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Antioxidant activities in extracts of selected indigenous vegetables from Kenya and Malawi

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Antioxidant activities and phytochemical compounds of ethanol and hot water extracts of 7 selected indigenous vegetable species from Malawi and Kenya were Spectrophotometrically determined and evaluated. Their effectiveness were also evaluated by their EC₅₀ values through interpolation from linear regression analysis of their respective data. Generally, ethanolic extracts portrayed high quantities of total phenol, carotenoids and lycopene while hot water extracts showed high ascorbic acid. The highest total phenol (475.88±0.02 mg/g) and lycopene (0.13±0.02 mg/g) were detected in the ethanol extracts of *I. batatas* and *C. gynandria*, respectively. In the hot water extracts, the highest ascorbic acid (2.59±0.06 mg/g) and flavonoids (156.43±0.02 mg/g) were from *M. esculenta*. Dose-dependent antioxidant activities of the extracts were observed. Based on the EC₅₀ values (mg/ml), the hot water extracts were significantly (p<0.05) more effective in all antioxidant activities assayed (DPPH, hydroxyl, superoxide anion radicals and reducing power) than ethanol extracts. It was observed that a single vegetable species did not possess all sorts of antioxidant phytochemical compounds in significant quantities and hence not effective in scavenging all different radicals. A combinatory intake of these vegetables species in sufficient concentrations should thus be recommended to enhance an optimal antioxidant capacity in the body.

Key words: Antioxidants, free radicals, health benefits, indigenous vegetables.

INTRODUCTION

Humans are constantly exposed to reactive oxygen species (ROS) produced by natural phenomena such as ultraviolet light or by anthropogenic activities. Excessive productions of these ROS than the body antioxidant system effectively terminate or retard them can negatively have impact on health by causing several oxidative stress related diseases including cancer, hypertension,

heart diseases and diabetes (Young and Woodside, 2001). The human body counteracts these diseases by producing antioxidants which are either naturally produced *in situ*, or externally supplied through foods or supplements. However, the available synthetic antioxidant supplements such as butylated hydroxyanisole, butylated hydroxytoluene and gallic acid esters have

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Table 1. Plant samples used for the study.

Kenya		Malawi	
Botanical name	Vernacular/common name	Botanical name	Vernacular/common name
<i>Urtica ferox</i>	Thabai, Hatha/Stinging nettle	<i>Ipomoea batatas</i>	Kholowa/Sweet potato leaves
<i>Corchorus olitorius</i>	Mlenda, Jute/ Saluyot	<i>Amaranthus spinosus</i>	Bonongwe/Green Amaranth leaves
<i>Cleome gynandra</i>	Sagati/Spiderplant	<i>Manihot esculenta</i>	Chigwada/Cassava leaves
<i>Solanum pseedocapsicum</i>	Monagu/Osuga/Black night shade		
<i>Brassica oleracea</i> (exotic vegetable)			

been suspected to cause or prompt negative health effects and observed to poses moderate antioxidant activities (Jeetendra et al., 2010). There is now a growing interest to substitute synthetic antioxidants with naturally occurring antioxidants from plant sources.

Most *in vitro* studies on plants have strongly supported the idea that plants constituent antioxidant activities capable of exerting protective effects against oxidative stress in biological systems (Rahmat et al., 2014; Kumar et al., 2010; Shimada et al., 2004). Apart from traditionally used natural antioxidants from tea, wine, and spices (Cao et al., 2012; Amro et al., 2002; Moure et al., 2001), Tomatoes, watermelons, guavas, papayas, apricots, pink grapefruits, blood oranges have also been observed to contain excellent antioxidant properties and high quantities of Carotenoids and lycopene (Johnson, 2002).

Strong antioxidant properties and high quantities of phytochemical compounds were also observed in Cap and Stipe from chicken drumstick mushroom species of *Coprinus* (Bo et al., 2010) and *Grifola frondosa*, *Morchella esculenta* and *Termitomyces albuminosus* mycelia (Mau et al., 2004). Similarly, indigenous vegetables from East-India and from West Africa have also been reported to constitute high levels of antioxidant components and activities (Odukoya et al., 2007; Gyngiri et al., 2012; Handique and Boruah, 2012)

Although many plant species have been investigated in search for novel antioxidants so far, fewer studies have been conducted on the edible green leafy indigenous vegetables of Sub-Saharan Africa and there is a high demand for a specific scientific data on their antioxidant potential. The present study qualitatively and quantitatively analyzed and determined the antioxidant phytochemicals compounds and evaluated antioxidant activities of seven indigenous vegetable species consumed in Kenya and Malawi summarized in Table 1 using spectroscopic methods. In the longer term, extracts of the vegetable species (or their active constituents) identified as having high levels of antioxidant activities *in vitro* may be of value in the design of further *in vivo* studies to unravel novel treatment strategies for disorders associated with ROS.

MATERIALS AND METHODS

Reagents, chemicals and standards

L-ascorbic acid, Tannic acids, Folin-ciocalteu's phenol, 1, 1-diphenyl-2-picrylhydrazyl (DPPH) were all purchased from Sigma-Aldrich, Germany. Sodium carbonate, aluminium chloride, 2, 6-Dichlorophenolindophenol and methanol were purchased from BDH Poole, England. All the chemicals used were of analytical grade. Deionized water was used throughout the experiment. Jenway 6405 UV/Visible Spectrophotometer by Buch Scientific Inc.USA was used for analysis.

Plant materials

Fresh leafy vegetable samples were bought from the local markets in Lilongwe, Malawi and Nairobi, Kenya and transported while still fresh in Cold chain box of between 2 to 6°C to University of Nairobi, Department of Biochemistry laboratory and kept at -80°C. *Brassica oleracea* was also bought from Kenya local market and studied for comparison because it is an exotic vegetable and it is widely consumed by most communities. The vegetables species used in the study are shown in Table 1.

Sample preparations and extraction

Samples were cleaned with deionized water and the leafy edible portions were chopped into very small tiny pieces prior to extraction. Two methods of extraction were deployed; hot water and ethanol (95% pure) extraction according to Bo et al. (2010). The hot water extracts were freeze-dried while the ethanol extracts rotary evaporated at 40°C to dryness. The dried extracts were used directly for analyses of antioxidant components or redissolved in water or ethanol to a concentration of 50 mg/ml and stored at 4°C for further analysis.

Determination of antioxidant phytochemicals

Total phenolic content

The total phenolic content of extracts was determined according to Barros et al. (2008) by Folin-Ciocalteu spectrophotometric method. Extract samples (1 ml) was mixed with equal volume of Folin and Ciocalteu's phenol reagent. After 3 min, 1 ml of saturated sodium carbonate solution was added to the mixture and adjusted to 10 ml with distilled water. The reaction was kept in the dark for 90 min, after which the absorbance was read at 725 nm. Tannic acid was used to construct the standard curve (0.01-0.4 mM). Estimations of

the phenolic compounds were carried out in triplicate. The results were presented as mean of three measurements and expressed as mg of tannic acid equivalents (TAEs) per g of each extract.

Total flavonoids content

Total flavonoid content was determined by the formation of a complex of aluminum flavonoid using the methodology of Oyedemi et al. (2010). Extracts solution 1 ml was diluted with 4.3 ml of 80% aqueous ethanol and to the test tubes 0.1 ml of 10% aluminium nitrate was added followed by 0.1 ml of 1 M aqueous potassium acetate. After 40 min at room temperature, the absorbance was determined spectrophotometrically at 415 nm. Total flavonoids concentration was calculated using quercetin as the standard. Absorbance = 0.002108 μ g quercetin - 0.01089. The results are presented as mean of three measurements and expressed as mg of quercetin per g of each extract.

Ascorbic acid determination

Ascorbic acid was determined from the extracts using the 2, 6-dichloro-phenolindophenol (Barros et al., 2008). The dried extract (100 mg) was dissolved in metaphosphoric acid (1%, 10 ml) for 45 min at room temperature and filtered through Whatman No. 4 filter paper. The filtrate (1 ml) was mixed with 2, 6-dichlorophenolindophenol (9 ml) and the absorbance was then measured within 30 s at 515 nm against a blank. Content of ascorbic acid were calculated on the basis of the calibration curve of authentic L-ascorbic acid (0.020-0.12 mg/ml; $Y = 3.4127X - 0.0072$ and results are presented as mean of three measurements, expressed as mg of ascorbic acid/g of extract.

β - Carotene and lycopene determination

β - Carotene and lycopene were determined according to the acetone-hexane mixture method of Nagata and Yamashita (1992) with some modifications. The dried extract (50 mg) was vigorously shaken with acetone-hexane mixture (4:6, 5 ml) for 1 min and filtered through Whatman No. 4 filter paper. The absorbance of the filtrate was then measured at $\lambda = 453, 505$ and 663 nm. Contents of β -carotene and lycopene were calculated according to the following equations: Lycopene (mg/100 ml) = $-0.0458 A_{663} + 0.372 A_{505} - 0.0806 A_{453}$; β -carotene (mg/100 ml) = $0.216 A_{663} - 0.304 A_{505} + 0.452 A_{453}$. The results are presented as mean of three measurements and expressed as mg of carotenoid/g of extract.

Antioxidant activities determination

DPPH Radical scavenging activity

The antioxidant activity of the extracts was measured on the basis of the scavenging activity of the stable 1, 1-diphenyl-2-picrylhydrazyl (DPPH) free radical according to the spectrophotometric method of Mensor et al. (2001). 1 ml of a 0.3 mM DPPH methanol solution was added to 2.5 ml solution of the extract or standards and allowed to react at room temperature for 30 min. The absorbance of the resulting mixture was then measured at 518 nm and converted to percentage antioxidant activity.

Hydroxyl radical scavenging activity

Scavenging ability on hydroxyl radicals was determined according to the method of Smirnov and Cumbers (1989) with some modifications. Hydroxyl radicals from the Fenton reaction reacted

with salicylate to form a colored material (2,3-dihydroxybenzoate). The hydroxyl radicals scavenging activity of an extract was assayed by the colour change of reaction system. 1 ml of the extract was mixed with 1 ml of $FeSO_4$ (9 mM) and 1 ml of salicylic acid (9 mM) in 95% ethanol. The reaction was initiated by the addition of 1 ml of H_2O_2 (8.8 mM). After 30 min incubation at $37^\circ C$, the absorbance of the mixture was determined at 510 nm against a blank and converted to percentage antioxidant activity.

Superoxide anion radical scavenging activity

The ability of extracts to scavenge superoxide radicals was measured according to Martin et al. (1987) spectrophotometric method where the superoxide anion radicals were generated from auto-oxidation of hematoxilin and was detected by an increase in absorbance at 560 nm. To a mixture (phosphate buffer 0.1M, pH 7.4, EDTA 0.1M and hematoxilin 50 μ M), 1 ml of extract was added and incubated at $25^\circ C$ for 10 min. Inhibition of auto oxidation of hematoxilin by boiled and ethanol extracts over the control was then measured.

Reducing power assay

The Oyaizu (1986) method was followed with some modifications to measure the power of extracts to reduce ferricyanide to ferrocyanide. A 2.0 ml of the extract was added to 2.0 ml of phosphate buffer (0.2 M, pH 6.6) and 2.0 ml of potassium ferricyanide (10 mg/ml), and the mixture incubated at $50^\circ C$ for 20 min. 1 ml of Trichloroacetic acid (50 mg/ml) was then added, and the mixture centrifuged at 4,000 rpm for 10 min. The upper layer (2.5 ml) was then gently mixed with deionised water (2.5 ml) and 0.5 ml ferric chloride (1 mg/ml) and the absorbance measured at 700 nm against a blank.

Determination of the EC_{50}

The EC_{50} was the effective concentration at which the DPPH radicals, hydroxyl radicals or superoxide radicals were scavenged by 50%, and absorbance was 0.5 for reducing power. This was obtained by interpolation from linear regression analysis of their respective data and results were normalized and expressed as EC_{50} values (mg/ml) for comparison. The lower the EC_{50} value, the more efficient the sample was.

Data analysis

The experimental data were subjected to an analysis of variance (ANOVA) for a completely random design to determine the least significant difference at the level of 0.05.

RESULTS AND DISCUSSION

Antioxidant components

Quantities of total ascorbic acid, flavonoids, phenol, β carotenoids and lycopene detected are shown in Table 2. Significantly higher ($p < 0.05$) quantities of total phenol, carotenoids and lycopene were detected in extracts of ethanol while ascorbic acid was detected in hot water extracts. No significant difference in total flavonoids content between hot water and ethanolic extracts was observed. The present findings of higher content of ascorbic acid obtained in hot water extracts contradict

Table 2. Contents of ascorbic acid, total flavonoids, total phenols, carotenoids and lycopenes in various sample extracts.

Extract	Vegetable specie	Antioxidant component (mg/g of extract)				
		Ascorbic acid ^a	Flavonoids ^b	Phenols ^c	βCarotenoids ^d	Lycopenes ^d
Ethanollic	<i>I. batatas</i>	1.93 ± 0.01	118.48 ± 0.06	475.88 ± 0.02	0.32 ± 0.08	0.08 ± 0.02
	<i>A. spinosus</i>	2.20 ± 0.02	99.31 ± 0.02	49.73 ± 0.03	0.36 ± 0.03	0.07 ± 0.03
	<i>M. esculenta</i>	0.70 ± 0.04	101.68 ± 0.03	246.77 ± 0.07	0.42 ± 0.03	0.07 ± 0.01
	<i>Urtica ferox</i>	2.17 ± 0.03	44.41 ± 0.04	41.11 ± 0.03	0.35 ± 0.02	0.04 ± 0.01
	<i>S. pseedocapsicum</i>	2.25 ± 0.05	21.74 ± 0.06	43.06 ± 0.04	0.15 ± 0.03	0.04 ± 0.002
	<i>C. olitorius</i>	1.04 ± 0.03	105.54 ± 0.03	158.59 ± 0.02	0.57 ± 0.04	0.04 ± 0.003
	<i>C. gynandra</i>	1.27 ± 0.02	13.96 ± 0.04	331.04 ± 0.01	0.71 ± 0.02	0.13 ± 0.02
	<i>B. oleracea</i>	2.40 ± 0.03	1.31 ± 0.03	11.24 ± 0.05	0.78 ± 0.02	n.d
Hot water	<i>I. batatas</i> tops	2.57 ± 0.05	149.69 ± 0.06	54.86 ± 0.07	0.02 ± 0.001	0.05 ± 0.001
	<i>A. spinosus</i>	1.96 ± 0.01	7.79 ± 0.02	23.38 ± 0.02	0.04 ± 0.01	0.02 ± 0.001
	<i>M. esculenta</i>	2.59 ± 0.06	156.43 ± 0.02	56.52 ± 0.03	0.06 ± 0.02	0.05 ± 0.002
	<i>Urtica ferox</i>	2.50 ± 0.02	57.25 ± 0.03	14.31 ± 0.04	0.01 ± 0.001	n.d
	<i>S. pseedocapsicum</i>	2.49 ± 0.03	141.31 ± 0.04	20.88 ± 0.04	0.08 ± 0.02	0.04 ± 0.01
	<i>C. olitorius</i>	2.43 ± 0.04	102.60 ± 0.04	51.54 ± 0.03	0.02 ± 0.01	0.01 ± 0.005
	<i>C. gynandra</i>	2.48 ± 0.07	119.87 ± 0.02	11.33 ± 0.02	0.06 ± 0.01	0.01 ± 0.003
	<i>B. oleracea</i>	2.56 ± 0.02	6.55 ± 0.001	8.40 ± 0.03	0.05 ± 0.02	0.01 ± 0.002

n.d=not detected or <0.01, each value is expressed as mean±SD (n=3); ^a mg ascorbic acid/g of extract; ^b mg of quercetin/g of extract; ^c mg of TAEs/g of extract; ^d mg of β carotenoids or lycopene/g of extract.

with the findings of Oboh et al. (2008) and, Adefegha and Oboh (2009) on tropical vegetables where high quantities of ascorbic acid were obtained in ethanol extracts. The observed variation between the current and the two studies might be due to the extraction methodology such that while they used distilled water at room temperature for extraction, boiling distilled water was used in this study which resulted in better dissolution of the ascorbic acid. Nevertheless, the best solvent for the extraction of compounds in plant food depends very much on the variety of constituents in the food matrix. It is therefore difficult to develop a general protocol for extraction of different compounds from various matrices. Ascorbic acid content in hot water extracts ranged from 1.96±0.01 mg/g (*A. spinosus*) to 2.59 ±0.06 mg/g (*M. esculenta*) and in ethanol extracts was between 0.70±0.04 mg/g (*M. esculenta*) to 2.40±0.03 mg/g (*B. oleracea*). The highest ascorbic acid content obtained in hot water extracts of *M. esculenta* agrees with the findings of Gyngiri et al. (2012) who also found relatively high quantities of ascorbic acid on the same vegetable species of Ghana and suggests the potential of the vegetable as a good source of ascorbic acid.

Although we found that there was no significant difference in the quantity of flavonoids between the extract, Sumazian et al. (2010) working on Malaysian vegetables found that flavonoids responded better in aqueous boiled extracts. Our present findings may suggest that flavonoids are relatively stable compounds and can be easily retained with either of the two extraction methods.

The range for total phenol content was between 8.40±0.03 (*B. oleracea*) and 56.52±0.03 (*M. esculenta*) for hot water and between 11.24±0.05 (*B. oleracea*) and 475.88±0.02 (*I. batatas*) for ethanol extracts, respectively. This suggest that the studied indigenous vegetables contain high quantities of phenol than the exotic *B. oleracea*. The current study further found that ethanol extracts had high phenol than hot water extracts. Phenolic acids have repeatedly been implicated as natural antioxidants in fruits and vegetables known to be effective antioxidants due to their hydroxyl groups (Boskou, 2006).

Our study reported β-carotenoid content ranging from 0.01±0.001 (*U. ferox*) to 0.08±0.02 (*S. pseedocapsicum*) and 0.15±0.03 (*S. pseedocapsicum*) to 0.78±0.02 (*B. oleracea*) for hot water and ethanol extracts, respectively. The highest quantities of lycopene detected were 0.05±0.002 (*M. esculenta*) and 0.13±0.02 (*C. gynandra*). The higher quantity of both carotenoids and lycopene in ethanolic extracts than hot water extracts suggest that ethanol is good extraction solvent for these compounds as has been also observed in Rao and Rao (2007).

Antioxidant properties

Hot water extracts had high DPPH scavenging abilities than ethanolic extracts (p<0.05). The DPPH radical scavenging ability for hot water extracts was between 51.05% (*B. oleracea*) and 96.74% (*I. batatas*) (Figure 1a) while for ethanolic extracts was from 31.03% (*B. oleracea*) to 95.40% (*C. gynandra*) (Figure 1b) at 20

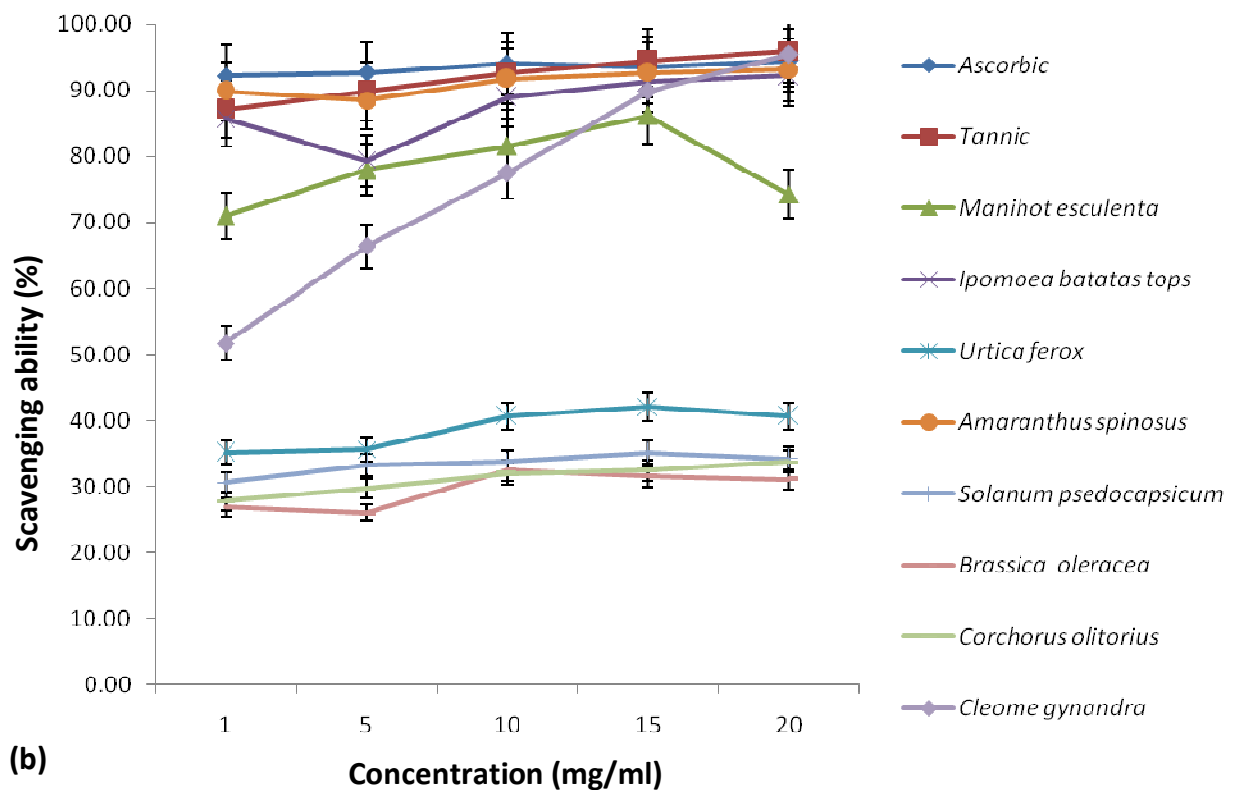
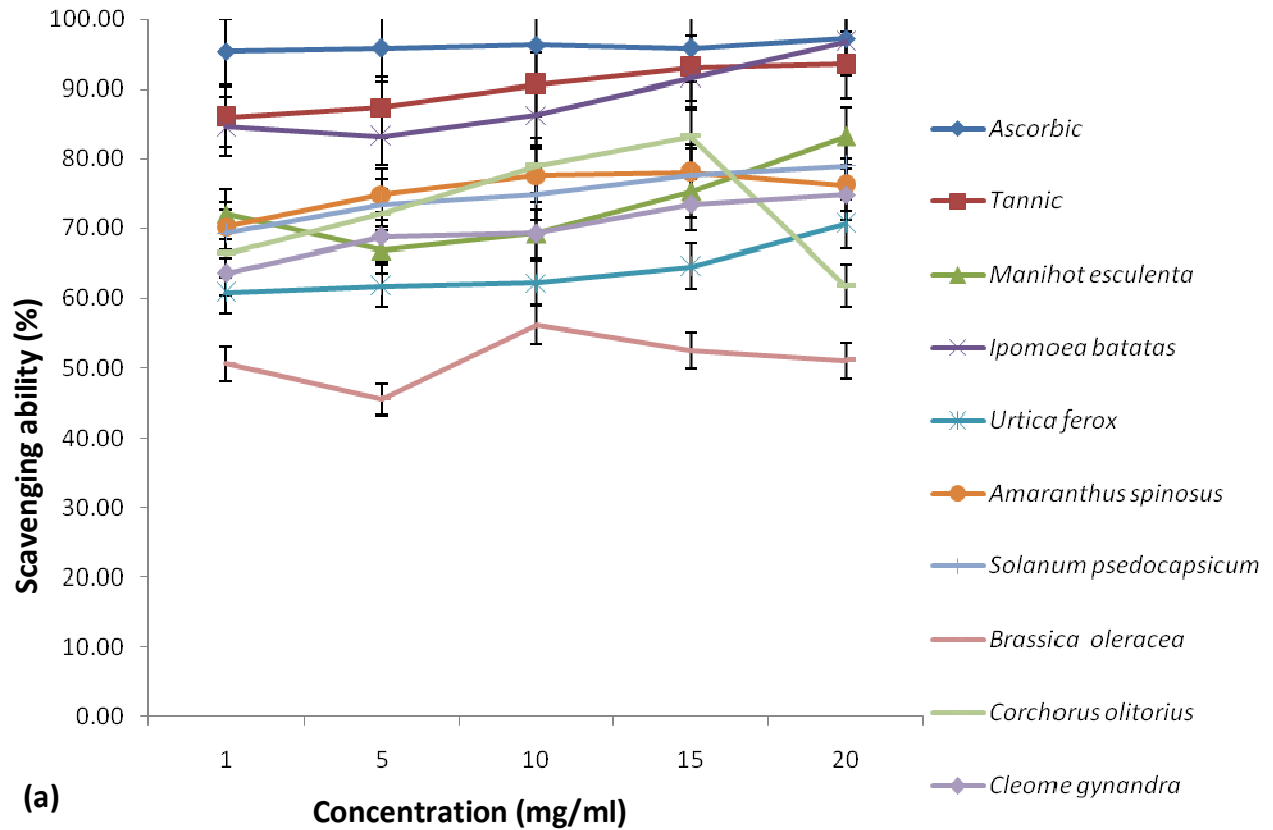


Figure 1. Scavenging ability of (a) hot water extracts (b) ethanolic extracts of various samples on DPPH radicals. Each value is expressed as mean \pm SD (n= 3).

mg/ml. This finding highlights the value of indigenous vegetables against the exotic commercial vegetables like *B. oleracea* in scavenging DPPH radicals.

Hydroxyl radicals are the major active oxygen species that cause lipid oxidation and immense biological damage (Kumar et al., 2008). They can react with lipids, polypeptides, saccharides, nucleotides, and organic acids, especially thiamine and guanosine, thereby causing cell damage (Jiao et al., 2005). Hydroxyl radical scavenging ability was from 79.22% (*C. gynandra*) to 95.01% (*B. oleracea*) for hot water extracts (Figure 2a) while for ethanol extracts was between 64.38% (*C. gynandra*) and 80.52% (*M. esculenta*) (Figure 2b). No significant difference ($p < 0.05$) in hydroxyl radicals scavenging ability between hot water and ethanol extracts was observed.

The hot water extracts had high abilities in scavenging superoxide anion radicals than ethanol extracts ($p < 0.05$). The highest superoxide radicals scavenging ability for hot water extracts was 91.29% (*S. pседocapsicum*) at 15 mg/ml with a gradually decrease to 81.79% at 20 mg/ml and the lowest ability was 36.66% (*C. gynandra*) at 20 mg/ml (Figure 3a). For the ethanol extracts, superoxide anion scavenging abilities was between 8.48% (*A. spinosus*) and 81.07% (*C. gynandra*) at 20mg/ml (Figure 3b). The highest superoxide anion scavenging abilities observed in hot water extracts of *S. pседocapsicum* and ethanol extracts of *C. gynandra* might be due to their high content of phenol, carotenoids and lycopene detected in these species.

The reducing power ranged from 0.33 (*C. gynandra*) to 2.31 (*M. esculenta*) for hot water extracts (Figure 4a) and 0.32 (*S. pседocapsicum*) to 2.76 (*A. spinosus*) (Figure 4b) at 20 mg/ml. No significant differences ($p < 0.05$) in reducing power between hot water and ethanol extracts was detected. The reducing power of both extracts increased with increasing concentration of the extract, indicating that some compounds in the extracts were electron donors and could also react with free radicals to convert them into more stable products and to terminate radical chain reactions.

The EC₅₀ values in antioxidant properties

The EC₅₀ values in antioxidant properties assayed herein are summarized in Table 3 and the results were normalized and expressed as EC₅₀ values (mg/mL) for comparison. Effectiveness of antioxidant properties inversely correlated with their EC₅₀ values.

Generally, the hot water extracts were significantly ($p < 0.05$) more effective in all antioxidant properties assayed than ethanol extracts. This finding contradicts with (Yang et al., 2006; Jan et al., 2011) who found ethanol extracts to be more effective than aqueous extracts. This contradiction might be due to the fact while they used distilled water at room temperature; our extracts were boiled with distilled water to completely dissolve

antioxidant compounds in the vegetable species. It was also observed that the ascorbic acid and tannic acid (standards) used were more effective in most antioxidant properties assayed than the vegetable species. This further supports the claims of Olajire and Azeez (2011), Smith and Eyzaguirre (2007), and Sumazian et al. (2010) but contradicts with Pourmorad et al. (2006).

With regard to DPPH radicals scavenging ability, extracts of *A. spinosus* were the most effective (0.56 mg/ml) among the ethanolic extracts while extracts of *I. batatas* were the most effective (0.59 mg/ml) among the hot water extracts.

Interestingly, the extracts of *B. oleracea* were the most effective in scavenging hydroxyl radicals among both ethanolic and hot water extracts with relatively lower EC₅₀ values of 0.56 and 0.73 mg/ml, respectively.

Extracts of *C. gynandra* and *M. esculenta* were the most effective (0.91 and 11.04 mg/ml) extracts in scavenging superoxide anion radicals among ethanol and hot water extracts, respectively. Among the ethanolic extracts, *A. spinosus* was the most effective (0.99 mg/ml) extract in reducing power while *C. olitorius* was the most effective (0.59 mg/ml) in reducing power among the hot water extracts.

The present EC₅₀ findings agree with (Pietta, 2000; Lako et al., 2007,) on radical-specific antioxidant potentials of plants and suggests that a single vegetable species or an extract might not offer 100% efficiency in scavenging all sorts of radicals the body system might produce.

Conclusion

From the findings, the seven indigenous vegetables exhibit appreciable antioxidants activities and phytochemical compounds. Dose-dependent antioxidant activities of the extracts were observed. Based on the EC₅₀ values, Hot water extracts were more effective than ethanol extracts. It was observed that a single vegetable species did not possess all sorts of antioxidant phytochemical compounds in significant quantities and hence not effective in scavenging all different radicals. A combinatory intake of these vegetables species in sufficient concentrations should thus be recommended to enhance optimal antioxidant capacity in the body. Investigations of individual compounds, their *in vivo* antioxidant activities and mechanisms are needed.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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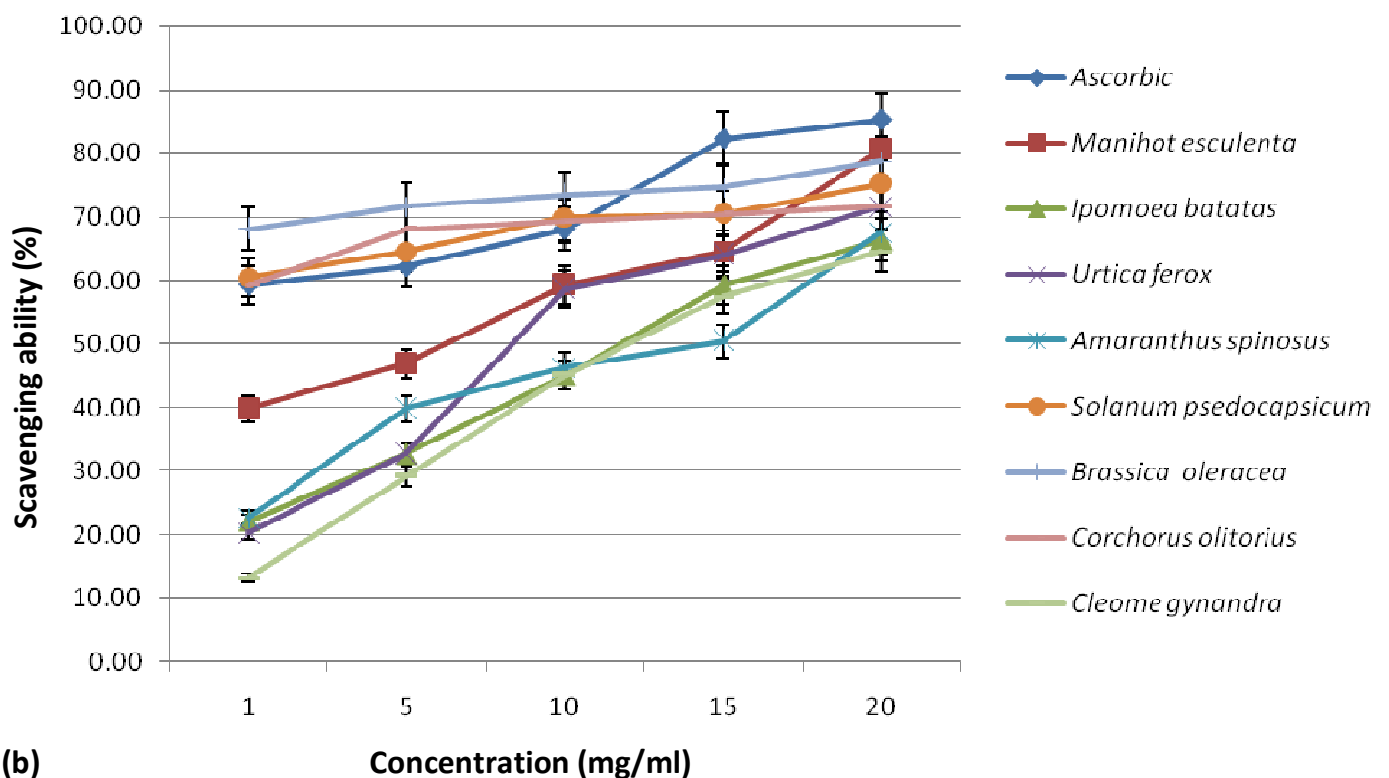
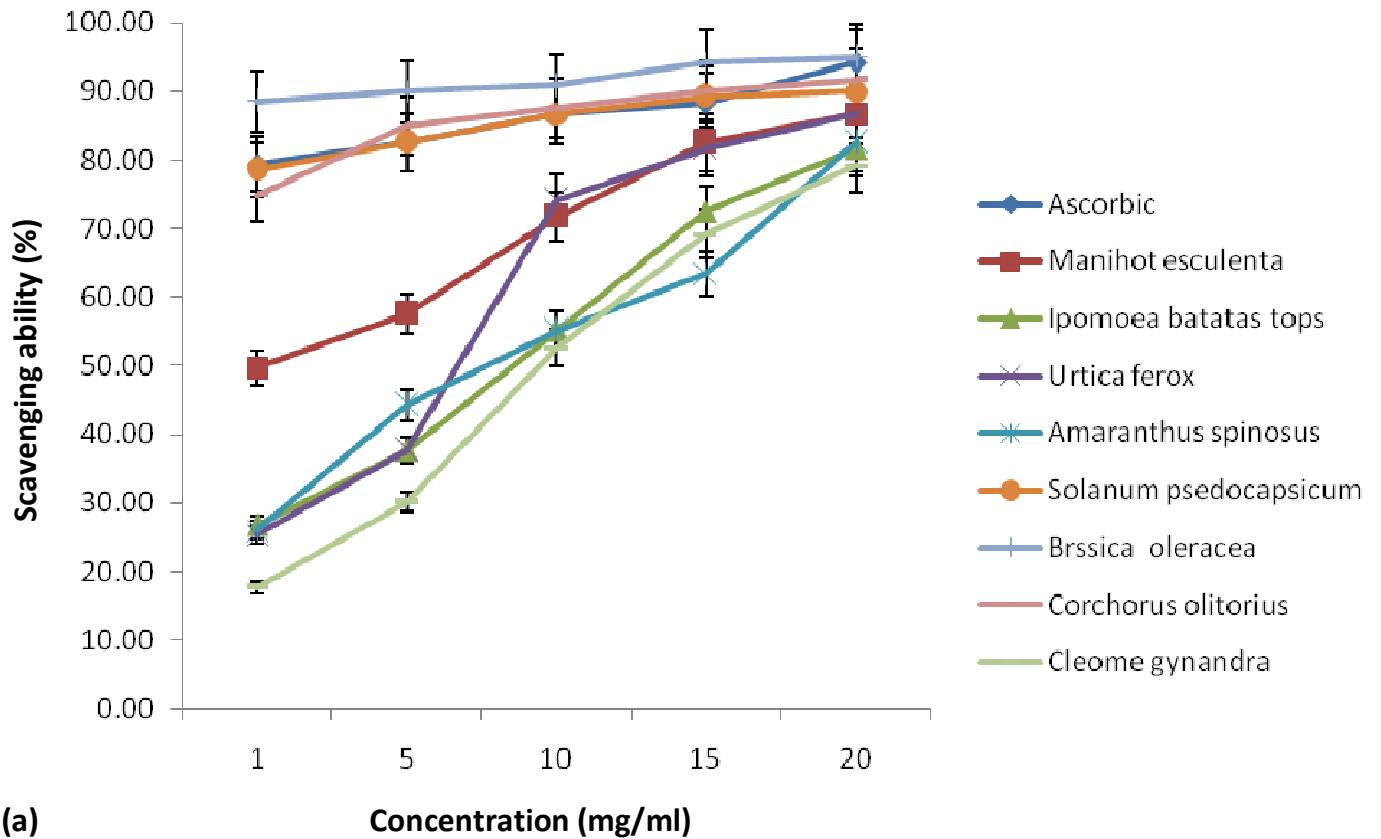


Figure 2 Scavenging ability of (a) hot water extracts (b) ethanolic extracts of various samples on hydroxyl radicals. Each value is expressed as mean \pm SD (n=3).

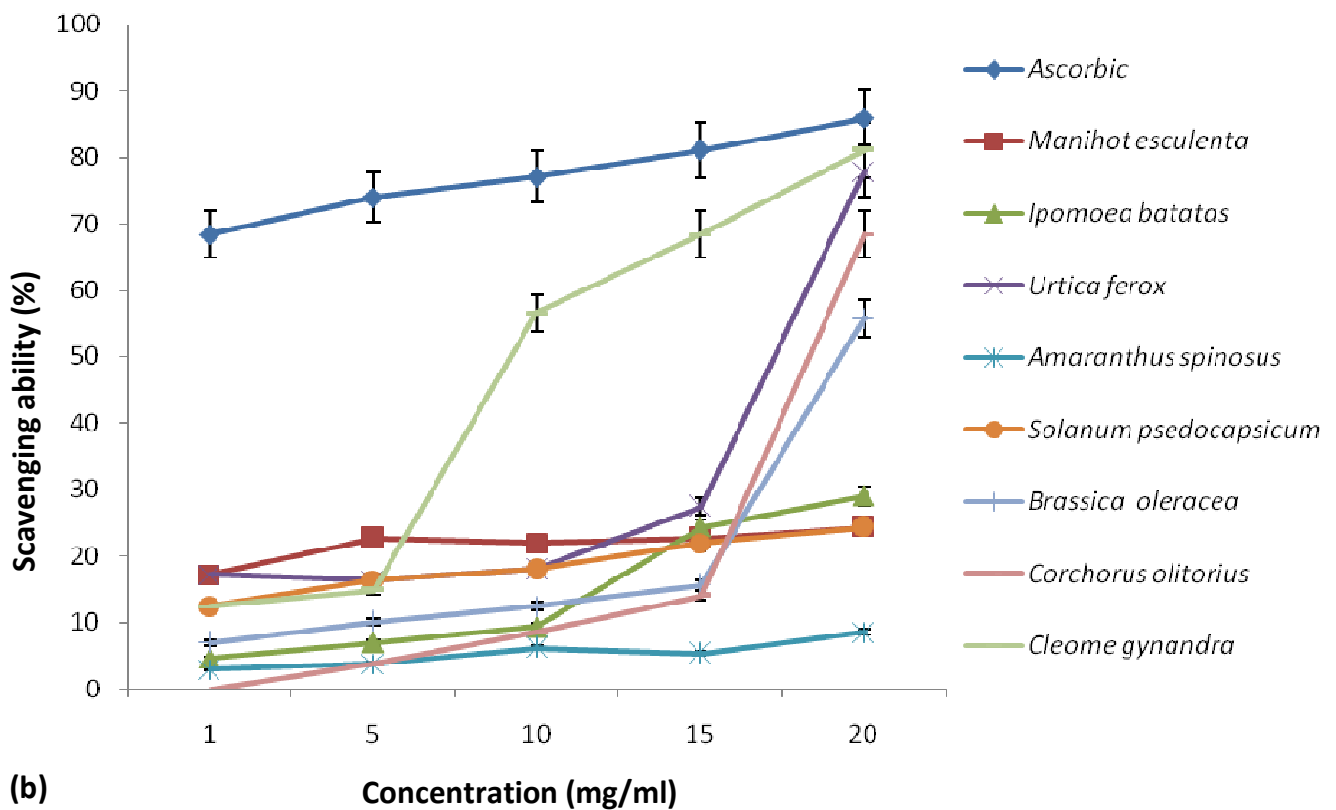
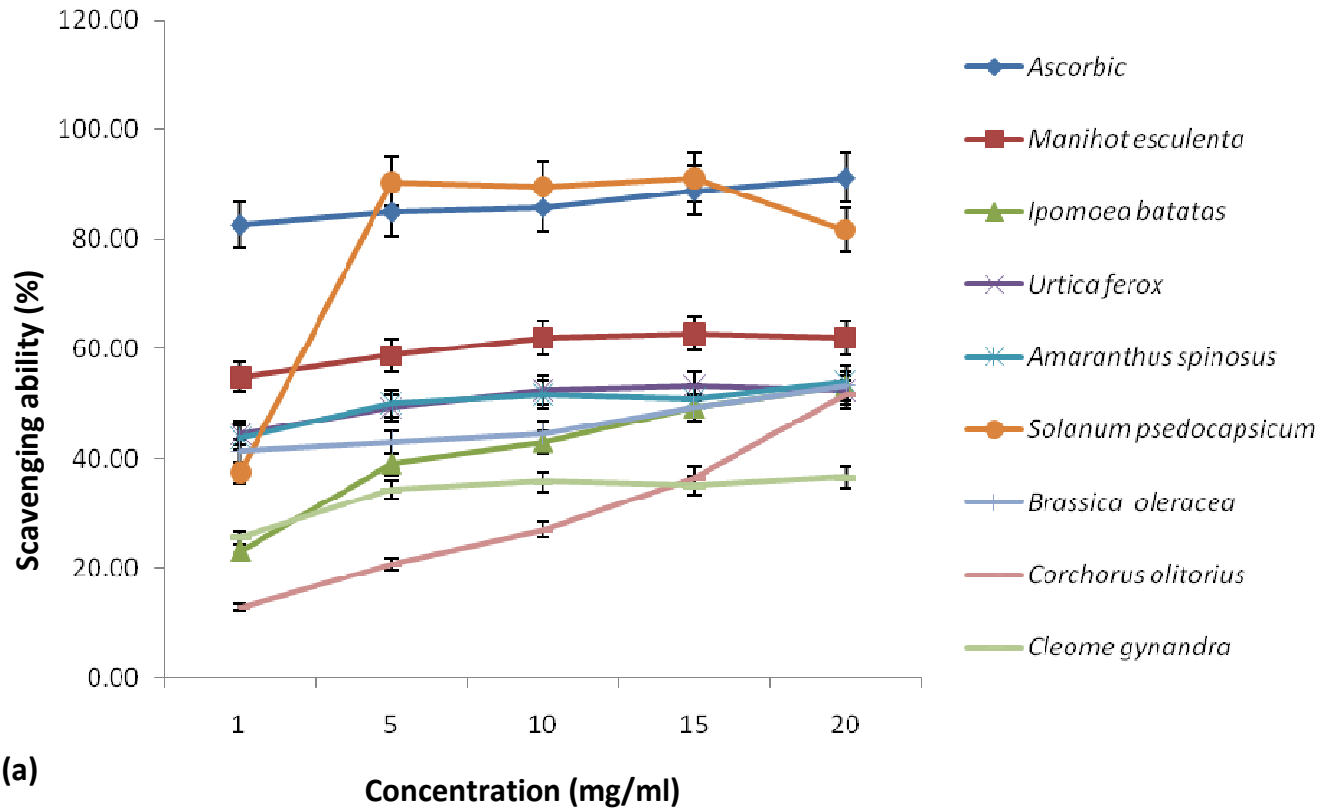


Figure 3 Scavenging ability of (a) hot water extracts (b) ethanolic extracts of various samples on superoxide anion radicals at 25°C incubation for 10 min. Each value is expressed as mean ± SD (n=3)

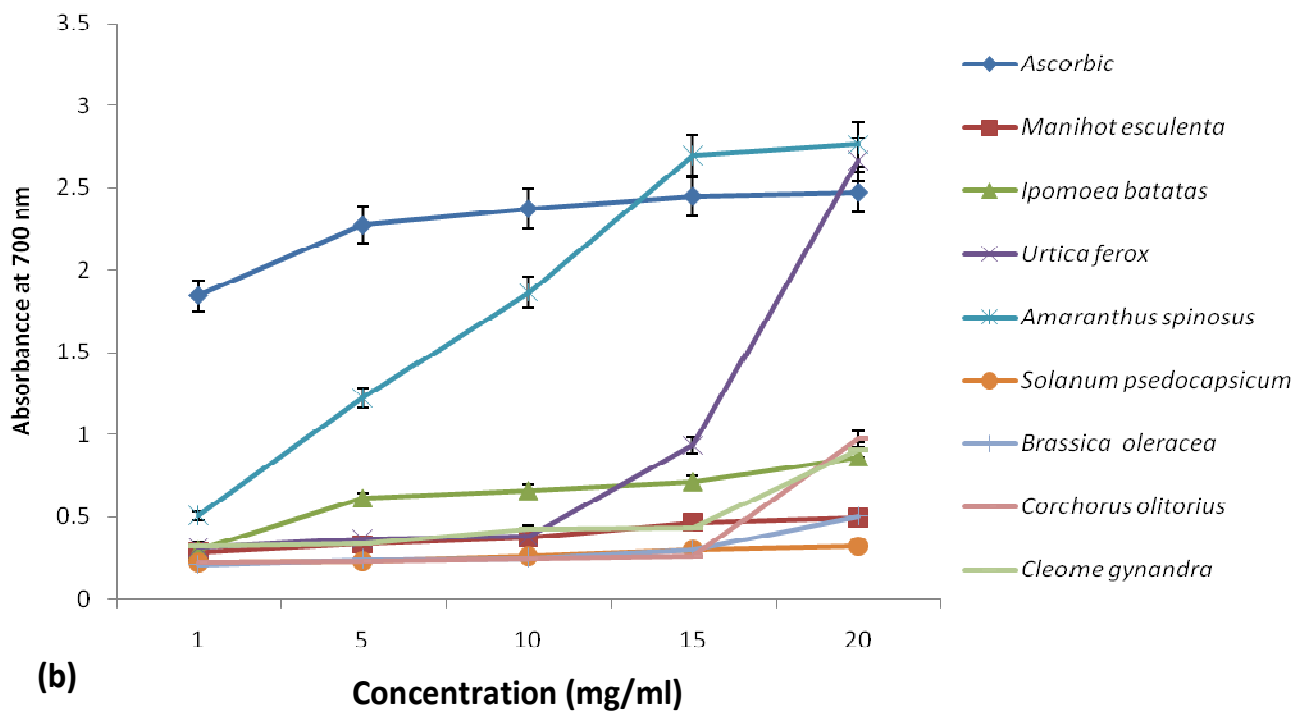
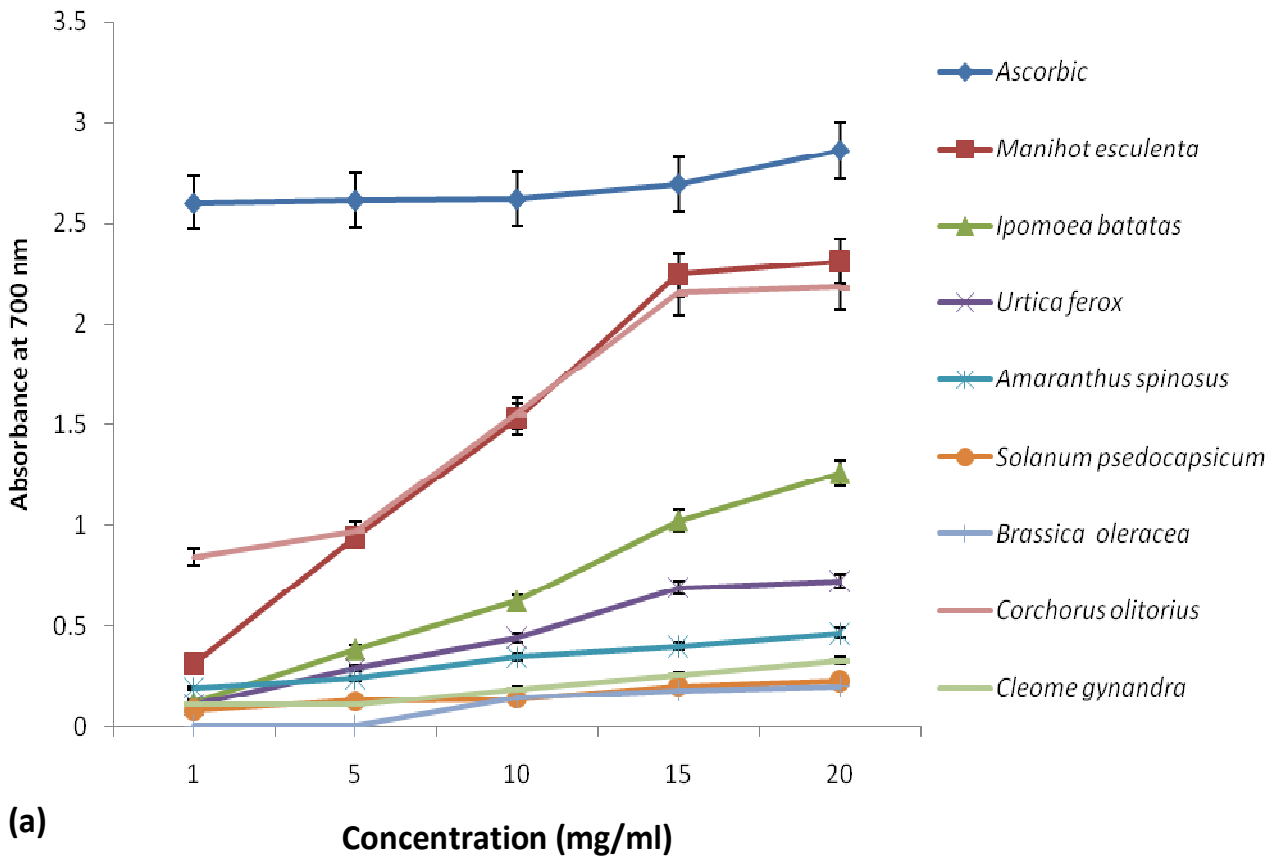


Figure 4. Reducing power of (a) hot water extracts (b) Reducing power of ethanolic extracts of various samples. Each value is expressed as mean \pm SD (n=3).

Table 3. EC₅₀ values of ethanolic and hot water extracts from various vegetable species in antioxidant properties.

Extract	Antioxidant attribute	EC ₅₀ (mg/mL)									
		<i>Ascorbic acid</i>	<i>Tannic acid</i>	<i>M. esculenta</i>	<i>I. batatas tops</i>	<i>U. ferox</i>	<i>A. spinosus</i>	<i>S. psedocapsicum</i>	<i>B. oleracea</i>	<i>C. oltorius</i>	<i>C. gynandra</i>
Ethanolic	1. Scavenging ability on DPPH radicals	0.54	0.57	0.70	0.58	n.e	0.56	n.e	n.e	n.e	0.97
	2. Scavenging ability on OH radicals	0.84	n.d	6.23	12.25	10.39	12.45	0.83	0.73	0.84	13.18
	3. Scavenging ability on superoxide radicals	0.73	n.d	n.e	n.e	16.83	n.e	n.e	23.88	20.19	11.04
	4. Reducing power	0.27	n.d	19.69	5.08	6.35	0.99	n.e	n.e	13.69	10.65
Hot water	1. Scavenging ability on DPPH radicals	0.52	0.58	0.69	0.59	0.82	0.71	0.72	3.45	0.75	0.79
	2. Scavenging ability on OH radicals	0.63	n.d	0.64	8.61	6.98	8.64	0.64	0.56	0.67	10.26
	3. Scavenging ability on superoxide radicals	0.61	n.d	0.91	16.03	9.12	9.93	1.34	16.04	20.53	n.e
	4. Reducing power	0.19	n.d	1.39	7.18	11.56	n.e	n.e	n.e	0.59	n.e

Each value is expressed as mean of three measurements. n.e= no effect, n.d= not done.

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