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Review Article

A Review on Genus *Saurauia*: Chemical Compounds and their Biological Activity

Gunawan Pasaribu[1,*], Emil Budianto[2], Herry Cahyana[2], Endang Saepudin[2]

ABSTRACT

Introduction: *Saurauia* plant has been widely used to treat a variety of diseases suffered by villagers at various places in the world. These species are widely used traditionally by the community as antidiabetic and digestive problems' remedy. This paper will present various uses and researches ever carried out by researchers in the world on various types of the genus *Saurauia*. **Methods**: The Information was collected from scientific journals, books, and reports. **Results:** This review summarizes the existing information on several species of *Saurauia* in relation to their chemical compounds and biological activity. There are some of chemical compounds present and identified in *Saurauia*, i.e. 3 β-hydroxy-Olean-12-en- 28-oic acid; 3,19-Dihydroxyurs-12-en-28-oic acid; 3-hidroksi, 12(13)-en, 28-oleanolat acid; actinidin; several monoterpene lactones; seven triterpenoids, namely, *cis*-3-*O*-*p*-hydroxycinnamoyl ursolic acid; *trans*-3-*O*-*p*-hydroxycinnamoyl ursolic acid; ursolic acid; oleanolic acid; corosolic acid; maslinic acid; and β-amyrin; and two steroids, stigmasterol; and β-sitosterol. There are several biological activities afforded by *Saurauia* i.e. antioxidant activity, anti-cholesterol, antidiabetic activity, antihyperlipidemic, analgetic activity, antimicrobial activity, wound-healing activity and immunostimulatory activity.

Key words: *Saurauia*, Chemical compounds, Biological activity, Human disease remedy.

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INTRODUCTION

Plants of the genus *Saurauia* are widely distributed in Indonesia. One species regarded as quite widely known is *Saurauia bracteosa*. This species grows widely in the Lake Toba's Catchment Area, located in North Sumatra, Indonesia. This species can be found all the way from Lumban Julu, Sipangan Bolon, Merek up to Sipiso-piso area. In the last two years there has been massive harvesting of *Saurauia* leaves because it is believed able to efficaciously cure various diseases. Many of the leaves are traded around the trans-Sumatra road.

"Pirdot/cep-cepan lembu" (*traditional name*) leave (*Saurauia vulcani* Korth) is one of woody plant species which have been used to cure diabetes in accordance with Karo's local perception/prudence. For such, dried leaves (5-8 pieces) are boiled in 1 liter of water to allow for the water to evaporate for particular duration such that half the volume of the aqueous mixture remains. After becoming cool, the supernatant (clear) portion of that half aqueous boiled-leaves can be consumed twice up to three times a day.[1] Pirdot (*Saurauia bracteosa* DC) leaves have tested as herbal tea.[2]

Meanwhile, *Saurauia roxburghii* is an evergreen tree species belonging to the family Actinidiaceae. This plant species is widely distributed in the coastal forest and hill tracts of Bangladesh, and also found outside Bangladesh country such as Vietnam, Nepal, India, Myanmar, Thailand, Cambodia, Laos, China (including Taiwan), Japan, and Malaysia. On the other hand, this species is less frequently encountered in the greater districts' area of Sylhet, Chittagong, and Chittagong's Hill Tracts in Bangladesh. Further, the stems and leaves of these plants are extensively used as herbal medicines against numerous severe diseases like asthma, bronchitis, hepatitis B, ulcers, and central nerves depression; and also in large numbers for the treatment of boils, Eczema, Epilepsy, Fever, Gout, and Piles.[3]

The species of *Saurauia nepaulensis* is used as firewood in Sikkim, India.[4] The other species, *Saurauia elegans,* is traditionally used as edible wild fruits in Benguet, Cordillera administrative region, the Philippines.[5] In 2001, On, *et al.* reported the other species, *Saurauia tristyla,* in Bavi National Park, Vietnam.[6]

About *Saurauia bracteosa*, the phase (period) of flowering and fruiting of this species has been studied enormously.[7] They reported that the period from flower initiation to fruit maturity of *Saurauia bracteosa* took 145 days in average. Flower initiation lasted for 16 days; small-bud stage occurred in 38 days; large-bud phase came about in 16 days; anthesis stage took 5 days in average; and fruit development would complete in 74 days.

Saurauia homotricha, a new species from montane forests of western Honduras and Nicaragua, is placed in the Central American series *Gymnogynae* Buscalioni and is most similar to *Saurauia rubiformis* Vatke, from which it differs most markedly in the type, length, and distribution of trichomes on the leaves and the abaxial surface of the sepals.[8]

Meanwhile, according to Silalahi, 2015, *Saurauia vulcanii* leaves are used for the remedy of diarrhea,

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gastrointestinal disorders, and injury in ethnomedicine by sub-ethnic Batak Simalungun, in North Sumatra Province, Indonesia.[9] The other species, *Saurauia laevigata,* is Honduran medicinal plant that used as digestive (stomach ache, ulcers, etc.).[10]

Saurauia species have been tried painstakingly to be described in New Guinea for lengthy years; in that the first effort was attempted by Miquel in 1869 and the last by Takeuchi in 2008. Consequently, *Saurauia* in New Guinea have long ever since been considered as a 'difficult' group to work with mainly due to the lack of a solid and taxonomically sound generic framework around which new taxa can be added. There is no definite understanding of *Saurauia*'s characters which are taxonomically significant.[11]

On the other hand, *Saurauia rufescens* B.J. Conn & Damas (Actinidiaceae) is described as a new species originated from the West Sepik region of Papua New Guinea. There are several morphological features that could distinguish *Saurauia rufescens* from another species of *Saurauia* (called *Saurauia excurrens*). The former species has red-brown indumentum; branchlets, which are sparsely covered with indistinct lenticels (while the latter species, *Saurauia excurrens* is densely covered with distinct lenticels); leaf margin (in the dormer species) is indistinctly crenulated with a single trichome, terminating each crenulation (while in the latter, *Saurauia excurrens* is with margin serrate with teeth c. 1 mm long); and interestingly the flowers (of both *Saurauia rufescens* and *Saurauia excurrens* species) occur amongst the foliage.[12] The spesies of *Saurauia taylorii* is a distinctive new species from The Kaijende Highlands of Papua New Guinea.[13]

Shu 2007 and He *et.al.*, 2005 explained that there were several species of *Saurauia* that grow in China. Those are among others *Saurauia griffithii, Saurauia miniata, Saurauia napaulensis, Saurauia erythrocarpa, Saurauia rubricalyx, Saurauia punduana, Saurauia thyrsiflora, Saurauia tristyla, Saurauia polyneura, Saurauia cerea, Saurauia yunnanensis, Saurauia macrotricha,* and *Saurauia sinohirsuta*.[14,15]

Saurauia napulensis, the Nepalese plants, several of the plant derived piscicides currently used in fishery management in many countries were originally used by the natives to stun and harvest fish for human consumption.[16]

Two new species of Saurauia from Mexico are *Saurauia madrensis* and *Saurauia cana. Saurauia madrensis* occurs in cloud forests and Liquidambar forests of the Sierra Madre in Chiapas. *Saurauia cana* is found in wet forest habitats north of the trans-Mexican volcanic belt in the Sierra Madre Oriental.[17] Therefore, there are four new species of *Saurauia* from South America i.e *Saurauia multinervis*, *Saurauia Schultesiana, Saurauia mexiae* and *Saurauia chaparensis.*[18] The species of *Saurauia homotricha*, a new species from Honduras and Nicaragua. It is placed in the Central American series Gymnogynae Buscalioni and is most similar to *Saurauia rubiformis* Vatke, from which it differs most markedly in the type, length, and distribution of trichomes on the leaves and the abaxial surface of the sepals.[8]

However, there is another *Saurauia* species (i.e. *Saurauia leeana*) which was classified in IUCN Red list as the threatened species 2019. This species in its location is restricted to Ulu Sungai Sungai in Kota Marudu, Sabah. *Saurauia leeana* is known as a single collection from Ulu Sungai Sungai's area in Kota Marudu. The area is located within Kinabalu Park, a Totally Protected Area (TPA). The estimated area of occupancy (AOO) is as large as 4 km^2 and so far is not in decline. The potential threat for this area is forest fire resulting from shifting agriculture which is carried out nearby and which could bring about negative impacts severely on the species (*Saurauia*) in the near future. Hence, it is assessed as Vulnerable D2.[19]

Similar to *Saurauia leeana,* according to Wihermanto 2004, *Saurauia bracteosa* DC., and *Saurauia cauliflora* DC (Saurauiaceae) are included in the endemic group of Java, further regarded as rare plants. These species are existed in the submontana zone and montane mountains in Java.[20] Species *Saurauia microphylla* (a native species) is an endemic flora of Java Island and listed under the IUCN Red List of Threatened Species 2016 (World Conservation Monitoring Center 1998).[21]

In another related case, there are some particular properties of *Saurauia vulcani* and simplisia ever examined. Characterization of ethanol extract from *Saurauia vulcani* extracts and simplisia exhibited specific properties, i.e. water (moisture) content at 6.65% and 7.25% respectively; percentage of water-soluble extract was 23.55% and 64.25% respectively. Still related, levels of ethanol soluble extract and simplisia were 20.32% and 66.45% respectively; total ash content was 4.01% and 0.60% respectively; and acid-insoluble ash content was 0.88% and 0.48% respectively.[22]

PHYTOCHEMICAL AND TOXICITY

There was phytochemical activity conducted by *Saurauia bracteosa* flower extract. The methanol extract of *Saurauia bracteosa* flower contained particular chemical compounds such as phenolic compounds, flavonoids, alkaloids, steroids and saponins. In the methanol extract, total flavonoid content amounted to 11,140 mg/kg.[23] On the other hand, Kadji *et.al,* 2013 showed that results of maceration and soxhlet extraction on *Saurauia bracteosa* leaves brought out the leaf extract which also contained phenolic compounds, steroids, flavonoids, and saponins.[24]

Maukar and Pontoh 2013 reported that there were phytochemical compounds and toxicity activity of *Saurauia bracteosa.* The toxicity expressed as the LC_{50} (lethal concentration) value was obtained through the analysis on *Saurauia bracteosa* leaves. As such, the obtained LC_{50} value was equal to 37.30 ppm. Meanwhile, the phenolic, flavonoid, and tannin contents in the leaves were *Saurauia bracteosa* leaves 43.06%, 6.52%, and 17.91%, respectively.[25]

Barcello also reported that *Saurauia* sp. (soybo), *Saurauia elegans* (uyok), and *Saurauia sparsifolia* (degway/sapuwan) contained steroids, saponin, flavonoid, polyphenol, and tannin.[26]

According to Salim *et al.* 2017, the dried *Saurauia cauliflora* leaves contained flavonoids, alkaloids, tannins, anthraquinone glycosides and steroids/triterpenoids.[27] Results of phytochemical screening on simplisia and ethanol *Saurauia vulcani* extract were essentially similar. Both items showed the presence of flavonoid, glycosides, saponins, tannins and steroids/ triterpenoids[22].

Muaja *et al.* 2013 have conducted phytocemical and Brine Shrimp Lethality Test on *Saurauia bracteosa* DC leaf extract. The leaf extract was further tested to examine its phenolic, flavonoid, and tannin contents. Results showed that *Saurauia cauliflora* leaf extract was regarded as toxic (LC_{50}: 35.4 ppm). The contents of phenolic, flavonoid, and tannin compounds in the extract were 128 ppm, 44.4 ppm and 86.75 ppm, respectively.[28]

Species of *Saurauia roxburghii* can be found in India as medicinal plant.[40] Furthermore, Ahmed *et al.* 2015 reported *in vivo* the Brine Shrimp's lethal active compounds which were isolated from *Saurauia roxburghii* leaves.[38] The LC_{50} data for various extracts, column fractions, three pure compounds of *Saurauia roxburghii*, and vincristine sulfate (VS) were shown in Table 1. The crude extracts and isolated pure compounds posed the potential cytotoxic activities which might provide support for some of their uses in ethnomedicine treatment.

CHEMICAL COMPOUNDS

Research results on the leaves of *Saurauia vulcani* Korth. plant were collected in Silangkitang Village, North Tapanuli, North Sumatera Province, Indonesia.[34] They found two triterpenoid compounds as

Table 1: LC_{50} data of *Saurauia roxburghii* leaf extract.

Extract samples	LC_{50} (µg/mL)
VS	0.32
Ethanol	12.59
n-hexane	14.79
Chloroform	14.06
Ethyl-acetate	15.47
H-13	11.75
H-19	10.96
Compound-1	4.37
Compound-3	6.92
Compound-4	11.88

Remarks: VS: Vincristine sulphate (Std.); column fractions of H-13 and C-19 using n-Hexane and chloroform as extracting solvent, respectively.

anti-cholesterol agent, 3β-hydroxy-Olean-12-en- 28-oic acid (1) and 3,19-Dihydroxyurs-12-en-28-oic acid (2). The chemical structure of compounds 1 and 2 was shown in Figure 2. Furthermore, Suparman *et al*. 2018 has characterized of *Saurauia bracteosa* extract compounds with IR and NMR spectroscopy. From the result of phytochemical test and characterization of secondary metabolite compound which successfully isolated is triterpenoid group compound.[41]

Two steroid compounds were isolated from the n-hexane extract of *Saurauia roxburghii* leaves. Based on the spectral analysis evidence using IR, 1H-NMR, and 13C-NMR devices, the chemical structures which were determined / identified turned out to be stigmasterol (1) and *β*-sitosterol (2), as presented in Figure 3.[3]

Situmeang *et al*, 2018 reported a chemical compound which was isolated from *Saurauia vulcani* leaves where their host trees grew in Silangkitang-Sipoholon, North Tapanuli Regency. They used extract ethyl-acetate solvent to isolate the compound. They reported the compound which was isolated, could be identified as 3-hidroksi, 12(13)-en, 28-oleanolat acid (Figure 4).[42]

Further, the chemical composition in the essential oil that resulted from the hydro distillation on the air-dried roots of *Saurauia lantsangensis* Hu was such that it gave the oil with a dark yellowish color, whereby the yield reached 0.27% (w/w). The GCMS analysis on the essential brought out the results that as many as 39 chemical components were detected, which in portion represented 96.41% of the oil. The essential oil was found out to be rich in oxygenated sesquiterpenes (36.24%), esters (17.50%), sesquiterpenes (12.57%), and oxygenated monoterpenes (3.64%). Major components of the oil were T-muurolol (13.85%), followed in the decreasing order by consecutively acetophenone (7.46%), *α*-cadinol (6.26%), methyl palmitate (5.36%), *n*-hexadecanoic acid (4.31%), torreyol (3.69%), and isospathulenol (3.48%).[37]

Chemical constituents in *Saurauia excelsa* plant species have been reported by particular researchers. They examined that *Saurauia excelsa* species was originated from Venezuela and belonged to the family Accinidaceae. It has been also reported that the species of this family contained actinidine (2-4) and several monoterpene lactones (2, 4, 5) (Figure 5). The authors are quite willing to report the isolation of n-tricosyl alcohol and p-sitosterol from a petroleum ether extract; and anabasine from the ethanolic fraction.[43]

Ahmed *et al*, 2016 reported the presence of particular chemical constituents in *Saurauia roxburghii* leaves. Continuous chromatographic separation and purification on the crude chloroform and *n*-hexane extracts from the leaves yielded seven triterpenoids, i.e. *cis*-3-*O*-*p*-hydroxycinnamoyl ursolic acid (**1**), *trans*-3-*O*-*p*-hydroxycinnamoyl ursolic acid (**2**), ursolic acid (**3**), oleanolic acid (**4**), corosolic acid (**5**), maslinic acid (**6**), and β-amyrin (**7**); and two steroids, i.e. stigmasterol (**8**) and β-sitosterol (**9**). The configurations of these isolated pure compounds were elucidated by using spectroscopic analysis.[44]

BIOLOGICAL ACTIVITY

Antioxidant activity

Barcelo 2015 reported that the DPPH (Diphenyl-2-picrylhydrazyl) radical-scavenging activity conducted by consecutively *Saurauia* sp. (soybo), *Saurauia elegans* (uyok) and *Saurauia sparsifolia* (degway/ sapuwan) fruit was 86.40 ppm.[26]

According to Lisi *et al* 2017, the antioxidant activity conducted by *Saurauia bracteosa* flower extract. The antioxidant activity of the methanol flower extract as expressed by the IC_{50} value amounted to 128,573 ppm.[23] On the other hand, Kadji *et al*., 2013 reported that the antioxidant activity conducted by *Saurauia bracteosa* leaves' extract (in both types of the extracts) afforded powerful antioxidant activity. The IC_{50} values of flower extract that resulted from the maceration and soxhlet extraction were 38,01 ppm and 28,18 ppm, respectively.[24]

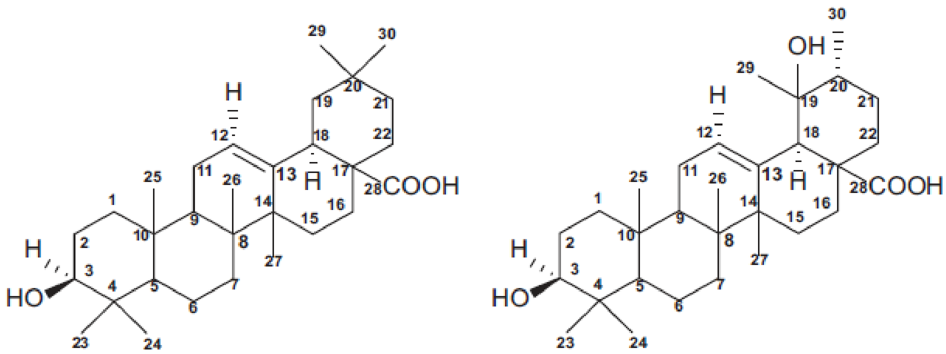
Furthermore, Zhu *et al* 2012 reported that the ethyl acetate extract of *Saurauia lantsangensis* exhibited an excellent DPPH radical-scavenging activity, which was higher than that of BHT (Butylated hydroxytoluene) at all the concentrations tested. At 50 *μ*g/ml concentration, the highest percentage of DPPH radical-scavenging activity at 94.3% was observed in the ethyl acetate extract, which was significantly higher ($p < 0.05$) than that of BHT (68.3%). From 0 to 100 *μ*g/ml concentration, the DPPH radical-scavenging activity of the ethyl acetate extract remarkably increased in a dose-dependent manner but less did so when the concentration exceeded 50 *μ*g/ml. The methanol extract showed stronger DPPH free radical-scavenging activity than BHT, at 25 and 50 *μ*g/ml concentrations. On the other hand, ethyl acetate extract and methanol extract exhibited an excellent superoxide anion radical-scavenging activity in a dose-dependent manner, which was higher than that of BHT. At 100 *μ*g/ml, the superoxide anion radical scavenging activities of the ethyl acetate extract, methanol extract, and BHT were (92.4±3.2), (83.6±2.8), and (76.7±3.3) %, respectively.[37] Parts of plants used and their bioactivity are presented in Table 2.

Lovena *et al* .2018 reported that the antioxidant activity value of the water extract from *Saurauia vulcani* IC_{50} values was 22,9182±1.32µg/ mL, whereas the IC_{50} value of the produced-quercetin was 4.96±0.02 µg/ml. These results showed that the ability of water extract from *Saurauia vulcani* leaves to capture free radicals was regarded as a strong antioxidant. This is because the water extract concentration lay in the range of 50-100 *μ*g/ml concentration, which belonged to the strong category.[31]

Anti-cholesterol

Musa *et al* 2019 reported that the compounds as extracted from *Saurauia vulcani* leaves were evaluated for their anti-cholesterol activity test in accordance with the Liebermann-Burchard (LB) colorimetric assay. Compounds 1-2 (Figure 1) showed a remarkable anti-cholesterol

Figure 1: *Saurauia vulcani* leaves.



1

2

Figure 2: Chemical structure of *Saurauia vulcani* compound.

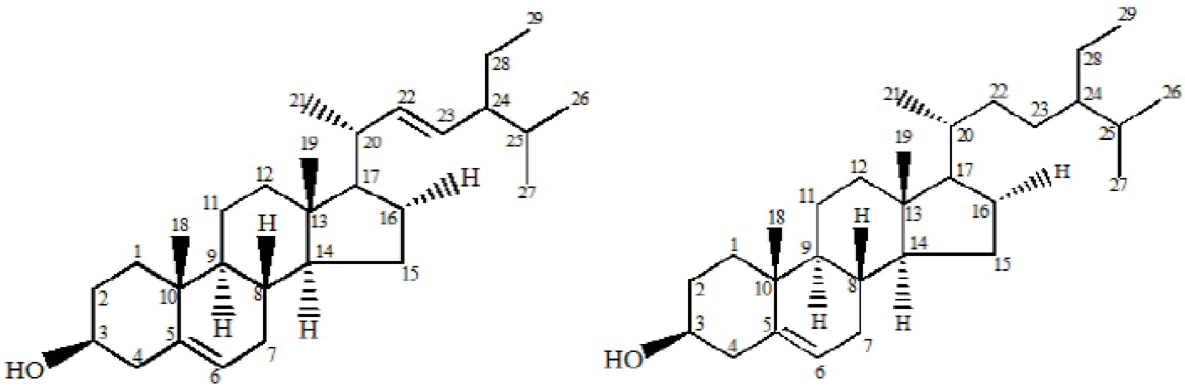


Figure 3: Chemical structure of *Saurauia roxburghii* compound; Stigmasterol (1) & β-sitosterol (2).

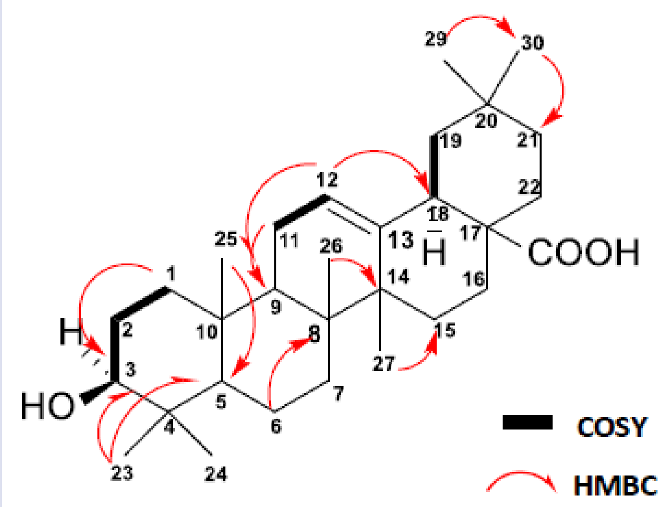
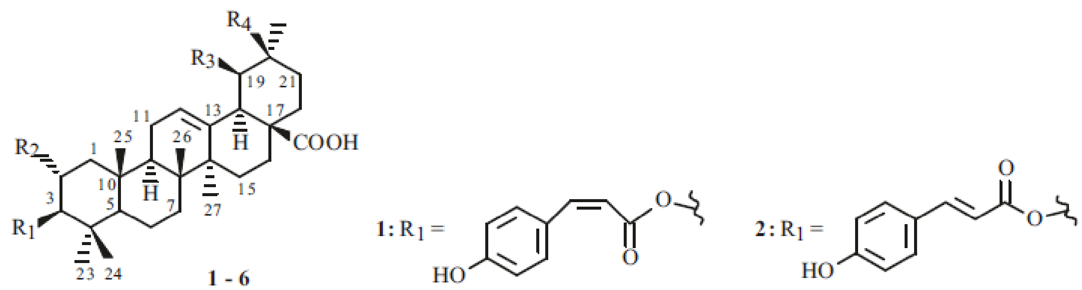


Figure 4: Chemical structure of 3-hidroksi, 12(13)-en, 28-oleanolat acid.



1, 2: $R_2 = R_4 = H$, $R_3 = CH_3$; **3:** $R_1 = OH$, $R_2 = R_4 = H$, $R_3 = CH_3$
4: $R_1 = OH$, $R_2 = R_3 = H$, $R_4 = CH_3$; **5:** $R_1 = R_2 = OH$, $R_4 = H$, $R_3 = CH_3$
6: $R_1 = R_2 = OH$, $R_3 = H$, $R_4 = CH_3$

Figure 5: Chemical structure of actinidine (2-4); and several monoterpene lactones (2, 4, 5).

Table 2: **Part of used of Saurauia species.**

No	Species	Part used	Activity
1	*Saurauia vulcani*	Leaves	Antidiabetic[1,29,30,31,32,33,22,30] Antioxidant[31] Anticholesterol[34] Antihyperlipidemic[35] Wound-healing[32] Immunostimulatory[36]
2	*Saurauia elegans* *Saurauia sparsifolia*	Fruit	Antioxidant[26]
3	*Saurauia bracteosa*	Flower Leaves	Antioxidant[23] Antioxidant[24]
4	*Saurauia lantsangensis*	Leaves	Antioxidant[37] Antimicrobial[37]
5	*Saurauia cauliflora*	Leaves	Analgetic[27]
6	*Saurauia roxburghii*	Leaves	Antimicrobial[38]
7	*Saurauia scaberrinae*	Leaves	Antimicrobial[39’]

activity. Most importantly, raising concentration of the compounds 1–2 exhibited a dose-dependent manner.[34]

Antidiabetic activity

Sitorus and Satria 2018 used *Saurauia vulcani* Korth. leaves, which were taken from Tarutung area, located in North Sumatera, Indonesia. Antidiabetic assay used in this study was male rats. Results showed that significant reduction in blood glucose levels of the rats (p<0.001) occurred at the dosage 50 mg/Kg BW.[29]

According to Hutahaean *et al.* 2018 the effect of *Saurauia vulcani* leaves' extract on blood sugar levels in the alloxan-induced diabetic mice (Table 3). Results revealed that the leaves' extract exhibited the potential capability as antihyperglycemic. The effects as obtained were equivalent to the effects of antidiabetic metformin drug.[30]

According to Lovena *et al*, 2018, antidiabetic activity caused by inhibition of this enzyme activity assay occurred on water extract of *Saurauia vulcani* leaf. Results showed that the acarbose had the ability to inhibit the activity of α-glucosidase with the IC_{50} values at 150.63 ± 0.25 µg/mL. Meanwhile, the extract afforded the ability to inhibit the activity of α-glucosidase with lower IC_{50} value i.e. 75.56 ± 1.07 µg/mL. Therefore, it can be inferred that the water extract exerted more significant capabilities in inhibiting the activity of α-glucosidase compared to those of acarbose.[31]

Anastasia *et al* 2018 reported that there occurred the effect of *Saurauia vulcani* in hyperglycemic rats. Results showed that administering of aqueous extract from *Saurauia vulcani* in hyperglycemia rats at the doses at consecutively 0.25 mL, 0.5 mL and 1.0 mL brought out significant effect (*P<0.05*), and such dose dependency brought about the decrease in the rats' blood glucose levels when compared with the negative control. Strepzotosin increased the blood glucose level in rats by observing the rat's obvious weight loss that visibly occurred within 7-10 days. Consequently, this occurrence indicated that there happened the damage of the irreversible pancreatic langerhans. Aqueous extract of *Saurauia vulcani*, which was administered for 15 days, caused the decrease in rats' blood glucose levels, but in the negative control treatment it showed that the blood glucose levels were in the range 387-493 mg/dL. From the test results hence it can be seen that the decrease in blood glucose levels began to visibly occur on day 3. As such, the largest decrease in blood glucose levels occurred in aqueous extract of *Saurauia vulcani* at 1 mL dose. Similar decrease also came about in the same *Saurauia vulcani* 's extract but at lower doses (i.e. 0.5 mL and 0.25 mL, respectively).[32]

The blood glucose rate of the mice treated with 200 mg/kg BW (113.4 mg/dl) pirdot (*Saurauia vulcani*) leaf extract significantly differed from that of the mice in the diabetes mellitus control group (364.8 mg/dl) (p<0.05). The ganglion cell layer of the retina increased by up to 7.59 µm, which differed from that of the diabetes mellitus group (3.67 µm) (*p<0.05*) treated with 250 mg/kg BW pirdot leaf extract. The external plexiform layer increased to 17.88 µm, which differed from that of the diabetes mellitus group (15.71 µm) (*p<0.05*) treated with 150 mg/kg BW pirdot leaf extract. The blood glucose rate obtained after treatment with pirdot leaf extract was lower than that of the diabetes mellitus control group.[33]

Sitorus 2015 reported the characterization on simplisia and ethanolic extract from Pirdot (*Saurauia vulcani* Korth) leaves, and study results of antidiabetic effect in the alloxan-induced diabetic mice. Ethanolic extract of *Saurauia vulcani* Korth leaves showed favorable results as antidiabetic effect, as indicated by significant depletion of blood glucose level in the alloxan-induced diabetic mice for ten days. Blood glucose level reduced by 55.11%, with ethanolic extract of *Saurauia vulcani* Korth leaves 200 mg / kg body weight, compared to the level with metformin 50 mg / kg body weight only, which revealed the blood glucose level reduction by 47.76%.[22]

Hutahayan *et al.* 2018 reported that *Saurauia vulcani* leaves extracts reduced the glucose to normal. In alloxan-induced diabetic mice, area of corpus cavernosa decreased significantly (*p<0.05*), and again *Saurauia vulcani* leaves extract decreased corpus cavernosa area to normal. The diameter of helicine artery follows the same trend. In sperm parameter assessment, sperm count in alloxan- induced diabetic mice decreased to 197 x 105, and in extract groups the sperm count were back to normal only in the highest dosage (338 x 105). There were no significant different in sperm quality (motility, viability, and normal percentage). In general, the result confirmed that the antihyperglycemic effect of *Saurauia vulcani* leaves extract, recommended its potency in penile contractile tissue improvement in diabetes, nevertheless it seems to have no effect on sperm quality.[35]

Antihyperlipidemic

Hutahaean *et al.* 2018 reported that the effect of *Saurauia vulcani* leaves on antihyperlipidemic effect was still not conclusive. This is because the extract lowered the total cholesterol significantly, but inflicted no significant effect on triglyceride, marked the noticeable reduction in the LDL, but significantly decreased the HDL level.[30]

Analgetic activity

According to Salim *et al*, 2017 reported the role of *Saurauia cauliflora* DC. leaves' extract as analgetic agent. Analgesic effect of the extract was evaluated by observing the response time of mices to infrared as pain inducer. Mice were grouped into six categories, which comprised: vehicle, antalgin 65 mg/kgBW, and extracts at the dose of consecutively 500 mg/kgBW, 250 mg/kgBW, 125 mg/kgBW, 62,5 mg/kgBW, whereby all were administered orally. The water content in the dried leaves' solid was 5.3%. The analgesic test results showed that the leaves' extract at the dose of 250 mg/kgBW brought about strong analgesic effect which was similar to that of the same extract at 500 mg/kgBW and that of antalgin at 65 mg/kgBW.[27]

Antimicrobial activity

Saurauia lantsangensis oil exhibited a promising antimicrobial effect which was determined by observing the diameters of inhibition zones (i.e. 13.3 – 16.2, 16.5 – 20.4, 13.5 – 16.6, and 16.5 – 22.7 mm), respectively, along with their respective MIC values (500 – 1000, 125 – 500, 250 – 500, and 250 – 500 *µ*g/ml) against consecutively Gram-

Table 3: Effect of *Saurauia vulcani* leaves' extract on blood sugar level in the alloxan-induced mice.

Treatments	Blood sugar level (mg/dL) on days				
	0	3	10	17	24
K1	109.4 ± 36.7a	226.8 ± 35.2 a	237.2 ± 43.9a	267.8 ± 47b	292.4 ± 74.9b
K2	102.6 ± 22.8a	230.2 ± 23.8 a	189 ± 30.3a	154 ± 36.7a	135 ± 25.1a
P1	97.2 ± 14.5a	301.4 ± 13 a	278.4 ± 97.4a	192 ± 76.9a	173 ± 74.8a
P2	117.0 ± 38.3a	225.2 ± 24.7 a	175.4 ± 24.9a	134.2 ± 21.5a	129.8 ± 23.4a
P3	122.4 ± 15a	279.8 ± 58.8 a	191.2 ± 41.5a	156 ± 27.9a	134.4 ± 41.7a

Remarks: Different superscripts mean statistically different (*P<0.05*).

Table 4: *In vitro* antibacterial activity conducted by *Saurauia roxburghii.*

Name of the bacteria	500 (μg disc^{-1})				400 (μg disc^{-1})					Com-1	Com-3	Com-4	Kanamycin
	Et	He	Ch	EA	H-13	C-15	C-19	E-18	E-24				
Gram positive													
B. cereus	16 ± 1	10 ± 1	13 ± 1	8 ± 2	8 ± 1	9 ± 1	10 ± 1	9 ± 1	12 ± 1	11 ± 1	14 ± 1	13 ± 1	34 ± 1
B. megaterium	15 ± 1	-	13 ± 1	-	-	7 ± 1	9 ± 1	-	-	8 ± 1	9 ± 1	14 ± 1	34 ± 1
B. subtilis	16 ± 2	12 ± 1	14 ± 1	10 ± 1	9 ± 1	9 ± 2	8 ± 1	8 ± 1	12 ± 1	12 ± 1	16 ± 1	15 ± 1	32 ± 2
S. Aureus	18 ± 2	11 ± 1	14 ± 1	8 ± 1	8 ± 1	8 ± 1	10 ± 1	12 ± 1	10 ± 1	12 ± 1	14 ± 1	16 ± 1	35 ± 1
B. Polymyxa	16 ± 1	10 ± 1	-	8 ± 1	10 ± 1	-	-	-	-	14 ± 1	12 ± 1	15 ± 1	33 ± 1
S. pneumoniae	16 ± 1	12 ± 1	9 ± 2	-	-	-	-	-	-	12 ± 1	8 ± 1	16 ± 1	34 ± 1
M. tuberculosis	22 ± 1	13 ± 1	20 ± 2	9 ± 2	10 ± 2	10 ± 2	12 ± 2	9 ± 1	12 ± 1	20 ± 2	16 ± 2	20 ± 2	31 ± 2
Gram negative													
E. coli	18 ± 2	13 ± 2	16 ± 1	12 ± 1	14 ± 2	10 ± 1	8 ± 1	7 ± 1	14 ± 2	12 ± 1	15 ± 1	12 ± 1	35 ± 1
Klebsiella sp	14 ± 1	9 ± 1	12 ± 1	7 ± 1	10 ± 1	-	-	-	-	9 ± 1	15 ± 2	13 ± 1	32 ± 2
Proteus sp	14 ± 1	8 ± 2	12 ± 1	8 ± 1	-	-	-	-	-	-	11 ± 1	14 ± 1	30 ± 3
S. typhi	15 ± 1	-	13 ± 2	10 ± 2	-	-	-	-	-	13 ± 1	-	-	33 ± 1
S. sonnei	14 ± 1	7 ± 2	15 ± 1	7 ± 1	10 ± 1	10 ± 1	13 ± 1	7 ± 1	12 ± 1	-	12 ± 1	13 ± 1	34 ± 1
P. aureus	18 ± 2	9 ± 1	16 ± 1	10 ± 1	-	7 ± 1	8 ± 1	14 ± 2	10 ± 1	12 ± 1	-	16 ± 1	34 ± 1
V. cholera	14 ± 1	-	13 ± 1	-	-	9 ± 1	8 ± 2	-	-	8 ± 1	10 ± 1	12 ± 1	31 ± 2

Remarks: Et: Ethanol extract, He: n-hexane extract, Ch: Chloroform, EA: Ethyl acetate extract, column fractions (H-13, C-15, C-19, E-18 and E-24) of various extract and three pure compounds (1, 3, 4), NA: No activity.

negative bacteria (*Pseudomonas aeruginosa*, *Escherichia coli*), Gram-positive bacteria (*Bacillus subtilis*, *Staphylococcus aureus*), and a yeast (*Hansenula anomala*).[37]

Ahmed *et al* 2015 reported *in vitro* the role of antibacterial activity isolated from the leaves of *Saurauia roxburghii* (Table 4). The crude extracts and isolated pure compounds of the leaves posed the potential antibacterial activities which might provide support for some of their uses in ethnomedicine treatment.[38]

Phoma sp. was an endophyte of the plant *Saurauia scaberrinae*, collected in Papua New Guinea. The isolated compound (Phomodione 4) showed activity against *S. aureus* (MIC of 1.6 lg/mL), *P. ultimum* (4–5 lg/mL), *S. sclerotiorum* (3–5 lg/mL) and *R. solani* (5–8 lg/mL). As reference, Cercosporamide that biosynthesized by the *Phoma sp*. endophytic isolate showed activity against S. aureus (MIC of 2 lg/mL), *P. ultimum* (3–4 lg/mL), *S. sclerotiorum* (5–8 lg/mL) and *R. solani* (8–10 lg/mL).[39]

Yu, *et al* 2010 reported that Pestalachloride A and pestalachloride B are the novel antibiotics isolated from *Pestalotiopsis adusta* of *Saurauia scaberrinae*. It has antifungal activity towards plant pathogens such as *Verticillium aiboatrum*, *Gibberella zeae* and *Fusarium culmorum.*[45]

Wound-healing activity

Anastasia *et al* 2018 reported the role of *Saurauia vulcani* as wound-healing agent. Results of this study indicated that oral administering of aqueous extract from *Saurauia vulcani*, Korth leaves could speed up the healing process of hyperglycemia wounds. Related with such, macroscopic findings indicated the reduction in the wound size on the 3rd day to 15th day compared to the negative control and positive control. Those macroscopic findings therefore indicated the positive effects of the leaves' extract on the process of wound healing.[32]

Immunostimulatory Activity

Saurauia vulcani Korth. leaves has a potential immunostimulant activity which the parameter showed the enhancement of erthrocyte value and lymphocyte. It was also obtained a good histologic spleen.[36]

CONCLUSION

There were some of the chemical compounds in Saurauia species that could be identified, i.e. 3β-hydroxy-Olean-12-en- 28-oic acid; 3,19-Dihydroxyurs-12-en-28-oic acid; 3-hidroksi, 12(13)-en, 28-oleanolat acid; actinidin; several monoterpene lactones; seven triterpenoids, namely, *cis*-3-*O*-*p*-hydroxycinnamoyl ursolic acid; *trans*-3-*O*-*p*-hydroxycinnamoyl ursolic acid; ursolic acid; oleanolic acid; corosolic acid; maslinic acid; and β-amyrin; and two steroids, stigmasterol; and β-sitosterol. Further, there were several biological activities afforded by Saurauia, i.e. antioxidant activity, anti-cholesterol, antidiabetic activity, antihyperlipidemic, analgetic activity, antimicrobial activity, wound-healing activity and immunostimulatory activity.

CONFLICTS OF INTEREST

The authors have declared no competing interest.

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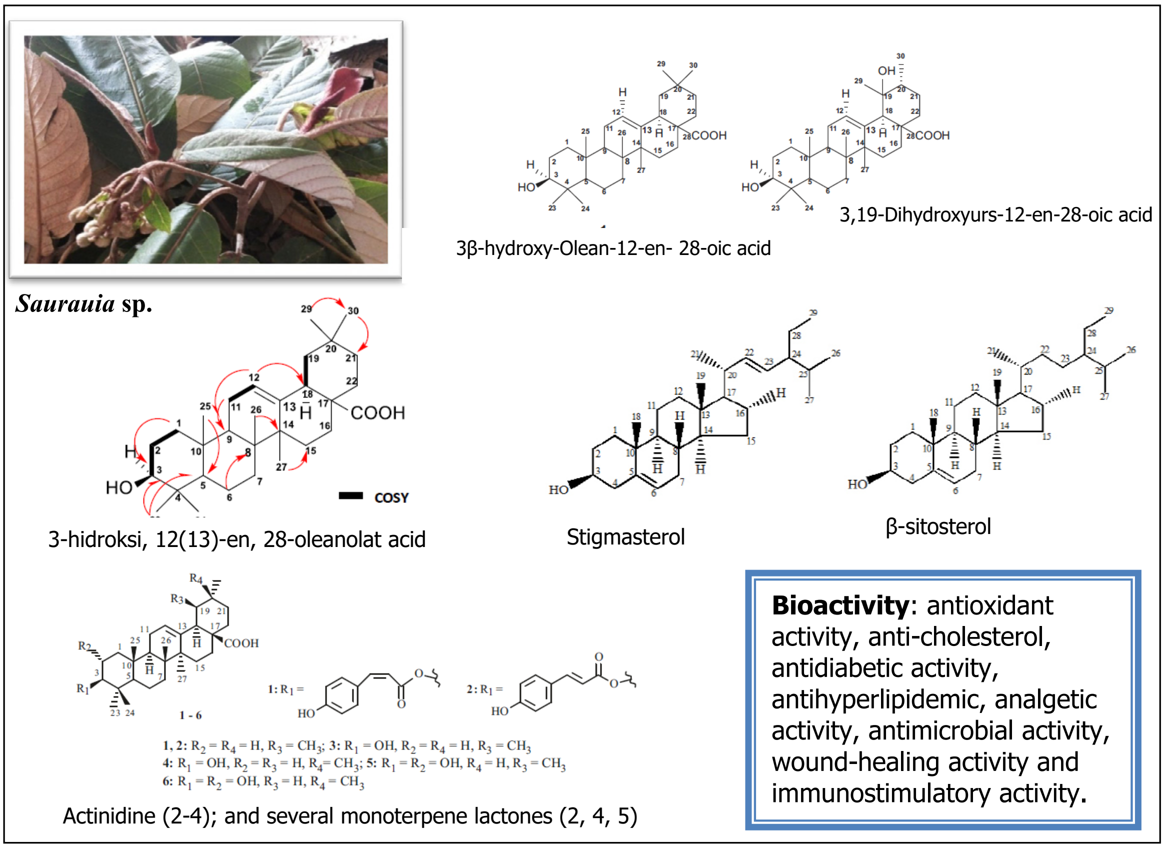
GRAPHICAL ABSTRACT



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