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Research Article

Phytochemical evaluation and study of in vitro antioxidant potential of ethanolic and aqueous extracts of *Amorphophallus campanulatus*: a popular tuber of West Bengal

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ABSTRACT

The use of herbal medicines worldwide had provided an excellent opportunity to India to look for therapeutic compounds from our ancient system of therapy, Ayurveda, which can be utilized for development of new drug. *Amorphophallus campanulatus* is grown wild and cultivated all over India. It is very popular for its edible corms and leaves, especially in Assam and Bengal and is cultivated there as a common food crop. Since ancient time, it has been considered as medicinal plant in Sushruta Samhita and Ayurveda. It is recommended for different ailments like digestive disorders, piles, buccal ulcers and as liver stimulant in Dravyaguna Vigyan. So, the ethanolic and aqueous extracts of this tuber were screened for the presence of in vitro antioxidant potential against 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical, ferric reducing power, hydroxyl radical, superoxide radical and lipid peroxidation. Total phenolic and flavonoid contents of both the extracts were also evaluated. IC_{50} values of ethanolic and aqueous extract of *Amorphophallus campanulatus* represented 676.37 and 820.46 µg/ml respectively for DPPH ; 665 and 968.64 µg/ml respectively for hydroxyl radical scavenging activity; 703.33 and 1097.61 µg/ml respectively for superoxide radical scavenging activity and 842.83 and 1337.35 µg/ml respectively in case of lipid peroxidation inhibition. The total phenol for ethanolic and aqueous extract was estimated to be 194.4 ± 2.2 mg % w/w and 104.6 ± 1.24 mg % w/w respectively (mg Gallic acid equivalent per gm dry weight of sample) and that of flavonoid was 6.75 ± 1.2 mg w/w and 1.50 ± 0.23 mg % w/w respectively (mg of Rutin equivalent per gm dry weight of sample). Ethanolic extract shows maximum antioxidant capacity in comparison to aqueous extract and hence can be utilized in future as therapeutic agent against free radical induced oxidative stress

Keywords: Antioxidant potential; DPPH; Free radical; Hydroxyl radical; Lipid peroxidation; Oxidative stress; Superoxide radical

INTRODUCTION

Molecular oxygen is an essential component for all living organisms, where it helps in the process of oxidation, which is a basic component of aerobic life and of our metabolism (Aiyegoro and Okoh, 2010). A part of the oxygen taken into living cells is converted to several harmful reactive oxygen species (ROS) and free radicals. Once formed, free radicals can start a chain of reactions, leading to the formation of more free radicals. When generation of ROS overtakes the antioxidant defense of the cells, the free radicals start attacking the cell proteins, lipids and carbohydrates and this leads to the development of degenerative diseases (Cotran et al., 1999). Even if a balance between oxidative damage and protective mechanisms is usually kept, there are specific situations, in which the excessive production of free radicals, or deficiencies in antioxidant defenses, leads to the appearance of oxidative stress (Halliwell B., 1989; Lata H, Ahuja G.K., 2003). The cause of a majority of disease conditions like atherosclerosis, hypertension, ischemic disease, alzheimer's disease, parkinsonism, cancer, diabetes mellitus and inflammatory conditions are being considered to be preliminarily due to imbalance between prooxidants and antioxidant homeostasis (Shirwaikar A and Somashekar A.P., 2003). One of the prime causes of this imbalance may be attributed to present day lifestyle of the urban people, in particular.

Clinical trials and epidemiological studies have established an inverse correlation between the intake of dietary antioxidants and the occurrence of oxidative stress related diseases. Hence the rationale for the use of antioxidants is well established in prevention and treatment of diseases where oxidative stress plays a major aetiopathological role. Antioxidants may protect the body against ROS toxicity either by preventing the formation of ROS, by bringing interruption in ROS attack, by scavenging the reactive metabolites or by converting them to less reactive molecules (Sen C.K., 1995;

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Hedge K, Joshi AB., 2009). Therefore the uses of antioxidants, both natural and synthetic, are gaining wide importance in prevention of diseases.

Amorphophallus campanulatus (Roxb.) commonly known as surana in *Sanskrit*, elephant yam in *English* and ol kachu in *Bengali* is a tuberous, stout, indigenous herb, 1.0-1.5 m in height. *Amorphophallus* is a large genus of some 170 tropical and subtropical tuberous herbaceous plants from the Arum family (Araceae). A few species are edible as "famine foods" after careful preparation to remove irritating chemicals. These are typical lowland plants, growing in the tropical and subtropical zones of the paleotropics, from West Africa to the Pacific Islands. *Amorphophallus campanulatus* also has its mention in Ayurveda. Traditionally the root is dried and used in the treatment of piles and dysentery. The fresh root acts as an acrid stimulant and expectorant, it is much used in India in the treatment of acute rheumatism. Especially in Ayurveda, it is used in arthralgia, elephantiasis, tumors, inflammations, hemorrhoids, hemorrhages, vomiting, cough, bronchitis, asthma, dyspepsia, colic, constipation, hepatosplenopathies, amenorrhea, dysmenorrhea, seminal weakness, fatigue and general debility (C.P. Khare, 2004). This is also a starch based food item but it has several important antinutrient components like steroids, alkaloids, tannins, glycosides, phenols, flavonoids, saponins etc.

Therefore the objective of the present study was to perform a comparative evaluation of the antioxidant potential and free radical scavenging activity of aqueous and ethanolic extracts of *Amorphophallus campanulatus.*

MATERIALS & METHODS

Procurement of plant materials

The tubers of Amorphophallus campanulatus were collected from local vegetable market of Kolkata district, West Bengal (India). Authentication was done by Dr. Krishnendu Sarkar, Associate Professor, Department of Botany, Rammohan College under University of Calcutta, West Bengal, (India).

Preparation of Aqueous Extract

The coarse plant material was used for preparation of extracts. The extraction of powdered tuber was done by using Soxhlet apparatus (M/s B.C. Chatterjee & Co., Kolkata, West Bengal, India). 100 gm of powdered sample was taken in the thimble of Soxhlet and extracted with 250 ml of distilled water continuously 8 hours for 4 days. The mixture was then filtered through muslin cloth, centrifuged and the collected filtrate was evaporated to dryness on hot plate at constant temperature of 60^{o}C. The clumpy dry powder obtained was scraped by knife, made into fine powder form and stored in air tight plastic vials.

Preparation of Ethanolic Extract

100 gm of powdered sample was taken in the thimble of Soxhlet and extracted with 250 ml of ethanol (70%) in the round bottomed flask continuously for three days. The mixture was then filtered through muslin cloth, centrifuged and the collected filtrate was evaporated to dryness using rotary evaporator (M/s B.C. Chatterjee & Co., Kolkata, West Bengal, India). The dried sample was collected and stored in air tight plastic vials for estimation of antioxidant property.

Reagents and Chemicals

2,2-diphenyl-1-picrylhydrazyl (DPPH), was obtained from Sigma, Aldrich. Gallic Acid, Quercetin, Rutin, Butylated hydroxytoluene (BHT), 2-deoxy-2-ribose, Potassium ferricyanide, Trichloroacetic acid (TCA), Ferric chloride ($FeCl_3$), Ethylenediaminetetraacetic acid (EDTA), Hydrogen peroxide (H_2O_2), Ascorbic acid, 2-thiobarbituric acid (TBA), Nitro blue tetrazolium (NBT), Riboflavin were procured from Hi- Media, Mumbai, India. Potassium chloride (KCl), Hydrochloric acid (HCl), Ethanol, Methanol, Aluminium chloride ($AlCl_3$), Sodium carbonate (Na_2CO_3), Sodium nitrite ($NaNO_2$), Sodium Hydroxide (NaOH), Di sodium hydrogen phosphate (Na_2HPO_4), Sodium dihydrogen phosphate (NaH_2PO_4) were procured from Merck India Ltd, Mumbai. All chemicals were of analytical grade.

Total phenols estimation

The total phenols of all extracts were measured at 765 nm by Folin Ciocalteu reagent (McDonald et al., 2001). The dilute aqueous and ethanolic extracts (0.5 ml of 1mg ml^{-1}) or Gallic acid (standard phenolic compound) was mixed with Folin Ciocalteu reagent (5 ml, 1:10 diluted with distilled water) and aqueous sodium carbonate (4 ml, 1 M). The mixture was allowed to stand for 30 min and the total phenols were determined by spectrophotometer at 765 nm. The standard curve was prepared using 0, 50, 100, 150, 200, 250 mg/L solutions of Gallic acid in methanol: water (50:50, *v/v*). Total phenol values were expressed in terms of Gallic acid equivalent (mg/100g of dry mass), which is a common reference compound. All tests were performed in triplicate and the graph was plotted with the average of the three determinations.

Total flavonoid estimation

Total flavonoid contents were measured with the aluminum chloride colorimetric assay (S.Kumar et al., 2008). Aqueous and ethanolic extracts (1.0 ml of 1mg ml^{-1}) and different dilution of standard solution of Rutin (10-100µg/ml) were added to 10ml volumetric flask containing 4ml of water. To the above mixture, 0.3ml of 5% $NaNO_2$ was added. After 5 minutes, 0.3ml of 10% $AlCl_3$ was added. After 6 min, 2ml of 1 M NaOH was added and the total volume was made up to 10ml with distilled water. Then the solution was mixed well and the absorbance was measured against a freshly prepared reagent blank at 510 nm. Total flavonoid content

of the extracts was expressed in terms of Rutin equivalent (mg/100g of dry mass), which is a common reference compound. The standard curve was prepared using 20, 40, 60, 80, and 100 µg/ml rutin solution in methanol: water (50:50, *v/v*). All tests were performed in triplicate and the graph was plotted with the average of the three determinations.

DPPH Radical Scavenging Activity

The stable DPPH radical was used for determination of free radical-scavenging activity of the extracts. 0.1 mM solution of DPPH in ethanol (22.2 mg in 1000 ml) was freshly prepared. 1 ml of different concentrations of aqueous and ethanolic extracts (100-1000 µg/ml) and standard ascorbic acid (100-1000 µg/ml) was added to 2 ml of ethanolic solution of DPPH. After 30 min at room temperature, the absorbance was recorded at 517 nm (Sreejayan and M.N.A. Rao, 1996; Mohammad T.A., 2009). Blank was performed in the same way with 1ml of ethanol instead of test substance. The percentage inhibition activity was calculated from:

Inhibition (%) = 1 – (sample OD/blank OD) × 100

All tests were performed in triplicate and the graph was plotted with the average of the three determinations. An IC_{50} was calculated as the concentration which brought about a 50% reduction in absorbance compared to blank. Ascorbic acid was used as standard.

Ferric Reducing Antioxidant Power (FRAP) Assay

Various concentrations of aqueous and ethanolic extracts (100-1000 µg/ml) and standard solutions of butylated hydroxytoluene (BHT) (100-1000 µg/ml) (1ml each), 2.5 ml of phosphate buffer (pH 6.6) and 2.5 ml of 1% potassium ferricyanide were mixed separately and allowed to incubate at 50ºC for 30 min. After incubation period 2.5 ml of 10% TCA was added to the mixtures and centrifuged for 10 min at 3000 rpm. About 2.5 ml of the supernatant was diluted with 2.5 ml water and shaken with 0.5 ml of freshly prepared 0.1% ferric chloride. The absorbance was measured at 700 nm**,** (M. Oyaizu 1986). All tests were performed in triplicate and the graph was plotted with the average of the three determinations.

Hydroxyl Radical scavenging Assay

Scavenging of hydroxyl free radical was measured by the method of (Halliwell and Chirico, 1993) with minor changes. All solutions were prepared freshly. 200µL of 2.8mM 2-deoxy-2-ribose, 1ml of various concentrations of aqueous and ethanolic extracts (100-1000 µg/ml), 400 µL of 200 µM $FeCl_3$, 1.04mM EDTA (1:1 V/V), 200 µL of H_2O_2 (1.0 mM) and 200 µL ascorbic acid (1.0 mM) was mixed to form a reaction mixture. After an incubation period of one hour at 37^{o}C the extent of deoxyribose degradation was measured by the TBA reaction. 1.5 ml of 2.8% TCA and 1 ml of 0.336% TBA was added and boiled for 20 min on boiling water bath. After cooling the absorbance was read at 532 nm against a blank (containing all reagents except the extracts). The percentage inhibition activity was calculated from:

Inhibition (%) = 1 – (sample OD/blank OD) × 100

All tests were performed in triplicate and the graph was plotted with the average of the three determinations. An IC_{50} was calculated as the concentration which brought about a 50% reduction in absorbance compared to blank. Quercetin was used as standard.

Assay for superoxide radical scavenging activity

The assay was based on capacity of the sample to inhibit blue formazon formation by scavenging the superoxide radicals generated in riboflavin-light-nitro blue tetrazolium (NBT) system. The reaction medium contained 2.5 mL of phosphate buffer (pH 7.6), 100 µL riboflavin (20 µg), 200 µL EDTA (12mM), 100µL NBT (0.1 mg) and 1ml of various concentrations of aqueous and ethanolic extracts (200-1200 µg/ml). The reaction was started by illuminating the reaction mixture for 5 minutes. The absorbance was measured at 590 nm. Blank was performed in the same way with 1ml of methanol instead of test substance (Beuchamp C, Fridovich I, 1971). The percentage inhibition activity was calculated from:

Inhibition (%) = 1 – (sample OD/blank OD) × 100

All tests were performed in triplicate and the graph was plotted with the average of the three determinations. An IC_{50} was calculated as the concentration which brought about a 50% reduction in absorbance compared to blank. Ascorbic acid was used as standard.

Lipid Peroxidation Assay

Normal male rats (250 g) were used for the preparation of liver homogenate. The perfused liver was isolated, and 10% (w/v) homogenate was prepared with homogenizer at 0-4°C with 0.15M KCl. The homogenate was centrifuged at 8,000 rpm for 15 min, and clear cell-free supernatant was used for the study of in vitro lipid peroxidation assay. Different concentrations (200-1200µg/ml) of extracts (1ml) were added in test tubes and 1 ml of 0.15 M KCl and 0.5 ml of rat liver homogenates were added. Peroxidation was initiated by adding 100 µL of 2 mM ferric chloride. After incubation at 37°C for 30 min, the reaction was stopped by adding 2 ml of ice-cold HCl (0.25 N) containing 15% TCA, 0.38% TBA, and 0.5% BHT. The reaction mixtures were heated at 80^{o}C for 30 min. The samples were cooled and centrifuged, and the absorbance of the supernatants were measured at 532 nm (Arora S, Singh R, 2009). The percentage inhibition of lipid peroxidation is calculated by the formula:

Inhibition (%) = 1 – (sample OD/blank OD) × 100

All tests were performed in triplicate and the graph was plotted with the average of the three determinations. An IC_{50} was calculated as the concentration which brought about a 50% reduction in absorbance compared to blank. Quercetin was used as standard.

Statistical analysis

Results were subjected to statistical analysis using Student's t test. In all the cases, results are the mean ± SD of at least three individual experimental data, each in triplicate.

RESULTS

Total phenolic content and total flavonoid content

The quantitative determination of the total phenolic content (TPC), is expressed as mg Gallic acid equivalents gm dry weight of sample. TPC of ethanolic extract of *Amorphophallus campanulatus* is 194.4 ± 2.2 mg *w/w* and that of aqueous extract is 104.6 ± 1.24 mg *w/w*. Total flavonoid content of the extracts is ex-

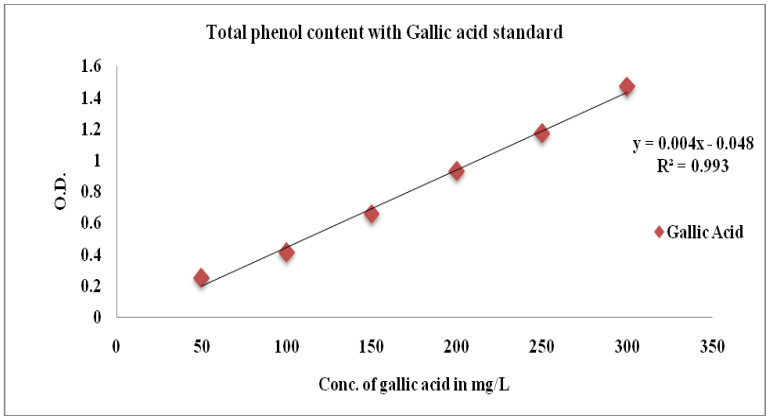

Figure 1a: Total phenol content with Gallic acid standard. The data are presented as means ± S.D of three independent experiments

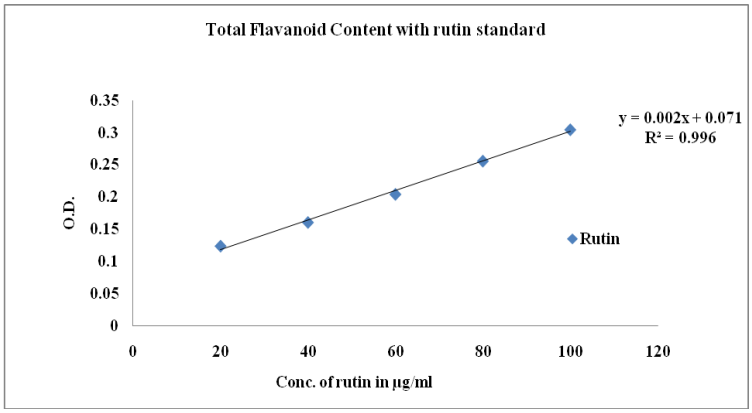

Figure 1b: Total Flavonoid Content with rutin standard. The data are presented as means ± S.D of three independent experiments

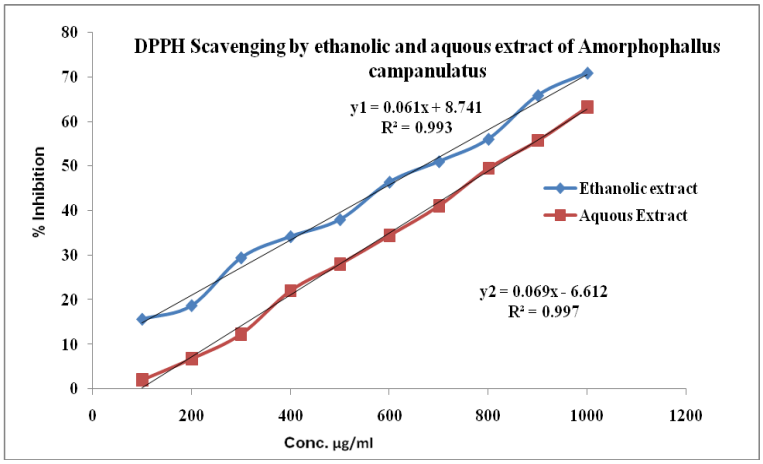

Figure 2a: DPPH Scavenging by ethanolic and aqueous extract of Amorphophallus campanulatus. The data are presented as means ± S.D of three independent experiments

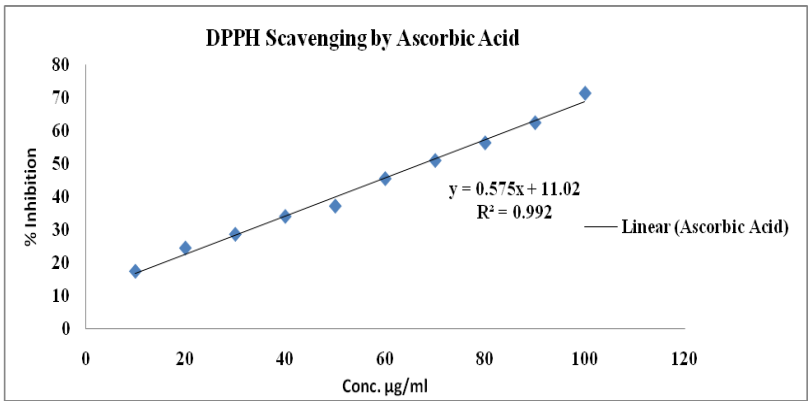

Figure 2b: DPPH Scavenging by Ascorbic Acid. The data are presented as means ± S.D of three independent experiments

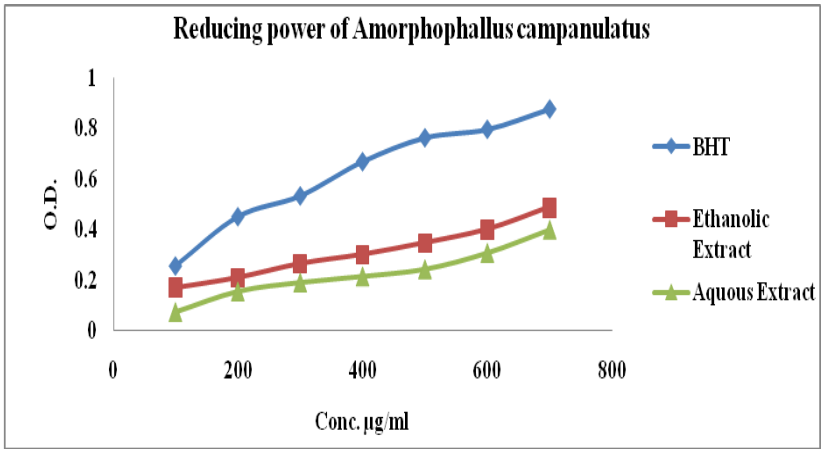

Figure 3: Reducing power (Fe^{3+} to Fe^{2+} conversion) shown by ethanolic and aqueous extract of Amorphophallus campanulatus and known antioxidant BHT; Butylated hydroxytoluene. The data are presented as means ± S.D of three independent experiments

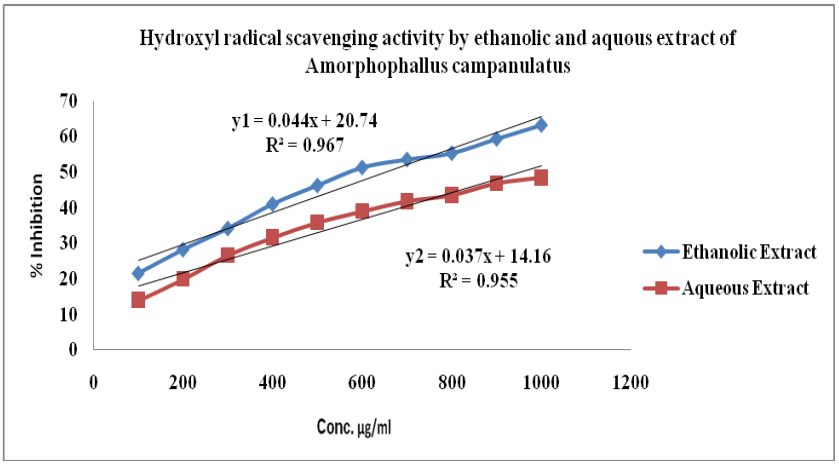

Figure 4a: Hydroxyl Radical Scavenging by ethanolic and aqueous extract of Amorphophallus campanulatus. The data are presented as means ± S.D of three independent experiments

pressed as mg of Rutin equivalent per gm dry weight of sample. Total flavonoid of ethanolic extract of *Amorphophallus campanulatus* is 6.75 ± 1.2 mg *w/w* and that of aqueous extract is 1.50 ± 0.23 mg *w/w.* Fig. 1a &1b shows the standard curve for total phenolic content with Gallic acid and total flavonoid content with rutin respectively.

DPPH Scavenging Assay

In the DPPH scavenging study, both the ethanolic and aqueous extracts of *Amorphophallus campanulatus* exhibits marked DPPH free radical scavenging activity in a concentration-dependent manner. Lower absorbance of the reaction mixture indicates higher free radical scavenging activity. Fig. 2a & 2b shows that % inhibition decreases the concentration of DPPH radical

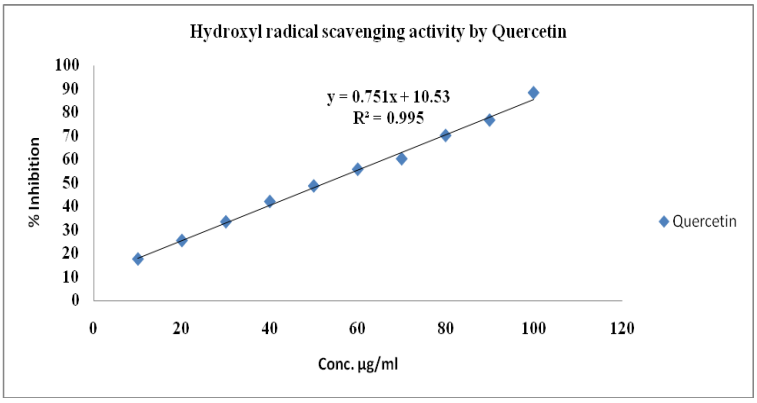

Figure 4b: Hydroxyl Radical Scavenging by Quercetin. The data are presented as means ± S.D of three independent experiments

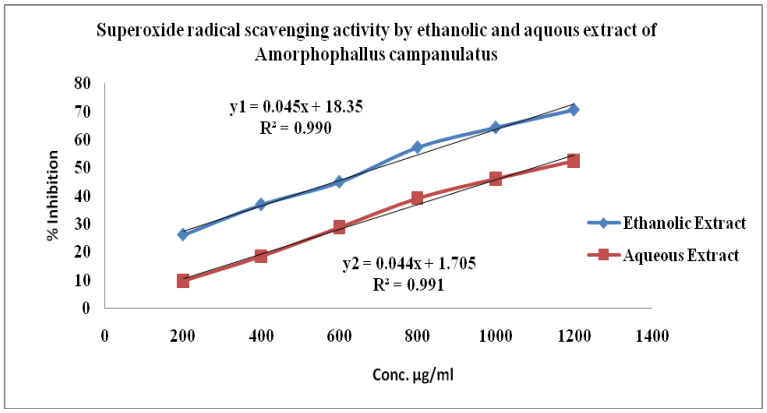

Figure 5a: Superoxide Radical Scavenging by ethanolic and aqueous extract of Amorphophallus campanulatus. The data are presented as means ± S.D of three independent experiments

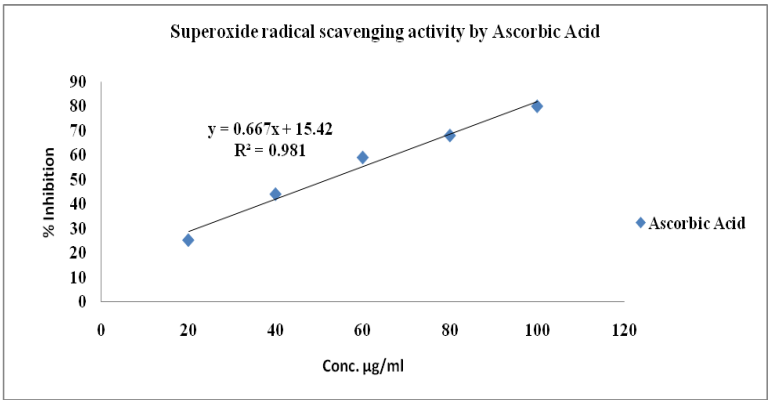

Figure 5b: Superoxide Radical Scavenging by Ascorbic Acid. The data are presented as means ± S.D of three independent experiments

due to scavenging ability of extract and standard ascorbic acid, as a reference compound. The ethanolic extract presents better activity at all concentrations when compared to the aqueous extract. The IC_{50} value for ethanolic extract was found to be 676.37 µg/ml which is significantly lower ($p < 0.05$) than that for aqueous extract 820.46 µg/ml. The IC_{50} value for standard Ascorbic acid is 67.79 µg/ml (Table 1).

Ferric Reducing Antioxidant Power (FRAP) Assay

Reducing power is a measure of reductive ability of antioxidants and is evaluated by the transformation of Fe^{3+} to Fe^{2+} in the presence of sample extract. The reducing capacity of a compound may serve as a significant indicator of its potential antioxidant activity. The reducing power of synthetic antioxidant BHT, ethanolic and aqueous extract of *Amorphophallus campanulatus* is shown in Fig. 3. The data shows an increase in the reducing power of both the extracts in a dose dependent manner. The ethanolic extract presents better activity at all concentrations when compared to the aqueous extract.

Hydroxyl Radical scavenging Assay

The ethanolic and aqueous extracts of *Amorphophallus campanulatus* are examined for their ability to sca-

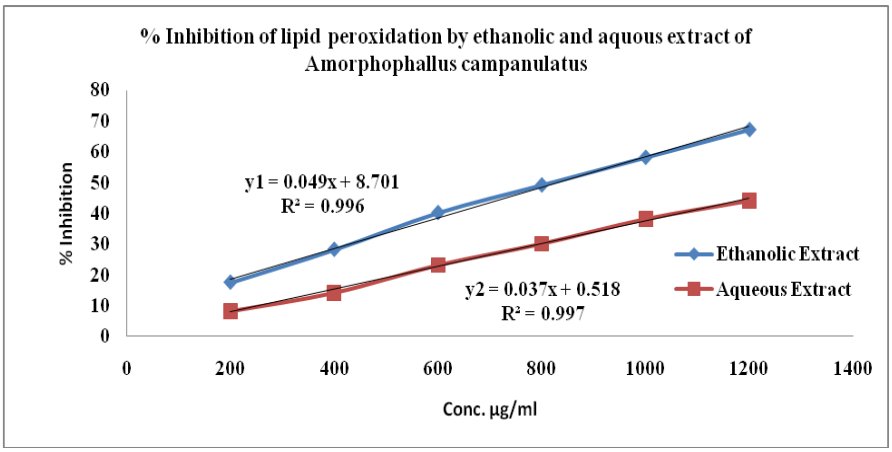

Figure 6a: % Inhibition of lipid peroxidation by ethanolic and aqueous extract of Amorphophallus campanulatus. The data are presented as means ± S.D of three independent experiments

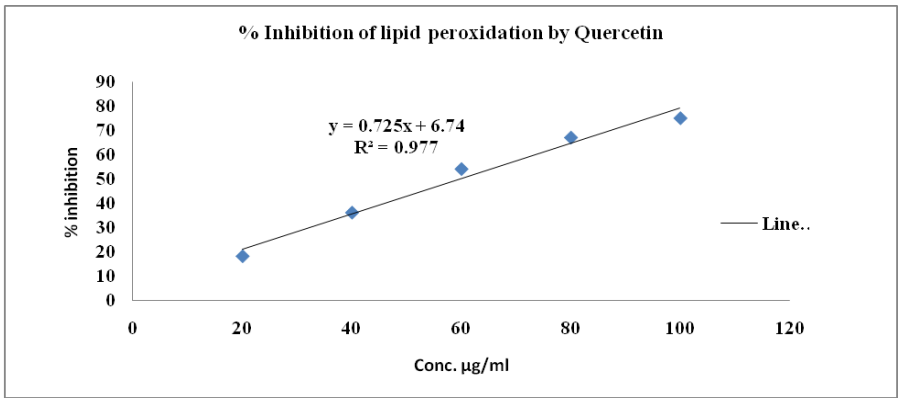

Figure 6b: % Inhibition of lipid peroxidation by Quercetin. The data are presented as means ± S.D of three independent experiments

Table 1: Results of all the % Inhibition studies

Results	Samples	Equation	R^2	IC_{50}
% Inhibition by DPPH	Standard Ascorbic Acid	y = 0.575x + 11.02	0.992	67.79 µg/ml
	Ethanolic Extract	y1 = 0.061x + 8.741	0.993	676.37 µg/ml*
	Aqueous Extract	y2 = 0.069x - 6.612	0.997	820.46 µg/ml
Hydroxyl Radical	Standard Quercetin	y = 0.751x + 10.53	0.995	52.55 µg/ml
	Ethanolic Extract	y1 = 0.044x + 20.74	0.967	665 µg/ml*
	Aqueous Extract	y2 = 0.037x + 14.16	0.955	968.64 µg/ml
Superoxide Radical	Standard Ascorbic Acid	y = 0.667x + 15.42	0.981	51.84 µg/ml
	Ethanolic Extract	y1 = 0.045x + 18.35	0.99	703.33 µg/ml*
	Aqueous Extract	y2 = 0.044x + 1.705	0.991	1097.61 µg/ml
Lipid Peroxidation	Standard Quercetin	y = 0.725x + 6.74	0.977	59.66 µg/ml
	Ethanolic Extract	y1 = 0.049x + 8.701	0.996	842.83 µg/ml*
	Aqueous Extract	y2 = 0.037x + 0.518	0.997	1337.35 µg/ml

Data set of n=3 and mean R^2 values obtained from the graphs.

* Significantly lower ($p<0.05$) than aqueous extract

venge hydroxyl radical. Both the extracts exhibit free radical scavenging activity in a concentration-dependent manner. Addition of ethanolic and aqueous extracts of *Amorphophallus campanulatus* to the reaction mixture remove the hydroxyl radicals from the sugar and protect it from degradation. Percent inhibition of the extracts and that of standard Quercetin is illustrated in Fig. 4a & 4b. The ethanolic extract presents better activity at all concentrations when compared to the aqueous extract. The IC_{50} value for ethanolic extract is found to be 665.00 µg/ml which is significantly lower ($p < 0.05$) than that for aqueous extract 968.64 µg/ml. The IC_{50} value for standard Quercetin is 52.55 µg/ml (Table 1).

Superoxide radical scavenging activity

Superoxide anions indirectly initiate lipid oxidation as a result of superoxide and hydrogen peroxide serving as precursors of singlet oxygen and hydroxyl radicals (Robak and Gryglewski, 1988). The ethanolic and aqueous extracts of *Amorphophallus campanulatus* are found to possess concentration dependent scavenging activity on superoxide generated by photoreduction of riboflavin. Percent inhibition of the extracts and that of standard Ascorbic acid is illustrated in Fig. 5a & 5 b. The ethanolic extract presents better activity at all concentrations when compared to the aqueous extract. The IC_{50} value for ethanolic extract is found to be 703.33 µg/ml which is significantly lower ($p < 0.05$) than that for aqueous extract 1097.61 µg/ml. The IC_{50} value for standard Ascorbic acid is 51.84 µg/ml; the results are presented in Table 1.

Lipid Peroxidation Assay

The ethanolic and aqueous extracts of *Amorphophallus campanulatus* are found to possess concentration dependent anti-lipid peroxidation activities. Percent inhibition of the extracts and that of standard BHT is illustrated in Fig. 6a & 6b. The ethanolic extract presents better activity at all concentrations when compared to the aqueous extract. The IC_{50} value for ethanolic extract was found to be 842.83 µg/ml which is significantly lower ($p < 0.05$) than that for aqueous extract 1337.35 µg/ml. The IC_{50} value for standard Quercetin is 59.66 µg/ml (Table 1).

DISCUSSION

Dietary components that can either sacrificially scavenge reactive oxygen species/reactive nitrogen species (ROS/RNS) to stop radical chain reactions, are considered as primary chain breaking antioxidants or free radical scavengers (FRS), or it can inhibit the reactive oxidants from being formed in the first place, considered as secondary or preventive antioxidants. The antioxidant activity of a compound has been attributed to various mechanisms viz prevention of chain initiation, binding of transition metal ion catalysts, decomposition of peroxides, prevention of continued hydrogen abstraction, reductive capacity and radical scavenging ability. Many plant extracts and phytochemicals have been shown to have antioxidant / free radical scavenging properties.

The results obtained in the course of this study, show that both the ethanolic and aqueous extract of *Amorphophallus campanulatus* possesses antioxidant potential. Both the extracts show their ability to scavenge DPPH radical, hydroxyl radical as well as superoxide radical. Moreover, the extracts also has the ability to inhibit lipid peroxidation, one of the most common pathways that lead to oxidative stress related degenerative disorders. The extracts also had sufficient reducing power as evidenced from the ferric reducing antioxidant power. Reducing power of a compound serve as a significant indicator of its antioxidant potential.

Phenolic compounds, the important plant constituents, are known powerful chain breaking antioxidants (Shahidi F, Wanasundara PK, 1992) because of their ability to scavenge hydroxyl groups which contribute directly to antioxidative action (Suresh Kumar P, 2008). Phenolic compounds are also effective hydrogen donors, which make them good antioxidants (Michalak A, 2006). It is suggested that polyphenolic compounds have inhibitory effects on mutagenesis and carcinogenesis in humans, when ingested up to 1g daily with a diet rich in fruits and vegetables (Tanaka T, 1998). The present study demonstrates that the ethanolic extract has better antioxidant potential than the aqueous extract as it possesses significantly higher amount of polyphenols and flavonoids which may be due to greater polarity of ethanol than water.

CONCLUSION

Amorphophallus campanulatus is popularly grown and available throughout the year all over West Bengal, India and is a very common food item among the Bengali people. Besides, it is also affordable by people from all socio-economic strata because of its low cost, easy availability and wild growth. As we are gradually progressing towards an era of nutraceuticals, extracts from this tuberous vegetable can be explored further from pharmacognostic approach to formulate drug against lifestyle induced oxidative stress disorders, for which the results of this study will be of immense help.

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