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Original article

Phytochemical characteristics of aerial part of *Cissus quadrangularis* (L) and its *in-vitro* inhibitory activity against leukemic cells and antioxidant properties

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ABSTRACT

Background and Objectives: *Cissus quadrangularis Linn,* is a rich bioresource for folk and traditional medicines from ancient times till date. The present study aimed to investigate the free radical scavenging and anticancer efficacy *in vitro* of the ethanolic and methanolic extract from the aerial parts of *Cissus quadrangularis* (L).

Material and Methods: *In vitro* cell-free antioxidant analyses were performed for the ethanolic extract of *Cissus quadrangularis* (L). (EECQ) and methanolic extract of *Cissus quadrangularis* (L). (MECQ) using different free radical scavenging assays includes DPPH, nitric oxide, superoxide, metal chelation, and hydrogen peroxide radical scavenging assays. *In vitro* leukemic cytotoxic assessment by MTT assay was performed both EECQ and MECQ extract against HL-60 cell lines.

Results: Strong antioxidant effects were recorded in EECQ and MECQ in all the cell-free models. The ethanolic extract exhibited a significant dose-dependent free radical activity in comparison with methanolic extracts. The EECQ and MECQ possess pronounced anticancer efficacy against leukemic cells HL-60 with an IC_{50} value of 36 µg/mL and 40 µg/mL respectively.

Conclusion: Present data indicates the presence of marked antioxidant and anticancer behaviors in the extracts of aerial portions of *Cissus quadrangularis* (L). extracts. Thus, *Cissus quadrangularis* (L). poses as a promising safe chemopreventive plant to combat cancer.

1. Introduction

Cancer is defined as a multistep disease incorporating external and internal factors like environmental, physical, chemical, metabolic, infectious organisms, mutations, and genetic factors (inherited mutations) which play a major role in the induction and progression of cancers (Croce, 2008). Cancer is a major life-threatening global health problem and facing multiple health challenges worldwide. In 2018, cancer burden increased to 18.1 million new cases and 9.6 million deaths worldwide (Bray et al., 2018). Limited progress of clinical rehabilitation including chemotherapy, radiation, surgery and immunomodulation is evident by the high mortality and morbidity rates and demands for new treatment regimens that are efficacious and safe in preventing cancer (Balunas and Kinghorn, 2005). Drug discovery from traditional medicinal herbs have played a significant role in the therapeutic management of cancer and, undoubtedly, most novel clinical applications of medicinal plants and its secondary metabolites and derivatives of the medicinal plants over the last five decades have been effectively applied against combating cancer (Greenwell and Rahman, 2015). In 2019, the National Cancer Institute, under the development therapeutics program collected about 80,000 plant samples from 25 tropical and subtropical countries and screened around 150,000 natural product fractions with modern high-throughput targeted screening technologies in 2019 for a target against cancer. Most of the cancer drugs on worldwide sales were natural compounds and natural product pharmacophore (Namiki, 1990). Therefore, natural compounds and natural product pharmacophore therapeutic approaches are promptly necessary and it has directed reconsideration of the treatment regimens for a safer drug to combat cancer.

Naturally occurring polyphenolic compounds, includes flavonoids, anthocyanidins, phenolic acids, and tannins, possess

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extraordinary free radical scavenging and anticancer properties. Recent research exhibits that the enhanced dietary consumption of natural antioxidant foods exhibits a significant reduction in cancer mortality, coronary heart disease, with longer life expectancy (Prasad et al., 2009; Chatterjee and Chandraprakash, 1994). Most of the dietary polyphenolic components are derived from plant products possesses high free radical quenching effects compared to the standard antioxidant vitamin C. Consumption of antioxidant-rich fruits and vegetables significantly decreases the risk of metabolic and cancer diseases signifying that naturally occurring antioxidants could be potentially effective drug targets.

Cissus quadrangularis (L). is a perennial climber of family vitaceae, that is widespread in tropical regions of India. It has been used to relieve dyspepsia, anorexia, flatulence, colic, seizures, tumors, epistaxis, asthma, abnormal menstrual disorders, inflammation, antibacterial infections and obesity (Nash et al., 2019; Sawangjit et al., 2017; Lee et al., 2018; Jainu and Devi, 2005). In recent decades, studies on anticarcinogenic properties of quercetin have shown its combating effects against cancer. Similarly, *in vitro* and *in vivo* studies have shown that quercetin induces cytotoxic effects on colon cancer, breast cancer, leukemia cells, and ovarian carcinoma. Toxicological reports demonstrate that the extract of *Cissus quadrangularis* (L). does not possess any adverse toxic effect (Zenebe et al., 2017; Jadhav et al., 2016; Tamburaci et al., 2018; Oben et al., 2008). Photochemical analysis showed to comprise of metal ions, resveratrol, piceatannol, pallidol, parthenocissus, 31 methyl triacontanoic acid, taraxeryl acetate, taraxerol, phenol, tannin, carotene, and vitamin. It also possesses novel flavonoids and indanes, phytosterols and keto-steroids which are useful and effective antioxidants (Zenebe et al., 2017; Sharp et al., 2007). Reports showed that *Cissus quadrangularis* (L). suppressed lipase and amylase effectively, thus maintaining a framework for weight reduction through diminished dietary fat, oxidative stress, and carbohydrate blocking Prasad and Udupa (1963). The present study aimed to investigate the free radical quenching and combating properties against cancer by the ethanolic and methanolic extract of *Cissus quadrangularis* (L).

2. Materials and methods

2.1. Collection and extraction of Cissus quadrangularis (L)

The fresh aerial parts of *Cissus quadrangularis* (L). were collected in Tamil Nadu, India, in January 2016. The specimen was taxonomically identified and authenticated at the Madras Herbarium (MH), Botanical Survey of India, Coimbatore, Tamil Nadu.

The aerial parts of *Cissus quadrangularis* (L). were dried in shades and blended to powder and kept in sterile plastic bags in a cool dry place until further used (extraction). About 100 g of the blended powder were used for ethanolic and methanolic extraction by a Soxhlet extractor based on the polarity of the extraction. These extracts were concentrated by rotary evaporator at 50 °C to dryness by using a water bath and stored separately at 2–8 °C until used. The dried ethanolic and methanolic extracts were reconstituted to 50 mg/ml in 2% dimethyl sulfoxide (DMSO) solution.

2.2. Phytochemical analysis

The extracts such as EECQ and MECQ were subjected to phytochemical analysis according to the standard methodology of Kumar et al. (2013).

2.3. In vitro antioxidant activity

Various concentrations increasing from 50 to 400 μg / mL of EECQ and MECQ were evaluated for their antioxidants activity in various *in vitro* models system. The antioxidant property was measured by using DPPH radical scavenging assay (Gyamfi et al., 2002) and Nitric oxide (NO^-) scavenging assay (Nathan and Hibbs, 1991). Hydroxyl radicals (-OH) scavenging activity (Ak and Gülçin, 2008), Superoxide radical (O^{2-}) scavenging activity (Nishimiki et al., 1972), ABTS radical scavenging activity ($ABTS^{\bullet+}$) (Re et al., 1999), and Ferric Reducing Antioxidant Potential (Fe^{3+}-Fe^{2+}) (Oyaizu, 1986) were also evaluated. Using a nonlinear regression algorithm, the concentration of extract needed to quench free radicals (IC_{50}) was estimated by. Quercetin was used as a reference compound for all the *in vitro* antioxidant assays. All the experiments were performed in triplicates.

2.4. In vitro anticancer property

Cell Line and Culture. HL 60 cell line was obtained from National Center for Cell Science (NCCS), Pune, India. The cells were cultured in RPMI-1640 (Gibco Co., Germany) supplemented with 10% fetal calf serum (FCS), penicillin (100 IU/ml), and streptomycin (100 μg/ml), at 37 °C with 5% CO_2 incubator.

Cell Treatment: HL 60 cells (2×10^5) were plated in 96 well plates and incubated for 48 h. After 48 h of incubation, the cells were treated with EECQ and MECQ for different concentration ranges (20–200 μg/ml), and incubated for 24 h at 37 °C with 5% CO_2 incubator. Control cells were treated with 2% DMSO alone. All the experiments were performed in triplicate.

Cytotoxicity Assays: After treatment, the medium (100 μL), were removed and the cells were incubated with 50 μL of 0.5% 3-(4,5-dimethyl-2-thiazolyl)-2,5-diphenyl-tetrazolium bromide (MTT) at 37 °C for 4 h. After incubation, the cells were added with 0.04 M HCl/isopropanol. Viable cells were measured at 570 nm and 50% inhibition of viability (IC_{50}) value was calculated. The blanks for the experiments were cells treated with 2% DMSO (Prasad et al., 2005). Cytotoxic effects were observed under a phase-contrast microscope at 100x magnification using a Nikon Eclipse Ti microscope. The cytotoxic efficacy of EECQ and MECQ on HL 60 was expressed as the percentage of cell viability, according to the following formula (Dai and Mumper, 2010):

$$\text{Percentage of } (\%)\text{cell viability} = \frac{A_{570} \text{ of treated cells}}{A_{570} \text{ of control cells}} \times 100$$

2.5. Statistical analysis

The data was given as the mean ± SD of six measurements. Statistical analysis was performed using SPSS version 20. The IC_{50} values of the extract were compared by ANOVA, followed by Dunnet's *t*-test (n = 6). $p < 0.05$ was considered significant.

3. Results

3.1. Phytochemical analysis

The extracts such as EECQ and MECQ were subjected to phytochemical analysis and the different fractions were identified as flavonoids, glycosides, tannins, phenolics, triterpenoids, saponins and glycosides (Table 1).

3.2. Inhibition of DPPH radical

Fig. 1 represents the efficacy of EECQ and MECQ for free radicals quenching generated by DPPH. At low concentrations, both EECQ and MECQ (25 μg/ml), has 29.6% and 24.2% respectively free radical quenching effects whereas high doses (400 μg/ml) of both extracts indicated the maximum activity. The free radical quenching ability

Table 1
Qualitative estimation of the phytochemicals present in the *Cissus quadrangularis* (L) extracts.

Test	Different Solvents	
	Ethanol	Methanol
Flavonoids	+	+
Alkaloids	–	–
Phenolics compounds	+	–
Tannins	–	+
Triterpenoids	+	+
Carbohydrates	–	–
Steroids	–	–
Saponins	+	+
Glycosides	+	–

of both EECQ and MECQ showed a significant level of free radicals with a quenching activity of about 73.5% and 67.5%, respectively. The IC_{50} value of the EECQ, MECQ and standard were 101.4 ± 6.3 μg/ml, 114.1 ± 5.8 μg/ml and 76 ± 4.3 μg/mL respectively.

3.3. Inhibition of hydroxyl radical

Hydroxyl radicals can cause oxidative damage to the macromolecules (DNA, lipids, and proteins). This analysis shows the scavenging capacity of the EECQ and MECQ extract along with the standard quercetin to decrease hydroxyl radical-facilitated deoxyribose sugar degradation by measuring iron (II)-dependent DNA damage in a Fe^{3+}-EDTA-ascorbic acid and H_2O_2 reaction mixture. The results showed significant inhibition as in Fig. 2. The IC_{50} value of the EECQ, MECQ and standard were 89.6 ± 5.4 μg/ml, 93.8 ± 4.6 μg/ml and 71.6 ± 3.8 μg/mL respectively.

3.4. ABTS radical scavenging property

The total antioxidant activity of EECQ and MECQ for various concentrations (25–400 μg/ml) were calculated by reduction of the blue colored $ABTS^{\bullet+}$ radical by the antioxidant and its decolorization. The percentage antioxidant activity can be measured spectrophotmetricaly at 734 nm in a dose-dependent manner as shown in Fig. 3. The IC_{50} value of the EECQ, MECQ and standard were 86.2 ± 5.5 μg/ml, 95.7 ± 4.3 μg/ml and 77.6 ± 3.4 μg/mL respectively.

3.5. Nitric oxide scavenging activity

Nitric oxide radical scavenged by EECQ and MECQ (25–400 μg/mL) and quercetin (reference compound) was dose-dependent as shown in Fig. 4. The IC_{50} value of the EECQ, MECQ and standard were 93.2 ± 3.3 μg/ml, 99.4 ± 3.3 μg/ml and 73.8 ± 3.3 μg/ml respectively. Comparatively, the EECQ displayed increased activity than MECQ in scavenging nitric oxide radicals.

3.6. Superoxide radical scavenging

Superoxide anion radical quenching reaction of EECQ and MECQ was measured by the phenazine methosulfate-nicotinamide adenine dinucleotide (PMS-NADH) system by generation of NADH and assayed by the reduction of NBT as shown in Fig. 5. The inhibition in absorbance at 560 nm with EECQ, MECQ, and the standard compound quercetin indicated their ability to scavenge superoxide anion radicals in a dose-dependent manner. Therefore, the higher superoxide anions radical scavenging effect of the EECQ and MECQ indicates the potential as antioxidant principles. As mentioned in Fig. 5, the IC_{50} values of EECQ, MECQ, and reference compound quercetin on superoxide quenching reaction were 100 ± 6.7 μg/ml, 107.9 ± 5.7 μg/ml and 74.9 ± 5.1 μg/mL respectively.

3.7. Reducing power

Fe^{3+} was transformed into Fe^{2+} in the presence of EECQ, MECQ, and the reference compound quercetin to assay the reductive capability. The highest reductive activity was shown at a minimum dose by the EECQ (25 μg/ml) as compared to MECQ. The IC_{50} value of the EECQ, MECQ and standard were 64.5 ± 3.8 μg/ml, 67.1 ± 4.3 μg/ml and 56.7 ± 2.4 μg/mL respectively.

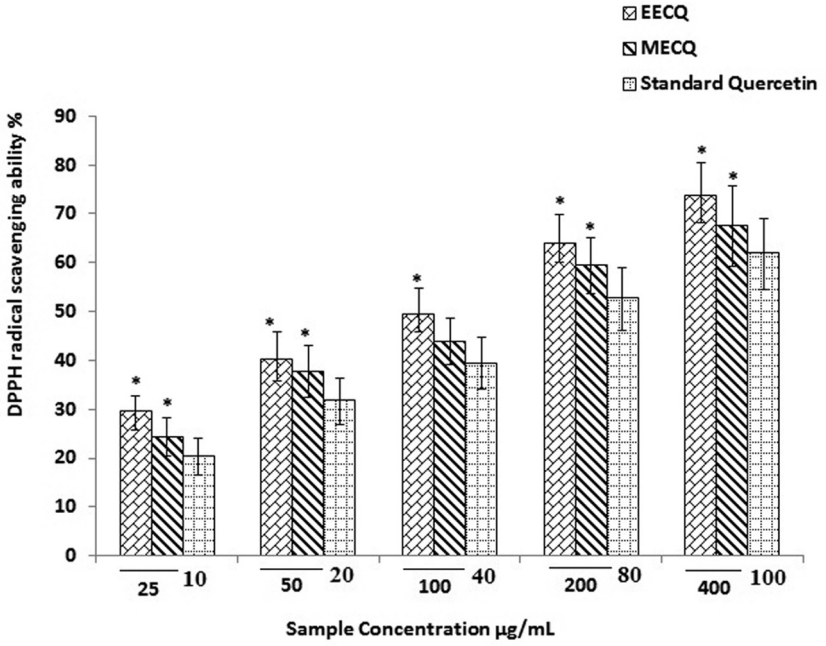

Fig. 1. DPPH radical scavenging assay. DPPH radical scavenging activity of ethanolic and methanolic extract of *Cissus quadrangularis* (L) with standard quercetin. Effect of DPPH radical scavenging activity in percentage was plotted against the concentration of sample. Values are mean ± SEM, statistical significant test for comparison was done by ANOVA, followed by Dunnet's *t*-test (n = 6). The values are $*p < 0.05$ when compared against reference compound quercetin. The IC_{50} value of the EECQ, MECQ and standard were 101.4 ± 6.3 μg/ml, 114.1 ± 5.8 μg/ml and 76 ± 4.3 μg/mL respectively.

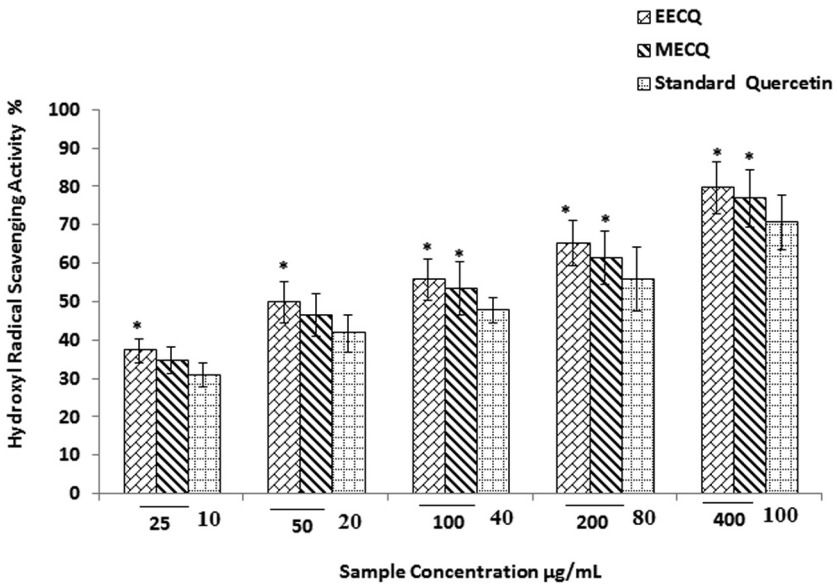

Fig. 2. Hydroxyl radical scavenging assay. Hydroxyl radical scavenging activity of ethanolic and methanolic extract of *Cissus quadrangularis* (L) with standard quercetin. Effect of hydroxyl radical scavenging activity in percentage was plotted against the concentration of sample. Values are mean ± SEM, statistical significant test for comparison was done by ANOVA, followed by Dunnet's *t*-test (n = 6). The values are ∗p < 0.05 when compared against reference compound quercetin. The IC_{50} value of the EECQ, MECQ and standard were 89.6 ± 5.4 µg/ml, 93.8 ± 4.6 µg/ml and 71.6 ± 3.8 µg/mL respectively.

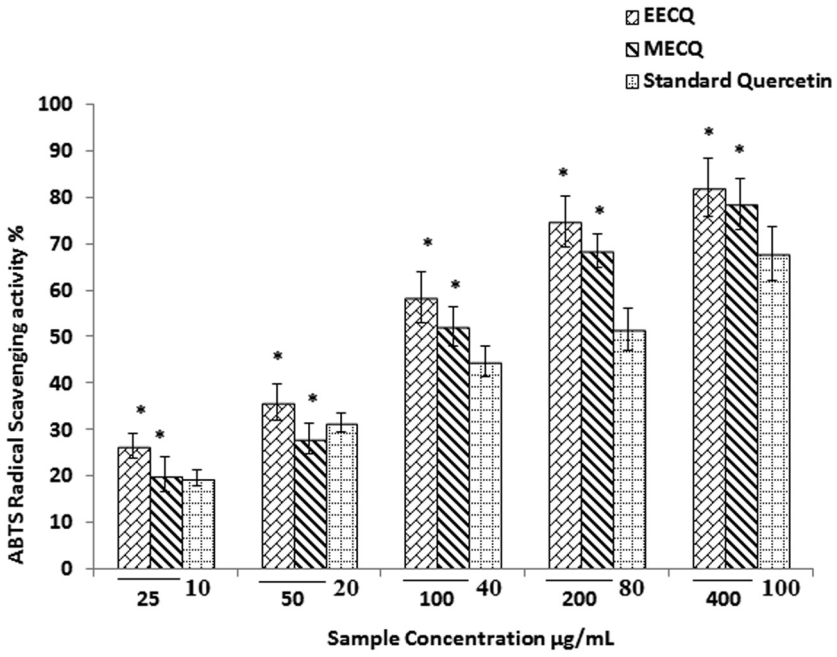

Fig. 3. ABTS radical scavenging assay. Total antioxidant activity of ethanolic and methanolic extract of *Cissus quadrangularis* (L) with standard quercetin. Effect of ABTS radical scavenging activity in percentage was plotted against the concentration of sample. Values are mean ± SEM, statistical significant test for comparison was done by ANOVA, followed by Dunnet's *t*-test (n = 6). The values are ∗p < 0.05 when compared against reference compound quercetin. The IC_{50} value of the EECQ, MECQ and standard were 86.2 ± 5.5 µg/ml, 95.7 ± 4.3 µg/ml and 77.6 ± 3.4 µg/mL respectively.

3.8. In vitro anticancer activity

Cytotoxicity assays were performed on EECQ and MECQ treated HL 60 leukemic cell lines. MTT assay was performed to testing the cytotoxic efficacy of EECQ and MECQ against leukemic cell lines as shown in Figs. 7 and 8. The cytotoxic effects of EECQ and MECQ were observed at different concentrations (0.5–100 µg/mL). Cell viability decreased in a concentration-dependent manner with the least viability (14.27%) with MECQ at 100 µg/mL, whereas, it was 18.8% at the same concentration for EECQ. The IC_{50} for cytotoxicity with MECQ was 40 µg/mL while, it was 36 µg/mL with EECQ. This is in consonance with the National Cancer Institute (NCI) guidelines of cytotoxicity that the IC_{50} of the crude extract should be <20 µg/mL (Boik, 2001). The cytotoxic potential of EECQ and MECQ demonstrates *Cissus quadrangularis* (L). as promising anticancer agents.

4. Discussion

Free radicals are constantly generated in the human system due to the oxygen utilized by the cells. This radical produces a series of reactive oxygen species (ROS) and reactive nitrogen species (RNS)

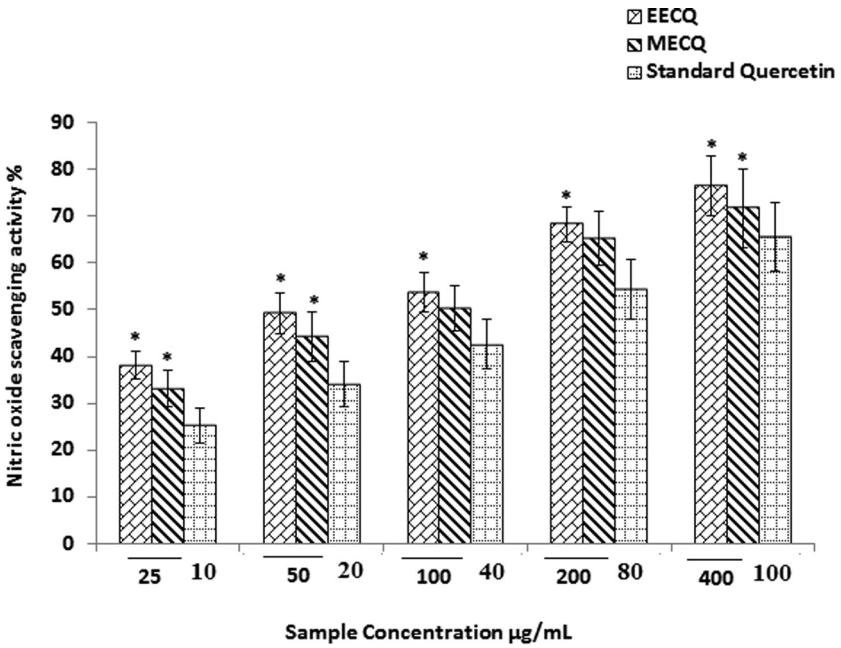

Fig. 4. Nitric oxide radical scavenging assay. The nitric oxide radical scavenging activity of ethanolic and methanolic extract of *Cissus quadrangularis* (L) with standard quercetin. The data represent nitric oxide radical scavenging activity in percentage was plotted against the concentration of sample. Values are mean ± SEM, statistical significant test for comparison was done by ANOVA, followed by Dunnet's *t*-test (n = 6). The values are $*p < 0.05$ when compared against reference compound quercetin. The IC_{50} value of the EECQ, MECQ and standard were 93.2 ± 3.3 µg/ml, 99.4 ± 3.3 µg/ml and 73.8 ± 3.3 µg/ml respectively.

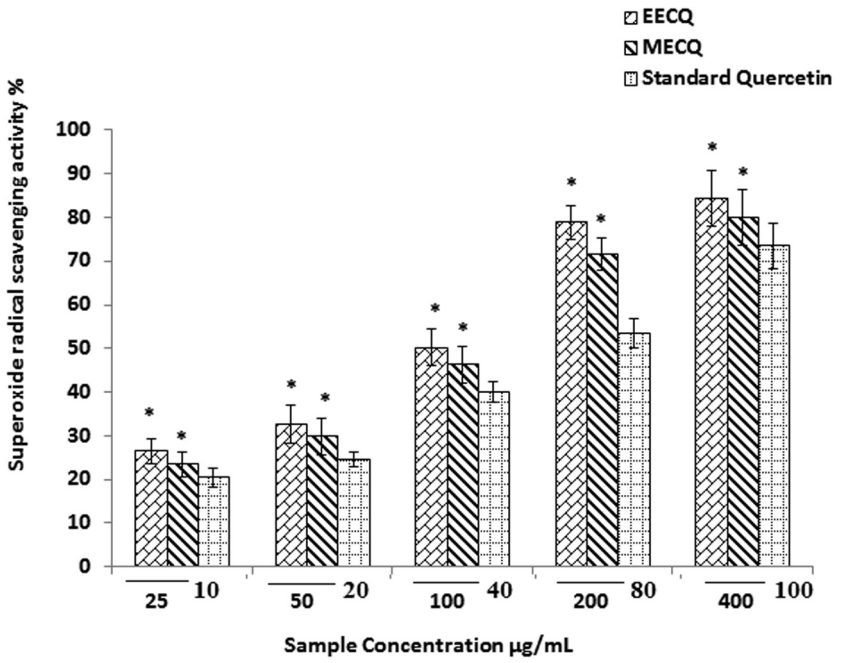

Fig. 5. Superoxide radical scavenging assay. Scavenging effect of ethanolic and methanolic extract of *Cissus quadrangularis* (L) with standard quercetin on superoxide. The data represent superoxide radical scavenging activity in percentage was plotted against the concentration of sample. Values are mean ± SEM, statistical significant test for comparison was done by ANOVA, followed by Dunnet's *t*-test (n = 6). The values are $*p < 0.05$ when compared against reference compound quercetin. The IC_{50} value of the EECQ, MECQ and standard were 100 ± 6.7 µg/ml, 107.9 ± 5.7 µg/ml and 74.9 ± 5.1 µg/mL respectively.

such as nitric oxide (NO), superoxide anion, singlet oxygen, and hydroxyl radicals that are associated with oxidative stress and many pathological conditions. Natural polyphenols are a beneficial photoactive found most often in plants with numerous pharmacological and biochemical properties like antimicrobial, antiviral, antiparasitic, antioxidant, anti-inflammatory, cytotoxic, and anticancer properties (Sugapriya, 2008; Dhanasekaran and Jaganathan, 2018). Antioxidants have a therapeutic effect by quenching free radicals which are harmful molecules generated as metabolic products by natural cells. The immune system has several pathways to combat oxidative stress by generating antioxidants that are either produced naturally *in situ* or delivered externally through foods and/or supplements. These antioxidants function as radical scavengers by reducing and restoring ROS-induced cell damage, thus enhancing immune protection and reducing the chance of cancer and degenerative diseases (Dhanasekaran et al., 2012). Phytochemicals present

in *Cissus quadrangularis* (Linn.) were similarly, confirmed by Vijayalakshmi et al.,(2013).

Increasing concentrations from 25 to 400 μg/mL of ethanolic and methanolic extract were examined for its antioxidant efficacy in *in vitro* antioxidant system. The extracts exhibited radical quenching ability *in vitro* in a dose-dependent manner with higher activity shown by methanolic extract than ethanolic extract (Figs. 1–6).

DPPH assay is a major assessment method evaluates free radical scavenging properties of antioxidant molecules by quenching the stable colored DPPH radical. Plant extracts containing antioxidants scavenge the radicals generated by DPPH and would facilitate an ambitious scaffold for prospective *in vivo* studies (Procházková and Wilhelmová, 2011). Prasad et al., (2005) documented that the phytochemicals like phenolics and flavonoid have the capacity to donate hydrogen and quench DPPH radicals. The IC_{50} of the methanolic extract was less compared with that of ethanolic extract but was not significant (Fig. 1). Another assay, $ABTS^{\cdot+}$ is used to determine the antioxidant ability. The treatment with ethanoic and methanolic extract of *Cissus quadrangularis* (L). preformed free radical cation significantly decreased it to ABTS in a dose-dependent manner which demonstrates that *Cissus quadrangularis* (L). extract possesses a potent antioxidant property (Fig. 3).

Nitric oxide (NO) is one of the major free radicals generated in human cells regulating different physiological processes. Nevertheless, there are several diseases associated with excess production of nitric oxide. Under aerobic conditions, nitric oxide is very unstable. NO reacts with O^2 to generate stable nitrate and nitrite which is scavenged by *Cissus quadrangularis* (L). extract and decreases the amount of nitrous acid (Skouta et al., 2019). The present investigation illustrates a significant NO scavenging activity of the ethanolic and methanolic extract of *Cissus quadrangularis* (L). (Fig. 4). This can be attributed to antioxidant property of flavonoids, which reacts with oxygen to bind with NO, resulting in reduced nitric oxide production. Hydroxyl radicals are the most important active oxygen species triggering lipid peroxidation, macromolecular damage (oxidative damage to DNA, lipids, and proteins) and enormous biological damage to the mammalian cells (Dhanasekaran, 2019). The present investigation illustrates that the ethanolic and methanolic extract of *Cissus quadrangularis* (L). scavenges for hydroxyl ions and inhibits free radical-mediated damage (Fig. 2). The scavenging ability can be attributed to the presence of flavonoids in these extracts.

Superoxide anion, another free radical, is also extremely harmful to cellular components (Antonio et al., 2014). Early studies revealed that polyphenols and flavonoids possess effective antioxidants primarily because of its ability to scavenge superoxide anions. The results shown in Fig. 5 revealed that superoxide radical quenching activities of ethanolic and methanolic extract of *Cissus quadrangularis* (L). increased markedly with increasing concentrations. The reducing power of a compound may assist as an important indicator of its potential antioxidant property. Moreover, antioxidant activity was due to different mechanisms such as protection of peroxide, oxidation, chain initiation, reducing capacity, and radical scavenging (Aleksandra et al., 2015). Fig. 6 a significant reducing power was observed with ethanolic and methanolic extract of *Cissus quadrangularis* (L). as to standard.

As per the NCI, the standard of cytotoxic effects for the plant crude extract are IC50 < 20 μg/mL (Boik, 2001), the IC_{50} values

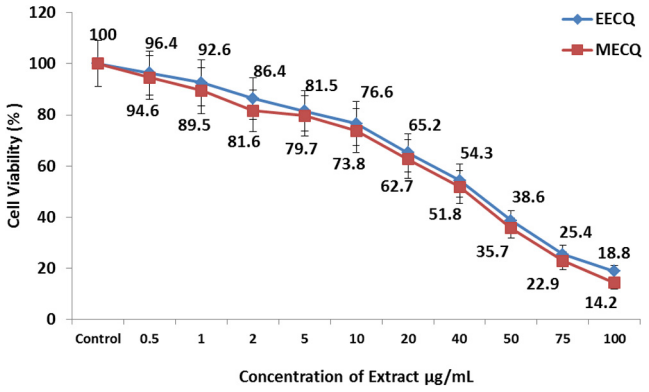

Fig. 7. MTT assay. Cytotoxic effect of EECQ and MECQ on HL 60 cell line.

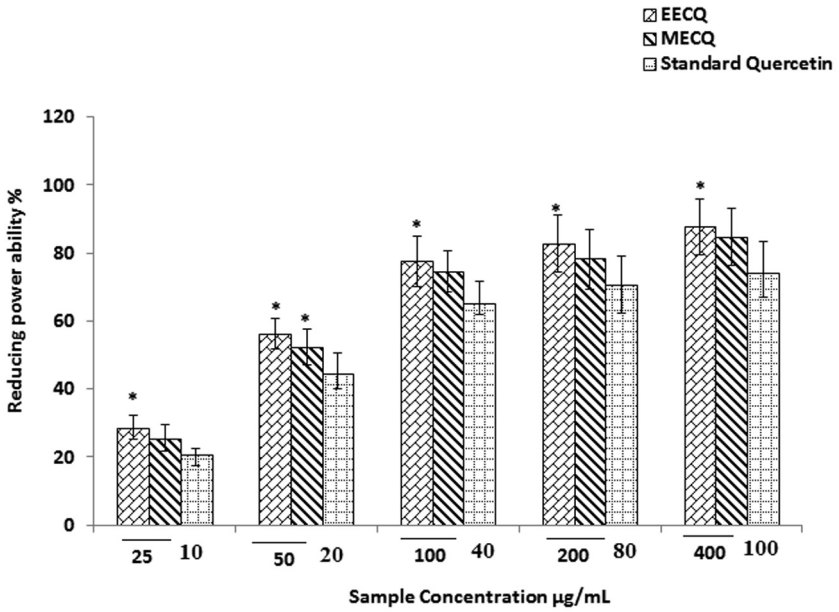

Fig. 6. Reducing power assay. The reductive abilities of ethanolic and methanolic extract of *Cissus quadrangularis* (L) with standard quercetin. The data represent reducing power ability in percentage was plotted against the concentration of sample. Values are mean ± SEM, statistical significant test for comparison was done by ANOVA, followed by Dunnet's *t*-test (n = 6). The values are $*p < 0.05$ when compared against reference compound quercetin. The IC_{50} value of the EECQ, MECQ and standard were 64.5 ± 3.8 μg/ml, 67.1 ± 4.3 μg/ml and 56.7 ± 2.4 μg/mL respectively.

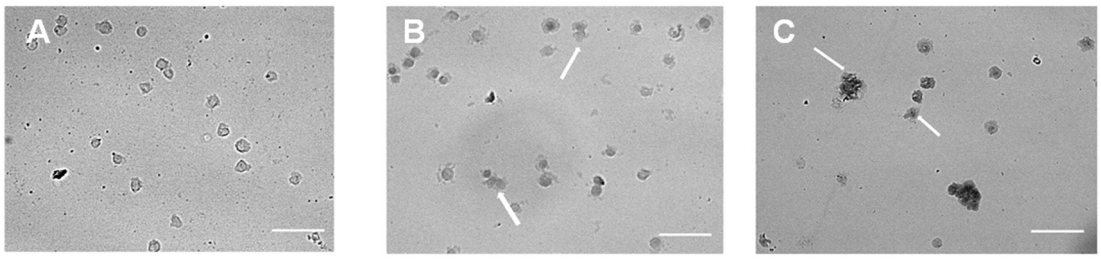

Fig. 8. Anticancer effect of *Cissus quadrangularis* (L). on HL-60 cell line A. Control cells HL 60 alone; B. EECQ extract treated HL 60; and C. MECQ extract treated HL 60.

for cytotoxicity was higher with methanolic extract than ethanolic extract on treated HL 60 leukemic cell lines (Figs. 7 and 8). Polyphenols and flavonoids are the best phytochemicals found abundantly in fruits and vegetables. Research shows the relative order of the antioxidant activity of flavonoids as quercetin > apigenin > fisetin > kaempferol Reports How quercetin as a major phytochemical which is presented in *Cissus quadrangularis* (L). that may prevent cancer, especially HL 60 leukemic cells. Vijayalakshmi et al. (2013) isolated quercetin from *Cissus quadrangularis* (L). and reported the cytotoxic activity on MCF-7 human breast cancer cell lines. It was believed that the presence of quercetin in *Cissus quadrangularis* (L). extract enhances the antioxidant activity with a cytoprotective role against oxidative stress. It appeared that quercetin present in *Cissus quadrangularis* (L). extract not only protects cells by quenching the free radicals but also helps apoptotic mediated cell death by acting as a pro-oxidant and inhibits tumorigenesis (Gibellini, 2010). Therefore, the anticancer therapeutic efficacy may be related to the presence of quercetin and other phytochemical components in *Cissus quadrangularis* (L). extract by enhancing the antioxidant activity. Furthermore, flavonoid compounds present in the extracts of *Cissus quadrangularis* (L). have potential anti-cancer activity.

5. Conclusion

The present investigation validates that *in vitro* antioxidant potential of ethanolic and methanolic extracts of *Cissus quadranqularis* (L). using various free radical assays that includes DPPH, nitric oxide, superoxide, hydroxyl radical, reducing power assay, and ABTS. *In vitro* cytotoxic effects of ethanolic and methanolic extracts of *Cissus quasdranqularis* (L). showed pronounced activity against HL 60 leukemic cells. The enhanced cytotoxic and antioxidant efficacy of *Cissus quadranqularis* (L). is attributed to the presence of bioactive molecules that have demonstrated these function in numerous other studies. Furthermore, future investigations need to focus on identifying bioactive molecules present in these extracts and its molecular mechanisms underlying the cytotoxic and antioxidant functions.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Authors' contributions

SD: concept and design of the study, data acquisition, and supervision of the study. The literature search, manuscript preparation, critical and final revision of the manuscript.

Financial disclosures

None.

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