Journal of Functional Food and Nutraceutical

A REVIEW ON THE HEALTH BENEFITS OF KALAKAI *(STENOCHLAENA PALUSTRIS)*

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ABSTRACT

Kalakai (*Stenochlaena palustris*) is a common plant in Kalimantan and Sumatra which has been consumed locally as a vegetable. Information about the benefits of kalakai as a functional food has spread widely in the community. However, scientific information and research investigating the potency of kalakai are scarce, and the scientific literature is dominated by local Indonesian-language journals. This review aims to explore and compile the potential health benefits of kalakai based on its nutritional and bioactive content. Kalakai is reported to have various health benefits such as high fibre, antianemia, antioxidant, antidiabetic and antimicrobial activity. Referring to the current status of research, the processing of kalakai as a food functional or nutraceutical ingredient for antioxidative function and controlling blood sugar are the most potential. However, clinical and safety trials still need to be carried out as part of the preparation for the use of kalakai as a functional and nutraceutical food ingredient in the near future.

Keywords: bioactive compounds; functional food; health benefits; kalakai; stenochlaena palustris

ABSTRAK

Kalakai (*Stenochlaena palustris*) merupakan tanaman yang umum di Kalimantan dan Sumatera yang banyak dikonsumsi secara lokal sebagai sayuran. Informasi tentang manfaat kalakai sebagai pangan fungsional telah tersebar luas di masyarakat. Namun, informasi ilmiah dan penelitian yang menyelidiki potensi kalakai masih langka, dan literatur ilmiah didominasi oleh jurnal lokal berbahasa Indonesia. Tinjauan ini bertujuan untuk mengeksplorasi dan menyusun potensi manfaat kesehatan dari kalakai berdasarkan kandungan nutrisi dan bioaktifnya. Kalakai dilaporkan memiliki berbagai manfaat kesehatan seperti serat tinggi, antianemia, antioksidan, antidiabetes dan aktivitas antimikroba. Mengacu pada status penelitian saat ini, pengolahan kalakai sebagai bahan pangan fungsional atau nutrasetikal dengan fungsi antioksidan dan pengendalian gula darah adalah yang paling potensial. Namun, uji klinis dan keamanan masih perlu dilakukan sebagai bagian dari persiapan penggunaan kalakai sebagai bahan pangan fungsional dan nutraceutical dalam waktu dekat.

Kata kunci: kalakai; kandungan bioaktif; manfaat kesehatan; pangan fungsional; stenochlaena palustris

Article Information

Article Type: Review
Journal Type: Open Access
Volume: 4 Issue 1

Manuscript ID
V4n11057-1

Received Date
17 July 2022

Accepted Date
05 September 2022

Published Date
20 September 2022

DOI: 10.33555/jffn.v4i1.98

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Citation:
Pandiangan, F.I., Oslo, E.A., Destine, F., Josephine., Anwar, R.A. 2022. A Review on the Health Benefits of Kalakai *(Stenochlaena palustris).* J. Functional Food & Nutraceutical, 4(1), pp.1-16

INTRODUCTION

Indonesia has the potential for biological wide-range plant biodiversity that has not been explored and utilized optimally. Based on the local wisdom approach, many traditional tribes have utilised plants and herbs to produce foods and medicine which have a positive effect on health (Falah and Hadiwibowo, 2017). One of the plants that have great potential as a functional food is Kalakai (*Stenochlaena palustris* (Burm.f.) Bedd.). Kalakai is also known locally by other names such as *lemidi*, *lemiding*, *ramiding*, and *paku hurang*, while in Bangka Belitung, this plant is known as *pucuk iding-iding* and *paku miding* (Roanisca et al., 2017). Kalakai or *kelakai* (Kalimantan Tengah/Selatan), *miding*, *lemiding* (Kalimantan Barat), *paku bang* (Jawa), *majamajang*, *bampesu*, *wewesu* (Sulawesi), *lemidi* (Sumatera) and *paku nyai* (Malaysia) (Wahab et al., 2015).

Kalakai *(Stenochlaena palustris)* is a common vegetable found in Kalimantan. Kalakai has been used by local residents of Kalimantan, for example, the Dayak tribe to be consumed as vegetables. This wild-growing vegetable is usually easily found in lush areas or forests, especially in Central and South Kalimantan. Kalakai can thrive on peat land due to the high-water intensity, so kalakai can regrow optimally even though it has been harvested several times as long as the water supply is still available in the soil (Shinta and Atyk, 2011). Besides being used as a source of food, the local people of Kalimantan have used kalakai for health and medicinal purposes for example to cure anemia, stimulate breastfeeding milk production for postpartum mother , antipyretic, skin infection and as a diarrhea medicine (Yulianthima, 2017; Mawaddah, 2019).

Currently, functional food and nutraceuticals market are experiencing growth. The health and wellness food market value is experiencing an increasing trend globally from 733 billion U.S. dollars in 2020 increased significantly to 1,000 billion U.S. dollars in 2026 also for the value of the global superfoods market of 137 billion U.S. dollars in 2020 increased significantly to 209 billion U.S. dollars in 2026 (Shahbandeh, 2021a; Shahbandeh, 2021b). This shows that there is an increasing public need for the importance of food products that have a positive effect on health. With its potential benefit to health and if optimally developed into a functional food and nutraceuticals product, kalakai has the potential to be accepted by the market in the future.

Information about the benefits of kalakai as a functional food has spread widely in the community. However, scientific information and research investigating the potency of kalakai are scarce, and the scientific literature are dominated by local Indonesian-language journals. Furthermore, not many scientific papers have reviewed the potential of kalakai for human health. This review aims to explore and compile the potential health benefits of kalakai based on the nutritional and bioactive content, therefore the potential applications to be a further functional food would be noticeable. With this review, hopefully, more people will be scientifically aware to utilise kalakai as food, medicine or a new food ingredient.

GENERAL INFORMATION ABOUT KALAKAI

Geography

Stenochlaena palustris, or more commonly known as kalakai originates from Palangkaraya area in Central Kalimantan (Indrayanti et al., 2016). This plant can grow almost everywhere, even in less fertile growth mediums. Because of this, it is very easily grown and has the potential to be planted anywhere. It is most commonly grown in nutritionally dense peats, but can also be grown in less fertile soil, such as quartz sand and alluvial soils (Thursina et al., 2010). It grows in tropical, subtropical, or Monsal climates (Royal Botanic Gardens Kew, 2022). Kalakai can be also found in several countries around Indonesia such as in Australia, Malaysia, Thailand, Papua New Guinea, and even India and China as presented in Figure 1.

Taxonomy & morphology

Kalakai is a plant of the *Stenochlaena* genus in Blechnaceae family and Pteridophyta Division. The complete taxonomic profile of kalakai are as follows:

Kingdom	: Plantae
Class	: Filicopsida
Order	: Filicales
Tribe	: Blechnaceae
Genus	: *Stenochlaena*
Species	: *Stenochlaena palutris*

Figure 1. Geographic Location of Kalakai Plants (Royal Botanic Gardens Kew, 2022)

Other scientific names of *Stenochlaena palustris* (Royal Botanic Gardens Kew, 2022):

- *Lomaria haenkeana* C.Presl
- *Lomaria juglandifolia* C.Presl
- *Lomaria scandens* Willd.
- *Onoclea scandens* Sw.
- *Stenochlaena blumeana* C.Presl
- *Stenochlaena fraxinifolia* C.Presl
- *Stenochlaena hainanensis* Ching & P.S.Chiu
- *Stenochlaena juglandifolia* C.Presl
- *Stenochlaena laurifolia* C.Presl
- *Lomariopsis scandens* Mett.
- *Olfersia scandens* C.Presl
- *Polypodium palustre* Burm.f.
- *Acrostichum laurifolium* Hook.
- *Acrostichum palustre* (Burm.f.) C.B.Clarke
- *Acrostichum scandens* Hook.
- *Chrysodium palustre* (Burm.f.) Luerss.
- *Pteris scandens* Roxb.

Kalakai (*Stenochlaena palustris*) is one of the pteridophyte plants that grow well during the rainy season. The plant height is approximately 50 cm while the length of its leaves is ranged from 7.5–10.2 cm. Through visual observation, there are two types of kalakai, for instance red kalakai and green kalakai, as shown in Figure 2. The differences in colour indicate the level of leaf ripeness. Red indicates that the leaves are still young, while green indicates that they are old or mature. Kalakai develops vegetatively with fairly high ability. There is a difference in growth rate between the dry season and the rainy season. In the dry season, the growth rate of kalakai is slower than in the rainy season. This is due to differences in the ability to produce biomass and the limited amount of water that can be utilized. This plant has a relatively short harvest period (4-6 days) meaning that within that period it can be harvested again and grows well in areas that have high humidity such as peatlands (Shinta and Atyk, 2011).

Figure 2. Kalakai Plant (*Stenochlaena palustris*) Has Both Red and Green Leaves (Hidayah, 2020)

General use

Kalakai can be easily obtained by the public without having to buy it in certain places such as market or shop. This plant is widely found in the neighbourhood where the Dayak people live. Even though it is highly nutritious, the use of kalakai is still very limited and basic, due to the lack of innovation in processing. Their main use is primarily just in dishes and traditional medicine. Kalakai is usually cooked and often eaten with rice. The entire plant is edible, but the leaves and stalks are the most common parts to be cooked, as shown in Figure 3. It is considered a very common ingredient in the cuisine of the people in Central Kalimantan. In addition, Kalakai leaves can also be used to make herbal drinks. To compensate for the lack of scent, ginger is usually added, due to its strong, powerful scent, and therapeutic benefits (Juliani et al., 2019). Specifically, the kalakai used by the Dayak tribe to treat anemia has not been studied, but it provides real empirical evidence (ethnobotany) (Yulianthima, 2017). In Dr. Duke's Phytochemical and Ethnobotanical Databases, *Stenochlaena palustris* has a function for the treatment of aperient and fever treatment (USDA, 2022).

Figure 3. Sayur Kalakai (Example of a Dish Using Kalakai)

Table 1. Energy and Macronutrient Composition of Kalakai per 100 g

Type of vegetables	Energy (kkal)	Water (g)	Carbohydrate (g)	Protein (g)	Total Fat (g)	Fibre (g)	References
Kalakai leaves	38	89.9	6.6	2.4	0.2	5.8	(Kementerian Kesehatan RI, 2018)
	-	91.6 ± 1.74	4.23 ± 0.1	0.24	0.3		(Wahab et al., 2015)
Kalakai leaves	-	9	-	-	2.6	2	(Maharani and Haidah, 2006)
	-	10.2	-	8.3	0.7	24	(Jaelani et al., 2019)
Kalakai stem	-	7	-	-	1.4	3.4	(Maharani and Haidah, 2006)
Kalakai flour	329	7.87	68.3	8.3	2.5	-	(Fahriza et al., 2021)

NUTRITION COMPOSITION OF KALAKAI

Table 1 presented the list of Energy and macronutrient composition of kalakai per 100 g. In general, kalakai has a high-water content, just like some common leafy vegetables. Flour kalakai tends to have a higher nutritional value because the water content has been removed. When compared to fresh spinach, kalakai has 2x higher in energy value, 2.5x higher in protein content and 8x higher in fibre (Kementerian Kesehatan RI, 2018). The fibre content in kalakai is considered the highest when compared to common leafy vegetables such as kale, cassava leaves and mustard greens. Kalakai stem has less fibre compared to kalakai leaves.

Vitamin C

Some people think that kalakai has a high level of vitamin C. Vitamin C or ascorbic acid is one of the vitamins that human beings need. It is a coenzyme. It is commonly used for collagen formation which hydroxylation proline and lysine into hydroxyproline. Vitamin C is also an antioxidant and an electron donor for the human body that had a moderate effect on reducing the severity and duration of cold symptoms (Padayatty and Levine, 2016). It can be seen in Table 2. that kalakai contains varying levels of vitamin C 8-47 mg per 100 g. Kalakai may have higher levels of Vitamin C than carrots, but less than spinach and sweet orange. The variation of nutrient contents including

vitamin C is more likely to happen due to variation in seasonal and temperature variability and precipitation variability (Phillips et al., 2018; Giulia et al., 2020).

Table 2. Vitamin C Content of Orange and Kalakai per 100 g

Vegetables	Vitamin C (mg)	References
Kalakai leaves	8	(Kementerian Kesehatan RI, 2018)
	33 ± 13.7	(Wahab et al., 2015)
Carrot	18	(Kementerian Kesehatan RI, 2018)
Spinach	41	(Kementerian Kesehatan RI, 2018)
Sweet orange	49	(Kementerian Kesehatan RI, 2018)

Iron (Fe)

Fe, known as iron, is an important element to form hemoglobin (Hb) and its function as a transporter, storage, and oxygen utilization. It aids in the formation of haemoglobin, myoglobin, and cytochrome (Qamariah and Yanti, 2018). As shown in Table 3, from several studies, the iron content of kalakai per 100 g varies greatly from 1 to 291 g. The difference in iron content might be explained due to the different methods of iron analysis in each study. Nevertheless, the content of fresh and red kalakai leaves tends to be higher when compared to fresh spinach.

Dietary iron comes in two forms, non-heme iron and heme iron, with heme iron being greater efficiently absorbed in the gut. The greater efficiency of absorption because of specific heme transporters which enable heme iron to pass directly across cell membranes and into the bloodstream, while non-heme iron's is unable to use these transporters, reduction of ferric iron to ferrous iron must take place before the absorption (Young et al., 2018). The bioavailability of heme iron is considered as high as the absorption percentage is 25-30% (Harvey et al., 2005) while the absorption of non-heme iron tends to vary between 1-10% (Beck et al., 2014; Asakura et al., 2017). A study reported that sources of iron derived from plant-based sources of non-heme iron, which tend to contain certain iron inhibitors such as phytic acid, calcium, and polyphenols, therefore the amount and level of bioavailability in foods are important to prevent or treat anemia (Skolmowska and Głąbska, 2019). The aforementioned study also suggested that people, whose diet is dominated by plant-based foods, to increase their vitamin C and other organic acids intake to improve the iron bioavailability from their meals.

Table 3. Comparison of Iron Content in Milk and Other Foods per 100g

	Iron (Fe) (mg)	References
Kalakai flour	39.43	(Fahriza et al., 2021)
Kalakai leaves	291,32	(Maharani and Haidah, 2006)
	1.1	(Kementerian Kesehatan RI, 2018)
Kalakai stem	221	(Maharani and Haidah, 2006)
Kalakai leaves	33.64	(Thursina et al., 2010)
	0.08	(Wahab et al., 2015)
Red Kalakai	4.153	(Irawan et al., 2006)
Spinach	3.5	(Kementerian Kesehatan RI, 2018)

Calcium (Ca)

The comparison of Calcium content per 100 g of foods is presented in Table 4. Most of the studies reported that the calcium in kalakai tends to be lower than in cow milk and spinach. On the other hand, only a study conducted by Maharani and Haidah, (2006) found the opposite finding. Another study reported that a high intake of calcium from plant-based foods can reduce the risk of osteoporosis and increase bone mineral density in postmenopausal Korean women therefore plant-based foods such as vegetables can be an important source of calcium and provide vitamins and minerals that have beneficial effects on bone (Park et al., 2011).

HEALTH BENEFITS

Anemia prevention

Not only for cooking, but kalakai are also often used as traditional medicinal plants that are beneficial, such as antiaging, and help increase Iron content. Many people believe that these leaves can help to increase Hb blood levels. This is mainly due to the high Iron (Fe) content that is known to be contained in kalakai. From table 5, several studies found that the administration of kalakai-based food to females with anemia can raise the Hb blood level. Consumption of kalakai will contribute to supplying non-heme iron content that will be absorbed by the body and increase blood levels, as indicated by an increasing amount of Haemoglobin levels (Petricka et al., 2018; Aden, 2019). They are also suitable for lactating mothers (Hadi, 2017; Fahruni et al., 2018; Mahdiyah, 2020) as iron content can affect breast milk production (Rahmadiliyani and Audita, 2017). It was also reported that anemia is very common for new mothers, as there is a correlation between breastfeeding and a decrease in iron content (Lakew et al., 2015). Therefore, it is due to these benefits that kalakai is often consumed by new mothers. However further research, such as the study with larger samples, is needed to confirm the validity of previous findings regarding the effects of kalakai consumption on blood Hb level. Additionally, the bioavailability of kalakai in the human digestive system through a specific absorption mechanism is also required.

Table 4. Comparison of Calcium Content in Milk and Other Foods per 100g

	Calcium (mg)	References
Kalakai leaves	18	(Kementerian Kesehatan RI, 2018)
Kalakai leaves	182	(Maharani and Haidah, 2006)
Kalakai leaves	69.7	(Thursina et al., 2010)
Kalakai leaves	6.76	(Wahab et al., 2015)
Kalakai stem	169	(Maharani and Haidah, 2006)
Cow Milk	143	(Kementerian Kesehatan RI, 2018)
Spinach	166	(Kementerian Kesehatan RI, 2018)

Having enough Iron is, in general, more important for females than males. This is especially important for menstruating females. It is recommended that adolescent (14-18 years old) females consume 15 mg/day, while males consume 11 mg/day. The difference is more significant in adults (>19 years old), as it is recommended that females consume 18 mg/day, while males consume 8 mg/day. In general, Iron consumption is also beneficial for health. Iron is used to produce myoglobin, which functions as an oxygen supplier for muscle tissues. Some hormones also require Iron, as they are beneficial in hormone production (Abbaspour et al., 2014).

Table 5. Several Research on the Effect of Kalakai Consumption to Hemoglobin Level

Research method		Results	References
Study design	Quasi Experiment	After administration, the Hb levels of female students who experienced anemia increased by 6.859 gr/dl.	(Mawaddah, 2019)
Sample	10 female students with anemia		
Variable	After administration of Kalakai syrup, Hb levels increased		
Instrument	Hemoglobin Testing System Quick Check		
Statistical	Paired T – Test		
Study design	Quasi Experiment	The result showed of significant increases on Hb levels (3.24 g/dl) after consuming Kelakai (*Stenochlaena palustris*) for a week ($p \leq 0.05$)	(Petricka et al., 2018)
Sample	66 anemic Midwifery students (8-11 g/dl)		

Variable	Kelakai (*Stenochlaena palustris*) (250 mg) and ferrous fumarate tablet (60 mg) were administrated daily for a week.		
Instrument	Hb testing system quick-check tool		
Statistical	Paired and independent t-test.		
Study design	Quasi Experiment	The effect of the combination of iron supplements (Fe tablets) and vegetable kalakai (*Stenochlaena palustris*) on the average Hb levels of adolescent girls after the intervention of a combination of Fe tablets and vegetable kalakai there increased by 1.106 gr/dl.	(Sibala, 2018)
Sample	34 females who are already menstruating		
Variable	The effect of the combination of iron and kalakai on Hb levels		
Instrument	Hemoglobin Digital (Hb meter)		
Statistical	Paired T – Test		
Study design	Quasi Experiment	Hb levels of pregnant women after consuming vegetable stew of kalakai compared to before consuming boiled vegetables of kalakai increased by a difference of 0.711 gr/dl.	(Aden, 2019)
Sample	29 Pregnant Women who experience a decrease in Hb		
Variable	Local food on Hb levels in pregnant women		
Instrument	Hemoglobin Digital		
Statistical	Paired T – Test		

Antioxidative properties

Kalakai has several bioactive substances that act as strong antioxidants and potential cytotoxic because of the flavonoids, phenols, saponins terpenoids, and content in the extract (Roanisca et al., 2017; Arullappan et al., 2017; Adawiyah and Rizki, 2018; Adawiyah et al., 2020). Figure 4 and 5 showed the basic structure of flavonoid and phenols. It was shown that Kalakai has the ability to become antioxidants and anticancer, which could help in preventing diseases caused by free radicals. These properties are mainly due to the phenolic and flavonoid content in kalakai**.** Table 6 showed total phenolic and flavonoid content, and antioxidative activity measured using 2,2-diphenyl-1-picryl-hydrazyl-hydrate (DPPH) assays. A study showed that kalakai is to able keep the freshness for up to two days after harvesting before it wilts, while a moisture restriction, storing the fronds at a low temperature and covering the cut ends of the ferns with wet cotton then wrapped after harvesting enhances the degenerative process of senescence (Gunawan-Puteri et al., 2021).

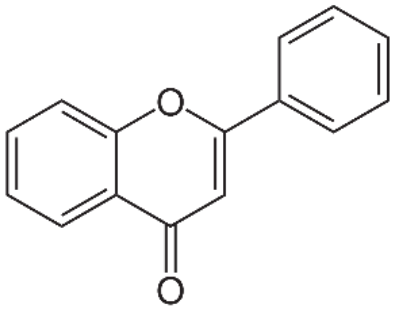

Figure 4. Basic Structure of Flavonoid

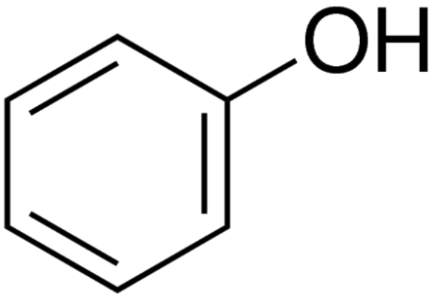

Figure 5. Basic Structure of Phenols

Table 6. Total Phenolic and Flavonoid Content, and Antioxidative Activity Measured Using DPPH Assays

Kalakai Extracts	Extraction	Phenolic Content (mg GAE/g)	Flavonoid Content (µg/mL of QE)	DPPH Assay	References
Leaves	Ethanol	3.80 ± 0.22	2.15 ± 0.005	24.24 ± 0.174 %	(Ndanusa et al., 2020)
Stem	Ethanol	2.30 ± 0.09	1.85 ± 0.030	89.96 ± 0.527 %	(Ndanusa et al., 2020)
Leaves	Ethanol	4.67	1.99	14.13 ppm (IC_{50})	(Kusmardiyani et al., 2016)
Kalakai root on peat soil	Ethanol	-	-	19,06 ppm (IC_{50})	(Adawiyah and Rizki, 2018)
Kalakai root on peat soil	Ethanol	-	-	24,40 ppm (IC_{50})	(Adawiyah and Rizki, 2018)
Leaves	Maceration.	14.5 ± 0.7	-	-	(Suhartono et al., 2012)
	Acetone	-	-	56,981 µg/mL	(Roanisca et al., 2017)
	Hexane	19.7 ± 0.8	12.4 ± 0.6	464.70 ± 20.75 (EC50)	(Chai et al., 2015)
	Chloroform	43.4 ± 2.4	1.7 ± 0.6	218.65 ± 9.57 (EC50)	(Chai et al., 2015)
	Ethyl acetate	133.0 ± 2.0	35.2 ± 1.3	49.68 ± 3.44 (EC50)	(Chai et al., 2015)
	Methanol	503.4 ± 22.8	6.9 ± 0.1	11.65 ± 0.46 (EC50)	(Chai et al., 2015)
	Water	319.5 ± 7.5	13.7 ± 0.1	19.30 ± 0.21 (EC50)	(Chai et al., 2015)
	Chloroform fraction	95.6 ± 0.9	–	134.80 ± 3.70 (EC50)	(Chai et al., 2015)
	Ethyl acetate fraction	415.2 ± 7.2	85.7 ± 5.4	15.03 ± 0.25 (EC50)	(Chai et al., 2015)
	N-butanol fraction	457.0 ± 9.5	58.3 ± 0.9	13.16 ± 0.22 (EC50)	(Chai et al., 2015)
	Water fraction	623.7 ± 5.1	7.5 ± 0.2	7.71 ± 0.11 (EC50)	(Chai et al., 2015)

The potent free radical-scavenging and antioxidant activity are highly dependent on the content and types of flavonoids contained. Flavonoids have been shown to exhibit antioxidant activity that has positive effects on human nutrition and health. The mechanism of flavonoid action is based on the scavenging or chelating process. A study conducted by (Suhartono et al., 2012). The purpose of this study was to determine the antioxidant activity contained in 75 µg/ml of kalakai leaf extract, and it was found that kalakai has a percentage of antioxidant activity of 27.64 ± 3.12, 16.60 ± 7.72, 60.10 ± 9.19 for ferrous ions, hydroxyl radical scavenging activity, hydrogen peroxide scavenging respectively. The aforementioned study suggested that kalakai has moderate antioxidant activity, so it has the potential to protect cells from H_2O_{2-} induced cytotoxicity with a decrease in the generation of Reactive oxygen species (ROS). Therefore, there is a potency of kalakai that exhibited higher cytotoxic effect against HeLa cells, and higher radical

scavenging activity to cure cancer in the future, but it obviously needs further isolation and purification, followed by structural elucidation, therefore, may reveal the potential pure compounds that exert its bioactivity (Arullappan et al., 2017).

Another study by Chai et al., (2015) found that Among the extracts, Methanol extraction had the highest total phenolic and total hydroxycinnamic acid contents. Among the fractions, the water fraction had the highest total phenolic and total hydroxycinnamic acid contents (Table 6). For the principal component isolation, water fraction is the best method to obtain the highest level of total hydroxycinnamic acid content with 154.3 ± 15.4 mg CAE/g. Another research also showed that due to the antioxidative properties, kalakai has anticholinesterase properties, which could aid in preventing cognitive diseases and disorders, such as Alzheimer's disease and dementia (Chear et al., 2016). In addition, a study by Adawiyah & Rizki (2018) found that the ethanolic extract from the roots of kalakai peat soil had a very strong antioxidant activity with high levels of flavonoids IC 50 of 19,06 ppm. Flavonoids as antioxidants have the potential to reduce levels of total cholesterol, triglycerides, low-density lipoprotein (LDL) and increase high-density lipoprotein (HDL). Flavonoids can prevent cell damage due to oxidative stress. Through in vivo testing, it was found that the administration of kalakai root extract with a dose of 400 mg/kg body weight, can reduce cholesterol and triglyceride levels in experimental rats whose results are close to simvastatin, a commonly prescribed medicine of lipid-lowering medication (Adawiyah et al., 2020). This opens up the possible application of kalakai as a functional food for hyperlipidaemia problems. In addition, a study found that phytosterols from kalakai may have a potential anti-breast cancer activity by inhibiting estrogenic receptor α and could be considered to prevent estrogen-dependent malignancies in humans, such as breast cancer (Marisa et al., 2021)

Antidiabetic

The alpha-glucosidase enzyme is known to be one of the main enzymes that break down carbohydrates into simple monosaccharides. It is an essential enzyme, as it helps convert complex carbohydrates into energy in the form of glucose. However, for those who have trouble regulating blood sugar levels, this enzyme activity may be detrimental. An example would be people who suffer from Diabetes, as an uncontrolled blood sugar level may lead to severe diseases (Domenichini and Ferri, 2022).

It is also known that *Stenochlaena palustris* exhibit alpha-glucosidase inhibitory (AGI) activity. AGIs are essential to diabetics, as they can halt the activity of the enzyme. This is done by preventing the breakdown of poly and oligosaccharides into monosaccharides. This delays the production of glucose and therefore delays the increase of blood glucose levels. However, most conventional AGIs are synthetic and may cause adverse side effects (Leng, 2016; Mahadika et al., 2017). Some research found that kalakai extract from young and mature have possessed potent, high natural alpha-glucosidase inhibitory (AGI) activity associated with hyperglycaemia treatment (Chai et al., 2015; Leng, 2016).

Methanol extract had better extraction capabilities when extracting the principal AGI components from *Stenochlaena palustris* (Chai et al., 2015; Gunawan-Puteri et al., 2021). For the alpha glucosidase inhibitors activity of S. palustris, water fraction showed the strongest alpha glucosidase inhibitors activity with EC50 2.92 ± 0.11 µg/ml (Chai et al., 2015) while different result was found by Gunawan-Puteri et al., (2021) that the ethyl acetate fraction had significantly higher alpha glucosidase inhibitory activity compared to the other fractions. Indeed, the smaller particle size of dried kalakai powder was shown to better facilitate the extraction of the principal AGI component. A study suggested that phenolic compounds, particularly hydroxycinnamic acids, and alkaloids may have contributed to the alpha glucosidase inhibitors and antioxidant activities detected in *Stenochlaena palustris* (Chai et al., 2015; Leng, 2016). However, the aforementioned study suggested that hydroxycinnamic acids is the most promising target for the isolation of alpha glucosidase inhibitors and antioxidants in *Stenochlaena palustris* while another study identified that astragalin or kaempferol 3-O-β-

glucopyranoside as the active compound which is responsible for the alpha glucosidase inhibitory activity in *palustris*(Gunawan-Puteri et al., 2021).

Antimicrobial properties

Research on the Antimicrobial properties effect of kalakai extract is still very limited. Extract of kalakai with various solvents showed a range of antimicrobial activity including gram-positive bacteria, gram-negative bacteria and fungi (Table 7). A study conducted by Budiarti et al., (2021) reported antimicrobial activity with methanol solvent of green kalakai (mature leaves) is higher than in red leaves (young frond). The study showed that the concentration of 90% of green kalakai had equivalent activity as ampicillin in *Staphylococcus aureus* while a concentration of 90% had equivalent activity as ketoconazole in *Candida albicans.*

When the zone of inhibition in *Staphylococcus aureus* is compared with the antibiotics standard zone of inhibition (susceptibility range set by CLSI), the antibiotic azithromycin had a standard zone of inhibition of 21-26 mm (Demissie et al., 2021), then the kalakai ethanol extract with concentrations of 60%, 75%, and 90% had equivalent inhibition zones, 23 mm, 25 mm, and 28 mm of each (Budiarti et al., 2021). This is similar to the antibiotics Amoxicillin and Ciprofloxacin for *Escherichia coli* which have standard inhibition zones of 15-22 mm and 30-40 mm respectively (Demissie et al., 2021), then the kalakai extract with 70%, 80% and 90% ethanol had an inhibition zone > 22 mm (Budiarti et al., 2021), exceeded the amoxicillin inhibition zone, however, it is still below the ciprofloxacin. For other studies that have been carried out (Table 7), there are no comparable studies with similar inhibition zone. Thus, kalakai ethanol extract may have potential as a natural antibiotic in the future.

The antimicrobial activity in table 7 showed the variation of the inhibitory activity due to the different mechanism of inhibition of the active compound contained in an extract. In addition, the possible explanation on why the low antimicrobial activity in kalakai is due to the compounds are still in a mixture of various compounds, so that the inhibition activity is not optimal (Roanisca et al., 2018).

USE OF KALAKAI AS A FUNCTIONAL FOOD

Several attempts have been made to use kalakai as raw material for the manufacture of functional food products but in rather limited quantities. Santoso et al., (2022) tried to formulate kalakai into coffee and tea drinks mixed with artificial sweetener and milk. Kalakai extract has a characteristic putrid aroma, which increases with the addition of the amount of kalakai extract into the drink. Coffee was able to mask the putrid aroma and milk helped to decrease the bitterness, astringency, and distinct aroma of the kalakai. The opposite occured in tea drinks, the Putrid aroma in tea drinks was still existed and tended to get stronger with the addition of the amount of kalakai extract in the drink, followed by a darker colour change. However, the leafy aroma in coffee was still detected at a higher concentration of kalakai. It appeared that the addition of Carboxymethylcellulose as the thickener in the beverage could reduce the flavour and aroma perception due to less free water available to transport those taste stimuli. It was found that the highest sucralose (0.02%) and CMC (0.15%) concentration was the most suitable for fixing the attributes of coffee with kalakai and milk. However, Through AGI assay, it was found that the AGI inhibition activity was very low (<20%), thus it can be concluded that the sample showed no inhibition activity. Another effort to utilise kalakai as a functional beverage product was initiated by Mahdiyah et al., (2021) to develop a fermented tea from the leaves of kalakai, with the process such as, drying the kalakai leaves, then the kalakai leaves was boiled and then mixed with a starter of microorganisms with addition sugar and fermented for a few days to produce fermented tea.

Fahriza et al., (2021) developing high-iron cookies products made from chickpea flour substituted with kalakai flour for anemic pregnant women. The purpose of this product is chickpea cookies substituted with kalakai flour to be an alternative snack to reduce the increase in anemia rates for pregnant women, especially iron anemia. There was an increase in the iron content of cookies along

with the increase in the number of substitutions of kalakai flour used. This also happened in a study on the manufacture and formulation of baby porridge flour made from cassava and kalakai, where the addition of kalakai flour to baby porridge flour, can increase the iron content in baby porridge flour. (Sholihah and Agustina, 2018).

However, sensory-wise, the more substitutions of kalakai flour in cookies, the lower the panelists' preference for the taste and aroma of cookie products. Another effect is by increasing the proportion of kalakai flour used, making the resulting cookies darker in color. For texture, the addition of kalakai flour still gives a crunchy and crunchy taste but is a little rough when consumed.

Table 7. Antimicrobial Activity on Kalakai

Microorganism	Solvent	Concentration	Inhibition zone (mm)	References
Gram Positive Bacteria				
Staphylococcus aureus	methanol	10%	7	(Erwin et al., 2016)
	methanol	15 %	7	(Erwin et al., 2016)
	methanol	20 %	8	(Erwin et al., 2016)
	methanol	25 %	9	(Erwin et al., 2016)
	methanol	30 %	10	(Erwin et al., 2016)
	Ethanol	10%	4,88	(Roanisca et al., 2018)
	Ethanol	45%	17	(Budiarti et al., 2021)
	Ethanol	60%	23	(Budiarti et al., 2021)
	Ethanol	75%	25	(Budiarti et al., 2021)
	Ethanol	90%	28	(Budiarti et al., 2021)
	n-hexane	30%	6.2	(Malik and Hendra, 2021)
	Ethyl Acetate	30%	7.1	(Malik and Hendra, 2021)
	Dichloromethane	30%	6.4	(Malik and Hendra, 2021)
Bacillus subtilis	Ethanol	5%	6	(Roanisca et al., 2018)
Gram negative Bacteria				
Escherichia coli	methanol	10%	7	(Erwin et al., 2016)
	methanol	15%	7	(Erwin et al., 2016)
	methanol	20%	7	(Erwin et al., 2016)
	methanol	25%	8	(Erwin et al., 2016)
	methanol	30%	12	(Erwin et al., 2016)
	Ethanol	5%	5,28	(Roanisca et al., 2018)
	Ethanol	10%	5,28	(Roanisca et al., 2018)
	Ethanol	50%	16	(Budiarti et al., 2021)
	Ethanol	60%	21	(Budiarti et al., 2021)
	Ethanol	70%	24	(Budiarti et al., 2021)
	Ethanol	80%	27	(Budiarti et al., 2021)
	Ethanol	90%	30	(Budiarti et al., 2021)
	n-hexane	30%	6.1	(Malik and Hendra, 2021)
	Ethyl Acetate	30%	6.1	(Malik and Hendra, 2021)
	Dichloromethane	30%	12.1	(Malik and Hendra, 2021)
Fungi				
Candida albicans	Ethanol	60%	13	(Budiarti et al., 2021)
		70%	17	(Budiarti et al., 2021)
		80%	21	(Budiarti et al., 2021)
		90%	24	(Budiarti et al., 2021)

One of the other food products made from kalakai is kalakai leaf chips (Indrayanti et al., 2016). In addition, the use of kalakai leaves formulated with ginger in herbal drinks has a significant effect on antioxidant activity and sensory properties with the formulation of kalakai leaves and ginger 50:50 is the best treatment, because the presence of ginger formulations can overcome the weakness of colour, aroma and taste of the leaves of kalakai which found in herbal drinks (Juliani et al., 2019).

CONCLUSION

To date, this study showed that kalakai has potential as an ingredient for functional and nutraceutical foods. The potential of the kalakai is also supported by several research findings such as high fibre content, iron content which showed it can increase Hb levels in the blood, antioxidative properties that can be useful for controlling free radicals, as a treatment for Alzheimer's treatment and also has the potential to reduce hyperlipidaemia. However, referring to the current status of research, the processing of kalakai as a food functional or nutraceutical ingredient for antioxidative function and controlling blood sugar are the most potential.

Research related to the health benefits of kalakai and its use as a functional food is still very limited. Further research is still needed to deeply understand the content of vitamins, minerals and bioactive components in red (young frond) and green (mature frond) kalakai and its potential health benefits. In addition, the potential for further research must cover the identification of the role of each bioactive component in kalakai on its certain functional effects, synergistic effects caused by the combination of kalakai with other ingredients, as well as clinical and safety tests that still need to be carried out as part of the preparation for the use of kalakai as a functional food ingredient. and nutraceuticals shortly.

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