Phytochemical Screening and Antioxidant Profile of *Syngonium podophyllum* Schott Stems: A Fecund Phytopharmakon

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Abstract: *Background*: Oxidative stress has been shown to play an imperative role in copious disease pathology. Plants are acquaintances of mankind and mainstay for the treatment of oxidative stress linked disorders. Therefore, the objective of the existing study was to assess the phytochemical contents and antioxidant activity of crude methanol extract (CME), n-hexane (NHF), chloroform (CLF), ethyl acetate (EAF) and aqueous (AQF) fractions of *Syngonium podophyllum* (*S. podophyllum*) Schott stems.

Methods: The *S. podophyllum* Schott stems extract and its fractions were subjected to phytochemical analysis to detect the presence of alkaloids, carbohydrates, saponins, tannins, resins, flavonoids and steroids. The antioxidant profile was determined by total antioxidant activity (TAA), reducing power activity (RPA) and DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity tests and correlated with the estimation of total flavonoid content (TFC).

Results: In CME and its fractions of *S. podophyllum* Schott stems all of the tested phytoconstituents (alkaloids, tannins, resins, flavonoids and steroids) were detected at various concentration except carbohydrates and saponins. In TAA test, highest absorbance (2.18 nm) which is a measure of high antioxidant activity was reported in CME compared to remaining fractions. Likely in RPA test with respect to all fractions similar denouements were found for CME (3.29 nm). In case of DPPH scavenging test, the CME showed highest scavenging activity (77.89 %) having IC_{50} of 41.02 µg/ml ($P < 0.05$) compared to remaining fractions. The antioxidant activity is possibly due to the highest TFC (7.45 mg of GAE/g of dried extract) reported in CME compared to existing fractions.

Conclusion: The aforementioned outcomes recommend that CME of *S. podophyllum* Schott stems can be a possible cradle of plant-derived natural antioxidant and can be used to avert diseases linked with free radicals.

Keywords: *Syngonium podophyllum*, Phytochemical Screening, Antioxidant Profile, Phenols, Oxidative Stress.

INTRODUCTION

For a long time, herbal medications are being used to alleviate a range of symptoms of various diseases. Despite having prodigious advances in modern medicine, medicinal plants still make noteworthy contribution to health care [1]. Interests regarding these plants are from their traditional uses in folk medicine and such interests are noticeable in developing countries. In addition, these plants are less expensive than modern medicines and have huge value in global market [2]. In 2012, this export value was more than US$2.2 billion. Although, in many countries traditional medicine is not strictly regulated, world health organization (WHO) is encouraging safer and rational use of these medications by synchronizing a network [3]. Based on the usage of medicinal plants by indigenous people for potential therapeutic purposes, numerous of compounds have been recognized using ethnobotany [4]. However, important phytochemicals including epigallocatechin, resveratrol, curcumin, gallate and genistein are known as pan-assay interference compounds, since the data regarding their activity obtained from their *in vitro* studies are frequently unpredictable. Due to this reason, in drug discovery, phytochemicals are not often suitable as lead compounds. But the pharmaceutical industry has persistently fascinated in mining folk medicine in drug discovery [5]. A significant number of drugs have been discovered based on the traditional uses of medicinal plants. In between 1981 to 2010, out of 1073 approved small-molecule drugs, about more than half of them either directly derived from or motivated by natural substances [6,7].

An enormous amount of medicinal plants have been screened to evaluate their antioxidant assets. Imbalance in free radical generation in the body can cause many degenerative diseases including arthritis, cardiovascular disease, neurodegenerative disorder and cancer through damaged proteins, lipids, nucleic acids and other cellular components [8]. Antioxidants

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are efficient at neutralizing free radical-mediated harmful effects. In fact, antioxidants from natural sources are effective both in the form of chemical constituent and in the form of raw extracts to prevent the damaging processes triggered by oxidative stress [9]. On the other hand, recently synthetic antioxidants including butylated hydroxyanisole and butylated hydroxytoluene are found to have adverse side effects in human body [10]. Nonetheless, the toxicity profiles of most of the medicinal plants are yet to be thoroughly identified, it is quite well known that drugs derived from natural products are safer than their synthetic counterparts.

The plant, *Syngonium podophyllum* (*S. podophyllum*) Schott is an evergreen climbing plant that belongs to the family Araceae [11]. Their stems can be 10 to 20 meters long that support themselves on tree trunks by means of adventitious roots. The species is native to and commonly found in diverse region of Latin America from Mexico to Bolivia and naturalized in the Florida, West Indies, Texas, Hawaii and many other places including Bangladesh [12]. Leaf stalks and younger stems of *S. podophyllum* are green or bluish-green in color. Adult leaves of this plant have leaflets that are typical to a certain extent unequal in size, with significantly larger central leaflet than other options. Stomachache can be treated by using the decoction of the crushed and boiled leaf of this plant [13]. Instead, milky-white sap obtained from a broken stem can be used topically to treat the bite of *Paraponera* ants [13]. Furthermore, the roots and bark of this plant have anti-inflammatory and antibacterial properties; whereas, the sap is swabbed into the cavity of an aching tooth to alleviate pain [13]. *S. podophyllum* is also used to treat superficial to deep wounds, and a range of skin disorders [14]. Dose-reliant effects have been observed when extracts of the leaves and bark used to treat edema. These effects suggest the high anti-inflammatory activity of *S. podophyllum* [14].

In our previous study, we had inspected the antioxidant activities of *S. podophyllum* leaves [15] and the encouraging results of the study lead us to further explore the antioxidant potential of other parts of the plant. Therefore, the intention of this study was to examine the phytochemical contents and antioxidant profile of *S. podophyllum* Schott stems.

MATERIALS AND METHODS

Chemicals

Methanol, ammonium molybdate, 2,2-diphenyl-1-picrylhydrazyl (DPPH), 2-deoxy-2-ribose, ascorbic acid (ACA), ethylenediaminetetraacetic acid (EDTA), trichloro acetic acid (TCA) and thiobarbituric acid (TBA) were procured from Sigma-Aldrich, USA. Butylated hydroxy toluene (BHT) and gallic acid (GA) was purchased from Merck, Germany and Wako pure chemicals Ltd., Japan respectively. Unless else stated, all remaining used chemicals were of analytical status and procured from Active Fine Chemicals Ltd., Bangladesh and other local sources.

Collection and Identification of Plant Materials

The *S. podophyllum* Schott stems were collected from Dhaka, Bangladesh in July 2016 and were taxonomically identified by an experienced taxonomist at the Bangladesh National Herbarium, Dhaka, Bangladesh. For this plant a voucher specimen (DACB-39385) was also deposited for future reference.

Drying and Grinding of Plant Materials

The collected plant parts were washed with fresh water, cut into small fragments, and shed dried for two weeks. The desiccated plant material was grounded into fine powdered form and deposited for further use.

Extraction and Fractionation of Plant Materials

The powder plant material (stems) was extracted using cold maceration method by taking 500 mg powder in 1.5 L methanol in a container composed of glass for 7 days. The extract was detached using Whatman filter paper (No.1) from other plant debris. The extract was concentrated by using rotary evaporator at 50°C temperature. The amount of yield in the extract was 8.77 g. The concerted methanolic extract was then partitioned successively by using the modified method of Kupchan [16] and the resultant partitions i.e., n-hexane (NHF) chloroform (CLF), ethyl acetate (EAT) and water (AQF) soluble fractions were evaporated to dryness and engendered NHF, 1.92 g; CLF, 1.58 g; EAF, 1.84 g and AQF 2.05 g extract respectively.

Qualitative Phytochemical Analysis

The preliminary phytochemical group test was carried out by following standard procedure [17]. The extract was screened for the presence of alkaloids, carbohydrates, saponins, tannins, resins, flavonoids and steroids

Total Flavonoid Content

The aluminum chloride ($AlCl_3$) colorimetric method as stated by Chang *et al*. with slight alterations was

used to detect the total flavonoid content (TFC) [18]. To begin with, 0.5 mL of several extracts (i.e., 1 mg/mL) were mixed with methanol (i.e., 1.5 mL), after that the adding of 10% $AlCl_3$ (i.e., 0.1 mL), 1M of potassium acetate (i.e., 0.1 mL) and finally 2.8 mL of distilled water. At 25 °C, the aforestated reaction mixture was saved for 30 min. Subsequently, the absorbance of the reaction mixture was measured at 415 nm. GA was used as a reference standard and the content TFC was estimated from the calibration curve. The TFC was represented as mg of GA equivalent (GAE)/g of dried sample.

Antioxidant Activity

In order to start antioxidant activity a solution of each obtained plant extract/fractions was made by using 98% methanol at 1 mg/mL concentration. The following tests were performed:

Total Antioxidant Activity

The method prescribed by Prieto *et al*. was followed to carry out the phosphomolybdenum assay of total antioxidant activity (TAA) [19]. A volume of 0.1 mL of test solution of diverse concentrations (50–500 µg/mL) mixed with the 1 mL of reagent solution (i.e., 28 mM sodium phosphate, 4 mM ammonium molybdate and 0.6 M sulfuric acid). Then, the tubes were allowed to incubate at 95°C in a hot water bath for 90 min. Subsequently, the absorbance of the solution was estimated at 695 nm after cooling to 25 °C. (+)-catechin (CTC) was used as a reference standard. Total antioxidant activity was calculated by using the following equation:

Total antioxidant activity (%) = ([(Ac – As/Ac)] ×100)

where, Ac is the absorbance of control and As is the absorbance of sample/standard solution.

Reducing Power Activity

The method of Oyaizu *et al*. with few adjustments was followed to determine the reducing power activity (RPA) [20]. Briefly, 0.2 mL of diverse concentrations of the test sample extracts (i.e., 50–500 µg/mL) were added distinctly with 0.2 M of phosphate buffer with pH 6.6 (i.e., 0.5 mL) and 1% of potassium ferricyanide (i.e., 0.5 mL). Afterward, the resultant mixture was permitted to incubate in a boiling water bath for 20 min at 50°C. After cooling at 25 °C, 10% of trichloroacetic acid (i.e., 0.5 mL) was added to it which was then centrifuged at 3,000 rpm for 10 min. Finally, obtained supernatant (i.e., 0.5 mL) was collected and 0.5 mL of distilled water was added to it. Later a 0.1% solution of ferric chloride (i.e., 0.1 mL) was mixed and finally the blend was left at room temperature for 10 min. The absorbance of the solution was determined at 700 nm. ACA was used as a reference standard.

DPPH Radical Scavenging Activity

The procedure of Kulisic *et al*. with few adjustments was used to resolve the DPPH radical scavenging activity [21]. A volume of 50 µL of tested sample solution of numerous concentrations (i.e., 25–400 µg/mL) was added with 950 µL of methanolic solution of DPPH (i.e., 3.4 mg/100 mL). Then the resultant mixture was allowed to incubate for 1 h in the dark at 37 °C. The invisibility of the original purple color was the marker of the free radical scavenging activity of the extracts. The absorbance of the solution was measured at 517 nm. BHT was used as a reference standard. The DPPH radical scavenging capacity was assessed by using the following equation:

DPPH radical scavenging activity (%) = ([1– (As/Ac)] ×100)

where, Ac is the absorbance of control and As is the absorbance of sample/standard solution.

Statistical Analysis

All analyses were performed in triplicates and results were represented as mean ± SD. The data in all the tests were examined by Student's t test. The data was entered into a Microsoft Excel 2007 (Roselle, IL, USA) database and analyzed using SPSS (version 15.0) for the statistical and graphical evaluations. The denouements were calculated as statistically significant at the value of $P < 0.05$.

RESULTS

Determination of Phytochemical Content

The phytochemical analysis of *S. podophyllum* stems extract and its fractions exposed the occurrence or absenteeism of numerous bioactive components for example alkaloids, carbohydrates, saponins, tannins, resins, flavonoids and steroids presented in Table 1. In case of crude extract and its fractions, carbohydrates and saponin were entirely absent. However remaining phytoconstituents were existing at innumerable concentration (i.e., largely, moderately, mildly).

Determination of TFC

The standard curve for GA ($y = 0.014x + 0.033$; $R^2 = 0.998$) was used to analyze the TPC of *S.*

Table 1: Phytochemical Screening of *S. podophyllum* Stems Extract and its Fractions

Phytochemicals	CME	NHF	CLF	EAF	AQF
Alkaloids	−	−	+	++	++
Carbohydrates	−	−	−	−	−
Saponins	−	−	−	−	−
Tannins	−	++	++	−	−
Resins	++	+	+++	−	−
Flavonoids	+++	+	+	++	+
Steroids	−	++	+++	−	−

Where, CME: Crude methanol extract; NHF: n-hexane fraction; CLF: Chloroform fraction; EAF: Ethyl acetate fraction; AQF: Aqueous fraction.
In view of power of the color reaction here, + = Present in mild amount, ++ = Present in moderate amount, +++ = Present in large amount, − = Not present.

podophyllum stems extract and its fractions. In this test, highest TFC was reported in CME (7.45 ± 0.38 mg of GAE/g of dried extract) then NHF, CLF, AQF and EAF which were 5.48 ± 0.55, 5.16 ± 0.29, 4.02 ± 0.48 and 2.26 ± 0.35 mg of GAE/g of dried sample, respectively (Figure **1**).

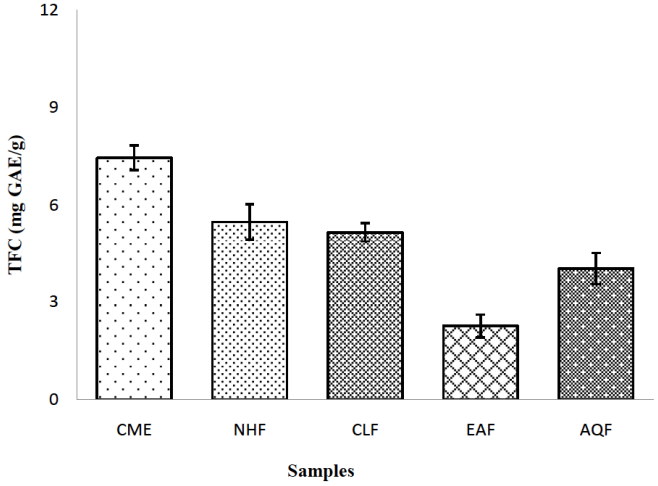

Figure 1: TFC of *S. podophyllum* stems extract and its fractions.

Values were represented as mean ± SD (n = 3). Where, CME: Crude methanol extract; NHF: n-hexane fraction; CLF: Chloroform fraction; EAF: Ethyl acetate fraction; AQF: Aqueous fraction.

Determination of TAA

In Figure **2**, the TAA of *S. podophyllum* stems extract and its fractions are mentioned. At highest concentration (500 µg/mL) the following sequence was reported CTC > CME > NHF > CLF > EAF > AQF.

Determination of RPA

The RPA of *S. podophyllum* stems extract and its fractions are showed in Figure **3**. In this test at maximum concentration (500 µg/mL), CME exerted highest (3.29 ± 0.73 nm) activity followed by NHF, CLF, EAF and AQF.

Determination of DPPH Radical Scavenging Activity

In DPPH radical scavenging test, amid CME and its fractions (NHF, CLF, EAF and AQF) highest radical scavenging was reported in CME (77.89 ± 1.05%) given in Figure **4**. The IC_{50} values of the extract and its fractions are presented in Figure **5**.

DISCUSSION

Medicinal plants are considered as the richest bio-resources. Use of these plants by the humans has a long recorded history [22]. Medicinal plants contain a range of phytochemical constituents and they are particularly useful to heal and cure various human diseases. Furthermore, research on medicinal plants nowadays is not limited to new drug discovery only, rather the research areas are expanding in association with diverse subjects [23]. In this study, phytochemical analysis and antioxidant activities of *S. podophyllum* Schott stems were carried out by using several tests.

Plants generate multiple secondary metabolite compounds including steroids, flavonoids, saponins, glycosides, alkaloids, terpenoids and glucosinolates to defend themselves from the continuous attack of environmental stresses and naturally occurring pathogens [24]. It has been found that plants that contain molecules including terpenoids, tannins, vitamins, phenolic acids, coumarins, alkaloids, quinones, flavonoids and other metabolites are responsible for the free radical scavenging and antioxidant properties [8,10]. In this study, at various concentration, copious phytoconstituents for example alkaloids, tannins, resins, flavonoids and steroids were reported in crude extract and its fraction. Almost similar

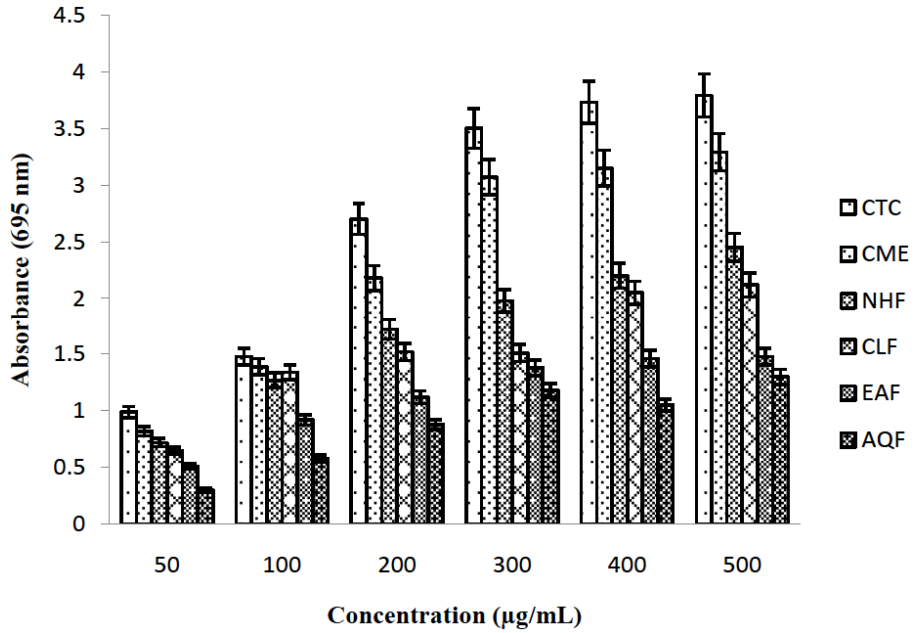

Figure 2: TAA of *S. podophyllum* stems extract and its fractions at various concentrations.

Values were represented as mean ± SD (n = 3). Where, CTC: (+)-catechin; CME: Crude methanol extract; NHF: n-hexane fraction; CLF: Chloroform fraction; EAF: Ethyl acetate fraction; AQF: Aqueous fraction.

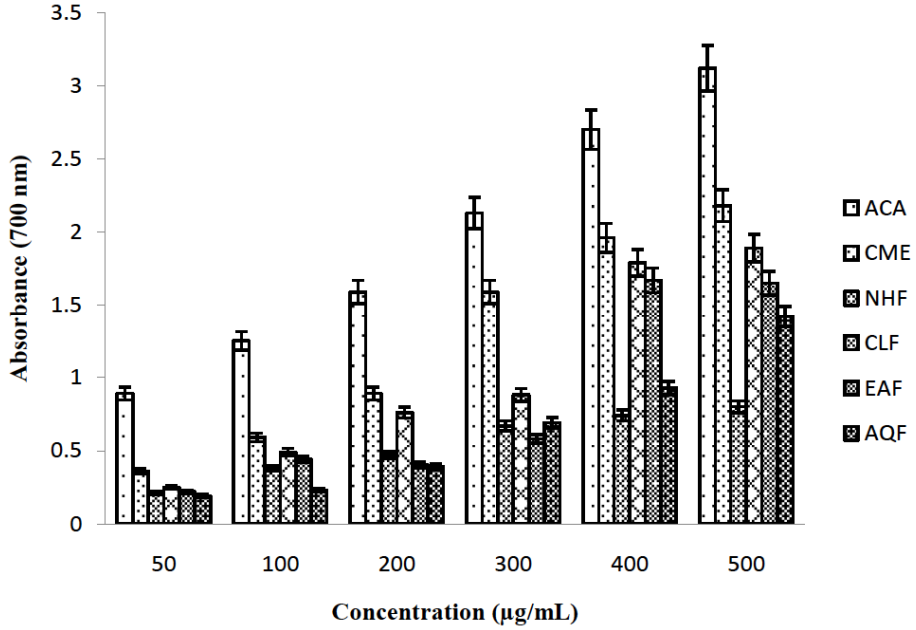

Figure 3: RPA of *S. podophyllum* stems extract and its fractions at various concentrations.

Values were represented as mean ± SD (n = 3). Where, ACA: Ascorbic acid; CME: Crude methanol extract; NHF: n-hexane fraction; CLF: Chloroform fraction; EAF: Ethyl acetate fraction; AQF: Aqueous fraction.

denouements were reported in a previous study of *S. podophyllum* leaves [25].

Scavenging ability of plants is mainly due to the phenolic compounds and their hydroxyl groups [25]. Instead, antioxidant activities exhibited by the plants are due the phenolic compounds present in plant parts [26]. In food industry, plant materials that have higher phenolic compounds are being used increasingly since they can slow down oxidative damage of lipids and can improve the nutritional value and quality of food [27]. Extracts of the plants also show antioxidant activity but their activities vary with the solvent because of the copious antioxidant activity of compounds with diverse polarity [28]. In this study amid crude extract and its fraction, highest TFC was reported in CME. The results

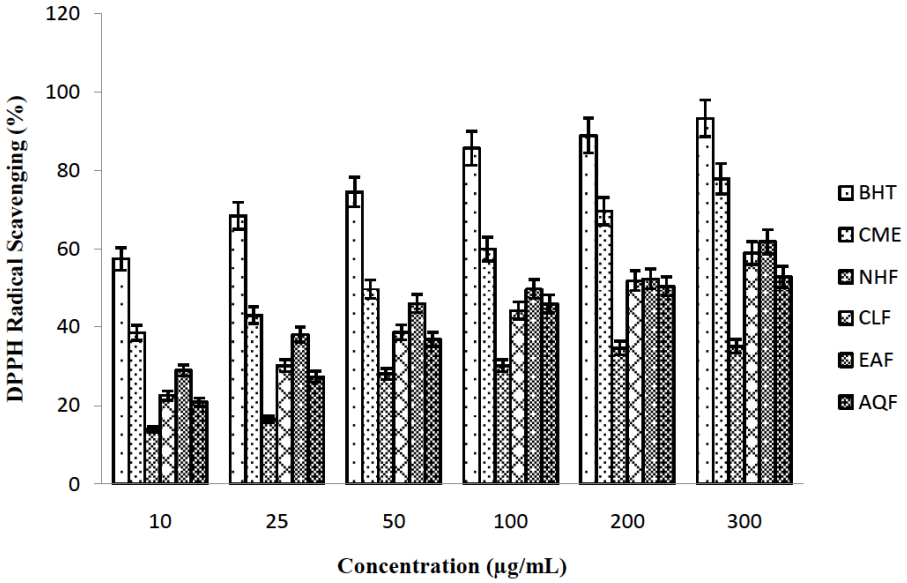

Figure 4: DPPH radical scavenging activity of *S. podophyllum* stems extract and its fractions at various concentrations.

Values were represented as mean ± SD (n = 3). Where, BHT: Butylated hydroxy toluene; CME: Crude methanol extract; NHF: n-hexane fraction; CLF: Chloroform fraction; EAF: Ethyl acetate fraction; AQF: Aqueous fraction.

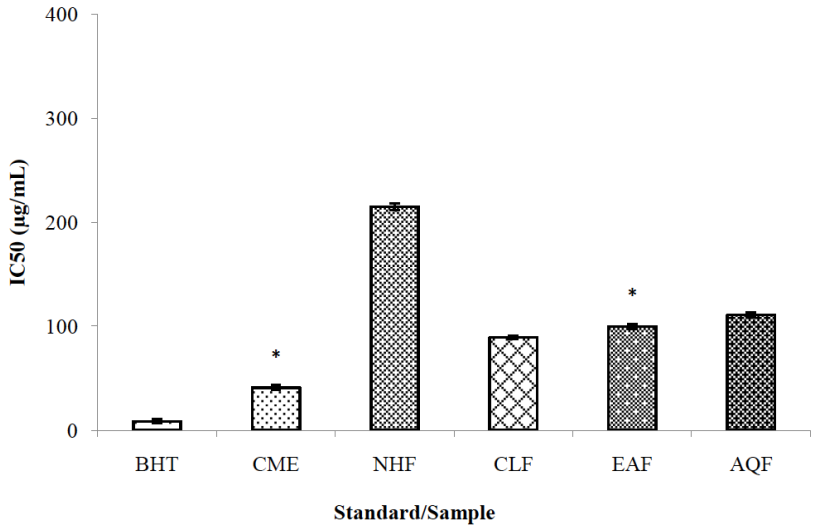

Figure 5: IC_{50} values of *S. podophyllum* stems extract and its fractions.

Values were expressed as mean ± SD (n = 3). Where, BHT: Butylated hydroxy toluene; CME: Crude methanol extract; NHF: n-hexane fraction; CLF: Chloroform fraction; EAF: Ethyl acetate fraction; AQF: Aqueous fraction.

*P < 0.05 significant difference from the standard.

of this study are analogous in a preceding study of Hossain *et al*. [15] and numerous studies reported that plant phenols are promising natural antioxidant [29].

The total antioxidant capacity of different fractions was determined spectrophotometrically following phosphomolybdenum method, which is mainly based on the reduction of molybdenum VI (Mo) to molybdenum V by the test sample and the following creation of green phosphate/Mo (V) mixes with an acme absorption at 695 nm [30]. In this study, for phosphomolybdate reduction, it was found that CME exerted the maximum TAA. Studies have revealed that a lot of flavonoids as well as associated polyphenols pay considerably to the phosphomolybdate scavenging action of the plants containing medicinal values [31].

In terms of reducing power assay, color of the test solution changes from yellow to green depending on the test specimen's reducing power. In this assay, the

reduction of the ferricyanide complex (Fe^{3+}) to the ferrous form (Fe^{2+}) indicates the occurrence of the reductants in the test solution and this Fe^{2+} can be determined by measuring the absorbance at 700 nm [32]. Previous studies have revealed that the reducing possessions have been exposed to exert antioxidant act owing to the donation of a hydrogen atom in order to halt the free radical chain [33]. In this study among crude extract and fractions, CME exerted an Increment of absorbance at 700 nm specifies a surge in reducing aptitude. Hossain *et al*. reported auspicious action for the study of antioxidant activities of *S. podophyllum* leaves [15]. Plant secondary metabolites play imperative roles in reactive oxygen species metabolism [34].

The firm DPPH were reduced by all of the plant extracts, thus the invisibility of purple color to varying extent depends on the existence of antioxidant compounds [35]. Furthermore, the degree of discoloration designates the scavenging potential of the extract [36]. In this study, maximum ability to counteract DPPH radicals was observed for the CME amid all the extracts tested, and a reasonable activity was found for other extracts. In a previous study, same authors stated alike outcomes [15]. Plants produce numerous low molecular weight antioxidants within the chloroplast stroma and cytosol using nicotinamide adenine dinucleotide phosphate as the final electron donor to combats against oxidative stress [37].

The existing study exposed a potent antioxidant activity of the *S. podophyllum* Schott stems, which may be an operative source of antioxidant defense. Moreover, the study also demonstrated a clear correlation between the antioxidant effect of the plant with the presence of polyphenols in general and flavonoids in particular.

CONCLUSION

The denouements of this study reported that, CME of *S. podophyllum* Schott stems exerted highest significant antioxidant and free radical scavenging activities as well as contained massive amounts of phenolic compounds with respect to remaining fractions. So CME can be considered as a basis of natural antioxidant. However, further studies are obligatory to isolate the bioactive compounds and detect the specific molecular mechanisms vital for antioxidant activity.

AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration between all authors. Authors MSU and MSH designed the study, wrote the protocol, managed the analyses of the study. Authors MSU, MSH, MTK, IR and AAM performed the laboratory tests and prepared the draft of the manuscript. Author MRJ participated in literature review and statistical analysis. Author DT revised and improved the manuscript. All the authors read and approved the final manuscript.

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COMPETING INTERESTS

The authors proclaim that they have no competing interests.

ABBREVIATIONS

ACA	=	Ascorbic acid
AQF	=	Aqueous fraction
BHT	=	Butylated hydroxy toluene
CLF	=	Chloroform fraction
CME	=	Crude methanol extract
CTC	=	(+)-catechin
DPPH	=	2,2-diphenyl-1-picrylhydrazyl
EAF	=	Ethyl acetate fraction
GA	=	Gallic acid
GAE	=	Gallic acid equivalents
NHF	=	n-hexane fraction
RPA	=	Reducing power activity
S. podophyllum	=	*Syngonium podophyllum*
TAA	=	Total antioxidant activity
TFC	=	Total flavonoid content
TPC	=	Total phenolic content

REFERENCES

[1] Mamun AA, Hossain M, Islam A, Zaman S, Uddin MS. *Asparagus racemosus* Linn. potentiates the hypolipidemic and hepatoprotective activity of fenofibrate in alloxan-induced diabetic rats. Plant 2017; 5(5-1): 1-12. https://doi.org/10.11648/j.plant.s.2017050501.11

[2] Uddin MS, Mamun AA, Hossain MS, Akter F, Iqbal MA, Asaduzzaman M. Exploring the effect of *Phyllanthus emblica* L. on cognitive performance, brain antioxidant markers and acetylcholinesterase activity in rats: promising natural gift for the mitigation of Alzheimer's disease. Ann Neurosci 2016; 23(4): 218-29. https://doi.org/10.1159/000449482

[3] Ahn K. The worldwide trend of using botanical drugs and strategies for developing global drugs. BMB Repo 2017; 50(3): 111.

[4] Sufian MA, Chowdhury TK, Mian MM, Mohiuddin M, Koly SF, Uddin MS, Sarwar MS. *In vitro* study on thrombolytic and membrane stabilizing activities of *Alternanthera paronychioides* and *Vernonia patula* leaves and stems. Annu Res Rev Biol 2017; 15(3): 1-9. https://doi.org/10.9734/ARRB/2017/34776

[5] Baell J, Walters MA. Chemical con artists foil drug discovery. Nature. 2014; 513(7519): 481.

[6] Atanasov AG, Waltenberger B, Pferschy-Wenzig EM, Linder T, Wawrosch C, Uhrin P, *et al*. Discovery and resupply of pharmacologically active plant-derived natural products: A review. Biotech Adv 2015; 33(8): 1582-614. https://doi.org/10.1016/j.biotechadv.2015.08.001

[7] Newman DJ, Cragg GM. Natural products as sources of new drugs over the 30 years from 1981 to 2010. J Nat Pro 2012; 75(3): 311-35.

[8] Uddin MS, Uddin GMS, Begum MM, Begum Y, Herrera-Calderon O, Islam MI, Abdel-Daim MM. Inspection of phytochemical content and in vitro antioxidant profile of *Gnaphalium luteoalbum* L.: An unexplored phytomedicine. J Pharm Nutr Sci 2017; 7(3): 136-146. https://doi.org/10.6000/1927-5951.2017.07.03.10

[9] Saeed N, Khan MR, Shabbir M. Antioxidant activity, total phenolic and total flavonoid contents of whole plant extracts *Torilis leptophylla* L. BMC Comp Alt Med 2012; 12(1): 221.

[10] Uddin MS, Mamun AA, Khanum S, Begum Y, Alam MS. Analysis of *in vitro* antioxidant activity of *Caryota urens* L. leaves: A traditional natural remedy. J Coast Life Med 2016; 4(6): 483-484. https://doi.org/10.12980/jclm.4.2016J6-65

[11] Hossain MS, Uddin MS, Moniruzzaman M, Asaduzzaman M. Comparative study of cytotoxic potential and phytochemical screening of *Xanthosoma sagittifolium* rhizome and *Syngonium podophylam* leaf. J Med Plants 2015; 3(3): 43-46.

[12] Hernandez J. In Hawaiian rainforests: Exotic aroid ecologies. Aroideana 2007; 30: 91-97.

[13] Tropical.theferns.info. Useful tropical plants. [cited 2017 June 25]: Available from: http://tropical.theferns.info/viewtropical.php?id=Syngonium+podophyllum

[14] Hossain MS, Uddin MS, Kabir MT, Akhter S, Goswami S, Mamun AA, *et al*. *In vivo* screening for analgesic and anti-inflammatory activities of *Syngonium podophyllum* L.: A remarkable herbal medicine. Annu Res Rev Biol 2017; 16(3): 1-12. https://doi.org/10.9734/ARRB/2017/35692

[15] Hossain MS, Uddin MS, Kabir MT, Begum MM, Koushal P, Herrera-Calderon O. *In vitro* screening for phytochemicals and antioxidant activities of *Syngonium podophyllum* L.: An incredible therapeutic plant. Biomed Pharmacol J 2017; 10(3): 1267-1277. http://dx.doi.org/10.13005/bpj/1229

[16] Kupchan SM, Karim A, Marcks C. Taxodione and taxodone, two novel diterpenoid quinone methide tumor inhibitors from *Taxodium distichum*. J Org Chem 1968; 90(21): 5923-4.

[17] Trease GE, Evans MC. Text book of pharmacognosy. London: Balliere Tindall, 1983.

[18] Chang CC, Yang MH, Wen HM, Chern JC. Estimation of total flavonoid content in propolis by two complementary colorimetric methods. J Food Drug Ana 2002; 10(3): 178-182.

[19] Prieto P, Pineda M, Aguilar M. Spectrophotometric quantitation of antioxidant capacity through the formation of a phosphomolybdenum complex: Specific application to the determination of vitamin E. Analy Bioche 1999; 269(2): 337-41.

[20] Oyaizu M. Studies on products of browning reaction antioxidative activities of products of browning reaction prepared from glucosamine. Japanese J Nutr 1986; 44 (6): 307-315.

[21] Kulisic T, Radonic A, Katalinic V, Milos M. Use of different methods for testing antioxidative activity of Oregano essential oil. Food Chem 2004; 85: 633-640

[22] Uddin MS, Nasrullah M, Hossain MS, Rahman MM, Sarwar MS, Amran MS, *et al*: Evaluation of nootropic activity of *Persicaria flaccida* on cognitive performance, brain antioxidant markers and acetylcholinesterase activity in rats: implication for the management of Alzheimer's disease. Ame J Psy Neurosci 2016; 4: 26-37. https://doi.org/10.11648/j.ajpn.20160402.12

[23] Kumar SN, Thampi N. Phytochemical screening and characterization of the bioactive compounds from the leaves of *Hyptis suaveolens* and *Spathodea campanulata*. J Che Pharma Res 2015; 7(7): 840-50.

[24] Rahman A, Haque A, Uddin MS, Mian MM, Sufian MA, Rahman MM, *et al*. *In vitro* screening for antioxidant and anticholinesterase effects of *Uvaria littoralis* Blume.: A nootropicphytotherapeutic remedy. J Intellectual Disability – Diag Treat 2017; 5(2): 50-60. https://doi.org/10.6000/2292-2598.2017.05.02.3

[25] Hatano T, Edamatsu R, Mori A, Fujita Y, Yasukara T, Yoshida T. Effects of the Interaction of Tannins with Co-existing Substances. VI.: Effects of Tannins and Related Polyphenols on Superoxide Anion Radical, and on 1, 1-Diphenyl-2-picrylhydrazyl Radical. Chem Pharm Bull 1989,37(8): 2016-2021.

[26] Pan Y, Wang K, Huang S, Wang H, Mu X, He C, *et al*. Antioxidant activity of microwave-assisted extract of longan (Dimocarpus Longan Lour.) peel. Food Che 2008; 106(3): 1264-70.

[27] Kähkönen MP, Hopia AI, Vuorela HJ, Rauha JP, Pihlaja K, Kujala TS, *et al*. Antioxidant activity of plant extracts containing phenolic compounds. J Agri Food Chem 1999; 47: 3954-3962.

[28] Caunii A, Pribac G, Grozea I, Gaitin D, Samfi I. Design of optimal solvent for extraction of bio–active ingredients from six varieties of *Medicago sativa*. Chem Cent J 2012; 6(1): 123-131. https://doi.org/10.1186/1752-153X-6-123

[29] Kasote DM, Katyare SS, Hegde MV, Bae H. Significance of antioxidant potential of plants and its relevance to therapeutic applications. Int J Biological Sci 2015; 11(8): 982-991.

[30] Kumar P, Kumar S, Kumar S, Kumar R. *In vitro* study of plant extract from *Chenopodium album* that inhibits a key enzyme in diabetes and its role in diabetic oxidative stress. Der Pharmacia Sinica 2015: 6(12): 48-61.

[31] Sharififar F, Dehghn-Nudeh G, Mirtajaldini M. Major flavonoids with antioxidant activity from *Teucrium polium* L. Food Chem 2009; 112: 885-888.

[32] Ganie SA, Haq E, Masood A, Hamid A, Zargar MA. Antioxidant and protective effect of ethyl acetate extract of *Podophyllum hexandrum* rhizome on carbon tetrachloride induced rat liver injury. Evidence-Based Compl Alt Medi 2011; 2011: 1-12. https://doi.org/10.1155/2011/238020

[33] Gordon MH. The mechanism of antioxidant action in vitro. in food antioxidants. Edited by Hudson BJ. London: Elsevier Applied Science; 1990.

[34] Baier M, Dietz KJ. Chloroplasts as source and target of cellular redox regulation: A discussion on chloroplast redox

signals in the context of plant physiology. J Exp Bot 2005; 56(416): 1449-62.

[35] Belaqziz M, Tan SP, El-Abbassi A, Kiai H, Hafidi A, O'Donovan O, McLoughlin P. Assessment of the antioxidant and antibacterial activities of different olive processing wastewaters. PloS One 2017; 12(9): e0182622. https://doi.org/10.1371/journal.pone.0182622

[36] Sowndhararajan K, Kang SC. Evaluation of *in vitro* free radical scavenging potential of Streptomyces sp. AM-S1 culture filtrate. Saudi J Biolo Sci 2013; 20(3): 227-33.

[37] Alscher RG, Donahue JL, Cramer CL. Reactive oxygen species and antioxidants: Relationships in green cells. Physiol Plant 1997; 100: 224-33. https://doi.org/10.1111/j.1399-3054.1997.tb04778.x

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