

## REVIEW ARTICLE

## Botanical Aspects, Phytochemicals and Health Benefits of Andaliman (*Zanthoxylum acanthopodium*)

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### ABSTRACT

Andaliman (*Zanthoxylum acanthopodium*) is a specialty spice widely found in the Provinces of North Sumatra and Aceh, Indonesia. The fruit is usually used by Batak people in North Sumatra as a food ingredient to cook Batak's cuisine such as arsik, tombur, and naniura. It is also used as one of the ingredients to make Indonesian spicy sauce called sambal. Andaliman fruit is reported to eliminate the undesirable smell in fish and raw meat. Moreover, it could also reduce total volatile base nitrogen content in fish which helps to prevent spoilage. Furthermore, andaliman has been reported to contain bioactive compounds which act as antioxidant, antimicrobial, anti-inflammatory, anti-aging, anti-acne, and anti-halitosis effects. This review focuses on the botanical aspects of and health potential exhibited by andaliman.

**Keywords:** andaliman; bioactive compounds; health benefits; *Zanthoxylum acanthopodium*

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### INTRODUCTION

Andaliman (*Zanthoxylum acanthopodium*) is a specialty spice in Indonesia, which is commonly found in the Provinces of North Sumatra and Aceh. The species itself is distributed particularly in Tapanuli, North Sumatra, at 1500 m above sea level at temperature between 15 - 18°C (Muzafri *et al.*, 2018). The fruit is usually used by Batak people in North Sumatra as food ingredient, and it is an economically important commodity because it

has a comparably expensive price in local markets (Sibarani *et al.*, 2013). *Z. acanthopodium* is relatively complex to grow in cultivation, and many local farmers rely on naturally-grown seedlings from recommended burning lands rather than sowing its seeds by themselves. Many natural populations occur in high slope habitat (Siregar, 2010). The plant also naturally occurs in rainforests and thickets at low and mid-altitude (Hartley, 1966). The genus (*Zanthoxylum*) belongs to the Rutaceae family, and plants included in this genus are mainly

used as spices and medicinal agents (Wijaya *et al.*, 2018). The genus has over 546 species from all over the world. *Zanthoxylum piperitum* (Japan), *Zanthoxylum schinifolium* (Korea), *Zanthoxylum simulans* (Taiwan), and *Zanthoxylum rhetsa* (India) have been used as traditional spices due to the natural flavors that produce unique sensations in the mouth (Wijaya *et al.*, 2018); but not limited to the utilization of the plants as medicinal agents.

*Z. acanthopodium* could also prolonged shelf life of the fish-based foods, such as arsik, tombur, and naniura, due to its antioxidant and antimicrobial activities. Andaliman could eliminate the undesirable smell in fish and raw meat (Muzafri *et al.*, 2018), also reducing total volatile base nitrogen (TVBN) content. Therefore preventing the spoilage of the fish. Andaliman produces strong tingling sensation and citrus-like aroma (Wijaya *et al.*, 2018). Besides, andaliman is usually used as one of the ingredients to make a chili-based paste which is known as *sambal* in Indonesia.

Andaliman has been reported to have several health effects. Studies showed that andaliman contains bioactive compounds which act as antioxidant and radical scavenging activity, antimicrobial, anti-inflammatory, antipyretics, anti-halitosis, anti-aging and anti-acne, and many else (Situmorang *et al.*, 2019; Muzafri *et al.*, 2018; Hanum & Laila, 2016; Suryanto *et al.*, 2005).

## BOTANICAL ASPECTS OF ANDALIMAN

### Origin and Botanical Classification

Andaliman (*Zanthoxylum acanthopodium*) is naturally distributed in North India, Nepal, Sikkim, East Pakistan, Burma, Thailand, and Southwest China. In Indonesia, this species only occurs in Aceh and North Sumatra. Andaliman belongs to the genus *Zanthoxylum*, which

distinguished from the other genus in Rutaceae family for the combination of three characters: armed, leaves alternate and compound (generally pinnate), and carpels entirely or partially distinct (Hartley 1966). Among the other Malesian *Zanthoxylum* species, *Z. acanthopodium* is clearly distinguished by their flattened and pseudostipular prickles. This species is different from *Zanthoxylum armatum* due to the observable leaflet main vein, the color of the anthers prior to anthesis, and the inflorescence that positioned in the axil of lateral leaves (Hartley 1966).

### Morphology and Structure

There are three varieties of andaliman that can be found in North Sumatra province, which are renowned as sihorbo, simanuk, and sitanga. These three varieties are commonly found in districts of Tapanuli, Tobasa, and Dairi. In specific, sihorbo has larger fruit, is less aromatic, and is not produced in abundant amounts. Simanuk has smaller fruit, a sharper aroma and taste, and a larger production yield. Sitanga has a very strong fruit flavor yet less preferred due to its bug aroma (Napitupulu *et al.*, 2004).

*Z. acanthopodium* plant is in the form of shrubs or small trees that can grow up to 5 m. This species has many spines on its stems and compound leaves spread out 5-20 cm long and 3-15 cm wide. The upper surface color of the leaves is shiny green while the lower surface is light green. The flowers are located on the axillary buds and the plant itself is androgynous which has staminate (pollen-producing male part) and carpellate (ovule-producing female part) with a pale yellow color. The shape of the fruit is like pepper, small round, could be light colored green and/or dark red (Siregar, 2003). It could turn into black when it is dried (Muzafri *et*

*al.*, 2018). The size of the fruit is 2-3 mm in diameter with one seed in each fruit colored in shiny black and covered with hard skin (Siregar, 2003). Black andaliman usually has no typical flavor of andaliman compared to the green or red andaliman. Red andaliman is the indication that the andaliman fruit is ripened and as the process goes on, it will turn into black (Wijaya *et al.*, 2018).

### Cultivation

Andaliman was found growing wild and it has not been widely cultivated. Plants grow naturally from seeds dispersed by birds (Siregar, 2010). Seeds can also be found near the old trees in prescribed burns area, and in soil seed bank of andaliman habitat (Nurlaeni and Junaedi, 2018). Andaliman is known to be difficult to propagate and shows a low germination rate. Furthermore, information about andaliman cultivation technique is still limited. An effort of andaliman propagation has been carried out in several studies. First, is the generative propagation, which requires dormancy-breaking treatments including the use of warm water and the potassium nitrate (KNO<sub>3</sub>) solution to soak the seeds (Siregar, 2010; Siregar, 2013). Secondly, is the vegetative propagation, which is using stem cutting of andaliman with additional plastic cover and plant growth regulators (Siregar, 2010). On the other hands, another vegetative technique has been done which is known as *in vitro* culture. Purohit *et al.* (2019) reported that another *Zanthoxylum* species (*Z. armatum*) could be cultured by indirect organogenesis using aseptic leaf explants in liquid Woody Plant Medium with various concentration of Thidiazuron.

### BIOACTIVE COMPOUNDS AND EXTRACTION TECHNIQUES

According to Muzafri, Julianti & Rusmarilin (2018), andaliman fruit extract produced the highest yield when it is extracted with methanol, then followed by with ethyl acetate, water, and hexane (4.15%, 3.97%, 3.23%, and 3.02%, respectively). These solvents worked for different phytochemicals. Alkaloids can be extracted with methanol, ethyl acetate, and hexane. Flavonoids, glycoside, and tannins can be extracted with water, methanol, and ethyl acetate. Saponins can be extracted with methanol, and ethyl acetate. Triterpens/steroids can be extracted with methanol and hexane, while glycoside anthraquinone can only be extracted with methanol (Muzafri, Julianti & Rusmarilin, 2018).

The solvent used for extraction of bioactive compounds in andaliman determines the stability of the compounds according to Suryanto, E., Sastrohamidjojo, H., & Raharjo, S. (2004). In addition, acetone and ethanol extracts are heat- and light-stable.

### HEALTH BENEFITS OF ANDALIMAN

Andaliman has been reported to exert health-beneficial effects. Researches showed that andaliman contains several functional properties including but not limited to antioxidant activity, antimicrobial activity, anti-inflammatory, anti-aging and anti-acne, and anti-halitosis effects.

#### Antioxidant Activity

Andaliman showed antioxidant activity when it is extracted with hexane, ethanol, and acetone. All extracts had 1,1-diphenyl-2-picrylhydrazyl (DPPH) scavenging activity, with the highest anti-radical activity was shown by

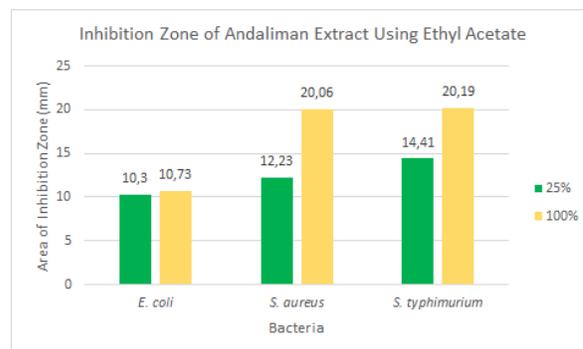
ethanol-extracted andaliman. The antioxidant properties of andaliman is due to the presence of flavonoid compound (Suryanto & Rahardjo, 2004). Another study was done by evaluating the petroleum ether-extracted andaliman. However, the extract showed a weak antioxidant activity compared to butylated hydroxytoluene (BHT) and quercetin that acted as the standards (Elenora Kristanty & Suriawati, 2014). A study conducted in 2015 generated results that andaliman extract had a lower antioxidant activity compared to that of Japanese pepper (Karnady, 2015).

### Antimicrobial Activity

Extract of andaliman has been reported to contain alkaloids, flavonoids, glycoside, saponins, tannins, triterpenoid/steroids, and glycoside anthraquinones. The substances that provide the antimicrobial activity are flavonoids, alkaloids, and tannins. Phenolic compounds seem to have better antimicrobial activities compared to flavonoids. Andaliman extract can be used to inhibit the growth of *Escherichia coli*, *Staphylococcus aureus*, *Staphylococcus typhimurium* (Guleria et al., 2013), *Bacillus stearothermophilus*, *Pseudomonas aeruginosa* and *Vibrio cholera* (Muzafri, Julianti & Rusmarilin, 2018).

Phenolic and flavonoids also reported to have antifungal activity which can inhibit the growth of *A. alternata* and *C. lunata* (Guleria et al., 2013). Alkaloids are reported for its antimicrobial activity against *Staphylococcus aureus*, *Streptococcus sanguis*, *Escherichia coli* and *Pseudomonas aeruginosa*. Berberine, beta-hydrastine, canadine and canadine are compounds that are included in alkaloids group and were reported to have antimicrobial activities (Muzafri, Julianti & Rusmarilin, 2018). As for the steroids, it prevented the growth of

*E. coli*, *Salmonella typhi*, *Staphylococcus aureus* and *B. subtilis*. Meanwhile, triterpenoids inhibited *B. subtilis*, *S. aureus* and *E. coli*. The examples of compounds in triterpenoids group are linalool, indole, and kadinen (Muzafri, Julianti & Rusmarilin, 2018).



**Figure 1.** Inhibition Zone of Ethyl Acetate Extract of Andaliman in Different Concentration against Several Pathogenic Bacteria

Methanol-extracted andaliman had the highest yield (4.15%) followed by extraction with ethyl acetate (3.97%), water (3.23%), and hexane (3.02%). Moreover, water- and methanol-extracted andaliman gave the highest growth inhibition towards *S. aureus* and as the concentration was getting higher, the inhibition zone increased. Ethyl acetate-extracted andaliman was reported to give the best antimicrobial effect compared to other solvent (Sitanggang, Duniaji & Pratiwi, 2019; Wijaya, Napitupulu, Karnady & Indariani, 2018). As shown in Figure 1, andaliman ethyl acetate extract showed inhibition effect to the growth of *S. typhimurium* and gave highest antimicrobial activities with minimum inhibitory concentration (MIC) value of 0.5% as reported by Muzafri et al. (2018).

Bacterial cell wall and porin protein of the bacteria would affect their susceptibilities towards the compounds and solvents used which makes the result varies (Muzafri, Julianti

& Rusmarilin, 2018). Andaliman extract can cause cell lysis by destroying the cell wall and causing the intracellular metabolites to leak out by increasing the permeability (Parhusip, Jenie, Rahayu & Yasni, 2010). The permeability increases due to the presence of phenolic compounds that can interact with the cytoplasmic membrane of the bacteria (Wijaya, Napitupulu, Karnady & Indariani, 2018).

### Anti-Inflammatory Effect

There is only one study available for the andaliman anti-inflammatory effect. According to a 2011 study, andaliman fruit extract was capable of promoting the anti-inflammatory activity by suppressing the inflammatory mediators such as TNF- $\alpha$ , IL-6, MMP9, COX-2 and iNOS in lipopolysaccharide (LPS)-induced macrophages. This study acted as *in vitro* cell model of gastric inflammation. The presence of glycoprotein, phenylpropanoids, neolignan and alkaloids may contribute to the anti-inflammatory properties of andaliman (Yanti, Nuriasari & Juliana, 2011).

### Anti-aging and Anti-acne

Aging can be defined as a condition where the human body starts to lose their physiological function which can be indicated by the decrease in reproductive rate (Flatt, 2012). Aging may also lead to the inability to respond towards stress conditions (Samarakoon, Ravishankar & Chandola, 2011). In most cases, people are being more concerned about skin aging. Skin aging can be caused by either intrinsic or extrinsic factors. Intrinsic factors such as genetic, hormones, and metabolism, while extrinsic factors are light exposure, pollution, radical, and toxins (Ganceviciene, Liakou, Theodoridis, Makrantonaki & Zouboulis,

2012). Exposure towards sunlight damages collagen and leads to cell death.

Hanum & Laila (2016) reported that peel-off gel mask (PGM) of andaliman can help to reduce skin pore size and remove dirt and dead cells from the skin. Formation of blackheads is correlated with big pore size which makes dirt or dust enter the skin easily. Aging and increase in body temperature when doing exercise can lead to a bigger pore size in the skin. Therefore, routine usage of PGM made from andaliman can be used as an alternative.

Black spots formation is also one of the concerns related to skin aging. Black spots are caused due to melanin production that is induced by sunlight exposure. Flavonoid content in andaliman can help to decrease melanin production by preventing tyrosine from becoming dihydroxyphenylalanine (DOPA) and DOPAquinone. Ethanolic extract of andaliman containing flavonoids can reduce acne due to its antimicrobial activity and anti-inflammation which helps the recovery of the skin (Hanum & Laila, 2018).

### Anti-Halitosis Effect

Halitosis is implied by bad smell from the mouth due to the production of volatile sulphur compounds (VSCs) by oral bacteria, and it is mostly caused by lack of oral hygiene, periodontal infection, oral carcinoma, food residues, and throat infection (Aylıkçı & Çolak, 2013). A study by Yanti *et al.* (2019) determined the anti-halitosis effect of *Z. acanthopodium* essential oil (ZAEO) on inhibiting and removing biofilm plaque, reducing acid production, and inhibiting VSCs with *Actinomyces viscosus* model *in vitro*. The lowest dose used (20 ug/mL) of ZAEO in the experiment inhibited and removed more than 50% of *A. viscosus* biofilms as well as total VSCs produced by the

microorganism. Consequently, the rapid production of acid by *A. viscosus* was also inhibited by ZAE0 in the concentration of 40 µg/mL. It is suggested that ZAE0 extract could be administered as a natural ingredient for halitosis treatment (Yanti *et al.*, 2019).

## CONCLUSION

Andaliman fruit might be used as an ingredient in functional foods development which has several health benefits such as antioxidant, antimicrobial, anti-inflammatory, anti-aging, anti-acne and anti-halitosis effects. Andaliman fruit is usually used for the making of *sambal* sauce by the Batak tribe, Indonesia. In foods, andaliman is added to make Indonesian dishes such as *arsik*, *tombur*, and *naniura*. Moreover, its extract can also be applied to fish and raw meat to prevent spoilage.

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