

# Wild Andaliman (*Zanthoxylum acanthopodium* DC.) Varieties as an Aromatic Plants from North Sumatera

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**Abstract:** Andaliman (*Zanthoxylum acanthopodium* DC.) is one of endemic plant in North Sumatera which produce essential oil. This study aims to explore the wild Andaliman varieties and their characteristics based on specimens and any information sourced from local community knowledge in North Sumatera. This research was conducted through a vegetation survey with local communities in three districts based on three altitude levels: North Tapanuli (1500-1600 masl), Samosir Island (1600-1700 masl) and Humbang Hasundutan (1700-1800 masl) using 20 x 20 m plot with three replicates at each altitude level, totaling nine plots. Observation was carried out through morphological characteristics: seeds, leaves, and prickles based on specimens from the fieldwork and observing fruits, leaves, stems and prickles based on local community knowledge by in-depth interview. The results showed that there were nine varieties Andaliman in North Sumatera: Siholpu, Siganjangpat, Sihalus, Sihorbo, Simanuk, Sirangkak and there were three unnamed varieties. Each variety grows in a different altitude and has morphological characteristics. Further research will be carried out, related to the essential oil content of each Andaliman variety and its ecological conditions.

## 1 INTRODUCTION

Andaliman (*Zanthoxylum acanthopodium* DC.) is a one of the Rutaceae family. (Hartley, 1966) reported the natural distribution of *Z. acanthopodium* in India, Nepal, Sikkim, Eastern Pakistan, Myanmar, Thailand, China and Sumatra (Indonesia). In Indonesia, this plant spread only in North Sumatera Province and Aceh. The fruit of Andaliman is often used by the Batak people as a spice for traditional cuisine (Raja and Hartana, 2017; Wijaya, 1999). Andaliman also an aromatic plant that can produce essential oils in the fruit (Moektiwardoyo et al., 2014; Wijaya et al., 2001; Majumder et al., 2014; He et al., 2018) and the leaf (Rakic et al., 2009; Devi et al., 2015; Rana and Blazquez, 2014).

Initially, Andaliman was not known to have several varieties. However, Siregar (2003) stated that there were two Andaliman “tuba sihorbo” and “tuba siparjolo” in Dairi. (Parhusip, 2006) also stated that there were three Andaliman varieties: Simanuk, Sihorbo and Sitanga around Toba Lake. Raja and Hartana, (2017) were reported that there were four Andaliman cultivars: Simanuk, Sihorbo, Silokot and Sikoreng which were distributed in Toba Samosir,

Simalungun, Dairi and North Tapanuli. Meanwhile according to (Simbolon, 2018) there were two varieties of Andaliman: Simanuk and Sihorbo in Dairi, Toba Samosir and Simalungun. The objective of this research is to explore the wild Andaliman varieties and their characteristics based on specimens and any information sourced from local community knowledge in North Sumatera.

## 2 METHOD

This research was conducted at 2019 through a vegetation survey with local communities in three districts based on three altitude levels: North Tapanuli (1.500-1.600 masl), Samosir Island (1.600-1.700 masl) and Humbang Hasundutan (1.700-1.800 masl) using 20 x 20 m plot with three replicates at each altitude level, totaling nine plots. Observation was carried out through morphological characteristics: seeds, leaves, and prickles based on specimens from the fieldwork and observing fruits, leaves, stems and prickles based on local community knowledge by in-depth interview.

### 3 RESULT AND DISCUSSION

#### 3.1 Botany of Andaliman

*Zanthoxylum acanthopodium*. Prodr. 1: 727, 1824. Type: *Wallich*, 1821, Nepal. "Scandent or erect shrubs or small trees to 6 m.; dioecious or (in Sumatera) with perfect flowers; apparently both deciduous and evergreen; branchlets villous with ferruginous hairs to glabrate, generally armed, the prickles flattened, predominantly pseudostipular, to 1.2 cm long. Leaves trifoliolate or imparipinnate 2-25 cm long; rachis villous to glabrate, often with flattened prickles, narrowly to broadly (to 3 mm, on either side) winged; petiolules obsolete to 3 mm long; leaflets 1-6 pairs, opposite, chartaceous, villous to sparsely hairy on the main veins below, with appressed hairs or glabrous above, often with flattened prickles along the midrib above and below, ovate to elliptic-lanceolate 1-12 cm long, 0.5-4.5 cm wide, base obtuse, main veins generally conspicuous, 10-28 on each side of the midrib, margins sub-entire to glandular crenate with as many as 8 crenations per cm., apex acute to acuminate, inflorescences axillary, paniculate to racemose, 0.5-2 cm long and generally glomerate. Staminate flowers about 3 mm long; pedicels obsolete to 2 mm long; perianth segments 6-8, undifferentiated although occasionally slightly unequal in size, uniseriate to irregularly biseriate, green or yellowish green elliptic to ligulate, 1-2 mm long, sparsely hairy to glabrous; stamens 6, about 2 mm long, anthers about 1 mm long and reddish purple prior to anthesis; disc pulvinate, about 0.75 mm high; rudimentary carpels 2-5. Carpellate flowers about 2 mm long; pedicels and perianth segments as in staminate flowers; rudimentary stamens none; disc pulvinate, 0.5-0.75 mm high; gynoecium 2-5 carpellate, sparsely hirsute to glabrous, about 1.5 mm high, styles about 0.75 mm long, divergent, articulating about 0.3 mm below the globose stigma. Perfect flowers (only in Sumatran specimens) about 3 mm long; pedicels and perianth segments as in staminate flowers; stamens 3-6, about 3 mm long, otherwise as in staminate flowers; gynoecium 2-4 carpellate, sparsely hirsute, otherwise as in carpellate flowers. Fruiting pedicels 0.5-1.5 mm long; follicles generally reddish, subglobose, about 4 mm, in diameter in 2's to 5's, the undeveloped carpels caducous". (Hartley, 1966).

#### 3.2 Andaliman Varieties in North Sumatera

The results showed that there were nine Andaliman varieties in North Sumatera, six varieties were already named, which are Siholpu, Siganjangpat, Sihalus Sihorbo, Simanuk, Sirangkak. Three other varieties have not been obtained the local names. However, Sihorbo variety is found in two districts, Samosir Island (SI) and Humbang Hasundutan (HH).

There were three Andaliman varieties in North Tapanuli District (1.500-1.600 m asl): Siholpu, Siganjangpat and Variety 3.

##### 3.2.1 Siholpu Variety

Based on local knowledge, Siholpu variety has greener leaves, smaller leaf size, more prickles in the middle of the leaf, short petiole. The fruit has a smaller size, the colour of the fruit is greener, the fruit stalks are short, the fruit is swarming, more fruit production than Siganjangpat variety, fruiting throughout the year, the fruit is preferred by the local community, the fruit has the spiciest taste and the most fragrant. The stem is brown and smaller in size. Prickles on the stems and leaves are longer and harder.

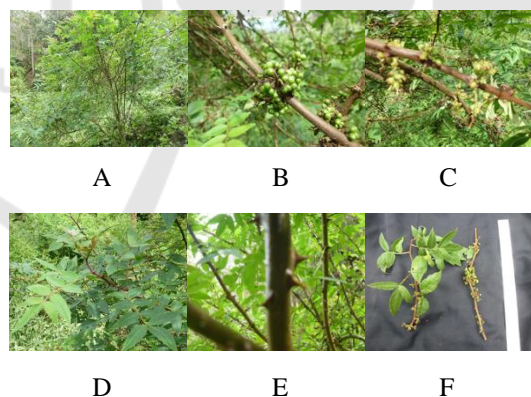


Figure 1: Siholpu Variety. A) Tree, B) Fruit, C) Flowers, D) Leaves, E) Prickles, F) Specimen.

Based on the specimen of Siholpu variety, leaves: trifoliolate or imparipinnate, 14 cm long, 7 leaflets, 5 cm long, 1.5 cm wide, there are prickles in the middle of the leaf. Seeds: black, subglobose, 0.25 cm long, 0.2 cm wide. Prickle: 1 cm long, 0.5 cm wide. There are many prickles on the twig.

### 3.2.2 Siganjangpat Variety

Based on local knowledge, Siganjangpat variety has yellowish leaves, bigger leaf size, leaves have less prickles, long petiole. Larger size fruits, fewer green fruits, longer fruit stalks, less fruit production (only bear fruit twice a year), fruit has a less spicy taste and less fragrant. The stem has a lighter colour and bigger size. Less prickles on the stems and the leaves.

Based on the specimen of Siganjangpat variety, leaves trifoliolate or imparipinnate, 20 cm long, 7 leaflets, 7.5 cm long, 1.5 cm wide, no prickles in the middle of the leaf. Seed: black, subglobose, 0.3 cm long, 0.2 cm wide. Prickle: 0.3 cm long, 0.1 cm wide. There are almost no prickles on the twig.

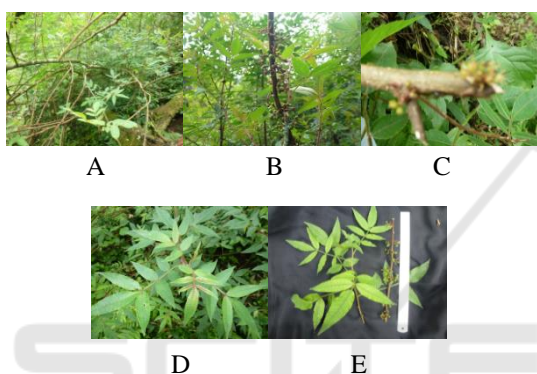


Figure 2: Siganjangpat Variety. A) Tree, B) Fruit, C) Flowers, D) Leaves, E) Specimen.

### 3.2.3 Variety 3

Based on local knowledge, Variety 3 has greener leaves, moderate and smaller prickles in the middle of the leaf, short petiole. Fruit has smaller size, greener fruit colour, short fruit stalk, the highest fruit production compared to Siholpu variety and Siganjangpat variety, fruit has a spicy taste and fragrant. The stem size is bigger and higher than Siholpu variety and Siganjangpat variety. Medium prickles, less prickles than Siholpu variety and more prickles than Siganjangpat variety.

Based on the specimen of Variety 3, leaves trifoliolate or imparipinnate, 15 cm long, 7 leaflets, 5.5 cm long, 1.8 cm wide, there are prickles in the middle of the leaf (moderate). Seeds: black, subglobose, 0.2 cm long, 0.2 cm wide. Prickle: 0.8 cm long, 0.5 cm wide. There are moderate prickles on the twig.

There were two Andaliman varieties in Samosir Island (1.600-1.700 m asl): Sihalus and Sihorbo.

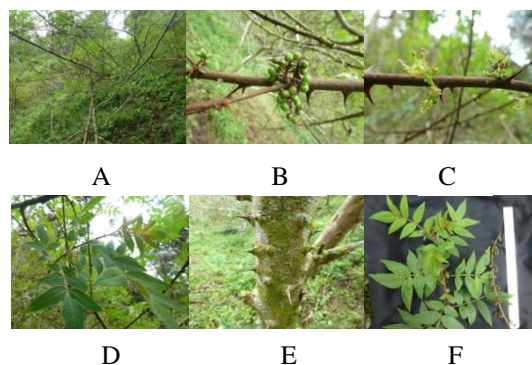


Figure 3: Variety 3. A) Tree, B) Fruit, C) Flowers, D) Leaves, E) Prickles, F) Specimen.

### 3.2.4 Sihalus Variety

Based on local knowledge, Sihalus variety has smaller leaf size, tight spacing between leaves, long petiole. The fruit has a smaller size and more durable to store, more fruit production, the fruit has the same taste and aroma as Sihorbo variety. The stem has a smaller size. Slightly prickles.

Based on the specimen of Sihalus variety, leaves trifoliolate or imparipinnate, 15.5 cm long, 7 leaflets, 5 cm long, 1.2 cm wide, no prickles in the middle of the leaf. Seeds: black, subglobose, 0.4 cm long, 0.2 cm wide. Prickle: 0.8 cm long, 0.3 cm wide. Slightly prickles on the twig.

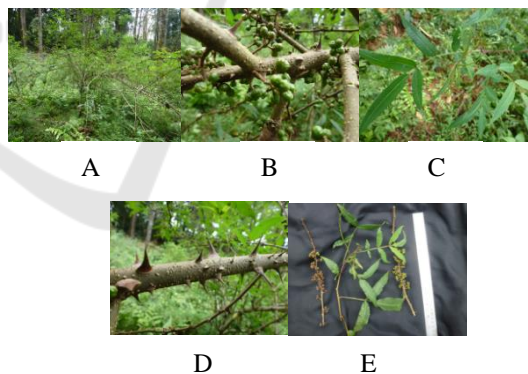


Figure 4: Sihalus Variety. A) Tree, B) Fruit, C) Leaves, D) Prickles, E) Specimen.

### 3.2.5 Sihorbo Variety (SI)

Based on local knowledge, Sihorbo variety (SI) has larger leaves, sparse spacing between leaves, short petiole. Fruit has a larger size and not durable to store, less fruit production, the fruit has the same taste and aroma as Sihalus variety. The stem has a larger size. There are many prickles.



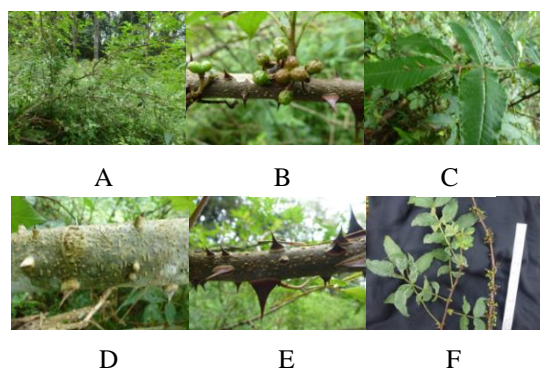


Figure 5: Sihorbo Variety (SI). A) Tree, B) Fruit, C) Leaves, D) Stem, E) Prickles, F) Specimen.

Based on the specimen of Sihorbo variety, leaves trifoliolate or imparipinnate, 13 cm long, 7 leaflets, 8 cm long, 2 cm wide, there are many prickles in the middle of the leaf. Seeds: black, subglobose, 0.5 cm long, 0.3 cm wide. Prickle: 2 cm long, 1.7 cm wide. There are many prickles on the twig.

There were five Andaliman varieties in Humbang Hasundutan District (1700-1800 masl): Simanuk, Sihorbo, Sirangkak, Variety 1 and Variety 2.

### 3.2.6 Simanuk Variety

Based on local knowledge, Simanuk variety has small green leaves with red leaves edges. Fruit is green rather black, small-sized fruit and has a lot of oil, many fruit production, fruit easily change colour to black, the fruit is preferred by local communities because it has a very spicy taste and fragrant. The stem is gray and taller than other varieties. Slightly prickles.

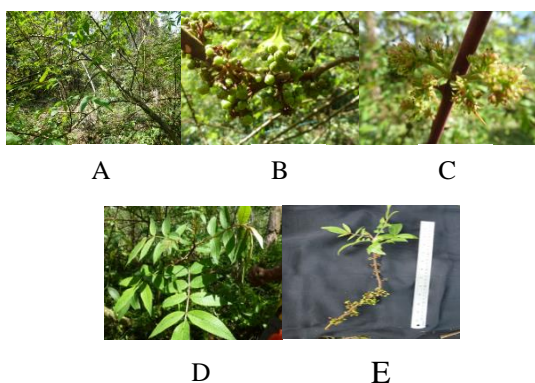


Figure 6: Simanuk Variety. A) Tree, B) Fruit, C) Flowers, D) Leaves, E) Specimen.

Based on the specimen of Simanuk variety, leaves trifoliolate or imparipinnate, 14 cm long, 7 leaflets, 5.5 cm long, 1.8 cm wide, slight prickles in the middle

of the leaf. Seeds: black, subglobose, 0.3 cm long, 0.2 cm wide. Prickle: 1 cm long, 0.5 cm wide. Slightly prickles on the twig.

### 3.2.7 Sihorbo Variety (HH)

Based on local knowledge, Sihorbo variety (HH) has long and large leaf sizes. The fruit has a large size, green and clumps like kaffir lime, the highest fruit production, the fruit has a less spicy taste and less fragrant. The stem is light green. There are very tight prickles.

Based on the specimen of Sihorbo variety, leaves trifoliolate or imparipinnate, 23 cm long, 7 leaflets, 9 cm long, 3 cm wide, there are many prickles in the middle of the leaf. Seeds: black, subglobose, 0.5 cm long, 0.3 cm wide. Prickle: 1.2 cm long, 0.7 cm wide. There are many prickles on the twig.

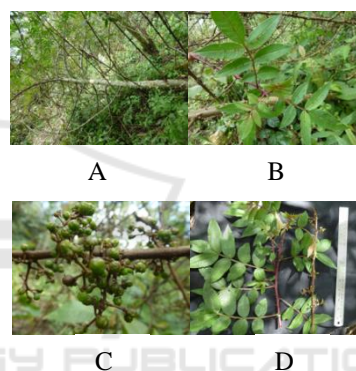


Figure 7: Sihorbo Variety (HH). A) Tree, B) Leaves, C) Fruit, D) Specimen.

### 3.2.8 Sirangkak Variety

Based on local knowledge, Sirangkak variety has green and red leaves. Fruit is rather a lot of production, the fruit has a spicy taste and fragrant. The stem is gray. There are many prickles.

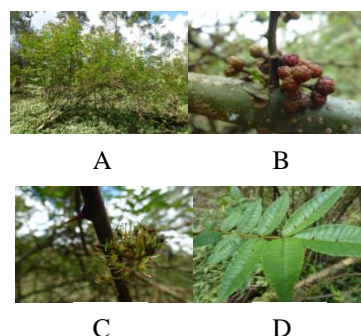


Figure 8: Sirangkak Variety. A) Tree, B) Fruit, C) Flowers, D) Leaves.

Based on the specimen of Sirangkak variety, leaves trifoliolate or imparipinnate, 15 cm long, 7 leaflets, 5.5 cm long, 1.5 cm wide, there are many prickles in the middle of the leaf. Seeds: black, subglobose, 0.5 cm long, 0.25 cm wide. Prickle: 1.8 cm long, 0.5 cm wide. There are many prickles on the twig.

### 3.2.9 Variety 1

Based on local knowledge, Variety 1 has green reddish leaves, bigger and longer size. The fruit has a bigger size, less fruit production, the fruit has a spicy taste and fragrant. The stem is reddish. There are many prickles.

Based on the specimen of Variety 1, leaves trifoliolate or imparipinnate, 17 cm long, 7 leaflets, 7 cm long, 2 cm wide, no prickles in the middle of the leaf. Seeds: black, subglobose, 0.5 cm long, 0.2 cm wide. Prickle: 0.5 cm long, 0.2 cm wide. Many prickles on the twig.

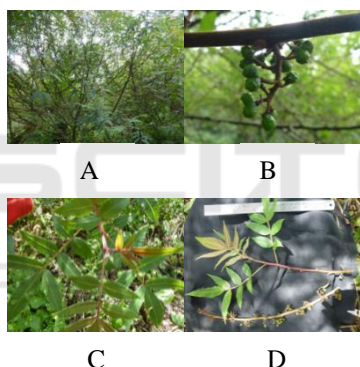


Figure 9: Variety 1. A) Tree, B) Fruit, C) Leaves, D) Specimen.

### 3.2.10 Variety 2

Based on local knowledge, Variety 2 has small leaves, green and short in size. Smaller fruit and less fruit production, fruit has a spicy taste and fragrant. The stem is gray. Short prickles.

Based on the specimen of Variety 2, leaves trifoliolate or imparipinnate, 12.5 cm long, 7 leaflets, 4 cm long, 1 cm wide, no prickles in the middle of the leaf. Seeds: black, subglobose, 0.3 cm long, 0.15 cm wide. Prickle: 0.3 cm long, 0.1 cm wide. There are short prickles on the twig.

Andaliman has several local names in North Sumatra: “andaliman” (Batak Toba), “tuba” (Batak Simalungun), “itir-itir” (Batak Karo) and “sinyarnyar” (Batak Angkola) (Raja and Hartana, 2017). Generally, the fruit of Andaliman in North

Sumatra tends to be utilized by Batak people as a unique spice. It can also be medicine for digestive disorders (Purba et al., 2018).

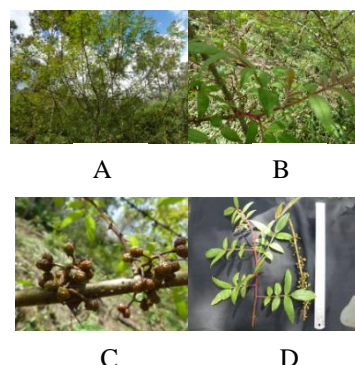


Figure 10: Variety 2. A) Tree, B) Leaves, C) Fruit, D) Specimen.

Andaliman (*Z. acanthopodium*) in India has several local names: “mukthruhi andaliman or toothache tree” in Manipur (Leishangthem and Sharma, 2014; Singh et al., 2003), “tambul” in Manipur (Ishwori et al., 2014), “eyar-ma” in Arunachal Pradesh (Ghosh et al., 2014), “timru” at Garhwal Himalayas (Kandari and Gusain, 2001). Local communities in India utilize the leaf, fruit, seed and stem bark of *Z. acanthopodium*. Young leaf and fruit as a medicine for fever, cough and bronchitis (Leishangthem and Sharma, 2014). Leaf and fruit are also used as a medicine for cancer, boils, female contraceptive, headache, fever, wounds, swelling and skin diseases (Ghosh et al., 2014). Fruit is used as a medicine for dysentery (Kala, 2005). Leaves and seeds as medicine for fever, dyspepsia (abdominal pain), cough, bronchitis, rheumatism (Singh et al., 2003). Seed powder and stem bark are used as toothache and tooth decay medicine. Fruit is used for spices and condiments, insecticides and pesticides (Kandari and Gusain, 2001). Leaf is consumed as vegetable (Gogoi et al., 2014; Konsam et al., 2016).

Moektiwardoyo et al., (2014) stated that there was 4.94% concentration of essential oil from Andaliman fruit. The active compound contents in Andaliman are reported to be used as an antibacterial (Ishwori et al., 2014; Parhusip, 2006; Saragih and Arsita, 2019), antifungal (Devi et al., 2015), cancer cell inhibitor (Zhao et al., 2005; Kristanty and Suriawati, 2014), preventing malaria mosquitoes (He et al., 2018), antioxidant (Tensiska et al., 2003; Gultom, 2011), antiradical (Suryanto et al., 2004) and antiinflammatory (Yanti, 2011).

Further research related to the essential oil content of each Andaliman variety and its ecological studies

are needed to support the cultivation of Andaliman as a producer of essential oils in wider use and increase added value for local communities in North Sumatera in the future.

## 4 CONCLUSION

The conclusion of this research:

1. There were nine varieties Andaliman in North Sumatera: Siholpu, Siganjangpat, Sihalus, Sihorbo, Simanuk, Sirangkak and there were three unnamed varieties.
2. Each variety grows in a different altitude and has morphological characteristics.
3. Further research will be carried out, related to the essential oil content of each Andaliman variety and its ecological conditions.

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## REFERENCES

- Devi, OZ, Rao, KS, Bidalia, A, Wangkheirakpam, R, Singh, OM., 2015. GC-MS Analysis of Phytocomponents and Antifungal Activities of *Zanthoxylum acanthopodium* DC. Collected from Manipur, India. *European Journal of Medicinal Plants*, 10(1), 1-9.
- Ghosh, G, Ghosh, DC, Melkania, U, Majumdar, U., 2014. Traditional Medicinal Plants used by the Adi, Idu and Khamba tribes of Dehang-Debang Biosphere Reserve in Arunachal Pradesh. *International Journal of Agriculture, Environment & Biotechnology*, 7(1), 165-171.
- Gogoi, D, Rajkhowa, RC, Handique, AK., 2014. Nutritive Values of some non-Conventional Leafy Vegetables of Ethnic Souces from Nagaland N.E. India. *International Journal of Emerging Science and Engineering (IJESE)*, 2(5), 78-79.
- Gultom, S. 2011., *Flavonoid Buah Andaliman (Zanthoxylum acanthopodium DC.) sebagai Antioksidan dan Inhibitor  $\alpha$  Glukosidase*. Tesis. Sekolah Pascasarjana. IPB. Bogor.
- Hartley, TG., 1966. A revision of the Malesian species of *Zanthoxylum* (Rutaceae). *J. Arnold Arboretum*, 47, 171-221.
- He, Q, Wang ,W, Zhu, L., 2018. Larvicidal activity of *Zanthoxylum acanthopodium* essential oil against the malaria mosquitoes, *Anopheles anthropophagus* and *Anopheles sinensis*. *Malar J*, 17(194), 1-7.
- Ishwori, L, Talukdar, AD, Singh, PK, Choudhury, DM, Nath, D., 2014. Antibacterial Activity of some Selected Plants Traditionally used as Medicine in Manipur. *African Journal of Biotechnology*, 13 (13), 1491-1495.
- Kala, CP., 2005. Ethnomedicinal botany of the Apatani in the Eastern Himalayan region of India. *Journal of Ethnobiology and Ethnomedicine*, 1(11), 1-8.
- Kandari, OP and Gusain, OP., 2001. *Garhwal Himalaya-Nature, Culture and Society*. Transmedia Publication, Srinagar. Garhwal.
- Konsam, S, Thongam, B, Handique, AK., 2016. Assessment of Wild Leafy Vegetables traditionally consumed by ethnic Communities of Manipur, Northeast India. *Journal of Ethnobiology and Ethnomedicine*, 12 (9), 1-15.
- Kristanty, RE, Suriawati, J., 2014. Cytotoxic and Antioxidant activity of Petroleum Extract of Andaliman Fruits (*Zanthoxylum acanthopodium* DC). *International Journal of Pharm Tech Research CODEN (USA): IJPRIF*, 6 (3), 1064-1069.
- Leishangthem, S and Sharma, LD., 2014. Study on some Important Medicinal Plants Found in Imphal-East District, Manipur, India. *International Journal of Scientific and Research Publication*, 4(9), 631-635.
- Majumder, M, Sharma, HK, Zaman, K, Lyngdoh, W., 2014. Evaluation of Physico-Chemical Properties and Antibacterial Activity of The Essential Oil Obtained from the Fruits of *Zanthoxylum acanthopodium* DC. Collected from Meghalaya, India. *International Journal of Pharmacy and Pharmaceutical Sciences*, 6 (5), 543-546.
- Moektiwardoyo, M, Muchtaridi, M dan Halimah, E., 2014. Chemical Composition and Locomotor Activity of Andaliman Fruits (*Zanthoxylum acanthopodium* DC) Essential Oil on Mice. *International Journal of Pharmacy and Pharmaceutical Sciences*, 6(2), 547-550.
- Parhusip, AJN., 2006. *Kajian Mekanisme Antibakteri Ekstrak Andaliman (Zanthoxylum acanthopodium DC) terhadap Bakteri Patogen Pangan*. Disertasi. Sekolah Pascasarjana IPB. Bogor.
- Purba, EC, Silalahi, M , Nisyawati., 2018. Gastronomic ethnobiology of “terites”- a traditional Batak Karo medicinal food: A ruminant’s stomach content as a human food resource. *Journal of Ethnic Foods*, 5, 114-120.
- Raja, RNL dan Hartana, A., 2017. Variasi Morfologi Andaliman (*Zanthoxylum acanthopodium*) di Sumatra Utara. *Floribunda*, 5(7), 258-266.
- Rakic, T, Sekulic, JS, Filipovic, B, Tadic, V, Stevanovic, B, Tan, K., 2009. Ecophysiological and Anatomical Characteristics of the Subtropical Shrub *Zanthoxylum acanthopodium* (Rutaceae) in Conditions of a Temperate Continental Climate (Serbia). *Arch. Biol. Sci*, 61(2), 249-260.
- Rana, VS, Blazquez, MA., 2014. Terpenoid Constituents od *Zanthoxylum acanthopodium* DC. Leaves. *Journal of Essential Oil Research*, 20(6), 515-516.
- Saragih, DE, Arsita, EV., 2019. Kandungan Fitokimia *Zanthoxylum acanthopodium* dan Potensinya sebagai Tanaman Obat di Wilayah Toba Samosir dan Tapanuli

- Utara, Sumatera Utara. *Pros Sem Nas Masy Biodiv Indon*, 5(1), 71-76.
- Simbolon, WE, Kardhinata, EH, Bangun, MK dan Simatupang, S., 2018. Identifikasi Karakter Morfologis Andaliman (*Zanthoxylum acanthopodium* DC.) di Beberapa Kabupaten di Sumatera Utara. *Jurnal Agroekoteknologi FP USU*, 6(4), 745-756.
- Singh, HB, Singh, RS, Sandhu, JS., 2003. *Herbal Medicine of Manipur*. Daya Publishing House. Delhi Vol. 1.
- Siregar, BL., 2003. Andaliman (*Zanthoxylum acanthopodium* DC) di Sumatera Utara: Deskripsi dan Perkecambahannya. *Hayati*, 10 (1), 38-40.
- Suryanto, E, Sastrohamidjojo, H, Raharjo, S, Tranggono., 2004. Antiradical activity of Andaliman (*Zanthoxylum acanthopodium* DC) Fruit Extract. *Indonesian Food and Nutrition Progress*, 11 (1), 15-19.
- Tensiska, Wijaya, CH, Andarwulan, N., 2003. Aktivitas Antioksidan Ekstrak Buah Andaliman (*Zanthoxylum acanthopodium* DC) dalam Beberapa Sistem Pangan dan Kestabilan Aktivitasnya terhadap Kondisi Suhu dan pH. *Jurnal Teknologi dan Industri Pangan XIV*, (1), 29-39.
- Wijaya, CH., 1999. Telaah Ringkas Rempah-Rempah Tradisional Andaliman, Rempah Tradisional Sumatera Utara dengan Aktivitas Antioksidan dan Antimikroba. *Bul. Teknol. Dan Industri Pangan X*, (2), 59-61.
- Wijaya, CH, Hadiprodjo, IT, dan Apriyantono, A., 2001. Komponen Volatil dan Karakterisasi Komponen Kunci Aroma Buah Andaliman (*Zanthoxylum acanthopodium* DC). *Jurnal Teknol. Dan Industri Pangan XII*, (2), 117-125.
- Yanti, Pramudito, TE, Nuriasari, N, Juliana, K., 2011. Lemon Pepper Fruit Extract (*Zanthoxylum acanthopodium* DC.) Suppress the Expression of Inflammatory Mediators in Lipopolysaccharide-Induced Macrophages in Vitro. *American Journal of Biochemistry and Biotechnology*, 7(4), 190-195.
- Zhao, Q, Cui, C, Cai, B, Qiu, F, Guo, T, Yao, X., 2005. Cell Cycle Inhibitory Activity of 137 Traditional Chinese Herbal Medicines Against tsFT210 Cell Line. *Pharmaceutical Biology*, 43 (2), 135-139.