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Phytochemical Analysis and Pharmacological Properties of *Epipremnum pinnatum* (L.) Fruit Extracts

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ABSTRACT

Epipremnum pinnatum (L.) Engl., belonging to the family Araceae, is a medicinal plant used by locals in many Asian countries to treat common ailments such as wounds and pain. In this study, the different parts of the fruits -peel, core, and kernels were analyzed for their phytochemicals and antioxidant potentials. Initial phytochemical investigation revealed that flavonoids, polyphenols, and sterols were found in all parts. Terpenoids were found in the core and peel extracts, while cardiac glycosides were found in the core and kernel extracts. The peel extracts were found to have the highest flavonoid content (308.9±19.2 mg quercetin equivalent per g fresh wt sample). It also exhibited the highest total antioxidant activity (EC_{50} = 23.1±4.2 ppm) among the three extracts, which is next to the activity of ascorbic acid (EC_{50} = 4.6±1.6 ppm) using the phosphomolybdate method. It also gave the highest DPPH-free radical scavenging activity (EC_{50} = 41.9±2.6 ppm) among the three extracts but lower activity than the ascorbic acid (EC_{50} = 1.1±0.5 ppm). At 200 ppm, the peel extracts exhibited a profound inhibitory effect (>50%) on the melanin production in zebrafish embryos. But, at this concentration, the peel extracts were also found to be toxic to the embryo, with 43% mortality. However, the extract did not exhibit antibacterial properties against *E. coli* and *S. aureus*. These results suggest the potential of the fruit parts, particularly the peel, as a source of natural compounds with pharmacological importance.

1. Introduction

Epipremnum pinnatum (L.) Engl., belonging to Family Araceae, is a medicinal plant used by locals in many Asian countries. In the Philippines, the community of Batan Island utilized the sap in treating cuts and wounds (Abe & Ohtani 2013). In Taiwan, the leaf sheath is chewed to improve dental health, while in Bali, Indonesia, the stem is used to cure sprain (Zumbroich 2011). Moreover, leaf decoctions of *E. pinnatum* were reported to be used in treating cancer in Singapore (Graham *et al.* 2000). These reports resulted in many investigations of its extracts to confirm its biological properties. *E. pinnatum* leaf and stem hexane extracts inhibited the proliferation of T-47D breast tumor cells through a type II non-apoptotic programmed cell death (Tan *et al.* 2005). Linnet *et al.* (2010) showed that the ethanolic extracts of the aerial parts exhibited anti-inflammatory and analgesic properties. Phytochemical screening of the leaf extracts revealed the presence of flavonoids, alkaloids, saponins, tannins, and glycosides (Masfria *et al.* 2019). Activity-guided isolation revealed the active compound β-damascenone responsible for the anti-inflammatory activity of *E. pinnatum* leaf extracts, which may act by inhibiting the NF-κB signaling pathway (Pan *et al.* 2019). On the other hand, leaf and stem extracts of *E. pinnatum* did not exhibit antimicrobial activity against *Staphylococcus aureus, Bacillus subtilis, Pseudomonas aeruginosa, Mycobacterium smegmatis* and *Candida albicans* (Chan *et al.* 2008).

However, there have been no reports on the biological activities of *E. pinnatum* fruits. The fruits of *Monstera deliciosa*, a plant species belonging to the same Family Araceae, had been found to possess volatile compounds such as limonene, linalool, butanoic acid, ethyl benzoate,

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and propyl butanoate and exhibited antioxidant activity (Barros *et al.* 2018). On the other hand, *Scindapsus officinalis* fruits inhibited the proliferation of various human carcinoma cells. They decreased the levels of indicators of oxidation, such as glutathione peroxidase and glutathione S-transferase (Shivhare *et al.* 2011). With this, the study aimed to determine the phytochemicals present in the different parts of *E. pinnatum* fruits and evaluate their antioxidant, antimicrobial and anti-melanogenic potentials.

2. Materials and Methods

2.1. Plant Sample Collection and Extract Preparation

The fruit samples of *E. pinnatum* were collected from a residential area in Tacloban City, Leyte, Philippines. The identification of the sample was confirmed by Asst. Prof. Jay T. Torrefiel, a botanist at the University of the Philippines Tacloban College. Upon arrival at the laboratory, the peel, cub, and kernel were removed separately. Then, each of the samples was added with 100 mL of methanol and left overnight at room temperature. The sample mixture was filtered through vacuum filtration, and the crude extracts were dried in vacuo using a rotary evaporator. Then, it was stored in the refrigerator (4°C) prior to analysis.

2.2. Phytochemical Analysis

The crude methanolic extracts of the *E. pinnatum* fruit were tested for the presence of alkaloids, flavonoids, polyphenols, saponins, sterols, terpenoids, and cardiac glycosides (Paduhilao II and Yap-Dejeto 2022).

2.2.1. Alkaloids

Each extract was dissolved in 2% Hydrochloric acid, boiled in a water bath, and then filtered. The filtrate was treated with Hager's reagent (1% picric acid solution). The occurrence of the yellow-colored precipitate detected the presence of an alkaloid.

2.2.2. Flavonoids

Each extract was treated with a few drops of NaOH solution. The formation of an intense yellow color, which becomes colorless upon the addition of 10 drops of 1% HCl, showed the presence of flavonoids.

2.2.3. Polyphenols

The extracts were dissolved in 2 ml distilled water and treated with two drops of 5% $FeCl_3$. The presence of brown precipitate indicated the presence of polyphenols.

2.2.4. Saponin

Extracts were dissolved with 5 ml distilled water in a test tube and were shaken. The occurrence of frothing that is stable for at least 15 minutes confirmed the presence of saponins.

2.2.5. Sterols

The presence of sterols was detected using the Liebermann-Burchard test. One (1) ml each of glacial acetic acid and chloroform were cooled and added to the extract aqueous solutions. The mixture was then treated with 1 drop of sulfuric acid. A formation of brown rings at the junction indicates the presence of phytosterols.

2.2.6. Terpenoids

Terpenoids were tested using the Salkowski reaction. Extracts were treated with 1 ml chloroform and 1 ml concentrated sulfuric acid. The presence of red or yellow coloration at the interface is positive for terpenoids.

2.2.7. Cardiac Glycosides

Using the Keller Killiani Test, the extracts were treated with 1 mL glacial acetic acid, followed by the addition of 2 drops of concentrated sulfuric acid. A green coloration indicates the presence of cardiac glycosides.

2.3. Determination of Total Flavonoid

The total flavonoid content of the extracts was determined using the aluminum chloride colorimetric method employed by Phuyal *et al.* (2020) with modifications. In separate test tubes, 1.0 ml of quercetin standard solutions (50, 100, 250, 500, 1000 ppm) and extracts were added with 4.0 ml distilled water and 0.3 ml 5% $NaNO_2$. After 5 minutes of incubation, 0.3 ml of 10% $AlCl_3$ solution was added, and the mixture was allowed to stand for 6 minutes. Then, 2.0 ml of 1 M NaOH solution was added, and the final volume was brought to 10.0 ml using distilled water. Finally, the mixture was allowed to stand for 15 minutes, and the absorbance was measured at 510 nm. The total flavonoid content was calculated using the calibration curve, and the result was expressed as mg quercetin equivalent per g dry weight.

2.4. DPPH-Radical Scavenging Activity

The free-radical scavenging activity of the extracts was determined using the 2,2′- diphenyl-1-picrylhydrazyl (DPPH) assay, following the method described by Iqbal *et al.* (2015) with some modifications. The DPPH solution (10 ppm) was freshly prepared in methanol. Ascorbic acid solutions

were used as standards (0.5, 1.0, 2.0, 4.0, 5.0 ppm), while the extract solutions were prepared in methanol with varying concentrations (10, 25, 50, 100, 250, 500 ppm).

In separate test tubes, 1.0 ml of standard and extract solutions were treated with 2.0 ml DPPH solution. The test tubes were then incubated in the dark for 30 minutes, and their absorbance was measured at 517 nm using a UV-Vis Spectrophotometer (Thermoscientific Genesys 150 UV-Vis Spectrophotometer, Massachusetts, USA). The % inhibition for each sample and standard was calculated using the following equation:

$$\% \text{ Inhibition} = (1\text{-Abs sample / Abs control}) \times 100$$

The graphs were plotted, and the scavenging activity was expressed in terms of EC_{50} (effective concentration in µg/mL samples or standard that reduces the absorbance of DPPH by 50% when compared to negative control. The experiment was done in triplicate.

2.5. Total Antioxidant Capacity

The total antioxidant capacity of the samples was tested using the phosphomolybdenum method (Jan *et al.* 2013). Three (3) ml of the reagent solution (0.6 M sulfuric acid, 28 mM sodium phosphate, and 4 mM ammonium molybdate) was added to the extract solution (0.3 ml) in a test tube. The covered test tubes were incubated in a water bath at 90°C for 1.5 hours. The absorbance of the mixture was measured at 765 nm after cooling. The standard used was ascorbic acid, and the antioxidant capacity was calculated using the formula below:

$$\text{Total antioxidant activity (\%)} = \frac{\text{Absorbance of the control} - \text{Absorbance of the sample}}{\text{Absorbance of the control}} \times 100$$

2.6. Antimelanogenic Determination using Zebrafish Model

2.6.1. Origin and Maintenance of Zebrafish

Adult zebrafish (*Danio rerio*) were purchased from a local aquarium fish dealer in Leyte-Leyte, Philippines. They were maintained using the standard protocol presented by Westerfield (2000). They were placed in an aquarium with a water aerator, maintained in a 14 h-day/10 h-night cycle, and were fed with commercial fish feeds. Since the genotype of the zebrafish is unknown, an initial experiment was conducted to determine that the embryo has pigmentations, and the pigmentation is inhibited by kojic acid, a known tyrosinase inhibitor.

2.6.2. Anti-Melanogenic Activity Assay

The anti-melanogenic properties of *E. pinnatum* extracts were evaluated using the zebrafish-based phenotypic assay reported by Choi *et al.* (2007). Male and female adult zebrafish were allowed to spawn in a separate chamber at the on-set of light, and the embryos were collected after 30 minutes. The embryos were distributed in a 24-well plate (10 per well × 3 wells) with 1.0 ml embryo medium: 10% Hank's with full-strength calcium and magnesium (Westerfield 2000). Embryos were then treated with extract solutions (50, 100, and 200 ppm) at 9 hpf. Kojic acid (20 mM) served as a positive control, while 0.1 % DMSO served as a negative control. The suspension of embryos was changed after 24 hours and subjected to the same treatment. At 55 hpf, images of the zebrafish were taken, and the melanin content was estimated using the following scoring system: <10% as none or mild, 10–49% as moderate, and >50% as profound.

2.7. Antibacterial Activity

The methanolic extract from the fruit peel was tested using the Kirby-Bauer disk diffusion method against *Staphylococcus aureus* (ATCC 25923) and the gram-negative bacterium *Escherichia coli* (ATCC 25922), which were obtained from the Department of Science and Technology (DOST)-Regional Standards and Testing Laboratory (RSTL), Region 8, Leyte, Philippines (Clinical and Laboratory Standards Institute 2020; Razmavar *et al.* 2014). The bacterial suspensions were prepared by dissolving bacterial colonies in a 0.9% sterile saline solution. Twenty microliters (20 µL) of the extract solution (100 mg/ml) were loaded onto 6 mm sterile Whatman No. 1 filter paper blank discs. The impregnated discs were then allowed to dry at 35°C for 2–3 hours before being placed on the inoculated plate. The plate was incubated in an inverted position at 37°C for 18 to 24 hours. The zone of inhibition was measured and expressed in millimeters. Gentamicin (10 µg/disk) and vancomycin (30 µg/disk) were used as positive controls, while 10% DMSO served as the negative control.

3. Results

3.1. Phytochemical Screening

The percent yields of extracts from the cub, peel, and kernel were 3.3 %, 1.2 %, and 29.8 %, respectively. The phytochemical screening of the different parts of *Epipremnum pinnatum* fruit (cub, peel, and

kernel) showed the presence of different secondary metabolites such as flavonoids, polyphenols, sterols, terpenoids, and cardiac glycosides, as shown in Table 1. The cub extracts revealed the presence of sterols, terpenoids, and cardiac glycoside in the methanolic extract. The methanolic extract of the peel, on the other hand, similarly contains sterols, terpenoids, and polyphenols. The kernel extract showed the presence of sterols and cardiac glycosides.

3.2. Flavonoid Content and Total Antioxidant Activity

The methanolic extract of the peel of *E. pinnatum* fruit reveals the highest amount of flavonoid content, as seen in Table 2, as compared to the other parts of the fruit. It also has the lowest EC_{50} value equivalent to EC_{50} = 23.1±4.2 ppm compared to the ascorbic acid standard (EC_{50} = 4.6±1.6 ppm) using the phosphomolybdate method. The results suggest that the peel has the highest total antioxidant activity compared to the other parts of the fruit. The methanolic extract of the peel also revealed a high DPPH-free radical scavenging activity because of its low EC_{50} value equal to EC_{50} = 41.9±2.6 ppm as compared to the other parts of the fruit, as shown in Table 2. However, this value is higher than the ascorbic acid standard value equivalent to EC_{50} = 1.1±0.5 ppm. But still, these values show the potential of the peel of *E. pinnatum* fruit as a source of natural compounds with antioxidant activity importance.

Table 1. Phytochemical investigation of the different parts of *Epipremnum pinnatum* fruit

	Cub	Peel	Kernel
Alkaloids (Hager's test)	-	-	-
Flavonoids	+	+	+
Polyphenols	-	+	-
Saponins	-	-	-
Sterols (Liebermann, Burchard)	+	+	+
Terpenoids (Salkowski's test)	+	+	-
Cardiac glycosides (Keller-Killiani test)	+	-	+

(+) indicates presence, (-) means not detected

Table 2. Flavonoid content, total antioxidant capacity, and DPPH-free radical scavenging activity of *Epipremnum pinnatum* fruit parts

Fruit parts	Flavonoid content (mg/g fresh wt sample)	Total antioxidant capacity EC_{50} (ppm)	DPPH-free radical scavenging activity EC_{50} (ppm)
Cub	79.3±8.5	103.6±34.1	151.7±18.2
Kernel	2.4±0.1	411.4±115.8	>500
Peel	191.5±20.6	23.1±4.2	41.9±2.6
Ascorbic acid	N/A	4.6±1.6	1.1±0.5

3.3. Antimelanogenic Activity

The effect of the methanolic extract from fruit peel was evaluated using the zebrafish model. As shown in Figure 1, results indicate that the fruit peel extracts exhibited a dose-dependent inhibitory effect on melanin formation in zebrafish. The 50 ppm and 100 ppm concentrations primarily showed mild (<10%) to moderate (10-49%) effects, while the highest concentration (200 ppm) demonstrated profound effects (>50%). A decrease in ocular melanin is more observable in 100 and 200 ppm (Figure 2). However, at these concentrations, the extracts also exhibited lethality toward embryos, with a 43% mortality rate and deformities such as bent tail and heart edema.

3.4. Antibacterial Activity

No zone of inhibition was observed for the methanolic peel extract of *E. pinnatum* when tested against the Gram-negative bacteria *Escherichia coli* and gram-positive bacteria *Staphylococcus aureus* (Table 3).

4. Discussion

Epipremnum pinnatum is widely used in traditional medicine preparations. Because of its medicinal properties, many studies have confirmed its potential for pharmacological application. However, all these studies are focused on leaf extracts of *E. pinnatum*. In this study, the different fruit parts (cub, seeds, and peel) of *E. pinnatum* were studied for their chemical constituents and pharmacological potentials.

Previous studies have shown that *E. pinnatum* leaf extracts contain alkaloids, flavonoids, glycosides, sterols, terpenoids, tannins, and phytosterol (Das *et al.* 2015; Pan *et al.* 2019). In fact, the leaf extracts were reported to contain the following compounds: gusanlungionoside C, citroside A, phenylalcohol glycoside phenylmethyl-2-O-(6-O-rhamnosyl)-ß-D-galactopyranoside, β-damascenone, megastigmatrienone, 3-hydroxy-β-damascenone, 3-oxo-7,8-dihydro-α-ionol (Pan *et al.* 2019), and 5,6-dihydroxyindole (Goh 1998). In this study, flavonoids and sterols can be found in the three parts of the fruits. However, much of the polyphenols are detected in the peel. Moreover, the peel has the highest flavonoid content among the three fruit parts. The high amount of flavonoids in the peel may explain the observed high antioxidant activity.

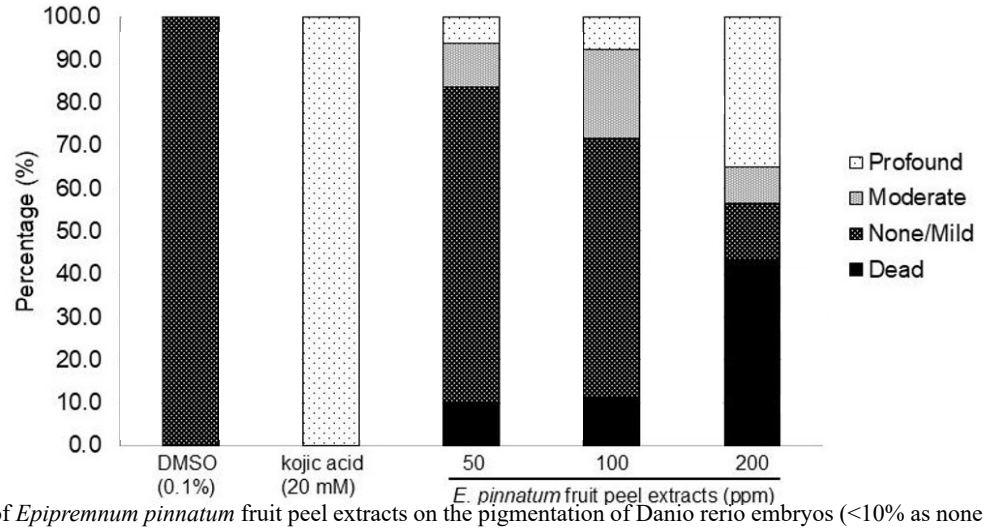

Figure 1. Effects of *Epipremnum pinnatum* fruit peel extracts on the pigmentation of Danio rerio embryos (<10% as none or mild, 10–49% as moderate, and >50% as profound)

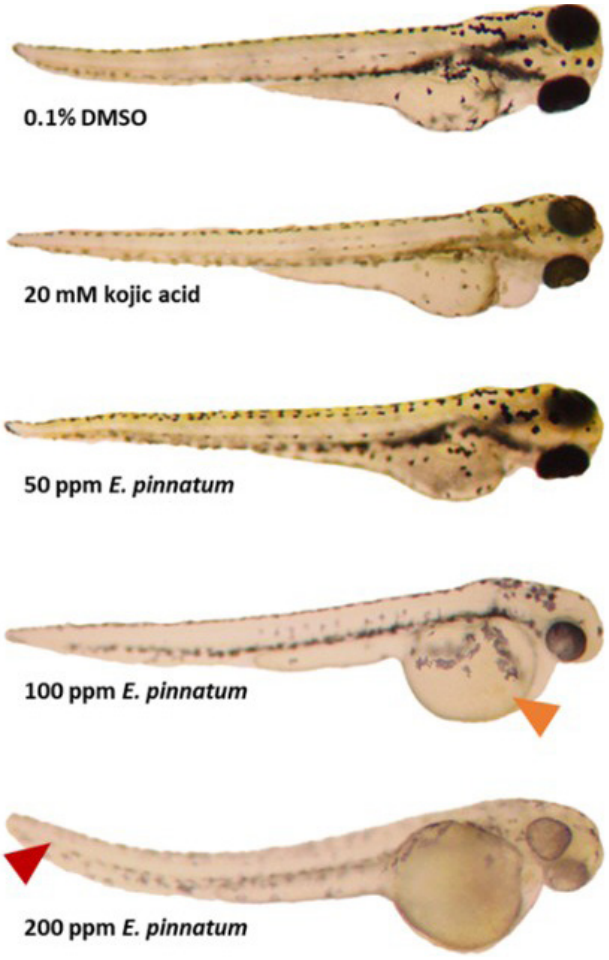

Figure 2. The phenotype of Danio rerio embryos was observed at 55 hpf after treatment with 1% DMSO, 20 mM kojic acid, and *E. pinnatum* fruit peel extracts (50, 100, and 200 ppm). Developmental defects are indicated by the orange arrow (heart edema) and red arrow (bent tail). The effects of the extracts on the embryo's pigmentation were viewed and photographed using a microscope (Olympus BX43)

Table 3. Zone of inhibition of *Epipremnum pinnatum* peel extracts

Test bacteria	Vancomycin (30 µg/disk)	Gentamicin (10 µg/disk)	*E. pinnatum* peel extract (100 mg/ml)
Staphylococcus aureus	25.67±1.15	N/A	-
Escherichia coli	N/A	16.33±0.58	-

The findings of this study, which indicate that the peel exhibits higher antioxidant activity compared to other parts such as the core, seeds, and pulp, align with similar research on various fruits. Peels extract from the fruits of two species of dragon fruit (*Hylocereus undatus* and *Hylocereus polyrhizus*), Phlegrean mandarin (*Citrus reticulata* Blanco), kiwifruit (*Actinidia deliciosa* var. deliciosa) and Borneo olive (*Canarium odontophyllum*) had higher antioxidant activity than the other parts (Nurliyana *et al.* 2010; Prasad *et al.* 2010; Costanzo *et al.* 2022; Liu *et al.* 2022). In fact, most fruit peels have been reported to be a potential source of nutraceuticals because they possess high levels of antioxidants and some minerals (Suleria *et al.* 2020; Hussain *et al.* 2023).

The decrease in melanin pigmentation in embryos treated with kojic acid suggests inhibition of melanin production. Kojic acid inhibits melanin synthesis by inhibiting the catecholase activity of tyrosinase (Cabanes *et al.* 1994). The peel extracts also showed an anti-melanogenic activity using a zebrafish-based assay. Profound inhibitory effect (>50%) on melanin production in zebrafish embryos was observed at 200 ppm. However, at this concentration, high mortality was also observed, and many of the embryos had abnormal developments. The presence of lethal compounds in the crude extracts such as calcium oxalate can cause this observation. Thus,

further fractionation and isolation of the compounds are recommended to identify the compounds that exhibit antimelanogenic activities. The enzyme tyrosinase catalyzes the production of melanin in zebrafish. In the presence of an inhibitor such as kojic acid, melanin production can be inhibited by the downregulation of tyrosinase activity. Tyrosinase is the enzyme that catalyzes the conversion of tyrosine to dopaquinone (Chang 2012). The leaf extracts *Cassia alata* inhibit melanin production in zebrafish embryos and can be implicated in the presence of flavonoids (Lelina and Fuentes 2018). Flavonoids such as luteolin exhibit antimelanogenic effects mainly via transcriptional factors MiTF (Choi *et al.* 2008; Liu-Smith & Meyskens 2016). Further, studies have supported the antimelanogenic activity through inhibition of the tyrosinase activity (Jeon *et al.* 2021; Khongkarat *et al.* 2024). The compounds, particularly flavonoids, present in the peel extracts of *E. pinnatum* may have also inhibited the tyrosinase from producing melanin.

The antibacterial property of extract was also tested against the gram-positive *Staphylococcus aureus* and gram-negative bacteria *Escherichia coli*. However, results showed that the fruit peel of *E. pinnatum* extract did not exhibit any antibacterial activity. This result is consistent with another study in which the leaf and stem extracts of *E. pinnatum* did not show any antimicrobial activity (Chan *et al.* 2008). However, the study also presented that antibacterial activity was demonstrated against *S. aureus* when fresh stem juices were used. The results may indicate that the antimicrobial compounds may be affected by the preparation processes, such as maceration. In conclusion, the fruit of *E. pinnatum* shows potential as a source of biologically active compounds, particularly those with antioxidant and antimelanogenic properties. The findings of this study warrant the need for further investigation to isolate and identify its active compounds and explore other pharmacological properties, such as anticancer activity.

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References

Abe, R., Ohtani, K. 2013. An ethnobotanical study of medicinal plants and traditional therapies on Batan Island, the Philippines. *J. Ethnopharmacol.* 145, 554-565. https://doi.org/10.1016/j.jep.2012.11.029

Barros, T., Galego, L., Pires-Cabral, P. 2018. Monstera deliciosa fruit: physicochemical characterization and potential for distillate production. *J. Food Meas. Charact.* 12, 2874-2882. https://doi.org/10.1007/s11694-018-9902-5

Cabanes, J., Chazarra, S., Garcia-Carmona, F., 1994. Kojic acid, a cosmetic skin whitening agent, is a slow-binding inhibitor of catecholase activity of tyrosinase. *J. Pharm. Pharmacol.* 46, 982-985. https://doi.org/10.1111/j.2042-7158.1994.tb03253.x

Chan, L.W., Cheah, E.L., Saw, C.L., Weng, W., Heng, P.W., 2008. Antimicrobial and antioxidant activities of cortex *Magnoliae officinalis* and some other medicinal plants commonly used in South-East Asia. *Chin. Med.* 3, 15. https://doi.org/10.1186/1749-8546-3-15

Chang, T.S., 2012. Natural melanogenesis inhibitors acting through the down-regulation of tyrosinase activity. *Materials*. 5, 1661-1685. https://doi.org/10.3390/ma5091661

Choi T.Y., Kim J.H., Ko D.H., Kim, C.H., Hwang, J.S., Ahn, S., Kim, S.Y., Kim, C.D., Lee, J.H., Yoon, T.J., 2007. Zebrafish as a new model for phenotype-based screening of melanogenic regulatory compounds. *Pigment Cell Res.* 20, 120-127. https://doi.org/10.1111/j.1600-0749.2007.00365.x

Choi, M.Y., Song, H.S., Hur, H.S., Sim, S.S., 2008. Whitening activity of luteolin related to the inhibition of cAMP pathway in α-MSH-stimulated B16 melanoma cells. *Arch. Pharm. Res.* 31, 1166-1171. https://doi.org/10.1007/s12272-001-1284-4

Clinical and Laboratory Standards Institute. 2020. Performance Standards for Antimicrobial Susceptibility Testing (30th ed., Vol. CLSI supplement M100). Wayne, PA: Clinical and Laboratory Standards Institute.

Costanzo, G., Vitale, E., Iesce, M.R., Naviglio, D., Amoresano, A., Fontanarosa, C., Spinelli, M., Ciaravolo, M., Arena, C., 2022. Antioxidant properties of pulp, peel and seeds of Phlegrean Mandarin (*Citrus reticulata* Blanco) at different stages of fruit ripening. *Antioxidants*. 11, 187. https://doi.org/10.3390/antiox11020187

Das, S.K., Sengupta, P., Mustapha, M.S., Kifayatudullah, M., Goussudin, M., 2015. Phytochemical investigation and antioxidant screening of crude leaves extract from *Epipremnum aureum. Int. J. Pharmacogn. Phytochem. Res.* 7, 684-689.

Graham, J.G., Quinn, M.L., Fabricant, D.S., Farnsworth, N.R., 2000. Plants used against cancer-an extension of the work of Jonathan Hartwell. *J. Ethnopharmacol.* 73, 347-377. https://doi.org/10.1016/S0378-8741(00)00341-X

Goh, S.H., 1998. Bioactive principles from folkloric anti-neoplastic plants and from bioprospecting the Malaysian forest. *Pure Appl. Chem.* 70, 2133.

Hussain, T., Kalhoro, D.H., Yin, Y., 2023. Identification of nutritional composition and antioxidant activities of fruit peels as a potential source of nutraceuticals. *Front. Nutr.* 9, 1065698. https://doi.org/10.3389/fnut.2022.1065698

Iqbal, E., Salim, K.A., Lim, L.B.L., 2015. Phytochemical screening, total phenolics and antioxidant activities of bark and leaf extracts of *Goniothalamus velutinus* (Airy Shaw) from Brunei Darussalam. *J. King Saud Univ. Sci.* 27, 224-232. https://doi.org/10.1016/j.jksus.2015.02.003

Jan, S., Khan, M.R., Rashid, U., Bokhari, J., 2013. Assessment of antioxidant potential, total phenolics and flavonoids of different solvent fractions of *Monotheca buxifolia* fruit. *Osong Public Health Res. Perspect.* 4, 246-254. https://doi.org/10.1016/j.phrp.2013.09.003

Jeon, J.S., Kang, H.M., Park, J.H., Kang, J.S., Lee, Y.J., Park, Y.H., Je, B.I., Park, S.Y., Choi, Y.W., 2021. A comparative study on photo-protective and anti-melanogenic properties of different *Kadsura coccinea* extracts. *Plants*. 10, 1633.https://doi.org/10.3390/plants10081633

Khongkarat, P., Sadangrit, P., Puthong, S., Meemongkolkiat, T., Phuwapraisirisan, P., Chanchao, C., 2024. Anti-tyrosinase and anti-melanogenic effects of piperine isolated from *Piper nigrum* on B16F10 mouse melanoma cells. *Heliyon*. 10, e33423. https://doi.org/10.1016/j.heliyon.2024.e33423

Lelina, F.M.U., Fuentes, R.G., 2018. *Cassia alata* leaf methanolic extracts decreased melanin pigmentation in Zebrafish. *Philipp. J. Nat. Sci.* 47, 41-47.

Linnet, A., Latha, P.G., Gincy, M.M., Anuja, G.I., Suja, S.R., Shyamal, S., Shine, V.J. , Sini, S., Shikha, P., Dan, M., Rajasekharan, S., 2010. Anti-inflammatory, analgesic and anti-lipid peroxidative effects of *Rhaphidophora pertusa* (Roxb.) Schott. and *Epipremnum pinnatum* (Linn.) Engl. aerial parts. *Indian J. Nat. Prod. Resour.* 1, 5-10.

Liu, Z., Shi, L., Qi, Y., Barrow, C.J., Dunshea, F.R., Suleria, H.A.R., 2022. Antioxidative properties and phenolic profile of the core, pulp and peel of commercialized kiwifruit by LC-ESI-QTOF-MS/MS. *Processes*. 10, 1811. https://doi.org/10.3390/pr10091811

Liu-Smith, F., Meyskens, F.L., 2016. Molecular mechanisms of flavonoids in melanin synthesis and the potential for the prevention and treatment of melanoma. *Mol. Nutr. Food Res.* 60, 1264-1274. https://doi.org/10.1002/mnfr.201500822

Masfria, M., Marianne, M., Permata, Y.M., 2019. Organic and inorganic analysis of *Rhaphidophora pinnata* (L.f.) Schott water extract. *J. Med. Sci.* 7, 3790-3793. https://doi.org/10.3889/oamjms.2019.505

Nurliyana, R., Zahir, I.S., Suleiman, K.M., Aisyah, M.R., Rahim, K.K., 2010. Antioxidant study of pulps and peels of dragon fruits: a comparative study. *Int. Food Res. J.* 17, 367-375.

Paduhilao II, J.E., Yap-Dejeto, L.G., 2022. Zoochemical analyses and *in vitro* antimicrobial activity of crude methanolic extract of *Perna verdis*. *Acta Med. Philipp.* 56, 82-89. https://doi.org/10.47895/amp.vi0.3136

Pan, S.P., Pirker, T., Kunert, O., Kretschmer, N., Hummelbrunner, S., Latkolik, S.L., Rappai, J., Dirsch, V.M., Bochkov, V., Bauer, R., 2019. C13 Megastigmane derivatives from *Epipremnum pinnatum*: β-damascenone inhibits the expression of pro-Inflammatory cytokines and leukocyte adhesion molecules as well as NF-κB signaling. *Front. Pharmacol.* 10, 1351. https://doi.org/10.3389/fphar.2019.01351

Phuyal, N., Jha, P.K., Raturi, P.P., Rajbhandary, S., 2020. Total phenolic, flavonoid contents, and antioxidant activities of fruit, seed, and bark extracts of *Zanthoxylum armatum* DC. *Sci. World J.* 2020, 1-7. https://doi.org/10.1155/2020/8780704

Prasad, K.N., Chew, L.Y., Khoo, H.E., Kong, K.W., Azlan, A., Ismail, A., 2010 Antioxidant capacities of peel, pulp, and seed fractions of *Canarium odontophyllum* Miq. fruit. *J. Biomed. Biotechnol.* 2010, 1-8. https://doi.org/10.1155/2010/871379

Razmavar, S., Abdulla, M. A., Ismail, S. B., Hassandarvish, P. 2014. Antibacterial activity of leaf extracts of *Baeckea frutescens* against Methicillin-Resistant *Staphylococcus aureus*. *Biomed. Res.Int.* 2014, 1-5. https://doi.org/10.1155/2014/521287

Shivhare, S., Patidar, A., Malviya, K., Shivhare-Malviya, K., 2011. Antioxidant and anticancer evaluation of *Scindapsus officinalis* (Roxb.) Schott fruits. *AYU.* 32, 388-394. https://doi.org/10.4103/0974-8520.93921

Suleria, H.A.R., Barrow, C.J., Dunshea, F.R., 2020. Screening and characterization of phenolic compounds and their antioxidant capacity in different fruit peels. *Foods.* 9, 1206. https://doi.org/10.3390/foods9091206

Tan, M.L., Muhammad, T.S.T., Najimudin, N., Sulaiman, S.F., 2005. Growth arrest and non-apoptotic programmed cell death associated with the up-regulation of C-myc mRNA expression in T-47D breast tumor cells following exposure to *Epipremnum pinnatum* (L.) Engl. hexane extract. *J. Ethnopharmacol.* 96, 375-383. https://doi.org/10.1016/j.jep.2004.07.005

Westerfield, M., 2000. *The Zebrafish Book. A Guide for the Laboratory Use of Zebrafish (Danio rerio)*, fourth ed, Univ of Oregon Press, Eugene, OR.

Zumbroich, T.J., 2011. To strengthen the teeth and harden the gums-Teeth blackening as medical practice in Asia, Micronesia and Melanesia. *Ethnobot. Res. Appl.* 9, 97-113. https://doi.org/10.17348/era.9.0.97-113