Journal of Tropical Biology and Conservation 19: 77–92, 2022 ISSN 1823-3902
E-ISSN 2550-1909

Research Article

Phenolic Content and Antioxidant Activity of ethanol extracts of *Etlingera pubimarginata* (Zingiberaceae), including notes on its Morphology

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Received 29 April 2022|Reviewed 14 July 2022|Accepted 01 August 2022|Published 15 October 2022
https://doi.org/10.51200/jtbc.v19i.3939

ABSTRACT

Ethanolic extracts of the dry weight leaves and rhizomes of *Etlingera pubimarginata* (Elmer) A.D.Poulsen were used in this study to determine its phenolic content and antioxidant activity. Total phenolic content was determined using the Folin-Ciocalteu method, while phosphomolybdenum method was used for the total antioxidant activity. Data revealed that the total phenolic content in *E. pubimarginata* leaves (27.25 ± 0.72 mg GAE/g dried sample) have greater amount of phenolics than its rhizomes (0.76 ± 0.11 mg GAE/g dried sample). Further, total antioxidant activity of *E. pubimarginata* was observed higher in leaves (34.83 ± 0.49 mg AAE/g dried sample) than rhizomes (1.82 ± 0.09 mg AAE/g dried sample), as well as the reducing power revealed to have higher amounts in the leaves (24.83 ± 2.99 mg GRPE/g dried sample) than the rhizomes (0.33 ± 0.10 mg GRPE/g dried sample). The high contents of phenolic compounds contribute to the antioxidant activity of extracts of *E. pubimarginata*. A perfect positive linear relationship was observed among the total phenolic content, total antioxidant activity, and reducing power ($r=1$, $p<0.001$) based on the correlation analysis. These imply that *E. pubimarginata* could be potentially used as a new source of natural antioxidant. Furthermore, a description of the species, including its updated distribution, phenology, and habitat and ecology are provided in this paper.

Keywords: gingers, total antioxidant activity, total phenolic content, Philippine endemic, reducing power

Introduction

Phenolics, the most investigated group of secondary metabolites (Maulana et al., 2019), are known to have antioxidant activity (Lestari et al., 2015). Phenolic compounds exhibit peroxide decomposition, free radical inhibition, metal inactivation or oxygen scavenging in biological systems (Babbar et al., 2015). Antioxidants, on the other hand, are compounds that have the ability to either delay or inhibit the oxidation processes (Pisochi & Negulescu, 2011).

Zingiberaceae species are used in traditional medicine as well as spice agents, and food flavourings (Boonmee et al., 2011; Larsen et al., 1999). Many of these species are also used in traditional cures and are apparently associated with women–related illnesses, such as postpartum medicine for women after confinement (Larsen et al., 1999). In the Philippines, determination of total phenolic content and antioxidant activity of some ginger species have been carried out (Mabini & Barbosa, 2018; Redondo & Barbosa, 2018; Barbosa & Nueva, 2019). Philippine ginger species were also studied for their pollen morphology (Mendez et al., 2017; Acma & Mendez, 2018; Mendez & Acma, 2019) and phytochemical screening and antioxidant activity (Barbosa et al., 2016), and discovery of some new species in the Philippines (Docot et al., 2019, 2021, 2022; Mazo, 2022). However, with more than 100 species of Zingiberaceae in the Philippines, studies conducted are scanty, hence more studies are wanting.

Etlingera pubimarginata (Elmer) A.D.Poulsen is a ginger species endemic to the Philippines. This species was formerly known as *Amomum pubimarginatum* Elmer until this species was transferred to *Etlingera* by Poulsen & Docot (2018) on the bases of morphological characters that resemble some *Etlingera* species found in Sulawesi (Poulsen, 2012). This species is distinct from other Philippine *Etlingera* species by having coriaceous, sharply pointed, stiff bracts and its fruits are subglobose to ovoid, densely covered with golden brown hairs (Naive et al., 2019). Aside from its type locality in Mt. Apo (Davao del Sur) (Elmer, 1915), some populations of *E. pubimarginata* were also reported in Claveria (Misamis Oriental) (Naive et al., 2019), Marilog District in Davao (Acma et al., 2020), and Cinchona Forest Reserve in Bukidnon (Jayme et al., 2020). For over a century since its first collection, no laboratory studies on this species were conducted. Thus, this study was conducted to determine the total phenolic content and antioxidant activity of the leaf and rhizome extracts of *E. pubimarginata* collected from Mt. Malambo, Marilog District, Davao City. A description of the species updated distribution, phenology, habitat and ecology, and notes are also discussed in this paper.

Material and Methods

Entry Protocol

A prior informed consent and a letter were personally submitted by NPM at the Barangay Captain's office of Barangay Datu Salumay to collect samples at Mt. Malambo. The gratuitous permit of Dr. Victor B. Amoroso issued by the Department of Environment and Natural Resources (DENR) – Region XI was used as the collection permit.

Place and Duration of the Study

The leaf and rhizome samples and voucher specimens were collected from Mt. Malambo in Marilog District, Davao City on September 25, 2021 (**Figure 1**). These samples were transported to Central Mindanao University in Bukidnon province for processing. The determination of total phenolic content (TPC), total antioxidant activity (TAA), and reducing power (RP) of dry weight leaves and rhizomes of *E. pubimarginata* were conducted at the Natural Science Laboratory of Natural Science Research Center (NSRC) in Central Mindanao University from September 2021 – January 2022.

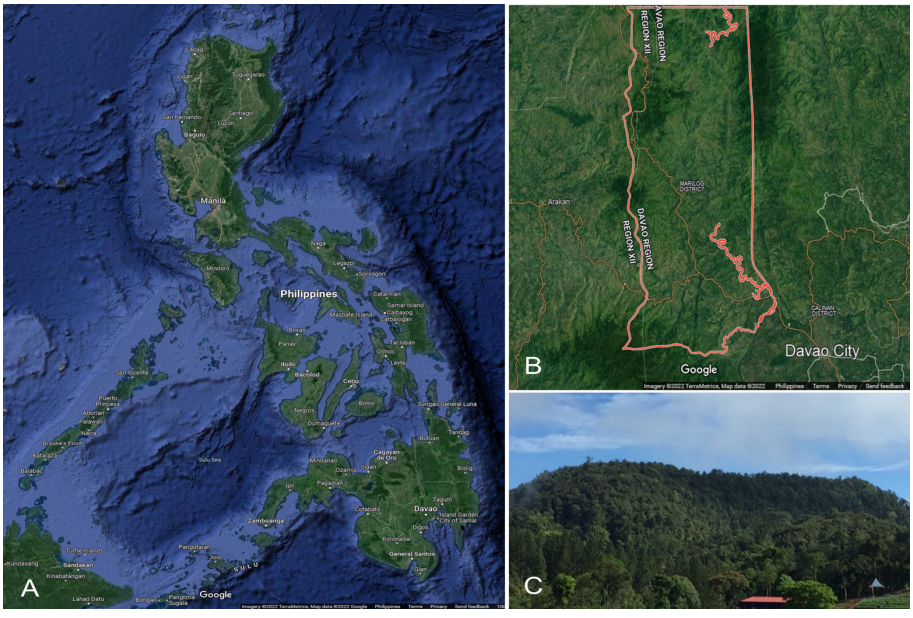

Figure 1. Site of collection of *E. pubimarginata* leaf and rhizome samples and voucher specimens. **A)** Map of the Philippines, **B)** Map of the Marilog District (red colour), **C)** Panoramic view of Mt. Malambo (A & B - ©2021 Google image).

Collection, Measurement, and Description of Plant Materials

The vegetative and reproductive parts of *E. pubimarginata* were collected for voucher purposes. Reproductive materials were preserved in 80% ethanol as pickled collection, and the herbarium specimens were dried. The herbarium specimens were then deposited at the Central Mindanao University Herbarium (CMUH). Five fresh individuals of *E. pubimarginata* were measured and described in the field (Mendez et al., 2017; Acma & Mendez, 2018). For the small and detailed floral parts, a stereo microscope at the NSRC Plant Tissue and Spore Culture Laboratory was used to view the dissected parts for description. After the microscopic examination of the floral parts, these were then placed inside the prepared pickled collection.

Sample Preparation and Extraction

Leaves and rhizomes of *E. pubimarginata* were collected and placed separately inside labelled plastic bags with wet tissue paper to prevent dehydration. These samples were brought to Central Mindanao University for further processing. Leaf and rhizome samples were washed, and the earthy matters were removed prior to air-drying. Dried samples were powdered and stored until used.

Extracts were prepared following the method of Padda & Picha (2008) with some modifications. The dried leaf and rhizome powder were extracted with absolute ethanol with a ratio 1 g: 25.0 mL at room temperature (25°C ± 2°C). The mixtures were shaken for 1 hour in an orbital shaker at 300 rpm and centrifuged for 5 minutes at 5,000 rpm. The supernatants herein referred as extracts were collected in separate 15 mL conical tubes. The concentration of the extracts was determined as 40,000 ppm (mg dried sample per liter test solution) based on the plant to solvent ratio used in extraction. These were then stored at 4°C ± 2°C and were used in the succeeding analyses. The ethanolic leaf and rhizome extracts of *E. pubimarginata* were subjected for the TPC, TAA, and RP determination in 96-well plate format colorimetric assays. Sample extraction was done in triplicates and analyzed in three trials per replicate.

Total Phenolic Content

The TPC of the extracts was determined using the method described by Ainsworth & Gillespie (2007) with some modifications. Briefly, 200 µL of the extracts and 200 µL of 10% Folin-Ciocalteu reagent were transferred in a 2-mL centrifuge tube. The reaction mixture was set aside for 5 minutes and added with 800 µL of 10% sodium carbonate. The mixture was set aside at room temperature (25°C) for 30 minutes and centrifuged at 11,000 rpm for three minutes. A 200 µL of the resulting solution was then transferred to the assigned

microplate wells. The absorbance was determined at 750 nm using a microplate reader (Molecular Devices Spectramax® 250). Likewise, the same method was done to prepare a standard calibration curve by using 200 µL of standard solutions with a concentration range of 0–100 ppm gallic acid (GA) in 10 ppm increment from a stock solution of 100 ppm GA in absolute ethanol. The TPC was determined and expressed as milligram gallic acid equivalent per gram dried sample (mg GAE/g dried sample) by interpolating sample absorbance against the standard calibration curve using the formula below:

$$Total\ Phenolic\ Content\ \left(\frac{mg\ GAE}{g\ dried\ sample}\right) = \frac{A}{B}$$

where: A = gallic acid concentration of the sample solution determined from the calibration curve (mg GAE/L)
B = the concentration of test solution (g/L, gram dried sample per L solution)

Total Antioxidant Activity

The TAA was determined using phosphomolybdenum method of Prieto et al., (1999) with slight modifications. Briefly, 50 µL of extracts were placed in centrifuge tubes and diluted with 200 µL (1:1 ethanol: water). The solution was added with 600 µL of reagent solution (prepared by mixing equal amounts of 0.6 M sulfuric acid, 28 mM sodium phosphate, and 4 mM ammonium molybdate) and incubated at 95°C for 90 minutes. The samples were allowed to cool at room temperature (25°C) and centrifuged for three minutes at 11,000 rpm. The absorbance of the supernatant was measured at 695 nm against a blank using a microplate reader (Molecular Devices Spectramax® 250). Also, the same method was done to prepare a standard calibration curve by using 200 µL of standard solutions with a concentration range of 0–150 ppm ascorbic acid (AA) in 15 ppm increment from a stock solution of 300 ppm AA in absolute ethanol. TAA was determined by interpolating sample absorbance against the standard curve. The TAA was calculated using the equation as follows:

$$Total\ Antioxidant\ Activity\left(\frac{mg\ AAE}{g\ dried\ sample}\right) = \frac{A}{B}$$

where: A = ascorbic acid concentration of the solution determined from the calibration curve (mg AAE/L)
B = concentration of the test solution (g/L, gram dried sample per L solution)

Reducing Power

The RP was determined by adapting the method described by Murugan & Iyer (2011) with some modifications. In a centrifuge tube containing 1 mL of

extracts, 200 µL of 0.2 M phosphate buffer (pH 6.6) and 200 µL of 1% (w/v) solution of potassium ferricyanide were added. After, the mixture was incubated at 50°C for 30 minutes. After cooling to room temperature (25°C), 200 µL of 1% (w/v) trichloroacetic acid was added. The mixture was centrifuged for three minutes at 11,000 rpm. An aliquot of 200 µL of the supernatant was transferred to a 96-well plate, and 20 µL of 1% (w/v) solution of ferric chloride was added. The absorbance was measured at 620 nm using a microplate spectrophotometer (Molecular Devices Spectramax® 250). Likewise, the same method was done to prepare a standard calibration curve by using 1000 µL of standard solutions with a concentration range of 0–100 ppm gallic acid (GA) in 10 ppm increment from a stock solution of 100 ppm GA in absolute ethanol. Sample concentration was determined by interpolating sample absorbance against the standard curve. The RP was expressed as milligram gallic acid reducing power equivalent per gram sample (mg GRPE/g sample) and calculated as follows:

$$Reducing\ Power\left(\frac{mg\ GRPE}{g\ dried\ sample}\right) = \frac{A}{B}$$

where: A = gallic acid concentration of the test solution determined from the calibration curve (mg GRPE/L)
B = concentration of the test solution (g/L, gram dried sample per L solution)

Statistical Analysis

The sample extraction was done in triplicates and TPC, TAA, and RP were analyzed in three trials. The data gathered among the TPC, TAA, and RP of *E. pubimarginata* were correlated using Pearson's correlation at 0.001 level of significance.

Results and Discussion

Gross Morphology of Etlingera pubimarginata (Elmer) A.D.Poulsen (**Figure 2**).

Plant Description: Terrestrial clumping perennial herb and reaches a height of about 2–2.5 m tall. *Rhizome* below the ground, greenish, sometimes pinkish, 1.2–1.5 cm in diam. *Leaves* distichous, ascending, young leaves purple at lower surface, lower leaves reduced; *lamina* oblong to broad lanceolate, 35–43 cm long × 12–14 cm wide, adaxially paler green, glabrous, abaxially green, glabrous; *midrib* adaxially yellowish to brownish, ridged, glabrous, abaxially reddish to brown, pubescent; *margin* entire, wavy, brown, hairy on the edges, *base*

rounded; *apex* shortly acuminate, recurved; Leaf sheath green with violet marks, grooved. *Petiole* short, grooved, greenish to brown, 1.2–1.4 cm long by 0.4–07 cm wide. *Ligule* entire, oblong to truncate, brown, hairy velvety, 5–6 mm long × 2–4 mm wide. *Inflorescence* short, lateral, elongated spike, bearing 1–3 flowers, 7.5 cm long × 3 cm wide. *Peduncle* short, submerged in the ground, pinkish when young, reddish brown when adult, 1.2–1.8 cm long × 0.4–0.6 cm wide. *Bracts* narrowly ovate with sharp, sturdy apex, red and ribbed, glabrous, margin entire, apex acute, 2.2 cm long by 0.8 cm wide. *Bracteoles* tubular, red, 2-tipped with sharp acute apex, glabrous towards the top, pubescent towards the bottom, 1.7 cm long × 0.4 cm wide. *Calyx* lanceolate to oblanceolate, red, tubular with sharp apex, glabrous towards the top, pubescent towards the bottom, 1.7 cm long × 0.3 cm wide. *Flower* 3–4 cm long × 1–2 cm wide; *corolla tube* white. *Corolla lobes* lanceolate to narrow oblong, glabrous, trilobed, pinkish to red, with numerous distinct veins, margin entire, apex rounded; *dorsal corolla lobe*, bright yellow, apex inward infolded and rounded, 10 mm long by 3 mm wide; *lateral corolla lobes* 11 mm long × 2 mm wide; *staminal tube* 3–4 cm, creamy white, glabrous. *Labellum* ovate, lower lobes folded over the stamen, longer than corolla lobes, glabrous, bright yellow, margin entire, apex rounded, 11 mm long × 6 mm wide. *Stamen* 3.5–4 cm long × 1–2 cm wide; *anther* creamy yellow, hairy in the dehiscent part, 6–8 cm long × 2–3.5 cm wide; *filament* 3.9–4.1 × 1 cm, glabrous. *Pistil* 3.4–3.7 ×1 cm; *stigma* creamy white, apex bilobed, white, hairy, 0.8–1.2 cm long; *ostiole* 1 mm, pubescent; *style* white, 2.9–3.1 cm long; *ovary* 1–2 mm × 0.3–0.4 mm. *Infructescence* lax, 7.5 cm long × 4–5 cm wide; *fruits* subglobose and beaked, calyx persistent, pubescent, reddish, 1.5–1.9 cm; *seeds* creamy yellow, 0.6–0.9 mm.

Phenology: Flowering and fruiting from January to April.

Local name and Use: The species is known as "tagbak" and the fruits are edible according to the local people of Brgy. Datu Salumay (Jason Batawan, pers. comm.).

Distribution: *Etlingera pubimarginata* is endemic to the Philippines. This species has been recorded only in some provinces of Mindanao Island, *viz.*, Cinchona Forest Reserve, Bukidnon (Jayme et al., 2020); Mt. Apo, Davao del Sur (Elmer, 1915); Claveria, Misamis Oriental (Naive et al., 2019); and Marilog District, Davao City (Acma et al., 2020).

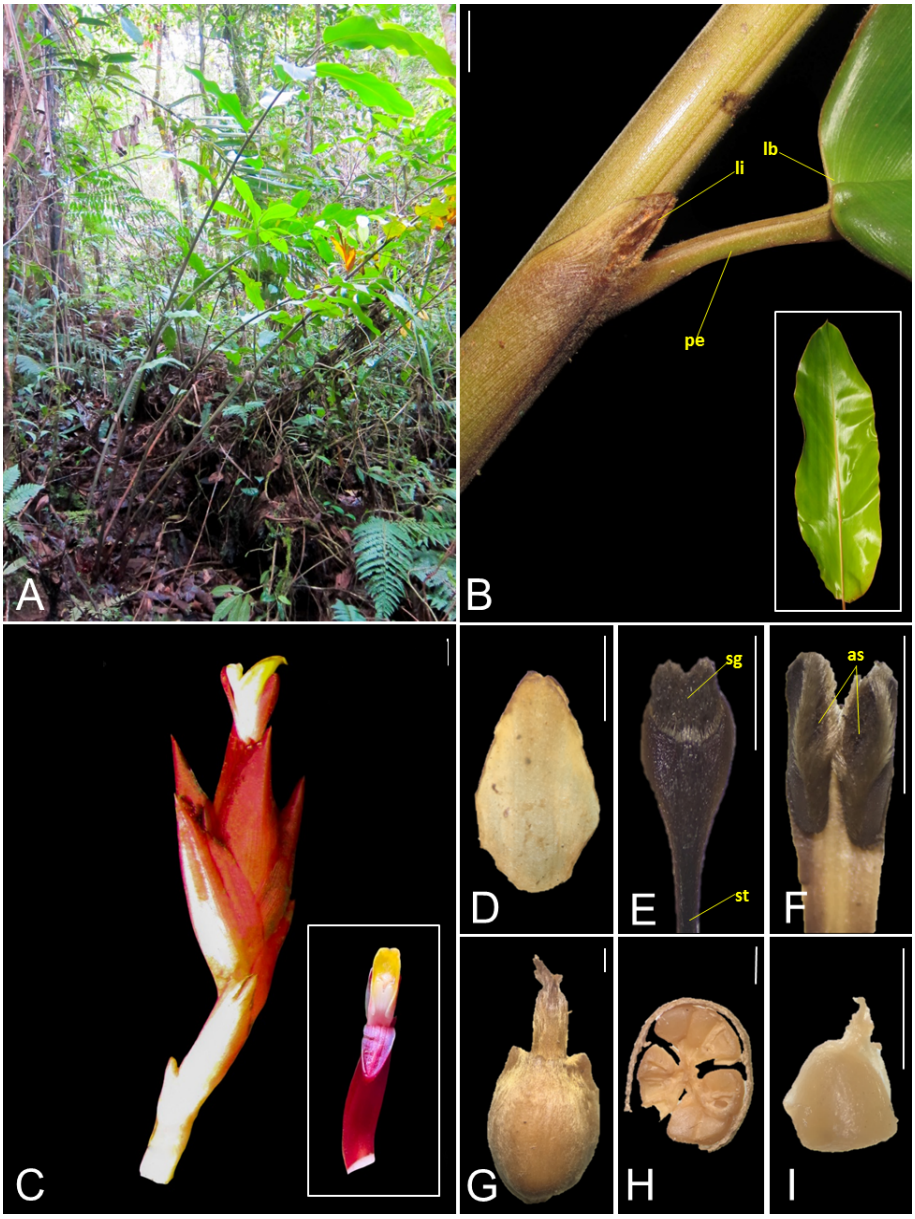

Figure 2. *Etlingera pubimarginata* (Elmer) A.D.Poulsen. **A)** Habit, **B)** Ligule and petiole (inset: leaf blade), **C)** Inflorescence (inset: flower, anterior view), **D)** Labellum (flattened), **E)** Pistil (sg – stigma; st – style, **F)** Stamen (as – anther sacs), **G)** Fruit, **H)** Cross section of the fruit, **I)** Seed. *Photographs:* N.P. Mendez (A–I). *Scale bars:* 1 cm - B; 0.8 cm - C; 0.5 cm – D, E, F, G, H, I.

Habitat and Ecology: *Etlingera pubimarginata* was found growing along the edge of a relatively disturbed and partially open forest at 1,200masl. The populations were found growing with *Paspalum conjugatum* P.J.Berguis (Poaceae) and associated with *Psychotria cuernosensis* Elmer (Rubiaceae), *Elatostema* sp. (Urticaceae), *Medinilla clementis* Merr. (Melastomataceae), *Aeschynanthus cardinalis* (Copel. ex Merr.) Schltr. (Gesneriaceae), *Pinanga* spp. (Arecaceae), *Freycinetia* spp. (Pandanaceae), and other ginger species, such as *Adelmeria alpina* Elmer, *Hornstedtia conoidea* Ridl., and *Plagiostachys albiflora* Ridl. (Zingiberaceae).

Specimens Examined: PHILIPPINES. Mindanao: Davao City, Marilog District, Brgy. Datu Salumay, Mt. Malambo, 1,220masl, 17 December 2021, NPM010, *N.P. Mendez with R.M. Tubongbanua*.

Other Specimens Examined: PHILIPPINES. Mindanao: Davao City, Marilog District, Brgy. Datu Salumay, Mt. Malambo, 1,200masl, flowering and fruiting 7 May 2018, VBA10862, *F.M. Acma with N.P. Mendez & V.B. Amoroso* (CMUH 00012089).

Notes: *Etlingera pubimarginata* closely resembles to the Philippine endemic *E. pilosa* by having sessile to short leaves, spiny apex bracts, and yellow labellum. However, the species differ in leaf apex (shortly acuminate *vs.* obtuse), ligule (oblong to truncate *vs.* ovate), lamina (oblong to broad lanceolate *vs.* narrowly obovate), bracts (narrowly ovate with sharp sturdy apex *vs.* boat-shaped to ovate and mucronate to acute apex), and labellum (11 × 2 mm *vs.* 10–12 × 5–6 mm).

Etlingera pubimarginata is unique by having deep red, spiny apiculate and sturdy bracts, bracteoles and calyx. The dorsal and lateral lobes are oblong and reddish and its labellum is bright yellow with lower lobes folded over the stamen. The lax inflorescence of *E. pubimarginata* also differs from the other Philippine *Etlingera* species and is unusual to the group.

Total Phenolic Content

The results of the TPC were derived from a calibration curve (y = 0.0546 x 0.0658, R^2 = 0.9946) of gallic acid (0–200 mg/mL). The ethanolic extracts of *E. pubimarginata* revealed that the leaves (27.25 ± 0.72 mg GAE/g dried sample) exhibited higher phenolic content than the rhizomes (0.76 ± 0.11 mg GAE/g dried sample) (**Table 1**).

Table 1. Mean TPC extraction yield of leaves and rhizomes of *E. pubimarginata*.

Plant parts	mg GAE/g dried sample
Leaves	27.25 ± 0.72
Rhizomes	0.76 ± 0.11

The mean value of the TPC in leaves (27.25 ± 0.72 mg GAE/g sample) in this study is relatively higher than the studies of Mabini & Barbosa (2018) with 0.55 mg GAE/g sample on methanolic extracts of *Etlingera philippinensis* (Ridl.) R.M.Sm., 1.95 mg GAE/g sample on ethanolic extracts of *Hedychium coronarium* Koenig, and 1.67 mg GAE/g sample on methanolic extracts of *Hornstedtia conoidea* Ridl. The mean value of TPC in rhizomes (0.72 ± 0.11 mg GAE/g sample) of *E. pubimarginata* is higher than the study of Mabini & Barbosa (2018) with 0.35 mg GAE/g sample on *E. philippinensis*, but lower in the studies of Barbosa & Nueva (2019) with 1.28 mg GAE/g sample on *H. conoidea* and Redondo & Barbosa (2018) with 1.48 mg GAE/g sample on *H. coronarium*. These slight variations in the mean values of TPC might be due to the different amounts of sugars, ascorbic acid, duration, or methods of extraction that may change the amount of phenolics (Burri et al., 2017).

On TPC of other *Etlingera* species, the work of Chan et al. (2007) revealed to have high amounts of phenolics on the species of *E. maingayi* (Baker)R.M.Sm. (1110 ± 93 mg GAE/100 g of leaves and 160 ± 52 mg GAE/100 g of rhizomes) and *E. elatior* (Jack.)R.M.Sm. (2390 ± 329 mg GAE/100 g of leaves and 326 ± 76 mg GAE/100 g of rhizomes). The values of the TPC on the work Sabli et al. (2012) closely resemble in the present study, *viz.*, *E. belalongensis* A.D.Poulsen (17.07 ± 0.32 mg GAE/1 g dried sample of rhizomes and 10.07 ± 0.25 mg GAE/1 g dried sample of stems) and *E. velutina* (Ridl.)R.M.Sm. (25.03 ± 0.46 mg GAE/1 g dried sample of rhizomes and 5.30 ± 0.1 mg GAE/1 g dried sample of stems), which also revealed to have high amounts of phenolics.

Phenolic compounds are important plant constituents with redox properties responsible for antioxidant activity (Soobrattee et al., 2005). The total phenolic compounds also play an effective role in stabilizing lipid peroxidation (Yen et al., 1993). These phenolic compounds contribute to antioxidant activity due to the arrangement of functional groups (hydroxyl) about its nuclear structure for hydrogen donation in order to stabilize radical molecules (Soobarattee et al., 2008; Alam et al., 2018).

The quantification of TPC in ethanolic leaf and rhizome extracts of *E. pubimarginata* employing Folin-Ciocalteu method, is convenient, simple, and reproducible (Cirillo & Lemma, 2012; Danciu et al., 2015). This method involves electron transfer in alkaline medium from phenolic compound to phosphomolybdic/phosphotungstic acid complexes to form blue complexes that are determined spectroscopically (Singleton et al., 1999).

Total Antioxidant Activity and Reducing Power

The results for the TAA of the ethanolic extracts of leaves and rhizomes of *E. pubimarginata* were calculated from a calibration graph which were linear over the calibration range with R^2 value of 0.9963 (y = 0.0149 x 0.0465) of L-ascorbic acid (0–100 mg/mL). The ethanolic extracts of *E. pubimarginata* revealed that the leaves (34.83 ± 0.49 mg AAE/g sample) have higher antioxidants compared to the rhizomes (1.82 ± 0.09 mg AAE/g sample). On the other hand, the data for the RP were derived from a calibration curve (y = 0.0505 x 0.5037, R^2 = 0.9975) of gallic acid (0–1000 mg/mL). The ethanolic extracts of *E. pubimarginata* revealed that the leaves (24.83 ± 2.99 mg GAE/g sample) is higher compared to the rhizomes (0.33 ± 0.10 mg GAE/g sample) (**Table 2**).

The mean value of TAA of the leaves (34.83 ± 0.49 mg TAA/g sample) of *E. pubimarginata* is higher compared to the studies of Mabini & Barbosa (2018) on *E. philippinensis* (0.79 mg AAE/g sample), Redondo & Barbosa (2018) on *H. coronarium* (2.94 mg AAE/g sample), and Barbosa & Nueva (2019) on *H. conoidea* (4.67 mg AAE/g sample). For the mean value of TAA of the rhizomes (1.82 ± 0.09 mg TAA/g sample), it is also higher than the studies of Mabini & Barbosa (2018) on *E. philippinensis* (0.55 mg AAE/g sample) and Redondo & Barbosa (2018) on *H. coronarium* (1.02 mg AAE/g sample), but lower than the study of Barbosa & Nueva (2019) on *H. conoidea* (with 2.03 mg AAE/g sample).

Table 2. Mean TAA and RP extraction yield of leaves and rhizomes of *E. pubimarginata*.

Plant parts	TAA (mg AAE/g dried sample)	RP (mg GRPE/g dried sample)
Leaves	34.83 ± 0.49	24.83 ± 2.99
Rhizomes	1.82 ± 0.09	0.33 ± 0.10

Recently, there has been an increase in research of the potential phytochemicals from plants for therapeutic uses because many phytochemicals have been demonstrated to have antioxidant activities (Kairupan et al., 2019). The TAA of plant extracts may be due to the presence of polyphenols, which act as reductants by donating electrons and reacting with free radicals converting them to a more stable product and subsequently terminating free radical chain

reaction (Gordon, 1990). Populations of *E. pubimarginata* were found at the montane forests of Mt. Malambo in partially open forest, which supported Frankel & Berenbaum (1999) that foliage of tropical forest plants produced more antioxidants when exposed to elevated light conditions.

Correlation among TPC, TAA, and RP

The contribution of the phenolic compounds in the ethanolic extracts of *E. pubimarginata* to the antioxidant activity was determined by Pearson's correlation coefficient. The results of the correlation analysis are summarized below (**Table 3**).

Table 3. Pearson's correlation coefficients among TPC, TAA, and RP.

Plant parts	TPC	TAA	RP
TPC	1	1**	1**
TAA	1**	1	1**
RP	1**	1**	1

Remarks: **Correlation is significant at 0.001 level

A perfect positive linear relationship was observed among the TPC, TAA, and RP ($r=1$, $p<0.001$). Results indicate that phenolic compounds significantly contribute to the antioxidant activities of *E. pubimarginata*.

Conclusions and Recommendations

The highest phenolic content was recorded higher in leaves (27.25 ± 0.72 mg GAE/g dried sample) than the rhizomes (0.76 ± 0.11 mg GAE/g dried sample). The TAA was also significantly higher in leaves (34.83 ± 0.49 mg AAE/g dried sample) than rhizomes (1.82 ± 0.09 mg AAE/g dried sample). In terms of the RP, the leaves (24.83 ± 2.99 mg GRPE/g dried sample) also obtained higher value than rhizomes (0.33 ± 0.10 mg GRPE/g dried sample). Overall, the leaves contributed the higher phenolic content and antioxidant activity than the rhizomes. A perfect positive linear relationship was observed among the TPC, TAA, and RP ($r=1$, $p<0.001$). These imply that the high contents of phenolic compounds contribute to the antioxidant activity of extracts of *E. pubimarginata*. Thus, the analyzed *E. pubimarginata* in this study contained phenolic compounds in good quality.

This calls for thorough phytochemical analyses to be done to identify the active phenolic and antioxidant components of this Philippine endemic ginger species, since this is the first report of the TPC, TAA, and RP of *E. pubimarginata*.

Acknowledgments

The authors would like to thank the Central Mindanao University for the opportunity to conduct this study. We thank the Commission on Higher Education (CHED) - Discovery-Applied Research and Extension for Trans-Inter-disciplinary Opportunities (DARE-TO) for partially funding this study. The Department of of Environment and Natural Resources (DENR) – Region XI for the issuance of gratuitous permit to Dr. V.B. Amoroso, and the barangay officials of Datu Salumay in Marilog District for allowing NPM to conduct a botanical fieldwork at Mt. Malambo. Due acknowledgments are also given to the concerned authorities of CMU NSRC Natural Science Laboratory for the analysis of samples, and Plant Tissue and Spore Culture Laboratory where the microscopy of floral parts was conducted. The help of Romeo M. Tubongbanua, Jr. in the field collection is also appreciated.

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