



REVIEW ARTICLE

# Review of Ethnopharmacology, Morpho-Anatomy, Biological Evaluation and Chemical Composition of *Syzygium polyanthum* (Wight) Walp.

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## ARTICLE HISTORY

Received: 17 June 2021  
Accepted: 23 October 2021

Available online  
Version 1.0 (Early Access): 25 December 2021  
Version 2.0 : 01 January 2022



## Additional information

**Peer review:** Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

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## CITE THIS ARTICLE

Abdulrahman M D. Review of Ethnopharmacology, Morpho-Anatomy, Biological Evaluation and Chemical Composition of *Syzygium polyanthum* (Wight) Walp. Plant Science Today. 2022;9(1):167-177. <https://doi.org/10.14719/pst.1386>

## Abstract

*Syzygium polyanthum* (Wight) Walp., a Myrtaceae member, is widely distributed in Southeast Asian countries. The Malays and Indonesians consume the leaves regularly as *Ulam* (food). It has also been used in traditional medicine to treat several ailments, including gastritis, hypertension, hypercholesterolemia, diarrhea, skin diseases, diabetes and endometriosis. So far, many publications on the biological activity and chemical profile of the plant have been published. There is a need to thoroughly examine the articles and combine the major findings highlighting the potential utility of the species. Thus, the present study aimed to review the ethnopharmacology, morpho-anatomy, biological evaluation and chemical composition of *S. polyanthum*. *In vivo*, *in vitro* antibacterial, antimicrobial, antidiabetic, antioxidants, essential oil and chemical composition of *S. polyanthum* were searched in Google Scholar, Scopus, Web of Science and PubMed. The investigations revealed that *S. polyanthum* is a medicinal plant with proven antioxidant, antibacterial, antifungal, antidiabetic and anti-inflammatory activities. The plant had a substantial impact on human health. Chemical ingredients extracted and characterised are monoterpene, sesquiterpene, oxygenated monoterpenes, oxygenated sesquiterpenes, phenolic and flavonoid compounds. The review found that the *in vitro* and *in vivo* biological evaluation of *S. polyanthum* was well documented. In order to have conclusive results on the plant leaves efficacy, a well-designed clinical trial is required. Efforts should also be taken for long-term conservation and management.

## Keywords

*Syzygium polyanthum*, phytopharmacology, phytochemistry, traditional uses

## Introduction

Since times, man has been utilising plants as the source of food and health care system to himself and his domesticated animals, it also serves as the source that provides readily available oxygen (1). Certainly, the great civilizations of the ancient Chinese, Indians and North Africans provide written evidence of man's ingenuity in utilizing plants for the treatment of a wide variety of ailments (2). To satisfy the curiosity and willingness in understanding the way environment and plants are interacting to help man survive, the field of ethnobotany is becoming pronounced globally (3, 4).

Many countries have adopted plants as the major source of their medical care due to the large costly price of modern medicine (1, 3). The accessibility and low-cost of the medicinal traditional system are two main

ideas that drive man reliance on plant (5). In this line, World Health Organisation (WHO) in 2013 documented that about 80% of the world population largely depend on the traditional medicinal system to treat their various ailments and improve their health status (4). It is estimated that 70-80% of people worldwide rely on traditional herbal medicine to meet primary health care needs and it is also used for income generation for livelihood improvement (6, 7).

There are approximately 250000 species of plants available globally, however, only 1% of tropical species have been studied for their medicinal properties (8). This contemporary world makes people more conscious of their well-being; people are now looking for a plant-based product to replace the expensive and synthetic products available all over the market (9). The demand for the product from plants source as a natural product will continue to increase because of their ability to cure and improve health status (10, 11). Traditional herbal medicine is given much attention when people begin to notice and observed the long-term effects of modern drugs. Studies have been conducted and documented to determine the efficiency of the traditional medicinal plants (12, 13). This study aimed to review the ethnopharmacology, morpho-anatomy, biological evaluation and chemical composition of *S. polyanthum* (Wight) Walp.

### Ethnopharmacology

*Syzygium polyanthum* is utilized for therapeutic purposes for a long time. Medically, the usage of plant parts has been developed as an alternative medical plant (14). *S. polyanthum* is among the preferred Ulam that has been taking for ages and is widely distributed all over Asian countries (1, 9, 15).

*Syzygium polyanthum* is locally called *Serai kayu*, *Serai kayu hutan*, *Daun salam* and many more other names among the people in Malaysia (16, 17). Whilst in Indonesia, it is named as Indonesian laurel or Bay leaf. In Indonesia it is one of the most popular medicinal plants with therapeutic value (18, 19). Mak, Doc maeo and Daeng klua are the Thai names, while San thuyen is the Vietnamese name (20). Parts of these plants are used to treat a variety of ailments around the world, particularly in Asia, Malaysia and Indonesia. These ailments include diabetes, high blood pressure, postpartum, cough, fever, vaginal infection, respiratory ailments, gastrointestinal, cancer and microbial diseases. Hypertension, diarrhea, diabetes and endometriosis have also been claimed to be cured (9, 17). South-East Asian cuisine is frequently flavored with this herb to give them a fresh, fragrant flavor (21). Its fruits and roots extracts can alleviate the effects of excessive alcohol intake (14). In Indonesia, the leaf is traditionally used to treat cardiovascular problems (22).

An ethnobotanical study conducted among diabetic outpatients at Health Community Centre in Medan, Indonesia, found *S. polyanthum* the most often used medicinal plant as traditional therapy for diabetes mellitus (23). It has long been used to treat a variety of ailments, the most well known of which being hypertension and diabetes (24,

25). As a traditional Malay remedy for hypertension, the leaves are ingested (15).

The leaves of *S. polyanthum* are well-known as a traditional remedy for diarrhea, cataracts, hypercholesterolemia, gastritis, skin problems and diabetes mellitus (14). Gastritis, diarrhea, itching, diabetic mellitus, astringent and scabies can all be treated using leaf extract (26). For diarrhea, a mixture of bark and leaves is used, while a mixture of leaves, bark and roots is crushed to provide relief from itching (27). Its leaves, bark, stem and roots are all used to treat diarrhea, diabetes and high blood pressure (28). Antidotes for alcohol intoxication include a blend of fruits and roots (27). It's also used to treat patients who have elevated uric acid levels (26). The leaves are mildly astringent or sour and when frying, the flavor intensifies (28). When the leaf is squeezed, it emits a pleasant scent (29). The leaf can be used as a seasoning, while the bark can be used to colour nets and woven bamboo (29). Its wood is used to make houses, furniture, tan fishing nets and colour bamboo matting brown-red (27).

Decoction and infusion are the most commonly used method to prepare the *Syzygium* plant parts; especially their leaves, bark and roots (9). In Malaysia, the plant parts of these plants are widely used in cooking as a result of scent color, flavor and odor (30-32). It is frequently used as flavor or spices for the dishes like vegetables, fish, meat, rice and many other types of food (33). Because of its strong aroma, it's commonly used as a spice in Indonesia (34). This plant plays an important role in the preparation of one of the favourites meals in Malaysia called 'nasi kerabu' and 'kerabu perut' or consumed raw leaves as 'Ulam' (16).

### Taxonomic History of Myrtaceae

Myrtaceae is a pantropical family of trees and shrubs with nearly about 55000 species, classified into two sub-families, 17 tribes and 142 genera (35). They are mainly found in a large number in Central America, South America, Australia and the southern hemisphere (36). In South-east Asian countries, they are widely disseminated and farmed (37).

Generally, the leaves of the Myrtaceae are in the opposite direction, internal phloem, evergreen and woody and abundance of oil glands in most of the members (38). The members are bisexual with polystemonous, fully inferior or partial inferior ovaries mostly with nectariferous hypanthium and actinomorphic flower (36). The monophyletic tribe Myrteae comprises most of the fleshy fruited Myrtaceae (39).

### Evolution and Ecological Distribution

The genus *Syzygium* Gaertn. Comprises of many species within the genus (40). *Syzygium* is the largest genus in the family of Myrtaceae, having approximately one thousand two hundred (1200) species (41). At the same time, it has been documented as the major (largest) genera of flowering plants (42). The genus was known for the ability to withstand drought which lead to their successful abundance. *Syzygium* species can be found in a wide range of environments (27).

History has shown that these species originated from South Asia countries like Nepal, Sri Lanka, Pakistan and India (38, 43). Though they are distributed all over the world, they are mostly found in tropical and subtropical regions (43). In terms of species richness, the genus is centered in Southeast Asia (44). This plant can be found in Thailand, Myanmar, Indo-China, Malaysia and Indonesia among other places (24).

From Malaysia to northeastern Australia, it has the most variety with numerous species that are poorly known and many more that have yet to be taxonomically defined (43). But for decades, the species *Syzygium* has been naturalized in Malaysia and became more successfully adapted to the environment (45). Members of this genus are reported to be rich in medicinally valuable volatile oils (46). Because of the extensive therapeutic potential, it has been widely disseminated (38).

Malaysia, Thailand, Indonesia and Singapore are among the Southeast Asian countries where *S. polyanthum* can be found. *S. polyanthum* is synonymous with *S. microbotryum*, *S. micranthum*, *S. cymosum*, *Myrtus cymosa*, *Eugenia resinosa*, *E. polyantha*, *E. nitida*, *E. polyantha*, *E. pamatensis*, *E. microbotrya*, *E. lucidula*, *E. junghuhniana*, *E. lambii*, *E. holmanii* and *E. atropunctata*. Indian Baywatch, Bay leaf and Japanese Baywatch are some of the common names for this species. The plant can be found in forests, streams, humid rainforests or waterlogged environments and hilly areas (38).

### Morphology

*Syzygium polyanthum* consists of densely foliaceous and large evergreen plants with thick bark and grayish brown wood (Fig. 1A). *S. polyanthum* has a taproot and a circular trunk with a slick surface (29). They have leathery leaves that are 6-12 cm long and shaped obovate elliptic or oblong ovate (Fig. 1B and C) (3). The leaves have a wide range of shapes, primary, secondary and tertiary veins are shiny and smooth and the tips are less acuminate and broad (47, 48). Panicles, which are 4-6 cm long and terminal or axillary, emerge from the branchlets beneath the leaves (Fig. 1B).

The flower from *S. polyanthum* is in a cluster of oblong or round shapes, yellowish white and scented (Fig. 1E). The calyx is about 4 mm long with a funnel shape and toothed (49). The petals look like a small disk, numerous stamens of about 4 mm long, but of different size and colour based on the species and environmental factor (49).

Fruits are oblong, ranging from 0.5-3.5 cm long, which are black or dark purple, the bear seed within the fruits (Fig. 1D). Lateral nerves 6-11 pairs, not tightly parallel; elliptic leaves to lanceolate with slightly citrus odor and mildly sour taste are summarized as the morphological key for identification (50).

### Anatomy

The leaf lamina transverse section revealed the presence of three layers of palisade mesophyll filling  $\frac{2}{3}$  part leaf lamina at adaxial part with four to five layers of spongy mesophyll (Fig. 2A) (35). Large intracellular space at the abaxial part (Fig. 2A). Oil glands were present at the adaxial part at



Fig. 1. *Syzygium polyanthum* whole plant (A), branch (B), leaf (C), Seed and flower (D) (116).

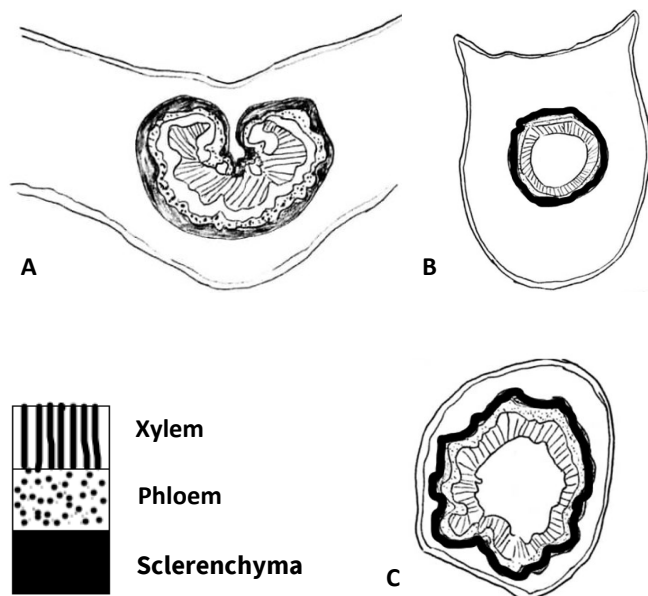
about  $\frac{1}{3}$  of the lamina transverse section (35). Anisocytic stomata; three non-radially arranged cells surround the guard cells (51). The subsidiary cells are mostly unequal in size, with one of the three being smaller than the other two [34].

The average stomatal length and width was 7-24 and 3-12  $\mu\text{m}$  respectively (35). Hypo stomatic stomata. A simple trichome was seen in the abaxial part of the lamina transverse (35). The vascular system at the midrib cross section was found an open system of vascular tissue,  $\frac{3}{4}$  or circular shape with an opening at the adaxial side (35, 50, 51).  $\frac{3}{4}$  of the petiole was occupied by parenchyma cells. Small oil glands were seen all over the petiole transverse section (Fig. 2A) (35).

Petiole anatomy have diagnostic taxonomical value for specie identification and later distinguished petiole vascular system as opened and 'closed system respectively (35). The vascular system at the petiole transverse section was found to be circle or oval shape vascular tissue, flat at adaxial surface and complete circle at the abaxial surface, sclerenchyma ensheathing the vascular tissue, follows by seven to eight layers parenchyma cells and small oil gland was seen all over the abaxial part. The over roll petiole transverse section is a circle shape at the abaxial surface and U shaped at the adaxial surface (Fig. 2B) (35).

Vascular system in the stem are significant importance for taxonomic identification of Myrtaceae family. Stem cross section were found to have closed vascular system. Vascular tissue is a circle form with no definite shape. Parenchyma pith was seen at the center of the vascular tissue. Sclerenchyma cells ensheathing the vascular tissue.  $\frac{1}{4}$  of the cross section of the stem was filled with parenchyma

cells.  $\frac{3}{4}$  of the stem cross section is circle at the adaxial surface and  $\frac{1}{4}$  at the abaxial surface is flat (Fig. 2C).



**Fig. 2.** Vascular bundle from the midrib (A), petiole (B) and stem (C) of *S. polyanthum* respectively.

### Biological Evaluation

Numerous studies on the biological evaluation of *S. polyanthum* parts (leaves, bark, stem, root) were conducted to investigate its biological activity against free radicals, bacterial, fungi or enzymes that cause diabetes (Supplementary Table 1). When compared to the other sections of the plant, leaves are determined to have the most biological activity (Supplementary Table 1).

Secondary metabolites were thought to be the most therapeutic component of the plant and they are largely produced in the leaves (16). A wide range of polarity, from non-polar to polar, should be used to extract the component from the plant parts (52). Extraction using different polarity solvents would be more successful in releasing the chemicals and obtaining extracts with semi-overlapping components (52). As can be seen in Supplementary Table 1, the biological potential of *S. polyanthum* was investigated using a variety of solvents.

### Antioxidants

Secondary metabolites come in a variety of shapes and functions, depending on the plant and its sections (38). Many nutritional supplements, nutraceuticals and functional food additives contain antioxidants, which help to preserve food by blocking oxidation processes and contribute to health promotion (53). Free radicals in the form of reactive nitrogen and oxygen species cause oxidative damage to nucleic acids, lipids and proteins. As a result, human chronic diseases such as aging, cancer and atherosclerosis may develop (21). A range of assays with diverse methods can be used to measure antioxidant activity (54). DPPH, FRAP and the Bleaching assays were among the methods employed to assess the antioxidant capacity of the oils and crude extract Supplementary Table 2.

*S. polyanthum* essential oil and crude extracts were discovered to protect against oxidative damage by blocking or quenching free radicals (Supplementary Table 2). Both extracts (Ethyl acetate and methanolic) have good antioxidants properties at  $IC_{50}$  of 13 and 21  $\mu\text{g/ml}$  respectively (55). The aqueous extract has an inhibition percentage of 84.83%, which is quite high (21). Leaves of *S. polyanthum* are known to contain active phenolic chemicals, which have antioxidant properties (21). They have been demonstrated to be effective as synthetic antioxidant replacements.

### Antidiabetic

Because of its great incidence and characteristics that might lead to other diseases, diabetes mellitus is a degenerative disease that receives a lot of attention when it comes to treatment (58). Diabetes currently affects 463 million people globally, with that number anticipated to increase to 578 million by 2030 (58). The antidiabetic investigation on the leaf revealed it to be promising against the diseases (24). Linalool, a recognized chemical with antidiabetic properties was found in the leaves (59). The presence of coumarins, flavonoids, terpenoids and polyphenols in the plant has been linked to their anti-diabetic properties (24).

Leaf has an antihyperglycemic action, lowering blood sugar levels from  $5.9 \pm 0.11$  mmol/L to  $3.4 \pm 0.05$  mmol/L respectively (24). The Butanol portion of *S. polyanthum* inhibited alpha glucosidase potently, as demonstrated by a low  $IC_{50}$  of 28 g/ml (59) and has 41.4% antidiabetic inhibition  $\alpha$ -glucosidase activity (29). At 500 g/ml, the fraction's ability to inhibit  $\alpha$ -glucosidase from acetone-water was at its peak, with a 97.34% inhibition rate (4:1) (57). The leaf extract has the potential to be used in the development of a functional drink to reduce diabetes risk (29). The diabetic volunteers in this study had high BGL levels, indicating that their diabetes was uncontrolled. The FBGL was reduced to 8.85% after 14 days of administration of the capsule (61). Leaf extracts given at a dose of 5.0 mg/kg body weight/day show an anti-diabetic effect (62). The ethanolic leaf exhibited  $IC_{50}$  of Alpha Glucosidase at 19.06 and Alpha Amylase at  $90.24 \pm 1.43$   $\mu\text{g/ml}$  respectively (63). The ethanolic leaves extract of *S. polyanthum* was found to be an efficient anti-hypoglycaemic agent, with an optimal dose of 5.0 mg  $\text{kg}^{-1}$  (64). Its leaves included essential oils, flavonoids, tannins, terpenoids and fatty acids, according to the phytochemical analysis (24). As a result, the existence of the aforementioned compound is related to the antidiabetic properties of the plant.

### Antibacterial

Due to their unrivalled chemical variety, natural chemicals in plant extracts or pure compounds can provide limitless potential for pharmacological therapy (25). There is an ongoing and urgent need to discover new antimicrobial compounds with diverse chemical structures and novel mechanisms of action due to an alarming increase in the incidence of new and re-emerging infectious diseases, as well as the development of resistance to antibiotics currently in clinical use. There are several methods for detecting anti-

bacterial activity currently available and the findings obtained vary because they are not all based on the same principles (Supplementary Table 1). The variations in the results could be due to the type of solvents utilized (Supplementary Table 1). The extracts from *S. polyanthum* leaves may be effective in the treatment of diaper rash, vaginal yeast infection, skin and other *Candida* infection-related disorders (18).

The use of essential oils as an antibacterial agent is becoming more popular, owing to its natural origin, broad spectrum of activity and generally recognized as safe status (23). Several bacterial were examined using various methods, including disc, agar and well diffusion method respectively Supplementary Table 2. *Bacillus subtilis* growth was substantially inhibited, while *Salmonella typhimurium*, *Staphylococcus aureus* and *Vibrio cholera* growth were marginally inhibited (65). Their main chemical ingredients, aldehydes and eugenol were involved in these antimicrobial activities (65). Methanolic and n-hexane extracts have IC<sub>50</sub> values of 23.16 and 35.01 and 49.25 and 27.54 at µg/ml respectively against *S. aureus* and *E. coli* (25). There was no activity on the gram negatives examined, but there was significant activity on the gram positives *Luteus* and *Mycobacterium smegmatis* (20). The leaves extract has a lot of effectiveness against the microorganisms that cause food poisoning (66). Its antibacterial properties may make it suitable for using as a natural food preservative.

### Antifungal

With the rising frequency of outbreaks of food-borne illnesses, food contamination has become a major concern (67). Plant bioactive plant extracts are widely used as medicine all over the world (67). All of the extracts are effective against *Mucor hialialis* (20). *Fusarium oxysporum* growth is significantly slowed (69). At 500 µg/ml *Candida tropicalis*, *Aspergillus flavin*, *Fusarium oxysporum* and *Aspergillus niger* showed significant growth suppression (68). This plant has antifungal properties against food spoilage fungi *Aspergillus* spp., *Euroticum* spp. and *Penicillium* spp. (70). These findings support the use of plant essential oils to keep bread fresh without the use of chemicals (70). The extract's antifungal activity increased significantly as concentrations were increased (71).

### Antihypertensive

Hypertension is a life-threatening condition. The % of people with a systolic blood pressure of 140 mmHg or higher grew from 17.31% in 1990 to 20.53 % in 2015 (72). At mg/kg, aqueous (20–100) and methanolic (40–100) extracts significantly reduced their blood pressure (15). According to this study, both methanolic and aqueous extracts of *S. polyanthum* leaves were able to cause significant vasorelaxation in normal and hypertensive rats (72). Acute ADSP (2.50 to 3.00 g/kg) and MESP (2.00 to 3.00 g/kg) treatment significantly lowered the hypertension (73). Have a reno protective effect in improving renal morphology in 22 hypertensive rats (74).

### Antidiarrhea

Diarrhea is one of the primary causes of death among children under the age of five in developing countries, account-

ing for 19% of all deaths among children under the age of five (75). The quest for antidiarrheal active extracts is critical to achieving diarrhea treatment. In animal models, a 30 % concentration of the extract shows effective antidiarrheal properties (75).

### Evaluation as Food Sanitizer

Fresh fruits and vegetables might include a variety of germs that originated in the growing environment (76). If appropriate decontamination procedures are not taken, bacteria will continue to multiply throughout postharvest handling and food processing, resulting in food spoilage (76). In this study, the total plate count was drastically reduced after exposure to 0.50 % for 5 min of soaking (66). There were no statistically significant differences in exposure times. In chicken and shrimp, 10 min of treatment with 1.0 % extract resulted in the greatest reduction in the microbial population (67).

### Antitumour

Plants are useful in medicine because they contain chemical components that have a physiological role in the human body (77). The early-antigen of Epstein-Barr virus, which was produced by a tumour promoter was fully repressed (78).

### Anticholesterol level

Obesity is characterized by an imbalance in energy intake and expenditure, resulting in the fat build up in the body. Natural products offer a wealth of possible components for use as an anti obesity treatment (79). Anticarcinogenic, anti oxidant, anti microbial and anti inflammatory effects have been discovered in hydroxychavicol. These findings imply that this herb could help with a range of health problems, including obesity (80). The extract inhibits pancreatic lipase activity by 43.14.02 % when used at 500 g/ml (79).

### Antiinflammatory

Inflammation manifests itself as pain, heat, redness, swelling and functional problems and is a common Défense response to tissue injury caused by physical trauma (81). The findings show that a dose of 75 mg/kg BW has the same effect as anti-inflammatory drugs in lowering edema volume in the rat foot (81).

### Antidental plaque

Everyone's right to health, especially their oral health, is unalienable. Plaque build-up was successfully reduced (82).

### Anticardiovascular

Cardiovascular disease (CVD) is becoming more common over the world. Each year, 17.9 million people die from cardiovascular disease, according to the World Health Organization (WHO) (82). The prevalence of cardiovascular disease was 48 % in 2013-2016, according to the National Health and Nutrition Examination Survey and it tends to climb with age (83). Administration of CRP and MPO decreased CRP and MPO levels in rats starting on day 4 after induction of myocardial infarction (83). Downregulation of *ADAM17*, which controls TNF regulation, is most likely the mechanism (84).

## Cytotoxicity evaluation

Toxicity is defined as any substance that caused harmful effects in a long run or immediately to the human system, after multiple or single consumption of such constituents within the first one to 24 hrs interval (85). The biological effect of the substance can be described as any changes or damages in an organ, or biochemical reaction that takes place within the body system of an organism. The leaves and fruit extracts of *S. polyanthum* were found to be inactive when tested using the brine shrimp lethality test (18). While in another study it demonstrated relatively little toxicity to brine shrimp larvae ( $LD_{50} > 1000 \text{ g/ml}$ ) (29). The results showed that the concentration with higher is more poisonous with  $LC_{50}$  values of  $707.945 \text{ }\mu\text{g/ml}$  for a 70% ethanol extract and  $977.237 \text{ }\mu\text{g/ml}$  for a 96% ethanol extract both of which were non-toxic since  $LC_{50}$  is below  $1000 \text{ }\mu\text{g/ml}$  (85). Normal mammalian cell lines are unaffected by the leaves of *S. polyanthum* (15). With  $IC_{50}$  values ranging from  $672.5759 \pm 42$  to  $126.0550 \pm 89 \text{ }\mu\text{g/ml}$ , the extract has a low cytotoxicity effect (87). At an  $IC_{50}$  of  $18.42 \text{ }\mu\text{g/ml}$ , the extracts were confirmed to be non toxic (68).

## Chemical contents

Many natural product chemists from throughout the world have been drawn to study physiologically active natural compounds derived from plants (18). Natural compounds with therapeutic characteristics are a valuable source of pharmacologically active molecules (110). Plant essential oils are highly volatile and have a distinct odour due to a complex blend of monoterpenes and sesquiterpenes (23).

The chemical makeup of essential oils of *S. polyanthum* has been researched on occasion by researchers from various parts of the world (3, 59, 99). Because of the medicinal properties of *S. polyanthum* essential oil (EO), increased phytochemical research on these species has focused on the EO. Monoterpenoids, sesquiterpenoids and fatty alcohols make up the majority of the EO. Chemical substances extracted from essential oils of the plant *S. polyanthum* are

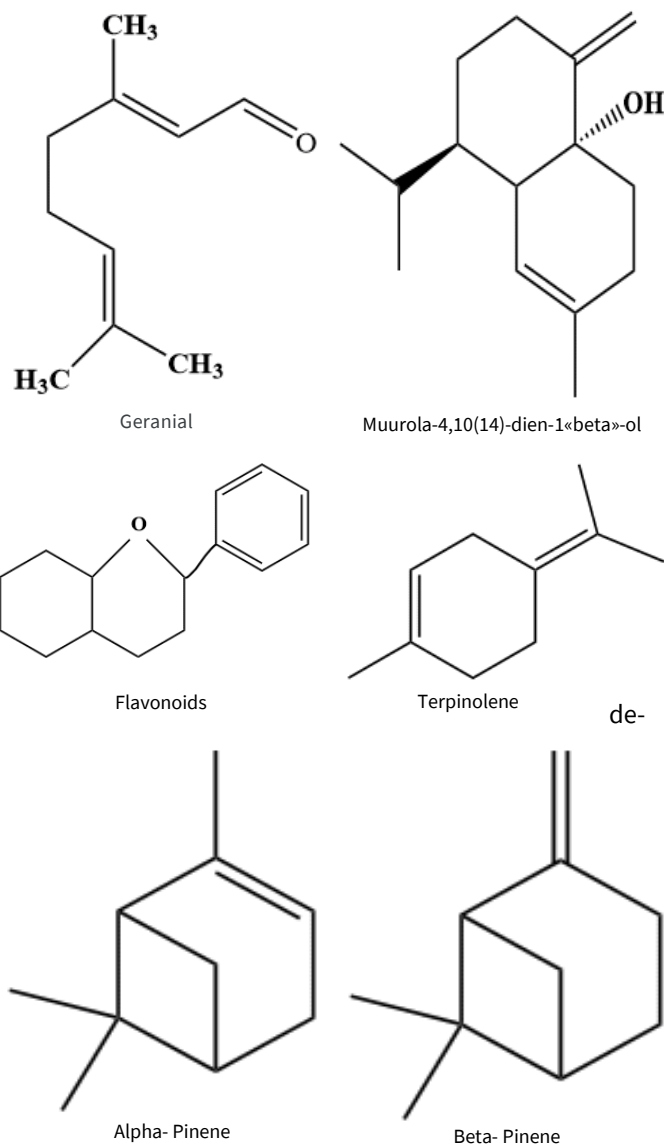
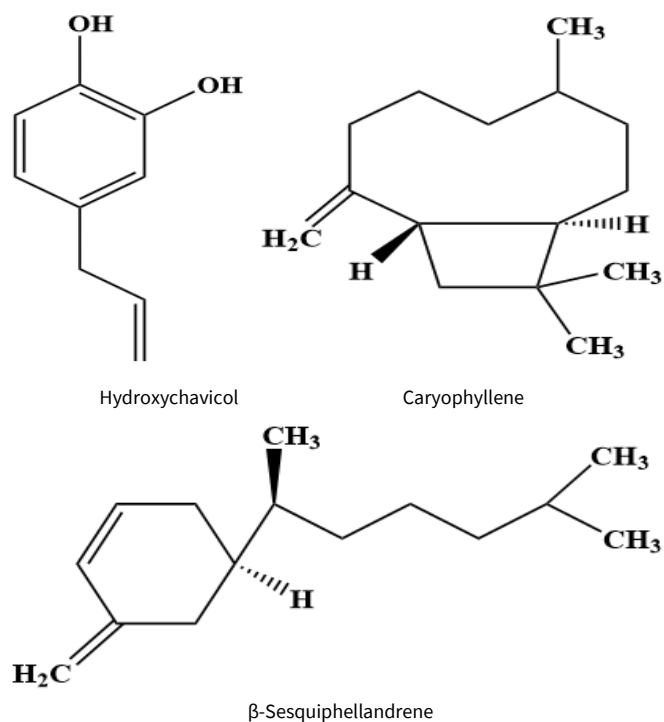


Fig. 3. Some of the chemical structure identified from *Syzygium polyanthum*

scribed (Fig. 3). These family members are known to be high in volatile oil (43). Several studies on the chemical constituents of *S. polyanthum* were conducted (Supplementary Table 2). The plants are particularly scented as a result of their composition (3).

GC/MS was used in several investigations, primarily on the leaves (65). Monoterpenes and sesquiterpenes are abundant in the plant, according to reports (Supplementary Table 2). Monoterpenes account for 53.8 % of the volatile oil's identified compounds, while sesquiterpene accounts for 16.22 % (3). Octanal (18.30), alpha-pinene (30.88) and alpha-caryophyllene (6.22) % are the major constituents (111), followed by 1-Decyl aldehyde (19.75), cis-4-decanal (43.489%) and capryl aldehyde (14.09) % (65).

Supplementary Table 2 also shows how the composition of essential oils from the *S. polyanthum* collected from different origins differ in terms of composition. This is due to the geographic origin, plant ontogeny and growing altitude of the plant habitat. The solvents used and the type of extraction used may also play a role in the difference in the chemical composition and its content. Squalene, for

example, is the most abundant chemical in leaves gathered from *S. polyanthum* in Kelantan in 2016, whereas alpha-pinene is the most abundant compound in leaves obtained from Besut Terengganu in Malaysia (3, 59).

Environmental conditions have an impact on the oil yield and chemical composition (3). Essential oil is used to cure a variety of ailments, including infections, as well as an insect repellent (112). Decanal is an agent that kills fungi and antimicrobials by preventing them from growing or reproducing (Supplementary Table 2). Essential oil is used in the pharmaceutical and cosmetic industries, as well as the tobacco and food businesses, as a taste enhancer and preservative (113). It is also used in the treatment of inflammation and chronic ulcer (3). The high hydroxychavicol content of this plant makes it a desirable dietary supplement for the treatment and prevention of a variety of ailments (80). The essential oils derived from the leaves of *S. polyanthum* will be useful as antidiabetic, antioxidant, antibacterial, antifungal and as food preservative sources.

## Conclusion

One of the most important sources for drug discovery is ethnomedicinal plants. *S. polyanthum* is an ethnomedicinal plant that is gaining popularity due to its diverse pharmacological properties. Numerous studies have been conducted on the plant parts, the majority of which have focused on the leaves. According to phytochemical studies, monoterpene, sesquiterpene, oxygenated monoterpenes, oxygenated sesquiterpenes hydrocarbons, phenolic and flavonoid compounds are responsible for the plant's medicinal activities.

Chemical profiling indicated irregularities in chemical composition, implying that the concentration contents of *S. polyanthum* fluctuate depending on plant location, age, collection time and processing method. As a result, a standard should be set up based on the following; geographic region, age, collection time and preparation procedure. Such efforts will lay a solid foundation for the plant's future development, modernization and clinical use, to find out which compound is responsible for these therapeutic effects of the leaves, to explore the principle of its action, a well designed clinical trial is required. It is also suggested to evolve conservation strategies of the plant in Asia to avoid extinction.

## Acknowledgements

I would like to express my sincere appreciation and gratitude to my supervisory team; Professor Dr. Nashriyah Mat and Professor Abdul Manaf Ali for their support and guidance. The chief editor, sectional editor and reviewers who volunteered their time and expertise to considerably improve the quality of this work are gratefully appreciated. Also, to Razeeqa Muhammad Shafiu, Dr. Abdulnadir Isah and Usman Muhammad for English proofreading.

## Compliance with ethical standards

**Conflict of interest:** Authors do not have any conflict of

interests to declare.

**Ethical issues:** None.

## Supplementary data

**Table 1.** Summary of the biological evaluation of *S. polyanthum*

**Table 2.** Chemical contents of *Syzygium polyanthum*

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