

## **The Ethnobotany and Ethnomedicine of *Zanthoxylum acanthopodium* in Lake Toba, North Sumatra, Indonesia**

*Etnobotani dan Pengobatan Tradisional Berbahan *Zanthoxylum acanthopodium* di Danau Toba, Sumatera Utara, Indonesia*

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### **ABSTRAK**

*Zanthoxylum acanthopodium* merupakan tanaman bernilai gizi dan obat yang dimanfaatkan untuk pangan dan pengobatan. Herba yang dikenal sebagai andaliman ini ditemukan tumbuh pada lahan terbuka, lahan budidaya maupun kawasan hutan sekunder di kawasan Danau Toba, Sumatera Utara. Penelitian ini bertujuan untuk menyediakan informasi etnobotani, produktivitas, dan perbanyakan kandungan minyak atsiri serta pemanfaatan *Zanthoxylum acanthopodium* dalam praktek pengobatan tradisional pada masyarakat local di Danau Toba. Karakter botani dikumpulkan dengan melakukan pengamatan fenologi, pengukuran produktivitas, dan penyulingan minyak atsiri. Aplikasi andaliman dalam pengobatan tradisional diketahui melalui wawancara mendalam terhadap petani dan praktisi herbal. Berdasarkan pengamatan lapangan di wilayah Danau Toba, periode pembungaan terjadi pada bulan Maret hingga April dan diikuti dengan fase berbuah pada bulan Mei hingga September. Bahan pangan ini juga disukai karena kandungan minyak atsiri yang beraroma citrus dan rasa yang pedas getir yang menggugah selera. Selain sebagai sumber gizi sehat, rempah ini juga diolah dan dimanfaatkan dalam pengobatan tradisional. Buah kering maupun segar dihancurkan menjadi pasta untuk mengurangi nyeri radang gigi serta pengobatan dyspepsia. Untuk menggunakan topikal, buah dihancurkan menjadi lotion untuk pengobatan kudis. Akar segar digunakan untuk menyembuhkan masalah gigi. Hampir semua bagian tanaman mengandung minyak atsiri dengan konsentrasi tertinggi pada buah (4,89%). Kearifan lokal telah mengungkap potensi minyak atsiri andaliman ini sebagai anti-mikroba yang dimanfaatkan lebih lanjut sebagai pengawet makanan. Untuk meningkatkan keberhasilan perbanyakan generatif, pematangan dormansi benih dengan pemberian perlakuan pembakaran dengan intensitas rendah dapat meningkatkan laju perkecambahan.

Kata kunci: andaliman, botani, etnobotani, minyak atsiri, perkecambahan

### **ABSTRACT**

*Zanthoxylum acanthopodium* is a nutritional plant utilized for both culinary and medicinal purposes. The herb, popularly known as andalimanis found in sloppy, barren,

cultivated lands and secondary forests in Lake Toba, North Sumatra. This study aimed to provide an ethnobotanical description, productivity and propagation, essential oil of andaliman and the application as traditional medicine in Lake Toba. Botanical characters were collected by observing phenology and distilling essential oils. The ethnomedicine information was collected through in-depth interviews with farmers and herbal practitioners, meanwhile, phytochemical content was identified based on various primary literature. Results showed flowering period occurs from March until April and followed by fruiting in May to September. Fruits were widely processed as cooking spices for various cuisines. It played an important role in local people's diet by supplying carbohydrate, minerals and vitamins. This ingredient was favoured for its citrus-colored oil content and a spicy taste with an appetizing aroma. This spice was also utilized in traditional medicine. Both dry and fresh fruits were used for gums and dental disorders as dyspepsia or lotion for scabies. Fresh roots were also used to cure dental problems. All plant parts contain essential oil with a higher concentration in fruits (4.89%). The local wisdom also reveals the essential oil utilization as an antimicrobial ingredient that could be further processed as a food preservative. To increase generative propagation, seed dormancy breaking treatment through a low-intensity burning can increase the germination rate.

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Keywords: andaliman, botany, essential oil, traditional medicine, propagation

## INTRODUCTION

Andaliman (*Zanthoxylum acanthopodium* DC.L) is one of important herbs for food and health of local communities in the Lake Toba highlands, North Sumatra, Indonesia (Natasutedja et al., 2020) (Junaedi and Nurlaeli, 2019). In this region, this herbaceous fruit is harvested from thorny shrubs of Rutaceae family that grow naturally in open land or secondary forests, and cultivated areas at an altitude of 1,000-1,500 m above sea level (asl). It found naturally in highlands, widely throughout Asia, and is known as *szechuan* pepper (Katzner, 2012; Jie et al., 2019).

The spicy and bitter taste of andaliman fruits have been used by the Batakese communities in around the Lake Toba and Tapanuli areas as a spice for a variety of processed dishes (Natasutedja et al., 2020; Asbur & Khairunnisyah 2018). In Himalaya, India and China the fruit have been used as seasoning with a distinctive flavor that arouses appetite; a distinctive citrus aroma that stimulate saliva production (Yonzon, 2016; Rai et al., 2013; Jie et al., 2019). The spice is also used by local people in food preservation

and to extends a food processed products' shelf life (Jie et al. 2019). Apart from being a nutritious food, andaliman fruit has also been used as an ingredient in traditional medicine (Jie et al., 2019) (Yonzon, 2016). In India and China, local peoples have been applied chewed fruits and leaves for toothache inflammation, cough, rheumatism, scabies treatment, etc (Rai et al., 2013; Yonzon, 2016; Jie et al., 2019). The utilization of this spice in traditional medicine also applies in Lake Toba communities, unfortunately, the dissemination of this local wisdom is very limited and diminish among the younger generation (Ali, 2019; Natasutedja et al., 2020).

During the last decade, global awareness on application of organic products has increased (Mank & Polonska, 2016). Various efforts have been conducted to explore local wisdom in natural ingredients utilization as a source of food, preservation and herbal medicine (Ali et al., 2015). However, these efforts face various challenges, including lack of information and mastery of propagation techniques or pre-processing of plant parts in the form of essential oils (Phuyal et al. 2019). Many potential herbal plant

including andaliman species face of failure in mass propagation and obstructs their productivity development. The germination of andaliman seeds is slow and heterogeneous, as the protective coat restricts water imbibition, oxygen diffusion and imposes mechanical resistance, resulting in seedling emergence problems (Rubio Neto et al. 2012). This study aimed to provide a botanical description, productivity, phytochemical constituents of andaliman (*Z. acanthopodium*) and the application as traditional medicine in Lake Toba region, North Sumatra Indonesia.

## MATERIALS AND METHODS

### A. Study Site

The research has been carried out through a combination of field surveys, propagation trials in greenhouses, productivity measurements in the laboratory and in-depth interviews with the community. The field surveys about botanical characters conducted on both

natural distribution and cultivation areas of andaliman in Humbang Hasundutan (1,400 m asl) and Simalungun (1,200 m asl) from January to June 2020 (Figure 1). The propagation trials and productivity measurements including essential oils distillation were conducted in Aek Nauli R&D station in Lake Toba, Simalungun, North Sumatra province (1,200 m asl).

### B. Botanical Survey

The activities included morphological measurement of all plant parts, phenology observation, collecting fruit, leaves, and twigs in both their natural distribution and cultivation areas. The morphological characters measured include total tree height, stem shape, crown and leaves. The phenological information collected includes the period of flowering and fruit formation, shape of flowers and fruits, and their productivity. Furthermore, ecological and environmental parameters are also measured, including planting patterns, light intensity, humidity, temperature, altitude, soil type and acidity.

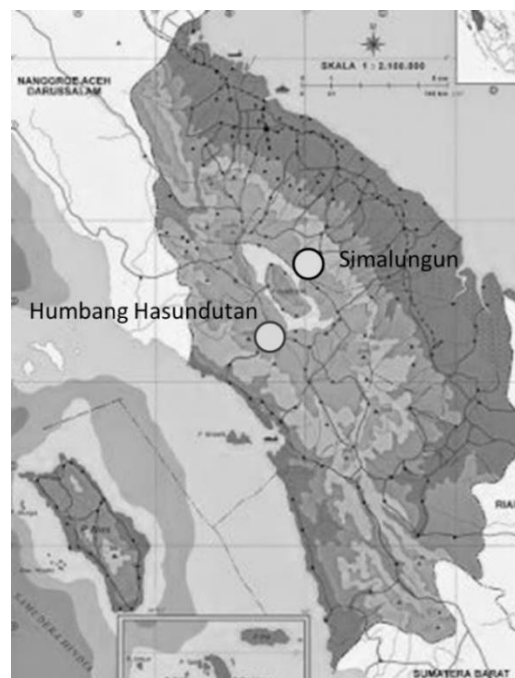


Figure 1. Study sites in lake Toba region, North Sumatra

### C. Fruit Productivity and Propagation Trial

To calculate the fruit productivity, a sampling was applied purposively with a 0.01 ha plot at each location. All andaliman trees are identified, but only All ripe fruit from five selected trees were harvested and weighed. Furthermore, The average number of fruits per kilogram was calculated by weighing 100 fruits. Fruit collected from each tree is identified and measured separately

A sub-sample of collected ripe fruits from each tree and location were sown in a greenhouse in Aek Nauli. A factorial randomized design was applied in order to find out the best scarification technique for increasing germination capacity. Two factors were employed: (1) mechanical seed dormation breaking (2 treatments: low temperature burning and no burning/control) and (2) seed origin/provenance (2 treatments: Humbang Hasundutan and Simalungun) with five replications.

Before sowed, the ripe seeds were selected through drying and soaking These were conducted because the protective coating on andaliman seeds limits water imbibition, oxygen diffusion and creates mechanical resistance. Drying will damage the seed coat so that water, air will be easily absorbed the seeds. Furthermore, submerged vigor seeds were germinated, while floating seeds were discarded.

Germination was conducted by sowing the seeds in two sand beds size 0.5 m x 1 m. Each replication consisted of 50 seeds, so that each seedbed contained 500 seeds. Then, the seedbeds were thinly covered with topsoil, paddy straw r dried imperata grass. Next, the dried grass material on the seedbed was burned. The low heat on the surface of seedbed is expected to reach the hard coat seeds and break the seed dormancy. Seeds without low temperature burning treatment were classified as control. After this prescribed burning, seedbeds

were watered sufficiently. Finally, the nursery maintained with regular watering in the morning and evening. The seeds germination capacities (percentage of survival rate, germination period) were observed for 90-100 days.

### D. Distillation of Essential Oils

All parts of the plant (fruits, leaves, stems and twigs) were subjected to a simple but effective steam distillation (Figure 2). For each load, 3 kg of plant part and repeated twice for each location (Humbang Hasundutan and Simalungun) were placed into the distillation vessel. Steam was generated by heating the water at vessel bottom. Steam flown upward through the perforated plate and into the extracted materials. The steam containing the volatile essential oils then leaves the tightly closed vessel through a pipe at the top of the vessel. The steam is then carried to a water-cooled multi-tubular stainless steel condenser, which is mounted vertically.

Cold water then cools the steam which converts the water favor back into water (hydrolate) and oil (essential oil). Then, the essential oil (lighter than water) and water condensate (hydrosol) are separated in a *Pyrex* florentine flask. The flask is designed to separate essential oils that float on top and aromatic water on the bottom. At the bottom of flask there is one outlet, allowing hydrosol to flow out during the distillation process. Meanwhile, the second outlet is located at the top and is used to pour the essential oils after distillation process is complete. At the termination of process, the essential oil accumulation (g) were measured (Aswandi & Kholibrina, 2020).

A factorial complete randomized design was applied to determine the difference in essential oil content in each plant part from the two cultivation locations. This design was chosen considering that the essential oils production is determined by many factors, including the place to grow and part of plant that is extracted.

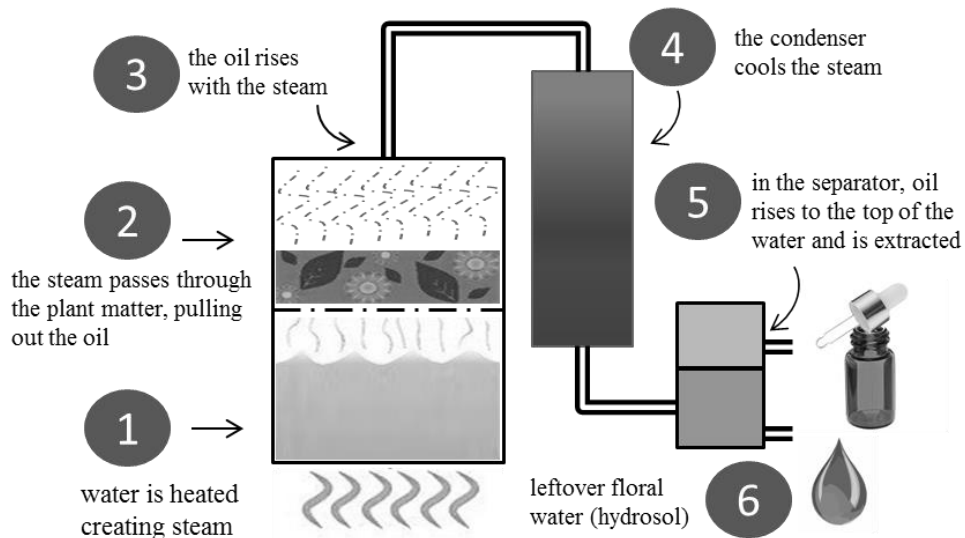


Figure 2. Schematic diagram of a steam distillation unit used in study

The hypothesis tested was that each part of plant and planting location produced different essential oils. In this design, two factors were employed: (1) plant plants (3 levels: fruit, leaves and twigs) and (2) provenance (2 levels as planting location, namely Humbang Hasundutan and Simalungun) with two replications.

**E. Ethnomedicine Survey**

Ethnomedicine information of andaliman was collected through in-depth interviews with ten andaliman farmers and five herbal practitioners in Humbang Hasundutan and Simalungun. Respondents were selected purposively considering their experiences in plant cultivation and traditional medicine. Data and information were collected through semi-structured interviews related to local wisdom in the planting and harvesting practices and the utilization of plant parts as traditional medicinal ingredients. Meanwhile, the phytochemical content was identified and traced based on various published primary literature (Katzer 2012; Yonzone et al., 2012; Rajendra and Samuel 2016; Asbur and Khairunnisyah 2018; Phuyal et al. 2019).

**F. Data Analysis**

The data from the morphological measurement of andaliman tree and

phenological observation were averaged and analyzed descriptively. Information on ecological and environmental parameters were also analyzed descriptively for each location. Fruit productivity data were also analyzed statistically including the mean and standard deviation. Fruit productivity (kg/ha) is estimated from average number of trees in sampling plot, the size of sampling plot applied, and average fruit production of each tree using following formula

$$Fp = \frac{Nt \times AP}{Ss}$$

Where:

Fp = Fruit productivity (kg/ha)

Nt = Number of trees in sampling plot (n)

AP = average fruit production of each tree (kg/tree)

Ss = Sampling plot size (ha)

A factorial experiment using completely randomized design operated with SPSS 14 for windows was applied in order to find out the best propagation technique (Nordstokke & Colp, 2014; Casler, 2015). Two factors were employed: (A) mechanical seed dormation breaking (2 level: low temperature burning and no burning/control) and (B) seed origin/provenance (2 level) so that number

of treatments equals  $2 \times 2 = 4$  treatment with five replications.

#### Hypotesis

$H_0$  = there are no differences in propagation capacities of both mechanical treatment and seed origin

$H_1$  = there are no differences in propagation capacities of both mechanical treatment and seed origin

A factorial experiment was also applied to determine the difference in essential oil content in each plant part from different cultivation locations (2 provenances). The hypothesis tested was that each part of plant and planting location produced different essential oils. Finally, data and information of phytochemical content identified and traced based on various published primary literatur.

## RESULTS

### A. Botanical Description

Andaliman plants have some particular characteristics in form of distinctive aromatic-berries fruits, thorny stems, branches and twigs, with a total height of 1 - 3 m (Figure 3). Long-stemmed, compound pinnate with odd leaflets, 5-25 cm long and 3-15 cm wide. On the leaves are found oil channel so that a distinctive and a pungent aroma spreads when it squeezed. The presence of essential oils in both fruits and leaves of *Z. acanthopodium* have been identified by Bhatt et al., 2018 and Asbur and Khairunnisyah, 2018).

Leaflets totaling 3-11 pieces with a length of 1-7 cm, 0.5-2.0 cm wide, spiny, oval to sharp, tapered tip, smooth serrated edge, the largest tip. The upper surface of the leaf is shiny green and the underside is light green or pale green. Young leaves have a green upper surface while the underside is reddish light green. These young leaves commonly appear at the beginning of the rainy season,

as this phenomenon is also common in other tree species (Omondi et al., 2016).

Compound fork-shaped flowers appear on the armpits of twigs, small size; flat or conical flower base; number of petals 5-7 with 1-2 cm long, pale yellow or white in color, often with red or purple spots at the petals base; androgynous flower, 5-6 stamens located at the base of the flower, reddish anthers, 3-4 pistils, and apocarp ovaries. Berries with a diameter of 2-3 mm, the young fruit is green and when ripe turns red, 10 - 20 fruits are attached to a stalk; the fruit has one seed, hard skin, shiny black and glandular.

In natural habitats, this species grows on open land or secondary forest with less to moderate soil acidity (pH 3-5). In Humbang Hasundutan and Simalungun, andaliman grows well on sandy loam soils, burnt soils, or clay to red laterite soils. Although altitude of Humbang Hasundutan area is higher than Simalungun, the microclimates almost similar. The daily average temperature is in the range 18-27 °C during the day and drops to 12-18 °C at night with a humidity of 75-87%. A different condition is the level of land openness, where the dominance of open land is higher in Humbang Hasundutan.

Andaliman also grows well as an intercropping plant in coffee plantations. The farmers usually use natural seedlings from wild trees around the garden and plant these material in the space between the coffee plants. Fertilization and intensive maintenance of arabica coffee trees which are widely cultivated in the Lake Toba highlands also support the growth and productivity of andaliman. With the high growth rate, at three years age the tree has reached a height of 2.5 to 3 m, so that the coffee canopy does not interfere with the absorption of sunlight by the plant.



Figure 3. Morphological characters of andaliman: (a) young fruit; (b) ripe fruits; (c) crown and leaves; and (d) spines on the leaves

### B. Productivity and Propagation Trial

Andaliman produce flowers and fruits almost through of the year but April to May is the period of mass flowering. The fruits ripe within 60-180 days after flower initiation, so the fruits are harvested in June to October. Andaliman fruit productivity in the peak harvest period in Humbang Hasundutan and Simalungun was presented in Table 1.

In the peak harvest time in Simalungun, each tree produces average 2.34 kg of fruits or 1,170 kg/ha . In other periods, the fruits productivity is around 0.25-1.0 kg/tree. This productivity is higher than Humbang Hasundutan with fruit productivity average 2.17 kg/tree or 1,086 kg/ha. The number of fruits for each kilogram in Simalungun is also less but heavier, indicates a relatively larger size and heavier fruits (Table 1).

Naturally, generative propagation has low germination capacity, which is only 12.2%. The germination period occurs from the 26th to 68th day after sowing. In order to find out the best propagation technique, a factorial experiment using completely randomized design was applied where mechanical seed dormation breaking with low temperature burning was employed. The mean and standard deviation of the

germination rate of andaliman fruits are presented in Table 2.

The results showed that the breaking of seed dormancy through low temperature burning increased the germination capacity up to 14.6%, higher than natural germination (12.2%). However, the analysis also showed that the germination rates were not different in the two provenances of seed. The length of germination period varies, start from 24 to 100 days after sowing, but generally after 42 days the seedlings appear diminished. The breaking of seed dormancy treatment also accelerates the germination period and the simultaneous germination up to day 37<sup>th</sup>. Naturally, the germination will occur on day 43<sup>th</sup> after sowing the seed.

### C. Content of Essential Oil

The essential oil content that was obtained from the steam distillation method for each part of the plant is shown in Table 3. The highest yield of essential oil was obtained from the distillation of fruits at 4.89%. The concentration of essential oil in the fruits is quite high, compare to its concentration in the leaves (0.38%) and in the twigs (0.20%). The essential oil content does not significantly differ between plants from Humbang Hasundutan and Simalungun (Table 3).

#### D. Traditional Applications

Andaliman fruits have been one of main ingredients of various typical cuisines of Batakese communities in the Lake Toba for centuries. This herb have preferred considering the distinctive taste with citrus aroma, bitter spicy and appetizing taste. In this local people, besides being processed with fish or meat, andaliman fruit have also consumed as pickles or chili sauce, especially as a complement to processed foods by grilling or frying. In the past, the mixing of andaliman fruits in processed food was also applied as a food preservative. This is especially considering the technique of extending the expiration time of processed foods by means of salting were limited due to lack of salt resources in these high altitudes region. Apart from being a source of healthy nutrition, this spice is also processed and applied in traditional

medicine (Table 4). Ripe fruit can be eaten separately or mixed with other foodstuffs to treat dyspepsia such as nausea, feeling full (bloating), ulcers and other symptoms of stomach pain. Both dried and fresh fruits are crushed into a paste, then rubbed on the gums to reduce the pain of tooth inflammation. In cold weather conditions, especially in high and mountain regions at an altitude of more than 1,200 m asl, andaliman fruit is often chewed to warm the body and overcome colds. The roots are also boiled to cure toothache. For topical application, the fruit is crushed into a lotion for the treatment of scabies. The bark is boiled and used as a cure for fever, colds and worm medicine. The essential oil derived from both dried and fresh fruit is used for inflammation of toothaches and to warm the body.

Table 1. Andaliman fruits productivity in the peak harvest period

Location Number of Tree	Productivity (kg/tree)	Weight of 100 Fruits (g)	Count of Fruits (fruit/kg)
<b>Humbang Hasundutan</b>			
1	2.34	5.19	19.268
2	1.63	4.93	20.284
3	2.26	5.15	19.417
4	2.51	5.21	19.194
5	2.12	5.09	19.646
Average	2.17	5.11	19.562
Std. Dev	0.33	0.11	439.12
<b>Simalungun</b>			
1	1.45	5.28	18.939
2	2.05	5.17	19.342
3	2.62	5.19	19.268
4	2.56	5.06	19.763
5	2.13	5.32	18.797
Average	2.34	5.20	19.222
Std. Dev	0.29	0.10	377.46

Table 2. Germination of andaliman fruits on mechanical seed dormation breaking using a factorial experiment using completely randomized design

Factor A: Mechanical Seed Dormationbreaking	Factor B: Seed Origin/Provenance	Germination Rate (Mean)	Germination Rate (StdDev)	Length of Germination Period (days)	Simultaneous Germination (t + 70%) (day)
A1. No burning (control)	B1. Humbang. Hasundutan	12.4 <sup>a</sup>	1.63	79	43
	B2. Simalungun	12.0 <sup>a</sup>	1.26	80	43
	Average	12.2 <sup>b</sup>	1.48	79 <sup>a</sup>	43 <sup>a</sup>
A2. low temperature burning	B1. Humbang. Hasundutan	14.4 <sup>a</sup>	1.63	65	37
	B2. Simalungun	14.8 <sup>a</sup>	2.42	67	36
	Average	14.6 <sup>c</sup>	1.89	66 <sup>b</sup>	37 <sup>b</sup>

Remarks: The difference in numbers after the mean score shows a significant difference based on Duncan's post hoc test on sig. 0.05



Table 3. Essential oil content in each part of the plant

Locations	Plant Parts	Essential oil content (%)	
		Mean	Std Dev
Humbang Hasundutan	Fruits	4.99 <sup>a</sup>	0.247
	Leaves	0.40 <sup>b</sup>	0.014
	Twigs	0.22 <sup>c</sup>	0.014
	Average	1.87 <sup>d</sup>	
Simalungun	Fruits	4.78 <sup>a</sup>	0.042
	Leaves	0.36 <sup>b</sup>	0.014
	Twigs	0.19 <sup>c</sup>	0.007
	Average	1.78 <sup>d</sup>	
<i>Pos Hoc Test Duncan</i>			
	Fruits	4.89 <sup>c</sup>	
	Leaves	0.38 <sup>b</sup>	
	Twigs	0.20 <sup>a</sup>	

Remarks: The difference in numbers after the mean score shows a significant difference based on Duncan's post hoc test on sig. 0.05

Table 4. The ethnomedicine of andaliman inataknes communities of lake Toba region

Plant Parts	Concoction	Disease/ Symptom	Proceesing Procedure	Treatments
Fruits	separately or mixed with other foodstuffs	dyspepsia such as nausea, bloating, ulcers, other symptoms of stomach pain	ripe fruit crushed, finely ground	eaten together with other foods until symptoms diminished
	Singe use	pain of tooth inflammation	both dried and fresh fruits are crushed into a paste	rubbed on the gum
	Single use	to warm the body and overcome colds	fruit is chewed	chew the fruits when it feels cold, especially at night
	Single use	scabies	fruit crushed into a paste	topical application
Roots	Single use	toothache	roots were boiled	drink boiled water 3 times a day until the symptoms reduced
Barks	Single use	fever, colds and wormy disease	barks were boiled	drink boiled water 3 times a day until the symptoms reduced
Essential oil	Single use	toothaches inflammation of, colds and to warm the body	distillation of both dried and fresh fruits	essential oil applied to the gums or mixed with local alcohol drinks ( <i>tuak</i> )

## DISCUSSION

In the Lake Toba region, Andaliman plants are found growing wild in hillside areas and open grasslands at an altitude of 1,000 - 1,400 m als with a temperature of 15 - 20°C. At altitudes lower than 900 m als, this plant is not found to grow naturally. The endemicity character that this species grows in areas with high altitudes is also found in China and India where this species grow at an altitude of up to 2,900 m asl (Katzner 2012; Rai et al., 2013).

In the natural habitat, andaliman is able to adapt and grow on open land with high

sunlight intensity or on secondary forest land with less acid to moderate acidity (pH 3-5). On sites that often experience recurrent fires, andaliman regeneration is relatively common. This is due to the heat of grasslands fires breaking the seeds dormancy which have hard seed coat. Recurrent fires of reeds and shrubs are a common phenomenon in Lake Toba region (Aswandi & Kholibrina, 2017). In this typology of critical land, colonization of this pioneer species is often found. Andaliman produce flowers and fruits almost throughout of the year, but April to May is the mass flowering period. The

massive flowering condition is supported by high intensity of sunshine period. If there is a long enough rain period at this time, fertilization often fails. In the peak harvest period, each Andaliman stem can produce 1.5-3.5 kg of fruit.

As an intolerant species, planting andaliman as an intercropping plant, especially between coffee trees, requires proper spacing. Fertilizer application and intensive maintenance of *Coffea arabica* cultivation also support the growth of andaliman trees, however a closed canopy will cause failure of andaliman's flowers formation. To overcome this problem, farmers usually prune the coffee canopy lower than the andaliman plant. Alternatively, this herb is planted prior to plant coffee, so that the sun can be absorbed maximally by andaliman canopy.

Almost no high technology is required in the harvesting of andaliman fruits. The ripe fruits that are dark green are harvested in a simple way: picking them by hand or knife. The harvested fruits are sold immediately, storage or delay in sending to market will cause the color of the fruits to turn black, thereby reduce fruits' freshness. Young and small fruits are left for the intermediate harvest period.

Until now, propagation is generally carried out generatively using natural seeds or seedling. However, these nurseries often face failure due to their low germination rate. The thick-hard fruit's coat have been identified as the main cause of this failure. Fortunately, a the local wisdom has been identified to break the seed dormancy by low intensity burning of the seeds. The seeds for sowing should be fresh and fully ripe while they are still hanging on the tree. The utilization of seeds that are found in the market results in very low germination rates.

However, the breaking of seed dormancy by low intensity burning did not improve propagation rate significantly. The germination rate still relatively low at the 14.6% level) but it was higher than that of natural germination (12.2%). However, the analysis also showed that these is no

difference of germination rates between two seed provenances. Several previous research results also showed a low germination rate of 3.6-17.5% (Asbur & Khairunnisyah, 2018; Junaedi & Nurlaeli, 2019).

The breaking of seed dormancy treatment also accelerates the germination period and the simultaneous germination up to the 37th day. Naturally, the germination will occur on day 43 after sowing the seed. Various study reported that the length of germination period also varies, from 24 to 100 days after sowing, but generally after 42 days the seedlings appear less (Asbur & Khairunnisyah, 2018; Junaedi & Nurlaeli, 2019). Beside the low germination rate, there were relatively few seedlings around the mother tree. However, sometimes farmers also obtain seedlings accidentally from burning weeds in old crop areas.

Both the low germination rate and relatively long germination period are due to the hard and thick seeds coat. This structure blocks water imbibition and gas exchange in the germination process. Volatile components, including terpenoid compounds found in seeds (Asbur & Khairunnisyah, 2018; Susanti et al., 2020) were also identified as germination inhibitors. Consequently, the efforts to break the dormancy of seeds which have thick seed coat and inhibiting compounds have not shown consistent results. As a culinary ingredient, andaliman fruits are sources of carbohydrates, minerals and vitamins. Furthermore, the nutritional value of andaliman mencakup carbohydrate, fats, protein, ash, water and essential oils. The main elements such as Na, Mg, K and Ca are found along with other supporting elements such as Fe, Zn, Mn and Ni (Katzer, 2012). Seeds serve as a source of protein, fat, fiber and sugar. In Chinese cuisine, andaliman is used as a table spice, either pure or in the form of flavored salt. Local community in Korea, west and southeast India also use this herb in variety of dishes (Katzer, 2012; Rai et al., 2013).

Various studies show that andaliman contains essential oils that smell like orange

and have a spicy taste like pepper or pepper (Rajendra & Samuel, 2016; Asbur & Khairunnisyah, 2018; Bhatt et al., 2018). The results of this research showed that the highest essential oil was obtained from the distillation of andaliman fruit at 4.89% (Table 3). The essential oil concentration of this research is higher than it was reported by (Katzer, 2012) at 4%. However, it is lower than reported in another study, which showed that the yield of andaliman fruit powder extract contains essential oil of 8.01 % (Asbur & Khairunnisyah, 2018). This difference in yield could be caused by different methods used for the extraction of these essential oils.

Despite lower concentration, other plant parts such as leaves, and twigs also contain essential oils. The leaves contain essential oil of 0.38%, while the amount of 0.20% is concentrated in twigs (Table 3). These results are within the range of yields of essential oil production from steam distillation of dry leaves, namely 0.16-0.50% (Phuyal et al., 2019). Considering the relatively high essential oil content, this herb has the potential for various utilization. Using the GC-MS analysis, Phuyal et al. (2019) identified a total of seventeen compounds contained in essential oil of andaliman leaves collected from various heights and populations, both wild and cultivated. The three main components are linalool, limonene and undecan-2-one. These essential oil compounds are suspected to inhibit the growth of pathogens (Natasutedja et al., 2020; Susanti, Situmorang & Fitri, 2020).

Andaliman also contains flavonoids, terpene alkaloids, benzophenthridine alkaloids, pyranoquinoline alkaloids, quaternary isoquinoline alkaloids, aporphyrine alkaloids and several of lignans (Susanti et al., 2020). Andaliman's distinctive taste is due to the significant content of terpenoids, namely geranyl acetate (35%), while the dominance of citrus aroma comes from limonene and citronellol compounds. Other components are  $\beta$ -myrcene,  $\beta$ -ocimene, linalool and E-1-

decenal (Katzer, 2012).

In addition, andaliman also contains several antioxidants, such as phytosterols, terpenes, and carotenes (Asbur & Khairunnisyah 2018; Bhatt et al., 2018). Andaliman, like other pepper spices, is an analgesic that can reduce or relieve pain. The high iron content helps the formation of hemoglobin, a protein in red blood cells that is responsible for carrying oxygen to all organs and tissues. This condition will accelerate the circulatory system in the body (Natasutedja et al., 2020; Susanti et al., 2020). This phenomenon is illustrated by local wisdom in Batakese communities, if the fruits were chewed to warm the body when they were cold, or to recover after illness. In addition to the Batak people in the Lake Toba highlands, the Himalayas, Tibet and surrounding areas also use this plant as an aromatic, tonic, appetite stimulant and stomachache medicine (Yonzone et al., 2012; Yonzone, 2016). Seeds are an important source of protein and minerals, such as vitamin A, iron, manganese, potassium, zinc and phosphorus. In addition, andaliman also contains several antioxidants, such as phytosterols, terpenes, and carotenes. Seeds contain large amounts of gamma-tocopherol, fat soluble pigments, and linoleic and palmitic acids (Asbur & Khairunnisyah, 2018; Bhatt et al., 2018).

Andaliman fruit also has the potential to boost the immune system (Rajendra & Samuel, 2016). With a high zinc content, T cells that function to control the immune response will be active to attack pathogens that cause a disease (Rajendra & Samuel 2016). This ability makes this ingredient potential as an anti-virus. The ability of essential oils contained to inhibit bacteria is one of criteria for selecting a compound to be applied as a natural food preservative.

Several important minerals are also found in small content. Some of them are phosphorus, manganese, copper, and iron. All these important elements are needed to build strong bones and prevent osteoporosis

(Asbur & Khairunnisyah, 2018).

Various antioxidants and organic acids such as phytosterols and terpenes contained in andaliman are identified as anti-inflammatory agents (Asbur & Khairunnisyah, 2018; Natasutedja et al., 2020; Susanti et al., 2020). Inflammation is a negative effect of oxidative stress caused by free radical activity. Antioxidant compounds can neutralize free radicals, thereby stopping the inflammation. In practice, andaliman is commonly used for arthritis and gout. Various chronic diseases such as heart disease, atherosclerosis, stroke, hypertension, gastric ulcers, and cancer are also initiated by oxidative stress, so that this spice has great development prospects as an herbal medicinal ingredient (Bhatt et al., 2018; Al, 2019).

### CONCLUSION

Andaliman fruit is one of the main ingredients of various culinary delights of Batakese communities in the Lake Toba highlands. It played an important role in local people's diet by supplying carbohydrate, minerals and vitamins. In this area, fruit productivity is relatively high, 1.1-1.2 tons/ha with the fruiting period from May to September. Naturally, generative propagation has low germination capacity with a long germination period. To increase generative propagation, seed dormancy breaking treatment through a low-intensity burning can increase the germination rate. This spice is also mixed and used in traditional medicine. Both dried and fresh fruit were for gums and dental disorders as dyspepsia or lotion for scabies and overcome colds and fever. All plant parts that adapt and grow in the critical lands contain essential oil with higher concentration in fruits (4.89%). The local wisdom also reveals the essential oil utilization as an antimicrobial ingredient that could be further processed as a food preservative.

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