



Efficacy of extraction solvents in phytochemical analysis of *Blumea lanceolaria* (Roxb.) Druce

Seema Khakhalary¹ and Silistina Narzari^{*2}

¹Department of Botany, B.H. College, Howly - 781 316, Assam, India

²Department of Biotechnology, Bodoland University, Kokrajhar – 783 370, Assam, India

*nsilistina@gmail.com

Received: 09 April 2025

Accepted: 10 June 2025

Abstract

Blumea lanceolaria (Roxb.) Druce is used as a remedy in folk medicine and health foods in Northeast India. Whole leaf or leaf extracts of this plant are utilized by the tribal natives of the study region. This study was designed to investigate the efficacy of *B. lanceolaria* extracts obtained using four different solvents of different polarity: hexane, chloroform, methanol and water. *B. lanceolaria*'s leaf extracts were analyzed for total phenols, total flavonoids and antioxidant activity. Total phenols and flavonoids were estimated using Folin-Ciocalteu reagent and Aluminium chloride via colorimetry. Antioxidant activity was evaluated by DPPH radical scavenging assay. Extracts obtained with highly polar solvents had higher levels of phenolics, flavonoids and antioxidant activity compared to those obtained with non-polar solvents. The polarity-dependent increase in antioxidant activity indicates that extracts prepared in high polarity solvents hold strong antioxidant compounds. The findings of this research indicate that polar solvents are more efficient than non-polar solvents for extracting phytochemicals from *B. lanceolaria* leaves, a natural source of antioxidants.

Keywords: Antioxidant, Extracts, Flavonoids, Phenolics, Solvents

1. Introduction

Antioxidants are essential for preventing tissue damage brought on by a variety of human disorders (Hou *et al.*, 2003). According to Xu *et al.* (2012) and Sarker and Oba (2020), antioxidants protect the body from disorders like cancer, atherosclerosis, neurological diseases, cardiovascular diseases, arthritis, diabetes mellitus and nephritis. Plants have strong antioxidants, thus including them in diets or using them as medicines can help prevent the development of certain diseases (Niggeweg *et al.*, 2004; Okello *et al.*, 2020). Natural antioxidants found in plants have garnered a lot of attention in recent years due to their widely recognized nutritional and medicinal benefits.

Antioxidant capacity is a commonly used criterion to describe the nutritional value of foods or plants as well as their bioactive constituents. Many reported studies have shown that plants contain many antioxidants including phenolics, flavonoids, tannins, vitamins, quinines, coumarins, lignans, ligins (Amarowicz *et al.*, 2004; Cai

et al., 2004). The ability of phenolic compounds to act as antioxidants is one of the many biological activities they are linked to (Gouveia *et al.*, 2011). This ability may aid in shielding cells from the oxidative damage brought on by free radicals (Auddy *et al.*, 2003; Breemen *et al.*, 2011). Dong *et al.* (2015) reported that the presence of phenolic chemicals like flavonoids, anthocyanins etc., are responsible for the antioxidant activity in most plants. According to Sani *et al.* (2014), flavonoids have anticancer, anti-inflammatory, neuroprotective and cardioprotective effects on people. However, environmental factors or extraction techniques can quickly alter the quantity and activity of flavonoids in medicinal plants. The type of solvent employed in the extraction process is largely responsible for the successful separation and identification of physiologically active chemicals from plant material.

According to reports by Turkmen *et al.* (2006), Al-

Mansoub *et al.* (2013) and Madiha *et al.* (2017), varied extract circumstances, such as solvents, extraction times and extraction methods led to variable extraction yields. Temperature, solvent concentration and solvent polarity are just a few of the variables that might affect the extraction and purification of phytochemical and antioxidant compounds from plant material. Some antioxidant compounds may not be soluble in a particular solvent, even though solvent extraction has been widely used to study antioxidant compounds from plants (Al-Mansoub *et al.*, 2013; Turkmen *et al.*, 2006; Madiha *et al.*, 2017).

The perennial herb *Blumea lanceolaria* (Roxb.) Druce, belonging to the family Asteraceae and locally known as "jwglauri", is found throughout tropical and subtropical areas. It has historically been used as a treatment for a wide range of illnesses, including haemorrhoids, ulcers, cancer and cough (Sawmliana, 2003; Chawngkunga, 2005; Saikia *et al.*, 2017). The inhabitants of Mizoram in NE India have reportedly used a decoction of its leaves to heal stomach ulcers, diarrhoea and wounds (Rai and Lalramnghinglova, 2010). According to phytochemical analysis, *B. lanceolaria* includes a variety of active ingredients including oils, tannins, alkaloids, phytosterols, phenols and flavonoids (Khakhalary *et al.*, 2022).

There have been few studies on the antioxidant activities of *B. lanceolaria* leaves. However, none of them investigated how the polarity of extraction solvents influences antioxidant potential (Saikia *et al.*, 2020). The current study investigated the effects of hexane, chloroform, methanol and water as extraction solvents for phytochemical analysis.

2. Materials and methods

2.1. Sample collection

Leaf samples of *B. lanceolaria* were collected from their natural habitat in Goalpara district of Assam. The plant was authenticated and taxonomically identified at the Department of Botany, Bodoland University, Kokrajhar, Assam and were deposited at Bodoland University Botanical Herbarium (herbarium number: BUBH0000868). The shade dried leaves were pulverized using a clean and sterile electric grinder. The dried powder was stored in an airtight container until further use.

2.2. Extract preparation

25g of sample was defatted with petroleum ether at a temperature ranged between 60-80°C and further extracted in a Soxhlet apparatus in each 250mL of hexane, chloroform, methanol and water. The extraction temperature was maintained. All the solvents used for extraction were evaporated in a rotary vacuum evaporator until a crude viscous semi solid extract was obtained. The extractive values of all the solvent extracts were recorded in terms of yield percentage (%) as per standard protocol of Alebiosu and Yusuf (2015).

Yield percent (%) = $a/b \times 100$

Where, a = dry weight of extract obtained

b = initial weight of powdered material

2.3. Total Phenolic Content (TPC)

The Total Phenolic Content (TPC) of the plant extract was determined by using Folin-Ciocalteu reagent following a slightly modified method of Ainsworth and Gillespie (2007). Gallic acid was used as a reference standard for plotting calibration curve. A volume of 0.5mL of the plant extract (100µg/mL) was mixed with 2mL of the Folin-Ciocalteu reagent (diluted 1:10 with de-ionized water) and were neutralized with 4mL of sodium carbonate solution (7.5%, w/v). The reaction mixture was incubated at room temperature for 30mins with intermittent shaking for color development. The absorbance of the resulting blue color was measured at 765nm using double beam UV-Vis spectrophotometer (UV Analyst-CT8200). The total phenolic contents were determined from the linear equation of a standard curve prepared with gallic acid. The content of total phenolic compounds expressed as mg/g gallic acid equivalent (GAE) of dry extract.

2.4. Total Flavonoid Content (TFC)

Total Flavonoid Content (TFC) of each plant extracts were determined by the Aluminium chloride colorimetry method (Muchandi and Dhawale, 2017) with few modifications. The standard quercetin was used to construct the calibration curve. In summary, 0.2mL of plant extracts and standard were separately mixed with 3mL of distilled water. To it 0.5mL of 5% NaNO₂ solution was added. After keeping it for 5 mins at room temperature, 0.6mL of 10% AlCl₃ solution was added. After another 6 mins, 0.2mL of 1M NaOH solutions were added and made-up final volume up to 5mL with distilled water. The solutions were mixed thoroughly. The absorbance of the reaction mixture was taken after 10mins of incubation at a wavelength of 510nm in double beam UV-Vis Spectrophotometer (UV Analyst-CT 8200). The amount of flavonoid was calculated from the quercetin calibration curve and the results are expressed as mg quercetin equivalent per g dry weight.

2.5. Antioxidant activity by DPPH assay

DPPH method was used to determine antioxidant activity of *B. lanceolaria* leaf extracts (Alhakmani *et al.*, 2013). 1ml of each extract and standard (ascorbic acid) at various concentrations (10 to 200 µg/mL) was taken in separate test tubes. To each test tube, 2mL of 0.1mM DPPH prepared in methanol was added making the final reaction volume 3mL. The mixture was vortexed and incubated in the dark at 37 °C for 30 minutes. After the incubation, absorbance of each solution was measured using UV-Vis spectrophotometry (Model no. UV Analyst-CT 8200) at 517nm wavelength. A mixture containing 1mL methanol and 2mL DPPH solution served as the blank. Ascorbic acid was used as the positive control. Ascorbic acid was used as positive control. The percentage of radical scavenging activity of extracts and ascorbic acid (Standard) were calculated by using the formula:

% Inhibition = $\frac{\text{Abs of control} - \text{Abs of sample}}{\text{Abs of control}} \times 100$

Inhibitory concentration (IC₅₀) of the extracts and ascorbic acid for DPPH free radical scavenging were calculated.

2.6. Statistical analysis

Three replications were conducted for each sample. All results are presented as means \pm standard deviation. Statistical analysis was performed using SPSS version 26.0 software.

3. Results and discussion

By extracting *B. lanceolaria*'s leaf extracts successively in a series of solvents of increasing polarity (hexane, chloroform, methanol and water), the impact of solvent polarity on the extraction efficiency of phytochemicals and antioxidant activity was investigated. In this manner, four different extracts were obtained. After extraction of 25g of dried powdered plant material, the highest yield percentage of crude extract was obtained using polar solvents. Among the solvent extracts used, the yield % was generally observed to be high in the methanol (18.2%) and water (12.2%) extracts. Extracts prepared with hexane and chloroform presented the lowest yield percentage i.e., 9 and 12% respectively. The effect of solvent polarity on the yield percentage of the crude extracts is mentioned to depend on various factors such as plant species, varying nature of the compounds present, solvent polarity and extraction time (Dhanani *et al.*, 2017; Madhiha *et al.*, 2017).

In Folin-Ciocalteu method, the total phenol component is represented as gallic acid equivalents using the standard curve ($y = 0.004x + 0.059$, $r^2 = 0.984$). Water and methanol were found to be the most effective solvents for extracting TPC, followed by hexane and chloroform. This suggests that the amount of TPC recovered from our sample was greater in polar solvents as opposed to less polar solvents (Table 1). The majority of the polar group compounds found in *B. lanceolaria* leaf extract were highly soluble in polar solvents. Consequently, a greater yield of phenolic content was obtained from *B. lanceolaria* leaf extraction as solvent polarity increased. This finding aligns with other studies. For example, Lee *et al.* (2007) demonstrated that water is the best solvent for extracting phenolic compounds from *Pleurotus citrinopileatus*. Similarly, Ozsoy *et al.* (2008) found that water extracts contained the highest total phenolic content in *Smilax excelsa* leaves, while ethyl acetate extracts

contained the least. Banerjee and Bonde (2011) reported that methanol, a polar solvent extracted significantly more total phenolics from *Bridelia retusa* Spreng bark compared to other solvents. Laglaoui *et al.* (2014) found that water extracts of *Mentha* species had the highest recovery percentage and extractable total phenolic content, followed by methanol extracts.

From the results depicted in Table 1, higher concentration of flavonoid was present in water and methanol leaf extracts. The total flavonoid contents of hexane extract (HE), chloroform extract (CE), methanol extract (ME) and water extract (WE) were 22.20 ± 1.01 mg QE/g dry extract, 24.39 ± 0.95 mg QE/g dry extract, 32.20 ± 0.98 mg QE/g dry extract and 58.62 ± 0.97 mg QE/g dry extract, respectively, as determined by the standard curve ($y = 0.004x + 0.714$, $r^2 = 0.917$). Min *et al.* (2005) reported that flavonoid concentration in plant extracts depends on the polarity of the solvents used in extraction. Previous research by Turkmen *et al.* (2006) and Lapornik *et al.* (2005) also demonstrated that the extraction yield of phenolic and flavonoid content is highly dependent on solvent polarity. Flavonoids are one of the most diverse and widespread categories of natural phenolics (Shimoi, 1996). Chloroform and hexane extracts had the lowest flavonoid concentrations, with the chloroform extract having 24.39 ± 0.95 mg QE/g dry extract and the hexane extract having 22.20 ± 1.01 mg QE/g dry extract. In this study, the water extract showed higher levels of total phenol and flavonoid contents than the other extracts. Both flavonoid and phenolic compounds are known to have multiple biological effects, including antioxidant activity (Amarowicz, 2007). These compounds act as antioxidants not only due to their ability to donate hydrogen or electrons but also because they are stable radical intermediates (Niciforovic *et al.*, 2010). Niciforovic *et al.* (2010) also reported that phenolic compounds have protective effects on humans when consumed as part of a diet. Flavonoids, a large family of polyphenolic components synthesized by plants, are natural antioxidants capable of scavenging free superoxide radicals, providing anti-aging benefits and reducing the risk of cancer (Pandey and Kumar, 2013).

The antioxidant capacity of *B. lanceolaria* was assessed using the DPPH test. In this investigation, both plant extracts and the standard lowered the DPPH radical at increasing concentrations, and the inhibitory effects of all extracts were similar to the standard used in this study. The water extract showed the highest radical scavenging activity, followed by the methanol extract, whereas the hexane extract exhibited the lowest activity with the highest IC₅₀ value. As a result, the more potent the antioxidant, the greater the drop in absorbance and hence the lower the IC₅₀ value. The strong activity of the water

Table 1. TPC and TFC in different extracts of *B. lanceolaria* leaves

Sl. No	Extract	TPC (gallic acid equivalent mg/g dry extract) *	TFC (quercetin equivalent mg/g dry extract) *
1	Hexane	15.29 \pm 0.50	22.20 \pm 1.01
2	Chloroform	12.11 \pm 0.01	24.39 \pm 0.95
3	Methanol	26.90 \pm 0.71	32.20 \pm 0.98
4	Water	71.11 \pm 0.49	58.62 \pm 0.97

*Values are the mean of triplicate experiments and represented as mean \pm SD.

extract may be attributed to the ability of polar solvents to extract larger amounts of antioxidant phytochemicals. Although the scavenging activity of the water extract exceeded that of ascorbic acid, it was evident that the extract possessed proton-donating ability, enabling it to function as a primary antioxidant. The IC₅₀ value obtained for the ascorbic acid standard in our DPPH assay (i.e., 116.51 ± 0.52 µg/mL) is higher than commonly reported values. We attribute this difference to methodological factors that can substantially influence the apparent potency of antioxidants in the DPPH system. In our protocol, the final reaction volume was 3mL (1mL standard/extract + 2mL of 0.1 mM DPPH) and the incubation was carried out for 30 min at 37 °C; variations in DPPH concentration, dilution within the reaction mixture and incubation conditions are known to shift IC₅₀ values upward. Additional factors such as the solvent used for the standard, blank correction and possible partial oxidation of ascorbic acid may also contribute to the observed value. Importantly, because all samples and the standard were assayed under identical conditions, the comparative antioxidant activity trends reported in this study remain valid.

The IC₅₀ values followed the order: water > methanol > chloroform > hexane (Table 2). Variation in antioxidant activity is influenced by the polarity of plant constituents (Hayouni *et al.*, 2007), with polar solvents extracting polar antioxidant molecules more effectively (Bimakar *et al.*, 2011). These findings agree with the observations of Bhaumik *et al.* (2008), who also reported stronger free radical scavenging activity in polar extracts of *B. lanceolaria*, particularly methanolic fractions. Similarly, the results of Vineet *et al.* (2015) demonstrated that *B. lanceolaria* possesses significant antioxidant potential, with polar extracts showing superior activity compared to non-polar ones. Both earlier studies support our findings that the effectiveness of *B. lanceolaria* extracts is closely related to solvent polarity and the presence of polar phytochemicals such as phenolics and flavonoids.

Liu *et al.* (2009) reported that phenols and flavonoids were the main antioxidant components, and their total contents were directly proportional to their antioxidant activity. This agrees with Rice-Evans *et al.* (1997) who reported that phenolic compounds and flavonoids have been associated with anti-oxidative action in biological systems acting as scavengers of singlet oxygen and free radicals. It was elucidated in our study that the water extract showed highest antioxidant activities than the other solvents. The current findings were consistent with those published in the literature, where phytochemicals such as phenol, flavonoid content and antioxidant activity were altered by extracting solvent. According to Tiwari *et al.* (2011), the type of solvent used will determine the compounds that are likely to be extracted from plant material. During extraction, organic solvents penetrate the solid substance and solubilize compounds of identical polarities. The difference in polarizability exposes

Table 2. IC₅₀ values of four extracts of *B. lanceolaria* in DPPH assay

Sl. No.	Extracts	IC ₅₀ (µg/mL)*
1	Hexane	172.64±1.38
2	Chloroform	155.97± 0.50
3	Methanol	144.29± 0.63
4	Water	113.43± 0.10
5	Standard (Ascorbic Acid)	116.51± 0.52

*Values are the mean of triplicate experiments and represented as mean ± SD

phytochemicals to a variety of unique interactions with polar solvents, resulting in polarity-dependent extraction yield variation, which explains this current observation.

4. Conclusion

In summary, the findings indicated that the solvent employed has a major impact on the recovery of phenols and flavonoid content in *B. lanceolaria*. Furthermore, polar solvent extracts, such as those made with water and methanol, demonstrated promising antioxidant potential as determined by the DPPH technique. Among the solvents investigated, water was shown to be most effective for extracting antioxidant components from *B. lanceolaria*. Thus, the current findings support the strong antioxidant activity of water extract when used in vitro. As a result, the extract might be used as a reliable and secure source of antioxidants.

Acknowledgement

The authors are thankful to the Department of Biotechnology, Bodoland University for providing the laboratory facilities to carry out the research.

References

- Ainsworth E A and Gillespie K M 2007. Estimation of total phenolic content and other oxidation substrates in plant tissues using Folin Ciocalteu reagent. *Nat. Protoc.* 2(4): 875-877.
- Alebious C and Yusuf A 2015. Phytochemical screening, thin-layer chromatographic studies and UV analysis of extracts of *Citrullus lanatus*. *J. Pharma. Chem. Biol. Sci.* 3(2): 214-220.
- Alhamani F, Kumar S and Khan S A 2013. Estimation of total phenolic content, in-vitro antioxidant and anti-inflammatory activity of flowers of *Moringa oleifera*. *Asian Pac. J. Trop. Biomed.* 3: 623-627.
- Al-Mansoub M A, Asmawi M Z and Murugaiyah V 2013. Effect of extraction solvents and plant parts used on the antihyperlipidemic and antioxidant effects of *Garcinia atroviridis*: A comparative study. *J Sci. Food Agri. Res.* 94(8): 1552-8.
- Amarowicz R 2007. Tannins: the new natural antioxidants?. *Eur. J. Lipid Sci. Technol.* 109: 549-551.
- Amarowicz R, Pegg R B, Rahimi-Moghaddam P, Barl B and Weil J A 2004. Free radical scavenging capacity and antioxidant activity of selected plant species from the Canadian prairies. *Food Chem.* 84 (4): 551-562.
- Auddy B, Ferreira M, Blasina F, Lafon L, Arredondo F, Dajas F, Tripathi P C, Seal T and Mukherjee B 2003. Screening of antioxidant activity of three Indian medicinal plants, traditionally used for the management of neurodegenerative diseases. *J. Ethnopharmacol.* 84(2): 131-138.
- Banerjee S K and Bonde C 2011. Total phenolic content and antioxidant activity of extracts of *Bridelia retusa* Spreng Bark: Impact of dielectric constant and geographical location. *J. Med.*

- Plants Res. 5(5): 817-822.
- Bhaumik U K, Kumar D A, Selvan V T, Saha P, Gupta M and Mazumder U K 2008. Antioxidant and free radical scavenging property of methanol extract of *Blumea lanceolaria* leaf in different in vitro models. Pharmacologyonline. 2: 74-89.
- Bimakr M, Rahman R A, Taip F S, Ganjloo A, Salleh L M, Selamat J and Zaidul I 2011. Comparison of different extraction methods for the extraction of major bioactive flavonoid compounds from spearmint (*Mentha spicata* L.) leaves. Food Bioprod. Process. 89 (1): 67-72.
- Breemen R, Tao Y and Li W 2011. Cyclooxygenase-2 inhibitors in ginger (*Zingiber officinale*). Fitoterapia. 82(1): 38-43.
- Cai Y, Luo Q, Sun M and Corke H 2004. Antioxidant activity and phenolic compounds of 112 traditional Chinese medicinal plants associated with anticancer. Life Sci. 74(17): 2157-2184.
- Chawngkunga C 2005. Medicinal Plants Used as Healing Agents by the Ethnic People of Mizoram, Aizawl. pp. 3-4.
- Dhanani T, Shah S, Gajbhiye N A and Kumar S 2017. Effect of extraction methods yield, phytochemical constituents and antioxidant activity of *Withania somnifera*. Arab. J. Chem. 10(1): S1193-9.
- Dong H, Zhang Q, Li L, Liu J, Shen L, Li H and Qin W 2015. Antioxidant activity and chemical compositions of essential oil and ethanol extract of *Chuanminshen violaceum*. Ind. Crops Prod. 76: 290-297.
- Gouveia S, Castilho P C and Castilho P 2011. Antioxidant potential of *Artemisia argentea* L'Her alcoholic extract and its relation with the phenolic composition. Int. Food Res. 44 (6): 1620-1631.
- Hayouni E A, Abedrabba M, Bouix M and Hamdi M 2007. The effects of solvents and extraction method on the phenolic contents and biological activities in vitro of Tunisian *Quercus coccifera* L. and *Juniperus phoenicea* L. fruit extracts. Food Chem. 105(3): 1126-1134.
- Hou W C, Lin R D, Cheng K T, Hung Y T, Cho C H, Chen C H, Hwang S Y and Lee M H 2003. Free Radical-Scavenging activity of Taiwanese native plants. Phytomed. 10(2): 170-175.
- Khakhalary S, Narzari S, Sarmah J, Paul M and Dutta T 2022. Chromatographic analysis of *Blumea lanceolaria* (Roxb.) Druce leaf extract: A traditional herbal drug of North East India. Appl. Biol. Res. 24(1): 96-104.
- Laglaoui A, Barchan A, Bakkali M, Arakrak A and Pagan R 2014. The effect of solvents polarity on the phenolic contents and antioxidant activity of three *Mentha* species extracts. Int. J. of Curr. Microbiol. Appl. Sci. 3(11): 399-412.
- Lapornik B, Prosek M and Wondra A G 2005. Comparison of extracts prepared from plant by products using different solvents and extraction time. J. Food Eng. 71(2): 214-222.
- Lee Y L, Huang G W, Liang Z C and Mau G L 2007. Antioxidant properties of three extracts from *Pleurotus citrinopileatus*. Food Sci. Technol. 40(5): 823-833.
- Liu S C, Lin J T, Wang C K, Chen H and Yang D 2009. Antioxidant properties of various solvent extracts from lychee (*Litchi chinensis* Sonn.) flowers. Food Chem. 114(2): 577-81.
- Madiha Y I, Rukayadi Y and Norhayati H 2017. Effects of extraction conditions on yield, total phenolic contents and antibacterial activity of methanolic *Cinnamomum zeylanicum* Blume leaves extract. Int. Food Res. J. 24(2):779-86.
- Min G and Zhao C 2005. Comparison of techniques for the extraction of flavonoids from cultured cells of *Saussurea medusa* Maxim. World J. Microbiol. Biotechnol. 21:1461-1463.
- Muchandi A A and Dhawale S C 2017. Estimation of total phenolic contents, total flavonoid contents and muscle coordination activity of ethanolic extract of *Stereospermum suaveolens* DC. Int. J. Res. Pharm. Nano Sci. 6(3): 118 - 124.
- Niciforovic N, Mihailovic V, Maskovic P, Solujic S, Stojkovic A and Muratspahic D P 2010. Antioxidant activity of selected plant species, potential new sources of natural antioxidants. Food Chem. Toxicol. 48(11): 3125-3130.
- Niggeweg R, Michael A J and Martin C 2004. Engineering plants with increased levels of the antioxidant chlorogenic acid. Nat. Biotechnol. 22(6): 746-754.
- Okello D, Lee J and Kang Y 2020. Ethnopharmacological potential of *Aspilia africana* for the treatment of inflammatory diseases. Evid. Based Complementary Altern. Med. 8091047: 1-11.
- Ozsoy N, Can A, Yanardag R and Akev A 2008. Antioxidant activity of *Smilax excels* L. leaf extracts. Food Chem. 110: 571-583.
- Pandey A K and Kumar S 2013. Chemistry and biological activities of Flavonoids: An overview. Sci. World J. 1-6.
- Rai P K and Lalramnghinglova H 2010. Ethnomedicinal plant resources of Mizoram, India. Implication of traditional knowledge in health care system. Ethnobotanical Leaflets. 14:274-305.
- Rice-Evans C, Sampson J, Bramley P M and Holloway D E 1997. Why do we expect carotenoids to be antioxidants in vivo. Free Radic. Res. 26(4): 381-398.
- Saikia K, Lalawmpuii R and Borhogain P 2017. Evaluation of in vitro antioxidant and cytotoxic activity of methanolic leaf extract of *Blumea lanceolaria* Roxb. Int. J. Tech. Res. Appl. 5: 54-57.
- Saikia K, Lalawmpuii R and Kalita P 2020. Evaluation of in vitro antioxidant and cytotoxic activity of methanolic leaf extract of *Blumea lanceolaria* Roxb. J. Med. Plant. Stud. 8(3): 10-13.
- Sani I, Abdulhamid A and Bello F 2014. *Eucalyptus camaldulensis*: Phytochemical composition of ethanolic and aqueous extracts of the leaves, stem-bark, root, fruit and seeds. Bello J. Sci. Innovative Res. 3(5): 523-526.
- Sarker U and Oba S 2020. Phenolic profiles and antioxidant activities in selected drought tolerant leafy vegetable amaranth. Sci. Rep. 10 (1): 18287-18311.
- Sawmliana M. 2003. The Book of Mizoram Plants. 1st Ed. Lois Bet, Chandmari, Aizawl. pp. 114.
- Shimoi K, Masuda S, Shen B and Kinai N 1996. Radioprotective effects of antioxidative plant flavonoids in mice. Mutat. Res. 350 (1):153-161.
- Tiwari P, Kumar B, Kaur M, Kaur G and Kaur H 2011. Phytochemical screening and Extraction: A Review. Intern Pharma. Sci. 1(1): 98-106.
- Turkmen N, Sari F and Velioglu Y S 2006. Effects of extraction solvents on concentration and antioxidant activity of black and black mate tea polyphenols determined by ferrous tartrate and Folin -Ciocalteu methods. Food Chem. 99(4):835-41.
- Vineet K M, Ajit K P, Nachimuthu S K, Bhim P S, Mishra V K, Passari A, Vanlalhmangaihi K, Kumar N S and Singh B P 2015. Antimicrobial and antioxidant activities of *Blumea lanceolaria* (Roxb.) J. Med. Plants Res. 9(4):84-90.
- Xu J G, Hu Q P and Liu Y 2012. Antioxidant and DNA-protective activities of chlorogenic acid isomers. J. Agri. Food Chem. 60 (46): 11625- 11630.