IJLSR (2017), Vol. 3, Issue 4 **Review Article**

IJLSR INTERNATIONAL JOURNAL OF LIFE SCIENCES AND REVIEW

Received on 20 January 2017; received in revised form, 16 April 2017; accepted, 18 April 2017; published 30 April 2017

A MINI REVIEW ON AN IMPORTANT MEDICINAL PLANT *CENTELLA ASIATICA*

Arpita Roy

M. Tech - Industrial Biotechnology, Department of Biotechnology, Delhi Technological University, New Delhi - 110042, India.

ABSTRACT: In the Ayurvedic system of medicine, *Centella asiatica* (gotu kola) is one of the important rejuvenating herbs for nerve and brain cells and is believed to be capable of increasing intelligence, longevity, and memory. It contains several active constituents, and the most important bioactive compounds are triterpenoid saponins, including asiaticoside, centelloside, madecassoside, and asiatic acid. It possesses anti-leprotic, anti-viral, anti-bacterial, anti-tumor activities. Due to its medicinal importance, this plant is being overexploited and to conserve this plant, it is necessary to micropropagate this plant in a laboratory with high biomass yield.

Keywords: *Centella asiatica*, Asiaticoside, Pharmacological activity, *In-vitro* studies

Correspondence to Author:
Arpita Roy

M. Tech - Industrial Biotechnology, Department of Biotechnology, Delhi Technological University, New Delhi - 110042, India.

E-mail: arbt2014@gmail.com

INTRODUCTION: Medicinal plants are the traditional source of many pharmaceutically important compounds. In recent times, they are utilized by the pharmaceutical companies for the preparation of several formulations. In the present time, there has been an increase in the use of herbal products around the world [1]. In the last 20 years, about 28% of new chemical compounds that are launched into the market are accounted for by the natural products [2]. World Health Organisation (WHO) also stated that more that 80% of the world's population relies on herbal medicines [3]. Importance of medicinal plants is due to the presence of specific chemical compounds that produce a physiological effect on the human body.

QUICK RESPONSE CODE

DOI: 10.13040/IJPSR.0975-8232.IJLSR.3(4).38-44

Article can be accessed online on: www.ijlsr.com

DOI link: http://dx.doi.org/10.13040/IJPSR.0975-8232.IJLSR.3(4).38-44

These bioactive chemical constituents of plants include saponin, flavonoids, alkaloids, sterols, tannins, phenols [4]. Medicinal plant-based drugs have an advantage over the other drugs because they are simple, effective and offer a broad spectrum of activity. Furthermore, they have very less adverse side effects as compare to chemotherapeutic drugs [5]. India is rich in medicinal plant diversity, and since the ancient times use of drugs of herbal origin is prevalent in the traditional system of medicines such as *Ayurveda* and *Unani*. There are about 426 biomes which comprise of different habitat diversity that gives rise to the richest centers for plant genetic resources in the world [6]. Out of 18,665 flowering species, only about 3000 plants have been used for the various formulations in the classic system of medicines such as *Ayurveda*, *Siddha* and *Unani* [7].

Centella asiatica is one of the important traditional medicinal plant belonging to family Apiaceae and commonly known as 'Gotu kol,' 'Indian Pennywort' or 'Mandookaparni' in India.

It is an important perennial medicinal herb found in the tropical and subtropical countries like India, Sri Lanka and Bangladesh. *C. asiatica* contains several triterpenes, saponins like asiaticoside, asiatic acid, sapogenins, madecassic acid, vellarin, adecassoside, glycosides and centelloside [8].

In India, it grows up to an altitude of 600-1800 meters above the sea level [9, 10] on moist, clayey or sandy soils forming a dense green carpet. *Centella asiatica* has a glabrous stem and long petiolated fleshy leaves rooting at nodes. Flowers are greenish to pinkish white and borne in dense umbels. Seeds are pumpkin shaped. It spreads by producing new plants on above ground runners. New plants can be separated from parent plant once they have taken roots. Leaves contain a high amount of triterpenoids [11]. It possesses several important properties like antileprotic, antistress, antifeedant, anti-tuberculosis activities, wound - healing properties [12, 13], antibacterial, antherosclerosis, and fungicidal activity [14].

It is used in the treatment of leprosy, wound, cancer, fever, allergies [15], abscesses, asthma, catarrh, convulsions, dysentery, eczema, gonorrhea, hypertension, bronchitis, headache, jaundice, pleuritis, rheumatism, ulcers, spasms, tuberculosis, urethritis, *etc*. [16] Leaves of this plant are rich in vitamin B and C. and minerals such as magnesium, potassium, calcium, phosphorus and aluminum [17].

It is also used as a brain tonic and blood purifier [18]. *C. asiatica* contains various flavonoids which include quercetin and kaempferol, rutin and naringin [19]. Due to its medicinal importance, this plant is overexploited, and there is a decline in the population of the *Centella asiatica*. International Union for Conservation of Nature and Natural resources (IUCN) listed it as threatened plant and endangered species [20].

It is considered as a brain tonic. It is also used for the treatment of asthma, bronchitis, elephantiasis, dropsy, gastric catarrh, kidney troubles, leucorrhoea, skin disease and urethritis [21] with antibacterial, anti-feedent, ant-filarial, anti-stress, anti-tuberculosis activities and wound healing properties [22, 23]. Anonymous, 1992 reported that *C. asiatica* plants contain the following glycosides: asiaticoside, indocentelloside, brahminoside, brahmoside, thankuniside, and isothankuniside. Asiaticoside is useful in the treatment of leprosy and tuberculosis. The plant shows good therapeutic effects on peptic ulcers.

Chemical Constituent: *Centella asiatica* contains various chemical constituents which includes triterpenoid saponins (asiaticoside, masecassoside, asiatic acid and medecassic acid) [24, 25], polyacetylenes [26], flavones [27], phytosterols and lipid [28] alkaloids, volatile oils, *etc*. [29] Bosse *et al*., (1979) [30] reported the amount of four active compounds which are asiatic acid (29-30%), madecassic acid (29-30%), madecassoside (1%) and asiaticoside (40%). They are the biologically active compounds and have potential to be promoted as commercial products (Indu Bala and Ng, 1999). In addition they also contain total phenolics about 23000mg/100gm [31, 32].

Saponins: Various saponins have been isolated from this plant which includes Asiaticoside, Madecassoside, Brahmoside, Centelloside, Thakuniside, *etc*. [33]

Asiaticoside: Asiaticoside was first isolated from leaves of Centella asiatica more than fifty six years ago by Polonoski (1951) [34]. It is one of the principle terpenoids of this plant; it acts as antibacterial and fungicidal agents against pathogens and fungi (Hausen, 1993) [35]. It helps in collagen I synthesis in human (Bonte F, Dumas M, Chaudagne C and Maybeck A (1994) [36], Influence of Asiatic acid, madecassic acid and asiaticoside on human collagen I synthesis, Planta Med.

It is clinically used as a wound healing agent in combination with madecassic and asiatic ascids (Hausen, 1993) [37].

Asiatic Acid: It is a pentacycluc triterpene compounds and the aglycone of asiaticoside. It exhibits bioactive efficacy [38] and also known to control cell division in human melanoma, heptoma cells and cytotoxic activity on fibroblast cells [39]. It shows protective activity against UV induced photoaging, wound healing, induces cell cycle arrest, and anti-proliferative effects on human breast, gastric, and urine cancer cells [40].

Madecassoside: It is a glycoside that acts as a strong anti-inflammatory agent [41].

Madecassic Acid: Its wound healing property has been attributed to its ability to stimulate collagen synthesis [42].

Triterpenic Acids: Several pentacyclic triterpenic acids have been isolated and characterized from this plant. They occur either in a free state or as aglycones of the naturally occurring saponins. *e.g*., asiatic acid, madasiatic acid, brahmic acid, isobrahmic acid, thankunic acid, betulic acid, centoic acid, centellic acid, 6b- Hydroxiasiatic acid & terminolic acid [43].

Phytosterols: The plant is reported to possess Stigmasterol, Campesterol, Beta-sitosterol, and stigmasterol-b-D-glucopyranoside [44]. Chowdhary *et al*., (2014) [45] reported the estimation of stigmasterol, and it is a useful substance in the medication of Alzheimer's disease. The stigmasterol obtained from best source is 0.0582%.

In a study, a patent published related to the role of stigmasterol in the treatment of Alzheimer's disease. In this invention, the use of stigmasterol is for the treatment of amyloidosis of beta-amyloid peptide and Alzheimer's diseases [46].

Thus the study of stigmasterol content in *Centella asiatica* is essential. Phytosterols have the ability to reduce cholesterol levels, and this was first demonstrated in humans in 1953 [47, 48]. Phytosterols were subsequently marketed as a pharmaceutical under the name Cytellin as to treat the elevated cholesterol [49, 50] reported that phytosterols have potential to inhibit stomach, lunch, breast and ovarian cancers. Phytosterols also have the potential to reduce the elevated triglyceride levels, which is a risk factor for cardiovascular diseases [51].

It was found that the level of triglycerides reduced by 14% by supplementing 1.6 g/day of plant sterols in a fermented milk beverage for six weeks [52]. The proposed mechanism behind the triglyceride-lowering effect of phytosterols is the reduction in triglyceride-rich very low-density lipoprotein particles produced by liver [53].

Nitrogen Containing Constituents: An alkaloid hydrocotylin, $C_{22}H_{33}O_8N$, melting point 110-12 ºC, has been isolated from this plant with 0.0016% yield. The plant also yields glycine, aspartic acid, glutamic acid, alanine and phenylalanine [54].

Flavonoids: It was found that leaves contain 3-glucosyl quercetin, 3-glucosylkaepferol and 7-glucosyl kaempferol [55].

Pharmacological Activities:

Wound Healing: Titrated extract of *Centella asiatica* which consist of a mixture of three triterpenes (asiaticoside, asiatic acid, and madecassic acid) stimulates glycosaminoglycan and collagen synthesis in rats [56]. Asiaticoside and asiatic acid were more active than madacassic acid in wound healing; thus, it appears to be an effective treatment of wound healing disturbances [57].

Central Nervous System: Mook-Jung *et al*., (1999) [58] reported that asiaticoside derivatives reduce or inhibit H_2O_2 induced cell death and lower the intracellular free radical concentration and protect against the effects of beta-amyloid neurotoxicity. *Centella asiatica* extract was found to increase brain GABA levels [59].

Memory Enhancing: Aqueous extract of *Centella asiatica* showed a significant effect in memory enhancement. This positive effect is due to the presence of brahminoside, brahmic acid, and brahmoside in plant [60, 61]. In a study, different doses of fresh leaf juice of *Centella asiatica* were given to seven-day-old neonatal rats for different time periods. These rats were then subjected to the spatial learning and passive avoidance tests along with the age-matched normal and saline control rats. Results showed that there was an improvement in spatial learning performance and enhanced memory retention in neonatal rats treated with higher doses. These results indicate that fresh leaf juice of *Centella asiatica* enhances memory retention [62].

Antibacterial: Anonymous, 1988 reported that asiaticoside was an active agent against *Bacillus leprae, Mycobacterium tuberculosis,* and *Entamoeba histolytica.* Methanolic extract of *Centella asiatica* showed inhibition zone against *V. alginolyticus, V. vulnificus,* and *Streptococcus sp.* [62]. Sankar *et al.,* (2010) [63] reported that methanolic extract of *Centella asiatica* showed antibacterial activity against three Vibrio species that are *V. harveyi*, *V. alginolyticus,* and *V. parahaemolyticus* but acetone, chloroform and hexane extract was not showed antibacterial activity against these species.

Antioxidant: In a study, it was reported that asiaticoside significantly increased the levels of catalase, superoxide dismutase, glutathione peroxidise, ascorbic acid and vitamin E in excision type cutaneous wounds in rats. The level of antioxidant activity was highest during the initial stages of treatment [64].

Hepatitis: It was found that titrated extract of *Centella asiatica* helps in the improvement in chronic hepatic disorders [65].

Cardiovascular: Montecchio *et al*., (1991) [66] reported that three-week treatment of triterpene fraction of *Centella asiatica* in clients with the post-phlebitic syndrome reduced the number of circulating endothelial cells as compared to the normal one. Cesarone *et al*., (1992) [67] reported that in a clinical trial *Centella asiatica* extract found to be efficacious in the treatment of reducing ankle, venous insufficiency, foot swelling, edema, improving capillary filtration rate and microcirculatory parameters.

Neuroprotective Effects: Ramanathan *et al*., (2007) [68] reported that *Centella asiatica* extract protects monosodium glutamate-induced neuro-degeneration. Water extract of *Centella asiatica* showed neuroprotective efficacy against 3-nitropropionic acid-induced oxidative stress in brain of prepubertal mice enhanced glutathione levels, antioxidant defenses in brain regions [69, 70].

Anti-diabetic: Chauhan *et al*., (2010) reported that triterpenic fraction of *Centella asiatica* is useful in diabetic microangiopathy by improving the micro-circulation and decreasing the capillary permeability. Also, triterpenoid fraction of *Centella asiatica* protects against the deterioration. Methanolic and ethanolic extracts had shown significant protection and lowered blood glucose levels to normal glucose levels in tolerance test.

***In-vitro* Studies:** In recent years, there has been an increased interest in *in-vitro* culture techniques which offer a viable tool for mass multiplication and germplasm conservation of rare, endangered and threatened medicinal plants. Therefore, it is important to develop an efficient micropropagation technique for *C. asiatica* to rapidly disseminate superior clones once they are identified. Tissue culture techniques can play an important role in the clonal propagation of elite clones and germplasm conservation of *C. asiatica*. Shoot regeneration from leaf derived callus and stem segments of *C. Asiatica* were reported. All parts of the plant have been used as the explant source. Nodal segments of mature plants have been however used in most cases.

Srivastava and Iqbal, (1999), reported use of nodal segments in *Ammi majus* L., nodal explants of *B. monnieri* were propagated *in-vitro* using liquid shake cultures nodal explants were also used for *Eclipta alba* shoot tip, nodal and internodal segments were reported in *Phyllanthus amarus*. Stem and leaf explants of greenhouse grown plants were used for the regeneration from callus cultures of *Centella asiatica*. Banerjee *et al*., (1999), used 5-6-month-old glasshouse-grown plants of Centella for *in-vitro* multiplication from leaf explants. Tiwari *et al.*, (2000) have reported micropropagation of Centella using nodal segments. Explants were collected from natural stands where it grows luxuriously around the marshy fringes of a pond.

Full strength Murashige & Skoog medium (1962) has been used for most of the herbaceous species. Multiple shoots were obtained from shoot tips (1-2 cm) derived from field-grown plants of *Bacopa monnieri* in Murashige and Skoog medium supplemented with 0.5 mg/l BAP within 6 days of culture, whereas in the case of *Paederia foetida* and *Centella asiatica* multiple shoots were obtained from field-grown plants in MS medium supplemented with 1.0 mg/l BAP within 7 days of culture.

Supplementation of Plant Growth Regulators such as 0.3 mg / l BAP and 0.2 mg / l kinetin have been found to show a good response of shoot proliferation in *Withania somnifera* with the regeneration of 85%. Full strength MS media with growth regulators such as 0.5 mg/l of BAP in combination with 0.01 mg/l NAA has been reported to give optimum results in *Utleria salicifolia*. Banerjee *et al.*, (1999) reported that in *Centella* initial sprouting required the presence of BAP (2 mg/l) and IBA (0.1 mg/l), however for multiple shoot induction a higher concentration of BAP (3.0 mg/l) and a lower concentration of NAA (0.05 mg/l) is required.

Tiwari *et al.,* (2000) reported that the bud break was dependent on BAP, the synergistic combination of 22.2mM BAP and 2.68mM NAA gave optimum result for the shoot number *i.e.* 4 to 5 shoots per node as well as for optimum frequency, *i.e.* 91%. Das *et al*., (2008) reported that MS media fortified with 4.0 mg/l BAP + 0.1 mg/l NAA showed average 10.2 ± 0.38 shoots per explants.

Status of *Centella asiatica:* The annual requirement of *Centella asiatica* was around 12,700 tonnes of dry biomass valued at rupees 1.5 billion. National Medicinal Plants Board, Government of India, has projected a combined demand of Centella and Brahmi of 6621.8 MT with an annual growth rate of 20.1% till the year 2004-05. This requirement is rising sharply given the popularity of mandukaparni-based drugs. Because of the large scale and unrestricted exploitation of this natural resource to meet ever increasing demand by the Indian pharmaceutical industry which is coupled with the limited cultivation and insufficient attempts for its replenishments, the wild stock of this medicinal important plant species has been markedly depleted and it is listed as a threatened species by International Union for Conservation of Nature and National Resources an endangered species. Further, there is some evidence of genotypic differences in the glycoside content and medicinal properties.

Side Effects and Toxicity: Alcoholic extracts of *Centella asiatica* have shown no toxicity at doses of 350 mg/kg when given to rats. Reported adverse effects include GI upset and nausea. Topical use of the extract has led to reports of rash. Three cases of jaundice with elevated liver enzymes were reported in Argentina following dosing of Centella. Patients had taken Centella (standardization and dose unknown) for 20-60 days and recovered on discontinuation of the herb.

CONCLUSION: *Centella asiatica* has been used for many years for the treatment of various diseases. A significant amount of work has been done on its pharmacological activity and possible applications of chemical compounds from the whole part of the plant. The present review shows that *Centella asiatica* contains several different phytocompounds like saponins, glycosides, phytosterols, flavonoids, *etc*. Out of these phytocompounds saponins, *i.e*. asiaticoside is an important one who is responsible for the different pharmacological activity.

It was found that asiaticoside is the main phytocompound which helps in the wound healing activity. *Centella asiatica* also helps in the improvement of neurodegenerative disorder, *i.e.* Alzheimer's as it improves the memory. So it can be utilized as a drug for the treatment of neurodegenerative disorders. *In-vitro* propagation shows that the plant has maximum growth in MS media with different concentration of auxins and cytokinins. Most commonly used cytokinin is BAP (1-4 mg/l) for the shooting multiplication. In future micropropagation and cryopreservation can be used for the conservation of the plant.

ACKNOWLEDGEMENT: Nil

CONFLICT OF INTEREST: Nil

REFERENCES:

1. Ahmad RU: Medicinal plants used in ISM – Their procurement, cultivation, regeneration and import/export aspects: a review. In: Govil JN, Singh VK & Hashmi S (eds) Medicinal Plants: New Vistas of Research, Part 1 (pp 221-258). Today and Tomorrow Printers and Publishers, New Delhi 1993.
2. Kumar DA and Seeni S: Rapid clonal multiplication through *in-vitro* axillary shoot proliferation of *Aegle marmelos* (L.) Corr., a medicinal tree. Plant Cell Reports 1998; 17: 422-26.
3. Anonymous In: The Wealth of India: A Dictionary of Indian Raw Materials and Industrial Products. CSIR, New Delhi, India 1998; 2: 116-18.
4. Anonymous: Wealth of India, Raw Materials, CSIR, New Delhi 1992; 2: 48.
5. Banerjee S, Zehra M and Kumar S: *In-vitro* multiplication of *Centella asiatica*, a medicinal herb from leaf explants. Current Science 1999; 76: 110-12.
6. Binns SE, Arnason JT and Baum BR: Phytochemical variation within populations of *Echinacea angustifolia* (Asteraceae). Biochem Syst Ecol, 2002; 30: 837-54.
7. Brinkhaus B, Lindner M, Schuppan D and Hahn EG: Chemical, pharmacological and clinical profile of the East Asian medicinal plant *Centella asiatica*, Phytomedicine 2000; 7(5): 427-48.
8. Brinker F: Herb Contraindications and Drug Interactions. 2nd ed. Sandy, OR: Eclectic Medical Publications 1998; 78.
9. Bradwejn J, Zhou Y, Kosyzycki D: A double-blind, placebo-controlled study on the effects of *Gotu kola* on acoustic startle response in healthy subjects. J Clin Psychopharmacol 2000; 20: 680-84.
10. Bosse JP, Papillon J, Frenette G, Dansereau J, Cadotte M, and Le Lorier J: Clinical study of a new antikeloid agent. Ann Plast Surg 1979; 3(1): 13-21.

11. Bhavan BV: Selected Medicinal Plants of India. Bombay, India; Tata Press 1992.
12. Cesarone MR, Incandela L and De Sanctis MT: Flight microangiopathy in medium to long-distance flights: prevention of edema and microcirculation alterations with a total triterpenic fraction of *Centella asiatica*. Angiology 2001; 52: S33-S37
13. Cesarone MR, Laurora G, Sanctis MT de and Belcaro: Activity of *Centella asiatica* in venous insufficiency. Minerva Cardioangiol 1992; 40(4): 137-43.
14. Chakraborty T, Babu SPS and Sukul NC: Preliminary evidence of antifilarial effect of *Centella asiatica* on *Canine dirofilariasis*. Fitoterapia 1996; 67: 110-12.
15. Chatterjee TK, Chakraborty A, Pathak M and Sengupta GC: Effects of plant extract *Centella asiatica* (Linn.) on cold restraint stress ulcer in rats. Indian Journal of Experimental Biology 1992; 30(10): 89-91.
16. Chauhan PK, Pandey IP and Dhatwalia VN: Evaluation of the anti-diabetic effect of ethanolic and methanolic extracts of *Centella asiatica* leaves extract on alloxan-induced diabetic rats. Advances in Biological Research 2010; 4(1): 27-30.
17. Chen YY, Wang CA, Liu HY, Qiu JS and Bao XH: Ag/SiO_2: A novel catalyst with high activity and selectivity for hydrogenation of chloronitrobenzenes. Chem Commun 2005; 42: 5298-300.
18. Chowdhary A, Chaturvedi P and Memon R: Stigmasterol variation in a *Medhya Rasayan* plant (*Centella asiatica* L.: Apiaceae) collected from different regions. Indian Drugs 2014; 51(03):
19. Darnis F, Orcel L, Saint-Maur PP and Mamou P: Use of a titrated extract of *Centella asiatica* in chronic hepatic disorders. Sem Hop 1979; 55(37-38): 1749-50.
20. Singh D, Singh P, Gupta A, Solanki S, Sharma E and Nema R: Qualitative estimation of the presence of bioactive compounds in *Centella asiatica*: an important medicinal plant. International Journal of Life Science and Medical Science 2012; 2.
21. Eun HC and Lee AY: Contact dermatitis due to madecassol. Contact Dermatitis 1985; 13: 310-13.
22. Gangaprasad A, Nair LG, Radhakrishnan K, Seeni S, Nair GM and Pushpangadan P: Micropropagation of *Utleria salicifolia* endemic and endangered ethnomedical plant of the Western Ghats. Journal of medicinal and Aromatic Plant Sciences 2003; 25: 19-24.
23. Gawde AJ and Pratkar GT: Micropropagation of *Eclipta alba* Hassk.: An approach to shorten the protocol. Indian Journal of Biotechnology 2004; 3: 128-32.
24. George S, Remashree AB, Sebastian D and Hariharan M: Phytomorphology 2004; 54: 31-34.
25. Grimaldi R, De Ponti F, D'Angelo L, Caravaggi M, Guidi G, Lecchini S, Frigo GM and Crema A: Pharmacokinetics of the total triterpenic fraction of *Centella asiatica* after single and multiple administrations to healthy volunteers. A new assay for asiatic acid. J Ethnopharmacol 1990; 28(2): 235-41.
26. Ghanti KS, Govindaraju B, Venugopal RB, Rao SR, Kaviraj CP, Jabeen FTZ, Barad A and Rao S: High frequency regenration from *Phyllanthus amarus* Schum. & Thonn. Indian Journal of Biotechnology 2004; 3: 103-07.
27. Guseva NG, Starovoitova MN and Mach ES: Madecassol treatment of systemic and localized scleroderma. Ter Arkh 1998; 70(5): 58-61.
28. Heupel RC: Isolation and primary characterization of sterols In: Analysis of Sterols and Other Biologically Significant Steroids. pp. 1-32 (W.D. Nes and E.J. Parish (eds), Academic Press, Inc, San Diego, CA) 1989.
29. Jones PJ: Ingestion of phytosterols is not potentially hazardous. The Journal of Nutrition 2007; 137(11): 2485-86.
30. Jorge OA and Jorge AD: Hepatotoxicity associated with the ingestion of *Centella asiatica*. Rev Esp Enferm Dig 2005; 97: 115-24.
31. Joy PP, Thomas J, Mathew S and Skaria BP: Medicinal Plants. Tropical Horticulture 2001; 449-32.
32. Kakkar KK: Mandukaparni- medicinal uses and therapeutic efficiency. Indian Drugs 1988; 26: 92-97.
33. Karthikeyan K, Chandran C and Klothungan S: Rapid clonal multiplication through *in-vitro* axillary shoot proliferation of *Centella asiatica* L. Indian Journal of Biotechnology 2009; 8: 232-35.
34. Kulkarni AA, Thengane SR and Krishnamurthy KV: Direct shoot regeneration from node, internode, hypocotyl and embryo explants of *Withania somnifera*. Plant Cell Tissue and Organ Culture 2000; 62 (3): 203-09.
35. Malloy MJ and Kane JP: A risk factor for atherosclerosis: Triglyceride-rich lipoproteins. Advances in Internal Medicine 2001; 47: 111-36.
36. Maquart FX, Chastang F, Simeon A, Birembaut P, Gillery P and Wegrowsky Y: Triterpenes from *Centella asiatica* stimulate extracellular matrix accumulation in experimental rat wounds. European Journal of Dermatologists 1991; 9(4): 289-9.
37. Montecchio GP, Samaden A, CarboneS, Vigotti M, Siragusa S and Piovella F: C*entella asiatica* Triterpenic Fraction (CATTF) reduces the number of circulating endothelial cells in subjects with postphlebitic syndrome. Haematologica 1991; 76(3): 256-59.
38. Mook-Jung I, Shin JE, Yun SH, Huh K, Koh JY, Park HK, Jew SS and Jung MW: Protective effects of asiaticoside derivatives against beta-amyloid neurotoxicity. Journal Neuroscience Res 1991; 58(3): 417-25.
39. Palaniselvam K, Velanganni AAJ, Govindan SN and Karthi: Leaf assisted bioreduction of silver ions using leaves of *Centella asiatica* L. and its bioactivity. E-Journal of Life Sciences 2012; 1: 46-49.
40. Palaniselvam K, Velanganni AAJ, Natanmurugaraj S and Karthi G: Bioreduction of *Centella asiatica* L and its bioactive investigation. International Journal of Agriculture and Life Sciences 2015; 1(1): 14-18.
41. Pandey NK, Tewari KC, Tewari RN, Joshi GC, Pande VN and Pandey G: Medicinal plants of Kumaon Himalaya, strategies for conservation. In: Dhar U (ed) Himalayan Biodiversity Conservation Strategies. Himvikas Publication, Nainital 1993; 3: 293-02.
42. Patra A, Rai B, Rout GR and Das P: Successful regeneration from callus cultures of *Centella asiatica* (Linn.) Urban. Plant Growth Regulation 1998; 24: 13-16.
43. Nuria P, Catherine N, Raimon F, Jordi C, Rosa C, Jesus V and Luis M: Danacol, Group "Plant sterol-enriched fermented milk enhances the attainment of LDL-cholesterol goal in hypercholesterolemic subjects." European Journal of Nutrition 2008; 47(1): 32-9.
44. Jogchum P, Mensink and Ronald P: Plant Stanol Esters Lower Serum Triacylglycerol Concentrations *via* a Reduced Hepatic VLDL-1 Production. Lipids 2009; 44(12): 1149-53.
45. Pollak OJ: Reduction of blood cholesterol in man. Circulation 2005; 7(5): 702-6.
46. Prakash E, Sha Valli Khan PS, Sairam Reddy P and Rao KR: Regeneration of plants from seed – derived callus of *Hybanthus enneaspermus* L. Muell- a rare ethnobotanical herb. Plant Cell Rep 1991; 18: 873-78.

47. Rao KGM, Rao SM and Rao SG: *Centella asiatica* (Linn) induced behavioral changes during growth spurt period in neonatal rats. Neuroanatomy 2005; 4: 18-23.
48. Ramanathan M, Sivakumar S, Anandvijayakumar PR, Saravanababu C and Pandian PR: Neuroprotective evaluation of standardized extract of *Centella asciatica* in monosodium glutamate-treated rats. Indian J Exp Biol 2007; 45(5): 425-31.
49. Rush WR, Murray GR and Graham DJ: The comparative steady-state bioavailability of the active ingredients of Madecassol. Eur J Drug Metab Pharmacokinet 1993; 18(4): 323-26.
50. Sahoo Y and Chand PK: Micropropagation of *Vitex negundo* L., A woody aromatic medicinal shrub, through high-frequency axillary shoot proliferation. Plant Cell Reports 1998; 18: 301-07.
51. Biradar SR, Bhagyashri D, Rachetti and Suryawanshi VS: Phytoconstituents of a valuable ayurvedic medicinal herb *Centella asiatica* (L) Urb. Trends in Biotechnology Research 2013; 2.
52. Sankar GK, Ramamoorthy K, Sakkaravarthi K and Elavarsi A: Antibacterial activity of herbal extract on pathogens isolated from the swollen hind gut of *P. Monodon* (fabricus), Der Pharmacia Sinica 2010; 1(3): 17-22.
53. Sharma BL and Kumar A: Biodiversity of medicinal plants of *Triyugi Narain* (Garhwal Himalaya) and their conservation. National conference on recent trends in spices & medicinal plant research, A-78 (2-4 April). Calcutta, WB, India, 1998.
54. Shukla A, Rasik AM, Jain GK, Shankar R, Kulshrestha DK and Dhawan BN: *In-vitro* and *in-vivo* wound healing activity of asiaticoside isolated from *Centella asiatica*. Journal of Ethnopharmacology 1999; 65(1): 1-11.
55. Singh HG: Himalayan herbs and drugs, importance and extinction threat. Journal of Medicinal and Aromatic Plant Sciences 1989; 19: 1049-56.
56. Singh S, Ray BK, Mathew S, Buragohain P, Gogoi S, Sharma BK and Deka PC: Micropropagation of a few important medicinal plants. Annals of Biology (Ludhiana) 1999; 15: 1-7.
57. Srivastava R, Shukla YN and Kumar S: Chemistry and pharmacology of *Centella asiatica*: a review. Journal of Medicinal & Aromatic Plant Science 1997; 19: 1049-56.
58. Shinomol KG and Muralidhara: Prophylactic neuroprotective property of *Centella asiatica* against 3-nitropropionic acid-induced oxidative stress and mitochondrial dysfunctions in brain regions of prepubertal mice. Neurotoxicology 2008; 29: 948-57.
59. Shinomol KG, Ravikumar H and Muralidhara: Prophylaxis with *Centella asiatica* confers protection to prepubertal mice against 3-nitropropionic-acidinduced oxidative stress in brain. Phytotherapy Research 2010; 24: 885-92.
60. Tilvis RS and Miettinen TA: Serum plant sterols and their relation to cholesterol absorption. The American Journal of Clinical Nutrition 1986; 43 (1): 92-7.
61. Tiwari KN, Sharma NC, Tiwari V and Singh BD: Micropropagation of *Centella asiatica* (L.), a valuable medicinal herb. Plant Cell, Tissue and Organ Culture 2000; 63: 179-85.
62. Tiwari V, Tiwari KN and Singh BD: Suitability of liquid cultures for *in-vitro* multiplication of *Bacopa monnieri* (L.) Wettst. Phytomorphology 2000; 50: 337-42.
63. Turton S. *Centella asiatica*. Aust J Herbalism 1993; 5: 60.
64. Upadhyay SC, Khosa RL, Sharma DN, Kumar M and Chanasuria JPN: Total glycoside content and antistress activity of Indian and Mauritius *Centella asiatica* – a comparison. Indian Drugs 1991; 28: 338-89.
65. Das R, Hasan MF, Hossain MS and Rahman M: Micropropagation of *Centella asiatica* L. an important medicinal herb. Progress Agric 2008; 19(2): 51-56.
66. Vogel HG, DeSouza N and D'Sa A: Effects of terpenoids isolated from *Centella asiatica* on granuloma tissue. Acta Therapeutica 1990; 16: 285-98.
67. Wang PJ and Charle A: Micropropagation through meristem culture in biotechnology in agriculture and forestry. Biotechnology Agriculture Bajaj Y.P.S. (eds), Springer Verlag, 1991; 41-44.
68. Wei LS, Musa N, Sengm CT, Wee W and Shazili NAM: Antimicrobial properties of tropical plants against pathogenic bacteria isolated from aquatic organisms, African Journal of Biotechnology 2008; 7(13): 2275-78.
69. Winkler JK, Rennick KA, Eller FJ and Vaughn SF: Phytosterol and tocopherol components in extracts of corn distillers dried grain. J Agr Food Chem 2007; 55: 6482-86.
70. Woyengo TA, Ramprasath VR and Jones PJH: Anticancer effects of phytosterols. European Journal of Clinical Nutrition 2009; 63(7): 813-20.

How to cite this article:
Roy A: A mini review on an important medicinal plant *Centella asiatica*. Int J Life Sci & Rev 2017; 3(4): 38-44. doi: 10.13040/IJPSR. 0975-8232.IJLSR.3(4).38-44.