

ISSN 1996-5052

Current Research in  
**Chemistry**

## Chemical Constituents and Biological Importance of Swertia: A Review

<sup>1</sup>Jagmohan S. Negi, <sup>2</sup>Pramod Singh and <sup>2</sup>Bipin Rawat

<sup>1</sup>Herbal Research and Development Institute, Mandal, Gopeshwar-246 401, Uttarakhand, India

<sup>2</sup>Department of Chemistry, HNB Garhwal University, Srinagar (Garhwal)-246 174, Uttarakhand, India

*Corresponding Author: Dr. J.S. Negi, Herbal Research and Development Institute, Mandal (Gopeshwar)-246401, Uttarakhand, India*

### ABSTRACT

Swertia, commonly known as 'Chirata' in indigenous systems of medicine, are used for treatment of a variety of ailments. Literature survey revealed that much phytochemical analysis has been done on genus Swertia by several groups. In this study, we had planned to document the active chemical constituents of valuable medicinal plants of genus Swertia. The major bioactives of Swertia are xanthenes, however, other secondary metabolites such as flavonoids, iridoid glycosides and triterpenoids are also active constituents of this genus. These secondary metabolites played significant role in biological activities such as hepatoprotective, antihepatotoxic, antimicrobial, anti-inflammatory, anticarcinogenic, antileprosy, hypoglycemic, antimalarial, antioxidant, anticholinergic, CNS depressant and mutagenicity.

**Key words:** Swertia, Gentianaceae, xanthenes, chiretta, biological activities

### INTRODUCTION

Swertia (family Gentianaceae) is a large genus of herbs distributed in the mountainous regions of tropical area at an altitude of 1200-3600 m. The herbal drug "chiretta" obtained from the dried plants of swertia species. The whole plants of Swertia are medicinal but roots are the most powerful parts (Anonymous, 1976). These are useful as a tonic without aroma or astringency. In Indian medical system chiretta is used as remedy for bronchial asthma, liver disorders, chronic fever, anemia, stomachic and diarrhoea. Chiretta is also used in dyeing cotton cloth and in liquor industry as bitter ingredients. In Ayurveda, *S. chirayita* is used as antipyretic, anthelmintic, antiperiodic, laxative and in asthma and leucorrhoea. In Yunani system the plant is used as astringent, tonic, stomachic, lessens inflammation, sedative to pregnant uterus and chronic fevers (Kirtikar and Basu, 1984).

*S. chirayita* has an established domestic (India) and international market which is increasing at a rate of 10% annually. In spite of the increasing demand by herbal industry the plant is still collected from wild. It is sparsely cultivated and negligible efforts have gone into developing proper agro-techniques of plant. It is harvested for the drug industry (Bentley and Trimen, 1880). *S. chirayita* is also used in British and American pharmacopoeias as tincture and infusions (Joshi and Dhawan, 2005). *S. angustifolia* resembles to *S. chirayita* very closely but differs from it in having thinner root, small wings and ridges on the stem. The dried plants of *S. angustifolia* and *S. paniculata* are used as substitute for *S. chirayita*. About 22,000 kg of the drug are said to be collected and sold annually in Himanchal Pradesh while the annual demand for chiretta in

India is reported to be 37,300 kg. Plants belonging to these families are found in all parts of world. They have been widely used in folk medicine. Simple polyoxygenated xanthenes have been isolated from most of them. Xanthone derivatives, flavonoids, iridoid glycosides, triterpenoids and dimeric xanthenes have been isolated from the genus *Swertia* (Tan *et al.*, 1991; Zhou *et al.*, 1989). The genus *Swertia* exhibit variety of biological activity such as hepatoprotective, antihepatotoxic, antimicrobial, anti-inflammatory, anticarcinogenic, antileprosy, hypoglycemic, antimalarial, antioxidant, anticholinergic, CNS depressant and mutagenicity. The pharmacological properties of *Swertia* have raised great interest. The purpose of this review to collect all the possible information regarding the chemical constituents and biological effects of the genus *Swertia*, thus will help to the researchers and scientists to take action for future study in this discipline.

## CHEMICAL CONSTITUENTS

Xanthenes are main secondary metabolites of *Swertia* species. Structures of xanthenes are related to that of flavonoids and their chromatographic behaviors are also similar. Although flavonoids are frequently encountered in nature, xanthenes have been found in limited number of families. They always occur in Gentianaceae and Guttiferae. Xanthenes are sometimes found as the parent polyhydroxylated compounds but most xanthenes are mono or poly methyl ethers or are found as glycosides (Hostettmann and Miura, 1977). Unlike iridoids, xanthenes are apparently not present in all plant species investigated in the family Gentianaceae. This is documented by the systematic study of Hostettmann-Kaldas *et al.* (1981). The natural xanthenes have been isolated mainly from about 150 plants associated with four families; Guttiferae, Gentianaceae, Moraceae and Polygalaceae. According to Vieira and Kijjoa (2005), 278 natural xanthenes were reported from total of 515 xanthenes. In this period, the xanthenes from higher plants appear to be associated mainly with the families Clusiaceae (55 species in 12 genera) and Gentianaceae (28 species in 8 genera). Isolated compounds and biological activities of *Swertia* species are listed in Table 1. Xanthenes isolated from nature are classified into six main groups; simple xanthenes, xanthone glycosides, prenylated xanthenes, xanthonolignoids, bis-xanthenes and miscellaneous xanthenes. These are further subdivided according to the degree of oxygenation into non-, mon-o, di-, tri-, tetra-, penta- and hexa-oxygenated substances (Mandal *et al.*, 1992b; Sultanbawa, 1980; Demirkiran, 2007).

Xanthenes and their glycosides (Fig. 1) have been isolated from *Swertia* species. Mangiferin is the most common C-glycosides in *S. chirayita*, *S. mussotii*, *S. cordata*, *S. macrosperma* and *S. connata*. Xanthone O-glycosides (swertianolin) from *S. japonica* and *S. ciliata* (Plouvier *et al.*, 1967) have been reported. The first xanthone O-glycoside, norswertianin-1-O-glucosyl-3-O-glucoside has been isolated from *S. perennis* (Hostettmann and Wagner, 1977). The isolated chemical constituents, ethno-pharmacology as well as the biological activities and pharmacological applications of *Swertia* species, covering the literature up to 2003 are compiled by Brahmachari *et al.* (2004). Xanthenes in *Swertia chirata*, *S. speciosa* and *S. paniculata* were determined by HPLC (Negi *et al.*, 2009a, 2010a, b). Mineral elements, based on their concentration can play different roles in human health and plant life. Nine elements (Zn, Cu, Mn, Fe, Co Na, K, Ca and Li) in *S. chirayita* and *S. speciosa* have been analyzed by atomic absorption spectrometry (Negi *et al.*, 2009b, 2010c). Kaempferol, catechin, epicatechin and Polyphenol Contents were also isolated and identified from *Swietenia macrophylla*, *Rhus coriaria* and *Rhus typhina* (Falah *et al.*, 2008; Kossah *et al.*, 2010). Extracts of *G. senegalensis* are rich in flavonoid content and showed anti-inflammatory activity (Sombie *et al.*, 2011). Leaf and stem of *Swertia chirata* showed significant antimicrobial activities against some Gram-positive and Gram-negative bacteria

Table 1: Isolated compounds and activity of different parts of Swertia species

Name of plant	Plant part	Isolated compounds	Activity	References
<i>S. chirayita</i> <i>Syn S. chirata</i>	Whole plant		Hepatoprotective	Balasundari <i>et al.</i> (2006)
			Antibacterial and antifungal	Awasthi <i>et al.</i> (2005)
	Whole plant		Antihepatotoxic	Karan <i>et al.</i> (1999a)
	Whole plant		Antihepatotoxic	Karan <i>et al.</i> (1999b)
			Antileprosy	Asthana <i>et al.</i> (2001)
		Chirat-16-en-3 $\beta$ -24-diol, 1,5,8-trihydroxy-3-methoxyxanthone-8-O- $\beta$ D-glucopyranoside		Chakravarti <i>et al.</i> (2001)
			Antiinflammatory	Banerjee <i>et al.</i> (2000)
			Anticarcinogenic	Saha <i>et al.</i> (2004)
			Hypoglycemic	Saxena <i>et al.</i> (1996)
		1,7,8-Trihydroxy-3-methoxyxanthone (swertianin), 1,8-dihydroxy-3,5-dimethoxyxanthone (Swerchirin), 1-hydroxy-3,5,8-trimethoxyxanthone, 1,5,8-trihydroxy-3-methoxyxanthone, 1,5,6-trihydroxy-3-methoxyxanthone and 1,3,6,7-tetrahydroxyxanthone-C2- $\beta$ -D-glucoside,	Antimalarial	Mandal and Chatterjee (1994)
	Aerial parts	(-) Syringaresinol, magniferin, 1,5,8-trihydroxy-3-methoxyxanthone, 1-hydroxy-3, 5,8-trimethoxyxanthone, 1-hydroxy-3,7,8-trimethoxyxanthone, amarogentin, sweroside Swerchirin	Hepatoprotective	Chakravarty <i>et al.</i> (1994)
			Blood sugar lowering	Saxena <i>et al.</i> (1993)
Whole plant		Antiinflammatory	Mandal <i>et al.</i> (1992a)	
		Hypoglycemic	Chandrasekar <i>et al.</i> (1990)	
	1,8-Dihydroxy-3,5-dimethoxyxanthone (swerchirin) $\beta$ -Sitosterol, feriedelin, swertinin, swertianin, swerchirin and isobellifolin	Hypoglycemic	Bajpai <i>et al.</i> (1991) Mishra and Joseph (1983)	
		Blood sugar lowering	Mukherjee and Mukherjee (1987)	
		Antifeedant	Malic <i>et al.</i> (1985)	
	Gentianin, gentiocrucin and enicoflavin		Sharma (1982)	
	1,5,8-Trihydroxy-3-methoxy, 1,5,8-trihydroxy-3-methoxy, 1,3,5,8-tetrahydroxy, 1,3,7,8-tetrahydroxy, 1,8-dihydroxy-3,5-dimethoxy, 1,8-dihydroxy-3,7-dimethoxy and 1-hydroxy-3,5,8-trimethoxyxanthone		Ghosal <i>et al.</i> (1973)	
Whole plant		Anthelmintic	Iqbal <i>et al.</i> (2006)	
Whole plant		Antimicrobia	Alam <i>et al.</i> (2009)	
Whole plant		Analgesic	Alam <i>et al.</i> (2010)	
<i>S. speciosa</i>	Aerial parts	1-Hydroxy-8glucosyloxy-3,5-dimethoxyxanthone, 1,8-dihydroxy-3,7-dimethoxyxanthone and 3-methoxy-1,5,8-trihydroxyxanthone		Khetwal and Bisht (1988)
		1,7-Dihydroxy-3-methoxyxanthone, 1,3-dihydroxy-7-methoxyxanthone, 1,8-dihydroxy-3,5-Dimethoxyxanthone, 1-hydroxy-3,7-dimethoxyxanthone, 1,7,8-trihydroxy-3-methoxyxanthone and mangiferin		Rastogi and Mehrotra (1979)

Table 1: Continued

Name of plant	Plant part	Isolated compounds	Activity	References
<i>S. paniculata</i>	Roots	1,8-Dihydroxy-3,5-dimethoxyxanthone (swerchirin), 1,5,8-trihydroxy-3-methoxyxanthone (bellidifolin), 7-methoxy apigenin-6-C-β-D-glucopyranoside (swertisin), flavone-C-glycoside and luteolin -6-C-β-D-glucopyranoside (homoorientin)		Verma and Khetwal (1985)
	Whole plant	Hederagenin, polyoxygenatedxanthone and xanthone-O-glycosides β-Sitosterol, ursolic acid, bellidifolin and hydroxytetramethoxyxanthone		Prakash <i>et al.</i> (1982)  Rastogi and Mehrotra (1979)
<i>S. japonica</i>	Whole plant	6'-O-α-L-Arabinopyranosylswertiamarin, 3'-O-β-D-Glucopyranosylswertiamarin, 4'-O-β-D-Glucopyranosylswertiamarin, 3'-O-β-D-Galactopyranosylswertiamarin, 6-O-α-D-Galactopyranosylswertiamarin, 6'-O-α-D-Manopyranosylswertiamarin, 6'-O-β-D-Fructofuranosylpyranosylswertiamarin and 5'-O-β-D-Glucopyranosylamaroswerin		Kikuchi and Kikuchi (2004)
	Whole plant	Swertiajaposide A, 3-butyl6'-O-α-L- arabinopyranosyl-β-D-glucopyranoside, 7R, 7'R, 8 S, 8'S-(+)-neo-olivil-4-O-β-D-glucopyranoside		Kikuchi and Kikuchi (2005)
		Methylbellidifolin, methylswertianin, swertianin, bellidifoline, norswertianin and desmethylbellidifolin	Hepatoprotective Antioxidant	Hase <i>et al.</i> (1997) Ashida <i>et al.</i> (1994)
			Hypoglycemic	Basnet <i>et al.</i> (1994)
	Whole plant		Anticholinergic	Yamahara <i>et al.</i> (1991)
	Roots	Bellidifolin, methylbellidifolin, swertianolin, amarogentin and amaroswerin		Ishimaru <i>et al.</i> (1990a)
	Roots	5-(3'-Glucosyl)-benzoyloxygentisic acid, 2,6 -dimethoxy-4-hydroxyphenol-1-glucoside		Ishimaru <i>et al.</i> (1990b)
Aerial parts	Gentianine and 5-hydroxymethylisochroman -1-one		El-Sedawy <i>et al.</i> (1989)	
	7-epi-(Di-m-hydroxybenzoyl)-logenic acid (senburiside II)		Ikeshiro and Tomita (1987)	
Whole plant	7-epi-(m-Hydroxybenzoyl)-2'-sinapoyl-loganic acid (senburiside I)	Antihepatotoxic	Hikino <i>et al.</i> (1984)	
	7-epi-(m-Hydroxybenzoyl)loganic acid (swertiaside)		Ikeshiro and Tomita (1985)	
	Biphenoiside A, biphenoiside B and 5-O-β-Glucopyranoside of bellidifolin		Ikeshiro <i>et al.</i> (1983) Sakamoto <i>et al.</i> (1982)	
	Semburin and isosemburin		Sakai <i>et al.</i> (1981)	
<i>S. pseudochinensis</i>		Hepatoprotective	Li <i>et al.</i> (2005)	
<i>S. mussotii</i>	Swertiamarin, mangiferin, swertisin, oleanolic acid, 1,5,8-trihydroxy-3-methoxyxanthone, 1,8-dihydroxy-3,7-dimethoxyxanthone and 1,8-dihydroxy-3,5-dimethoxyxanthone		Yang <i>et al.</i> (2005)	

Table 1: Continued

Name of plant	Plant part	Isolated compounds	Activity	References
<i>S. davidi</i>	Whole plant	1,3, 8-Trihydroxy-7-methoxyxanthone, 2,8-dihydroxy-1,6-dimethoxyxanthone, 1,8-dihydroxy-2,6-dimethoxyxanthone, 1,2,8-trimethoxyxanthone, 1,3,5,6-tetrahydroxyxanthone, 1,8-dihydroxy-3,7-dimethoxyxanthone, $\beta$ -daucosterol, clerosterol 3 $\beta$ -O-[6'-O-hydrobenzene- $\beta$ -D-glucoside], ursolic acid and 3 $\beta$ ,28-dihydroxylup-20 (29)-ene, erythrocentaurin Demetylbellidifolin		Zhang <i>et al.</i> (2009)
	Whole plant	2,5-Dimethoxyl-1, 4-dicarboxyl benzene (VIII), 1,5,8-trihydroxyl-3,4-dimethoxyl xanthone (IX) and 1,8-dihydroxyl-3-(3'-hydroxyl-butoxy) xanthone (X).	Antioxygenated	Jiang <i>et al.</i> (2004) Tan <i>et al.</i> (2003)
<i>S. mileensis</i>		2'-O-Acetyl-4'-O-transferuloylswertiamarin, 2'-O-acetyl-4'-O-cisferuloylswertiamarin, 2'-O-acetyl-4'-O- trans-p-coumaroylswertiamarin, 2'-O-acetyl-4'-O-cis-p-coumaroylswertiamarin and 4'-O-cis-p-coumaroylswertiamarin		Kikuzaki <i>et al.</i> (1996)
<i>S. alata</i>	Aerial parts	3-Methoxy-1,7,8-trihydroxyxanthone, 1,8-dihydroxy-3,5-dimethoxyxanthone and 1,8-dihydroxy-3,7-dimethoxyxanthone,		Khetwal <i>et al.</i> (1997)
<i>S. ciliata</i>	Whole plant	Oleanolic acid, swertisin, swertiamarin and bellidifolin March 19, 2011		Khan <i>et al.</i> (1979)
	Aerial parts	Norswertianolin, swertianolin and isoswertianolin	CNS depressant	Rastogi and Mehrotra (1979)
	Aerial parts	1-Hydroxy-3,5,7,8-tetramethoxyxanthone and bellidifolin		Rastogi and Mehrotra (1979)
		Oleanolic acid, sitosterol, swertisin and swertiamarin		Rastogi and Mehrotra (1979)
<i>S. corymbosa</i>			Antimicrobial	Ramesh <i>et al.</i> (2002)
<i>S. calycina</i>	Whole plant	Swerchirin		Ya <i>et al.</i> (1999)
			Antifungal	Rodriguez <i>et al.</i> (1995)
<i>S. punctata</i>	Roots	1-O-Primeverosyl-3,8-dihydroxy-5-methoxyxanthone, 1-O-gentiosyl-3,7-dimethoxy-8-hydroxyxanthone, Isobellidifolin, methylbellidifolin, isoswertianin, methylswertianin and norswertianin-1-O- $\beta$ -D-glucosid		Menkovic <i>et al.</i> (2002)
<i>S. punicea</i>	Whole plant	6'-O- $\beta$ -D-Glucopyranosylsweroside (Swertiapunimarin), sweroside, oleanolic acid, swertiamarin, methylswertianin, $\beta$ -Sitosterol and daucosterol		Tan <i>et al.</i> (1993)
	Whole plant	Puniceaside A, B, C, D and E	Neuroprotective	Du <i>et al.</i> (2010)
	Whole plant	1,3,5,8-Tetrahydroxy-7-(1',3',6',7'-tetrahydroxy-9'-oxo-4'-xanthyl) xanthone 2'-C- $\beta$ -D-glucopyranoside		Tan <i>et al.</i> (1992)
	Whole plant	1,5,8-Trihydroxy-3-methoxy-7(1',3',6',7'-tetrahydroxy-9'-oxo-xanthyl) xanthone 2'-C- $\beta$ -D-glucopyranoside		Tan <i>et al.</i> (1991)

Table 1: Continued

Name of plant	Plant part	Isolated compounds	Activity	References
<i>S. cordata</i>	Aerial parts	Decussatin, gentiacaulein-1,8-dihydroxy-2,4,6-trimethoxyxanthone, methyl swertianin and 1-hydroxy-3,5,7,8-tetramethoxyxanthone		Fukamiya <i>et al.</i> (1990)
	Whole plant		Anti-diabetic	Tian <i>et al.</i> (2010)
	Whole plant	Swertiapuniside		Tan <i>et al.</i> (1992a)
		1-Hydroxy-3,5,7,8-tetramethoxyxanthone and 1,7-dihydroxy-3,5,8-trimethoxyxanthone		Atta-ur-Rahman <i>et al.</i> (1994)
<i>S. franchetiana</i>	Aerial parts	Ursolic acid and mangiferin		Khan and Haqqani (1981)
		1,5,8-Trihydroxy-3-methoxy-7-(5',7',3'',4''-tetrahydroxy-6'-C-β-D-glucopyranosyl-4'-oxy-8'-flavyl)-xanthone (Swertifrancheside)		Wang <i>et al.</i> (1994)
	Whole plant	Senburiside II, senburiside IV, senburiside I, swertiamarin, gentiopicroside and sweroside		Wang <i>et al.</i> (2005a)
	Whole plant	7-O-[β-D-xylopyranosyl-(1→2)-β-D-xylopyranosyl]-1,7,8-trihydroxy-3-methoxyxanthone, 7-O-[α-L-rhamnopyranosyl-(1→2)-β-D-xylopyranosyl]-1,7,8-trihydroxy-3-methoxyxanthone, 8-O-β-D-glucopyranosyl-1,3,5,8-tetrahydroxyxanthone, 1-O-β-D-glucopyranosyl-1-hydroxy-3,7,8-trimethoxyxanthone, 1-O-[β-D-xylopyranosyl-(1→6)-β-D-glucopyranosyl]-1-hydroxy-2,3,5-trimethoxyxanthone and 1-O-[β-D-xylopyranosyl-(1→6)-β-D-glucopyranosyl]-1-hydroxy-3,5-dimethoxyxanthone		Wang <i>et al.</i> (2005b)
<i>S. angustifolia</i>	Whole plant	Angustiamarin, angustioside, sweroside, swertiamarin and epi-eustomoside		Luo and Nie (1992)
<i>S. macrosperma</i>	Whole plant	Caffic acid disaccharide ester, mangiferin, bellidifodin and bellidifodin-8-O-β-D-glucopyranoside		Zhou and Liu (1990)
	Whole plant	1,3,5,8-Tetrahydroxy-7-(1',3',5',8'-tetrahydroxy-2'-xanthonyl)xanthone (Swertiabisxanthone-I)		Zhou <i>et al.</i> (1989)
<i>S. herba</i>		Amarogentin, amaroswerin	Mutagenicity	Kanamori <i>et al.</i> (1986)
		Methylbellidifolin, methylswertianin, swertianin, desmethylbellidifolin and 5,8-dimethylbellidifolin		Kanamori <i>et al.</i> (1984)
<i>S. petiolata</i>	Aerial parts	1-Glycosyloxy-3-hydroxy-5,8-dimethoxyxanthone, 1,8-dihydroxy-3,5-dimethoxyxanthone and 1,3-dihydroxy-3-methoxyxanthone		Khetwal <i>et al.</i> (1990)
	Aerial parts	1,3-Dihydroxy-5,8-dimethoxyxanthone and 2-hydroxydimethylterephthalate		Kulanthaivel and Pelleter (1988)
		2,3-seco-2→3-Lactone, 1β,3β-epoxy-hop-17(21)ene (Swertialactone C), and 2,3-seco-2→3 lactone, 1β,3β-epoxy-hop-16-ene (Swertialactone D)		Bhan <i>et al.</i> (1987)
	Whole plant	3β-Hydroxylup-13(18)-ene, 3β-hydroxylup-12-ene-28-oic acid and ursolic acid		Bhana <i>et al.</i> (1988)

Table 1: Continued

Name of plant	Plant part	Isolated compounds	Activity	References
<i>S. iberica</i>	Roots	1,3,8-Trihydroxy-7-methoxyxanthone and 1,2,3-trioxy-7,8-dimethoxyxanthone		Denisova <i>et al.</i> (1980)
<i>S. bimaculata</i>		1,3-Dihydroxy-4,5-dimethoxyxanthone		Rastogi and Mehrotra (1979)
<i>S. dilatata</i>		Gentiacaulein, bellidifolin, methylbellidifolin, decussatin, swertianin, methylswertianin and norswertianin		Rastogi and Mehrotra (1979)
<i>S. perennis</i>		1,8-Dihydroxy-3,7-dimethoxyxanthone		Rastogi and Mehrotra (1969)
<i>S. longifolia</i>	Aerial parts	Isobellidifolin, bellidin, gentisein and 1,5- dihydroxy-3-methoxy-6-O-premeverosyl xanthone		Hajimehdipour <i>et al.</i> (2003)
	Aerial parts	1,8-Dihydroxy-3,5-dimethoxyxanthone, 1,8-dihydroxy -2,6-dimethoxyxanthone and 2,8-dihydroxy-1, 6-dimethoxyxanthone		Hajimehdipour <i>et al.</i> (2006)
		Ursolic acid and bellidifolin		Rastogi and Mehrotra (1979)
<i>S. decussata</i>		Tetraoxygenated and pentaxygenated xanthenes		Rastogi and Mehrotra (1979)
		1-Hydroxy-3,7,8-trimethoxy, 1,8-dihydroxy-3,7 -dimethoxy, 1,7-dihydroxy-3,8-dimethoxy and 1,7,8-trihydroxy-3-methoxyxanthenes		Rastogi and Mehrotra (1969)
	Whole plant	1,7,8-Trihydroxy-3-methoxyxanthone (swertianin) and 1,3,7- trihydroxy-8-methoxyxanthone	Antioxidant	Patro <i>et al.</i> (2005)
	Whole plant	1-Hydroxy-3,7,8-trimethoxy, 1,8-dihydroxy-3,7 -dimethoxy, 1,7-dihydroxy-3,8-dimethoxy and 1,7,8-trihydroxy-3-methoxyxanthenes	Antioxidant	Chintalwar and Chattopadhyay (2006)
		1,7,8-Trihydroxy-3-methoxyxanthone		Rastogi and Mehrotra (1969)
<i>Swertia delavayi</i>	Whole plant	Oleanolic acid, gentioperoside, swertiamarin, daucosterol, swertiadecoraxanthone-II, isovitexin and isoorientin		Xia <i>et al.</i> (2008)
<i>Swertia pubescens</i> <i>Franch</i>	Whole plant	Isoorientin, gentiopicroside, glucose and oleanolic acid		Zhang <i>et al.</i> (1996)
<i>Swertia tetraptera</i>	Whole plant	Oleanolic acid, 1,3-dihydroxy-4,7- dimethoxyxanthone, 1-hydroxy-2,3,5- trimethoxyxanthone and beta-sitosterol.		Niu <i>et al.</i> (1991)
		1,3-dihydroxy-4,7-dimethoxyxanthone		
<i>Swertia corymbosa</i>	Whole plant		Antimicrobial	Ramesh <i>et al.</i> (2002)
<i>Swertia mileensis</i>	Aerial parts	Acyl secoiridoid glucosides, swertiamarin, 2'-O-acetylswertiamarin and amarogentin,		Kikuzaki <i>et al.</i> (1996)
	Whole plant	Swerilactones A and B	Anti-HBV	Geng <i>et al.</i> (2009)
	Whole plant	Swerilactosides A,B and C		Geng <i>et al.</i> (2010)

(Alam *et al.*, 2009). Several isolated chemical constituents viz, coumarins, flavonoids, phytosterol, phenols, tenins, alkaloids, triterpenes, anthraquinones and biological activities of Toona species were documented by Negi *et al.* (2011).





should also have anti-inflammatory activity (Mandal *et al.*, 1992a). For bellidifolin and swerchirin a strong hypoglycemic activity has been reported by Saxena *et al.* (1993) and Basnet *et al.* (1994). *S. paniculata* is used in the Indian System of Medicine as a bitter tonic and in the treatment of some mental disorders (Prakash *et al.*, 1982). *S. hookeri* extract is used in the treatment of microbial infections and as a mood elevator (Ghosal *et al.*, 1980). Swertifrancheside isolated from *S. franchetiana* was found to be potent inhibitor of the DNA polymerase activity of human immunodeficiency virus-1 reverse transcriptase (HIV-1RT). Naturally occurring xanthenes have emerged out as an important class of organic compounds in view of their remarkable pharmacological and other biological activities. It has now been observed that a number of plant products which are in regular use as chemotherapeutic agents contain xanthenes as active constituents. Mangiferin was the first xanthone to be investigated pharmacologically and has been found to exhibit a broad spectrum of biological activities. It shows monoamine oxidase inhibition, cardiogenic, convulsant and choleric activities (Ghosal *et al.*, 1973; Bhattacharya *et al.*, 1972). Pronounced anti-inflammatory activity has also been observed in mangiferin. Oral and topical compounds containing mangiferin are useful for the treatment of diseases caused by herpes virus. Mangiferin has been found to protect the liver of the rats from high altitude hypoxia. On the other hand Ghosal *et al.* (1975) have observed the opposite CNS depressant effect for xanthone-O-glycosides in mice and rats. The extract of most of *Swertia* species showed mutagenic activities. The antimalarial drug AYUSH-64 contains *S. chirayita* as one of the ingredients. Xanthenes of *S. chirayita* are reported to produce CNS depression (Ghosal *et al.*, 1973). The total extract of *S. chirayita* showed significant antifeedant activity against *Jute semilooper* (Malic *et al.*, 1985). Norswertianolin, an O-glycoside has been reported to produce antitubercular activity. The O-glycosides of *S. purpurescens* are known to produce CNS depression in albino rats and mice (Ghosal *et al.*, 1974). 1,8-Dihydroxy-3,5-dimethoxyxanthone (swerchirin), isolated from the hexane fraction of *Swertia chirayita*, has a very significant blood sugar lowering effect in fasted, fed, glucose loaded and tolbutamide pre-treated albino rats.

## CONCLUSION

As a conclusion, the present study has shown that mainly xanthenes from genus *Swertia* are responsible for several types of biological activities. Apart from these flavonoids, iridoid glycosides and triterpenoids are also secondary metabolites isolated from this genus which also contribute their role in biological activities.

## ACKNOWLEDGMENT

The authors are thankful to Dr. Asha Budakoti, NCL, Pune for providing some references.

## REFERENCES

- Alam, K.D., M.S. Ali, S. Parvin, S. Mahjabeen, M.A. Akbar and R. Ahamed, 2009. *In vitro* antimicrobial activities of different fractions of *Swertia chirata* ethanolic extract. Pak. J. Biol. Sci., 12: 1334-1337.
- Alam, K.D., M.S. Ali, S. Mahjabeen, S. Parvin, M.A. Akbar and R. Ahamed, 2010. Report: Analgesic activities of ethanol extract of leaf, stem and their different fractions of *Swertia chirata*. Pak. J. Pharm. Sci., 23: 455-457.
- Anonymous, 1976. The Wealth of India. CSIR, New Delhi, pp: 79-80.

- Ashida, S., S.F. Noguchi and T. Suzuki, 1994. Antioxidative components, xanthone derivatives, in *Swertia japonica* Makino. *J. Am. Oil Chem. Soc.*, 71: 1095-1099.
- Asthana, J.G., S. Jain, A. Mishra and M.S. Vijaykanth, 2001. Evaluation of antileprotic herbal drug combinations and their combination with Dapsone. *Indian Drugs*, 38: 82-86.
- Atta-ur-Rahman, A. Pervin, M. Feroz, M. Iqbal Choudhary and M.M. Qureshi *et al.*, 1994. Phytochemical studies on *Swertia cordata*. *J. Nat. Prod.*, 57: 134-137.
- Awasthi, A.K., G.S. Bisht and B. Anroop, 2005. *In vitro* antimicrobial activity of *Swertia cordata*. *Ind. J. Nat. Prod.*, 21: 27-29.
- Bajpai, M.B., R.K. Asthana, N.K. Sharma, S.K. Chatterjee and S.K. Mukherjee, 1991. Hypoglycemic effect of swerchirin from the hexane fraction of *Swertia chirayita*. *Planta Med.*, 57: 102-104.
- Balasundari, P., R. Parimala, Abhaydharmasi, S.K. Singh and V. Ravichandran, 2006. Hepatoprotective activity of *Swertia chirata*. *Hamd. Med.*, 49: 53-56.
- Banerjee, S., T.K. Sur, S. Mandal, P.C. Das and S. Sikdar, 2000. Assessment of the anti-inflammatory effects of *Swertia chirata* in acute and chronic experimental models in male albino rats. *Ind. J. Pharmacol.*, 32: 21-24.
- Basnet, P., S. Kadota, T. Namba and M. Shimizu, 1994. The hypoglycaemia activity of *Swertia japonica* extract in streptozotocin induced hyperglycaemic rats. *Phytother. Res.*, 8: 55-57.
- Bentley, R. and H. Trimen, 1880. *Medicinal Plant*. J and A Churchill, London, pp: 183.
- Bhan, S., R. Kumara, A.K. Kalla and K.L. Dhar, 1987. Isomeric 2,3-seco-hopene lactones from *Swertia petiolata*. *Phytochem.*, 26: 3363-3364.
- Bhana, S., R. Kumar, A.K. Kalla and K.L. Dhar, 1988. Triterpenoids from *Swertia petiolata*. *Phytochem.*, 27: 539-542.
- Bhattacharya, S.K., S. Ghosal, R.K. Chaudhuri and A.K. Sanyal, 1972. *Canscora decussata* (Gentianaceae) xanthenes III: Pharmacological studies. *J. Pharm. Sci.*, 61: 1838-1840.
- Bhattacharya, S.K., P.K.S.P. Reddy, S. Ghosal, A.K. Singh and P.V. Sharma, 1974. Chemical constituents of Gentianaceae, XIX, CNS depressant effects of swertiamarin. *J. Pharm. Sci.*, 65: 1547-1549.
- Brahmachari, G., S. Mondal, A. Gangopadhyay, D. Gorai, B. Mukhopadhyay, S. Saha and A.K. Brahmachari, 2004. *Swertia* (Gentianaceae): Chemical and pharmacological aspects. *Chem. Biodivers.*, 1: 1627-1651.
- Chakravarti, A.K., T. Sarkar and B. Das, 2001. Structure and synthesis of glycoborine, a new carbazole alkaloid from roots of *Glycosmis arborea*. *Ind. J. Chem.*, 40: 228-231.
- Chakravarty, A.K., S. Mukhopadhyay, S.K. Moitra and B. Das, 1994. (-)-Syringaresinol, a hepatoprotective agent and other constituents from *Swertia chirata*. *Ind. J. Chem.*, 33: 405-408.
- Chandrasekar, B., M.B. Bajpai and S.K. Mukherjee, 1990. Hypoglycemic activity of *Swertia chirayita* (Roxb. ex Flem.) Karst. *Ind. J. Exp. Biol.*, 28: 616-628.
- Chintalwar, G.J. and S. Chattopadhyay, 2006. Structural confirmation of decussatin, a *Swertia decussata* xanthone. *Nat. Prod. Res.*, 20: 53-56.
- Demirkiran, O., 2007. *Topics in Heterocyclic Chemistry*. Springer Berlin/Heidelberg, New York.
- Denisova, O.A., V.I. Glyzin, A.V. Patudin and D.A. Fesenko, 1980. Xanthenes from the roots of *Swertia iberica*. *Chem. Nat. Compounds*, 16: 145-149.

- Du, X.G., W. Wang, S.P. Zhang, X.P. Pu and Q.Y. Zhang *et al.*, 2010. Neuroprotective xanthone glycosides from *Swertia punicea*. *J. Nat. Prod.*, 73: 1422-1426.
- El-Sedawy, A., Y.Z. Shu, M. Hattori, K. Kobashi and T. Namba, 1989. Metabolism of Swertiamarin from *Swertia japonica* by human intestinal bacteria. *Plant. Med.*, 55: 147-151.
- Falah, S., T. Suzuki and T. Katayama, 2008. Chemical constituents from *Swietenia macrophylla* bark and their antioxidant activity. *Pak. J. Biol. Sci.*, 11: 2007-2012.
- Fukamiya, N., M. Okano, K. Kondo and K. Tagahara, 1990. Xanthonones from *Swertia punicea*. *J. Nat. Prod.*, 53: 1543-1547.
- Gaur, R.D., 1999. Flora of the District Garhwal North West Himalaya: With Ethnobotanical Notes. Transmedia, Srinagar, pp : 811.
- Geng, C.A., Z.Y. Jiang, Y.B. Ma, J. Luo and X.M. Zhang *et al.*, 2009. Swerilactones A and B, anti-HBV new lactones from a traditional Chinese herb: *Swertia mileensis* as a treatment for viral hepatitis. *Org. Lett.*, 11: 4120-4123.
- Geng, C.A., X.M. Zhang, Y.B. Ma, Z.Y. Jiang, J.F. Liu, J. Zhou and J.J. Chen, 2010. Three new secoiridoid glycoside dimers from *Swertia mileensis*. *J. Asian Nat. Prod. Res.*, 2: 542-548.
- Ghosal, S., P.V. Sharma, R.K. Chaudhuri and S.K. Bhattacharya, 1973. Chemical constituents of the gentianaceae V: Tetraoxygenated xanthonones of *Swertia chirata* buch.-ham. *J. Pharm. Sci.*, 62: 926-930.
- Ghosal, S., V.P. Sharma and R.K. Chaudhuri, 1974. Chemical constituents of gentianaceae. X. Xanthone-O-glucosides of *Swertia purpurascens* Wall. *J. Pharm. Sci.*, 63: 1286-1290.
- Ghosal, S., P.V. Sharma, R.K. Chaudhuri and S.K. Bhattacharya, 1975. Chemical constituents of gentianaceae XIV: Tetraoxygenated and penta-oxygenated xanthonones of *Swertia purpurascens* Wall. *J. Pharm. Sci.*, 64: 80-83.
- Ghosal, S., K. Biswas and D.K. Jaiswal, 1980. Xanthone and flavonol constituents of *Swertia hookeri*. *Phytochem.*, 19: 123-126.
- Hajimehdipour, H., Y. Amanzadeh, S.E. Sadat Ebrahimi and V. Mozaffarian, 2003. Three tetraoxygenated xanthonones from *Swertia longifolia*. *Pharm. Biol.*, 41: 497-499.
- Hajimehdipour, H., M.G. Dijoux-Franca, A.M. Mariotte, Y. Amanzadeh, S.E. Sadat-Ebrahimi and M. Ghazi-Khansari, 2006. Two new xanthone diglycosides from *Swertia longifolia* Boiss. *Nat. Prod. Res.*, 20: 1251-1257.
- Hase, K., J. Li, P. Basnet, Q. Xiong, S. Takamura, T. Namba and S. Kadota, 1997. Hepatoprotective principles of *Swertia japonica* Makino on d-galactosamine/ lipopolysaccharide-induced liver injury in mice. *Chem. Pharm. Bull.*, 45: 1823-1827.
- Hikino, H., Y. Kiso, M. Kubota and M. Hattori, 1984. Antihepatotoxic principles of *Swertia japonica* herbs. *Shoyakugaku Zasshi*, 38: 359-360.
- Hostettmann, K. and H. Wagner, 1977. Xanthone glycosides. *Phytochem.*, 16: 821-829.
- Hostettmann, K. and I. Miura, 1977. A new Xanthone Diglucoside from *Swertia perennis* L. *Helv. Chim. Acta.*, 60: 262-264.
- Hostettmann-Kaldas, M., K. Hostettmann and O. Sticher, 1981. Xanthonones, flavones and secoiridoids of american *Gentiana* species. *Phytochem.*, 20: 443-446.
- Ikeshiro, Y., T. Kubota and Y. Tomita, 1983. Two bitter biphenyl glucosides from *Swertia japonica*. *Plant. Med.*, 47: 26-29.
- Ikeshiro, Y. and Y. Tomita, 1984. A new iridoid glucoside of *Swertia japonica*. *Planta Med.*, 50: 485-488.

- Ikeshiro, Y. and Y. Tomita, 1985. Iridoid glucoside of *Swertia japonica*. *Planta Med.*, 5: 390-393.
- Ikeshiro, Y. and Y. Tomita, 1987. Senburiside II, a new iridoid glucoside from *Swertia japonica*. *Planta Med.*, 53: 158-161.
- Iqbal, Z., M. Lateef, M.N. Khan, A. Jabbar and M.S. Akhtar, 2006. Anthelmintic activity of *Swertia chirata* against gastrointestinal nematodes of sheep. *Fitoterapia*, 77: 463-465.
- Ishimaru, K., H. Sudo, M. Satake, Y. Matsunaga, Y. Hasegawa, S. Takemoto and K. Shimomura, 1990a. Amarogentin, amaroswerin and four xanthenes from hairy root cultures of *Swertia japonica*. *Phytochem.*, 29: 1563-1565.
- Ishimaru, K., H. Sudo, M. Satake and K. Shimomura, 1990b. Phenyl glucosides from a hairy root culture of *Swertia japonica*. *Phytochem.*, 29: 3823-3825.
- Jiang, D.J., J.L. Jiang, H.Q. Zhu, G.S. Tan, S.Q. Liu, K.P. Xu and Y.J. Li, 2004. Demethylbellidifolin preserves endothelial function by reduction of the endogenous nitric oxide synthase inhibitor level. *J. Ethnopharmacol.*, 93: 295-306.
- Joshi, P. and V. Dhawan, 2005. *Swertia chirayita*- an overview. *Curr. Sci.*, 89: 635-640.
- Kanamori, H., I. Sakamoto and M. Mizuta, 1984. Studies on the mutagenicity of *Swertia herba*. III: Components which become mutagenic on nitrite treatment. *Chem. Pharm. Bull.*, 32: 2290-2294.
- Kanamori, H., I. Sakamoto and M. Mizuta, 1986. Studies on the mutagenicity of *Swertia herba*. III: Components which become mutagenic on nitrite treatment. *Chem. Pharm. Bull.*, 34: 1663-1666.
- Karan, M., K. Vasisht and S.S. Handa, 1999a. Antihepatotoxic activity of *Swertia chirata* on carbon tetrachloride induced hepatotoxicity in rats. *Phytother. Res.*, 13: 24-30.
- Karan, M., K. Vasisht and S.S. Handa, 1999b. Antihepatotoxic activity of *Swertia chirata* on paracetamol and galactosamine induced hepatotoxicity in rats. *Phytother. Res.*, 13: 95-101.
- Khan, T.A., M.H. Haqqani and N.M. Nisar, 1979. Chemical investigation of *Swertia alata*. *Planta Med.*, 37: 180-181.
- Khan, M.I. and M.H. Haqqani, 1981. Chemical investigation of *Swertia cordata*. *Fitoterapia*, 52: 165-166.
- Khetwal, K.S. and R.S. Bisht, 1988. A xanthone glycoside from *Swertia speciosa*. *Phytochem.*, 27: 1910-1911.
- Khetwal, K.S., B. Joshi and R.S. Bisht, 1990. Tri- and tetraoxygenated xanthenes from *Swertia petiolata*. *Phytochem.*, 29: 1265-1267.
- Khetwal, S., S. Pande and U. Tiwari, 1997. Xanthenes from *Swertia alata*. *Ind. J. Pharm. Sci.*, 59: 190-191.
- Kikuchi, M. and M. Kikuchi, 2004. Studies on the constituents of *Swertia japonica* Makino I. On the structures of new secoiridoid diglycosides. *Chem. Pharm. Bull.*, 52: 1210-1214.
- Kikuchi, M. and M. Kikuchi, 2005. Studies on the constituents of *Swertia japonica* Makino II. on the structures of new glycosides. *Chem. Pharm. Bull.*, 53: 48-51.
- Kikuzaki, H., Y. Kawasaki, S. Kitamura and N. Nakatani, 1996. Secoiridoid glucosides from *Swertia mileensis*. *Planta Med.*, 62: 35-38.
- Kirtikar, K.R. and B.D. Basu, 1984. *Indian Medicinal Plants*. Latit Mohan Basu, Leader Road, Allahabad, India, pp: 1664-1665.
- Kondo, Y., F. Takano and H. Hojo, 1994. Suppression of chemically and immunologically induced hepatic injuries by gentiopicoside in mice. *Planta Med.*, 60: 414-416.

- Kossah, R., C. Nsabimana, H. Zhang and W. Chen, 2010. Optimization of extraction of polyphenols from syrian sumac (*Rhus coriaria* L.) and chinese sumac (*Rhus typhina* L.) fruits. *Res. J. Phytochem.*, 4: 146-153.
- Kulanthaivel, P. and S.W. Pelletier, 1988. Isolation of a new xanthone and 2-hydroxydimethylterephthalate from *Swertia petiolata*. *J. Nat. Prod.*, 51: 379-381.
- Li, J.C., L. Feng, B.H. Sun, T. Ikeda and T. Nohara, 2005. Hepatoprotective activity of the constituents in *Swertia pseudochinensis* (Pharmacognosy). *Biol. Pharm. Bull.*, 28: 534-537.
- Luo, Y.H. and R.L. Nie, 1992. Studies on iridoid glycosides from *Swertia angustifolia*. *Yao Xue Xue Bao*, 27: 125-129.
- Malic, R.N., P.C. Das and S.M. Chatterji, 1985. Antifeeding properties of *Swertia chirata* against jute semilooper (*Anomis sabulifera* Guen). *Curr. Sci.*, 54: 1110-1112.
- Mandal, S. and A. Chatterjee, 1994. Seminar on Research in Ayurveda and Siddha. CCRAS, New Delhi, pp: 58-59.
- Mandal, S., P.C. Das and P.C. Joshi, 1992a. Anti-inflammatory action of *Swertia chirata*. *Fitoterapia*, 62: 122-128.
- Mandal, S., P.C. Das and P.C. Joshi, 1992b. Naturally occurring xanthones from terrestrial flora. *J. Ind. Chem. Soc.*, 69: 611-636.
- Menkovic, N., K. Savikin-Fodulovic and V. Bulatovic, 2002. Xanthones from *Swertia punctata*. *Phytochem.*, 61: 415-420.
- Mishra, K.P. and T.G. Joseph, 1983. A note on the study of the market sample of *Swertia chirata* Buch. Hum. Ex. Wall. Bull. Med. Ethnobot. Res., 4: 154-157.
- Mukherjee, B.B. and S.K. Mukherjee, 1987. Blood Sugar Lowering Activity of *Swertia chirata* (Buch-Ham) Extract. *Pharm. Biol.*, 25: 97-102.
- Negi, J.S., P. Singh, G.J. nee Pant and M.S.M. Rawat, 2009a. Quantitative assessment of xanthone derivatives in *Swertia chirata* (Wall.) by RP-HPLC with UV detection. *Med. Plants Int. J. Phytomed. Related Ind.*, 1: 97-100.
- Negi, J.S., P. Singh, M.S.M. Rawat and G.J. nee Pant, 2009b. Study on the trace elements in *Swertia chirayita* (Roxb.) H. Karsten. *Biol. Trace Element Res.*, 133: 350-356.
- Negi, J.S., P. Singh, G.J. Pant and M.S.M. Rawat, 2010a. RP-HPLC analysis and antidiabetic Activity of *Swertia paniculata* (Wall.). *Nat. Prod. Comm.*, 5: 907-910.
- Negi, J.S., P. Singh, M.S.M. Rawat and G.J. nee Pant, 2010b. Qualitative and quantitative determination of major xanthones in *Swertia speciosa* by high performance liquid chromatography. *Med. Plants Int. J. Phytomed. Related Ind.*, 2: 45-50.
- Negi, J.S., P. Singh, G.J. nee Pant and M.S.M. Rawat, 2010c. Study on the variations of mineral elements in *Swertia speciosa* (G. Don). *Biol. Trace Element Res.*, 138: 300-306.
- Negi, J.S., V.K. Bisht, A.K. Bhandari, M.K. Bharti and R.C. Sundriyal, 2011. Chemical and pharmacological aspects of *Toona* (Meliaceae). *Res. J. Phytochem.*, 5: 14-21.
- Niu, B., J. Guo, J. Chen and J. Ma, 1991. Chemical constituents of *Swertia tetraptera* Maxim. *Zhongguo Zhong Yao Za Zhi*, 16: 549-550.
- Patro, B.S., G.J. Chintalwar and S. Chattopadhyay, 2005. Antioxidant activities of *Swertia decussata* xanthones. *Nat. Prod. Res.*, 19: 347-354.
- Plouvier, V., J. Massicot and P. Rivaille, 1967. On gentiacauleine, a new tetra-substituted xanthone, aglycone of gentiacauloside of *Gentiana acaulis* L. *C R Acad. Sci. Hebd. Seances Acad. Sci. D.*, 264: 1219-1222.

- Prakash, A., P.C. Basumatary, S. Ghosal and S.S. Handa, 1982. Chemical constituents of *Swertia paniculata*. *Planta Medica*, 45: 61-62.
- Ramesh, N., M.B. Viswanathan, A. Saraswathy, K. Balakrishna, P. Brindha and P. Lakshmanaperumalsamy, 2002. Antimicrobial and phytochemical studies of *Swertia corymbosa*. *Fitoterapia*, 73: 160-164.
- Rastogi, R.P. and B.N. Mehrotra, 1969. *Compendium of Indian Medicinal Plants*. Vol. 1, Central Drug Research Institute, Lucknow and Publications and Information Directorate, New Delhi, pp: 396.
- Rastogi, R.P. and B.N. Mehrotra, 1979. *Compendium of Indian Medicinal Plants*. Vol. 2, Central Drug Research Institute, Lucknow and Publications and Information Directorate, New Delhi, pp: 654-655.
- Saha, P., S. Mandal, A. Das, P.C. Das and S. Das, 2004. Evaluation of the anticarcinogenic activity of *Swertia chirata* Buch-Ham, an Indian medicinal plant, on DMBA-induced mouse skin carcinogenesis model. *Phytother. Res.*, 18: 373-378.
- Sakai, T., H. Naoki, H. Kameoka and K. Takaki, 1981. Structure of semburin and isosemburin, 2, 8-dioxabicyclo[3.3.1]nonanes isolated from the volatile oil of *Swertia japonica* Makino. *Chem. Lett.*, 8: 1257-1258.
- Sakamoto, I., T. Tanaka, O. Tanaka and T. Tsuyoshi, 1982. Xanthone glucosides of *Swertia japonica* Makino and a related plant: Structure of a new glucoside, isoswertianolin and structure revision of swertianolin and norswertianolin. *Chem. Pharm. Bull.*, 30: 4088-4091.
- Saxena, A.M., M.B. Bajpai, P.S. Murthy and S.K. Mukherjee, 1993. Mechanism of blood sugar lowering by a swerchirin-containing hexane fraction (SWI) of *Swertia chirayita*. *Indian J. Exp. Biol.*, 31: 178-181.
- Saxena, M.A., P.S. Murthy and S.K. Mukherjee, 1996. Mode of action of three structurally different hypoglycemic agents: A comparative study. *Ind. J. Exp. Biol.*, 34: 351-355.
- Sharma, P.V., 1982. Alkaloids of *Swertia chirata*. *Ind. J. Pharm. Sci.*, 44: 36-52.
- Sombie, P.A.E.D., A. Hilou, C. Mounier, A.Y. Coulibaly, M. Kiendrebeogo, J.F. Millogo and O.G. Nacoulma, 2011. Antioxidant and anti-inflammatory activities from Galls of *Guiera senegalensis* J.F. Gmel (Combretaceae). *Res. J. Med. Plant*, 5: 448-461.
- Sultanbawa, M.U.S., 1980. Xanthonoids of tropical plants. *Tetrahedron*, 36: 1465-1506.
- Tan, P., C. Hou, Y. Liu, L.J. Lin and G.A. Cordell, 1991. Swertipunicoside. The first bisxanthone C-glycoside. *J. Org. Chem.*, 56: 7130-7133.
- Tan, P., C.Y. Hou, Y.L. Liu, L.J. Lin and G.A. Cordell, 1992a. 3-O-Demethylswertipunicoside from *Swertia punicea*. *Phytochem.*, 31: 4313-4315.
- Tan, P., Y.L. Liu and C.Y. Hou, 1992b. Structure of swertiapuniside from *Swertia punicea* Hemsl. *Yao Xue Xue Bao*, 27: 476-479.
- Tan, P., Y. Liu and C.Y. Hou, 1993. Swertiapunimarin from *Swertia punicea* Hemsl. *Acta. Pharm. Sin.*, 28: 522-525.
- Tan, G.S., K.P. Xu, F.S. Li, P.S. Xu, G.Y. Hu, D.J. Jiang and Y.J. Li, 2003. Daviditin B from *Swertia davidi* Franch. *Yao Xue Xue Bao*, 38: 931-933.
- Tian, L.Y., X. Bai, X.H. Chen, J.B. Fang, S.H. Liu and J.C. Chen, 2010. Anti-diabetic effect of methylswertianin and bellidifolin from *Swertia punicea* Hemsl. and its potential mechanism. *Phytomed.*, 17: 533-539.
- Verma, D.L. and K.S. Khetwal, 1985. Phenolics in the roots of *Swertia paniculata* Wall. *Sci. Culture*, 51: 305-306.

- Vieira, L.M.M. and A. Kijjoa, 2005. Naturally-occurring xanthenes: Recent developments. *Curr. Med. Chem.*, 12: 2413-2446.
- Wang, J.N., C.Y. hou, Y.L. liu, L.Z. lin, R.R. Gil and G.A. cordell, 1994. Swertiflanchesides an HIV-reverse transcriptase inhibitor and the first flavone-xanthone dimmer from *Swertia franchetiana*. *J. Nat. Prod.*, 57: 211-217.
- Wang, S.S., W.J. Zhao, X.W. Han and X.M. Liang, 2005a. Two New iridoid glycosides from the Tibetan Folk Medicine *Swertia franchetiana*. *Chem. Pharm. Bull.*, 53: 674-676.
- Wang, S.S., X.W. Han, Q. Xu, H.B. Xiao, X.M. Liu, Y.G. Du and X.M. Liang, 2005b. Xanthone glycosides from *Swertia franchetiana*. *J. Asian Nat. Prod. Res.*, 7: 175-179.
- Xia, C.L., G.M. Liu and H. Zhang, 2008. Chemical constituents from herbs of *Swertia delavayi*. *Zhongguo Zhong Yao Za Zhi*, 33: 1988-1990.
- Ya, B.Q., L.C. Nian and C. Li, 1999. Protective effect of swerchirin on hematoiesis in <sup>60</sup>Co irradiated mice. *Phytomed.*, 6: 85-88.
- Yamahara, J., M. Kobayashi, H. Matsuda and S. Aoki, 1991. Anticholinergic action of *Swertia japonica* and an active constituent. *J. Ethnopharmacol.*, 33: 31-35.
- Yang, H., C. Ding, Y. Duan and J. Liu, 2005. Variation of active constituents of an important Tibet folk medicine *Swertia mussotii* Franch. (Gentianaceae) between artificially cultivated and naturally distributed. *J. Ethnopharmacol.*, 98: 31-35.
- Zhang, Y., X. Xu, C. Hou and J. Yang, 1996. Chemical constituents of *Swertia pubescens* Franch. *Zhongguo Zhong Yao Za Zhi*, 21: 103-104.
- Zhang, J.S., X.M. Wang, X.H. Dong, H.Y. Yang and G.P. Li, 2009. Studies on chemical constituents of *Swertia mussotii*. *Zhong Yao Cai*, 32: 511-514.
- Zhou, H.M., Y.L. Liu, G. Blasko and G.A. Cordell, 1989. Swertiabisxanthone-I from *Swertia macrosperma*. *Phytochem.*, 28: 3569-3571.
- Zhou, H.M. and Y.L. Liu, 1990. Structure of swertiamacroside from *Swertia macrosperma* C. B. Clark. *Acta. Pharm. Sin.*, 25: 123-126.