

# **Antioxidant Capacity of Indigenous Root and Tuber Crops of Sri Lanka as Affected by Simple Processing**

## **ABSTRACT**

The indigenous root and tuber crops in Sri Lanka have not been exploited by the food industry. With a view to establish their nutritional importance and promote consumption and industry usage, the study determined the contents of selected bio active compounds in 15 root and tuber crops varieties namely, *Amorphophallus campanulatus*, *Canna indica* (2 Selections), *Dioscorea alata* (6 varieties), *D. bulbifera*, *D. esculenta*, *Maranta arundinacea* and *Xanthosoma sagittifolium* (3 varieties), both in their raw and processed (boiled) forms. Antioxidant capacity (AOC) of yams was determined by Ferric Reducing Antioxidant Power (FRAP) Assay and 2,2-diphenyl-1-picrylhydrazyl (DPPH) Radical Scavenging Assay. Total Phenolics (TPC) and ascorbic acid contents (AAC) were determined by Folin-Ciocalteu method and 2,6-dichlorophenol indophenol visual titration method, respectively. Chemical analyses were performed on triplicate samples. The AOC in the raw form ranged from 56 mg TE/g dry weight (*D. bulbifera*) to 30 mg TE/g dry weight (*M. arundinacea*) while it showed a 0.4% (*D. alata* 'Raja ala') to 45% (*D. alata* 'Hingurala') decrease when boiled. The TPC in the raw form was highest in *D. bulbifera* (190.5 GAE; mg/100 g) while it was lowest in *D. esculenta* (6 mg/100 g). *Dioscorea alata* 'Jaffna Rasawalli' showed the highest loss (95%) of phenolics when subjected to boiling. The *Xanthosoma sagittifolium* varieties 'Kiri ala' and 'Isuru' had the highest AAC (12 mg/100 mg) in raw form while it was lowest (2 mg/100 mg) in *M. arundinacea*. *D. bulbifera* and *X. sagittifolium* 'Kaha kiri ala' retained relatively higher levels of antioxidants in their boiled forms. The contents of bioactive compounds in yams tended to decrease when subject to boiling. However, the degree of loss depended on the yam variety. Further research should focus on developing processing technologies to minimize the loss of bioactive compounds in root and tuber crops.

**Keywords:** Antioxidants, ascorbic acid, boiling, indigenous roots and tubers, phenolics, processing

## **1. INTRODUCTION**

Root and tuber crops are basically the plants which store edible starch in underground stems, rhizomes, corms, tubers and roots and are originated from diversified botanical sources. In tropical regions, they serve either as primary, secondary or supplementary staples to meet the calorie needs of people [1]. They are also an important sources of starch for industrial applications, processed products and animal feed [2]. Root and tuber crops therefore, have a significant role to play in food security and elimination of poverty in developing countries.

Among the root and tuber crops, potato, cassava, sweet potato, aroids (taro), yams and selected minor tuber crops (eg. yam bean, country potato, arrowroot) are considered commercially important. However, their relative importance as a dietary component depends on the country or population. Root and tuber crops have been playing a major role in fulfilling the carbohydrate needs of Sri Lankans where over 55 traditional / indigenous root and tuber crop species have been identified. Although a few selected species are commercially grown, a wide variety of cultivars are scattered in the Island. They are commonly referred to as "local yams" and are under-exploited despite their potential benefits. Yams are considered as nutritionally important tuber crops because of their high energy contribution and high minerals contents [3]. These traditional root and tuber crops can be grown with minimum agricultural inputs under less favourable conditions and therefore, could be promoted in sustainable farming [4].

Research has been done on nutritional properties of various root and tuber crops grown in different parts of the world. Chandrasekara and Kumar [5] reviewed the functional properties of root and tuber crops in which limited quantitative data were provided mainly on potato, sweet potato, cassava and a few selected yam and taro cultivars grown in Africa and some other regions. No reports are available on the bioactive compounds of indigenous root and tubers grown in Sri Lanka. Among the limited research conducted to-date, proximate composition and mineral contents of *Dioscorea alata* and *Amorphophallus paenoiifolius* [6], and mineral contents of *D. alata*, *D. esculenta* and *Xanthosoma* sp. [3] have been reported. Focus of some other studies was on starch properties of a few selected minor root and tuber crops [7].

Oxidation is a chemical process where free radical mediation reactions cause several degenerative actions in human body, such as aging, cancer, coronary heart diseases and Alzheimer's disease. These reactions can be neutralized by antioxidants. Human body can gain these bioactive compounds from the diets they consume. Therefore, consumption of antioxidant-rich food is a current trend and research is conducted worldwide to ascertain the availability of bioactive compounds in food items and to promote their consumption [8].

Phenolic compounds or phenols are organic molecules containing a hydroxyl group or groups combined to an aromatic hydrocarbon. They are synthesized in organisms to withstand ecological pressures such as wounds and damage from UV radiation. Phenolic compounds contained in plants are reactive towards oxidation process and have multiple beneficial effects on human health [9, 10, 11]. Ascorbic acid, commonly known as vitamin C, also acts as an antioxidant. It is an essential nutrient which helps repair body tissues and enzymatic production of different neurotransmitters for better functioning of immune system [12].

Characterization of nutritional profile is important in the process of popularization and industrial exploitation of root and tuber crops for the food industry. Due to the ease of their crop management, promoting yams could be a positive approach to reduce malnutrition in the developing world. In the present study, therefore, the antioxidant capacity, phenolics and ascorbic acid contents of a range of traditional root and tuber crops were estimated both in their raw and cooked forms.

## **2. MATERIAL AND METHODS**

### **2.1. Sample Preparation**

Samples of 15 yam cultivars were obtained from field collections of the Horticultural Crop Research and Development Institute (HoRDI), Gannoruwa and Root and Tuber Crop Unit, Agro-Technology Park, Gannoruwa, Sri Lanka. Details of the species and varieties used are presented in Table 1. Pest- and disease-free samples were collected at proper maturity stage, cleaned and peeled. Those were sliced and dried in a hot air oven at 55°C for 6 h and powdered using a grinder. Ground samples were stored in air tight containers at -20°C until used for analyses [13]. To prepare cooked samples, roots and tubers were boiled at 80°C for 10 min. For the chemical analyses, analytical grade chemicals (Sigma) were used and preliminary trials were conducted to standardize the procedures.

### **2.2. Determination of Antioxidant Capacity (AOC) with Ferric Reducing Antioxidant Power (FRAP) Assay**

Ferric Reducing Antioxidant Power (FRAP) Assay was performed according to the method described by Benzie & Strain [14] with minor modifications. Fresh FRAP reagent was prepared at 37 °C by mixing 25 ml of Sodium acetate buffer (300 µM, pH 3.6), 2.5 ml of TPTZ [2,4,6-Tri(2-pyridyl)-s-triazine] solution (40 µM HCl as solvent) and 2.5 ml of Iron (iii) Chloride solution (20 µM), as the solutions in 10:1:1 ratio. Hundred micro litres of the methanolic extract (with 80% methanol) of prepared yam samples were mixed with 900 µl of freshly prepared FRAP reagent at pH 3.6. The samples were incubated for 4 min and the absorbance was measured at 593 nm using a spectrophotometer (Jenway 6300, United Kingdom). Trolox was used as the standard for calculations and the antioxidant capacity (AOC) was expressed as Trolox Equivalent AOC (mg TE / g dry weight) [14].

### **2.3. Determination of Antioxidant Capacity with DPPH Radical Scavenging Assay**

The antioxidant capacity of yam samples was determined by 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay. Methanolic extract of the powdered yam sample was obtained and a volume of 0.5 ml of the extract was mixed with 0.5 ml of 80% methanol. A DPPH solution (2.5 ml) was made by mixing 3.94 mg of DPPH powder with 100 ml of absolute methanol. The blank sample was made with 0.5 ml of methanol and 2.5 ml of DPPH solution. All samples were incubated at room temperature for 1 h in the dark and the absorbance was measured at 517 nm using a UV-Visible spectrophotometer (Shimadzu-UV-120-02, United Kingdom). Results were expressed as IC<sub>50</sub> value which denotes the concentration of the sample required to scavenge 50% of DPPH radicals [15, 16].

**Table 1. Details of root and tuber crops used in the study**

Common name/s	Botanical name	Family	Vernacular name / Cultivar name	Storage structure
Elephant foot yam	<i>Amorphophallus paeoniifolius</i>	Araceae	Kidaram	Corm
Stink lily				
Canna	<i>Canna indica / edulis</i>	Cannaceae	Buthsarana – Red Selection	Rhizome
	<i>Canna indica</i>	Cannaceae	Buthsarana – White Selection	Rhizome
Yam	<i>Dioscorea alata</i>	Dioscoreaceae	Dandila	Tuber
Purple yam, Greater yam	<i>Dioscorea alata</i>	Dioscoreaceae	Guru ala	Tuber
	<i>Dioscorea alata</i>	Dioscoreaceae	Hingurala	Tuber
	<i>Dioscorea alata</i>	Dioscoreaceae	Jaffna Rasawalli	Tuber
	<i>Dioscorea alata</i>	Dioscoreaceae	Kahata ala	Tuber
	<i>Dioscorea alata</i>	Dioscoreaceae	Raja ala	Tuber
Ariel yam	<i>Dioscorea bulbifera</i>	Dioscoreaceae	Udala	Tuber, Bulbils
Lesser yam	<i>Dioscorea esculenta</i>	Dioscoreaceae	Kukulala	Tuber
Arrowroot	<i>Maranta arundinaceae</i>	Marantaceae	Arukka/Hulan keeriya	Rhizome
Taro	<i>Xanthosoma sagittifolium</i>	Araceae	Kaha kiri ala	Corm
	<i>Xanthosoma sagittifolium</i>	Araceae	Kiri ala	Corm
	<i>Xanthosoma sagittifolium</i>	Araceae	Isuru	Corm

#### 2.4. Determination of Total Phenolic Content (TPC)

The total phenolic contents (TPC) of root and tuber samples were determined by the Folin-Ciocalteu method as described by Thaipong *et al.* [17] with slight modifications [16]. From the powdered yam sample, 0.5 g was mixed with 100 ml of absolute methanol and kept in an electric shaker for 24 h. A volume of 150  $\mu$ l from the filtered extract, 150  $\mu$ l of Folin-Ciocalteu reagent (3 ml of Folin-Ciocalteu reagent diluted with 50 ml of distilled water) and 2400  $\mu$ l of distilled water were added together and mixed in a vortex. The above mixture was allowed to react for 3 min. It was then mixed with 300  $\mu$ l of 1 M Na<sub>2</sub>CO<sub>3</sub> solution in a vortex. The samples were incubated at room temperature for 2 h and the absorbance was measured at 765 nm using a UV-Visible spectrophotometer (Jenway 6300, United Kingdom). Results were expressed in Gallic Acid Equivalents (GAE; mg/100 g of dry weight) using a Gallic acid (0 - 0.1 mg/ml) standard curve.

## 2.5. Determination of Ascorbic Acid Content (AAC)

Ascorbic acid contents (AAC) of yam samples were estimated using the 2,6-Dichlorophenol Indophenol visual titration method as described by Ranganna [18]. Accordingly, 10 g of fresh yam sample was homogenized with 3% HPO<sub>3</sub> and the volume was made up to 100 ml using HPO<sub>3</sub>. Five milliliters of the filtered extract was titrated with previously standardized dye until a pink colour which persisted for 15 s was obtained. The AAC was calculated according to Ranganna [18].

## 2.6. Experimental Design and Statistical Analysis

All chemical analyses were performed on triplicate samples. Analysis of variance (ANOVA) procedure was performed to determine statistical significance among varieties when  $p < 0.05$  using R i386 3.3.3. statistical software. The correlations between antioxidant capacity and phenolic and ascorbic acid contents were established by regression analysis using Minitab (ver. 15).

## 3. RESULTS AND DISCUSSION

### 3.1. Antioxidant Capacity (AOC) of Roots and Tubers

The antioxidant capacity (AOC) of plant extracts is measured using a variety of *in vitro* assays. However, the total antioxidant properties of tissues cannot be expressed using any single method because of the complex nature of phytochemicals involved [19]. Therefore, it is advisable to employ two or more methods to evaluate the total antioxidant activity of plant extracts. In the present study, FRAP assay and DPPH assay were used to quantify the AOC of roots and tubers.

The AOC of roots and tubers obtained from both assays are presented in Table 2. Based on the results of FRAP assay, the AOC of raw yams ranged from 30 – 56 mg TE/g DW. There were significant differences ( $P < .05$ ) in AOC among varieties. *Dioscorea bulbifera* (Ariel yam/Udala) showed the highest mean AOC of 55.67 mg TE/g DW, followed by *Xanthosoma sagittifolium* 'Kaha kiri ala', *Amorphophallus campanulatus*, *Canna indica* 'White', *D. alata* 'Dandila' and *C. indica* 'Red'. *Maranta arundinaceae* showed the lowest AOC of 29.99 mg TE/g DW. The higher antioxidant properties of *Dioscorea* species have also been proven in the studies conducted in Nepal [20]. When comparing the AOC of cooked root and tuber samples, *Dioscorea bulbifera* recorded the highest AOC content of 47.96 mg TE/g DW against the lowest value of 19.71 mg TE/g DW reported for *D. alata* 'Hingurala'.

In DPPH radical scavenging assay, the DPPH reagent provides DPPH radicals into the medium. When the medium contains antioxidants, they stabilize DPPH radicals similar to how antioxidants neutralize harmful free radicals in human body. IC<sub>50</sub> value or the 50% scavenging activity is the concentration of the sample extract needed to react with 50% of DPPH radicals. IC<sub>50</sub> value is inversely proportional to the antioxidant activity and therefore, a higher AOC is indicated by a lower IC<sub>50</sub> value [21]. Significant differences ( $P < .05$ ) were present among varieties in the AOC obtained from DPPH assay (Table 2). Among the raw samples, the highest AOC (lowest IC<sub>50</sub> value of 0.63 mg/ml) was shown by *Amorphophallus campanulatus* followed by *Dioscorea alata* 'Kahata ala'; IC<sub>50</sub> = 0.64 mg/ml) and *D. bulbifera* (IC<sub>50</sub> = 0.68 mg/ml). In contrast to the results obtained with FRAP assay, the highest AOC shown by *A. campanulatus* with DPPH assay could be attributed to some interference caused by the high level of anthocyanins present in the extract [21]. According to DPPH assay, *Dioscorea alata* 'Jaffna Rasawalli' showed the lowest AOC (highest IC<sub>50</sub> value of 1.81 mg/ml). However, when subjected to boiling, *D. bulbifera* showed the highest AOC (IC<sub>50</sub> = 0.96 mg/ml) while *D. esculenta* 'Kukulala' had the lowest AOC (IC<sub>50</sub> = 2.76 mg/ml; Table 2).

**Table 2. Antioxidant capacity of 15 root and tuber crop varieties.**

Variety	Antioxidant capacity			
	mg TE/g DW)		IC <sub>50</sub> value	
	(FRAP assay)		(DPPH assay)	
	Raw form*	Cooked form*	Raw form*	Cooked form*
<i>Amorphophallus campanulatus</i>	47.74±2.2	42.26±2.6	0.63±0.01	1.37±0.01
<i>Canna indica</i> - Red Selection	40.45±6.4	38.29±6.4	1.79±0.06	2.10±0.07
<i>Canna indica</i> - White Selection	41.88±1.3	35.67±3.2	1.64±0.00	2.04±0.03
<i>Dioscorea alata</i> - Dandila	40.58±3.1	34.58±3.1	0.69±0.02	1.08±0.04
<i>Dioscorea alata</i> - Guru ala	36.05±2.7	27.25±2.7	1.36±0.04	1.35±0.06
<i>Dioscorea alata</i> - Hingurala	36.23±3.8	19.71±3.8	1.76±0.04	1.68±0.02
<i>Dioscorea alata</i> - Jaffna Rasawalli	37.60±4.5	28.59±4.5	1.81±0.02	1.18±0.02
<i>Dioscorea alata</i> - Kahata ala	38.90±1.0	29.53±4.5	0.64±0.01	1.49±0.02
<i>Dioscorea alata</i> – Raja ala	31.62±0.8	31.49±0.8	1.69±0.01	1.54±0.06
<i>Dioscorea bulbifera</i>	55.67±2.2	47.96±2.2	0.68±0.01	0.96±0.03
<i>Dioscorea esculenta</i>	33.38±1.5	28.82±1.5	1.78±0.04	2.76±0.02
<i>Maranta arundinaceae</i>	29.99±0.7	27.32±0.7	1.21±0.01	2.13±0.01
<i>Xanthosoma sagittifolium</i> - Kaha kiri ala	47.76±2.5	40.15±2.5	0.87±0.01	1.18±0.03
<i>Xanthosoma sagittifolium</i> - Kiri ala	34.70±2.2	28.27±2.2	0.93±0.04	2.16±0.00
<i>Xanthosoma sagittifolium</i> – Isuru	31.29±1.1	27.27±1.1	1.49±0.01	1.64±0.02

Values are mean ± SEM (Standard error of mean).

\*Means are significantly different at P=.05. DW: dry weight, TE: Trolox equivalent

### 3.2. Total Phenolic Content (TPC) of Roots and Tubers

The total phenolic content (TPC) of raw yams ranged from 6 – 190 GAE mg/100 g (Table 3). *Dioscorea bulbifera* recorded the highest significant TPC of 190.54 GAE mg/100 g in raw form. However, *A. campanulatus* (Kidaram; 70.8 GAE mg/100 g) resulted the highest TPC after cooking, followed by *D. bulbifera* (51.8 GAE mg/100 g). *D. esculenta* and *M. arundinacea* had low TPCs relative to other varieties. *D. alata* ‘Jaffna Rasawalli’ showed the lowest TPC in cooked form.

### 3.3. Ascorbic Acid Content (AAC) of Roots and Tubers

In the raw form, *Xanthosoma sagittifolium* varieties 'Kiri ala' and 'Isuru' contained the highest ascorbic acid (AA) levels (12.12 mg /100 mg) while *M. arundinaceae* had the lowest (2.38 mg / 100 mg). *D. alata* 'Jaffna Rasawalli' (7.2 mg / 100 mg) showed the highest AAC in boiled form while *A. campanulatus* (2.22 mg / 100 mg) showed the lowest AAC in boiled form (Table 3). Ascorbic acid or vitamin C can easily get destroyed in the heating process. For retention of it in cooked foods, it is recommended that those foods be cooked as fast as possible with less heat and a small amount of water [22].

Variety	Total phenolic content (GAE; mg/100 g DW)		Ascorbic acid content (mg/100 mg)	
	Raw form*	Cooked form*	Raw form*	Cooked form*
<i>Amorphophallus campanulatus</i>	79.74±11.55	70.82±12.4	2.96±0.91	2.22±0.00

Table 3. Total phenolic content and ascorbic acid content of root and tuber crops

<i>Canna indica</i> - Red Selection	66.69±1.91	34.19±2.82	7.57±1.86	4.54±0.00
<i>Canna indica</i> - White Selection	84.18±4.27	41.07±2.06	5.78±1.86	4.54±0.00
<i>Dioscorea alata</i> - Dandila	97.73±6.05	15.89±2.05	8.89±1.57	2.22±0.00
<i>Dioscorea alata</i> - Guru ala	75.26±8.58	7.77±0.94	6.30±1.10	2.70±0.00
<i>Dioscorea alata</i> - Hingurala	11.51±2.77	2.29±0.80	4.76±1.17	2.86±0.00
<i>Dioscorea alata</i> - Jaffna Rasawalli	18.94±4.58	0.89±0.56	7.50±0.00	7.20±0.00
<i>Dioscorea alata</i> - Kahata ala	75.51±3.53	11.71±1.36	2.70±0.00	2.70±0.00
<i>Dioscorea alata</i> – Raja ala	14.90±0.95	4.93±2.71	11.11±0.00	2.96±0.91
<i>Dioscorea bulbifera</i>	190.54±14.7	51.78±12.8	11.11±1.24	6.06±0.00
<i>Dioscorea esculenta</i>	5.98±0.92	1.39±0.44	6.67±0.00	5.19±0.91
<i>Maranta arundinaceae</i>	7.03±0.01	7.03±1.60	2.38±0.00	2.38±0.00
<i>Xanthosoma sagittifolium</i> -Kaha kiri ala	34.84±0.84	15.20±0.65	8.08±1.24	3.03±0.00
<i>Xanthosoma sagittifolium</i> - Kiri ala	14.05±1.80	8.57±4.19	12.12±1.86	4.54±0.00
<i>Xanthosoma sagittifolium</i> - Isuru	14.05±0.04	8.57±0.31	12.12±1.94	4.54±0.00

Values are mean ± SEM (Standard error of mean).

\*Means are significantly different at  $P=0.05$ . GAE: Galli acid equivalent; DW: Dry weight; FW: Fresh weight.

### 3.4. Effect of Cooking on Contents of Bioactive Compounds

The percentage decreases of AOC, TPC and AAC when subject to boiling of yams are shown in Table 4. In general, the AOC, TPC and AAC were lower in the processed form in comparison to the raw form of yams. *Dioscorea alata* varieties of 'Jaffna Rasawalli' (46%), 'Guru Ala' (24%), 'Kahata ala' (24%) and 'Hingurala' (24%) a relatively higher decline in AOC after boiling, compared to other yams. On the other hand, *D. alata* 'Raja ala' revealed the lowest percentage decline of 0.4% in its AOC after cooking, followed by *Canna indica* 'Red Selection' (5%) and *M. arundinaceae* (9%). Other species have lost the AOC in moderate levels ranging from 11 – 19%. Thus, *D. bulbifera* and *X. sagittifolium* 'Kaha kiri ala' retained relatively higher levels of antioxidants even after simple cooking (Figure 1A and Table 4).

Antioxidant capacity of plant parts can decrease when subject to processing due to several reasons. Antioxidants can be degraded due to formation of some other compounds having pro oxidant action, altering the structure of existing antioxidants [23]. When subject to heating at or above 65 °C, antioxidants tend to degrade in considerable amounts. Some antioxidants can also be leached out into water used in cooking. In the present study, yams with bright coloured flesh showed a prominent colour change in cooking water due to leaching out of water soluble pigments which are also antioxidants.

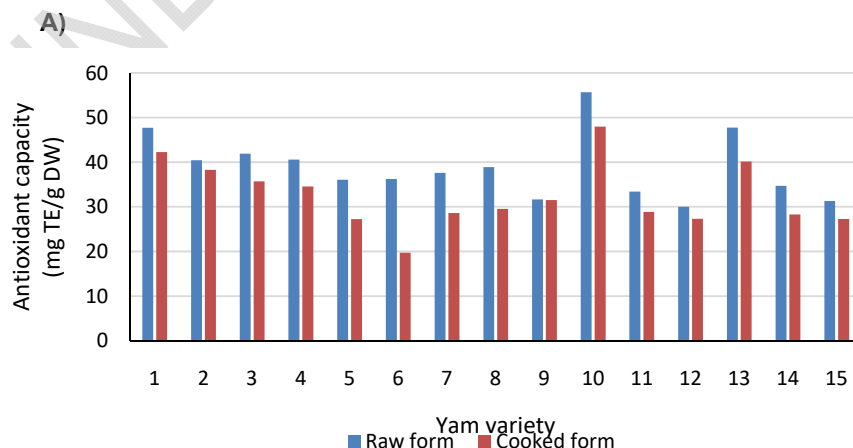
The varieties with highest TPC in raw form, *D. bulbifera* and *D. alata* 'Kahata ala' showed a drastic decline in TPC after boiling (73% and 84.5%, respectively; Table 4). Nevertheless, *D. alata* 'Jaffna Rasawalli' showed the highest percentage decline of TPC (95%) after cooking while *M. arundinaceae* showed no detectable change in phenolic contents (Figure 1B and Table 4). The loss of phenolic compounds could be due to several reasons. Initially, phenolics can be leached out into the water used in cooking of yams. Secondly, thermal alteration of the structure and

degradation of phenolic compounds can take place at temperatures above 65°C [23]. Heat can cause phenols to combine with other molecules and/or combine among phenols which can produce non-phenolic compounds. The resultant compounds may not always give the same health benefits as by phenolics. However, in some cases, heating can enhance the health benefits of phenolics for humans due to formation of highly beneficial new compounds. Nevertheless, it depends entirely on the type of crop and the types of bio active compounds in it [24]. Blanching, freezing and vacuum frying have also reported to cause a decrease in TPC of yams [5].

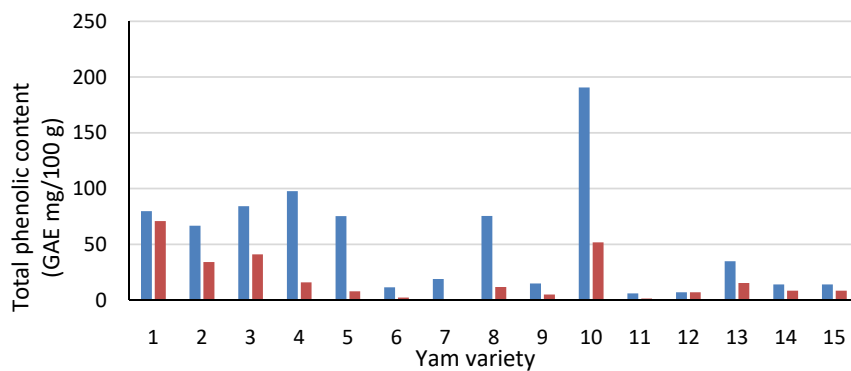
The yam varieties with highest ascorbic acid content in raw form, *X. sagittifolium* 'Isuru', *D. alata* 'Raja ala' and *D. bulbifera* showed a considerable decrease in AAC after boiling (62.5%, 73% and 45%, respectively; Table 4). In contrast, varieties such as *D. alata* 'Jaffna Rasawalli', *C. indica* 'White Selection' and *A. campanulatus* showed the minimum change in AAC when subjected to cooking (Figure 1C and Table 4). Ascorbic acid is lost mostly due to chemical and enzymatic oxidation during processing. Ascorbic acid oxidase is an enzyme that directly affects degradation of AA during storage. However, this enzyme denatures when subject to high heat treatments. In addition, other plant enzymes, such as peroxidases are indirectly responsible for the degradation of AAs [25]. Moreover, AA is water soluble and therefore, it can leach into the water used in cooking. As the heating time increases, the percentage loss of AA also increases [22]. Usually, AAC is lower in root and tubers compared to that of fruits and vegetables.

### 3.5. Correlations among Bioactive Compounds

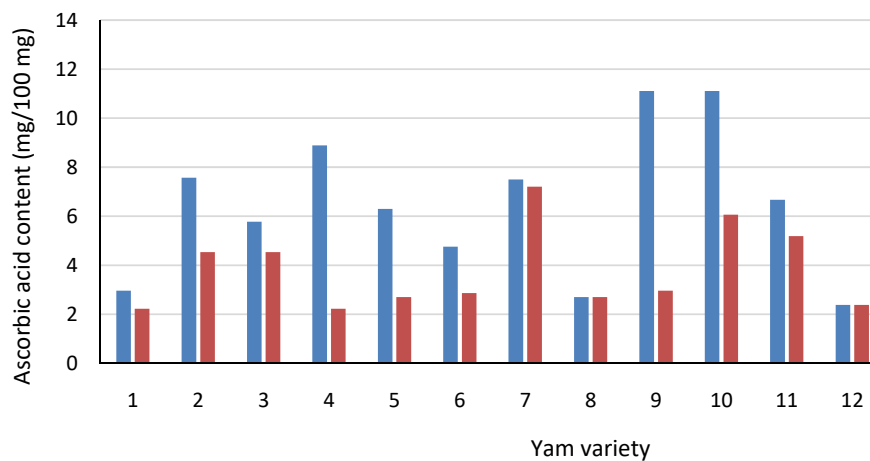
Studies conducted using a variety of crops have shown that the antioxidant activities obtained by FRAP assay and DPPH assay highly correlated with TPC [17]. It is due to the fact that, phenolic compounds which are known as hydrophilic antioxidants are abundant in plant materials. A similar relationship was observed in the present study between the TPC and AOC measured with both FRAP assay (Positive relationship;  $r^2 = 66.5\%$ ; Fig. 2A) and DPPH assay (Negative relationship;  $r^2=28.8\%$ ; Fig. 2B). Results obtained from the two antioxidant assays, DPPH and FRAP assay, also showed a considerable correlation (Negative correlation;  $r^2= 29.9\%$ ; Figure 2C). As the results obtained by DPPH radical scavenging assay is expressed by  $IC_{50}$  value, it can be stated as negatively correlated. There was no consistent correlation between AAC and AOC measured from both FRAP and DPPH assays ( $r^2=0.9$  and  $r^2=0.0\%$ , correspondingly). The correlation between AAC and TPC was also not consistent ( $r^2=0.3\%$ ; Results not shown).



B)



C)

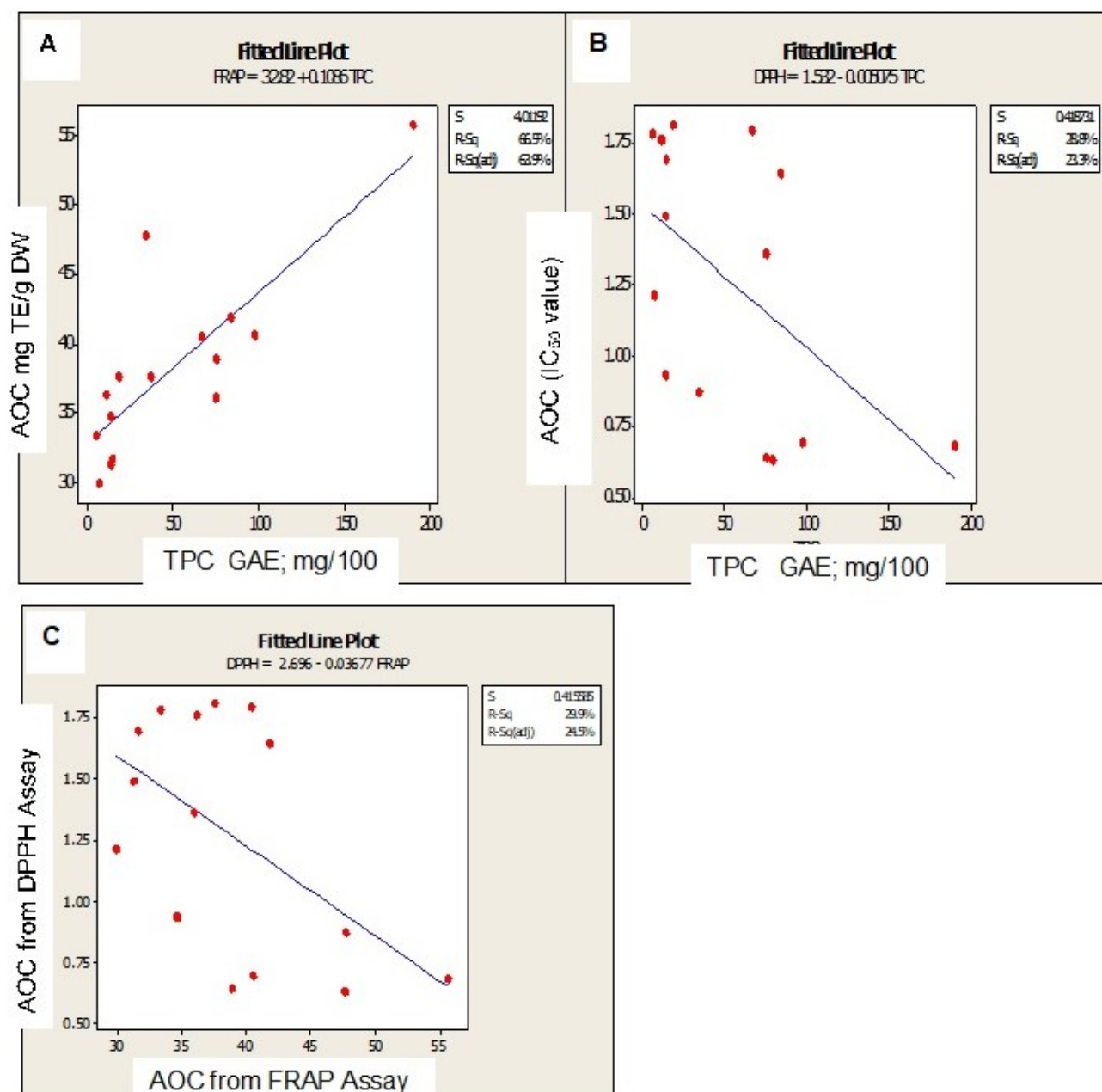


**Figure 1. Changes in antioxidant capacity as given by FRAP assay (A), total phenolic content (B) and ascorbic acid content (C) of root and tubers in their raw and cooked forms.**

Yam varieties: 1- *Amorphophallus campanulatus*, 2- *Canna indica* 'Red Selection', 3- *C. indica* 'White Selection', 4- *Dioscorea alata* 'Dandila', 5- *D. alata* 'Guru ala', 6- *D. alata* 'Hingurala', 7- *D. alata* 'Jaffna Rasawalli', 8- *D. alata* 'Kahata ala' 9- *D. alata* 'Raja ala', 10- *D. bulbifera*, 11- *D. esculenta*, 12- *Marantha arundinacea*, 13- *Xanthosoma sagittifolium* 'Kaha kiri ala', 14- *X. sagittifolium* 'Kiri ala', 15- *X. sagittifolium* 'Isuru'

**Table 4. Percentage change of bioactive compounds in cooked root and tuber**

Variety	Percentage decrease after boiling (%)		
	Antioxidant capacity (FRAP assay)	Total phenolic content	Ascorbic acid content
<i>Amorphophallus campanulatus</i>	11.5	11.2	25.0
<i>Canna indica</i> - Red Selection	5.30	48.7	40.0
<i>Canna indica</i> - White Selection	14.8	51.2	21.4
<i>Dioscorea alata</i> - Dandila	14.8	83.7	75.0
<i>Dioscorea alata</i> - Guru Ala	24.4	89.7	57.1
<i>Dioscorea alata</i> - Hingurala	45.6	80.1	39.9
<i>Dioscorea alata</i> - Jaffna Rasawalli	24.0	95.3	4.0
<i>Dioscorea alata</i> - Kahata ala	24.1	84.5	0.0
<i>Dioscorea alata</i> – Raja ala	0.40	66.9	73.4
<i>Dioscorea bulbifera</i>	13.8	72.8	45.4
<i>Dioscorea esculenta</i>	13.7	76.8	22.2
<i>Maranta arundinaceae</i>	8.90	0.00	0.00
<i>Xanthosoma sagittifolium</i> - Kaha kiri ala	15.9	56.4	62.5
<i>Xanthosoma sagittifolium</i> - Kiri ala	18.5	39.0	62.5
<i>Xanthosoma sagittifolium</i> - Isuru	12.8	39.0	62.5
<b>samples</b>			



**Figure 2.** Correlation between total phenolic content (TPC) and antioxidant capacity (AOC) as given by (A) FRAP assay (B) DPPH radical scavenging assay and (C) correlation between AOC from two assays.

#### 4. CONCLUSION

In conclusion, the underutilized indigenous root and tubers of Sri Lanka are rich in bioactive compounds. Both the antioxidant capacity and phenolic contents are significantly higher in *Dioscorea bulbifera* and *Amorphophallus campanulatus*. The two *Canna indica* Selections also display considerably high contents of bioactive compounds. In general, the contents of bioactive compounds in yams tended to decrease when subject to boiling. However, the degree of loss depends on the yam variety. *D. bulbifera* and *A. campanulatus* could be promoted as alternatives to imported potato. Further research should focus on developing processing technologies to minimize the loss of bioactive compounds in root and tuber crops.

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