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Review Article

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CHEMICAL AND POTENTIAL BIOLOGICAL PERSPECTIVES OF GENUS *SENECIO* [ASTERACEAE]

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ABSTRACT

Ethnopharmacological Relevance: The plant of the genus Senecio [Astereaceaes] is widely distributed ,and have long been used in folk medicine for the treatment of various ailments particularly treatment of dysentery, conjunctivitis, infections, rheumatism, cancer, cough suppressant, asthma, bronchitis, eczemainflammation, and muscular pain. **Aim of the Review:** In present review we emphasized the recent progress in the chemistry and biologyog this genus as well as its traditional uses.This database may provide guidance for researchers, chemists and herbologists for further investigation in the field. **Materials and Methods:** All literature available on the genus Senecio was collected via electronic search [using Scifinder, Google scholar, Scirus and Web of science], books, thesis and journals. **Results:** Ethnobotanical uses of different species of genus Senecio have been reported from China, Pakistan, India, Malasiya,Australia and Nepal for their different types of ailments,Genus Senecio possesses different chemical constituents including alkaloids,glycosides, sugar, sesquiterpenoids, monoterpenoids, diterpenoids, triterpenoids, flavonoids,coumarins, and some other compounds.Crude extract, fraction, and isolated secondary metabolities of genus Senecio have shown a wide range of pharmacological activities including antibacterial, antifungal, antifeedant,antioxidant and cholinesterase inhibiting activities. **Conclusion:** The leaves and roots of Senecio plants have been used for the treatment of dysentery, conjunctivitis, infections, rheumatism, fever in the folk medicine system for years without any adverse effect.However there is a need to search for individual secondary metabolities responsible for these actions and study their mode of actions, and physiological pathways in sufficient details.

KEYWORDS: The genus Senecio, which belongs to the tribe Senecioneae.

1. INTRODUCTION

The genus Senecio, which belongs to the tribe Senecioneae, is the largest and most complex genus in the family of the Asteraceae [Compositae] and includes more than 1500 species with a worldwide distribution [B. Nordenstam et al 1977] that have been extensively investigated for their secondary metabolities. pyrrolizidine alkaloids [Pas], eremophilanolides and cacalolides are particulary characteristic for species of this genus [E.Burgueno et al 2004].

The plants of this genus have been studied extensively because of the traditional medicinal uses associated with them. The leaves, stems and flowers are used mostly in folk medicine for the treatment of various ailments [G. B. Hammond et al 1998 E. Uzun, et al 2004]. These plants are the major sources of bioactive pyrrolizidine alkaloids [Pas] and the furanoeremophilane sesquiterpenoids and these are the phytoconstituents which are responsible for almost all of pharmacological activities of this genus [F. Bohlmann, et al 1986,W. H. Heywood et al 1977, D. J. Robins et al 1982]. The chemical constituents of the genus Senecio include notably sesquiterpenoids, monoterpenoids [F. Bohlmann, et al 1985,S. Dupre et al 1991], diterpenoids [C. Dong-Liang et al 1992], triterpenoids [P. Torres et al 1998], essential oils [Y. Zhao et al 2011], pyrrolizidine alkaloids, phenolic and flavonoid compounds [B. E. Juarez et al 1995, P. Torres et al 1997,E, M. Suleimenov et al 2000, H. Zhong-Mei et al 2010,T. Dao-peng et al 2010]. Most of the aquatic plants of this genus are known for containing furanoeremophilanes [A. B. Pomilio et al 1997, E. A. Jares et al 1990], steroids [M. C. Tettamanzi et al 1992] and the pyrrolizidine alkaloids senecionine and platyphylline [J. A. Paiva, et al 2004,C. M. Silva, et al 2006] with toxic properties.Chemically investigated parts of the Senecio speciesinclude roots, leaves, stems, flowers, aerial parts, and whole plants. The PAs and furanoeremophilanes are the most important constituents of this genus. Somecompounds isolated from the genus Senecio and even crude extracts are known antimicrobial activity, including antibacterial, antifungal, and antitubercular activities.

2. Traditional Uses

The plants of the genus Senecio are used traditionally for medicinal purposes that include treatment of dysentery, conjunctivitis, infections, rheumatism, cancer, cough suppressant, asthma, bronchitis, eczema and inflammation.Senecioaryunensis is used in traditional Chinese medicine in northwestern China to treat dysentery, conjunctivitis and tumefaction [The Encyclopedia et al 1977].

The aerial parts ofSenecio canescens areused for the treatmentof infections the leaves are especially used topically for treatment of rheumatism [A. White, et al 1976]. Senecio integrijolius is used in traditional Chinese medicine and has been investigated for its cytotoxic effect [The Encyclopedia et al 1977]. Senecio graveolensis characterized by a typical smell and is used as a popular medicine to counteract mountain sickness and as an emenagogue, digestive and cough suppressant [J. Bautista et al 1991]. South American traditional system of medicine reported the use of Senecio species as a remedy for altitude sickness [‘soroche’] and to relieve stomach pain [S. Abdo et al 1992, L. A. Loyola et al 1985].

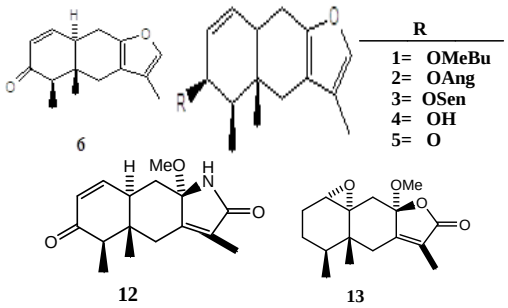
In traditional medicine, the use of Senecio species for treatment of asthma, coughs, bronchitis, eczema and wound healing have also been reported [E.Burgueno et al 2004, G. B. Hammond et al 1998, E. Uzun, et al 2004]. This species is used in traditional medicine for the treatment of skin, respiratory and osteoarticular diseases [A. A. Bolzan et al 2007]. Senecio tenuifoliusBurm.f is poisonous to livestock, but the leaves of the plant are used topically as remedy for skin diseases to reduce swelling and pain [C. K. Parikh et al 1999, D. S. Bhakuni et al 1982].

3. Chemical constituents

The chemical constituents of the genus Senecio includealkaloids, sesquiterpenoids, monoterpenoids, diterpenoids, triterpenoids, flavonoids, coumarins, and some other compounds.The chemicals reported from some of the plants of this genus are as follows.

3.1. Senecio flavus

3β-Methylbutyryloxyeuryopsin,[1] 3β angeloyloxyeuryopsin,[2] and 3β-senecioyloxyeuryopsin,[3] 3β-Hydroxyeuryopsin,[4] Euryopsin-3-one,[5] Furanoligularenone,[6] 3-Oxo-8α,12α-dimethoxy-8,12-dihydro-10αH-furanoeremophil-1-ene,[7] 3-Oxo-8α-methoxy-10αH-eremophila-1,7[11]-dien-12,8β-olide[9] 3-Oxo-8α-hydroxy-10αH-eremophila-1,7[11]-dien-12,8β-olide,[10] 3-Oxoeremophila-1,7[11]-dien-12,8β-olide,[11] 3-Oxo-8α-methoxy-10αH-eremophila-1,7[11]-dien- 12,8β-lactam,[12] 1β,10β-Epoxy-8α-methoxyeremophil-7[11]-en-12,8β-olide[13][P. Torresa et al 1999].

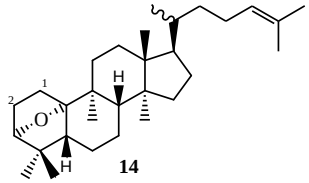


3.2. Senecio ruwenzoriensis

Bisline, Isoline, Ruwenine, Ruzorine, Isolinecic acid, Pyrrolizidine alkaloids **[**E, M. Suleimenov et al 2000**].**

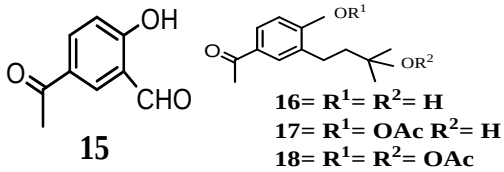
3.3. Senecio selloi

[20R]-3α, 10α-Epoxy-9-epi-cucurbita-24-ene,[14] [20 S]-3α,10α-Epoxy-9-epi-cucurbita-24-ene[2][G. R. Ckera et al 1999].



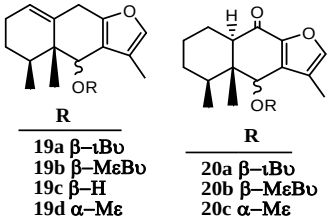
3.4. Senecio groveolens

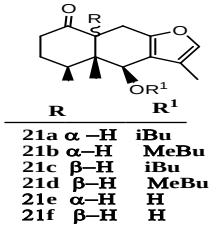
5-Acetylsahcylaldehyde,[15] 4-Hydroxy-3-[-hydroxyisopenryl] acetophenone,[16] 4-Aceroxy-3-[3-hydroxyisopentyl] aetophenone,[17] 4-Acetoxy-3-[3’-acetoxytsopentyl]acetophenone[18] [L. A. Loyola et al 1985], Dihydroeuparin [J. I. D. Graw et al 1962], 4-hydroxy-3-[isopenten-2-yl] acetophenone [F. Bohlmann et al 1970], 3-hydroxy-2,2-dimethyl-6-acetylchromane[S. Valverde et al 1972].

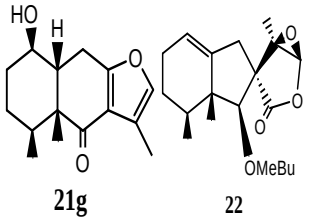


3.5. Senecio auricula var. major

6α-Methoxyeuryopsin,[19d] 6β-[2-Methylbutyryloxy]-furanoeremophilan-1-one,[21b] 6β-Isobutyryloxysenberyinone,[21c] 6β-[2-Methylbutyryloxy]-senberginone,[21d] 6β-Hydroxy-1OαH-furanoeremophilan-l-one,[21e] 6β-Hydroxy-lOβH-furanoeremophilan-l-one,[21f] lβ-Hydroxy-lOβH-furanoeremophilan-6-one,[21g] 1lβ, 12β-Epoxy-6β-[2-methylbutyryloxy]- $\Delta^{1[10]}$7-epi-dihydrobakkenolideA[senauricolide][22] furanoeremophilanes,[19a] [F. Bohlmann, et al 1986][19b] [F. Bohlmann et al 1977],[20a] [J. Harmatha, et al1969,Z. Samek et al1969],[20b] [A. H. Mericli,et al 1989],[20c][F. Bohlmann et al 1976] and,[21a] alkaloids [F. M. Panizo et al 1974].

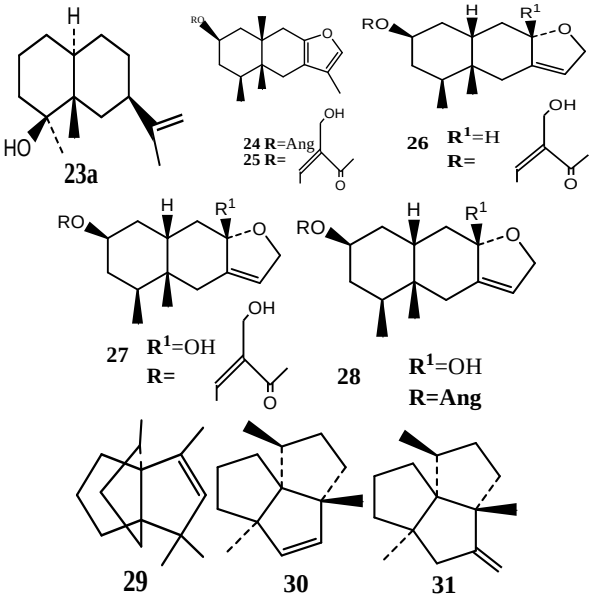






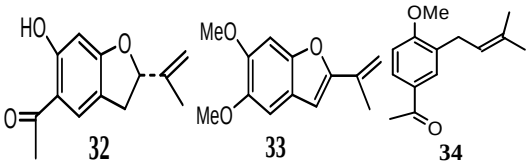
3.6. Senecio alatus

4-hydroxy-10x-H-eremophil-11[12]en,[23a] 2β-Angeloyloxy-10β-H furanoeremophilane,[24] 2β-[5-hydroxyanggeloxyloxy]-10β-H-furanoeremophilane,[25] 2β-[5-hydroxyanggeloxyloxy]-8β-H-eremophilanolide,[26] 2β-Angeloyloxy-8β-hydroxy-10β-H-eremophilanolide,[27] 2β- Angeloyloxy-8β-hydoxy-10β-H-eremophilanolide[28] [F. Fohlmann, et al 1980],eremophilane derivatives,[29][L. H. Zalkow et al 1978],[30][L. H. Zalkow et al 1977] and[31] [F. Bohlmann et al 1979].



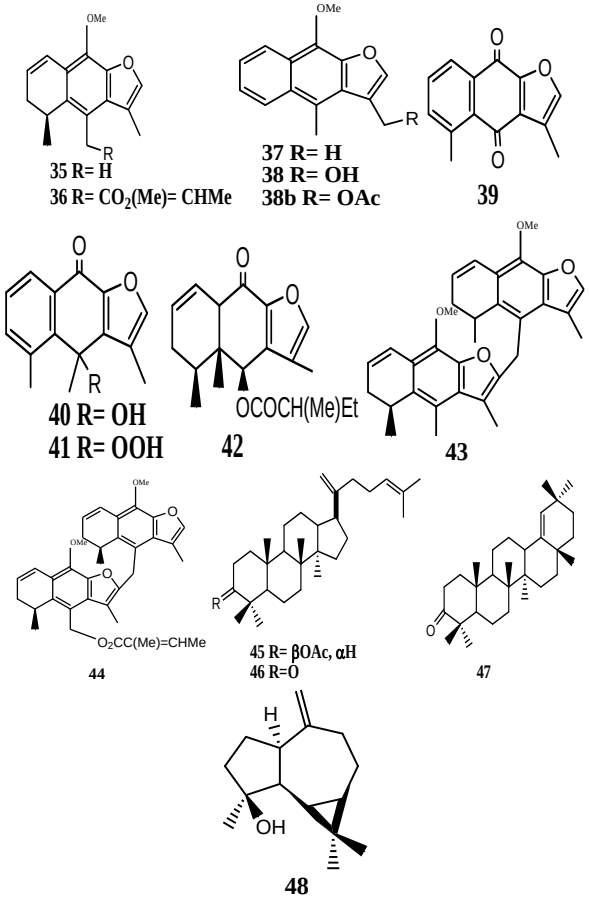
3.7. Senecio amplexicaulis

4-hydroxy-10x-H-eremophil-11[12] ene[23a] afforded α- and β-farnesene [1 and 2], β-squiphellandrene, linalolacetate, p-hydroxyacetophenone derivatives[32] [B. Kamthory et al 1939],[33] [T. Murae et al 1968],[34] [F. Bohlmann et al 1978a].



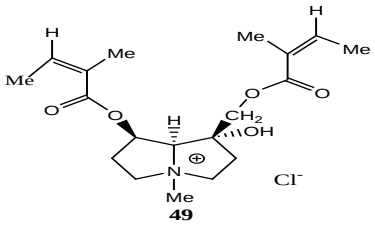
3.8. Senecio canescens

Cacalohastine[35] [K. Hayashi et al 1973,F. Bohlmann et al 1978b], lupeol, α-amyrin, sitosterol,stigmasterol, 14-angeloyloxy cacalohastine[36][F. Bohlmann et al 1977], dehydrocacalohastine[37] [K. Hayashi et al 1973,F. Bohlmann et al 1978b], 13-Hydroxy-3,4-dehydrocaealohastine[38] [S. Abdo, et al 1992], 9,13-acetoxydehydrocacalohastine[38b] [F. Bohlmann et al 1978b, F. Bohlmann et al 1978c], maturinone[39] [P. M. Brown et al1969,H. Kakisawa et al 1969], cacalonol[40] [T. Takemoto et al 1975,], cacalonol hydroperoxide,[41] 6β-[2-methylbutanoyloxy]-9-oxo-l[l0]-furanoeremophilene[42] [F. Bohlmann et al 1984], dimeric sesquiterpenes[43] [F. Bohlmann et al 1978b], l4-Angezoyloxy-l2-[cacalohastin-l4-yl]cacalohastine,[44] dammaradienyl acetate[45][D. J. Roy et al1981, J. D. P.Teresa,et al 1986], dammaradienone[46][J. D. P.Teresa, et al 1979, I. Wahlberg et al1971], germanicone[47] [A. Gonzales,et al 1981],spathulenol[48] [T. D. Hubert et al 1985].



3.9. Senecio integrifolius var Fauriri

N-Methyl-O^7.O^9-diangeloyl-lα-hydroxyl-platyneciniumchloride,[49] O^7-Angeloylturneforcidine,[50] 1,2-Dihydrosenkirkin,[51] O^7-Angeloylheliotridine-N-oxide [E. Roeder et al 1991],neosenkirkine [H. L. Zalkow et al 1988], otonecine alkoloides[L. B. Bull, et al 1968,N. H. Amsterdam et al 1962,C.C.J. Culvenor, et al 1967].



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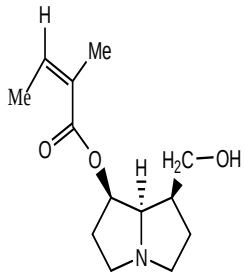

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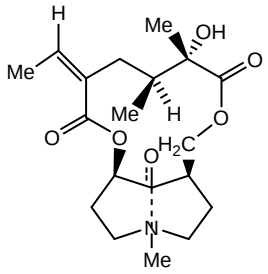

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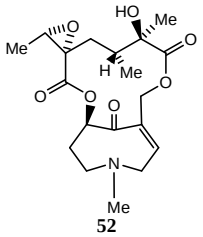
3.10. Senecio argunensis

Pyrrolizidine alkaloid-ocoscnine,[52] erucifoline,[53] 21-hydroxyintegerrimine[54] [K. Lru et al 1991], senecionine[55] [X. T et al 1979],integerrimine[56] [G. G. Habermehl et al 1988], seneciphylline[57] [E. Roder et al 1990].



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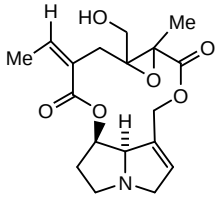

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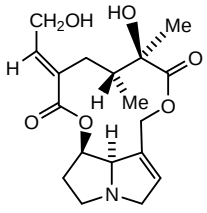

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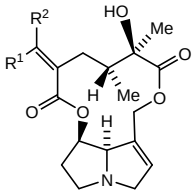
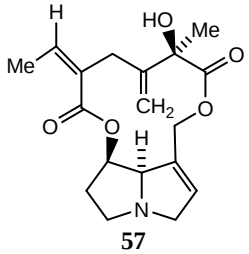


55 R^1= Me, R^2=H
56 R^1= H, R^2= Me



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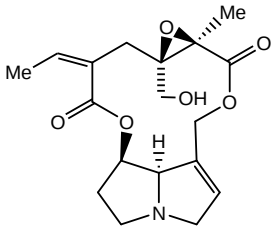
3.11. Senecio persoonii

Two toxic pyrrolizidine alkaloids- seneciphylline[57] [E. Roeder et al 1992], erucifoline[58] [K. Liu et al 1991],seneciphylline-N-oxide [E. Roeder et al 1993], erucifoline-N-oxide [H. J. Segall et al 1983].



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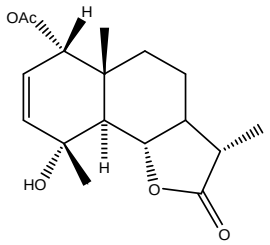
3.12. Senecio chrysanthemoides

Two lactones chrysanthemolide-lα-acetoxy-4α-hydroxy-5α,6β,7α,llβ-H-eudesm-2-en-12, 6- olide[59] and l-acetylerivanin-lα-acetoxy-3α-hydroxy-5α,6β,7α,11β-H-eudesm-4[15]en-12,6-olide.[60] [N. Mengi et al 1991], pyrrolizidine alkaloid seneciophylline, an acetylenic ester, a triterpene and derivatives of benzoquinone and euparin [K. L. Handa, et al 1957] have been reported.



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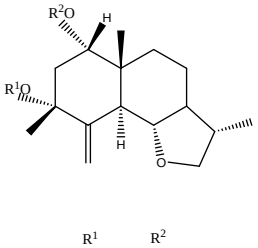
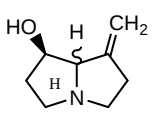


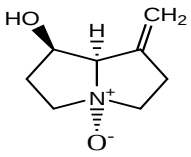
	R^1	R^2
60	H	Ac

3.13. Senecio schweinfurthii

Predominant alkaloid are 7β-hydroxy-l-methylene-8α-pyrrolizidine,[61a] 7β-hydroxy-l-methylene-8β-pyrrolizidine[61b] and 7β-hydroxy-l-methylene-8α-pyrrolizidine N-oxide[62][M. H. Benn, et al 1995].



61a- 8α-H
61b- 8β-H



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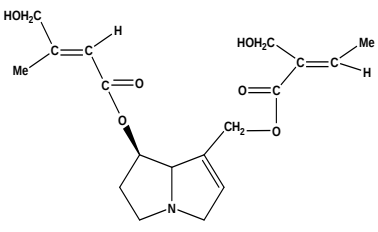
3.14. Senecio doria

Pyrrolizidine alkaloid doriasenine[63] [E. Roder et al 1988].



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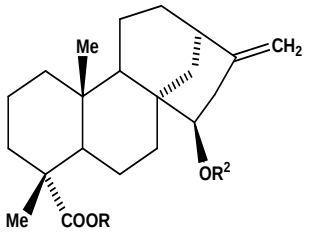
3.15. Senecio rufus

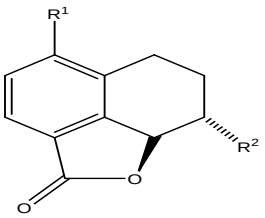
Two diterpene glycosides- rufusoside A[ent-l5α-[α-L-arabinopyranosyloxyl]-kaur-16-en-l9-oic acid],[64] Rufiisoside B[ent-l5α-[α-L-arabinopyranosyloxyl]-kaur-16-en-19-oic acidβ-D-glucopyranosyl ester],[65] a glycoside andglycone[D. L. Cheng,et al 1993].



	R^1	R^2
64	H	α-L-arabinopyranosyl-
65	β–glucopyranosyl	α-L-arabinopyranosyl-

3.16. Senecio gilliesiano

Norsesquiterpene lactone, isocoumarine retronecine, senecionine, platyphyllide, 1-hydroxy platyphyllide[66] [F. H. Guidugli, et al 1986], pyrrolizidine alkaloids[M. J. Pestchankar et al 1985, Pestchankar, et al 1985, Pestchankar, et al 1986], Furanoeremophilanes sesquiterpene [M. S. Ascheri et al 1980, M. S. A. Salmeron et al 1983].



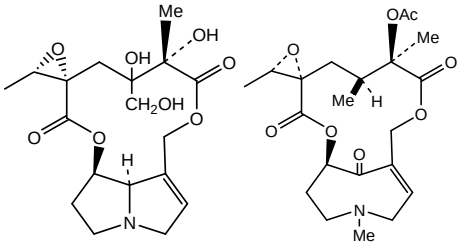
66 R^1 = OH; R^2 =

3.17. Senecio gallicus

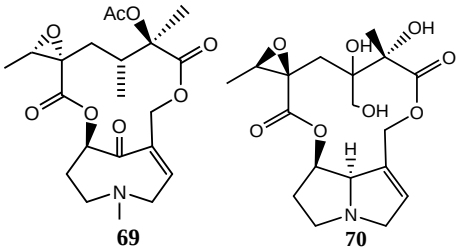
Alkaloids namely ligularlzine, senkirkine and seneclonine-N-oxide [J. D. Urones et al1988], flavonoids [R. M. A et al 1981] acetophenones and terpenoids [P. Teresa et al 1988].

3.18. Senecio adonidlfolius

Polyphenols [S. Ferry et al 1977], alkaloids [S. Ferry et al 1976], 12,13,19-trihydroxy-15,20-epoxy-15,20-dlhydro [12S,15R,20R] senecionan-11,16-dione,[67] 4,8-secosenecionane[J. D. Urones et al 1988], florosenine,[69] 12,13,19-trihydroxy-15,20-epoxy-15,20-dihydro-[12S,1SR,20R]-senecionan-11,16-dione[70] [E. Roeder, et al 1990b], adonifoline[71] [L. Witte et al 1992].



67 68



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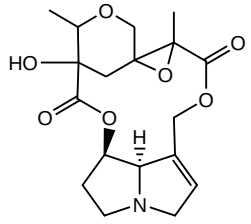
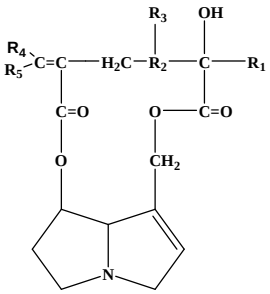


71

3.19. Senecio Longilobus

Senecionine,[72] integerrimine, seneciphylline [C. A. Ray, et al 1987], retrorsine [R. Adams et al 1949], Riddelliine [H. J. Segall et al 1978].



	R_1	R_2	R_3	R_4	R_5
Senecionine	CH_3	CH	CH_3	H	CH_3
integerrine	CH_3	CH	CH_3	CH_3	H
seneciphylline	CH_3	–C‖	CH_2	H	CH_3
retrosine	CH_2OH	CH	CH_3	H	CH_3

72

3.20. Senecio glabellus

Senecionine[72] [R. Adams et al 1953], integerrimine[72] [C. A. Ray, et al 1987].

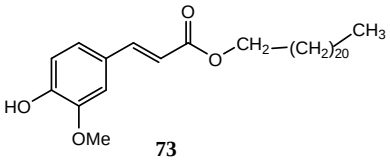
3.21. Senecio platyphylloides

Lactone [F. Bohlmann et al 1977].

3.22. Senecionelumbifolius

Ferulic acid, n-docosyl ester,[73] 2-isopropylidene-3-oxo-5-acetal-6-hydroxy-benzodihydrofuran,[74] 4-O-geranyl-

sinapyl alcohol,[75] 4-0-geranyl-sinapyl aldehyde,[76] linoleic acid 4-0-geranyl sinapyl ester[77] [Y. Zhao et al 1994].



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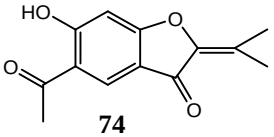

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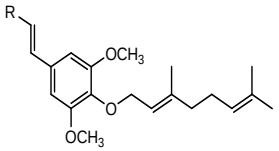
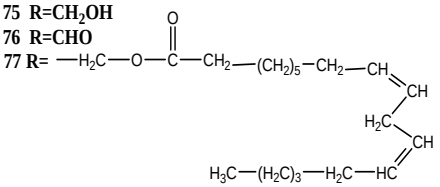
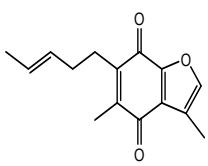


75 R=CH_2OH
76 R=CHO
77 R=



3.23. Senecio virgaureus

Benzofuranosesquiterpenes: 2-[3-pentenyl]-3,7-dimethylbenzofuran-1,4-dione,[78] l-hydroxy-2-[3-pentenyl]-3,7-dimethylbenzofuran,[79] l-methoxy-2-[3-pentenyl]-3,7-dimethylbenzofuran,[80] furanoeremophilanes[81,82] [Z. J. Jia et al 1991].



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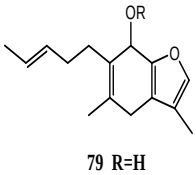
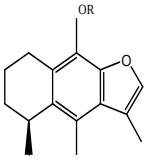


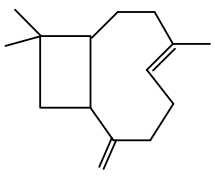
79 R=H
80 R=Me



81 R=H
82 R=Me

3.24. Senecio bonariensis

Pyrrolizidinealkaloids [J. A. Paiva, et al 2004], sesquiterpenoides-β-caryophyllene,[83] β-caryophyllene oxide,[84] germacrene D[85][C. M. Silva et al 2010].



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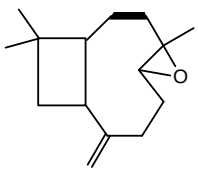

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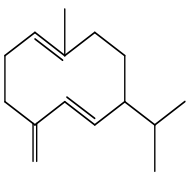

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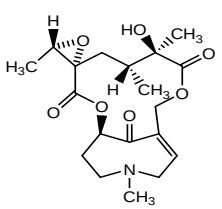
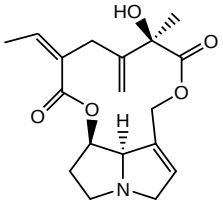
3.25. Senecio lorenthii

Otosenine[86] [M. Noorwalaa, et al 2000], seneciphylline[87][R. J. Molyneux, et al 1982].



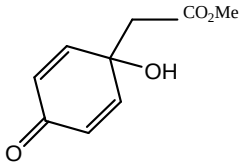
86



87

3.26. Senecio minutes

Friedelin [J. D. P. Teresa,et al 1980], 3-epifriedelinol [J. D. P. Teresa et al 1979], fatty acids: lauric; myristic; palmitic; and Stearic, faradiol, maniladiol [P. Torres et al 1992], arnidiol [J. S. Pyrek et al 1973], jacaranone,[88] methyl-1-hydroxy-2,6-dimethoxy-4-oxocyclohexanacetate[89] [P. Torresb, et al 2000].



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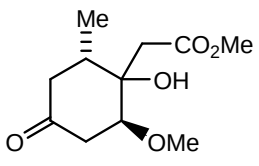

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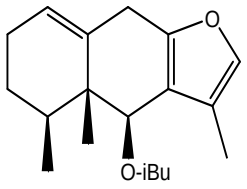
3.27. Senecio boissieri

Isohumulene[F. Bohlmann, et al 1974],lupeol [G. Ourisson et al 1962, E. Wenkert,et al 1978], lupanone [A. Chaterjee et al 1966,M. Reina,et al 2002], 3-epifriedelinol [J. D. P. Teresa et 1979], 6β-isobutyryloxy-1[10]-furanoeremophilene,[90] 6β-isobutyryloxy-1-oxo-10α-furanoeremophilene[91] [P. Torres, et al 1998], triterpenoids [P. Torresb, et al 2000].



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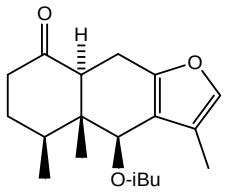

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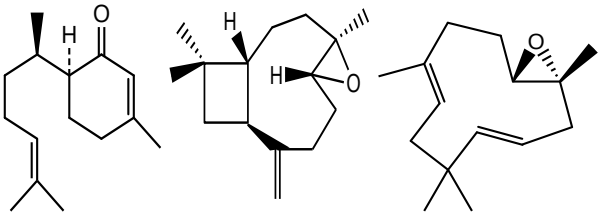
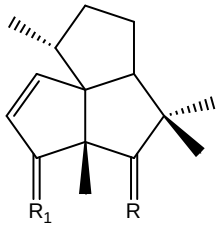
3.28. Senecio palmensis

Sesquiterpenes,[6S]-2,10-Bisaboladien-1-one,[92] 6,7-Epoxy-3[15]-caryophyllene,[93] 6,7-Epoxy-2,9-humuladiene,[94] 5α-angeloyloxysilphinen-3-one,[95] 5α-senecioyloxysilphinen-3-one,[96] 5α-acetoxysilfinen-3-one,[97] 5α-tigloyloxysilphinen-3-one,[98] 3β-hydroxy-5α-angeloyloxysilphinene,[99] silphinen-3,5-dione,[100] 5α-hydroxysilphinen-3-one,[101] 5β-hydroxysilphinen-3-one,[102] 5β-acetoxysilphinen-3-one,[103] 5β-isobutyryloxysilphinen-3-one,[104] 5α-isobutyryloxysilphinen-3-one [M. Reina, et al 2002].



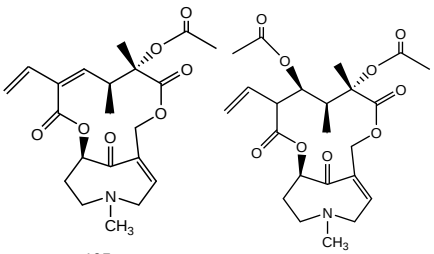
92 93 94

95 R=Oang R_1= O
96 R=Osen R_1= O
97 R=OAc R_1= O
98 R=Otig R_1= O
99 R=Oang R_1= OH
100 R=R_1=O
101 R=OH R_1= O
102 R=OH R_1= O
103 R=OAc R_1= O
104 R=Oisobut R_1= O



3.29. Senecio. kaempferi

Two hepatotoxic otonecine-type pyrrolizidine alkaloids-Clivorine[105] and ligularine,[106] [G. Lin, et al 2000].



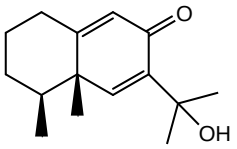
105 106

3.30. Senecio brasiliensis populations

N-oxide pyrrolizidine-alkaloids [G. Schmeda, et al 1987].

3.31. Senecio desfontaznez

Eremophilanes, furoeremophilanes and pyrrolizidines, 11-hydroxyeremophil 6[7], 9[10]-dien-8-one[107] [A. A. Ahmed et al 1991].



107

3.32. Senecio pandurifolius

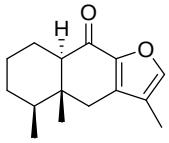
Essential oils: α-cuprenene, borneol, β-eudesmol, 1-undecene, [E]-caryophyllene, nonadecane, hexadecane, α-zingiberene, borneol, 1-undecene, E-γ-bisabolene bicyclogermacrene dehydroaromadendrene,γ-curcumene, undecane, α-zingiberene, [E,E]-α-farnesene, [E]-caryophyllene, 6-methoxy-2-[1-buten-3-yl]-naphthalene, β-eudesmol, α-Longipinene, silphiperfol-6-ene, β-elemene, β-curcumene, docosane,tricosane, pentacosane, benzene acetaldehyde and decanal [N. Kahriman et al 2011].

3.33. Senecio tenuifolius

3-methyl-6,7-dihydrobenzofuran-4[5H]-one, methyl ester hydroquinone and 1,2- benzenedicarbocylic acid [M. Manubolu, et al 2013].

3.34. Senecio filaginoides var. filaginoides

10H-9-oxofuranoeremophilane[108] [L. Arancibia et al 2013].



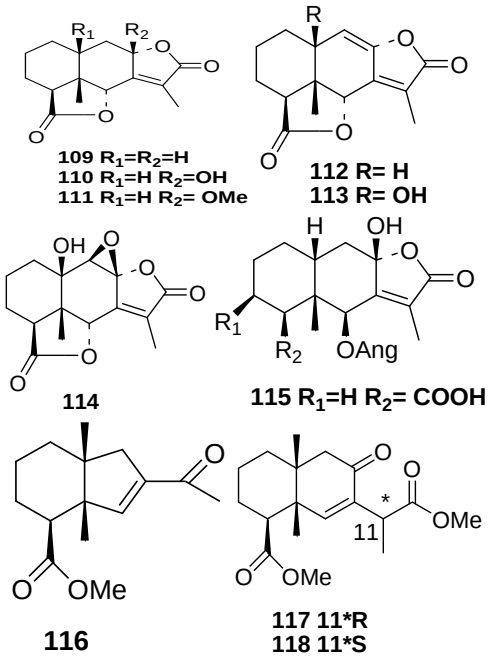
108

3.35. Senecio delphinifolius

Flavonoids, terpenes, alkaloids and saponins [Zellagui, et al 2004, Z. Amarl, et al 2012].

3.36 Senecio przewalskii

8β-Methoxyermophil-7[11]-en-6α,l5,8α,12-diolide,[111] eremophil-8[9]7,[11]-dien-6α15;8,12-diolide,[112] 10β-hydroxyeremophil-8[9]7[11]-dien-6α,15;8,12-diolide,[113] 10β-hydroxy-8β,9β-epoxyermophil-7[11]-en-6α,15;8α,12-diolide,[114] 8β-hydroxy-6β-angeloyloxyertnzophil -7-[11]-en-8α,12-olide-15-oic acid,[115] 2-acetyl-3α,β-methyl-3α,4,5,6,7,7a-hexahydroinden-4β-carboxylic methyl ester,[116] 11[RS]-8-oxoeremophil-6[7]-en-dimethyl-12,15-dioate,[117,118] 2-acetyl-5,6-dimethoxybenzofuran,2-propenyl-5-acetyl-7-hydroxy-2,3-dihydroxybenzofuran,5-acetyl-7-methoxybenzofuran, and 1,3-dimethoxy-4,6,1 l-trimethylnaphthofuran [Y. Zhao et al 1995, Z. J. Jia et al 1994].



109 R_1=R_2=H
110 R_1=H R_2=OH
111 R_1=H R_2= OMe

112 R= H
113 R= OH

114

115 R_1=H R_2= COOH

116

117 11*R
118 11*S

3.37. Senecio faurie

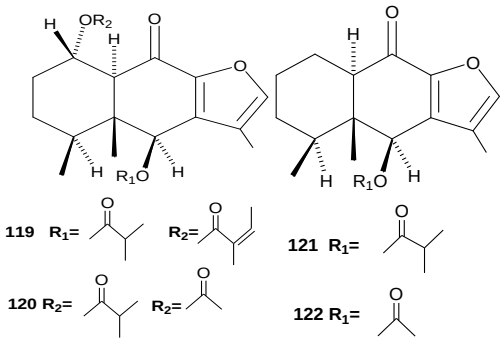
Eremophilanodiolides,[109,110] [Y. Moriyama et al 1976].

3.38. Senecio graveolens

Essential oils, hydrocarbons [α-pinene, α-phellandrene, α-terpinene, p-cymene, sabinene, γ-terpinene, 1-methyl-4-isopropenylbenzene and terpinolene] also alcohols [terpinen-4-ol, α-eudesmol and β-eudesmol], ketones [acetone and piperitenone] and an aldehyde [isovaleraldehyde] [C. Perez, et al 1999].

3.39. Senecio patagonicus

lα-angeloxy-6β-isobutyroxy-9-oxo-l0αH-furanoeremophilane[119] lα-acetoxy-6β-isobutyroxy-9-oxo- l0αH-furanoeremophilane,[120] 6β-isobutyroxy-9-oxo-10αH furanoeremophilane[121] 6β-acetoxy-9-oxo-l0αH furanoeremophilane[122] [L. Villarroel et al 1987,L. Villarroel et al 1991].

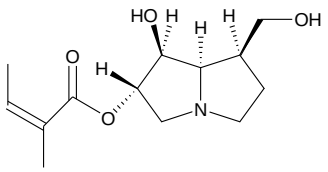


3.40. Senecio chilensis

lα-angeloxy-6β-isobutyroxy-9-oxo-l0αH-furanoeremophilane,[119] lα-acetoxy-6β-isobutyroxy-9-oxo-l0αH-furanoeremophilane,[120] 6β-isobutyroxy-9-oxo-10αH-furanoeremophilane[121] [L. Villarroel et al 1991].

3.41. Senecio nemorensis

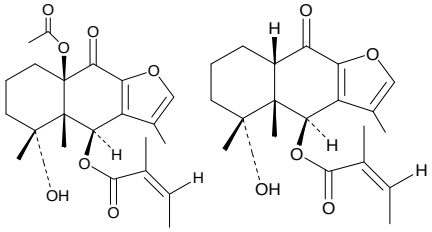
6α-Angeloylplatynecine[123] [V. Christov et al 2005], 7-angeloylplatynecine, neosarracine [L. Witte et al 1993], 9-angeloylplatynecine, sarracine [V.Christov et al 1997], mono- and open-chain diester platynecine and retronecine[T. Hartmann et al 1997].



123

3.42. Senecio fistulosus

Furanoeremophilanes- 4α-hydroxy-6β-angeloxy- 10β-acetoxy-9-oxofuranoeremophilane[124] 4α-hydroxy-6β-angeloxy-9-oxofuranoeremophilane[125] [L. Villarroel et al 1985].



124 125

3.43. Senecio vira-vira

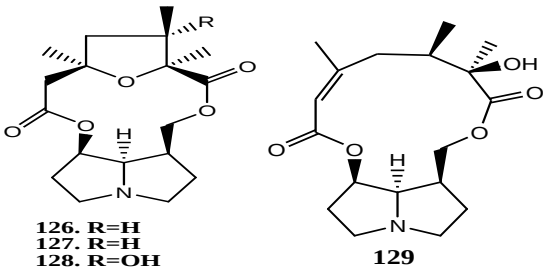
Quercetin 3-0-α-chamnopycanoside, quercetin 3-0-β-rutinoside [T. J. Mabry, et al 1970, K. R. Markham,et al 1978], isorhamnetin 3-0-β-robinobioside [C. A. Buxhi et al 1982], anacrotine [1C. K. Atal, et al 1966], neoplatyphylline [C. C. J. Culvenor et al 1968], uspallatine [M. J. Pestchanker, et al 1985], sitosterol, campesterol, stigmasterol, α- and β-arnyrins, stigmasta-3,5dien-7-one, and stigmasta4,6-dien-3-one [E. Jares et al 1986].

3.45. Senecio brasiliensis

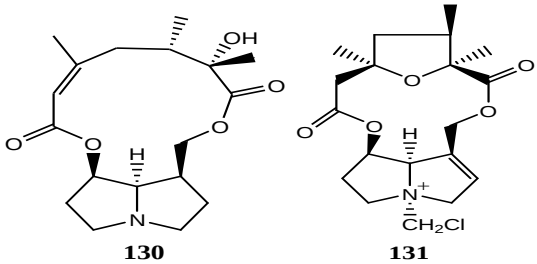
Pyrrrolizidinealkaloids- Integerrimine and retrorsine [G. Schmeda, et al 1987].

3.46. Senecio bracteatus

Pyrrolizidine alkaloid-iodanthine,[130] retroisosenine,[126] chloromethylretroisosenine chloride[131] [A. L. Perez-Castorena et al 1999], bulgarsenine[129] [P. Castorena, et al 1998], mulgediifoliine[127] [R. D. Vivar, et al 1995], [12S]-12-hydroxyretroisosenine[128] [P. Castorena, et al 1998].



126. R=H
127. R=H
128. R=OH
129



130 131

3.47. Senecio iodanthus

Pyrrolizidine alkaloid-iodanthine,[130] retroisosenine[126] [A. L. Perez-Castorena et al 1999], bulgarsenine[129] [P. Castorena, et al 1998].mulgediifoliine[127][R. D. Vivar, et al 1995],].

3.48. Senecio trapezuntinus

[E]-β-farnesene [O. Uçuncu, et al 2008].

3.49. Senecio vernalis
Spathulenol, 1,8-cineole, m-cymene, isobicyclogermacrenal and α-phellandrene, [D. Nori-Shargh, et al 2008]. β-pinene and α-pinene, Δ-3-carene, germacrene D,Z-β-ocimene, and α-humulene [A. Usta, et al 2009].

3.50. Senecio platyphyllus var. platyphyllus
E-caryophyllene, germacrene D and E-β-farnesene [A. Usta, et al 2009].

3.51. Senecio glaucus subsp. Coronopifloius
Myrcene and dehydrofukinone [H. L. D. Pooter, et al 2006].

3.52. Senecio leucostachys
Sabinene, α-phellandrene, germacrene D and β-caryophyllene [R. R. Vera et al 1994 ,N. Mengi, et al 1995, A. M. El-Shazly et al 1999, V. T. Balzaretti, et al 2000, M. Mirza et al 2008, A. G. Belaunde et al 2007, G. F. Zuniga et al 1996].

3.53. Senecio squalidus
P-cymene and α-phellandrene [J. C. Chalchat, et al 2004].

3.54. Senecio aegyptius var. discoideus
1,10-epoxyfuranoeremophilane [E.Burgueno-Tapia et al 2004].

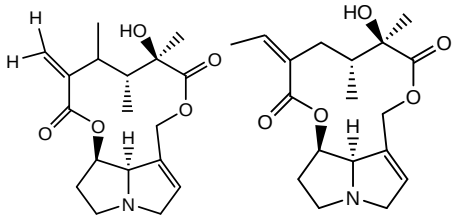
3.55. Senecio graveolens
α-Terpinene, p-cymene, terpinen-4-ol, and α-phellandrene [C. Perez, et al 1999], p-hydroxyacetophenone [L. A. Loyola et al 1985].

3.56. Senecio farfarifolius
α-Pineneand 1, 8-cineole [K. H. C. Baser et al 2004].

3.57. Senecio nutans
Oxygenated monoterpene hydrocarbons predominate [V. D. Feo, et al 2003].

3.58. Senecio longipenicillatus
α-pinene, α-humulene and germacrene D [M. Rondon et al 2006].

3.59. Senecio madagascariensis
Senecivernine,[132] senecionine,[133] integerrimine,[134] senkirkine,[135] mucronatinine,[136] retrorsine,[137] usaramine,[138] otosenine,[139] acetylsenkirkine[140] desacetyldoronine[141] florosenine,[142] doronine[143] [D. R. Gardner,et al 2006], [14-isovaleryloxy-1,2-dehydrocacalol methyl ether,[144] [E. B. Tapia et al 2007, E. Burgueno- Tapia, et al 2001].



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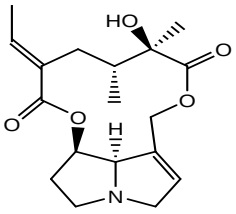

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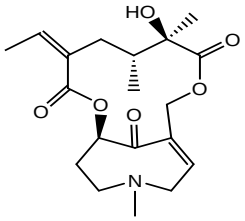

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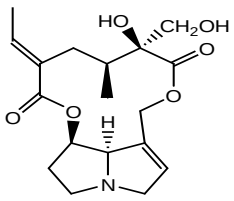

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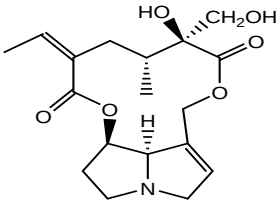

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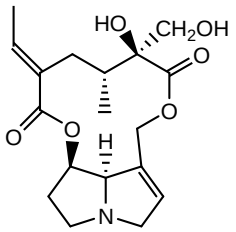

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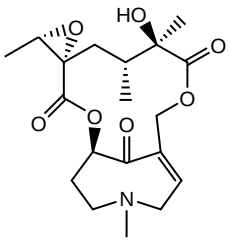

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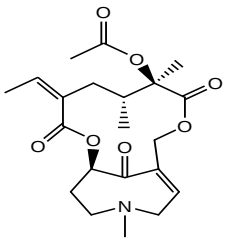

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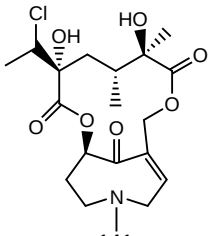

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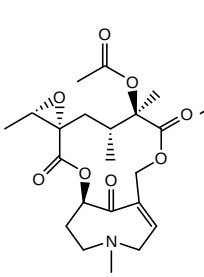

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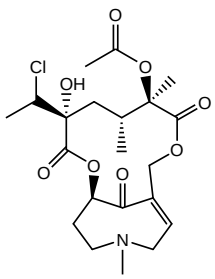

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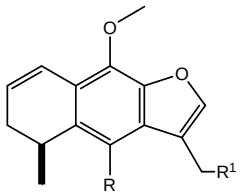
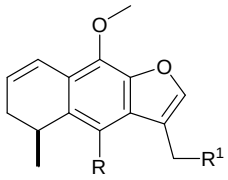


144 R=CH_2O-*i*Val R^1=H

3.60. Senecio barba-johannis

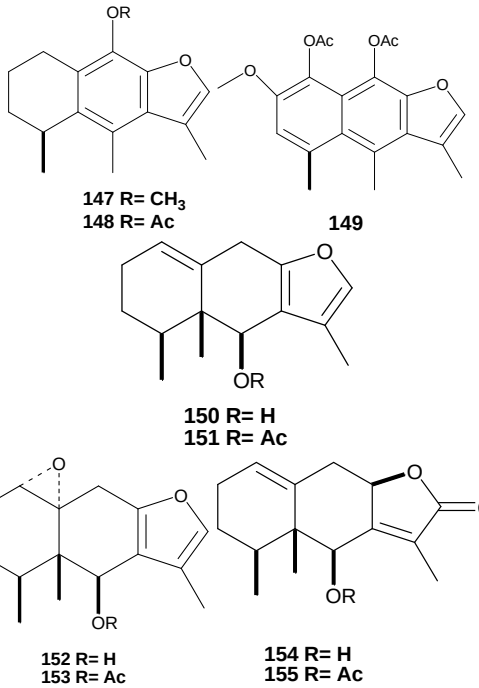
13-hydroxy-14-oxocacalohastine,[145] 13-acetyloxy-14-oxocacalohastine,[146] [E. Burgueno- Tapia,et al 2004,E. Burgueno- Tapia,et al 2006].



145 R= CH=O R^1= OH
146 R= CH=O R^1= OAc

3.61. Senecio toluccanus

Cacalol methyl ether,[147] cacalol acetate,[148] 1-acetyloxy-2-methyloxy-1,2,3,4-tetradehydrocacalol acetate,[149] 6-hydroxyeuryopsin,[150] 6-acetyloxyeuryopsin,[151] 1[10]-epoxy-6-hydroxyeuryopsin,[152] 6-acetyloxy-1[10]-epoxyeuryopsin,[153] toluccanolide A,[154] toluccanolide A acetate,[155] [E. Burgueno- Tapia,et al 2004,E. Burgueno- Tapia,et al 2006]



147 R= CH_3
148 R= Ac

149

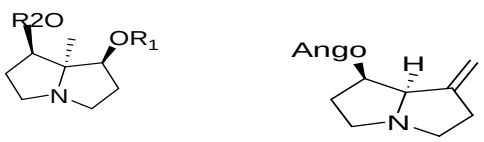
150 R= H
151 R= Ac

152 R= H
153 R= Ac

154 R= H
155 R= Ac

3.62. Senecio doratophyllus

Sarracine,[156] Neosarracine,[157] 7b-[Angeloyloxy]-1-methylidene-8a-pyrrolizidine[158] [A.-L. Pe´rez-Castorena, et al 1999].

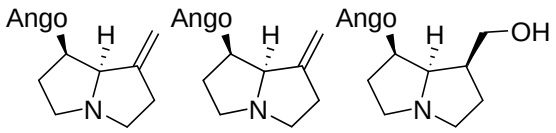


	R1	R2
156	Sarr	Ang
157	5-OH-Tigl	Ang

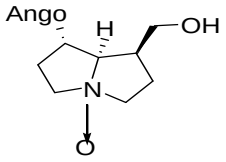
158

3.63. Senecio.chrysocoma

7b-[Angeloyloxy]-1-methylidene-8a-pyrrolizidine[159][A.-L. Pe´rez-Castorena,et al 1999], 7a-[Angeloyloxy]-1-methylidene-8a-pyrrolizidine[160] [J. R. Liddell,et al 1993], 7-[Angeloyloxy]platynecine[161][M. R. Grue et al 1993],7a-[Angeloyloxy]-1-methylidene-8a-pyrrolizidine N-oxide[162][J. R. Liddell, et al 1993].



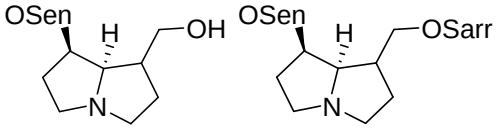
159 160 161



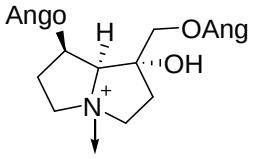
162

3.64. Senecio.cacaliaste

7-[Senecioyloxy]retronecine,[163] 9-[Sarracinoyloxy]-7-[senecioyloxy]-retronecine,[164] 7,9-Bis[angeloyloxy]-1a-hydroxy-Nmethylplatynecinium Chloride[165][E. Roeder, et al 1984].



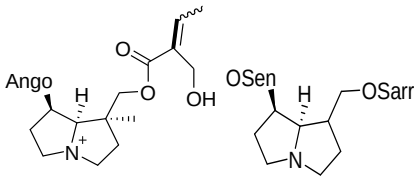
163 164



165

3.65. Senecio.kaschkarovii

Triangularine,[166] Neotriangularine,[167] 9-[Sarracinoyloxy]-7-[senecioyloxy]-retronecine[168][D.-L. Cheng, et al 1992].

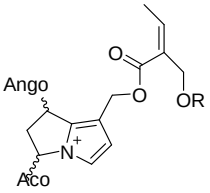


166 (E)
167 (Z)

168

3.66. Senecio.mikanoides

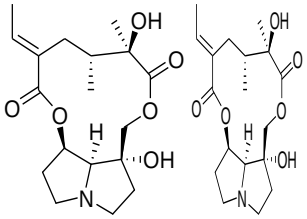
Senampelin E,[169] Senampelin F,[170] Senampelin G[171][F. Bohlmann et al 1979].



169 R =Tigl
170 R =Sen
171 R =Ang

3.67. Senecio.hadiensis

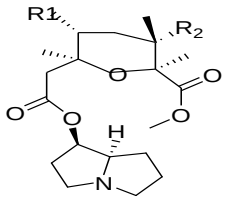
Hadiensine,[172] 12-O-Acetylhadiensine[173] 12-O-Acetylhadiensine N-oxide,[174] Hadiensine N-oxide,[175] Neorosmarinine[176][O. Were, et al 1993].



	R	X
172	H	-
173	Ac	-
174	Ac	O
175	H	O

3.68. Senecio.roseus

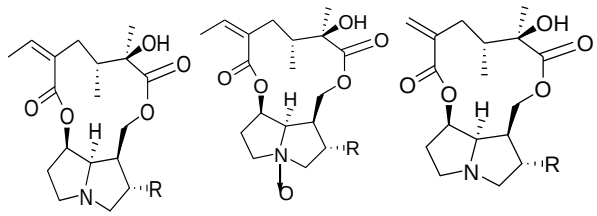
Retroisosenine,[177] Mulgediifoliine,[178] [12S]-Hydroxyretroisosenine,[179] [13R]-Hydroxyretroisosenine[180][A.-L. Pe´rez-Castorena et al 1997].



	R1	R2
177	H	H
178	H	H
179	H	OH
180	OH	H

3.69. Senecio.syringifolius

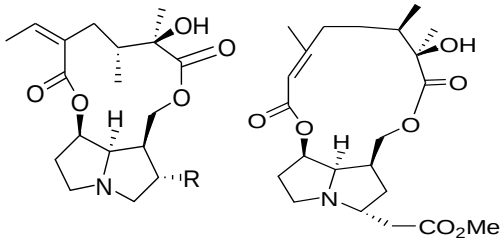
Rosmarinine[181][H. L. DeWaal, et al 1940], Rosmarinine N-oxide[182] Neoangularine[183][O. Were et al 1993].



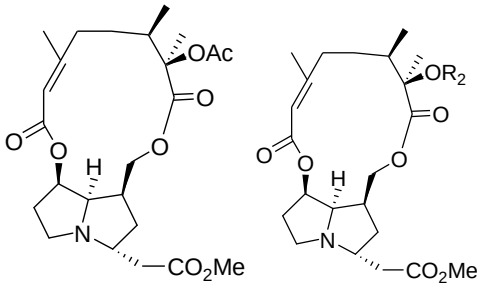
181 R= OH 182 R= OH 183

3.70. Senecio.callosus

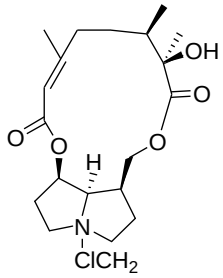
Rosmarinine,[184] Bulgarsenine,[185] Callosine. 11-O-Acetylbulgarsenine[186][A. RomoDeVivaretal1996]. [11OAcetylbulgarsenineNoxide. N [Chloromethyl] bulgarsenine,[187] N[Chloromethyl]bulgarsenine[188][A.-L. Pe´rez-Castorena, et al 1998].



184 R= OH 185



186 187



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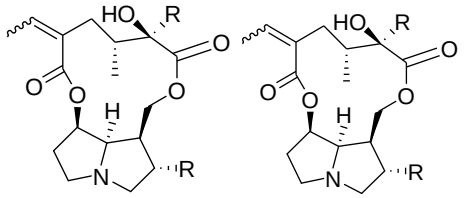
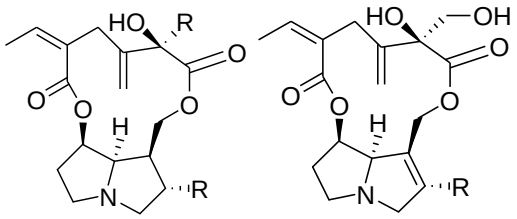
3.71. Senecio. oxiphyllus

Retrorsine,[189] Usaramine,[190] Seneciphylline,[191] Riddelliine[192][H. C. Krebs,et al 1996].



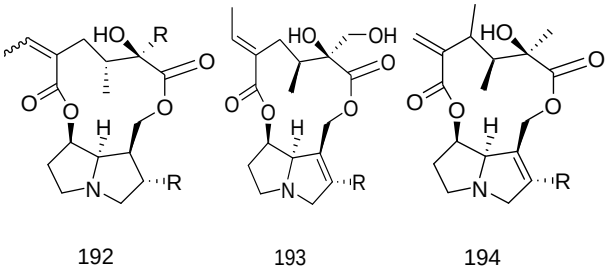
189 190



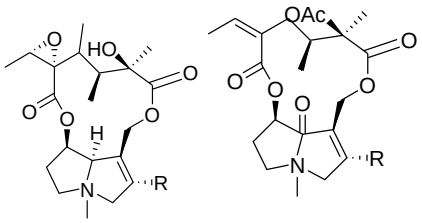
191 192

3.72. Senecio. Madagascariensis

Usaramine,[192] Mucronatinine,[193] Senecivernine,[194] Otosenine.[195] Acetylsenkirkine,[196] Desacetyldoronine,[197] Florosenine,[198] Doronine[199][D. R. Gardner, et al 2006].



192 193 194



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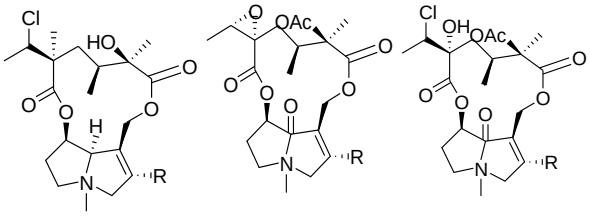
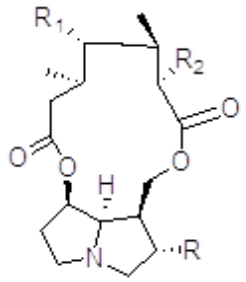


197 198 199

3.73. Senecio. Bracteatus

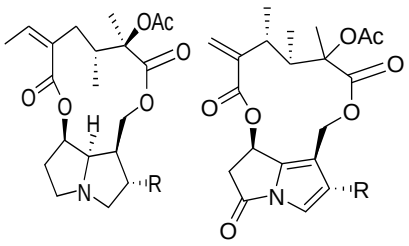
Retroisosenine[200] [A.-L. Pe´rez-Castorena,et al 1999], Mulgediifoliine,[201] [12S]-Hydroxyretroisosenine[202][A. R. D. Vivar et al 1995].



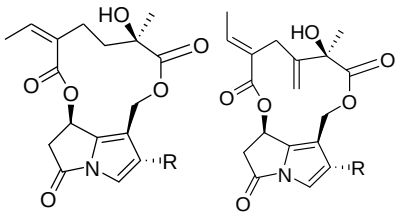
	R1	R2
200	H	H
201	H	H
202	H	OH

3.74. Senecio. pterophorus

Acetylseneciphylline[203][J. R. Liddell, et al 1993], Pterophorin[204][F. Bohlmann,et al 1977], Seneciphylline,[205] Spartioidine[206][J. R. Liddell, et al 1993].



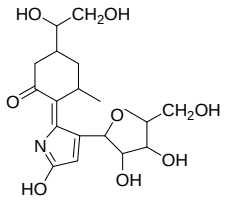
203 204



205 206

3.75. Senecio.cannabifolius

Cannabiloid B[207][B. Wu, W et al 2006].



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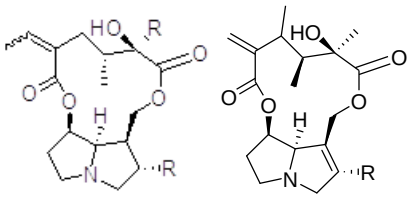
3.76. Senecio.gilliesiano

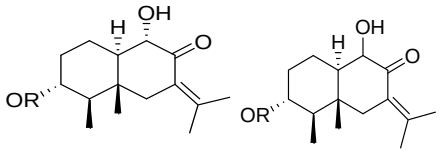
Retrorsine,[208] Senecionine[209][F. H. Guidugli et al 1986].



208 209

3.77. Senecio lividus

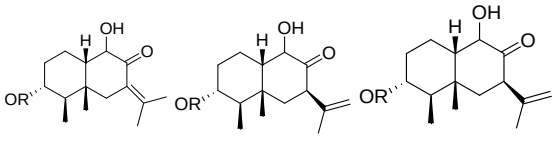
3a-[4'-[Angeloyloxy]angeloyloxy]-9a-hydroxy-10aHeremophil- 7[11]-en-8-one,[210] 3a-[5'[Angeloyloxy]angeloyloxy]-9a-hydroxy-10aHeremophil-7[11]-en-8-one,[211] 3a[4'[Angeloyloxy]angeloyloxy]9hydroxyeremophila7[11],9dien8one,[212] 3a[5'[Angeloyloxy]angeloyloxy]-9-hydroxyeremophila-7[11],9-dien-8-one[213][J. M. Cardoso et al 1987].



210 R = A 212 R = A
211 R = B 213 R = B

3.78. Senecio. Speciosus

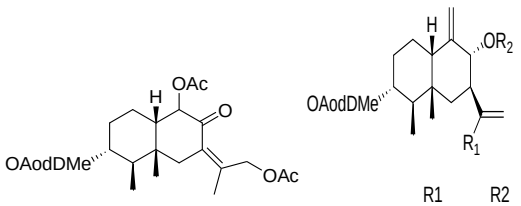
4'-[Angeloyloxy]isosenspeciosone,[214] 5'[Angeloyloxy]isosenspeciosone,[215] 5'[Angeloyloxy]8a,Odihydrosenspeciosone,[216] 5'[Angeloyloxy]senspeciosone,[217] 9b,13Diacetoxy8oxoisosenspeciosoltrieneester,[218] 8aHydroxy9oxosenspeciosol triene ester,[219] 8a,13-Diacetoxy-9-oxosenspeciosol triene ester[220][F. Bohlmann, et al 1978].



214 R = C
215 R = D

216 R = D

217 R = D

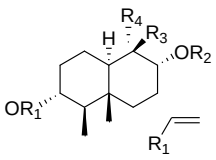


	R1	R2
219	H	H
220	Aco	Ac

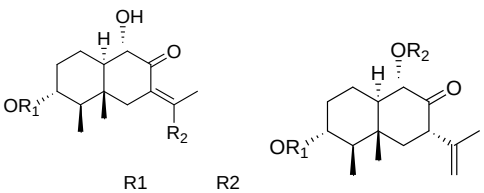
218

3.79. Senecio.erubescens var crepidifolius

3α-[{[2Z]-4-[[2Z]-Hex-2-enoyl}oxy]hex-2-enoyl}oxy]-7α,10aH-eremophil-11-ene-8a,9a-diol,[221] 3α-{[2Z]-4-[Angeloyloxy]-hex-2-enoyl]oxy}-7a,10aHeremophil-11-ene-8α,9a-diol,[222] 3a,9a-{[[2Z]-Dihex-2-enoyl]oxy}-7a,10aH-eremophil- 11-en-8a-ol,[223] 9,13-Dihydroxy-3a-{[[2E,4E,6E]-5-methyldodeca,[224] 2,4,6-trienoyl]oxy}-10aH-eremophil-7[11]-en-8-one,[225] 9a-Hydroxy-3a-{[[2E,4E,6E]-5-methyldodeca-2,4,6- trienoyl]oxy}-10aH-eremophil-7[11]-ene-8-one,[226] 3a-[[2Z]-4-{[[2Z]-Hex-2-enoyl]oxy}hex-2-enoyloxy]-9a-hydroxy-10aH-eremophil-7[11]-en-8-one9,[227] 3a-[[2Z]-4-{[[2Z]-Hex-2-enoyl]oxy}hex-2-enoyloxy]- 9a-hydroxy-7a,10aH-eremophil-11-en-8-one[228][F. Bohlmann,et al 1985].



	R1	R2	R3	R4
221	H	H	=	O
222	E	OH	H	OH
223	C	OH	H	OH
224	F	OH	H	FO

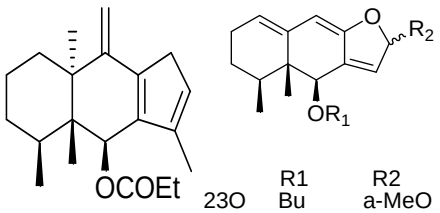


	R1	R2
225	MeDod	OH
226	MeDod	H
227	E	H

228

3.80. Senecio.pachyphyllos

6b-[Propionyloxy]-10aH-furanoeremophilan-9-one.[229] 8,12-Epoxy-6b-[isobutyryloxy]-12a-methoxyeremophila-1[10], 7[11],8-triene,[230] 8,12-Epoxy-6b-[isobutyryloxy]-12b-methoxyeremophila1[10], 7[11],8triene,[231] 8,12Epoxy12amethoxy6b[propionyloxy]eremophil-1[10],7[11],8-triene,[232] 8,12-Epoxy-12b-methoxy-6b-[propionyloxy]eremophila-1[10],7[11],8-triene[233][M. Ahmed,et al 1991].

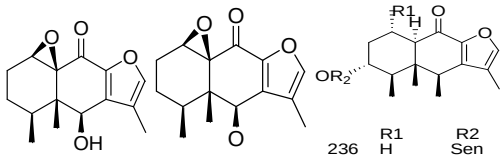


	R1	R2
23O	Bu	a-MeO
231	Bu	b-MeO
232	EtCO	a -MeO
233	EtCO	b - MeO

229

3.81. Seneciosmithii

1b,10b-Epoxy-6b-hydroxyfuranoeremophilan-9-one,[234] 1b,10b-Epoxyfuranoeremophilane-6,9-dione,[235] Euryopsonol senecioate,[236] 1a-Hydroxyeuryopsonol senecioate,[237] 1a-Hydroxyeuryopsonol angelate,[238] 1a-Hydroxyeuryopsonol isobutyrate[239][F. Bohlmann et al 1981].

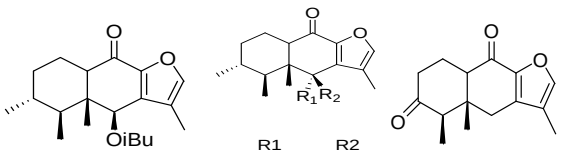


	R1	R2
236	H	Sen
237	OH	Sen
238	OH	Ang
239	OH	Bu

234 235

3.82. Senecio pseudoorientalis

6β-[Isobutyryloxy]furanoeremophil-1[10]-en-9-one,[240] 6α[Angeloyloxy]furanoeremophil-9-en-1-one,[241] 6βHydroxyfuranoeremophil9en1one,[242] 6β[Isobutyryloxy]furanoeremophil9-en-1-one,[243] 6α[Isobutyryloxy] furanoeremophil-9-en-1-one,[244] Furanoeremophil-1-en-3-one[245][F. Bohlmann,et al 1980].

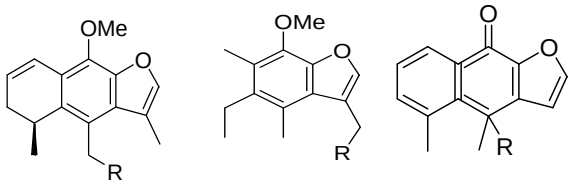


	R1	R2
241	AngO	H
242	H	OH
243	H	BuO
244	BuO	H

240 245

3.83. Senecio.canescens

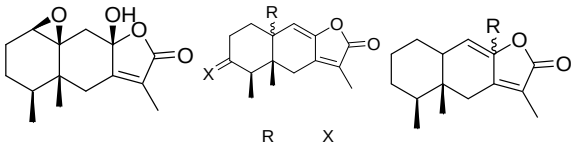
Cacalohastine,[246] 14-[Angeloyloxy]cacalohastine,[247] 3,4-Dehydrocacalohastine,[248] 13-Acetoxy-3,4-dehydrocacalohastine,[249] 3,4-Dehydro-13-hydroxycacalohastine,[250] Cacalonol,[251] Peroxycacalonol[252][S. Abdo,et al 1992].



246 R = H
247 R = AngO
248 R = H
249 R = AcO
250 R = OH
251 R = OH
252 R = OOH

3.84. Senecio.tsoongianus

Tsoongianolide F,[253] Tsoongianolide A,[254] Tsoongianolide B,[255] Tsoongianolide E,[256] Tsoongianolide C,[257] Tsoongianolide D[258][Y. Zhao,et al 2004].



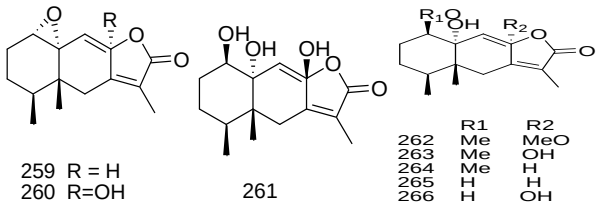
253

	R	X
254	a- OH	H2
255	b- OH	H2
256	b- OH	=O

257 R = b-OH
258 R = a-OH

3.85. Senecio.mairetianus

Mairetolide A,[259] Mairetolide B,[260] Mairetolide H,[261] Mairetolide C,[262] Mairetolide D,[263] Mairetolide E,[264] Mairetolide F,[265] Mairetolide G[266][A.-L. Pe´rez-Castorena, et al 2006].



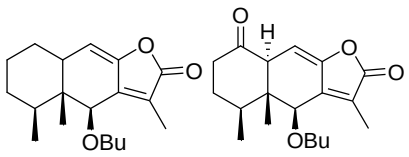
259 R = H
260 R=OH

261

	R1	R2
262	Me	MeO
263	Me	OH
264	Me	H
265	H	H
266	H	OH

3.86. Senecio.boissieri

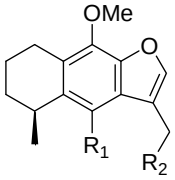
6β-[Isobutyryloxy] furanoeremophil-1[10]-ene,[267] 6β-[Isobutyryloxy]-10aH-furanoeremophilan-1-one[268][P. Torres et al 2000].



267 268

3.87. Senecio. picardae

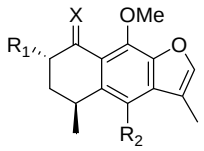
13-Acetoxycacalol methyl ether,[269] 14-Oxocacalol methyl ether,[270] 13-Acetoxy-14-oxocacalol methyl ether,[271] 13-Acetoxy-14-[angeloyloxy]cacalol methyl ether[272][F. Bohlmann,et al 1990].



	R1	R2
269	Me	AcO
270	CHO	H
271	CHO	AcO
272	AngOCH2	AcO

3.88. Senecio.fuertesii

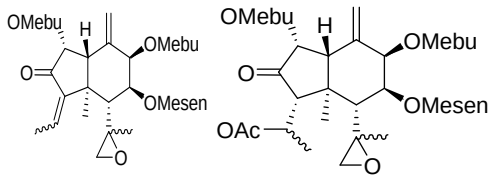
1-Oxocacalol methyl ether,[273] 1,14-Dioxocacalol methyl ether,[274] 2-Acetoxycacalol methyl ether[275][F. Bohlmann,et al 1990].



	R1	R2	X
273	H	Me	O
274	H	CHO	O
275	AcO	Me	H2

3.89. Senecio.implexus

[3Z]-Implexin,[276] [3E]-Implexin,[277] 14-Acetoxy-3,14-dihydroimplexin[278][F. Bohlmann,et al 1981].

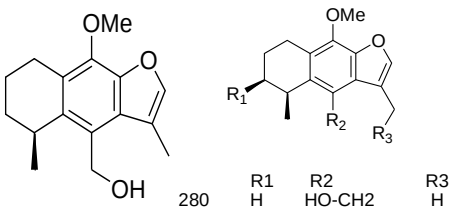


276 3Z
277 3E

278

3.90. Senecio.othonnae

14-Hydroxycacalol methyl ether,[279] 1,2-Dehydro-14-hydroxycacalol methyl ether,[280] 14-[Angeloyloxy]-1,2-dehydrocacalol methyl ether,[281] 14-[Angeloyloxy]-1,2-dehydro-3b-hydroxycacalolmethyl ether,[282] 14-[Angeloyloxy]-1,2-dehydro-3b,13-dihydroxycacalolmethyl ether[283][F. Bohlmann,et al 1977].

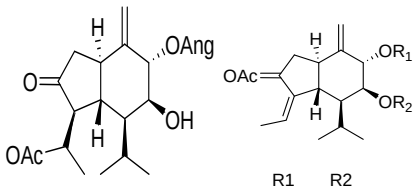


279

	R1	R2	R3
280	H	HO-CH2	H
281	H	AngOCH2	H
282	OH	AngOCH2	H
283	OH	AngOCH2	OH

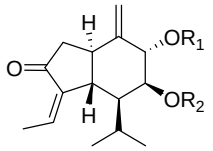
3.91. Senecio.yugua

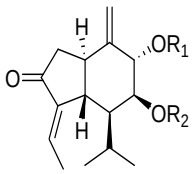
14-Acetoxy-7α-[angeloyloxy]-6β-hydroxyoplop-8[10]-en-2-one,[284] [3Z]-2β-Acetoxy-7α-[angeloyloxy]-6β-hydroxyoplopa-3[14]-8[10]-diene,[285] [3Z]-2β-Acetoxy-6β-[angeloyloxy]-7αhydroxyoplopa3[14],8[10] diene,[286] [3Z]2βAcetoxy6bhydroxy7a[[4methylsenecioyl]oxy]oplopa-3[14],8[10]-diene,[287] [3Z]-2β-Acetoxy-6β,7αdihydroxyoplopa-3[14],8[10]-diene,[288] [3Z]-6β-Hydroxy-7α-[[4-methylsenecioyl]oxy]oplopa-3[14],8[10]-dien-2-one,[289] [3Z]-6β-Hydroxy-7α-[senecioyloxy]oplopa-3[14],8[10]- dien-2-one,[290] [3Z]-7α-[Angeloyloxy]-6β-hydroxyoplopa-3[14],8[10]-dien-2-one,[291] [3Z]-6β-[Angeloyloxy]-7α-hydroxyoplopa-3[14],8[10]-dien-2-one,[292] [3E]-7α-[Angeloyloxy]-6β-hydroxyoplopa-3[14],8[10]-dien-2-one,[293] [3E]-6β-[Angeloyloxy]-7α-hydroxyoplopa-3[14],8[10]-dien-2-one[294][M. A. Aal,et al 1988].



	R1	R2
285	Ang	H
286	H	Ang
287	Mesen	H
288	H	H

284





	R1	R2
289	Mesen	H
290	Sen	H
291	Ang	H
292	H	Ang

	R1	R2
293	Ang	H
294	H	Ang

4. Biological Activities.

Various biological activities reported from the plants of the genus Senecio.

4.1. Antibacterial and Antifungal Activities. In the folk medicine, Senecio species were used for the treatment of wounds and as antiemetic, anti-inflammatory, and vasodilatory preparations. More recently, antibacterial and antifungal activities of extracts and compounds isolated from Senecio species were reported. The MeOH extract of S. vulgaris showed antimicrobial activity against the Gram-positive bacteria Bacillus subtilis [minimal-inhibitory concentration [MIC] 0.5 mg/ml] and Staphylococcus aureus [MIC 0.125 mg/ml]. The MeOH extracts from both S. inaequidens and S. vulgaris showed low activity against dermatophytes. The hexane extract of S. vulgaris showed significant activity against Trichophyton tonsurans [MIC 0.031 mg/ml] **[**M. R. Loizzo, et al 2004**].** Although their activities were less potent than those ofchloramphenicol, Cannabiloid B and CannabisideB S.Cannabiside C Cannabilactone A isolated from S. cannabifolius, showedantibacterial activities against the Gram-positive bacteria S. aureus and B. subtilis, butnot against Gram-negative bacteria **[**B. Wu, W.et al 2006**].** Assessed by the agar-well diffusion method, the isolated essential oil of S.graveolens showed antimicrobial activity against Micrococcus luteus ATCC 9341, oxacillin-sensitive and oxacillin-resistant S. aureus, as well as antifungal effects againstclinically isolated Candida albicans. The MIC values for M. luteus, oxacillin-sensitive S.aureus, and C. albicans were 8.73, 10.91, and 2.13_10_2 mg/ml, respectively. Theantimicrobial activity related to known antibiotics was calculated. These results werecompatible with a potential concentration-dependent selectivity of the antifungal effectof S. graveolens essential oil Moreover, the minimal bactericidal concentration [MBC] was above 87.3 mg/ml. Thus, the MBC/MIC ratio was clearly higher than 1 [above 8],indicating a bacteriostatic effect of the essential oil **[**C. Perez,et al 1999**].**The aerial parts of S. aegyptius var. discoideus afforded six new eremophilanederivatives, 8a-Methoxy-1-oxo-10aH-eremophil-7[11]-ene-12,8-lactam and 1b-Hydroxy-8aH-eremophil-7[11],9-dien-12,8-olide 1b,8a-Dihydroxyeremophil-7[11],9-dien-12,8-olide 1b-Hydroxy-8a-methoxyeremophil-7[11],9-dien-12,8-olid1b,10b-Epoxy-8a-hydroxyeremophil-7[11]-en-12,8-olid250 1b,10b-Epoxy-8a-methoxyeremophil-7[11]-en12,8- Olide The antibacterial activities of these compounds weretested against two microorganisms, a Gram-positive [Bacillus cereus] and a Gramnegative bacterium [Serratia sp.], at concentrations of 200 and 400 mg/ml. The growthof both microorganisms was inhibited by compounds 1b-Hydroxy-8aH-eremophil-7[11], 9-dien-12,8-olide 1b,8a-Dihydroxyeremophil-7[11],9-dien-12,8-olide1b-Hydroxy-8a-methoxyeremophil-7[11], 9-dien-12,8-olid1b,10b-Epoxy-8 ahydroxy eremophil-7[11]-en-12,8-olid2501b,10b-Epoxy-8a-methoxyeremophil-7[11]-en-12,8-Olide inhibited the growth of B. cereus, but had no effect on the growth of Serratia sp. [E. H. H.et al 2005].

4.2. Antitubercular Activity. S. chionophilus is a small, woody shrub growing in theMountains in South America, above 1500 m. Infusions of its aerial parts androots are traditionally used in Chile for treating heavy colds and runny noses. Allcompounds isolated from this species were evaluated for their antitubercular potentialagainst Mycobacterium tuberculosis, in a microplate Alamar Blue assay. Compounds1a-Hydroxy-6b-[[2-methylbutyryl] oxy]-10aH-furanoeremophilan-9-one, 6b-[Angeloyloxy]-1a-hydroxy-10aH-furanoeremophilan-9-one and 4-Hydroxyacetophenone exhibited mild antitubercular activity, with MIC values of 119, 114 and 121 mg/ml, respectively. This is the first evidence that sesquiterpenoids of thefuranoeremophilane type may be considered as potential antitubercular leads. Inaddition, the comparison of the antitubercular activities of betulinic, oleanolic, andursolic acids, with MICs of 32, 64, and 32 mg/ml, respectively, with those of inactiveanalogues indicated that the presence of a COO group in a polycyclic triterpeneskeleton appears to be

necessary for the observed activity against M. tuberculosis [J.-Q. Gu,et al 2004].

4.3. Anti-Inflammatory Effects. To investigate the anti-inflammatory effect of thetotal flavonoids of S. scandens, various inflammatory models, including the swelling ofear induced by xylene in mice, the permeability increase of blood capillary by aceticacid in mice, and the cotton-pellet granuloma in mice, were used. In addition, air-sacmodels of synovitis in mice were set up and the amount of white blood cells [WBCs] and the content of prostaglandin E2 [PGE2] were measured in the inflammatoryexudate. The total flavonoids had significant inhibitory action on auris swell induced byxylene in mice and the penetration of capillary vessels in mice. The flavonoids also significantly decreased the proliferation of granuloma caused by implantation of cottonpellets in mice. The amount of WBCs and the content of PGE2 in the experimentalgroups were obviously lower than those in the control groups. The total flavonoids showed significant anti-inflammatory activity, which is relevant to the inhibition of theproduction and release of the inflammatory factor PGE2 [W. P. Zhang et al 2008].

4.4. Antiulcer Activity. The leaves and inflorescences of S. brasiliensis are utilized inthe traditional medicine for the treatment of inflammatory processes as a bloodregulator. Moreover, this plant is also used in the folk medicine to relieve stomach pain.The crude alkaloid extract of S. brasiliensis inflorescences, containing a mixture of the PasIntegerrimine, Senecionine Retrorsine, Usaramine, and Seneciphylline, was evaluated for preventive antiulcer effects onstandardrodent models of induced gastric and duodenal ulcers. In the HCl/EtOH-, indomethacin/bethanechol-, and hypothermic restraint-induced gastric ulcers, the lesion wassignificantly inhibited [$p<0.001$] by the PAs [po]. In the pylorus-ligature, PAs [id] significantly increased the gastric juice content and the pH values and decreased theacid output. In the cysteamine-induced duodenal ulcers, PAs [po] showed significantinhibition [$p<0.001$] of the duodenal lesions when compared to the respective control.The levels of the somatostatin hormone in the blood samples of animals pretreated withthe PA mixture [12.5mg/kg] and the free mucus and prostaglandin synthesis after theadministration of the PA extract [po] also increased [$p<0.001$]. The results suggestedthat the PA extract from S. brasiliensis inflorescences presents a significant antiulcereffect in the selected ulcer models. One of the mechanisms involved in the action of thePA extract is cytoprotection. Additional studies are in progress to determine otherpossible mechanisms involved in the antiulcer effect of PAs [W. Toma.et al 2004].

4.5. Antifeedant Effects. Species belonging to the family Asteraceae are animportant source of terpenes and alkaloids with biological activity. The tricyclopentanoidsesquiterpene 11b-acetoxy-5a-[angeloyloxy] silphinen-3-one [487], isolated fromS. palmensis **[**A. Gonzalez-Coloma, et al 1995**],** as well as related C[5]/C[11]-substituted derivatives were found tobe very efficient antifeedants against several divergent insect species **[**A.Gonzalez-Coloma, et al 1995**].**Todemonstrate the importance of this class of molecules as model insect antifeedants andtheir potential as new GABA modulators, **[**M. Reina et al 2002**]** carried out additionalchemical work on S. palmensis, resulting in the isolation of the known sesquiterpenes [6S]-Bisabola-3,7[11]-dien-2-one, 5a-[Angeloyloxy]silphinen-3-one ,5a-Acetoxysilphinen-3 one, and 6,7-Epoxyhumula-2,9-diene. The new silphinenes 5a-[Senecioyloxy] silphinen-3-one, 5a-[Tigloyloxy] silphinen-3-one, and 5a-[Angeloyloxy]-3b-hydroxysilphinene]Caryophyllanes. A series ofsemisynthetic analogues, such as silphinen-3,5-dione and 5-hydroxysilphinen-3-one, was also generated, to carry out a preliminary structure – activity study on theantifeedant action of these molecules against several divergent insect species, includingthe lepidopteran Spodoptera littoralis, the chrysomelid Leptinotarsa decemlineata[Colorado potato beetle, CPB], and five aphid species with diverse host adaptations. Insummary, C [5]-substituted silphinenes, such as [6S]-Bisabola-3, 7[11]-dien-2-one, 5a-[Angeloyloxy]silphinen-3-one , 5a Acetoxysilphinen-3-one, and 6,7-Epoxyhumula-2,9-diene. The new silphinenes 5a [Senecioyloxy]silphinen-3-one, 5a-[Tigloyloxy]silphinen-3-one, and 5a-[Angeloyloxy]-3b-hydroxysilphinene]Caryophyllanes.
are more efficientCPB and aphid antifeedants than their biogenetic precursors 6,7-Epoxycaryophyll-3[15]-ene Humulanes6,7-Epoxyhumula-2,9-diene.Acomparative study of their activities with that of C[5]/C[11]-substituted analogues showed that esterification at C[5] and acetylation at C[11] are important structuralrequirements for the antifeedant activity of these molecules **[**M. Reina et al 2002**].**Compounds 1a-Acetoxy-8b-methoxyeremophil-7[11]-en-12,8-olide and 1a-[Angeloyloxy]-6b-hydroxy-8b methoxyeremophil-7[11]-en-12,8-olide, isolated from S. miser, were found to be effective antifeedants against Myzus persicae and L. decemlineata, respectively **[**M. Reina et al 2001**]**Similarly,several sesquiterpene lactones with a g-butenolactone group have been reported ashaving moderate to high potency as L. decemlineata antifeedants. The PA 37 was found to be an effective antifeedant against L. decemlineata [not adapted to PAs] **[**M. Reina et al 2001**]** Previous data have shown that the CPB is sensitive to the macrocyclic diestersenecionine , the open diester PA echimidine, and the saturated monoester PA 3'-acetyltrachelanthamine, but with too few structural features in common to draw anyconclusions on structure –activity relationships. Also the PA N-oxide Integerrimine N-oxide was found tobe a strong CPB antifeedant **[**M. Reina et al 2001**]** Previous reports have shown that some PA N-oxides, including senecionine N-oxide, are active antifeedants against some aphid species andS. Littoralis, but they were found to be less potent than their tertiary bases. The datapresented by **[**M. Reina et al 2001**]** suggest that the CPB putative taste receptors can interactwith different

PAs [and N-oxides] of different structural classes with high molecularselectivity. Little is known, however, about the molecular mechanisms that modulatePA insect taste reception. Several PAs, including N-oxides and Senecionine, have demonstratedsignificant binding activity to muscarinic and serotonin receptors, indicating that thesecompounds can affect several molecular targets besides long-term toxicity throughDNA alkylation by PA metabolites generated in the liver. Therefore, the interferenceof PAs with neuronal signal transduction could mediate insect taste regulation asproposed for chrysomelid beetles. The PAs 37 and Senecionine were not toxic to S. littoralis.Tertiary PAs are deleterious to organisms with a microsomal cytochrome P450 system,but S. littoralis larvae can clearly tolerate PAs. These larvae prevent PA poisoning byrapid and efficient excretion of the absorbed tertiary alkaloid. In contrast, compoundIntegerrimine was moderately toxic to L. decemlineata, but Senecionine was not. A previous experiment hasshown that ten other PAs were not toxic to this insect. Oreina beetles [Chrysomelidae] are able to take up plant alkaloid N-oxides and eliminate tertiary PAs. Similarly, L.decemlineata beetles could eliminate tertiary PAs efficiently enough to avoid poisoning,with some exceptions [such as Senecionine] [M. Reina et al 2001].

4.6. Cytotoxicity towards the Human Hepatoma Cell Line Huh-7. A number of traditional remedies used in South Africa contain PAs, some of which are hepatotoxic [V. Steenkamp, et al 2001]. Investigated the effect on human Huh-7 cells of S. latifolius, aplant that is a component of some traditional remedies and known to contain toxic PAs.The cells were also treated with solutions of the standard pyrrolizidine retrorsine. The changes in the gross morphology of the cells were studied using light microscopyafter haematoxylin and eosin staining. The cytoskeleton was investigated usingfluorescence-labelled anti-b-tubulin antibody and the nuclear organisation was studiedusing fluorescence-labelled antinuclear antibodies. The plant extracts induced dosedependentgross morphological changes. At high doses, necrosis was observed and atlower doses, destruction of the cytoskeleton, nuclear fragmentation, and apoptosis weredetected. Doses of less than the equivalent of 330 ng/ml retrorsine led to multinucleatedcells with failure in spindle formation and clumping of nuclear chromatin.This latter finding suggests that chronic low-dose treatment with such traditionalremedies could induce teratogenic and/or carcinogenic effects [V. Steenkamp, et al 2001].

4.7. Antimitotic Effects.the antimitotic activity ofPAs extracted from S. brasiliensis, stored for more than 23 years under variableconditions of temperature and humidity and exposed to light. Both the crude alkaloid [containing IntegerrimineRetrorsine, and impurities] and pure integerrimine conserved the ability toinduce acute toxicity in mice, leading to the death of the animals in less than 24 h. Thealkaloids also conserved the potential to induce significant increases in micronucleus frequencies in polychromatic erythrocytes of mouse bone marrow, compared to thenegative control. The administration of alkaloids to lymphocyte cultures blocked withcytochalasin-B showed no significant increase in the micronucleus frequency in binucleated cells, probably due to the lack of a metabolic activation mechanism.However, an antimitotic effect was observed [R. Santos-Mello, et al 2002].

4.8. Angiotensin-Converting Enzyme Inhibitory Activity. Extracts of S. samnitumand the derived methyl ester of chlorogenic acid have been shown to inhibit theangiotensin-converting enzyme [ACE] by using an in vitro bioassay based on theenzymatic cleavage of the chromophore-fluorophore labeled substrate dansyltriglycineinto dansylglycine, which was quantitatively measured by HPLC. The most effectivefraction of the S. samnitum extract, obtained in AcOEt, inhibited the activity of ACE to52.56_0.23% [SD] at 300 mg/ml. The major constituent of this fraction, Chlorogenic acid methyl ester, showed asignificant ACE inhibition of 56.78_0.25% at a concentration of 82.5 mg/ml. The ACEinhibitory property of different extracts of S. samnitum may imply that in vivo, theseextracts may have a hypotensive effect [R. Tundis et al 2005].

4.9. Insecticidal, Neurotoxic, and Glutathione-Depleting Activities. The active insecticidal component of S. palmatus was identified as jacaranone, a neurotoxicant and glutathione-reactive quinol previously known to have insect antifeedant activity. Further, it was observed that mono- and bisglutathione [GSH] adducts were formed on incubation of Jacaranone with GSH and rat liver GSH S-transferase. The toxic action of Jacaranone in mice [intraperitoneal LD50¼150– 200 mg/kg] was associated with both neurological signs and GSH depletion in the liver 90 min after the treatment. The neurotoxic effect [tail raising, tremors, lachrymation, and ataxia] led to death in 30– 90 min [H. Xu et al 2003].

4.10. Phytotoxic activity

The cacalolides, eremophilanolides of Senecio madagascariensis, S. barba-johannis, S. toluccanus demonstrated potential phytotoxic effects on L. sativa [E. Burgueno- Tapia et al 2004].

4.11. Anti-proliferative activity

Effect ofS. palmatus extract on cell proliferation and differentiation was studiedperformed to investigate the effect of intermedeol on proliferation and differentiation of human leukemia-derived HL-60 cells as well as the underlying mechanisms for these effects. Intermedeol exhibited a potent antiproliferative activity against HL-60 cells. In addition, this compound was found to be a potent inducer for HL-60 cell differentiation as assessed by nitroblue tetrazolium reduction test, esterase activity assay, phagocytic activity assay, morphology change, and expression of CD14 and CD66b surface antigens.

These results suggest that intermedeol induces differentiation of human leukemia cells to granulocytes and monocytes/macrophage lineage. Moreover, the expression level of c-myc was down-regulated during intermedeol-dependent HL-60 cell differentiation, whereas p21 [CIP1] was up-regulated. Taken together, our results suggest that intermedeol may have potential as a therapeutic agent in human leukemia [S. H. Jeong, et al 2002].

4.12. Antiviral activity

S. tsoongianus is a widely distributed Chinese medicinal herb traditionally used for the treatment of hepatitis B, dermatosis and inflammation. The sesquiterpene lactone isolated from it showed suppressive activity on the expression of hepatitis B virus surface antigen [HBsAg] and hepatitis B virus e antigen [HBeAg] in the HepG 2.2.15 cell lines. The sesquiterpenes also decreased the number of infectious virions released without having effect on intracellular hepatitis B virus DNA. These results suggest that enantiomeric sesquiterpene lactones may possess the potential to work synergistically with other antiviral compounds for the treatment of HBV infection [L. H. Zalkow, et al 1985].

4.13. Antioxidant activity

The antioxidant properties of the methanol, n-hexane and ethyl acetate extracts from Senecio stabianus Lacaita were studied. The antioxidant activities were carried out using two different in vitro assays, namely 2,2-diphenyl-1-picrylhydrazyl [DPPH] test and 2, 2-azinobis-[3-ethylbenzthiazoline-6-sulphonate] [ABTS] test. The ethyl acetate extract showed the highest activity with inhibitory concentration 50% [IC_{50}] values of 35.5 and 32.7 mg/mL on DPPH test and ABTS test, respectively [E. Burgueno-Tapia, et al 2006].Methanolic and ethyl acetate extract of Senecio gibbosus demonstrated good radical scavenging activity as evaluated by the 2,2-diphenyl-1-picrylhydrazyl [DPPH] test with inhibitory concentration 50% [IC_{50}] values of 0.02 and 0.01 mg/mL, respectively.

The ethyl acetate extract of S. inaequidens showed better antioxidant activity than extract of S. vulgaris at the concentration of 0.312 mg/mL. The ethyl acetate extract of S. inaequidens inhibited 61.60% of the DPPH free radical whereas the extract of S. vulgaris showed 44.57% inhibition [F. Conforti,et al 2006a, R. Tundis,et al 2007].

Total phenolic content and total flavonoid content in alcoholic extract of aerial parts of Senecio tenuifolus burm was determined in addition to antioxidant activity. The extract with highest amount of phenolic compounds exhibited the maximum antioxidant activity **[**S. Aparna.et al 2013**]**.

The antioxidant activity of extract of Senecio splendens was determined using ABTS method and the chemical structures present were identified as 5-O-caffeoylquinic acid [5-CQA], 3,4-di-O-caffeoylquinicacid [3,4-DCQA], 3,5-di-O-caffeoylquinic acid [3,5-DCQA] and 4,5-di-O-caffeoylquinic acid [4,5-DCQA]. 3, 5-DCQA being the most abundant compound among the four isomers. The evaluation of radical scavenging activity of each isomer revealed that 3,4-DCQA possessed best antioxidant activity while 3,5-DCQA accounted for the highest radical scavenging capacity owing to it being present in the highest amount [Y. F. Shang,et al 2010].

4.14. Anti-gout Activity

Leaf extract of.Senecio splendens is efficacious against collagen-induced arthritis [CIA] in mice. Also, the levels of rheumatoid factor, anti-type II collagen antibody, tumor necrosis factor-alpha, interleukin-1, and interleukin-6 in serum were reduced by its administration. The study suggested that leaf extract of might be effective for the treatment of inflammatory arthritis like human rheumatoid arthritis [E. M. Choi.et al 2008].

4.15. Anti-hepatotoxicactivity

Hepatotoxicity produced by carbon tetrachloride, D-galactosamine, alpha-naphthylisothiocyanate and DL-ethionine was inhibited in rats by pretreatment with methanolic extract ofSenecio splendens [Compositae]. Ethyl acetate extract fractionated from the methanolic extract showed a strong inhibitory effect. 3, 4-dicaffeoylquinc acid [DCQA], isolated from the methanolic extract was examined for its anti-hepatotoxicity. Pretreatment with DCQA [5 and 10 mg/kg, p.o.] significantly reduced serum aminotransferases [alanine and aspartate], sorbitol dehydrogenase, gamma-glutamyltransferase, alkaline phosphatase, and lactate dehydrogenase activities during carbon tetrachloride or galactosamine induced hepatotoxicity, suggesting that DCQA is responsible for the antihepatotoxic activity of Ligularia fischeri. DCQA also partially restored bile flow and reduced total bilirubin and cholic acid concentrations in rats. Treatment with DCQA inhibited the increase in triglyceride, cholesterol, and total lipids in DL-ethionine-induced fatty liver. The study justifies the traditional use of this plant in the treatment of jaundice and hepatic failure [E. M. Choi.et al 2008].

CONCLUSION

The genus Senecio [Asteraceaca], widely distributed throughoutthe world, is known to be a source of PAs, eremophilanolides and furanoeremophilanes[M. Reina,et al 2001]. PAs are widespread in this genus. They areresponsible for the heptatotoxic and carcinogenic effects of this genus [D.-L. Cheng,et al 1992]. Thesesquiterpenoids with eremophilane, cacalol, bisabolane, eudesmane, oplopane, andgermacrane skeletons are among the most studied sesquiterpenoids isolated fromSenecio species. Other types of sesquiterpenoids as phomalairdanes, caryophyllanes, humulanes, presilphiperfolenes, aromadendranes, himachalanes, africananes, pentalenanes, bakkanes, and

valeranes, along with diterpenoids, triterpenoids, steroids, andflavonoids, are also important components. The present review compiles the majority ofthe components isolated from Senecio species and summarizes the biological activitiesof this genus

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