Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 5 [8] July 2016: 22-32

Online ISSN 2277-1808
E-ISJN: A4372-2590
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804

ORIGINAL ARTICLE **OPEN ACCESS**

Antioxidant activities and phytochemical screening of *Amomum muricarpum, Hornstedtia conoidea* and *Etlingera philippinensis*

Gina Batoy Barbosa[1,2*], Nonita P. Peteros[2], and Ellen D. Inutan[2]
1- Department of Chemistry, College of Arts and Sciences, Central Mindanao University, University Town, Musuan, Philippines
2- Department of Chemistry, College of Science and Mathematics, Mindanao State University-Iligan Institute of Technology, Iligan City, Philippines
Email: ginavbatoy@yahoo.com

ABSTRACT
Prime concern on human health preservation has escalated interest on search for more natural antioxidant sources. Despite the reported potential values of some Zingiberaceae species, less emphasis is still given to other Zingiberaceae plants especially those found in the Philippines. To the best of the authors' knowledge this is the first scientific report on Philippine endemic Hornstedtia conoidea and Etlingera philippinensis. The water and ethanol extracts of the leaves and rhizomes of Amomum muricarpum, H. conoidea and E. philippinensis were subjected to in vitro 1,1-Diphenyl-2-picrylhydrazyl (DPPH) radical-scavenging (antioxidant) activity assay and phytochemical analysis. Ascorbic acid was used as standard. High DPPH radical scavenging activities were observed in the water extracts of E. philippinensis and H. conoidea leaves and the ethanol extract of A. muricarpum rhizome with percentage DPPH inhibition of 92.07 ± 0.51, 92.97 ± 0.23, and 94.73 ± 0.06, respectively at 500 µg/mL. Phytochemical analysis revealed the presence of alkaloids, flavonoids, saponins, tannins and steroids in the plant extracts. This current study suggests that the extracts of these investigated plants are potential sources of antioxidants. Further investigations are needed to exploit other possible potential medicinal uses of these plants.
Keywords: DPPH radical scavenging activity, phytochemical screening, *Amomum muricarpum* , *Hornstedtia conoidea Etlingera philippinensis*

Received 10.05.2016 Revised 09.06.2016 Accepted 20.06. 2016

INTRODUCTION

Reactive oxygen species (ROS) are implicated in the pathogenesis of several diseases [1]. Hence, the accumulation of reactive and highly cytotoxic ROS must be under tight control [2]. Endogenous antioxidants defend our body from such phenomena. However, these antioxidants are gradually consumed over time and risk of oxidative stress increases with age [3]. Prevention strategies, such as exogenous antioxidants supplementation, may help restore the balance. Hence, natural antioxidants play key roles in this strategy [3].

Addition of natural antioxidants can increase shelf-life of food products containing fats and oils. In addition, natural antioxidants are safe and impart health benefits to the consumer [4]. The antioxidant compounds can be derived from natural sources such as plants [5].

There is increasing interest in the radical-scavenging activities of some natural antioxidants, especially those found in edible plants, which may play a role in preventing various chronic diseases [6]. Modern consumers ask for natural products, free of synthetic additives [7]. Therefore, the application of natural antioxidants will probably continue even in the future.

The Ginger family, Zingiberaceae, is a monocotyledonous [8] and the largest family in the order Zingiberales that comprises generally 300 genera and 1000 species [9]. It is among the plant families which are widely distributed throughout the tropics particularly in Southeast Asia [10]. Zingiberaceae species grow naturally in damp, shaded parts of the lowland or on hill slopes, as scattered plants or thickets [10]. Most members of the family are easily recognized by the characteristic aromatic leaves and fleshy rhizome when both of them are crushed, the elliptic to elliptic–oblong leaves arranged in two ranks

on the leaf-shoot [10], and typically have large rhizomes [11]. Many plants belonging to the family are used for food, spice [11] and a history of medicinal use in systems of traditional medicine [8] and [11].
Z. officinale has shown significant efficacy in nausea, vomiting, motion sickness and arthritis, and active compounds with antioxidant, anti-mutagenic, antimicrobial and anticancer properties have been isolated and require further scrutiny [12]. Ginger rhizomes are used traditionally for management of different gastrointestinal disturbances. Several studies proved that the rhizome possesses diverse biological activities such as cytotoxic, antioxidant, and anti-inflammatory effects [13]. *Zingiber zerumbet* (L.) Smith rhizomes have been demonstrated to possess anti-inflammatory, antinociceptive, antiulcer, antioxidant, anticancer, antimicrobial, antihyperglycemic, antiallergic, antioxidant, and antiplatelet activities at different doses/concentrations [14].
Amomum is the second largest genus in the Zingiberaceae family and has 24 species. In 1909, H.N. Ridley in Leaflets of Philippine Botany reported three species of *Amomum* from South Negros, namely *Amomum fusiforme* Ridl., *Amomum lepicarpa* Ridl. and *Amomum lepicarpa pubescens* Ridl. Elmer (1915) described the following species of *Amomum* from the Philippines: *Amomum propinquum* Ridl. from Baguio; *Amomum mindanaense* Elm. from Todaya (Mt. Apo), District of Davao, Mindanao, June 1909; *Amomum muricarpum* Elm. from Todaya (Mt. Apo), District of Davao, Mindanao, June 1909; *Amomum palawanense* Elm. from Puerto Princesa (Mt. Pulgar), Palawan; *Amomum pandanicarpum* Elm. from Todaya (Mt. Apo), District of Davao, Mindanao, May and September, respectively, 1909; *Amomum pubimarginatum* Elm. from Todaya (Mt. Apo), District of Davao, Mindanao, May, 1909. In 1919, Elmer reported the presence of 4 species of *Amomum* found in the Sorsogon peninsula [15].
Amomum muricarpum Elmer (Fig. 1) belongs to class Equisetopsida C. Agardh subclass Magnoliidae Novák ex Takht., superorder Lilianae Takht. order Zingiberales Griseb., family Zingiberaceae Martinov and genus *Amomum* Roxb. It was discovered in Mt. Apo, Todaya, Davao, Philippines in 1909 by Adolph Daniel Edward Elmer. It is commonly known as tugis in Bukidnon and tagbak in Bisaya.
A. muricarpum Elmer grows 1 – 1.5 m long and most of its leaves are found at the upper 2/3 portion while there are reduced leaves at lower 1/3 portion. Leaves are lanceolate, generally 23-28 x 6-7 cm, base rounded, apex acuminate, margins entire. Its petiole is sub-sessile and its ligules are wavy to truncate, 1.5 to 2.0 mm and smooth. It has obconic inflorescence, 7-6 x 3.5 – 4 cm, and its bracts are membranous, triangular and slightly pubescent, pinkish. The plant's bracteoles are tubular, apex irregularly toothed, pinkish measuring 6-7 mm long. It's calyx is elongated, fused, tubular, pinkish in color but tips are light green and hairy. The dorsal lobe of *A. muricarpum* is oblong while lateral lobe narrow oblong, yellow with red marks at center. The fruits of *A. muricarpum* are rambutan-like, with spines, fruits reddish purplish when mature [15].

Figure 1. *A. muricarpum* plant (A) and its rhizome (B).

A. muricarpum could be found in the inner forest of Impalutao, Impasugong, Bukidnon, Philippines Forest Reserve (Center for Ecological Development and Recreation). It is distributed in Cuernos Mountains, Davao Oriental, Mt. Hamiguitan and Negros (new distribution record). This species is rare and vulnerable. Fruits are reported by the local people (Mandaya) to be edible. According to the local guide, Larry Cahilog, the fruits of this plant are eaten by wild cats (*Viverra tagalonga*) and rodents [15].
In China, *A. muricarpum* is commonly known as you guo dou kou (Pinyin, China). Distribution of *A. muricarpum* is in China to Indo-China and Philippines (Mindanao).
Giang et al. [16] isolated a new natural diarylheptanoid, designated muricarpin, together with four diarylheptanoids from the rhizomes of *A. muricarpum* Elmer (Zingiberaceae) growing in Vietnam. Three known compounds, 1,7-bis(3,4-dihydroxyphenyl)heptan-3-yl acetate, 1-(4'-hydroxyphenyl)- 7 -(3″,4″dihydroxyphenyl) heptan-3-yl acetate and 1-(3',4'-dihydroxyphenyl)- 7- (4″-hydroxyphenyl)-

heptan-3-one were isolated for the first time from the genus *Amomum*, meanwhile (5R)-5-hydroxy-1,7-bis(4-hydroxyphenyl)- heptan-3-one was found for the first time in plants.

Hornstedtia conoidea Ridl. (Fig. 2) is commonly known as panaon, pinoon, and panon in Bisaya, tagbak in Mandaya, and puso-puso in Tagalog. The plant grows up to 3m tall with green to brownish rhizome. Its leaves are broad lanceolate, coriaceous, base cuneate, or obtuse while its petioles are sessile. The ligule of *H. conoidea* Ridl. is oblong and pubescent. It has spindle-shaped inflorescence, 9 x 3 cm. Involucre is present in the plant and its bracts are triangular, 6 x 2 cm, red except at base which is whitish. Its bracteole is tubular, membranous, pink at upper part, white at base, and 3 cm long. The calyx of the plant is elongated, membranous and light pink, 40 x 5 cm. It has an oblong and red corolla, 1.5 x 0.5 cm. *H. conoidea* Ridl. has a red and oblong labellum, without staminodes, 1.5 x 0.8 cm. The spindle – shaped inflorescence, presence of an involucre, and absence of staminode qualifies this species to belong to the genus *Hornstedtia* [15].

H. conoidea was found at 105 and 190 m above sea level and was recorded growing in the secondary growth dipterocarp forest of Bislig Experimental Forest, Bislig, Surigao del Sur, Mindanao, Philippines. This was also recorded to be present beside the river of the Mt. Hamiguitan Range Natural Park, Davao Oriental, Philippines. It is also distributed in Cuernos Mountains (type locality), Negros Oriental, Philippines, Surigao del Sur, Davao Oriental, and is endemic in the Philippines. This species is common in Surigao del Sur but their number may decline due to over collection of its fruits and no efforts to propagate the plant. The fruits of this plant are reported by the local people (Cebuano, Kamayo) to be edible [15].

(A) (B)

Figure 2. *H. conoidea* plant (A) and its rhizome (B).

Etlingera philippinensis (Ridl.) M. Sm. (Fig. 3) was discovered in 1904 in the district of Davao, Mindanao, Philippines by E.B. Copeland. *E. philippinensis* was also reported to be found in Laguna, Quezon, Sorsogon, Mindoro, Palawan, Panay, Negros, Biliran, Leyte, Philippines, specifically in low and medium elevation forests. It belongs to the genus *Etlingera* and has subterranean, creeping and aromatic rhizomes. *Etlingera* plants can grow up to 5-6 m tall, forming dense clumps with stout and pungent rhizomes (3-4 cm diameter). Its leaves (100-150 cm long) are lanceolate and green. Crushed leaves emit a pleasant sour fragrance. The species is native to Malaysia and Indonesia, and is widely cultivated in the tropics for its inflorescences as spice [17].

(A) (B)

Figure 3. *E. philippinensis* Plant (A) and its rhizome (B).

Work published so far covers many aspects but it is limited to the best-known fruits and vegetables [18]. Existing research work indicates that utilization of underexploited sources and better evaluation of ethnic and traditional foods can offer many benefits in the promotion of human health [18].

Despite the reported potential value of commonly known Zingiberaceae plants such as *Z. officinale* and *C. longa*, other plant species in this family especially those found in the Philippines, are not yet explored well. To the best of the authors' knowledge, there is no available scientific study on the antioxidant activity and phytochemical screening of *A. muricarpum* and Philippine endemic *E. philippinensis* and *H. conoidea*.

This study aimed to determine the radical scavenging activity using DPPH assay and phytochemicals present in the water and ethanol extracts of the leaves and rhizomes of the *A. muricarpum*, *H. conoidea*, and *E. philippinensis.*

MATERIALS AND METHODS

Chemicals and Reagents

1,1-Diphenyl-2-picrylhydrazyl (DPPH) radical was purchased from Wako Chemical Co., Tokyo, Japan. All other chemicals used were of analytical reagent grade.

Plant materials

H. conoidea and *E. philippinensis* were collected in June 2014 from Kibawe, Bukidnon, Philippines (7°34'7.77"N 124°55'51.2184"E and 7°33'33.8976"N, 24°55'58.7964"E, respectively) in June, 2014. *A. muricarpum* plants were collected from Center for Ecological Development and Recreation (CEDAR), Impalutao, Impasugong, Bukidnon, Philippines (8°14'57.714"N, 125°01'50.7792"E) in October, 2014. Gratuitous permit was properly secured from the Department of Environment and Natural Resources (DENR) - Region 10. Plant samples were identified by Dr. Florfe M. Acma and Prof. Hannah P. Lumista of the Center of Biodiversity Research and Extension in Mindanao (CEBREM), Central Mindanao University, University Town, Musuan, Bukidnon. Voucher specimens of the plant samples were deposited at Central Mindanao University Herbarium (CMUH).

The plant leaf and rhizome samples were air-dried for three to four weeks, powdered using a blender, and stored inside airtight plastic container prior its extraction.

Preparation of plant extracts

Water extract preparation. Freshly collected leaves and rhizomes of the plant samples were cut into small pieces and boiled in sufficient distilled water for five minutes. The mixture was then filtered. The filtrate was freeze dried to remove water and the residue was stored at least -15 °C until analysis.

Ethanol extract preparation. Powdered leaf and rhizome samples were separately soaked in 95% ethanol for 48 hours and filtered. The solvent in the filtrate was removed *in vacuo* using a rotary evaporator at a temperature below 40°C. The ethanol extract was stored inside refrigerator prior its usage.

DPPH Radical Scavenging Activity

DPPH radical scavenging activities of the water and ethanol extracts were determined using the method of Lee and Shibamoto (2001) as cited by [19]. Briefly, various amounts of the samples (500 µg/mL, 100 µg/mL, 50 µg/mL, 10 µg/mL) were mixed with 3 mL of methanolic solution of DPPH (0.1 mM). The mixture was shaken vigorously in a vortex mixer for 10 s and allowed to stand in the dark at room temperature for one hour. Then absorbance was measured at 517 nm against methanol as a blank in the Lasany double beam UV-Vis spectrophotometer model LI-2800 (Haryana, India).

The DPPH solution alone in methanol was used as control. Each sample was assayed in triplicate and mean values were calculated. L-ascorbic acid was used as standard. The radical scavenging activity of samples corresponds to the intensity of quenching DPPH. The percent of DPPH discoloration of the samples was calculated and the results was expressed as percentage inhibition using the formula (equation 1) shown below.

$$\% \text{ Inhibition} = [(A_{control} - A_{sample}) / A_{control}] \times 100 \quad (1)$$

where $A_{control}$ and A_{sample} are the absorbance values of the control and test sample, respectively.

The effective concentration of sample required to scavenge DPPH radical by 50% (EC_{50}) was obtained by linear regression analysis of dose-response curve plotting between % inhibition and concentration.

Phytochemical Screening

Phytochemical screening was performed following the method described by Aguinaldo et al., [20].

RESULTS

DPPH Assay

The data (Table1) represent the percentage inhibition of DPPH radical by the scavenging activity of the water and ethanolic extracts of the leaves and rhizomes of the studied Zingiberaceae plants. This is visibly indicated by the discoloration of the DPPH solution from purple to yellow.

Notable radical scavenging activities were observed in the water extracts of the rhizomes (9.79 ± 0.27) and leaves (6.64 ± 0.06) of *E. philippinensis* which were significantly higher than that of ascorbic acid at 10 µg/mL. Ethanol extract of the *A. muricarpum* rhizomes exhibited the highest radical scavenging activity of 94.73 ± 0.06 at 500 µg/mL. This radical scavenging activity is nearly the same when compared to that of the standard ascorbic acid (97.27 ± 0.40). This was followed by the water extract of *H. conoidea* leaves (92.97 ± 0.23), water extract of *E. philippinensis* leaves (92.07 ± 0.51), ethanolic extract of the *A. muricarpum* leaves (49.37 ± 0.23), ethanolic extracts of the *E. philippinensis* leaves (40.61 ± 0.87), water extract of the *A. muricarpum* leaves (39.90 ± 0.82), water extract of the *A. muricarpum* rhizomes (35.36 ± 0.18), and ethanolic extract of *H. conoidea* leaves (27.74 ± 0.07).

At 500 µg/mL, radical scavenging activities were significantly higher in the leaves of *H. conoidea* and *E. philippinensis* than in its rhizomes in both water and ethanolic extracts, and in the water extract of *A. muricarpum.* Ethanolic extract of *A. muricarpum* had higher radical scavenging activity in its rhizomes than its leaves. However, varying trends in the radical scavenging activities were observed at lower extract concentrations.

The concentration of the extracts to scavenge 50% of the DPPH radical (EC_{50}) ranged from 251.4054 µg/mL in the water extract of the *E. philippinensis* leaves to 1821.964 µg/mL in its rhizomes. These values are not comparable to that of the standard ascorbic acid which has EC_{50} of 87.48 µg/mL.

Phytochemical Screening

Phytochemical screening of water and ethanolic extracts of the leaves and rhizomes of *A. muricarpum*, *H. conoidea*, and *E. philippinensis* showed the presence of alkaloids, flavonoids, saponins, tannins, steroid (Table 2).

DISCUSSION

DPPH Radical scavenging activity

Free radicals cause lipid peroxidation and production of highly toxic lipid derivatives, which in turn can modify cell functions and even may lead to cell death [1]. Cellular damage or oxidative injury arising from free radicals or ROS now appears the fundamental mechanism underlying a number of human neurodegenerative disorders, diabetes, inflammation, viral infections, autoimmune pathologies and digestive system disorders [21].

DPPH radical scavenging assay has been widely used to evaluate the radical scavenging ability of the plant extracts as it is simple and highly sensitive [22]. The DPPH assay utilizes $DPPH^{\bullet}$ radical, one of the few stable organic nitrogen radicals, which bears a deep purple color [23]. DPPH radical is a free radical and accepts an electron or hydrogen radical to become a stable diamagnetic molecule [24]. This assay is based on the measurement of the reducing ability of antioxidants toward $DPPH^{\bullet}$ [23]. The reduction capability of DPPH radicals was determined by the decrease in its absorbance at 517 nm induced by antioxidants [24]. DPPH was reduced to a pale yellow color due to the abstraction of hydrogen atom from antioxidant compound [24]. The more antioxidants occurred in the extract, the more the DPPH reduction will occur [24].

An antioxidant, which can quench reactive free radicals, can prevent the oxidation of other molecules [25], protects the body from reactive species [26], and may, therefore, have health-promoting effects in the prevention of degenerative diseases [25]. Naturally occurring antioxidant supplements from plants are vital to counter the oxidative damage in cells [21].

Thus, an increase in the consumption of dietary antioxidants, which can scavenge free radicals, may be a strategy to prevent free radical-induced damage to biomolecules of lipids, proteins, and DNA, including low density lipoprotein oxidation and cancer cell initiation, an important beginning stage of carcinogenesis [27]. Antioxidant research is a key topic in both the medical and food industry today [26].

Zingiberaceae plants have received much attention since they produce many complex compounds that are useful in food as herbs and spices, flavoring and seasoning, and in the cosmetics and medicinal industries as antioxidant and antimicrobial agents [28]. Several past antioxidant studies on gingers species were confined to rhizomes [29, 10, 30, 14, 31, 32]. Although leaves of ginger species have been used for food flavoring and in traditional medicine, little research has been done on their antioxidant properties until recent years [17].

Table 1. DPPH radical scavenging activity of the water and ethanol extracts of the leaves and rhizomes of *A. muricarpum*, *H. conoidea*, and *E. philippinensis*

Sample	Plant Part	Extraction Solvent	Average % Inhibition*				
			10 µg/mL	50 µg/mL	100 µg/mL	500 µg/mL	EC_{50}
Ascorbic acid (standard)			5.97 ± 1.07	44.50 ± 1.21	93.53 ± 1.73	97.27 ± 0.40	87.48
H. conoidea	Rhizomes	Water	1.69 ± 0.56	2.72 ± 0.24	4.25 ± 0.24	19.56 ± .41	1322.544
		Ethanol	2.74 ± 0.07	4.44 ± 0.18	7.06 ± 0.31	25.12 ± 0.23	1043.724
	Leaves	Water	0.00 ± 0.00	12.02 ± 0.39	27.48 ± 2.46	92.97 ± 0.23	257.7912
		Ethanol	2.89 ± 0.50	4.44 ± 0.07	6.75 ± 0.13	27.74 ± 0.07	934.2471
E. philippinensis	Rhizomes	Water	9.79 ± 0.27	10.69 ± 0.24	11.72 ± 0.12	20.65 ± 0.48	1821.964
		Ethanol	0.50 ± 0.07	1.13 ± 0.06	4.65 ± 0.06	18.99 ± 0.33	1311.394
	Leaves	Water	6.64 ± 0.06	15.25 ± 0.35	26.87 ± 0.81	92.07 ± 0.51	251.4054
		Ethanol	1.08 ± 0.18	5.05 ± 0.48	9.95 ± 0.06	40.61 ± 0.87	616.3048
A. muricarpum	Rhizomes	Water	0.62 ± 0.00	4.02 ± 0.27	8.35 ± 0.10	35.36 ± 0.18	707.3991
		Ethanol	1.59 ± 0.27	8.92 ± 0.23	21.76 ± 0.55	94.73 ± 0.06	261.5508
	Leaves	Water	1.90 ± 0.16	3.30 ± 0.06	5.92 ± 0.37	39.90 ± 0.82	629.9164
		Ethanol	1.40 ± 0.20	3.87 ± 0.33	10.84 ± 0.67	49.37 ± 0.23	505.7599

* - mean of 3 replicates and expressed as mean ± RSD

Table 2. Phytochemical profile of the water and ethanolic extracts of the leaves and rhizomes of *A. muricarpum*, *H. conoidea*, and *E. philippinensis*

Phytoconstituents	*H. conoidea*				*A. muricarpum*				*E. philippinensis*			
	Roots		Leaves		Roots		Leaves		Roots		Leaves	
	A	E	A	E	A	E	A	E	A	E	A	E
Alkaloids	-	+	+	+	+	+	-	++	-	+	+	+
Flavonoids	+++	+++	+++	+++	+++	+++	+++	+	+++	+++	+++	+++
Saponins	+++	+++	+++	+	+++	+++	+++	+++	+++	++	++	+++
Tannins	+	+	++	+	+	+	+	+	-	+++	+++	+
Steroids (2-deoxysugars)	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
Anthraquinone	-	-	-	-	-	-	-	-	-	-	-	-
Cyanogenic glycosides	-	-	-	-	-	-	-	-	-	-	-	-

Legend: "A" Water extract, "E" Ethanolic extract, "+" Present, "–" Absent, "+" poor, "++" moderate, "+++" heavy

In Zingiberaceae, it is generally believed that antioxidants and other secondary metabolites are transported to the rhizomes where they are accumulated [33]. This implies that rhizomes would have higher antioxidant activity than would other plant parts [33]. Rhizomes of cultivated species have been reported to possess radical-scavenging compounds comparable to commercial antioxidants on a weight per weight basis [33].

In this study, ethanol extract of *A. muricarpum* has higher radical scavenging activity in its rhizomes than its leaves. However, *A. muricarpum* water extract and both water and ethanol extracts of *H. conoidea* and *E. philippinensis* have higher antioxidant activity than in its rhizomes.

Findings on the DPPH radical scavenging activities of *H. conoidea* and *E. philippinensis* and on the water extract of *A. muricarpum* were similarly observed in some previous studies. A study on 26 ginger species, belonging to nine genera and three tribes, showed that antioxidant properties of leaves were strongest in *Etlingera* followed by *Alpinia* and *Hedychium*. Eleven out of 14 species (78%) had significantly higher values in leaves than in rhizomes. Similar trends were also observed in other species of *Zingiber*, *Boesenbergia* and *Elettariopsis* [17]. Another study on the *Etlingera elatior* revealed significantly higher antioxidant properties in leaves than inflorescences and rhizomes [17].

Moreover, ethyl acetate extracts from *Alpinia zerumbet* leaves showed higher DPPH radical scavenging activities than those from rhizomes [34]. The antioxidant activities of methanol extracts from two *Z.*

officinale varieties (Halia Bentong and Halia Bara) as determined by the DPPH assay and the total amounts of phenolics and flavonoids were higher in leaves than those of the rhizomes and stems. On the other hand, the ferric reducing/antioxidant potential activity of the rhizomes was higher than that of the leaves [35].

In comparison between the extraction solvents, higher antioxidant activities were observed in the water extracts of *H. conoidea* leaves and *E. philippinenses* leaves and rhizomes than in its ethanol extracts. Better activities were observed in the ethanol extracts than water extracts of *H. conoidea* rhizomes and both *A. muricarpum* leaves and rhizomes.

Varying results were also observed in the study of Yeh et al. [36]. The antioxidant effect of the ethanol extracts of two *Z. officinale* Roscoe varieties, namely: Guangdongginger and Chu-ginger in Taiwan, were found to be more effective than water extracts in Trolox equivalent antioxidant capacity and Ferric reducing ability of plasma. Contrarily, ginger water extracts were more effective in free radical scavenging activities and chelating abilities [36].

Ten water extracts from herbs (i.e. *Aegle marmelos* L*., Andrographis paniculata Nees, Chrysanthemum indicum L., Cymbopogon citratus Stapf., Hibiscus sabdariffa L., Jubliang and Z. officinale* Rosc.) prepared by boiling in hot water for 10 min displayed to be good sources of water soluble antioxidants, phenolic compounds and antimutagens [37].

Comparative study on the antioxidant activity of *E. elatior* flower from Indonesia using DPPH assay revealed that *E. elatior* in the methanol extract has higher antioxidant potential as compared to ethyl acetate extract [38].

Ethanol is more efficient in cell wall and seed degradations which have non-polar character and cause polyphenols to be released from cells. More useful explanation for the decrease in activity of water extract can be ascribed to the enzyme polyphenol oxidase, which degrade polyphenols in water extracts, whereas in methanol and ethanol they are inactive [39]. These may explain higher antioxidant activity in some ethanol extracts in this study.

Antioxidant activities were found to be not comparable with the standard ascorbic acid. These results were similar to that obtained in the study of Peteros and Uy [40] on the crude methanol extract of four Philippine medicinal plants namely: *Brucea amarissima* (Lour.) Merr. Bark, *Intsia bijuga* (Coebr.) O. Kuntze, *Laportea meyeniana* Warb, and *Pipturus arborescens* (Link) C.B. Rob leaves. This is understandable, since L-ascorbic acid is already in a pure form, while the crude plant extracts still need to be processed in order to isolate the compounds responsible for their antioxidant activity [40]. The DPPH radical scavenging abilities of the *Z. officinale* varieties (Halia Bentong and Halia Bara) rhizomes extracts were less than those of butylated hydroxytoluene (96.21%) and α-tocopherol (89.57%) at 45 µg/mL [41].

Phytochemical analysis

Natural products are gaining attention owing to their rich phytochemistry and risk-free use [42]. The phytochemical constituents of plants have received much attention due to their potential utilization in the nutraceutical and drug industries [43].

Spices and herbs contain free radical scavengers like polyphenols, flavonoids and phenolic compounds [44]. These natural antioxidants present in herbs and spices are responsible for inhibiting or preventing the deleterious consequences of oxidative stress [44]. Fruits and vegetables are also known to contain various forms of phytochemicals and antioxidants, particularly polyphenol compounds (e.g., flavonoids and anthocyanins). Their frequent consumption has been associated with a lowered risk of heart disease, cancer, hypertension, and stroke [14].

Antioxidant activity of the plants is due to the presence of flavones, isoflavones, flavonoids, anthocyanin, coumarin, lignans, catechins and isocatechins [5]. Phenolic compounds play key role as antioxidants due to the presence of phenolic groups (hydroxyl substituents next to their aromatic structures), which enable them to scavenge free radicals [43].

Flavonoids, alkaloids, saponins, tannins and steroids found in the water and ethanol extracts of *H. conoidea, E. philippinensis* and *A. muricarpum* were similarly observed in other Zingiberaceae plants. *Z. officinale* was reported to contain alkaloid [45-46], tannin [45-46], carotenoids [45], saponin [45, 47], flavonoids [45-46], and cardiac glycosides [46]. Flavonoid compounds (quercetin, apigenin, luteolin, and myricetin) and phenolic acids (gallic acid, vanillic acid, ferulic acid, tannic acid and caffeic acid) were identified with different concentration in leaves and rhizomes of ginger varieties. The most abundant phenolic acid in ginger was gallic acid, and flavonoids were quercetin and apigenin [48].

Methanol and ethyl acetate extracts of the flower of *E. elatior* revealed the presence of tannins, flavonoids, saponin and steroid [38]. The methanol extract of the leaves of *Curcuma alismatifolia* Gangnep were found to contain flavonoids, alkaloid and gum [49].

The antioxidant activities revealed in this study may be attributed to the presence of flavonoids in all the water and ethanol extracts of *H. conoidea, E. philippinensis* and *A. muricarpum* leaves and rhizomes. Several studies revealed the association of flavonoids to the antioxidant activity of plant extracts. *Z. officinale* is extensively reported to possess antioxidant activity against a variety of free radicals [5]. The high level of total phenolic and flavonoid in Halia Bara (*Z. officinale* variety) indicated high antioxidant activities [35]. Essential oil from *E. elatior* has high total phenolic content and total flavonoid content and possessed antioxidant activity when evaluated using the DPPH assay [50]. Oral administration of water extract of *Z. officinale* along with paraben significantly ($p \leq 0.05$) ameliorates paraben-induced lipid peroxidation in the liver of mice [51].

The total phenolic and flavonoid contents appear to be responsible, at least in part, for the *Ficus virens* var. sublanceolata and *Ficus auriculata* extracts' excellent antioxidant capacity and all the extracts exhibited dose-dependent antioxidant activity employing 2,2'-azino-bis(3- ethylbenzothiazo- line-6-sulphonic acid and DPPH radical scavenging capacities, ferric reducing power and lipid peroxidation inhibition properties [52].

Positive and significant relationship ($r^2=0.942$) with high significance ($P<0.001$) was obtained between total flavonoid content and vitamin C equivalent antioxidant capacity in the six cultivars of plums studied [25]. The high alkaloid and flavonoids contents of the plants, suggests their antioxidant potentials and justifies their therapeutic actions, which could be used in drug formulation. The antioxidant potentials of plants have been linked with their flavonoids contents [53].

The phytochemical analysis of the crude extracts 12 traditionally used Indian medicinal plants indicated the presence of major phytocompounds, including phenolics, alkaloids, glycosides, flavonoids, and tannins, which may have been responsible for the observed antioxidant activity [54]. It was suggested that there seemed to be a good correlation among gallic acid, and other phenolic and flavonoid compounds and antioxidant activity and other biological activity in *Citrus aurantium* [26].

Flavonoids are a group of polyphenolic compounds, diverse in chemical structure and characteristics, found ubiquitously in plants [55]. They constitute an enormous collection of biologically active compounds that are ubiquitous in plants, many of which have been used in traditional Eastern medicine for thousands of years [41]. Flavonoids are potent antioxidants, free radical scavengers [55, 41], metal chelators and inhibit lipid peroxidation [55], thus displaying anti-aging properties and reducing the risk of cancer [41]. The structural requirements for the antioxidant and free radical scavenging functions of flavonoids include a hydroxyl group in carbon position three, a double bond between carbon positions two and three, a carbonyl group in carbon position four, and polyhydroxylation of the A and B aromatic rings [55]. The presence of phenolic compounds such as eugenol, shogaols, zingerone, gingerdiols, gingerols, diacetoxy-[6]-gingerdiol, etc., in ginger oil and oleoresins may be responsible for their antioxidant properties [56]. They were found to be better antioxidants than butylated hydroxyanisole [56].

Several alkaloids of various structural types have been found to be potent inhibitors of $^1O_2$ [57]. Two quinolone alkaloids, 3,8-dihydroxyquinoline and 2,8-dihydroxy-3,4-dimethoxyquinoline, and 2,4-di-tertbutylphenol isolated from the dried body of *Scolopendra subspinipes* showed DPPH radical scavenging activity [58]. The alkaloids cepharanthine and fangchinoline from *Stephania rotunda* have effective antioxidant and radical scavenging activity [59]. *Coptidis Rhizoma* and the alkaloids contained therein clearly have beneficial uses in the development of therapeutic and preventive agents for Alzheimer's disease and oxidative stress-related disease [60].

Tannins, a unique group of phenolic metabolites with molecular weights between 500 and 30000 Da, are widely distributed in almost all plant foods and beverages [61]. Tannins were found to have redox potentials similar to those of structurally related simple phenolics but 15-30 times more effective at quenching peroxyl radicals than simple phenolics or Trolox. Polygalloyl glucose, a tannin, reacted an order of magnitude more quickly with hydroxyl radical than mannitol. These results suggest that tannins, which are found in many plant-based foods and beverages, are potentially very important biological antioxidants [62].

Using the Folin-Ciocalteu and DPPH assays, respectively, highest total phenolic content and ascorbic acid equivalent capacity were observed in the polymeric tannin fraction of *Alpinia galanga* rhizomes, in the crude extract and non-polymeric phenolic fractions fraction of *Curcuma longa* rhizomes, and in the polymeric tannin fractions fraction of *E. elatior* leaves [17].

The presence of alkaloids and tannins in the *A. muricarpum*, *H. conoidea*, and *E. philippinensis* extracts possibly contribute to antioxidant activities demonstrated in these plants.

CONCLUSION

DPPH radical scavenging activity and phytochemical analysis of the *A. muricarpum*, *H. conoidea*, and *E. philippinensis* were done for the first time. *A. muricarpum* rhizomes showed considerable high radical scavenging activity. It is noteworthy that the leaves of *H. conoidea* and *E. philippinensis* exhibited better radical scavenging activity than its rhizomes. The presence of flavonoids and tannins and the observed radical scavenging activity in this current study may suggest the antioxidant property of these studied plants. Investigation at the molecular level on this Zingiberaceae species is needed to exploit its potential medicinal uses.

ACKNOWLEDGEMENT

The authors express their gratitude to the Commission on Higher Education – Faculty Development Program II (CHED-FDP II) and Central Mindanao University (CMU) for the scholarship grant. Special thanks to Karleen Garcia, Marvelous Grace Villazorda, and Enjelyn Gomez for the assistance in the DPPH assay and phytochemical analyses. Sincere thanks also to Dr. Florfe M. Acma and Conchita Cano for the assistance in locating the plant samples and to CEDAR, Philippine Department of Environment and Natural Resources- Region 10 for providing the *A. muricarpum* plant samples.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. Nanjundaiah SN, Annaiah HN, and Dharmesh SM (2011). Gastroprotective Effect of Ginger Rhizome (*Zingiber officinale*) Extract: Role of Gallic Acid and Cinnamic Acid in H+, K+-ATPase/H. pylori Inhibition and Anti-OxidativeMechanism. Hindawi Publishing Corporation Evidence-Based Complementary and Alternative Medicine Volume 2011, Article ID 249487, 13 pages doi:10.1093/ecam/nep060 PP 1-13
2. Shao HB, Chu LY, Lu ZH, and Kang CM (2008). Primary antioxidant free radical scavenging and redox signaling pathways in higher plant cells. *Int. J. of Biol. Sci;* 4(1): 8-14.
3. Amorati R, Foti MC, and Valgimigli L (2013). Antioxidant Activity of Essential Oils. *J. Agric. Food Chem*; 61: 10835−10847.
4. Reddy V, Urooj A, and Kumar A (2005). Evaluation of antioxidant activity of some plant extracts and their application in biscuits. *Food Chem*; 90: 317–321.
5. Kumar G, Karthik L, Rao KVB (2011). A Review on Pharmacological and Phytochemical Properties of *Zingiber officinale* Roscoe (Zingiberaceae). *Journal of Pharmacy Research;* 4(9): 2963-2966.
6. Choi HS, Song HS, Ukeda H, and Sawamura M. (2000). Radical-Scavenging Activities of Citrus Essential Oils and Their Components: Detection Using 1,1-Diphenyl-2-picrylhydrazyl. *J. Agric. Food Chem*; 48(9): 4156-4161.
7. Suhaj, M. (2006). Spice antioxidants isolation and their antiradical activity: a review. *J. Food Compost Anal;* 19: 531–537.
8. Wohlmuth H, Deseo MA, Brushett DJ, Thompson DR, MacFarlane G, Stevenson LM, and Leach DN (2010). Diarylheptanoid from *Pleuranthodium racemigerum* with *in Vitro* Prostaglandin E2 Inhibitory and Cytotoxic Activity. *J. Nat. Prod;* 73(4): 743–746.
9. Sahu R and Saxena J (2013). Screening of Total Phenolic and Flavonoid Content in Conventional and Non-Conventional Species of Curcuma. *Journal of Pharmacognosy and Phytochemistry*; 2 (1): 176-179.
10. Habsah M, Amran M, Mackeen MM, Lajis NH, Kikuzaki H, Nakatani N, Rahman AA, Ghafar, and Ali AM (2000). Screening of Zingiberaceae extracts for antimicrobial and antioxidant activities. *Journal of Ethnopharmacology;* 72: 403–410.
11. Kuo YJ, Hsiao PC, Zhang LJ, Wu MD, Liang YH, Ho HO and Kuo YH (2009). Labdane Diterpenoid Glycosides from *Alpinia densespicata* and Their Nitric Oxide Inhibitory Activities in Macrophages. *J. Nat. Prod;* 72(6): 1097–1101.
12. Ahmad I, Zahin M, Aqil1 F, Hasan S, Khan MSA, Owais M (2008). Bioactive compounds from *Punica granatum*, *Curcuma longa* and *Zingiber officinale* and their therapeutic potential. *Drugs Fut*; 33(4): 329-346.
13. El-Abhar HS, Hammad LN, Gawad HS (2008). Modulating effect of ginger extract on rats with ulcerative colitis. *J Ethnopharmacol*; 118(3): 367–372.
14. N. J. Yob, S. Mohd. Jofrry, M. M. R. Meor. Mohd. Affandi, L. K. Teh, M. Z. Salleh, and Z. A. Zakaria, "*Zingiber zerumbet* (L.) Smith: A Review of Its Ethnomedicinal, Chemical, and Pharmacological Uses," *Evidence-Based Complementary and Alternative Medicine*, vol. 2011, Article ID 543216, 12 pages, 2011. doi:10.1155/2011/543216
15. Acma FM and Gruezo WSM (2010). Biosystematics of the Genus *Amomum* ROXB. (FAMILY ZINGIBERACEAE) in the Philippines. Doctoral Dissertation. Philippines: University of the Philippines - Los Baῆos.
16. Giang PM, Son PT, Matsunami,K and Otsuka H (2011). One new and several minor diarylheptanoids from *Amomum muricarpum*. *Nat. Prod. Res*; 26(13): 1195-2000.
17. Chan EWC, Ng VP, Tan VV, and Low YY (2011). Antioxidant and Antibacterial Properties of *Alpinia galanga*, *Curcuma longa*, and *Etlingera elatior* (Zingiberaceae). *PHCOG J*; 3(22): 54-61.
18. Dimitrios B (2006). Sources of natural phenolic antioxidants. Trends in Food Science & Technology. 17: 505–512.

19. Abbasi MA, Aslam A, Riaz T, Rehman AU, Shahzadi T, Siddiqui SZ, Irshad M, and Ajaib M (2011). Investigation on the comparative antioxidant potential of various fractions of *Vitex negundo* of Pakistani origin. *Bioscience Research*; 8(1): 01-07.
20. Aguinaldo AM, Espeso EI, Guevara BQ, Nonato MG (2005). Phytochemistry. In: Guevara BQ (ed.) A Guidebook to Plant Screening: Phytochemical and Biological. University of Santo Tomas, Manila, Philippines.
21. Sharma V and Singh M (2012). In vitro radical scavenging activity and phytochemical screening for evaluation of the antioxidant potential of *Operculina turpethum* root extract. *Journal of Pharmacy Research*; 5(2):783-787.
22. Phang CH, Malek SNA and Ibrahim H (2013). Antioxidant potential, cytotoxic activity and total phenolic content of *Alpinia pahangensis* rhizomes. *BMC Complementary and Alternative Medicine;* 13:243.
23. Prior RL, Wu X and Schaich K (2005). Standardized Methods for the Determination of Antioxidant Capacity and Phenolics in Foods and Dietary Supplements. *J. Agric. Food Chem;* 53(10): 4290-4302.
24. Basma AA, Zakaria, Z, Latha，L, Sasidharanet, S (2011). Antioxidant activity and phytochemical screening of the methanol extracts of *Euphorbia hirta* L. *Asian Pacific Journal of Tropical Medicine*; 4(5)386-390.
25. Kim DO, Jeong SW, Lee CY (2003). Antioxidant capacity of phenolic phytochemicals from various cultivars of plums. *Food Chem*; 81: 321–326.
26. Karimi E, Oskoueian E, Hendra R, Oskoueian A and Jaafar HZE (2012). Phenolic Compounds Characterization and Biological Activities of *Citrus aurantium* Bloom. *Molecules;* 17: 1203-1218.
27. Song W, Derito CM, Liu MK, He XJ, Dong M and Liu RH (2010). Cellular Antioxidant Activity of Common Vegetables. *J. Agric. Food Chem;* 58: 6621–6629.
28. Chen IN, Chang CC, Ng CC, Wang CY, Shyu YT, Chang TL (2008). Antioxidant and Antimicrobial Activity of Zingiberaceae Plants in Taiwan. *Plant Foods Hum Nutr*; 63:15–20.
29. Jitoe A, Masuda T, Tengah IGP, Suprapta DN, Gara IW, and Nakatani N. (1992). Antioxidant activity of tropical ginger extracts and analysis of the contained curcuminoids. *J. Agric. Food Chem;* 40(8): 1337–1340.
30. Zaeoung S, Plubrukarn A, and Keawpradub N (2005). Cytotoxic and free radical scavenging activities of Zingiberaceous rhizomes. *Songklanakarin J. Sci. Technol;* 27(4): 799–812.
31. Oboh G, Akinyemi AJ, Ademiluyi AO (2012). Antioxidant and inhibitory effect of red ginger (*Zingiber officinale* Var Ruba) and white ginger (*Zingiber officinale* Roscoe) on Fe^{2+}, induced lipid peroxidation in rat brain in vitro. *Exp Toxicol Pathol;* 64:31–36.
32. Chan EWC, Lim YY, Wong SK (2011). Antioxidant properties of ginger leaves: An overview. *Free Rad. Antiox*; 1(1): 6-16.
33. Chan EWC, Lim YY and Omar M (2007). Antioxidant and antibacterial activity of leaves of *Etlingera* species (Zingiberaceae) in Peninsular Malaysia. *Food Chem;* 104:1586–1593.
34. Elzaawely AA, Xuan TD, Tawata S (2007). Essential oils, kava pyrones and phenolic compounds from leaves and rhizomes of *Alpinia zerumbet* (Pers.) B.L. Burtt. & R.M. Sm. and their antioxidant activity. *Food Chem*; 103: 486–494.
35. Ghasemzadeh A, Jaafar HZE, and Rahmat A (2010). Antioxidant Activities, Total Phenolics and Flavonoids Content in Two Varieties of Malaysia Young Ginger (*Zingiber officinale* Roscoe). *Molecules*; 15: 4324-4333.
36. Yeh HY, Chuang CH, Chen HC, Wan CJ, Chen TL, Lin LY (2013). Bioactive components analysis of two various gingers (*Zingiber officinale* Roscoe) and antioxidant effect of ginger extracts. LWT - Food Science and Technology. Xxx: 1-6 (article in press)
37. Kruawan K and Kangsadalampai K (2006). Antioxidant activity, phenolic compound contents and antimutagenic activity of some water extract of herbs. *Thai J. Pharm. Sci;* 30: 28-35.
38. Maimulyanti A and Prihadi AR (2015). Chemical composition, phytochemical and antioxidant activity from extract of *Etlingera elatior* flower from Indonesia. *Journal of Pharmacognosy and Phytochemistry;* 3(6): 233-238.
39. Vijayan C, Adersh M, Reji SR & Nair GM (2013). Screening biological activities of *Orthosiphon aristatus*. *Int J Pharm Pharm Sci;* 5(4): 594-600.
40. Peteros NP and Uy MM (2010). Antioxidant and cytotoxic activities and phytochemical screening of four Philippine medicinal plants. *J. Med. Plant. Res.* 4(5): 407-414.
41. Ghasemzadeh A, Jaafar HZE, and Rahmat A (2010). Identification and Concentration of Some Flavonoid Components in Malaysian Young Ginger (*Zingiber officinale* Roscoe) Varieties by a High Performance Liquid Chromatography Method. *Molecules*; 15: 6231-6243.
42. Butt MS and Sultan MT (2011). Ginger and its Health Claims: Molecular Aspects. *Critical Reviews in Food Science and Nutrition*; 51:383–393
43. Bua-in S and Paisooksantivatana Y (2009). Essential Oil and Antioxidant Activity of Cassumunar Ginger (Zingiberaceae: *Zingiber montanum* (Koenig) Link ex Dietr.) Collected from Various Parts of Thailand. *Kasetsart J. (Nat. Sci.)*; 43 : 467 – 475.
44. Khalaf NA, Shakya AK, Al-othman A, El-agbar Z, Farah H (2008). Antioxidant Activity of Some Common Plants. *Turk J Biol;* 32: 51-55.
45. Otunola GA, Oloyede OB, Oladiji AT, and Afolayan AJ (2010). Comparative analysis of the chemical composition of three spices – *Allium sativum* L., *Zingiber officinale* Rosc. and *Capsicum frutescens* L. commonly consumed in Nigeria. *Afr. J. Biotechnol;* 9(41): 6927-6931.
46. Motawi TK, Hamed MA, Shabana MH, Hashem RM and Naser AFA (2011). *Zingiber officinale* acts as a nutraceutical agent against liver fibrosis. *Nutrition & Metabolism;* 8(40): 1-11.
47. Omoya FO and Akharaiyi FC (2012). Mixture of Honey and Ginger Extract for Antibacterial Assessment on Some Clinical Isolates. *Int. Res. J. of Pharmaceuticals;* 2(5): 127-132.

48. Ghasemzadeh A and Ghasemzadeh N (2011). Effects of shading on synthesis and accumulation of polyphenolic compounds in ginger (*Zingiber officinale* Roscoe) varieties. *J. Med. Plant. Res*; 5(11): 2435-2442.
49. Akter RSM, Hasan R, Siddiqua SA, Majumder MM, Hossain MM, Alam MA, Haque S, Ghani A (2008). Evaluation of analgesic and antioxidant potential of the leaves of *Curcuma alismatifolia* Gagnep. S. *J. Pharm. Sci;* 1(1&2): 3-9.
50. Abdelwahab SI and Zaman FQ (2010). Chemical composition, antioxidant and antibacterial properties of the essential oils of *Etlingera elatior* and *Cinnamomum pubescens* Kochummen. *J Sci Food Agric*; 90: 2682–2668.
51. Asnani VM and Verma RJ (2009). Ameliorative effects of ginger extract on paraben-induced lipid peroxidation in the liver of mice. *Acta Poloniae Pharmaceutica ñ Drug Research*;66(3): 225-228.
52. Shi YX, Xu YK, Hua HB, Na Z, Wang WH (2011). Preliminary assessment of antioxidant activity of young edible leaves of seven Ficus species in the ethnic diet in Xishuangbanna, Southwest China. *Food Chem*; 128: 889–894.
53. Eleazu, C.O., Eleazu, K.C., Awa, E and Chukwuma, S.C (2012). Comparative study of the phytochemical composition of the leaves of five Nigerian medicinal plants. *J. Biotechnol. Pharm. Res;* 3(2): 42-46.
54. Aqil F, Ahmad I, and Mehmood Z (2006). Antioxidant and Free Radical Scavenging Properties of Twelve Traditionally Used Indian Medicinal Plants. *Turk J Biol*; 30: 177-183.
55. Cook NC and Samman S (1996). Flavonoids---Chemistry, metabolism, cardioprotective effects, and dietary sources. *J. Nutr. Biochem*; 7: 66-76.
56. Singh G, Kapoor IPS, Singh P, Heluani CSD, Lampasona MPD, Catalan CAN (2008). Chemistry, antioxidant and antimicrobial investigations on essential oil and oleoresins of *Zingiber officinale*. *Food and Chemical Toxicology;* 46: 3295–3302.
57. Larson RA (1988). Review article number 30 The antioxidants of higher plants. *Phytochemistry;* 27(4): 969 978.
58. Yoon MA, Jeong TS, Park DS, Xu MZ, Oh HW, Song KB, Lee WS, and Park HY (2006). Antioxidant Effects of Quinoline Alkaloids and 2,4-Di-tert-butylphenol Isolated from *Scolopendra subspinipes. Biol. Pharm. Bull*. 29(4): 735—739.
59. Gülçin I, Elias R, Gepdiremen A, Chea A, and Topal F (2010). *Journal of Enzyme Inhibition and Medicinal Chemistry*; 25(1): 44–53.
60. Jung HA, Min BS, Yokozawa T, Lee JH, Kim YS, and Choi JS (2009). Anti-Alzheimer and Antioxidant Activities of Coptidis Rhizoma Alkaloids. *Biol. Pharm. Bull;* 32(8): 1433—1438.
61. Serrano J, Puupponen-Pimiä R, Dauer A, Aura AM and Saura-Calixto F (2009). Tannins: Current knowledge of food sources, intake, bioavailability and biological effects. *Mol Nutri Food Res;* 53:S310-S29.
62. Hagerman AE, Riedl KM, Jones GA, Sovik KN, Ritchard NT, Hartzfeld PW, and Riechel TL (1998). *J. Agric. Food Chem;* 46(5): 1887-1892.

CITATION OF THIS ARTICLE

Barbosa, G. B., Peteros, N. P. and Inutan, E. D. Antioxidant activities and phytochemical screening of *Amomum muricarpum, Hornstedtia conoidea and Etlingera philippinensis* . Bull. Env. Pharmacol. Life Sci., Vol 5 [8] July 2016: 22-32