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A Review on the Morphology, Nutritional Value, Traditional Uses, Phytochemistry, and Biological Activities of *Pycnarrhena cauliflora* and Its Synonyms

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The leaves of *Pycnarrhena cauliflora*, locally known as 'pokok Ajinomoto', are consumed as flavour enhancers by East Malaysian communities. The plant also plays a significant role in traditional medicine especially to treat snake bites, eye irritation, headache, and seizures. An extensive literature search on the species revealed that besides taxonomic description as well as toxicity against HeLa human cervical and breast cancer cell lines, there is no report on the plant chemistry. The species has nevertheless been classified as the synonym of several other species which are *Antitaxis cauliflora* Miers., *Pycnarrhena longifolia*, (Decne. ex Miq.), *Antitaxis longifolius* (Decne. ex Miq.) Mier., and *Gabila longifolia* (Decne. ex Miq, B). Among these synonyms, the plant is closely related to the species *P. longifolia*. Thus, a complete review of *P. cauliflora* and its synonyms is important to revise and evaluate its potential for further studies and commercialisation. The information on the species was collected from scientific journals, books, and reports searched through available databases such as Google Scholar, PubMed, Directory of Open Access Journals, Science Direct, Bioline International and Reaxys. This review provides an insight on the morphology, nutritional value, traditional uses, phytochemistry, and biological activities of *P. cauliflora* and its synonyms published between 1981 to 2021 in scientific journals, books, and reports.

Keywords: *Pycnarrhena*; morphology; nutritional value; traditional uses; phytochemical constituents; biological activities

I. INTRODUCTION

P. cauliflora is a liana type of plant and it is found throughout the tropical regions, particularly in Borneo (Hoot *et al.,* 2009). Depending on the local ethnics, this species has been called 'pokok ajinomoto', 'kiamis,' 'tapa,' 'tapa tahambia' or 'tapa bohuang' in Sabah or 'sengkubak' and 'kemangi imbo' in Indonesia. This plant is reported to exhibit medicinal value in the treatment of eye irritation, headache, and seizures (Rahayu *et. al.,* 2007; Santoso *et al.,* 2019). Moreover, the leaves of this plant are also used as one of the ingredients in

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the making of rice wine ('tapai'), and as a food flavour enhancer (Figure 1).

Figure 1. *P. cauliflora* marketed product as food flavour enhancer (Navarooms, n.d).

P. cauliflora belongs to the moonseed family, Menispermaceae (formerly Pseliaceae) (Hassler, 2020). Thus far, 70 genera with approximately 450-500 species have been reported in the family. The species in this family is most commonly found in tropical rainforests, whereby 77 species from the 19 genera are in China (Hoot *et. al.,* 2009; Xianrui *et al.*, 2008). Apart from *P. cauliflora*, the genus *Pycnarrhena* consists of nine other species which are distributed within the Indo-Malayan to other tropical regions (Table 1). The habitat of the species in this genus can be found mostly in a forest with a higher altitude of more than 500 m in sandy soil and limestone (Hoot *et al.,* 2009). However, there are also few species such as *P. novoguineensis* and *P. pleniflora* which can be found at 50-100 m altitude (Forman, 2016); species *P. cauliflora* has also been reported at the area < 50 m altitude with high humidity and sufficient amount of sunlight throughout the year (Afrianti, 2007).

Table 1. The Distribution of *Pycnarrhena* Species

Plant Species	Distribution	References
P. lucida	Cambodia, China, India, Indonesia, Laos, Malaysia and Thailand	(Xianrui *et al.,* 2008)
P. poilanei	China, Vietnam and Thailand	(Xianrui *et al.,* 2008)
P. macrocarpa	Yunnan, China and India	(Xianrui *et al.,* 2008)
P. manillensis	Philippines	(Forman, 1972)
P. novoguineensis and *P. ozantha*	West New Guinea, Territory of New Guinea and Australia	(Forman, 1972; Forman, 2007)
P. pleniflora	Pakistan and India	(Forman, 1972)
P. tumefacta	Central and East Malesia, Solomon Island, Vanuatu and Indonesia	(Miers, 1867; Forman, 1972)
P. mecistophylla	Assam and Meghalaya, India	(Hassler, n.d.)
P. cauliflora	Lesser Sunda Island, Sumatra and Java, Indonesia East Malaysia	(Hassler, 2020; Mohammed *et al.,* 2020)

According to the 'Catalogue of Life *Pycnarrhena cauliflora* Diels', the plant is synonym to several species such as *Antitaxis cauliflora* Miers., *Pycnarrhena longifolia*, (Decne. ex Miq.), *Antitaxis longifolius* (Decne. ex Miq.) Mier., and *Gabila longifolia* (Decne. ex Miq, B). A thorough literature review showed that the plant is closely related to the species *P. longifolia,* and besides taxonomic description, there is no report on the other synonyms. Thus, this review provides an overview of the morphology, nutritional value, traditional uses, phytochemistry, biological activities, and safety of *P. cauliflora* and its synonyms published in scientific journals, books, and reports available between 1981 to 2021 in databases such as Google Scholar, PubMed, Directory of Open Access Journals, Science Direct, Bioline International and Reaxys. Considering its traditional uses and the recent reported biological activities, this review is much needed to organise and revise the plant's systematic classification as well as to evaluate its potential for further studies and commercial exploitation.

II. MORPHOLOGY

The systematic revision for the *Pynarrhena* (Miers) genus has been proved to be very difficult due to lack of available materials, particularly on their fruits and inflorescences. Besides, the morphology of the species in the genus has also been reported to differ from the other genus of the family (Wang *et al*., 2007). The most noticeable difference is that the genus possesses foliaceous cotyledon, and a stylar scar on the terminal and ventral side. In addition, this genus has no endosperm, the embryo is slightly curved, not sculptured endocarp with condyle. The early revision done by Forman (1968) had recognised ten species including *P. macrocarpa*, *P. poilanei*, *P. lucida*, *P. pleniflora*, *P. longifolia*, *P. manillensis*, *P. novoguineensis*, *P. tumefacta*, *P. ozantha*, and *P. montana*. However, the characterisation of each species was also challenging due to considerable variations between the specimens. At that time, *P. cauliflora* had been classified to be the synonym of *P. longifolia* along with *Cocculus longifolius* Decne. ex Miq., Ann. Mus. Lugd.-B, *Antitaxis longifolius* (Decne. ex Miq.) Miers, Contrib. Bot., *Gabila longifolia* (Decne. ex Miq.) Baillon in Adansona, and *Antitaxis cauliflora* Miers. However, only the morphological description of the species *P. cauliflora* and *P. longifolia* were published. Thus, this section will discuss the morphology of these two species.

Figure 2. *P. longifolia* (specimen from Kew's Herbarium)

Figure 3. *P. cauliflora* (specimen from Bogoriense LIPI Cibinong's Herbarium)

The herbarium specimen of *P. cauliflora* and *P. longifolia* is shown in Figure 2 and Figure 3, respectively. Both plant species are of liana type exhibiting long and large woody wine of stems 10-40 m in length and 0.7-5 cm in diameter (Forman, 1972; Mustofa & Jumina, 2013; Chinh *et al*., 2017). The leaves of both plants have been described differently: *P. cauliflora* is non-layered leaves with a longer shape sized ranging from 7.5 – 21 cm to 3 -9.5 cm (Afrianti, 2007) whereas *P. longifolia* leaves showed petioles, usually puberulous size 18 – 2.5 cm (Forman, 1972). The apex abruptly gradually acuminate and the base obtuse to rounded 8-12(-18) cm in length and 3-6(-8) cm in width (Forman, 1972). The lateral nerves contain 6-8 pairs.

The flowers of both species were also slightly different. Afrianti (2007) reported that the flower of *P. cauliflora* is glabrous, the outer layer smaller than the inner, and it grows spread to 6-9 sepals. The stamens are 2-12 bearing 2-4 ovaries. Contrarily, the flower of *P. longifolia* was described as both male and female. The male flower of *P. longifolia* is minutely puberulous pedicels (5-10 mm) long; outer sepals (2-4) inner sepals yellow (3). The female flower of *P. longifolia* is minutely puberulous; outer sepals (1-2); inner sepals yellow (4-6) (Forman, 1972). There was no report on the fruit and pollen grain morphology of *P. cauliflora*. The fruit of *P. longifolia* had been described as borne on unbranched puberulous to subglabrous peduncles in 7- 20 mm long, globose with 12-15 mm in diameter, and minutely tomentellous or puberulous (Forman, 1972) while the pollen grain of *P. longifolia* as prolate with an average size of {13.6 µm (P) × 10.2 µm (E)} and exine thickness 1.0 µm. The lumina (gaps) is greater than muri (breath of ridge) and the muri ornamentation is smooth (Ferguson, 1975).

The morphology description above, definitely could tell that *P. cauliflora* and *P. longifolia* are differed to some aspects. It is well known that as the morphology of the plants is difference, to a certain extent, the phytochemical and biological activities will be also different.

III. NUTRITIONAL VALUE

From the information collected, there is no report on the nutritional value of *P. cauliflora*. However, sensory test based on organoleptic properties (taste, aroma, and appearance) of the plant leaves extract revealed a concentration of 0.25% with a priority number of 0.482 as the most favourable among the participants (Setyiasi *et al*., 2013).

On the other hand, proximate analysis on the leaves of its close related synonym, *P. longifolia*, indicated that the plant leaves contained key nutritional components such as carbohydrate, fibre, fat, and protein in the percentage of 47.6%, 15.7%, 12.1%, and 7.0%, respectively. The leaves are also rich in amino acids, minerals, sugars and bioactive compounds such as flavonoids and phenolic which could serve as functional food (Purba *et al.*, 2014), and contain about 6.6% moisture, and 11.6% ash (Mohammed *et al.,* 2020). Estimating moisture content in food products is essential prior to consumption as it affects the food quality in terms of texture and shelf life. Lower humidity contributes to a more rigid texture, while higher humidity provides a medium for microbial growth and is directly connected to long-term storage, freshness, and stability of nutrients. The leaves' lower moisture content is an advantage in the product preparation as many products of *P. cauliflora* are being sold in the form of flakes and powder.

IV. TRADITIONAL USES

A perusal of literature revealed that *P. cauliflora* traditional usage is more prominent in Kalimantan, Indonesia and East Malaysia. Apart from food enhancers and seasoning, the leaves of *P. cauliflora* have been used traditionally to treat various ailments including eye irritation, headache, fever, seizures, malaria, stomach bloatedness, and snakebite (Table 2). On the other hand, only two traditional uses have been reported for *P. longifolia* where the leaves are used to reduce fever in East Malaysia, and the roots for the treatment of snakebite in India (Ghosh, 2014; Mohammed *et al.,* 2020). It seems like the species are closely related in their traditional usage.

Table 2. Traditional Uses of *P. cauliflora*

Traditional Use	Location	Plant Part	References
Eye's irritation treatment	East Kalimantan	Not stated	(Rahayu *et al.,* 2007)
	East Kalimantan	Not stated	(Sutedjo *et al.,* 2007)
Headache relief	Centre Kalimantan	Leaves	(Santoso *et al*., 2019)
Seizures relief	Centre Kalimantan	Leaves	(Santoso *et al*., 2019)
Reducing fever	West Kalimantan	Leaves	(Kamaludin, 2018)
Malaria treatment	Indonesia	Root	(Ramadani *et al*., 2017)
Bloated stomach treatment	Kalimantan	Leaves	(Afrianti, 2007)
Ghost disturbance treatment	Kalimantan	Leaves	(Afrianti, 2007)
Food enhancer and seasoning	Sumatra	Leaves	(Puspita *et al.,* 2020)
	Sabah	Leaves	(Salim *et al.,* 2020)
	Central Kalimantan	Leaves	(Wardah & Sundari, 2019)
	East Kalimantan	Not stated	(Maharani *et al*., 2020)
	East Kalimantan	Not stated	(Sutedjo *et al.,* 2007)
	West Kalimantan	Leaves	(Satrima *et a*l., 2015)
	West Kalimantan	Not stated	(Kardina *et al.,* 2019)
	West Kalimantan	Not stated	(Wiwik *et al.,* 2019)
After giving birth treatment	Central Kalimantan	Not stated	(Wardah & Sundari, 2019)
Meat processing	East Kalimantan	Not stated	(Maharani *et al*., 2020)
Cancer/tumor treatment	West Kalimantan	Not stated	(Yusra *et al.,* 2020)
Snakebite treatment	Sabah	Leaves	(Salim *et al.,* 2020)

V. PHYTOCHEMISTRY

Besides phytochemical screening of the main groups of phytochemicals (alkaloids, flavonoids, tannin, terpenoids, steroids, saponin and phenol), there is no report on their isolation from *P. cauliflora*. Based on the reported qualitative phytochemical screening data on different parts of the plant shown in Table 3, *P. cauliflora* was found to content high in alkaloid (+++) and traces of flavonoids, tannins, terpenoids,

steroids, saponins, and phenolics (+). Nevertheless, some volatile constituents from the leaves of *P. cauliflora* and *P. longifolia* detected through GC-MS analysis have been recently reported (Puspita & Setyo, 2020; Mohammed *et al.,* 2020). Although the class of compound is the same, the volatile compounds detected in both species are different (Table 4). This data is an evidence to support the dissimilitude between the species. The compound names and their structures are shown in Table 4.

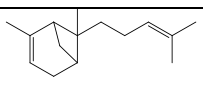
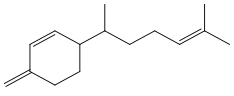
For *P. longifolia*, ten compounds of the bisbenzylisoquinoline, isoquinoline and aporphine groups of alkaloid were isolated in the early 80s. The names and the structures of the alkaloids are shown in Table 5 below. Based on the phytochemistry data reported on both species, there is a need to further explore the chemistry of *P. cauliflora* in order to compare the chemical constituents of both species.

Table 3. Phytochemical Screening of *P. cauliflora*

Phytochemical Constituents	Qualitative content	Part	References
Alkaloid	+++	Leaf	(Purba *et. al.,* 2014; Pamuji, 2015; Masriani *et. al.,* 2019; Fadly, 2020)
	+	Branch	(Masriani *et. al.,* 2019; Fadly, 2020)
	+	Root	(Masriani *et al.,* 2019)
Flavonoid	+	Leaf	(Pamuji, 2015; Masriani *et. al.,* 2019; Fadly, 2020)
	+	Branch	(Masriani *et. al.,* 2019; Fadly, 2020)
Tanin	+	Leaf	(Purba *et. al.,* 2014; Pamuji, 2015)
Terpenoid	+	Leaf	(Masriani *et. al.,* 2019; Fadly, 2020)
	+	Branch	-
	+	Root	(Masriani *et al.,* 2019)
Steroid	+	Leaf	(Pamuji, 2015; Masriani *et. al.,* 2019; Fadly, 2020)
	+	Branch	(Masriani *et. al.,* 2019; Fadly, 2020)
	+	Root	(Masriani *et al.,* 2019)
Saponin	+	Leaf	(Masriani *et. al.,* 2019; Fadly, 2020)
	+	Root	(Fadly, 2020)
Phenol	+	Leaf	(Pamuji, 2015; Fadly, 2020)
	+	Branch	(Fadly, 2020)

Qualitative approximation scale: '+' trace, '++' moderate, '+++' high, and '-' negative

Table 4. GC-MS Analysis of Volatile Components of *P. cauliflora* and *P. longifolia*

Plants	Part	Class of Compound	Compound Name	Molecular structure	References
P. cauliflora	Leaf	Terpenes	α- bergamotene **1**		(Puspita & Setyo, 2020)
			β-sesquiphellandrene **2**		

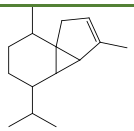
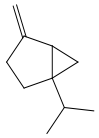
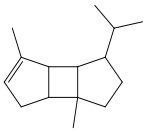
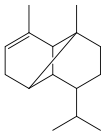
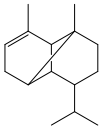
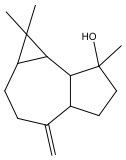
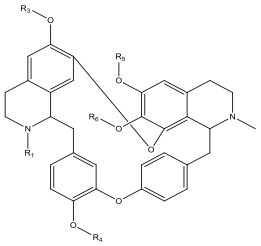
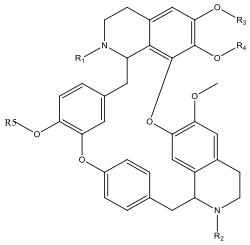
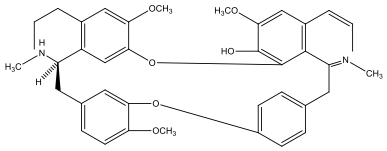
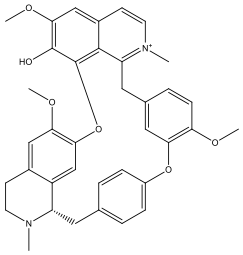
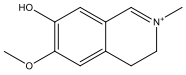
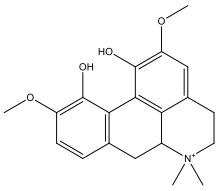
P. longifolia	Leaf	Terpenes	α-cubebene **3**		(Mohammed *et al.,* 2020)
			Sabinene **4**		
			α-bourbonene **5**		
			α-ylangene **6**		
			α-copaene **7**		
			Spathulenol **8**		

Table 5. Alkaloids Isolated from *P. longifolia*

Class of alkaloid	Compound name	Molecular structure	References
Bisbenzylisoquinolines	Daphnoline **9** Homoaromoline **10** Aromoline **11** Obaberine **12**	 **9**: (1-R, 1'-S). R1 = R3 = R5 = CH3.R2 = R4 = R6 = H **10** : (1-R, 1'-S). R1 = R2 = R3 = R4 = R5 = CH3.R6 = H **11**: (1-R, 1'-S). R1 = R2 = R3 = R5 = CH3.R4 =R6 = H **12**: (1-R, 1'-S). R1 = R2 = R3 = R4 = R5 = R6 = CH3	(Siwon *et. al.,* 1981; Grundon, 1983)

	Limacine **13** Krukovine **14**	 **13**: (1-R, 1'-R). R1 = R2 = R3 = R5 = R6 = CH3.R4 = H **14**: (1-R, 1'-R). R1 = R2 = R3 = R6 = CH3.R4 = R5 = H	(Siwon *et al.*, 1981; Grundon, 1983)
	Colorflammine **15**		(Van Beek *et al.,* 1982)
	Berbacolorflammine **16**		(Van Beek *et al.,* 1982)
Isoquinoline	Pycnarrhine **17**		(Siwon *et. al.,* 1981; Grundon, 1983; Lundström, 1983; Lundström, 1985)
Aporphine	Magnoflorine **18**		(Siwon *et. al.,* 1981; Kametani & Honda, 1985)

VI. BIOLOGICAL ACTIVITIES

Different parts and extract types of *P. cauliflora* have been reported to possess various biological activities including cytotoxic, antioxidant, antiparasitic, anticancer, and protein tenderiser properties. Only two were reported for *P. longifolia* which were antioxidant and antimicrobial properties. The research on the biological activities mainly focussed on the cytotoxic activity towards cancerous cells. From the biological activities tested, the root extract of *P. cauliflora* seems to be a potent cytotoxic agent against human breast cancer T47D cell line with IC_{50} value of 1.5 ± 0.2 µg/ml (Masriani *et al.,* 2014). In addition, the infusion of root and stem extract also displayed strong antiparasitic activity against *Plasmodium falciparum*, *Babesia divergens*, and *Leishmania infantum* with EC_{50} values of 3.3 µg/ml, 1.2 ± 0.7 µg/ml, and 1.7 ± 0.7 µg/ml, respectively (Ramadani *et al.,* 2017), which are worthy of further exploration. These properties and the biological activities of *P. cauliflora* and *P. longifolia* are summarised in Table 6 and Table 7 below.

Table 6. Biological activities of *P. cauliflora*

Biological Activities	Part	Extract type	Activity Tested	Dosage/ IC_{50}/EC_{50}/ Percentage	Results	Notes	References
Cytotoxic	Root	Ethanol	Human cervical cancer HeLa cell line (MTT Assay)	23.2 ± 0.74 µg/mL	The ethanol extract of root was the most active and selective against human cervical cancer HeLa cells	Root > Stem > Leaves	(Masriani *et al.*, 2013)
	Stem			129.3 ± 33.82 µg/mL			
	Leaves			203.2 ± 24.79 µg/mL			
	Root						
	Root	Crude alkaloids	Human breast cancer T47D cell line	1.5 ± 0.2 µg/mL	The extract exhibited strong cytotoxic effect on T47D cells with IC_{50} of 1.5 ± 0.2 µg/ml.	The selectivity index (SI) was 21.6	(Masriani *et al.*, 2014)
	Leaves	Methanol	Brine Shrimp Lethality Test	248.75 ppm	The LC_{50} value of the extract was 248.75 ppm	The extract with LC_{50} < 1000 ppm has anticancer potential	(Purba *et al.*, 2014)
	Roots	n-Hexane	Human cervical cancer HeLa cell line (MTT Assay)	141.7 µg/mL	The dichloromethane extract of roots exhibited the highest IC_{50} with the value 70.0 µg/mL and has the ability to induce apoptosis mechanisms	The IC_{50} value of doxorubicin in this experiment was 1.08 µg/mL	(Masriani *et al.*, 2019)
		Dichloromethane		70.0 µg/mL			
		Methanol		99.1 µg/mL			
	Branches	n-Hexane		130.8 µg/mL			
		Dichloromethane		90.7 µg/mL			
		Methanol		393.4 µg/mL			
	Leaves	n-Hexane		>500 µg/mL			
		Dichloromethane		>500 µg/mL			
		Methanol		368.8 µg/mL			
	Stem	Ethanol, liquid-liquid partitioned into: n-hexane dichloromethane of pH 3 dichloromethane of pH 7 dichloromethane of pH 9	Human breast cancer T47D cell line (MTT assay)	125.60 µg/mL	The dichloromethane of pH 7 showed the highest cytotoxic activity on human breast cancer T47D cell line	The dichloromethane of pH 7 with the concentration of 180 µg/mL showed the apoptosis induction up to 40.29% .	(Masriani *et al.*, 2019)
				115.61 µg/mL			
				59.30 µg/mL			
				130.32 µg/mL			
	Root	Ethanol	Human cervical cancer HeLa cell line (Flow cytometer)	56.31 %	The extract with the concentration of 12.5 µg/mL exhibited the highest percentage of apoptosis induction		(Masriani *et al.*, 2013)
	Root		Human cervical cancer HeLa cells (Flow cytometer)	52.95 %	The extract with the concentration of 12.5 µg/mL increased the cell cycle arrest at G0/G1 phase from 49.46 % to 52.95 %	The effect of the extract on HeLa cell cycle arrest appears to be concentration-independent where the higher the concentration, the lower the percentage of the cells in the G0/G1 phase	(Masriani *et al.*, 2013)
	Root	Crude alkaloids	Human breast cancer T47D cell line (Flow cytometer)	24.25 %	The extract with the concentration of 4 µg/mL increased the cell cycle arrest at G2/M phase from 20.45 % to 24. 45 %		(Masriani *et al.*, 2014)
Antioxidant	Leaves	Methanol	DPPH	608.81 ppm	The extract exhibits strong antioxidant activity	IC_{50} < 1000 ppm was characterised as strong antioxidant activity	(Purba *et al.*, 2014)
	Root	Methanol	DPPH	5.48 µg/mL	The extract exhibits very strong antioxidant activity	This IC_{50} value was characterised as strong antioxidant activity	(Masriani & Jumina 2015)
	Leaves	Ethanol	DPPH	99.18 µg/mL	The extract exhibits strong antioxidant activity		(Fadly, 2020)
	Stem	Ethanol	DPPH	55.68 µg/mL	The extract exhibits strong antioxidant activity		(Fadly, 2020)
Antiparasitic	Root and stem	Dichloromethane	Antiplasmodial activity against *Plasmodium falciparum*	3.3 µg/ml	The extract was active against the parasite	High activity can be obtained from the root extract	(Ramadani *et al.*, 2017)
	Root and stem	Methanol	Antiprotozoal activities against *Babesia divergens*	1.2 ± 0.7 µg/ml	The extract was active against the parasite	High activity can be obtained from the root extract	(Ramadani *et al.*, 2017)
	Root and stem	Dichloromethane	Antiprotozoal activities against *Leishmania infantum*	1.7 ± 0.7 µg/ml	The extract was active against the parasite	High activity can be obtained from the root extract	(Ramadani *et al.*, 2017)
Protein tenderiser	Leaves	Aqueous	Casein substrate in different temperature	1.1170 U/mL	The activity of the enzyme was high at 50°C	The optimum temperature for this reaction was 50°C	(Noviyanti & Ardiningsih, 2012)
Anticancer	Root	Methanol	8-OHdG Expression	0.38 µg/mL	The extract was active in inhibition of 8-OHdG expression	The extract managed to decrease the expression percentage from 31.32 % to 17.82 %.	(Masriani & Jumina, 2015)

Table 7. Biological activities of *P. longifollia*

Biological Activities	Part	Extract type	Activity Tested	Dosage/ IC_{50}/EC_{50}/ Percentage	Results	Notes	References
Antioxidant	Leaves	Methanol	DPPH	87.27 ± 0.25%	The results demonstrated very high antioxidant activity of the extract	-	(Mohammed *et al*., 2020)
Antimicrobial	Leaves	Methanol	*E. coli,* *B. cereus* *S. enterica* serovar *typhimurium*, and *S. aureus*	7.67 ± 0.58 8.67 ± 0.58 7.00 ± 0.00 9.33 ± 0.58	The extract inhibited the growth of four selected pathogens including *S. aureus*	The antibacterial activity slightly increased with higher concentrations	(Mohammed *et al*., 2020)

VII. SAFETY

Since the species *P. cauliflora* has a diverse traditional usage, particularly as food (Table 2), the safety aspect of this plant is important to be highlighted. Toxicity evaluation by Pamuji (2015) on the ethanolic leaves extract of *P. cauliflora* at a very high dose revealed that the extract did not cause death in the animal test and had no effect on acute toxicity parameters with a lethal dose (LD_{50}) greater than 5000 mg/kgbb. The author concluded the extract was non-toxic.

VIII. CONCLUSIONS

This review has shown that *P. cauliflora* and *P. longifolia* differ in certain aspects of morphology, traditional usage, phytochemistry, and biological activities. The biological aspect of *P. cauliflora* has been studied more compared to *P. longifolia*, and findings revealed that the former could be a potent source of anticancer drugs. Apart from the phytochemical screening test, no isolates have been identified. Thus, the chemistry of the former needs to be explored to support its biological activities and traditional usage, as well as to further evaluate the potential of this plant for commercial exploitation.

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