

Circaea lutetiana (L) PLANT AND ITS CHEMICAL COMPOSITION

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ABSTRACT

Circaea lutetiana is a medicinal plant in the *Onagraceae* family. The plant has been used for the treatment of wounds. As its chemical composition possesses valuable components, the infusion has been drunk or washed for treatment of injuries. The paper identified the chemical components of the leaves and stems of the plant *Circaea lutetiana*. The compositions of *Circaea lutetiana* leaves and stems were extracted with hexane and analyzed using gas chromatography-mass spectrometry (GC-MS). The method of peak area normalization was used to identify 22 compounds. Among them, The primary compounds (leaves and stems) are esters (30,799%), alkanes (12,69%), fatty acids (carboxylic acids), oxo-fatty acids (7,038%), phytosterols (3,43%), triterpenoids (3,01%). Analysis of each part of the plant (stems, leaves, and fruits) and more detailed information on the specific plants were investigated.

Keywords: *Circaea lutetiana* L, Hexane Extract, GC-MS, Antioxidant, Extraction.

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INTRODUCTION

Circaea lutetiana is a medicinally important herb of the family *Onagraceae* (fireweed). Among 12 species in Asia, 2 species (*Circaea alpina* L. and *Circaea lutetiana* L.) are growing on the territory of Kazakhstan. The name of the genus *Circaea* is given in honor of "Circe" (lat.), a sorceress in ancient Greek mythology and the name of the species *lutetiana* originates from the old name of Paris - "Lutetia" (lat.), a city that in ancient times was known as the city of witches.¹ Since ancient times, the indigenous Indians have used infusions made from *Circaea lutetiana* to heal wounds, Chinese traditional medicine, in turn, used the plant for colic, dysuria, and dysmenorrhea.² Phenolic compounds such as derivatives of kaempferol and quercetin exhibit antioxidant activity.³ Since these two flavonoids are found in the species *Circaea lutetiana*, the extract from this plant is expected to exhibit similar activity. In addition, recent studies of the compound enotein B (ellagitannin) show that this substance has antioxidant, anticancer, immunomodulatory, and antimicrobial effects *in vivo* and *in vitro*.⁴ Moreover, *Circaea lutetiana* has been used as a cosmetic, namely, a lotion that has an effect on cleansing, moisturizing, softening the skin, removing acne, controlling oil, whitening, and retaining moisture.⁵ Flavonoids were discovered to be the most abundant category of chemicals in *Circaea*'s chemical components. Among the main components are apigenin C-glycosides such as vitexin, isovitexin, isoorientin, vicienin-1, and vicienin-2. Apart from C-glycosides, O-glycosylated flavones, and flavonols have been discovered including apigenin 7-O-glucoside, luteolin 7-O-glucoside, quercetin 3-O-glucoside (isoquercitrin), and kaempferol 3-O-glucoside (astragalin).^{6,7} The growth of plants depends on the concentration of mineral nutrients available in the soil. Concentrations of nutrients can have a significant impact on plant quality. Depending on the mineral nutrient and pH of the soil, the composition of the plant may change. It can lead to the deficiency of some very important components. Contaminations of water also play an important role in the growth of the plant.⁸⁻¹¹ Crude oil contamination of soil is also one of the main factors affecting the composition of plants. Petroleum hydrocarbons associated with changes in carbon/nitrogen (C/N) ratio may also lead to affect the sorption of certain minerals from the soil.

Depending on the study abiotic stress, like water and atmospheric factor, to plants accounts for 50% of all diseases.¹²⁻¹⁵ Therefore, the phytochemical compositions of plants have specific importance on their beneficial effects.¹⁶ From the beginning of time, herbal remedies have played an important role in human health. Until now, medicinal plants have been used for the treatment of many diseases, even diabetes, and cancers.¹⁷ In this study, we determined the chemical composition of *Circaea lutetiana* by gas chromatography-mass spectrometry (GC-MS).

EXPERIMENTAL

Plant Material

The part (leaves and stems) of the plant *Circaea lutetiana* was collected in September 2019 from the Bayanaul National Park of Pavlodar region territory of the Republic of Kazakhstan. Subsequently, it was dried at room temperature in a well-ventilated room and then cut into small pieces.

Extraction

The dried and powdered *Circaea lutetiana* (5 g) was extracted in three consecutive portions of hexane. The volume of each portion was 75 ml. The extraction time of each portion was 3 days. Filtered extracts were combined and concentrated under reduced pressure with a vacuum rotary evaporator Eyela N-1200B. Then the dry extract was stored at 4°C. For GC-MS analysis, 1 mg of dry extract was dissolved in 1 ml of hexane. GC-MS conditions: Qualitative and quantitative analysis of the samples under study was carried out by gas chromatography-mass spectroscopy on an Agilent GC System 7890A gas chromatograph with an Agilent 5975C (MSD) mass-selective detector under the following conditions: HP-5MS capillary column 30 m x 0.25 mm (film thickness 0.25 µm). The carrier gas was helium at a flow rate of 1 ml/min. Mass spectra were recorded using ionization energy of 70 eV. For data processing, Agilent Technologies MSD ChemStation software was used in combination with AMDIS 32 and NIST 2017 (version 2.3).

RESULTS AND DISCUSSION

The compositions of *Circaea lutetiana* in hexane extract from the leaves and stems were analyzed by GC-MS (Figs.-1 and 2). 25 main compounds were detected on a chromatogram with a NIST 2017. The main components are: esters (30,799%), (Octadecanoic acid, 2,3-bis(acetyloxy)propyl ester 5,511%, 9-Octadecenoic acid (Z)-, 2,3-bis(acetyloxy) propyl ester 4,948%, dodecanoic acid 3-dodecanoyloxy-propyl ester 3,253%); alkanes (12,69%) (tetratetracontane 4,791%, nonacosane 2,517%); fatty acids (carboxylic acids) and oxo-fatty acids (7,038%) (7H-Benzimidazo [2,1-a]benz[de]isoquinoline-3-carboxylic acid, 7-oxo 3,815%), phytosterols (3,426%) (γ-Sitosterol 2,649%); triterpenoids (3,104%) (lupeol 2,073%, β-Amyrin 1,31%) as the major constituents. These results indicated that the differences in the volatile profiles^{16,17} of the species are primarily qualitative.¹⁸⁻²⁰ These findings suggest that *Circaea lutetiana* could play a critical role in the development of new herbal medicines.

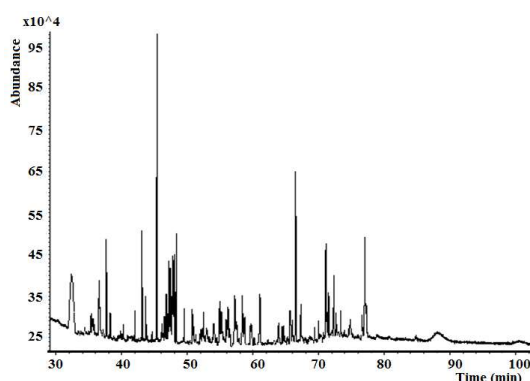
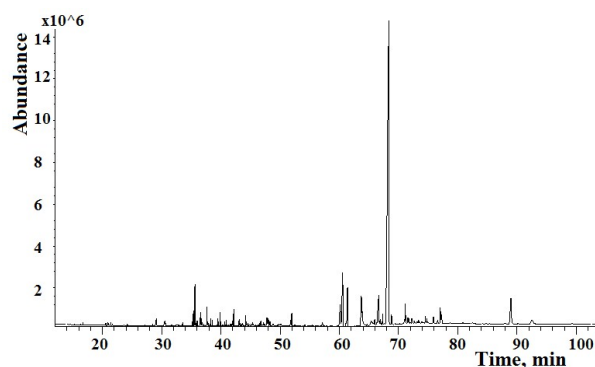


Fig.-1: Chromatogram of Hexane Extract from the Stems Part of *Circaea lutetiana*

Fig.-2: Chromatogram of Hexane Extract from the Leaves Part of *Circaea lutetiana*Table-1: Component Composition of the *Circaea lutetiana*

No.	AComponent	Formula	Leaves			Stems		
			^a IR	Retention time, min	Content, %	^a IR	Retention time, min	Content, %
Fatty acids (carboxylic acids) and oxo-fatty acids (7,038%)								
1	Hexanoic acid	C ₆ H ₁₂ O ₂	990	12.704	0.032	-	-	-
2	n-Heptanoic acid	C ₇ H ₁₄ O ₂	1087	15.853	0.009	-	-	-
3	n-Octanoic acid	C ₈ H ₁₆ O ₂	1180	18.875	0.027	-	-	-
4	Nonanoicacid	C ₉ H ₁₈ O ₂	1273	21.672	0.060	-	-	-
5	9-Oxononanoic acid	C ₉ H ₁₆ O ₃	1483	27.125	0.023	-	-	-
6	Dodecanoic acid	C ₁₂ H ₂₄ O ₂	1568	29.147	0.795	-	-	-
7	Tetradecanoicacid	C ₁₄ H ₂₈ O ₂	1768	33.540	0.126	-	-	-
8	Lauricanhydride	C ₂₄ H ₄₆ O ₃	1859	35.647	1.310	-	-	-
9	n-Hexadecanoicacid	C ₁₆ H ₃₂ O ₂	1968	37.661	0.841	-	-	-
10	7H-Benzimidazo[2,1-a]benz[de]isoquinoline-3-carboxylic acid, 7-oxo	C ₁₉ H ₁₀ N ₂ O ₃	3771	88.957	3.815	-	-	-
Alcohols (1,043%)								
11	1-Hexadecanol	C ₁₆ H ₃₄ O	1880	35.996	0.203	-	-	-
12	1-Octadecanol	C ₁₈ H ₃₈ O	2097	39.894	0.402	-	-	-
13	Ethanol,2-(octadecyloxy)-	C ₂₀ H ₄₂ O ₂	2328	44.212	0.306	-	-	-
14	Ethanol,2-(hexadecyloxy)-	C ₁₈ H ₃₈ O ₂	2143	40.680	0.132	-	-	-
Ketones (0,869%)								
15	Hexahydrofarnesylacetone	C ₁₈ H ₃₀ O	1844	35.317	0.63	-	-	-
16	2-Pentadecanone, 6,10,14-trimethyl-	C ₁₈ H ₃₆ O	-	-	-	1844	35.314	0.239
Cyclic ketones (1,161%)								
17	7,9-Di-tert-butyl-1-oxaspiro(4,5)deca-6,9-diene-2,8-dione	C ₁₇ H ₂₄ O ₃	1923	36.857	0.174	-	-	-
18	3-Phenyl-2-benzofuran-1(3H)-one	C ₁₄ H ₁₀ O ₂	1957	37.248	0.012	-	-	-
19	4,8,12,16Tetramethylheptadecan-4-olide	C ₂₁ H ₄₀ O ₂	2364	44.602	0.071	2364	44.597	0.174
20	β- Amyrin	C ₃₀ H ₄₈ O	-	-	-	3028	64.448	0.730
Alkaloids (0,837%)								
21	Peiminine	C ₂₇ H ₄₃ NO ₃	3328	71.530	0.338	3571	74.781	0.499

Steroids (1,752%)								
22	Stigmasta-3,5-dien-7-one	C ₂₉ H ₄₆ O	3389	72.665	0.064	3511	73.343	0.519
23	Stigmastane-3,6-dione, (5 α)-	C ₂₉ H ₄₈ O ₂	3601	76.594	0.259	3604	76.598	0.910
Ester (30,799%)								
24	Dodecanoic acid, 3-hydroxypropyl ester	C ₁₅ H ₃₀ O ₃	-	-	-	1862	35.432	0.438
25	1,2Benzenedicarboxylic acid, bis(2-methylpropyl) ester	C ₁₆ H ₂₂ O ₄	-	-	-	1870	35.817	0.122
26	Glycidylpalmitate	C ₁₉ H ₃₆ O ₃	-	-	-	2329	43.802	0.174
27	9,19-Cyclolanostan-3-ol, 24-methylene-, (3 β)-	C ₃₂ H ₅₄ O ₂	-	-	-	3511	73.349	0.758
28	Dodecanoic acid, 3-hydroxypropyl ester	C ₂₁ H ₄₀ O ₃	1850	35.519	0.315	-	-	-
29	Adipic acid, isohexyl 2-methoxyethyl ester	C ₁₂ H ₂₂ O ₆	1911	36.635	0.506	-	-	-
30	Hexadecanoic acid, ethyl ester	C ₁₈ H ₃₆ O ₂	1993	38.247	0.189	1993	38.246	0.315
31	1-Hexadecanol, acetate	C ₁₈ H ₃₆ O ₂	2009	38.527	0.151	-	-	-
32	Isopropyl palmitate	C ₁₉ H ₃₈ O ₂	2023	38.819	0.011	-	-	-
33	Tetradecanoic acid, 2,3-dihydroxypropyl ester	C ₁₇ H ₃₄ O ₄	2068	39.432	0.212	-	-	-
34	Octadecanoic acid, ethylester	C ₂₀ H ₄₀ O ₂	2196	41.895	0.034	-	-	-
35	n-Octadecylethanoate	C ₂₀ H ₄₀ O ₂	2208	42.160	0.446	2195	41.891	0.082
36	Glycidylpalmitate	C ₁₉ H ₃₆ O ₃	2244	43.029	0.173	-	-	-
37	Tributylacetyl citrate	C ₂₀ H ₃₄ O ₈	2250	43.160	0.209	-	-	-
38	Glycidolstearate	C ₂₁ H ₄₀ O ₃	2309	43.809	0.020	-	-	-
39	Eicosanoic acid, ethylester	C ₂₂ H ₄₄ O ₂	2395	45.259	0.008	-	-	-
40	Hexanedioic acid, bis(2-ethylhexyl) ester	C ₂₂ H ₄₂ O ₄	2398	45.335	0.069	2398	45.345	4.774
41	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	C ₁₉ H ₃₈ O ₄	2519	47.377	0.081	2490	47.379	1.974
42	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	C ₁₉ H ₃₈ O ₄	-	-	-	2245	43.031	1.674
43	Hexadecanoic acid, 2,3-bis(acetyloxy)propyl ester	C ₂₃ H ₄₂ O ₆	2681	51.975	0.751	-	-	-
44	Phthalic acid, di(2-propylpentyl) ester	C ₂₄ H ₃₈ O ₄	2527	48.302	0.193	-	-	-
45	Octadecanoic acid, 2,3-bis(acetyloxy)propyl ester	C ₂₅ H ₄₆ O ₆	2861	57.143	0.314	-	-	-
46	Octadecanoic acid, 2,3-bis(acetyloxy)propyl ester	C ₂₅ H ₄₆ O ₆	2944	60.555	5.511	-	-	-

47	Dodecanoic acid 3-dodecanoyloxy-propyl ester	C ₁₇ H ₃₅ NO ₃	3040	61.374	3.253	-	-	-
48	9-Octadecenoic acid (Z)-, 2,3-bis(acetyloxy)propyl ester	C ₂₅ H ₄₄ O ₆	3231	68.342	4, 948	-	-	-
49	Dodecanoic acid, octadecyl ester	C ₃₀ H ₆₀ O ₂	3265	68.813	2,348	-	-	-
50	Hexadecanoic acid, hexadecyl ester	C ₃₂ H ₆₄ O ₂	3364	72.237	0.207	-	-	-
51	Octadecanoic acid, octadecyl ester	C ₃₆ H ₇₂ O ₂	3746	80.890	0.148	-	-	-
52	Hexadecanoic acid, octadecyl ester	C ₃₄ H ₆₈ O ₂	3547	75.900	0.391	-	-	-
Alkanes (12,69%)								
53	2,6,10-Trimethyltridecane	C ₁₆ H ₃₄	1449	26.700	0.015	-	-	-
54	Octadecane	C ₁₈ H ₃₈	1800	34.366	0.020	-	-	-
55	Eicosane	C ₂₀ H ₄₂	2000	38.335	0.023	-	-	-
56	Docosane	C ₂₂ H ₄₆	2200	41.973	0.140	2200	41.968	0.426
57	Tricosane	C ₂₃ H ₄₈	2300	43.674	0.078	2300	43.671	1.061
58	Pentacosane	C ₂₅ H ₅₂	2500	47.191	0.117	2500	49.493	0.818
59	Hexacosane	C ₂₆ H ₅₄	2600	49.495	0.044	2600	52.246	0.584
60	Nonacosane	C ₂₉ H ₆₀	2900	60.140	2.517	-	-	-
61	Triacontane	C ₃₀ H ₆₂	3000	61.125	0.371	-	-	-
62	Tetratetracontane	C ₄₄ H ₉₀	-	-	-	3209	67.225	4.791
63	Hentriacontane	C ₃₁ H ₆₄	-	-	-	3100	64.688	0.545
64	Heneicosane	C ₂₁ H ₄₄	-	-	-	2100	40.189	0.193
65	Octacosane	C ₂₈ H ₅₈	-	-	-	2773	52.441	0.967
fatty amide (0,358%)								
66	Hexadecanamide	C ₁₆ H ₃₃ NO	2187	41.628	0.062	-	-	-
67	Octadecanamide	C ₁₈ H ₃₇ NO	2374	45.133	0.040	-	-	-
68	cis-9,10-Epoxyoctadecanamide	C ₁₈ H ₃₅ NO ₂	2542	48.753	0.193	-	-	-
69	1H-Pyrrole-2,5-dione, 3-ethyl-4-methyl-	C ₇ H ₉ NO ₂	1239	20.573	0.063	-	-	-
Terpenes (0,132%)								
70	Neophytadiene	C ₂₀ H ₃₈	1837	35.171	0.132	-	-	-
Aromatic hydrocarbons (0,003%)								
71	Benzene, (1-propylnonyl)-	C ₁₈ H ₃₀	1742	33.264	0.003	-	-	-
Olefinic compound (0,008%)								
72	3-Octen-2-one	C ₈ H ₁₄ O	1040	14.573	0.008	-	-	-
Oxyaldehyde (0,006%)								
73	4-Oxohept-2-enal	C ₆ H ₈ O ₂	1031	14.461	0.006	-	-	-
Aromatic carboxylic acids (0,112%)								
74	Mediagenic acid	C ₃₀ H ₄₆ O ₆				3584	75.025	0.112
Triterpenoids (3,104%)								
75	β-Amyrin	C ₃₀ H ₅₀ O	-	-	-	3353	71.511	1.031
76	Lupeol	C ₃₀ H ₅₀ O	-	-	-	3368	72.299	2.073
Phytosterols (3,426%)								
77	γ-Sitosterol	C ₂₉ H ₅₀ O	-	-	-	3312	71.085	2.649
78	Stigmastanol	C ₂₉ H ₅₂ O	-	-	-	3317	71.240	0.777
Aromatic carboxylic acids (0,068%)								

79	Oroxylin A	C ₁₆ H ₁₂ O ₅	-	-	-	2238	42.867	0.068
^a Compound: Listed in order of elution from an HP-5MS column;								
^a IR: Identification based on retention index and based on comparison of mass spectra.								

According to the results of the study, the main components were found in both leaves and stems (Table-1). These components are very important for the parts that have been found. For example, Alkanes impart hydrophobic properties to the leaf and act as the plant's first line of defense against the external environment, preventing water loss through evaporation. Long-chain alkanes are widely used for terrestrial plant biomarkers.^{21,22} Esters are also very important compounds for plants. They give many specific odors and flavors to plants. Esters perform a structural function in plant cell membranes and play an important part in plant cell division. Panax and Glycyrrhiza plants, for example, are famous traditional medicine that includes saponins, ginsenosides, and glycyrrhizin, all of which have different beneficial effects.²³⁻²⁶ Therefore, the determination and isolation of such components from the plant can help to increase the development of medicine. We assume that it is very important to determine the medicinal components in the plant. Especially, an analysis of each part of the plant (stems, leaves, and fruits) gives even more detailed information on the specific plants.

CONCLUSION

In this work, the chemical composition of the leaves and stems of *Circaea lutetiana* has been determined. As the results of this study, main 22 compounds were analyzed from the plant. The presence of these bioactive compounds could imply that the plant extract has anti-inflammatory, antimicrobial, and anticancer properties. The findings can be applied to future studies of *Circaea lutetiana* to further our understanding of this plant. Further phytochemical research on the leaves and stems of *Circaea lutetiana* opens the door to the development of new plant-based preparations.

REFERENCES

1. C.P. Hoch, J.V. Crisci, T.N. Hiroshi, B.R. Paule, *Systematic Botany*, **18**, 1(1993), <https://doi.org/10.2307/2419786>
2. S. Granica, J.P. Piwowarski, A.K. Kiss, *Actabiologica Cracoviensia Series Botanica*, **55**, 1(2013), <https://doi.org/10.2478/abcsb-2013-0005>
3. A. Kozhantayeva, S. Rakhmadiyeva, *Chemical Bulletin of Kazakh National University*, **3**, (2020), <https://doi.org/10.15328/cb1151>
4. Sowndarya Sampath, Vidhya Veeramani, Gopal Shankar Krishnakumar, Udhayakumar Sivalingam, Suguna Lakshmi Madurai, Rose Chellan, *Biomedicine & Pharmacotherapy*, **93**, (2017), <https://doi.org/10.1016/j.biopha.2017.06.056>
5. O.E. Afieroho, K.C. Ugoeze, *Tropical Journal of Pharmaceutical Research*, **13**, 11(2014), <https://doi.org/10.4314/tjpr.v13i11.20>
6. D.E. Boufford, P.H. Raven, J.E. Averett, *Biochemical Systematics and Ecology*, **6**, 59(1978), [https://doi.org/10.1016/0305-1978\(78\)90025-X](https://doi.org/10.1016/0305-1978(78)90025-X)
7. A. Kozhantayeva, S. Rakhmadiyeva, G. Ozek, *Rasāyan Journal of Chemistry*, **13**, 4(2020), <https://doi.org/10.31788/RJC.2020.1345919>
8. Qaderi Mirwais, Martel Ashley, Dixon Sage, *Plants*, **8**, 65(2019), <https://doi.org/10.3390/plants8030065>
9. A. Akhmetzhan, N. Abeu, S.N. Longinos, A. Tashenov, N. Myrzakhmetova, N. Amangeldi, Z. Kuanyshova, Z. Ospanova, Z. Toktarbay, *Polymers*, **13**, 3084(2021), <https://doi.org/10.3390/polym13183084>
10. R. Suya Padhra Haridha, F. Jeyamangalam, R. Mary Jenila and S. C. Vella Durai, *Rasāyan Journal of Chemistry*, **14**, 4(2021), <https://doi.org/10.31788/RJC.2021.1446515>
11. D. Dutta, M. J. Bordoloi and N. K. Bhattacharyya, *Rasāyan Journal of Chemistry*, **14**, 4(2021), <https://doi.org/10.31788/RJC.2021.1446353>
12. O. Yessimova, S. Kumargaliyeva, M. Kerimkulova, K. Mussabekov, Zh. Toktarbay, *Rasāyan Journal of Chemistry*, **13**, 1(2020), <https://doi.org/10.31788/RJC.2020.1315566>
13. Athar Habib-ur-Rehman, Ambreen Sarah, Javed Muhammad, Hina Mehwish, Rasul Sumaira, Zafar Zafar Ullah, Manzoor Hamid, Ogbaga Chukwuma, Afzal Muhammad, Al-Qurainy Fahad, Ashraf

- Muhammad, *Environmental Science and Pollution Research*, **23**, 18320(2016), <https://doi.org/10.1007/s11356-016-6976-7>
14. S.S. Kozhabekov, A.A. Zhubanov, Zh. Toktarbay, *Oil & Gas Science and Technology - Rev. IFP Energies Nouvelles*, **74**, 28(2019), <https://doi.org/10.2516/ogst/2019004>
 15. Akhmetzhan Ayatzhan, Ayezkhon Tashenov, Abeu Nurgeldi, Ospanova Zhanar, Toktarbay Zhexenbek, Abdiyev Kaldibek, Nuxat Nuraje, *Polymers for Advanced Technologies*, **32**, 2669(2020), <https://doi.org/10.1002/pat.4999>
 16. Memete, A. R., Timar, A. V., Vuscan, A. N., Miere, F., Venter, A. C., & Vicas, S. I., *Plants*, **11**(2), 152(2022), <https://doi.org/10.3390/plants11020152>
 17. Neupane, N.P., Yadav, E., Verma, A., *Edible Plants in Health and Disease*, (2022), https://doi.org/10.1007/978-981-16-4880-9_8.
 18. Marcel Bliedtner, Imke K. Schäfer, Roland Zech, Hans von Suchodoletz, *Biogeosciences*, **15**, 3927(2018), <https://doi.org/10.5194/bg-15-3927-2018>
 19. M.S. Rukshana, A. Doss, T.P. Kumari Pushpa Rani, *Asian Journal of Plant Science and Research*, **7**, 9(2017).
 20. Xie Lei, L.W. Wagner, R.H. Ree, P.E. Berry, Jun Wen, *Molecular Phylogenetics and Evolution*, **53**, 995(2009), <https://doi.org/10.1016/j.ympev.2009.09.009>
 21. B.T. Rosemary, A. McNerney Francesca, *Geochimica et Cosmochimica Acta*, **117**, 161(2013), <https://doi.org/10.1016/j.gca.2013.04.016>
 22. Sawai Satoru, Saito Kazuki, Triterpenoid, *Frontiers in Plant Science*, **2**, 25,(2011), <https://doi.org/10.3389/fpls.2011.00025>
 23. J. P. Vincken, L. Heng, A. de Groot, H Gruppen, *Phytochemistry*, **68**, 275(2007), <https://doi.org/10.1016/j.phytochem.2006.10.008>
 24. M. Wen, R. Jetter, *Journal of Experimental Botany*, **60**, 1811(2009), <https://doi.org/10.1093/jxb/erp061>
 25. Sumanth Mullangi and Kunta Ravindhranath, *Rasāyan Journal of Chemistry*, **13**, 3(2020), <http://dx.doi.org/10.31788/RJC.2020.1335819>
 26. Muhammad Irham, Muhammad Irpan, Dewi Sartika, Gartika Setiya Nugraha and Dian Budi Dharma. *Rasāyan Journal of Chemistry*, **14**, 4(2021), <http://doi.org/10.31788/RJC.2021.1446454>

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