup>[48]</sup> observed that crude benzene extract of *Swertia chirata* shows anti-inflammatory action in acute models and suggested that it is due to one of the major xanthone derivatives, 1, 5-dihydroxy-3, 8-dimethoxy xanthone. The anti-inflammatory effects of aqueous suspension of total xanthones of *Swertia chirata* aerial parts in 5 percent gum acacia were investigated against Carrageenin, 5-HT, Dextran, Bradykinin and PGE1 induced hind paw oedema in albino rats at a dose level of 50 mg/kg body weight (oral route). In experimental models of acute and subacute inflammation, anti-inflammatory effects of *S. chirata* was found to be less effective when compared with standard anti-inflammatory drugs like phenylbutazole (50 mg/kg, i.p) and betamethasone (0.5 mg/kg, i.p)<sup>[49]</sup>.

### Ulcer preventive activity

Rafatullah *et al.*<sup>[50]</sup> reported that the ethanolic extract of *S. chirata* significantly reduced the intensity of gastric mucosal damage induced by indomethacin and necrotizing agents. It has been also found that pretreatment of rats with ethanolic extract of *Swertia chirata* significantly prevented ethanol-induced gastric wall mucus depletion and restored the non-protein sulfhydryl content in the glandular stomachs. Extracts of *S. chirata* and a few other plants in combination also possess anti-ulcerogenic activity<sup>[22]</sup>. These findings support the use of *Swertia chirata* for the treatment of gastric ulcers in traditional medicine.

### Antileishmanial activity

Amarogentin, a secoiridoid glycoside isolated from plant *Swertia chirata*, showed strong antileishmanial activity, in a hamster model of experimental leishmaniasis. The antileishmanial activity of amarogentin rich *S. chirata* extract was examined in free as well as two different vesicular forms (liposomes and niosomes). Medda *et al.*<sup>[51]</sup> reported that the vesicular bound amarogentin

was found to be more active leishmanicidal agent in comparison to free amarogentin. In case of both vesicular forms, niosomal form was found to be more effective than the liposomes vesicular form at the same microviscosity level. Hence, amarogentin incorporated in liposomes or niosomes may have clinical application in the treatment of leishmaniasis. It has been also reported that the methanolic extract of *Swertia chirata* is used to prevent the leishmaniasis disease by the inhibition of catalytic activity of topoisomerase I enzyme of *Leishmania donovani*<sup>[27,28]</sup>.

### Antimalarial activity

Xanthones isolated from *S. chirata* was found to be reputedly effective against malarial disease<sup>[41,48]</sup>. The whole plant extract of *Swertia chirata* also showed the antimalarial activity<sup>[10,16,24]</sup>. Bhat *et al.*<sup>[22]</sup> showed that the under *in vitro* conditions, aqueous and organic solvent extracts obtained from *Swertia chirata* were tested on malaria strain *Plasmodium falciparum* FCK 2. The antimalarial activity of the plant extracts on thin blood smears was followed by quantification of the activity by use of [35S]-methionine incorporation into parasite proteins to determine the value that inhibits (IC<sub>50</sub>) and have significant inhibitory effect on *P. falciparum*.

### Anthelmintic activity

The crude aqueous (CAE) and methanolic extracts (CME) of *S. chirata* whole plant showed an anthelmintic effect on live *Haemonchus contortus*. Moreover, in the *in vivo* study, the whole plant of *S. chirata* administered as crude powder (CP), CAE and CME at the dose of 3 g/kg to sheep naturally infected with mixed species of gastrointestinal nematodes, showed a significant reduction in egg per gram of faeces<sup>[20,52]</sup>. Chaudhuri *et al.*<sup>[10]</sup> reported that the extracts of *S. chirata* are used in the treatment of helminthic disease.

### Anticarcinogenic activity

Saha *et al.*<sup>[3]</sup> showed that crude extract and a purified 'Amarogentin' rich extracts from the *Swertia chirata* has potential to activate all the four detoxification enzymes (GST, GPx, SOD and CAT), in different degrees after the treatment. The activation of the enzymes shows significant

## Review

reduction in the formation of malondialdehyde (MDA) during lipid peroxidation and inhibition of incidence as well as multiplicity of DMBA induced papillomas. Banerjee *et al.*<sup>[48]</sup> also reported that several varieties of xanthenes isolated from the *S. chirata* showed potent anti-carcinogenic activity.

### Enzyme inhibition activity

A methanolic extract of *Swertia chirata* which was found to inhibit the catalytic activity of topoisomerase I of *Leishmania donovani*. Amarogentin is a potent inhibitor of type I DNA topoisomerase from *Leishmania* and shows its effect by interaction with the enzyme, preventing binary complex formation<sup>[27, 53]</sup>.

### Modulation of detoxification enzyme

Many natural compounds are now known to have a modulatory role on physiological functions and biotransformation reactions involved in the detoxification process, thereby affording protection from cytotoxic, genotoxic and metabolic actions of environmental toxicants. As part of a programme on evaluation of food, beverage and traditional medicinal plants for their anticarcinogenic activity, their effects on detoxification enzymes were also studied<sup>[54]</sup>. The effect of water infusions as well as crude and purified components of these plants on glutathione-S-transferase (GST), glutathione peroxidase (GPx), superoxide dismutase (SOD), and catalase (CAT) was analyzed in mice that were exposed to the chemical carcinogen DMBA. All the four enzymes were found to be activated in different degrees after the treatment of *S. chirata* extract. The activation of the enzymes was accompanied by significant reduction in lipid peroxidation<sup>[54]</sup>.

### Antiviral activity

The inhibitory effect on the plaque formation of HSV-1 with *S. chirata* plant extract was carried out by plaque reduction assay. For this purpose, virus stock was seeded with various dilutions of plant extract (1:32 to 1:256 and also subtoxic dilution, 1:54) and observed for plaque inhibition. *Swertia chirata* plant extract at 1:64 dilution inhibited HSV-1 plaque formation at more than 70% inhibitory level<sup>[55,56]</sup>. Vero E6 cells were

treated with *S. chirata* plant extract (1:64 dilutions) at 4, 8 and 24 hours of post infection dose (PID). Maximum reduction in number of fluorescent cells was observed at 4 hours PID and even single fluorescent cells observed suggested the drug inhibited viral infectivity. *S. chirata* plant extract subsequently added at 8 and 24 hour PID showed a significant reduction of positive fluorescent and a complete inhibition was observed at a concentration of 0.1 mg/ml compared with controls<sup>[56-58]</sup>. Infected cell cultures treated with *Swertia chirata* extract at various time intervals, tested by PCR, failed to show amplification at 12, 24-72 hours. HSV-1 infected cells treated with Acyclovir (antiviral drug) did not show any amplification by PCR. In this preliminary study, plant extract of *Swertia chirata* showed antiviral properties against Herpes simplex virus type-1<sup>[56,59,60]</sup>.

### Apoptosis and cell proliferation

The effect of crude and purified extracts of *Swertia chirata* on apoptosis and cell proliferation was studied in mice skin exposed to DMBA. Results show that both extract significantly inhibited cell proliferation and induced apoptosis. This observation suggests the chemopreventive potential of *Swertia chirata*<sup>[3]</sup>. Saha *et al.*<sup>[61]</sup> reported that amarogentin rich fraction of *S. chirata* also showed antiproliferative and pro-apoptotic activity in mouse skin carcinogenesis model.

### Cytotoxic activity

Cytotoxic concentration (CC<sub>50</sub>) of the test compound was determined by conducting MTT [3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazoliumbromide] assay. The CC<sub>50</sub> value of *Swertia chirata* was calculated at 1:54 dilution. The CC<sub>50</sub> value was calculated by regression analysis showing percent cell viability by MMT assay. In the plating efficiency assay toxicity of cells was checked by serial passaging of the cells for three times and no effect on cell growth was noticed in the treated cells<sup>[56]</sup>.

### Anti central nervous system depressant activity

Swertiamarin, a secoiridoid glycoside isolated from *Swertia chirata* was evaluated for its anti central nervous system (CNS) depressant activity. It was found that swertiamarin significantly re-

versed the mangiferin-induced CNS-stimulating effects in albino mice and rats. The results indicate that swertiamarin and mangiferin antagonize each other *in vivo* and thereby reverse their CNS effects<sup>[28,62]</sup>. Banerjee *et al.*<sup>[48]</sup> reported that the total xanthenes of *Swertia chirata* possess significant CNS stimulant action.

### Fever lowering activity

An infusion of the herbs, prepared by extracting 15 gm of chirayata in 250 ml of hot water with aromatics like cloves and cinnamon, should be given in doses of 15 to 30 ml, helps in lowering the temperature. Singh *et al.*<sup>[20]</sup> reported that water extract of the whole plant is consumed to treat chronic fever. The extract of *Swertia chirata* whole plant is used in the treatment of malarial fever<sup>[48,63]</sup>.

### Anti DNA damage activity

HSV-1 infected cell cultures treated with *Swertia chirata* extract at various time intervals (0, 12, 24, 48, 72 hours) were harvested. Nucleic acid (DNA) extracted from the tissue culture fluid (TCF) was subjected to PCR using HSV-1 type specific primers. *Swertia chirata* extract treated infected cultures at 12 and 24-72 hours duration failed to show any PCR amplification. However HSV-1 infected cultures showed a 147 base pair product in 2% agarose gels at 24, 48, 72 hour time period. Acyclovir treated virus cultures did not show any amplification and HSV-1 virus control showed amplification. The antiviral activity of various concentration of acyclovir against HSV-1 was carried out. Acyclovir treated HSV-1 infected cells at low concentration showed PCR amplification. These results show the protection of DNA damage by the extract of *S. chirata*<sup>[56]</sup>.

### Antimicrobial activity

Alam *et al.*<sup>[64]</sup> reported that the petroleum-ether, dichloromethane, ethanolic extract and methanol fractions of *Swertia chirata* showed significant antimicrobial activities against some gram-positive and gram-negative bacteria and mild to moderate activity against some fungi. Dichloromethane extract showed better result in comparison to other solvent extract. The aqueous extract of Sudarshan Churna (ASC) using the paper

disc diffusion method showed antimicrobial activity against the gram-negative bacteria *K. pneumoniae*, *E. coli*, and gram-positive bacteria *S. aureus*, *P. vulgris* and found less effective against gram-positive bacteria *S. epidermidis* and *B. subtilis*<sup>[2]</sup>. Bhargava *et al.*<sup>[65]</sup> also showed that root extract of *Swertia chirata* has strong antimicrobial activity.

### Analgesic activity

The ethanol extract of *Swertia chirata* leaf, stem, and their different fractions *i.e.* petroleum-ether, dichloromethane, and methanol fraction possess analgesic activity in Swiss albino mice animal model. Among different fractions petroleum-ether fraction showed significant inhibition where as methanol fraction showed moderate inhibition<sup>[66]</sup>.

### Insecticidal activity

Mallikarjun *et al.*<sup>[67]</sup> reported that the different solvent extract of *S. chirata* has antimosquito (insecticidal) activity against second instar larvae of *Aedes aegypti*. The insecticidal activity of the plant extracts depends on the concentrations of solvent as well as dose of the plant extracts. In the different solvent extracts, chloroform extract was more effective in killing larvae followed by ethanol and petroleum ether extracts.

## CONCLUSION

It is well known that the available synthetic drug molecules may not be able to completely cure the fatal diseases. But it has already been proved that some of these diseases are the result of side effects of the drugs. So there is a need to find out other safer alternatives for the treatment. In view of increasing awareness about health and increased used of phytochemicals in the prevention and treatment of common as well as serious diseases, there is a need to explore the possibilities of including phytochemicals in our daily diet. The different extracts of *S. chirata* protect significantly against diseases and oxidative damage induced by various oxidants. These results show the importance of different chemical constituents present in *S. chirata* in the maintenance of biological homeostasis involving pro-oxidant and antioxidant profiles in the cell. The chemical constitute of *S. chirata* are popular in ayurvedic formula-



## Review

tions. They may have significant potential applications in the food industry for the preservation of food products and advantages over synthetic food antioxidants. The study described that the plant contains antioxidant compounds that can explain and justify their use in traditional medicine in the past as well as present. From the work cited in the article it can be concluded that promising phytochemicals are widely distributed in medicinal plants of Gentianaceae. Animal research has thrown light on anti-inflammatory, analgesic, antiasthmatic, anticonvulsant, antihistaminic, antimalarial, diuretic, hepatoprotective and hypoglycemic activities of phytochemicals present in the *Swertia chirata*. Amarogentin and swerchirin should particularly be screened for large scale clinical trials. Topoisomerase inhibition and hypoglycemic activities are of special interest. The literature shows an extensive use of this plant throughout the world and research should be carried out to determine the active principles present in the various parts of the plant to evaluate their medicinal properties. The studies reported in the literature are not sufficient to arrive at a definite conclusion regarding their remedial powers. In view of increasing awareness about health and increased use of phytochemical in the prevention / treatment of common as well as serious diseases, there is need to find out some safe alternative drug/ nutraceuticals which are used in our day to day life in one or the other form.

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