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Genus Phyllanthus: Traditional uses and biological activities

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ABSTRACT

Medicinal plants represent essential elements of traditional medicine. They have been used to treat various ailments. Phyllanthus (Euphorbiaceae) is a large genus that includes important medicinal plants. It has about 1000 plant species, comprising trees, shrubs and herbs. Phyllanthus species are known globally for their medicinal uses and are used in the treatment of many diseases. It has been estimated that more than 500 chemical constituents have been obtained from species of this genus. The medicinal value of different plant parts is proven scientifically. The extracts prepared from Phyllanthus plants displayed anti-cancer, anti-inflammatory, anti-diabetic, anti-oxidant, anti-bacterial, nephroprotective, hepatoprotective, immunomodulatory effects. Phyllanthus species have been the focus of many biological and phytochemical studies in recent years, due to their wide distribution. This review emphasizes the importance of Phyllanthus plants, showing their traditional uses and scientifically proven biological effects to open the door to take advantage of them in medicine and industry.

1. Introduction:

Medicinal plants have been used as medicinal and nutritional agents in many countries (Okiki et al., 2022). The effectiveness of these plants may not be due to single ingredient, but to the combination of the plant components (Akhtar and Gayathri, 2015). *Phyllanthus* (Euphorbiaceae) is a large genus, distributed in tropical and subtropical regions (Mao et al., 2016). The genus comprises about 1000 species (Sarin et al., 2014), including trees, shrubs. The genus rarely includes herbs (Basavaraju and Gunashree, 2022). The name *Phyllanthus* means "leaves and flowers" because the flower, as well as the fruit, seems to become one with the leaf (Khabiya et al., 2019). Many *Phyllanthus* species are considered as important medicinal and ornamental plants (Sarg et al., 2011). Different parts of those plants have been scientifically proven to exert medicinal values (Sibiya et al., 2020). *Phyllanthus* has recently been the focus of numerous studies, due to its many medicinal properties in folk medicine, wide distribution, and numerous secondary metabolites (Eldeen et al., 2011). It has been estimated that more than 500 chemical constituents have been obtained from species of this genus (Geethangili and Ding, 2018).

This review emphasizes the importance of *Phyllanthus* plants, showing their traditional uses and biological effects to open the door to take advantage of them in medicine and industry.

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2. Traditional uses of *Phyllanthus* plants

Treatment using medicinal plants is a part of traditional medicine. These treatments have been developed by the local people (Geetangili and Ding, 2018). Each country has its own history of these treatments, such as “Ayurvedic medicine” in Southeast Asia, “Unani medicine” in Arab countries in the middle east, as well as “Traditional Chinese Medicine” which originated from China (Geetangili and Ding, 2018). The WHO confirmed that this medicine is important to meet the health requirements, mainly in the developing countries (Saini et al., 2022). In recent years, traditional medicine has greatly aided in the biosynthesis of *Phyllanthus* natural products (Sibiya et al., 2020).

The extracts prepared from various parts of *Phyllanthus* plants are used to treat cancer, wounds, urinary tract disorders, sexually transmitted diseases, hypertension, diabetes (Sarin et al., 2014), and chronic liver disease (Okiki et al., 2022). Ayurveda uses the most abundant species for their beneficial properties to treat genitourinary, respiratory and digestive disorders (Mao et al., 2016). The fruits of *P. emblica* are used in Ayurveda as medicinal agent against inflammation and jaundice, and serve as rasayana (Saini et al., 2022). Niruri (*P. niruri*) is an herb traditionally known in India for its medicinal effects in dysentery, hyperglycemia, irritating sores, jaundice, and liver disease (Bavarva and Narasimhacharya, 2007). Traditionally, *P. acidus* is used as a blood purifier (Jain and Singhai, 2011). *P. muellerianus* is used in Ghana and other areas of West Africa to control wounds, wound infections, pain, inflammation, fever and menstrual disorders (Boakye et al., 2016). *P. simplex* has traditionally been used to treat hepatitis, gonorrhea, itching, diarrhea, hyperglycemia, jaundice, pruritus, and inflammation (Chouhan and Singh, 2011).

3. Pharmacological properties of *Phyllanthus*

3.1 Hepatoprotective effect:

The hepatoprotective effect of the crude extracts of *Phyllanthus* species against liver damage has been well studied. Hepatotoxicity induced by CCl_4 in rats was prevented by pretreatment with leaf and fruit extracts of *P. niruri*, indicating the hepatoprotective activity of this plant (Harish and Shivanandappa, 2006). Treatment with *P. amarus* reduced the liver and kidney toxicity imposed by rifampicin and carbon tetrachloride CCl_4 in a dose-dependent manner (Ogunmoyole et al., 2020). Relatedly, oral administration of alcoholic extracts of *P. niruri* and *P. urinaria* provided hepatoprotection in rats with CCl_4-induced (chronic) liver injury (Prakash et al., 1995). Oral administration of the methanolic extracts of *P. acidus* and *P. urinaria* reduced the increase in ALT and AST levels, and also elevated the activity of liver reduced glutathione peroxidase and reduced liver infiltration and necrosis in rats with CCl_4-induced acute liver damage (Lee et al., 2006). The aqueous extract of *P. acidus* leaves prevented the toxicity of acetaminophen (APAP) and thioacetamide in rats (Jain and Singhai, 2011). Previous study revealed that alcoholic extracts of the aerial parts and roots of *P. atropurpureus* had antihepatotoxic properties, similar to silymarin. Both of them improved the SGPT and SGOT levels (Sarg et al., 2011).

The methanolic extracts of three *Phyllanthus* plants showed hepatoprotective effect_against *tert*-butyl hydroperoxide induced toxicity in HepG2 cells, with EC_{50} of 12 µg/ml for *P. polyphyllus*, 19 µg/ml for *P. emblica* and 28 µg/ml for *P. indofischeri* (Srirama et al., 2012). In general, many *Phyllanthus* species contain various compounds with hepatoprotective effect such as flavonoids, lignans and tannins (Sarg et al., 2011).

3.2 Nephroprotective activity of *Phyllanthus*

Nephrotoxicity is a serious kidney problem caused by drugs or toxins (Moirangthem et al., 2017). Previous studies had showed that the methanolic leaves extract of *P. niruri* may help in reducing nephrotoxicity induced by gentamicin in rats (Reddy et al., 2015).

In another study, the aqueous leaves extract of *P. niruri* helped to keep kidney function near to normal and prevent histopathological changes by ameliorating fibrosis, inflammation, oxidative stress and apoptosis while enhancing proliferation of the kidney in diabetes mellitus (Giribabu et al., 2017).

Ellagic acid, an ingredient in *P. niruri*, has been reported to be responsible for protective effect of the plant against renal damage induced by calcium oxalate (Li et al., 2022).

Similarly, oral administration of *P. amarus* seed extract and methanolic leaves extract of *P. acidus* showed protection against gentamycin-induced renal damage (Bakhtiary et al., 2012). The ethanolic extract *P. emblica* showed protection against kidney damage induced by ethylene glycol and ammonium chloride in rats (Halim et al., 2019). The aqueous extract of *P. fraternus* showed protection against nephrotoxicity induced by cyclophosphamide in albino rats (Moirangthem et al., 2017).

3.3 Immunomodulatory activity

In previous study, *P. muellerianus* methanolic leaf extract exhibited both immune-boosting and immunosuppressing actions. In cyclophosphamide-induced myelosuppression, the extract caused a decrease in total leukocytes count and a decrease in lymphocyte proliferation and an increase in neutrophil proliferation (Ofokansi et al., 2018). The methanolic extract of *P. niruri* plant displayed immunomodulatory activity and modulated the innate and adaptive immunity (Eze et al., 2014). Aqueous extract of *P. niruri* induced macrophage proliferation and NO secretion after *Streptococcus sanguinis* infection, indicating potential immunomodulatory activity (Hutomo et al., 2018). Catechin and quercetin in *P. niruri* can inhibit the expression of TNF-α, IL-1, IL-6, and iNOS thereby inhibiting the excessive inflammation process and playing an immunomodulatory role (Sukmanadi et al., 2020).

P. amarus exerted a potent immunosuppressive effect, through many immunomodulatory mechanisms. Rats treated with *P. amarus* exhibited a dose-dependent inhibition of lipopolysaccharide-stimulated B-cell proliferation and concanavalin A–stimulated T-cell proliferation, and decreased expression of CD4+ and CD8+ in splenocytes and in serum cytokines of T helper (Th1) (IL-2 and IFN-γ) and Th2 (IL-4) (Ilangkovan et al., 2015). *P. acidus* extract showed an immunomodulatory property. The result was shown from the increase in total leukocyte count and leukocyte differential, antibody titer value (Nurfadhilah et al., 2022).

3.4 Anti-inflammatory

The anti-inflammatory properties of some *Phyllanthus* species have been well documented. In a rat model of carrageenan-induced acute inflammation. Treatment with aqueous leaf extract of *P. muellerianus* reduced the maximal swelling attained from the inflamed control response. In the chronic inflammation caused by the adjuvant, *P. muellerianus* treatment reduced the total limb swelling over 16 days in the polyarthritic stage (Boakye et al., 2016). Using carrageenan induced edema test, *P. acidus* leaves extract, methanolic extract of *P. niruri*, the whole plant aqueous extract of *P. fraternus*, ethanolic extract of malacca leaves (*P. emblica*) showed anti-inflammatory properties (Oseni et al., 2013; Hossain et al., 2016; Mostofa et al., 2017; Asmilia et al., 2020). In another study, *P. emblica* fruit extract showed dose-dependent inhibition of nitric oxide in lipopolysaccharide stimulated RAW264.7 cells and significantly high cyclooxygenase (COX-2) inhibition (Li et al., 2022). The ethanol extract of *P. simplex* plant significantly inhibited NO production in isolated rat peritoneal macrophages. It also has a significant effect in inhibition of paw edema induced by carragennan and granuloma formation induced by cotton pellet (Chouhan and Singh, 2011).

Standardized extracts of *P. amarus* attenuated tumor necrosis factor (TNF-a) secretion induced by LPS, and reduced the expression of endotoxin-induced nitric oxide synthase (iNOS) and COX-2 (Kiemer et al., 2003). *P. amarus* has been shown to target the NF-κB, MAPK and PI3K-Akt signaling pathways to exert its anti- inflammatory effects by downregulating the inflammatory response (Harikrishnan et al., 2018).

3.5 Lung diseases

Previous study demonstrated that the methanolic extract of *P. emblica* leaves can play an important role in the treatment of CCl_4-induced pulmonary damages instigated with CCl_4. Administration of methanolic extract of *P. emblica* leaves resulted in a dose-dependent reduction in the oxidative injuries in rats. Histopathological damages such as damaged alveoli, infiltration of macrophages and and changes in Clara cell architecture was normalized by the co-administration of the extract (Tahir et al., 2016).

In previous study, the aqueous fruit extract of *P. emblica* protected the lung from inflammatory damage. The authors also concluded that the extract can prevent precancerous lung lesions by regulating the IL-1β/miR-i101/Lin28B pathway (Wang et al., 2017).

3.6 Antioxidant activity

The antioxidant capacity of *Phyllanthus* species was extensively studied (table 1). Phenolic compounds have the best antioxidant effect -among natural antioxidants- due to their ability to quench oxygen-derived free radicals by donating a hydrogen atom or electron to a free radical (Upadhyay et al., 2014). Total phenolic content (TPC) of different extracts of *Phyllanthus* species was determined.

TPC was found to be (207 and 205 mg/GAE/g) for *P. myrtifolius* and *P. urinaria*, respectively (Eldeen et al., 2011). It has also been indicated that TPC in the ethanolic aerial parts extract of *P. fraternus* is about 230.85 ± 0.59 mg/g GAE (Upadhyay et al., 2014). The TPC in the ethanolic seed extract of *P. acidus* was found to be 3.19 mg of gallic acid equivalent/g (GAE/g) (Chigurupati, 2020). According to (Khabiya et al., 2019) TPC in methanolic extracts of different *Phyllanthus* species (*P. reticulatus*, *P. virgatus, P. acidus*, *P. virosus*, *P. amarus*, *P. emblica*, *P. fraternus*, *P. maderaspatensis*, *P. urinaria*) ranged from 41.801 to 87.542 mg/g of the dry weight of extract (GAE/g). The TPC of the methanolic whole plant extracts of *P. niruri, P. debilis* and *P. urinaria* were found to be (197.09 ± 0.03, 159.13 ± 0.02, 308.71 ± 0.04) mg GAE/g DW, respectively (Zain and Omar, 2018).

Table 1*: Antioxidant activity of some Phyllanthus species*

Species	extract/ plant part	Technique	Conc.	Results	Ref.
P. fraternus	Ethanol (Aerial part)	DPPH	500 µg/ml	radical scavenging 1.10±capacity=94.59	(Upadhyay et al., 2014)
		Lipid peroxidation	4000 µg/ml	Percentage 96.55 =inhibition 0.27±	
P. acidus	Water (fruits)	DPPH	-	IC50= 26.06 µg/ml	(Andrianto et al., 2017)
	Ethanol (seed)	DPPH	-	IC50= 28.26 ± 0.39 µg/ml	(Chigurupati, 2020)
		ABTS	-	IC50= 23.44 ± 0.48 µg/ml	
P. emblica	Methanol (leaves)	DPPH	-	IC50 = 39.73 ± 2.12 µg/ml	(Tahir et al., 2016)
		Nitric oxide	-	IC50 = 39.14 ± 2.31 µg/ml	
		Lipid peroxidation	-	IC50 = 84.10 ± 3.04 µg/ml	
P. niruri	Methanol	DPPH	-	EC50= 29.3 ± 0.01 µg/ml	(Zain and Omar, 2018)
	Methanol	ABTS	-	26.0 ± 0.02 EC50= µg/ml	
P. urinaria	Methanol	DPPH	-	EC50= 15.8 ± 0.01 µg/ml	
	Methanol	ABTS	-	11.2 ± 0.01 EC50= µg/ml	
P. debilis	Methanol	DPPH	-	EC50= 26.3 ± 0.01 µg/ml	
	Methanol	ABTS	-	16.2 ± 0.03 EC50= µg/ml	
P. muellerianus	Aqueous (aerial parts)	DPPH	-	IC50 = 0.12 µg/ml	(Boakye et al., 2016)
P. chamaecristoides	Aqueous (leaves and stems)	DPPH	-	EC50= 0.03 mg/ml	(Menéndez-perdomo

P. microdictyus		DPPH	-	EC50= 1.16 mg/ml	et al., 2017)
P. williamioides		DPPH	-	EC50= 0.15 mg/ml	
P. amarus	Ethanolic (leaves)	DPPH	-	IC50 = 38.38 mg/ml	(Bello, M., and Ibaba, 2020)
		FRAP	-	IC50 = 29.31 mg/ml	
		TBARS	-	IC50 = 29.34 mg/ml	

Values represent mean ± standard deviation. DPPH: 2,2-diphenyl-1-picrylhydrazyl, FRAP: Ferric reducing antioxidant power, ABTS: 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid), TBARS: Thiobarbituric acid reactive substances, Con: concentration.

3.7 Antibacterial activity

Pathogenic microorganisms develop resistance to conventional antibiotics, resulting in the need for alternative treatments (Okiki et al., 2022). Medicinal plants are rich in antimicrobial compounds and their use in medicine is beneficial because they have less side effects (Jahan and Akter, 2015).

The antimicrobial components of plants are secondary metabolites that inhibit bacterial growth, bacterial adhesion, exopolysaccharide synthesis, DNA gyrase, plasma membrane function and energy metabolism (Natarajan et al., 2014). The antimicrobial activity of some species of the genus *Phyllanthus* against many bacterial strains such as *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Staphylococcus epidermidis*, *Streptococcus pneumoniae*, *Shigella flexneri*, *Salmonella typhimurium*, *Pseudomonas aeruginosa*, are presented in table 2.

***Table 2**: Antibacterial activity of some Phyllanthus species*

Species	**Extract/ plant part**	**Micro-organisms**	**MIC values**	**Ref.**
P. reticulatus	EE / leaves	*Shigella dysenteria* (BMLRU1011)	31.3 mg/ml	(Islam et al., 2013)
		Salmonella typhi (BMLRU1009)	62.5 mg/ml	
		Pseudomonas aeruginosa (BMLRU1007)	15.6 mg/ml	
		Shigella sonnei (BMLRU1015)	31.3 mg/ml	
		Sarcina lutea (BMLRU1012)	31.3 mg/ml	
		Bacillus megaterium (BMLRU1010)	31.3 mg/ml	
		Bacillus subtilis (BMLRU1008)	62.5 mg/ml	
		Staphylococcus aureus (BMLRU1002)	15.6 mg/ml	
		Bacillus cereus (BMLRU1004)	31.3 mg/ml	
		Staphylococcus-ß-haemolytica (BMLRU1006)	62.5 mg/ml	
P. amarus	ME/ leaves	*Staphylococcus aureus* (ATCC 25923)	25 mg/ml	(Okiki et al., 2022)
		Escherichia coli (ATCC 35218)	50 mg/ml	
		Klebsiella pneumoniae (ATCC 34089)	6.25 mg/ml	
		Pseudomonas aeruginosa (ATCC27853)	50 mg/ml	
		Salmonella Typhi (ATCC 22648)	12.5 mg/ml	
P. wightianus	ME/ leaves	*Staphylococcus epidermidis* (MTCC 435)	31.25 µg/ml	(Natarajan et al., 2014)
		Streptococcus pneumoniae (MTCC 655)	15.62 µg/ml	
		Shigella flexneri (MTCC 1457)	125 µg/ml	
		Salmonella typhimurium (MTCC 98)	500 µg/ml	

		Pseudomonas aeruginosa (MTCC 741)	250 µg/ml	
		Klebsiella pneumoniae (MTCC 109)	500 µg/ml	
P. urinaria	ME/ WP	*Bacillus licheniformis* (ATCC12759)	154 µg/ml	(Eldeen et al., 2011)
		Bacillus spizizenii (ATCC6633)	79 µg/ml	
		Staphylococcus aureus (ATCC12600)	39 µg/ml	
		Escherichia coli (ATCC25922)	185 µg/ml	
		Klebsiella pneumoniae (ATCC13883)	156 µg/ml	
		Pseudomonas stutzeri (ATCC17588)	117 µg/ml	
P. myrtifolius	ME/ WP	*Bacillus licheniformis* (ATCC12759)	75 µg/ml	
		Bacillus spizizenii (ATCC6633)	20 µg/ml	
		Staphylococcus aureus (ATCC12600)	40 µg/ml	
		Escherichia coli (ATCC25922)	306 µg/ml	
		Klebsiella pneumoniae (ATCC13883)	178 µg/ml	
		Pseudomonas stutzeri (ATCC17588)	78 µg/ml	
P. maderaspatensis	EE/Sh	*Salmonella typhimurium* (MTCC98)	625 µg/ml	(Rani and Raju, 2014)
		Staphylococcus aureus (MTCC 737)	625 µg/ml	
		Pseudomonas aeruginosa (MTTC 1688)	312 µg/ml	
		Klbsiella pneumoniae (MTCC 109)	312 µg/ml	

AE: Aqueous extract, EE: ethanolic extract, PEE: petroleum ether extract, CE: chloroform extract, ME: methanolic extract, WP: whole plant, Sh: shoot, ATCC: American Type Culture Collection.

3.8 Antidiabetic activity

Diabetes is a common disease that affects many people in several countries. There is interest in finding and discovering new antidiabetic drugs with high safety, due to the many toxicities of hypoglycemic drugs (Akhtar and Gayathri, 2015).

Herbal preparations and herbs are used more widely to treat and control diabetes mellitus instead of modern hypoglycemic drugs (Bashir et al., 2018).

Using alloxan-induced diabetic model, previous investigations revealed that the ethanolic extracts of *P. fraternus* whole plant and *P. amarus* leaf have antidiabetic effect and significantly improved blood glucose levels (Garg et al., 2008; Shetti and Kaliwal, 2015). Another *in vivo* study indicated that ethanolic fruit extract of *P. emblica* had significant hypoglycemic activity and can imporve insulin resistance by enhanced insulin sensitivity in the peripheral tissues (Bashir et al., 2018).

Likewise, previous research has shown that oral administration of ethanolic leaf extract of *P. amarus* for 45 days caused a decrease in blood glucose level, an improvement in body weight in diabetic mice, a decrease in glucose-6-phosphatase and fructose-1-6-disphosphatase activities in liver, and significant increase in the activity of glucokinase in liver of diabetic mice compared with that of diabetic control (Shetti et al., 2012).

Phytochemicals in *P. urinaria* have also been shown to be effective as an alternative to the Metformin drug in the treatment of diabetes (Akhtar and Gayathri, 2015). In addition, the alcoholic extract of *P. niruri* showed antidiabetic activity in normal, insulin-dependent diabetes mellitus (Bavarva and Narasimhacharya, 2007).

Relatedly, oral administration of methanolic extract of *P. niruri* aerial parts significantly reduced blood glucose levels, triglycerides and total cholesterol levels in diabetic and normoglycaemic rats (Okoli et al., 2010).

It has been suggested that the hypoglycemic properties of the aerial parts of *P. niruri* may be due to inhibition of glucose absorption and improvement of glucose storage (Okoli et al., 2011).

3.9 Cytotoxic activities

Cytotoxic activity of *P. amarus* leaf extract was tested against HCT 15 and T47D cell lines. The results showed that the inhibitory effect on HCT 15 cell line was greater than T47D. Growth inhibition increased from 8.86% to 87%, and from 8.39 % to 86.01%, for the HCT 15 and T47D cell lines, respectively, with the increasing concentration (Pammi and Giri, 2021).

Acetone and hydroethanolic extracts of aerial parts of *P. phillyreifolius* exhibited low levels of cytotoxicity against HEK293 cell line, reducing cell viability to 50% at concentrations of 489 and 387 µg/ml for Acetone and hydroethanolic extracts, respectively (Grauzdytė et al., 2018). The ethanol extract of *P.*

niruri had a potential cytotoxic effect towards human leukemic cells MOLT-4 cells (IC_{50}= 97.06±18.29 µg/ml). It was found that p53 expression was increased after MOLT-4 treatment with methanolic extract, suggesting that p53 induction may play a role in cell apoptosis (Puspita and Alhebshi, 2019).

Previous research revealed that methanolic extracts of several *Phyllanthus* species (*P. amarus, P. watsonii*, *P. niruri*, and *P. urinaria*) can inhibit the growth of lung (A549) and breast (MCF-7) carcinoma cells with IC_{50} values of 50–180 µg/ml. The extract also reduced the adhesion and migration of the carcinoma cells (Lee et al., 2011).

Previous study showed that the bark extract of *P. emblica* had cytotoxic effect (IC_{50} of 52.2 µg/ml) and induces apoptosis of the KKU-452 CCA cell line. The extract also inhibited cell migration at 25 and 50 µg/ml by 42.8 and 32.9%, respectively (Samatiwat et al., 2021).

Similarly, Previous investigation revealed that *P. reticulatus* leaf extracts have anti-proliferative, apoptotic and antimigratory activities against liver cancer cell line (HepG2) (Deivayanai et al., 2019). However, preliminary in vitro data are insufficient and unreliable, as all experiments are performed in an environment other than the human body (Tang and Sekaran, 2011).

The cytotoxic activity of crude methanol, hexane and ethyl acetate extracts of *P. niruri* (aerial parts), *P. pectinatus* (leaves and fruits) and *P. acidus* (leaves) was evaluated with an in vitro growth inhibition assay system against four human cancer cell lines, breast cancer cell line (MCF7), epidermal carcinoma of cervix cell line (CaSki), ovarian cancer cell line (SKOV3) and colon cancer cell line (HT29). The results showed that methanolic and ethyl acetate extracts of *P. pectinatus* leaves were active against SKOV3 cell with an IC_{50} value of 4.8 and 5.8 µg/ml, respectively. The ethyl acetate extract of *P. pectinatus* fruits was active against MCF7 and CaSki cells, with an IC_{50} values of 18.1 and 19.4 µg/ml, respectively. The study suggested that *P. pectinatus* may be useful in the discovery of anticancer drug (Ramasamy et al., 2011).

3.10 Other biological activities:

Previous study revealed that ethanolic extract of *P. amarus* leaves can reverse the deleterious effects of prolonged highly active antiretroviral therapy administration on the experimental rats (Bello and Ibaba, 2020).

Ethanolic extracts of *P. fraternus* have been shown to have anticoagulant effects. The extract increased clotting time and bleeding time in rabbits –in vitro- (Koffuor and Amoateng, 2011). It was suggested that the alkaloid extract of *P. amarus* had significant activity against plasmodium (Uzuegbu et al., 2022). The methanolic extract of *P. reticulates* leaves exhibited anti-diarrhoeal properties in several experimental animals with diarrhea (Nesa et al., 2014).

4. Conclusion

In this work, *Phyllanthus* species were reviewed for their biological activities and traditional uses. These species have been shown to have many biological activities, so they represent valuable natural sources in the pharmaceutical industry. More research is needed to explore the exact mechanisms of these biological activities and identify the active ingredients responsible for them.

Conflict of interest statement

Authors declare that there is no conflict of interest.

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