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An ethnobotanical study of traditional steam-bathing by the Batak people of North Sumatra, Indonesia

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Abstract. This study aimed to document (1) the Batak people's knowledge of the use of medicinal plants for steam-bathing, (2) the preparation and operation of steam-bathing, and (3) the benefits of steam-bathing. To attain these objectives, data were collected by using ethnobotanical survey and interview methods. The survey was conducted in Kabanjahe and Berastagi traditional markets, in Kaban Tua village, and in Tanjung Julu village. The participants for the interview were nine medicinal plants traders, nine midwives, and 32 mothers. The basic principle of steam-bathing by the Batak people is based on thermotherapy and aromatherapy. A total of 59 species (belonging to 37 genera and to 25 families) have been documented as medicinal plants for their use as steam-bathing materials by the Batak people. The traders, midwives and mothers are all aware of the benefits of steam-bathing. *Gaultheria leucocarpa* Blume and *Cinnamomum porrectum* (Roxb.), the species that produce distinctive aromas and reduce pain, would be interesting to study for their phytochemical and pharmacological properties.

Additional keywords: *Cinnamomum porrectum* (Roxb.), essential oils, *Gaultheria leucocarpa* Blume

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Introduction

More than 80 ethnic groups (Bangun 2010) live on the island of Sumatra, which has ~10 000 species of plants (Anwar *et al.* 1987), many of which have medicinal uses. Various studies have been conducted on the general benefits of medicinal plants used by various ethnic groups on Sumatra, including the Minangkabau (Ardan 2000), Rejang (Darnaedi 1999), Malay (Mahyar *et al.* 1991; Grosvenor *et al.* 1995; Rahayu *et al.* 2000; Susiarti *et al.* 2008), Lahat (Harmida and Yuni 2011), Serampas (Hariyadi and Ticktin 2012), and Batak (Silalahi *et al.* 2013, 2015*a*; Silalahi 2014) groups. However, these studies have been concerned only with the benefits of medicinal plants in general.

The medicinal herbs consumed during the postpartum period have been widely reported by Abu-Irmaileh and Afifi (2003) and de Boer and Lamxay (2009). Even though the use of medicinal plants to maintain the health of women after childbirth (postpartum) has been widely reported, the results mostly emphasise the medicinal plants consumed in the form of herbs (Abu-Irmaileh and Afifi 2003; de Boer and Lamxay 2009). Steam-bathing, one of the traditional practices of the Batak ethnic groups such as the Minahasa (Zumsteg and Weckerle 2007), the West Halmahera (Wakhidah 2015), and the Lao (Lundh 2007; de Boer and Lamxay 2009; Lamxay 2011; de Boer *et al.* 2011), functions to reduce mortality and to restore the health of postpartum women (Silalahi 2014; Silalahi *et al.* 2015*b*). Broadly, it is carried out to stimulate postpartum recovery and health, including production of breast milk, improvement of the blood circulatory system, healing of the reproductive organs (Lundh 2007; Zumsteg and Weckerle 2007; Nasution 2009; Lamxay 2011; Wakhidah 2015), as well as to reduce high blood pressure and to treat asthma (Hannuksela and Ellahham 2001).

It has been reported that medicinal plants used in steam-bathing contain essential oils (Zumsteg and Weckerle 2007; Lundh 2007; Lamxay 2011) in various quantities and species, varying from one ethnic group to another (Zumsteg and Weckerle 2007; Lamxay 2011; Wakhidah 2015). Materials used in steam-bathing are sourced from the surroundings (yards, agroforests, and forests) and markets (Zumsteg and Weckerle 2007; Silalahi *et al.* 2015*b*). The traditional markets in Kabanjahe and Berastagi in North Sumatra are the centre of trading for medicinal plants and steam-bathing materials (Silalahi 2014; Silalahi *et al.* 2015*b*).

Ethnobotanical research can be conducted by means of surveys at markets and local communities (Martin 1995; Alexiades and Sheldon 1996). This combined approach is expected to provide comprehensive information about medicinal plants, including their uses and benefits (Martin 1995; Betti 2002; Lee *et al.* 2008), price (Martin 1995; Betti 2002), conservation status (Betti 2002; van Andel *et al.* 2012), and potential development (van Andel *et al.* 2007, 2012), as well as for the purpose of bioprospecting.

The Batak ethnic groups in northern Sumatra comprise five subethnic groups: Karo, Phakpak, Simalungun, Toba, and Angkola-Mandailing. The Batak Karo subethnic group occupies the highland plateau and central region of the Karo District, while the Batak Angkola-Mandailaing subethnic group inhabits the lowland and central regions of the Mandailing District. Both subethnic groups still maintain the culture of steam-bathing, particularly to promote health and recovery postpartum. Cultural and topographic differences (Bangun 2010) affect the way these groups exploit natural resources in connection with the maintenance of good health.

Previous research about steam-bathing has used the local communities as the participants (Zumsteg and Weckerle 2007; Lundh 2007; Lamxay 2011; Wakhidah 2015), or has involved surveys (Nasution 2009). However, in this research, both approaches were combined. The objectives of this study were (1) to document the medicinal plants used by the Batak people for steam-bathing and to document the process of its preparation and operation, and (2) to look for potential new plants as aromatherapy essentials that have not previously been reported.

Materials and methods

Study area

The study was conducted during August–December 2012 and in December 2015 at four sites in North Sumatra, Indonesia (Fig. 1). The first site is located in the Kabanjahe traditional market, the second site is in the Berastagi traditional market, the third site is in the Kaban Tua village, and the fourth site is in the Tanjung Julu village (Fig. 1).

This study combined the ethnobotanical approach through communities (the Kabantua and the Desa Tanjung Julu village) with market surveys (the Kabanjahe and the Berastagi traditional markets). The local communities in the Kaban Tua and Tanjung Julu villages have used traditional steam-bathing by using traditional saunas to maintain body fitness, especially for postpartum mothers. The Kabanjahe and the Berastagi traditional markets are the centres of trade for traditional medicinal plants in North Sumatra.

The Kabanjahe traditional market lies at 3°11′N, 98°31′E, ~76 km away from Medan (the capital of North Sumatra). Trading activities in the market take place every day, from 0700 to 1800 hours, but the busiest day (market day) is Monday. The Berastagi traditional market is located at 3°11′25″N, 98°31′05″E, ~66 km away from Medan. Trading is conducted there every day from 0700 to 1800 hours but the market day is Saturday. The medicinal plant traders in both markets were of the Batak Karo subethnic group and comprised eight women and one man. The traders of medicinal plants developed their ability to trade and mix herbs using knowledge inherited from their parents (by being invited, as children, to help in the transactions as well as in gathering activities: Silalahi *et al.* 2015*b*), from experience, and simply from learning.

Kaban Tua village is located at 3°2′00″N, 98°26′02″E at an altitude of 1100 m above sea level and ~105 km away from Medan. The total area of Kaban Tua village is 4.75 km^2 and it is inhabited by people of the Batak Karo subethnic group. The postpartum mothers have used the *oukup* (the Batak Karo term for steam-bathing) to improve fitness and stamina. Steam-bathing materials are obtained from the surrounding forest, home garden or traditional market. Approximately 98% of the villager population comprises farmers who grow various crops, such as sweet orange (*Citrus sinensis*), pepper (*Capsicum annum*) and eggplant (*Solanum melogena*).

The Tanjung Julu village is located at 0°46′79″N, 99°39′62″E, at an altitude of 200–400 m above sea level and ~601 km away from Medan. The total area of the village is 8.5 km^2 and the area is inhabited by the Batak Angkola-Mandailing subethnic group, approximately 95% of which are farmers growing a mixture of rubber (*Hevea brasiliensis*) and cinnamon (*Cinnamomum burmannii* (Nees and T.Nees) Bl.). The local communities in the Tanjung village have used the tradition of *marsidudu* (the name given to steam-bathing by the Batak Angkola-Mandailing) especially for postpartum mothers, but at the time of this research the tradition has been in decline. All of the research sites have a tropical climate with bimodal seasonality (dry season from April to August and rainy season from August to April).

Data collection

Information concerning the use of steam-bathing was obtained by means of interviews. Informants consisted of nine traders of medicinal plants, nine midwives, and 32 mothers. The informants in the local community surveys were the mothers who had taken steam-baths and they were selected with purposive snowball sampling methods. (Purposive sampling is a technique of determining informants based on criteria set by researchers, in this case the criteria used were informants who knew the ingredients and processes of steam bathing. Snowball sampling is a technique of determining informants who have been recommended by previous informants.) All traders of medicinal plants in Kabanjahe and Berastagi traditional markets were designated as respondents, while midwives and mothers were selected with purposive snowball sampling method (16 informants in the Kaban Tua village and 16 informants in the Tanjung Julu villages). The midwives had special skills in preparing for steam-bathing and five were selected in Kaban Tua village and four were selected in Tanjung Julu village. The informants were 35–78 years old. Information on the diversity of medicinal plants used as ingredients in steam-baths was obtained from semi-structured and in-depth interviews, as well as from participative observation methods (where researchers participated in community actitivies). The data obtained were analysed quantitatively according to relative frequency of citation (RCF), use value (UV), and the index of cultural significance (CSI). Guides to conducting interviews (Martin 1995; Alexiades and Sheldon 1996; Silalahi *et al.* 2015*b*) were followed.

Medicinal plants used as ingredients in steam-baths were collected as voucher specimens; notes on local names, uses, life form, treatment, and preparation were prepared for each species. Initial identification of collected voucher specimens was later confirmed by taxonomists at the University of Indonesia in Depok, or at the Herbarium Bogoriense of the Indonesian Institute of Sciences at Cibinong in Bogor, Indonesia. Scientific

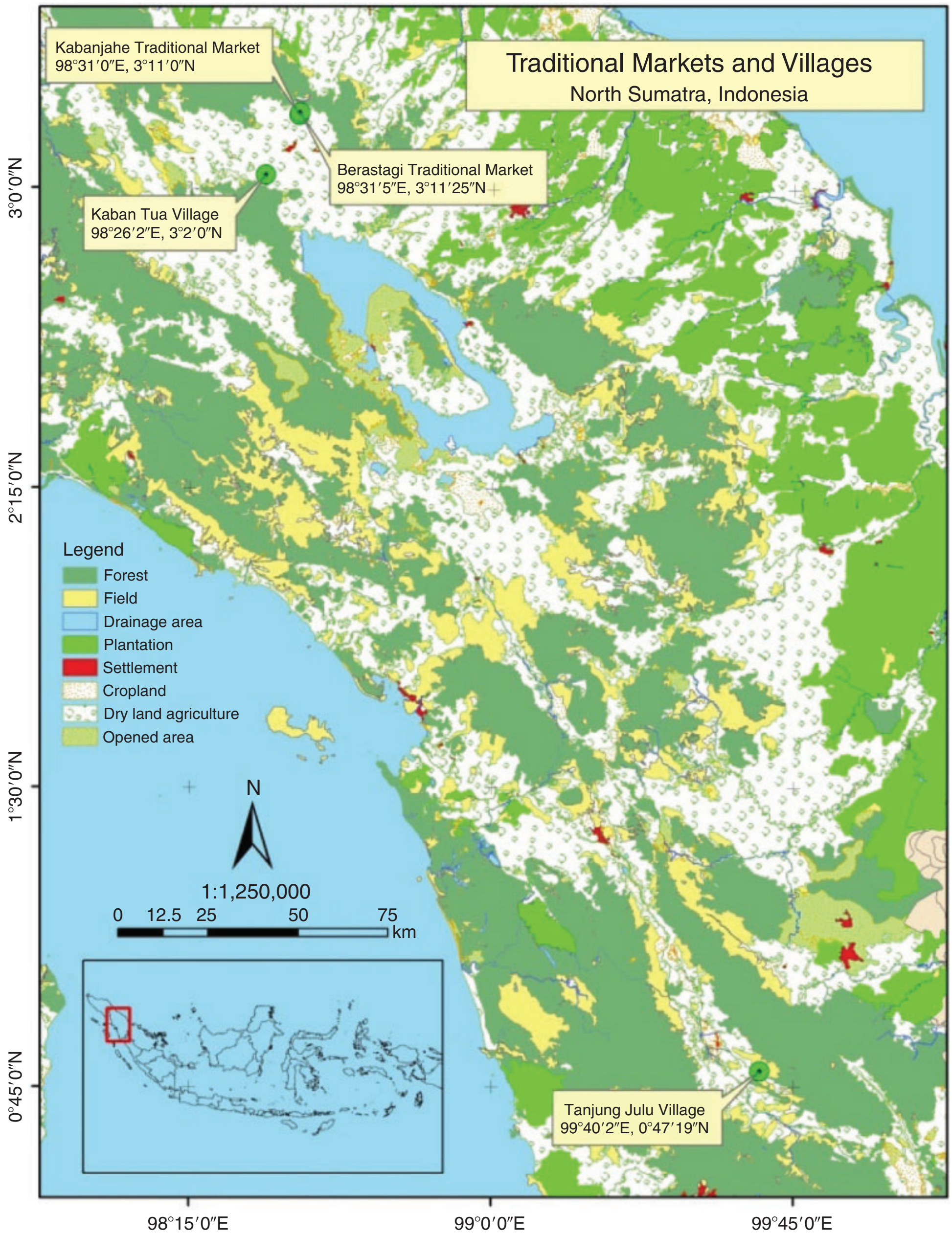

Fig. 1. Study sites at Kabanjahe, Berastagi, Kaban Tua, and Tanjung Julu in North Sumatra, Indonesia.

names of the medicinal plants were verified online with The Plant List 2016 (http://www.theplantlist.org/, accessed 2016). Voucher specimens were lodged with the Herbarium of the University of Indonesia, Depok, Indonesia. Qualitative data included species of medicinal plants, organs harvested, supply, and resource acquisition. The data were analysed using descriptive statistics. Qualitative analysis in this study was based on the RFC, the UV and the CSI.

The RFC, proposed by Tardío and Pardo-de-Santayana (2008), shows the local importance of each species, and it is a result of the frequency of citation (FC, the number of informants mentioning the use of the species) divided by the total number of informants (n), without considering the use categories. This index varies from 0 (where nobody refers to the plant as useful) to 1 (where all informants mention the use of the species).

$$\mathrm{RFC} = \frac{\mathrm{FC}}{n}$$

The relative importance of each plant species known locally to be used for traditional saunas was expressed as the UV, which was calculated using the following formula (Phillips 1996):

$$\mathrm{UV} = \frac{\sum U}{n}$$

where UV is the use value of a species, U is the number of use-reports that are cited by each informant for a given plant species, and n is the total number of informants that are interviewed for a given plant.

Calculation of CSI (Turner 1988) uses three components, namely the quality of use, the intensity of use, and the exclusivity of use with the following formula:

$$\mathrm{CSI} = \sum_{k=1}^{n} (\mathrm{q} \times \mathrm{i} \times \mathrm{e}) n\mathrm{i}$$

where CSI is equal to the sum of individual-use values from 1 to n, with n representing the last use described; the subscript k represents the value 1 through n, consecutively. For each use given, q is quality value, i is intensity value, e is exclusivity value (Turner 1988).

For each species, the authors reviewed the available literature for phytochemical profiles using scientific databases (such as Scopus, Pubmed, Journal, Science Direct, and Google Scholar). Then, to complete the analysis, secondary data were used (data were obtained from the publications of other researchers).

Results

Local knowledge of traditional steam-bathing by Batak people

The Batak people recognised that pregnancy and the postpartum period may cause deaths. It was believed that keeping the body of postpartum mothers warm through steam-bathing could reduce the risk of postpartum death. The Batak Karo people call steam-bathing *oukup*, while the Batak Angkola-Mandailing people call it *marsidudu*. The postpartum mothers take steam-bathing treatments once or twice 7–14 days after childbirth. During our study in Kabanjahe and Berastagi traditional markets, we found that steam-bathing treatment is not only practiced by postpartum mothers, but also by anyone who wants to be physically fit and healthy.

The medicinal plants used in steam-bathing are mostly plants that produce distinctive aromas when boiled, such as species of Zingiberaceae, Rutaceae and Lamiaceae. The plant materials for steam-bathing are cut into small pieces and then boiled in a thick pot (with a lid), which contains ~20 L of water. The pot is then placed in a special room to allow steam-bathing to take place. A postpartum mother, or anyone who wishes to take a steam-bath, then sits on a chair and is covered with a blanket or a mat made from screw-pine (*Pandanus* sp.) leaves (Fig. 2). The lid of the pot is opened gradually in the closed room so that the room is heated. The temperature is regulated by opening the lid of the pot gradually and at the same time stirring the ingredients in the pot to produce aromatic vapours. The heat in the room will stimulate the body to sweat and the sweating is believed to drive out toxic compounds from the body, producing a relaxing effect, and improving the circulatory system. The steam-bathing lasts for ~20–30 min, depending on the ability of the body to tolerate the heat.

The Batak people believe that steam-bathing by postpartum mothers restores health, increases production of breast milk, improves the blood circulatory system, cleans the reproductive organs, reduces cholesterol levels, cures diabetes mellitus, smoothes the skin, and cures headaches (Table 1).

Recognition of the benefits of steam-bathing varied among respondents, with each set of respondents recognising different benefits: the traders identified 10 medicinal benefits (mean ± s.d. = 7.8 ± 2.03), midwives identified six benefits (4.1 ± 1.17) and mothers only five (2.9 ± 1.03) (Table 1). Restoration of stamina by means of a steam-bath is recognised by all informants, whereas the other benefits are known only by some informants (Table 1). Traders know only the following benefits: curing rheumatism, curing polyps, reducing cholesterol levels, and curing diabetes mellitus. The empirical prevention and cure of diabetes mellitus by the Batak people relates to the increase of physical activity which results in sweat release, similar to traditional steam-bathing activity.

Several medicinal plant traders in Kabanjahe and Berastagi traditional markets sell steam-bathing materials in plastic packages, so they look cleaner and more practical than when packaged otherwise (Fig. 3*a*). Packages of steam-bathing materials vary in terms of the number of species, volume, and price. The price of each package, ~40 000–60 000 rupiah (equivalent to US$3–5), is directly proportional to the number of species and the volume. Steam-bathing materials in plastic bags can include 15–29 species (depending on prices and traders) and last up to 3–4 months. Prior to packaging, the steam-bathing materials are dried in the sun, or air-dried by hanging them from the ceiling of the store (Fig. 3*b*); drying is done to avoid spoilage. Small holes are poked into the plastic bags, which are hung from the shop ceiling; the holes in the plastic bags allow air circulation to prevent the materials from becoming mouldy. The rhizomes of Zingiberaceae and fruits of Rutaceae are used fresh for steam-bathing, while leaves and seeds of the others species listed in Table 1 are dried before use.

Fig. 2. The process of steam-bathing in a *Pandanus* mat as practiced by the Batak ethnic groups in North Sumatra.

Diversity of medicinal plants used in traditional steam-bathing

In the present study, 59 species, 37 genera, and 25 families of medicinal plants were recorded as materials used for steam-bathing (Table 2). In total, 58 species were traded, but the number of species traded by each trader varies from 40 to 50 species (mean = 41.78 ± 3.19). Thirty-two species were used by midwives and mothers. The number of medicinal plant species known to midwives varies from 20 to 30 (mean = 26.22 ± 3.40), and 10–20 species were known to mothers (mean = 16.38 ± 3.02). Twenty-seven species of steam-bathing materials are known and used by traders but not used by midwives and mothers, including *Strobilanthes cernua* Blume, *Antrophyum calfolium* Blume, *Adianthum* sp., *Usnea barbata*, *Cinnamomun porrectum* (Roxb.) Kosterm., *Melastoma malabathricum* L., and *Myristica fragrans* Houtt.

Thirty species of medicinal plants sold as steam-bathing materials by traders are also used by midwives and mothers. The main species of medicinal plants used in steam-bathing are two species of Lamiaceae (*Ocimum americanum* L., *Ocimum basilicum* L.) and Liliaceae (*Allium cepa* L., *Allium sativum* L.), one species of Lauraceae (*Cinnamomun burmannii*), one species of Myrtaceae (*Syzygium aromaticum* (L.) Merril & L.M. Perry), one species of Pandanaceae (*Pandanus amaryllifolius* Roxb.), one species of Piperaceae (*Piper betle*), two species of Poaceae (*Cymbopogon citratus* (DC.) Staft., *Andropogos nardus* L.), seven species of Rutaceae, and the rest are from the Zingiberaceae. In traditional steam-bathing, the leaves (40 species), fruits (14 species), and rhizomes (9 species) constitute the most important parts of the plant (Fig. 4). The materials of steam-bathing are herbs (36 species), trees (14 species), shrubs (14 species), liana (1 species), and lichen (1 species) (Table 2).

The relative use of medicinal plants as materials for steam-bathing by Batak people is represented as RFC categories (Fig. 5). In total, 10 species of steam-bathing materials have RFC values of 0.80–1.00, 7 species have values of 0.60–0.80, and 10 species have values of 0.40–0.60. Only one steam-bathing ingredient is cited by almost 100% of respondents, whereas 10 species are cited by more than 80% of respondents. *Citrus hystrix* DC, *Zingiber officinale* Rosc, *Etlingera elatior* (Jack.) R.M.Sm., *Curcuma domestica* Val., *Alpinia galanga* (L.) Willd., *Citrus aurantiifolia* (Christm.) Swingle, *Cymbopogon citratus*, and *Pogostemon cablin* (Blanco) Benth. are frequently used by Batak people as steam-bathing materials. The RFC value of a given species is directly dependent on the number of informants who mention its use. Although *Gaultheria leucocarpa* Blume and *Cinnamomum porrectum* have low RFC values of 0.40 and 0.34 respectively, both have been used by all the traders as materials in steam-bathing. Both plants also have a refreshing odour so they have potential for the development of further steam-bathing materials.

The UV range of the medicinal plants as steam-bath material was 0.10–4.14 (Table 2). The plants with the highest UV were species that were considered to be the most important ingredients by the Batak people, as shown by their frequency of use (Table 1). Three of the plants with the highest UV were *Citrus hystrix* (4.08), *Zingiber officinale* (3.56), and *Etlingera elatior* (3.12). The UV is helpful in determining the plants with the highest use (most frequently indicated) in the treatment of an

Table 1. The medicinal benefits of steam-bathing according to the Batak people in North Sumatra

Medicinal benefits	No. of responses		
	Traders of medicinal plants ($n = 9$)	Midwives ($n = 9$)	Mothers ($n = 32$)
Restoring stamina	9	9	32
Cleansing women's reproductive organs	9	9	20
Improving blood circulation	9	9	18
Increasing breast milk production	8	6	12
Curing headache	7	2	11
Smoothing the skin	7	2	0
Curing rheumatism	7	0	0
Curing polyps	6	0	0
Reducing cholesterol levels	5	0	0
Curing diabetes mellitus	4	0	0

Fig. 3. (*a*) Steam-bathing materials. (*b*) The stall and traders of medicinal plants in the Kabanjahe traditional market. Photographs by M. Silalahi.

Table 2. The medicinal plants that are used as steam-bathing materials by the Batak people of North Sumatra, Indonesia

KJ, Kabanjahe; BR, Berastagi; T, traders; K, Batak Karo; M, Batak Angkola-Mandailing; RFC, relative frequency of citation; UV, use value; CSI, cultural significance index

Family	Scientific name (life form)	Local name	Specimen no.	Wild/ cultivated	Part used	Use	RFC	UV	CSI	Villages/markets	Floristic region
Acanthaceae	*Strobilanthes cernua* Bl. (Herb)	*Paris*	KJ 27	Wild	Leaves	Oukup, bone fractures	0.14	1.40	9.00	KJ, BR	Malesian
Adianthaceae	*Antrophyum callifolium* Bl. (Herb)	*Dilah hantu hara*	BR 135	Wild	Leaves	Oukup	0.01	0.26	1.50	KJ, BR	Indian
	Adiantum sp. (Herb)	*Regi-regi*	BR 245	Wild	Leaves	Oukup	0.10	0.18	1.50	KJ, BR	Indian
Apiaceae	*Coriandrum sativum* L. (Herb)	*Ketumbar*		Cultivated	Fruits	Oukup, rheumatism	0.015	1.46	6.00	KJ, BR	Caribbean
	Foeniculum vulgare Mill. (Herb)	*Adas*		Cultivated	Fruits	Oukup, rheumatism	0.012	1.38	6.00	KB, BR, K	Caribbean, Oceania, North America
Araceae	*Acorus calamus* L. (Herb)	*Salin batu* (M)	M45	Cultivated	Rhizomes	Oukup, fever, malnutrition	0.40	2.7	12.00	M	North America
Asteraceae	*Leontopodium alpinum* Colm. ex Cass. (Herb)	*Binara rembang*	KJ154	Wild	Leaves	Oukup	0.34	0.16	3.00	KJ, BR, K	Eurasia
Ericaceae	*Gaultheria leucocarpa* Bl. (Tree)	*Kalin cahyo*	KJ35	Wild	Leaves	Oukup, rhematism	0.46	0.46	12.00	KJ, BR, K	Malesian
Fabaceae	*Desmodium gangenticum* (L.) DC (Shurb)	*Nahang angin*	BR 21	Wild	Leaves	Oukup, rheumatism	0.02	0.16	3.00	KJ, BR	Indochina
Gesneriaceae	*Episcia* sp. (Herb)	*Baruk-baruk*	BR31	Wild	Leaves	Oukup, kidney disease	0.10	0.18	4.50	KJ, BR	
Lamiaceae	*Coleus amboinicus* Lour. (Herb)	*Terbangun rata*	KJ12	Cultivated	Leaves	Oukup, diarrhoea	0.08	1.34	6.00	KJ, BR	Caribbean, North America
	Ocimum americanum L. (Herb)	*Ruku-ruku begu*	KJ12	Cultivated	Leaves	Oukup	0.62	0.72	6.00	KJ, BR, K,M	Africa
	Ocimum basilicum L. (Herb)	*Kumangi*		Cultivated	Leaves	Oukup	0.56	0.96	6.00	KJ, BR, K, M	Oceania, Caribbean, North America
	Ocimum sanctum L. (Herb)	*Ruku-ruku*	KJ90	Cultivated	Leaves	Oukup	0.32	0.52	1.50	KJ, BR	Caribbean
	Pogostemon cablin Blanco (Benth) (Herb)	*Nilam*	KJ95	Cultivated	Leaves	Oukup, diarrhoea	0.50	1.48	9.00	KJ, BR, K, M	Malesian, Indochina
Lauraceae	*Cinnamomum burmanni* (Nees and T.Nees) Bl. (Tree)	*Kulit manis*		Cultivated	Leaves	Oukup, rheumatism	0.86	1.92	9.00	KJ, BR, K, M	Malesian, Indochina
	Cinnamomum porrectum (Roxb.) Kosterm. (Tree)	*Pirawas*	KJ101	Wild	Leaves	Oukup	0.34	0.56	9.00	KJ, BR, K	Malesian
	Cinnamomun sp. (Tree)	*Gajah menta*	KJ176	Wild	Leaves	Oukup	0.10	0.16	1.50	KJ, BR	Malesian
Liliaceae	*Allium cepa* L. (Herb)	*Pia*		Cultivated	Bulbs	Oukup, diarrhoea, fever, malnutrition, rheumatism, ulcer	0.54	3.50	24.00	KJ, BR,K	North America
	Allium sativum L. (Herb)	*Lasuna*		Cultivated	Bulbs	Oukup, cholesterol, diarrhoea, hypertension, rheumatism	0.44	2.70	30.00	KJ, BR,K	North America
Lycopodiaceae	*Lycopodium carinatum* Desv. ex Poir. (Herb)	*Tamtam jumalo*	KJ87	Wild	Whole	Oukup, cancer, bone fractures	0.10	0.14	4.50	KJ, BR	Caribbean, North America

Melastomaceae	*Melastoma malabathricum* L. (Shurb)	*Sanduduk*	KJ58	Wild	Leaves	Oukup, diarrhoea, bone fractures	0.16	1.28	9.00	KJ, BR	Indochina
	Melastoma sylvaticum Schltdl. (Shurb)	*Siduduk tonggal*	KJ67	Wild	Leaves	Oukup, bone fractures, stomach ache	0.08	0.22	15.00	KJ, BR	Indochina
Myristicaceae	*Myristica fragrans* Houtt. (Tree)	*Pala*		Cultivated	Fruits	Oukup, rheumatism, syphilis, tooth ache	0.10	0.70	18.00	KJ, BR	Malesian
Myrtaceae	*Syzygium aromaticum* (L.) Merril and L.M. Perry (Tree)	*Cengkeh*		Cultivated	Flower, Leaves	Oukup, bone fractures, rheumatism, syphilis, tooth ache	0.96	2.26	24.00	KJ, BR, K, M	Malesian
Pandanaceae	*Pandanus amaryllifolius* Roxb. (Herb)	*Pandan*		Cultivated	Leaves	Oukup	0.88	2.64	3.00	KJ, BR, K, M	Malesian
Piperaceae	*Piper aduncum* L. (Liana)	*Belo-belo*	K45	Wild	Leaves	Oukup, eye infection, injury,	0.32	0.46	18.00	KJ, BR, K	Caribbean, North America, Oceania
	Piper attenuatum Buch.-Ham. ex Miq. (Liana)	*Belo karangan*	K26	Wild	Leaves	Oukup, injury, malnutrion	0.12	0.86	15.00	KJ, BR	Malesian
	Piper betle L. (Liana)	*Belo situhu* (K), *simanat* (M)		Cultivated	Leaves	Oukup, eye infection, fever, malnutrition	0.62	2.9	18.00	KJ, BR, K, M	Malesian
	Piper nigrum L. (Liana)	*Lada*		Cultivated	Fruits	Oukup, heart disease, maintance stamina, rheumatism	0.18	2.24	15.00	KJ, BR	Malesian
Poaceae	*Andropogon zizanioides* (L.) Urb. (Herb)	*Akar wangi*		Cultivated	Roots	Oukup	0.10	0.16	3.00	KJ, BR	Malesian
	Cymbopogon citratus (DC.) Staft. (Herb)	*Sereh* (K), *sangge-*sangge (M)		Cultivated	Stem, Leaves	Oukup, rheumatism	0.86	1.58	12.00	KJ, BR, K, M	Caribbean, North America, South America
	Andropogon nardus L. (Herb)	*Sereh wangi* (K), *sangge-sangge holing* (M)	KJ 60	Cultivated	Stem, Leaves	Oukup, rheumatism	0.78	0.9	9.00	KJ, BR, K, M	Malesian
	Leptapsis sp. 1 (Herb)	*Putar balik*	KJ75	Wild	Leaves	Oukup, kidney disease	0.015	0.1	3.00	KJ, BR	Malesian
Ranunculaceae	*Nigella sativa* L. (Herb)	*Jintan*		Cultivated	Fruits	Oukup, rheumatism	0.20	0.24	4.50	KJ, BR, K	
Rutaceae	*Citrus hystrix* DC. (Tree)	*Rimo mungkur* (K), *utte mungkur* (M)		Cultivated	Leaves, Fruits	Oukup, headache, aphrodisiac, fever, rheumatism, diabetes mellitus	1.00	4.08	30.00	KJ, BR, K, M	Indian
	Citrus medica L. (Tree)	*Rimo gawang* (K), *utte gawang* (M)	K21	Cultivated	Leaves, Fruits	Oukup	0.60	0.52	6.00	KJ, BR, K, M	Indian
	Citrus nobilis Lour. (Tree)	*Rimo puraga* (K), *utte puraga* (M)	K35	Cultivated	Leaves, Fruits	Oukup	0.72	0.86	6.00	KJ, BR, K, M	Indian
	Citrus aurantiifolia (Christm.) Swingle (Tree)	*Rimo bunga* (K), *utte bunga* (M)	M54	Cultivated	Leaves, Fruits	Oukup, cough, cholesterol	0.80	1.16	12.00	KJ, BR, K, M	Indian
	Citrus sp. 1 (Tree)	*Rimo kayu* (K), *utte hau* (M)	M76	Cultivated	Leaves, Fruits	Oukup, cholesterol	0.60	0.24	6.00	KJ, BR, K,M	Indian
	Citrus sp. 2 (Tree)	*Rimo kejaren* (K), *utte kejaren* (M)	M98	Cultivated	Leaves, Fruits	Oukup, cholesterol	0.40	0.3	3.00	KJ, BR, K, M	Indian
	Citrus sp. 3 (Tree)	*Rimo malam*		Cultivated	Leave, Fruits	Oukup, cholesterol	0.42	0.24	3.00	KJ, BR, K,	Indian
Sterculiaceae	*Helicteres isora* L. (Herb)	*Lada putar*		Cultivated	Fruits	Oukup, aphrodisiac, syphilis, rheumatism	0.08	0.7	12.00	KJ, BR	Indian

(*Continued*)

Table 2. (Continued)

Family	Scientific name (life form)	Local name	Specimen no.	Wild/ cultivated	Part used	Use	RFC	UV	CSI	Villages/markets	Floristic region
Usneaceae	*Usnea barbata* (Lichen)	*Tai angin*	KJ 45	Wild	Whole	Oukup, aphrodisiac, rheumatism, syphilis	0.12	0.26	15.00	KJ, BR	Malesian
Styraceae	*Styrax benzoin* Dryand. (Tree)	*Kemeyan*		Cultivated	Sap	Oukup, fever, head-ache, malnutrition	0.10	1.9	18.00	KJ, BR	Malesian
Verbenaceae	*Vitex trifolia* L. (Shrub)	*Salagundi*	KJ44	Cultivated	Leaves	Oukup, cough, fever	0.08	0.5	12.00	KJ, BR	Malesian
Zingiberaceae	*Alpinia galanga* L. (Willd.) (Herb)	*Kelawas*		Cultivated	Leaves	Oukup, itch, head-ache, rheumatism	0.98	2.86	24.00	KJ, BR, K, M	Malesian
	Boesenbergia rotunda (L.) Mansf. (Herb)	*Temu kunci*		Cultivated	Rhizomes	Oukup, maintance stamina, fever	0.560	2.18	18.00	KJ, BR, K	Indian
	Curcuma longa L. (Herb)	*Kuning gersing*		Cultivated	Leaves	Oukup, diarrhoea, stomach ache, injury	0.80	2.14	24.00	KJ, BR, K, M	Malesian
	Curcuma heyneana Val. and Zijp. (Herb)	*Kuning gajah*		Cultivated	Rhizomes, Leaves	Oukup	0.18	0.12	6.00	KJ, BR	Malesian
	Curcuma zanthorrhiza Roxb. (Herb)	*Temulawak*		Cultivated	Leaves	Oukup, stomach ache, malnutrition	0.108	2.56	18.00	KJ, BR	Malesian
	Etlingera elatior (Jack.) R.M.Sm. (Herb)	*Cekala*	K16	Cultivated	Leaves, fruits	Oukup, headache, cough, cholesterol, fever	0.92	3.12	24.00	KJ, BR, K, M	Malesian
	Kaempferia galanga L. (Herb)	*Keciwer*		Cultivated	Rhizomes	Oukup, diarrhoea, malnutrition, rheu-matism, stomach ache	0.60	2.06	24.00	KJ, BR	Malesian, Indochina
	Zingiber aromaticum Val. (Herb)	*Lempuyang wangi*		Cultivated	Rhizomes	Oukup, headache	0.44	1.14	9.00	KJ, BR, K, M	Malesian, Indian
	Zingiber amaricans Bl. (Herb)	*Lempuyang*		Cultivated	Rhizomes	Oukup	0.18	0.46	6.00	KJ, BR	Malesian, Indian
	Zingiber officinale Rosc. (Herb)	*Bahing*		Cultivated	Leaves, Rhizome	Oukup, cough, fever, injury, headache, rheumatism	0.86	3.56	24.00	KJ, BR, K, M	Indian
	Zingiber purpureum Roscoe (Herb)	*Bungle*		Cultivated	Rhizome	Oukup, rheumatism	0.18	0.7	9.00	KJ, BR	Malesian, Indian
	Zingiber zerumbet (L.) Roscoe ex Sm (Herb)	*Lempuyang gajah*		Cultivated	Rhizomes	Oukup, rheumatism	0.08	0.46	9.00	KJ, BR	Malesian, Indian
	Zingiber sp. (Herb)	*Alia*	KJ12	Cultivated	Leaves	Oukup	0.12	0.24	9.00	KJ, BR	Malesian

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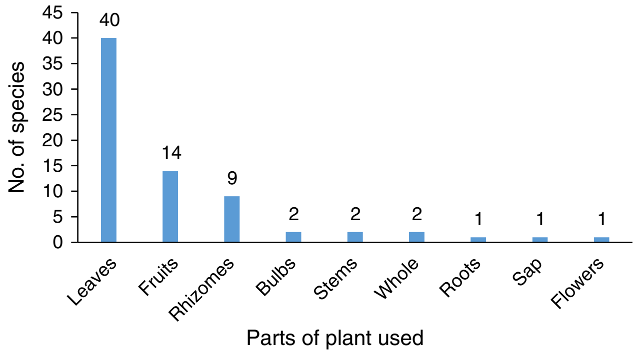

Fig. 4. The relationship between the number of species and the parts of the plant used for preparing steam-baths.

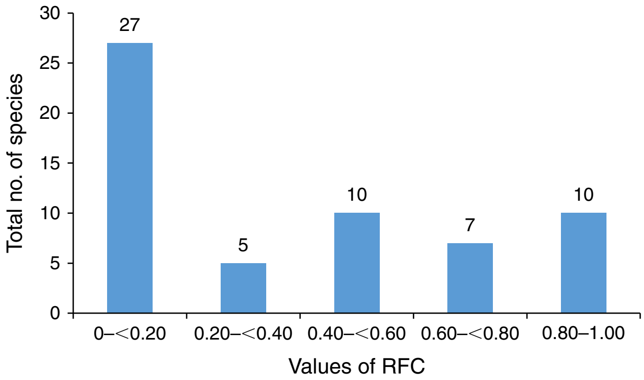

Fig. 5. The number of species for each RFC group of steam-bathing materials by Batak people in North Sumatra, Indonesia.

ailment. UVs are high when there are many use-reports for a plant and low when there are few reports related to its use.

In the present study, the CSIs of the medicinal plants were ~1.50–30.00. The group of plants with CSI values of 30 are the main steam-bathing materials, which are recognised by almost all respondents, such as *Citrus hystrix* and *Allium sativum*, whereas the plants that are recognised by few of the respondents have CSI values of 1.5–24.00 (Table 2).

The essential oils contained in medicinal plants and used as steam-bathing materials

Most of the medicinal plants used in steam-bathing are rich in essential oils or volatile oils. From the published literature, we found that there are at least 167 types of essential oils in *Alpinia galanga*, 136 types in *Citrus hystrix*, 88 types in *Cymbopogon citratus*, 77 types in *Andropogon nardus*, 154 types in *Etlingera elatior*, 207 types in *Ocimum basilicum*, and 137 types in *Zingiber officinale* (Appendix 1). The main function of steam-bathing is the aromatherapy, which promotes relaxation. Although much research has been conducted on essential oils in various steam-bathing materials, some species that contain volatile oils, such as *Cinnamomum porrectum*, *Gaultheria leucocarpa*, and *Strobilanthes cernua*, have not been studied. Since they empirically afford a distinctive aroma that is expected to provide a relaxing effect, we need further research concerning the essential oils in these plants, especially *Gaultheria leucocarpa* and *Cinnamomum porrectum*. Nevertheless, several steam-bathing materials, such as *Melastoma malabathricum* and *Melastoma sylvaticum* Schltdl., which are used as additional materials, have few or no essential oils.

Some of the plants used in steam-bathing have been documented to have ethnomedicinal uses in several tropical regions but are understudied for their potential pharmacological activity. *Citrus hystrix* oil causes a significant increase in blood pressure and a significant decrease in skin temperature (Hongratanaworakit and Buchbauer 2007) and inhibits the growth of bacteria that cause skin diseases such as *Bacillus subtilis*, *Staphylococcus epidermis*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* (Kongtun and Surachedkaiti 2009). *Alpinia galanga* has also been found to be beneficial in the treatment of bronchitis, heart disease and diabetes (Indrayan *et al.* 2009; Rao *et al.* 2010). *Etlingera elatior* has antioxidant activity (Abdelwahab *et al.* 2010; Jackie *et al.* 2011; Adliani *et al.* 2012) and antiaging properties (Ismail *et al.* 2004; Allaith 2008; Nithitanakool *et al.* 2014). This species contains essential oils dominated by mono- and sesquiterpenoids (Wong *et al.* 2010; Abdelwahab *et al.* 2010; Abdelmageed *et al.* 2011), which are volatile (Zulak and Bohlmann 2010) and remove body odour (Chan *et al.* 2011). Essential oils in the leaves of *Etlingera elatior* can reduce body odour (de Guzman and Siemonsma 1999; Wijekoon *et al.* 2011) because they inhibit the growth of microbes (de Guzman and Siemonsma 1999; Lachumy *et al.* 2010).

Discussion

The steam-bathing practised by the Batak people is based on thermotherapy and aromatherapy. Hence, plants used for steam-bathing are those that produce aromatic compounds. Steam-bathing is a local knowledge of the Batak people in which essential oils of plants are used for improving human health, i.e. for restoring stamina of postpartum mothers and treating different ailments. Compared with other advanced extraction methods, the steam distillation process is still preferred because of its low system cost, cleanliness, high production and low operational cost (Masango 2005) to obtain essential oils from plants (Dhobi *et al.* 2009; Andrade *et al.* 2013).

The room temperature in steam-bathing is regulated through the open pot lid, and the aroma is regulated by stirring the ingredients. Thermotherapy and aromatherapy are believed to affect the psychological and emotional conditions of postpartum mothers (Zumsteg and Weckerle 2007; Lamxay 2011), leading to improved stamina. The fragrances affect physiological and psychological aspects, such as: changes in autonomic heart rate, breathing rate, blood pressure, eye-blinks, skin temperature, and skin conductance (Brauchli *et al.* 1995; Bensafi *et al.* 2002), changes in brain wave activities, and changes in mood, which makes people feel more relaxed (Field *et al.* 2005).

The maximum effect of steam-bathing is achieved when carried out for 15–30 min. Xu *et al.* (2015) stated that heat-stimulating times of 30 and 60 min may be more effective for relieving lower back pain. Steam-bathing by the Batak people is capable of restoring the stamina of postpartum mothers through improved blood circulation and reduced pain, as confirmed by

Campbell *et al.* (2004), Hannuksela and Ellahham (2001), and Chaichian *et al.* (2009). Warming the body reduces pain because it stimulates the body to release endocrine hormones and endogenous opioid peptides, resulting in relaxation of the cells of the body and reducing the sensitivity of nerve cells (Chaichian *et al.* 2009). Campbell *et al.* (2004) stated that if the body is warm it will activate receptors that cause blood vessels to become vasodilatated. Warming the body will improve oxygen transportation systems (circulatory O_2), which will open the pores of the skin and activate sweat glands instantly, in turn releasing toxic compounds from the body.

The essential oils reduce body odour and pain through stimulation of the endocrine, respiratory and nervous systems. Essential oils such as limonene, pinene and methyl chavicol possibly mediate the stimulating effect on sympathetic activity, whereas kaffir lime oil causes a significant increase in blood pressure and a significant decrease in skin temperature (Hongratanaworakit and Buchbauer 2007). Terpinen-4-ol, 1,8-cineole, fenchol derivatives are used for inhalation of the oils when suffering from respiratory diseases (Kubota *et al.* 1999; Mallavarapu *et al.* 2002; Jirovetz *et al.* 2003), and camphor and camphene are used for rheumatic pain (Kubota *et al.* 1999; Mallavarapu *et al.* 2002; Jirovetz *et al.* 2003; Indrayan *et al.* 2009; Rao *et al.* 2010). Linalool has a sedative effect on the central nervous system, and hypnotic, anticonvulsant and hypothermic properties (Elisabetsky *et al.* 1995).

The essential oils derived from some of the steam-bathing ingredients have great potential in research and commercialisation for aromatherapy and spa practices; these include: *Citrus hystrix* (Chaisawadi *et al.* 2007; Chan *et al.* 2009), *Curcuma domestica*, *Cymbopogon citratus* (Sureechatchaiyan *et al.* 2011), *Gaultheria leucocarpa* and *Cinnamomum porrectum*. *Gaultheria leucocarpa* and *Cinnamomum porrectum* in this study produced distinctive aromas and reduced pain. Thus, it will be interesting to study these plants for their phytochemical and pharmacological properties.

Although most of the steam-bathing ingredients contained essential oils, *Melastoma malabathricum* and *Melastoma sylvaticum* had no essential oils. These plants were utilised to control or reduce the evaporation rate through chemical binding or attraction, or simply by increasing the mass of additional plant material in the boiling water or on the glowing embers, so the aromas from the essential oils would be stable and last longer (de Boer and Lamxay 2009). To obtain the optimum effect of steam-bathing, the temperature of the ingredients must be regulated because, on the one hand, warming helps the evaporation of essential oils but, on the other hand, high temperatures damage essential oils (Kasuan *et al.* 2013; Wu *et al.* 2014). For example, in uncontrolled temperatures, some important volatile compounds, such as terpinolene, linalool and terpinen-4-ol, are absent due to thermal degradation from fast heating of extracted material (Kasuan *et al.* 2013).

In this study, the traders took 56 species as steam-bathing ingredients, which has cost implications. The concentration and types of the essential oils of the plants are different, so the ingredients are complementary. *Alpinia galanga* rhizomes mainly contain eucalyptol (Wu *et al.* 2014) and 1,8-cineole (Jirovetz *et al.* 2003) whereas its leaves mainly contain 1,8-cineole and camphor (Jirovetz *et al.* 2003). The leaves of *Etlingera elatior* mainly contain β-pinene, whereas its stem mainly contains 1,1-dodecanediol diacetate (Jaafar *et al.* 2007). The leaves of *Citrus hystrix* mainly contain β-citronellal (Loh *et al.* 2011), whereas its fruits mainly contain sabinene (Tinjan and Jirapakkul 2007; Kasuan *et al.* 2013) and limonene (Hongratanaworakit and Buchbauer 2007). Although the essential oils in the steam-bathing materials are complementary, it is possible for them to be overlapping. The steam-bathing materials could be made more economical by reconsidering the inclusion of complementary materials so that the number of plant species is reduced. The number of species from the Zingiberaceae and Rutaceae could probably be decreased. However, further analysis is necessary to ensure the efficacy of such reductions.

Conclusions

This study showed that the Batak people still preserve a rich ethnobotanical knowledge. The study provides a detailed description of 59 plants and species that are used in traditional steam-bathing by Batak people. The steam-bathing practiced by the Batak people is based on the principles of thermotherapy and aromatherapy. The steam-bathing materials that have high RFC values (0.08–1.00), such as *Citrus hystrix*, *Zingiber officinale*, *Etlingera elatior*, *Curcuma domestica*, *Alpinia galanga*, *Citrus aurantiifolia*, *Cymbopogon citratus*, and *Pogostemon cablin*, are frequently used by Batak people as steam-bathing materials. Some of the species (e.g. *Gaultheria leucocarpa*, *Cinnamomum porrectum*) would be interesting to study for their phytochemical and pharmacological properties.

Conflicts of interest

The authors declare no conflicts of interest.

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Appendix 1. The essential oils of steam-bathing materials used by Batak people in North Sumatra, Indonesia

Species	Content of the essential oils
Etlingera elatior (Jack.) R.M.Sm	Dodecanal[A,B,D,E], Decanal[A,C,D,E], α-Caryophyllene, 2-Tridecanone, 2-Undecanone, β-Myrcene, β-pinene[A,B,C], Dodecane[A,B,D], 1-dodecanol[B,D,E], 2-Undecanone, Dodecanoic acid[C,D,E], 2-Tridecanone, Acetic acid, Bicyclo[3.1.1]hept-2-ene,2,6,6-trimethyl, Bicyclo[3.1.1]heptan-3-one[A,B], Eicosane[B,C], 1-Tetradecene[B,E], 1- Limonene, 1-Decanol[B,D], α-Pinene[C,D], Hexadecanol, Cyclododecane[C,E], Tetradecanoic acid, Undecane[D,E], *trans*-(*Z*)-α-Bisabolene epoxide, 3-Bromo-7-methyl-1-adamantane, Carboxylic acid, 7,11-Dimethyl-3-methylene,1,6,10-Dodecatriene, β-Farnesene, 7-Methylene-9-oxabicyclo[6.1.0]non-2-ene, 2-Pentadecyn-1-ol,(*E*)-10-Pentadecenol; 1,3-Propanediol, 2-dodecyl, (−)-α-Terpineol (*p*-menth-1-en-8-ol)[(1)], Bicyclo[3.1.1]heptan-3-ol, Bicyclo[3.1.1]hept-3-ol,Bicyclo[3.1.1]hept-2-ene-2-methanol, Cyclohexane,Cyclohexanol, 2-Cyclohexen-1-one, Cyclohexanone, n-Decanoic acid, Dodecyl ester, 1-Nonanol,Cis-6-Nonenal,phenyl-n-Hexadecanoic acid, 2,6,10-Dodecatrien-1-ol,1,6,10-Dodecatriene, 1,6,10-Dodecatrien-3-ol, 9-Tetradecen-1-ol,1,13-Tetradecadiene, 1,12-Tridecadiene,1-Tetradecanol, 1-Undecene[B], Borneol, Camphene, Camphor, Caryophyllene, Caryaphyllene oxide,(+)-*d*-Cadinene,Copaene, 1-Cyclohexylnonene, Cyclododecane, Decyl ester, Diacetate, 2,3-dihydroxypropyl octadec-9-enoate (glyceryl palmitoleate), Dihydrocavreol, 1,2-Dimethylcyclooctane, 1,1-Dodecanediol, Dodecamethyl, Cyclohexasiloxane, (*E*)-5-Dodecene, Elaidic acid, β-Elemene, 2-Ethyl fenchol, Eucaplytol, (*Z*)- β-Farnesene, Formic acid, (*Z*)- β-Farnesene, Glyceryl monooleate, (Z)-3-Hexadecene, (*E*)-2-Hexenal, 1-Heptadecene, *D*-Limonene, 1,3,8-*p*-Menthatriene, *Trans* nerolidol, Octadac-9-enoic acid, 9-Octadecenal,Oleic acid, Sabinene, α-Terpinene, α-Terpineol, α-Terpinolene, Tetradecyl ester, 1,13-Tetradecadiene, α-Thujene[C], β-caryophyllene, Decyl acetate, 9-decen-1-ol, α-p-Dimethylstyrene, Dodecyl acetate, Hexadecane, α-humalene, Myrcene, Nerolidol, 2-Nonanol, Linalool, β-Phelladrene, Furfuril alcohol, Furfural, Para-cymene, (Z)-9-Tetradecen-1-ol, Tetradecyl acetate, Tetradecanol, Terpineol, (Z)-5-Tetradecen-1-ol, Tetra-3-carene, 2-Tridecanone, 10-Undecena, Toluene[(D)], Cyclotetradecane, Cycotetracosane, Dodecane-1–2-diol, 3-Dodecyl cyclohexanone, 5-Eicosene, Hexadecanedinitrile, Hexadecanoic acid, 1-Hexadecene, 1-Heneicosyl formate, Icosane, 2-Methyl-1-hexadecanol, 4-Hydrazono-5-hydroxymino, Oisopropylidene, Cis-13-octadecenoic acid, 9,12 Octadecadienoic acid, Oxirane, (9E, 12E)-9,12-Octa decadienoicacid, 17-Pentatriacontene, Propanedioic acid, Quinoline, 4,5,6,7-Tetrahydrobenzofuraxane, Cis-9-Tetradecen-1-ol, 9-Tricosane, 2-Tridecanone, Cis vaccenic acid, Tridecane, Cholest-5-en-3-ol, Undecanal, 6-Nitro-2-metylpyrrolo[2,3], 1,2, Benzenedicarboxylic acid[E].
Alpinia galanga L. (Willd.)	β-Pinene[F,G,H,I], α-Pinene, α-Terpineol[F,G,H], Camphene, Fenchene, α-Phellandrene, γ-Terpinene, Linalool, Fenchol, Borneol, Geraniol, Myrtenol[F,G], Camphor[F,G,I], 1,8-Cineole[F,I], β-Farnesene[F,J], Terpinen-4-ol[F,H], β-Terpinen, 2,4(8)-*p*-Menthadiene, 2-Isopropyltoluene, Eucalyptol, 1-Methyl-3-(1′-methylcyclopropyl) cyclopentene, 2,2-Dimethylheptane, Undecane, Linalool, 2-Methyloctane, Camphene hydrate, 4-Carvomenthenol, (+)-Sabinol, Fenchyl acetate, Citronellyl formate, Benzylacetone, *p*-Menth-1-en-3-one, l-Bornyl acetate, Thymyl acetate, Benzalacetone, Nerol acetate, Caryophyllene, α-Caryophyllene, Methyl isoeugenol, Dihydro-cis-α-copaene-8-ol, Aciphyllene, 2-Methyl-decane, 3,7,11-Trimethyl-3-hydroxy-6,10-dodecadien-1-yl acetate, 1-Methylene-2*b*-hydroxymethyl-3, 3-dimethyl-4*b*-(3-methylbut-2-enyl)-cyclohexane, 2-(1,1-Dimethylethyl)-6-(1-methylethyl)phenol,1-Formyl-2, 2-dimethyl-3-trans-(3-methyl-but-2-enyl)-6-methylidene-cyclohexane,Methyltrans-2-phenyl-1-cyclopropane-carboxylate, Bicyclo[6.1.0]non-1-ene, 3,5-Dimethyl-4-octanone, 2-Methyl-3-(3-methylbut-2-enyl)-2-(4-methyl-pent-3-enyl)-oxetane, Bornylane, Scytalone, 3-Ethyl-3-methyl-decane, 9-Oxononanoic acid, 2-(Fench-2-yl)fenchane[G], Ethyl acetate, (*E*)-2-Hexenal, (*E*)-2-Hexenol, Hexanol, Methyl isobutyl ketone, α-Thujene, Tricyclene, 1-Octen-3-ol, Sabinene, Myrcene, δ-3-Carene, α-Terpinene, *p*-Cymene, Limonene, β-Phellandrene, Benzyl alcohol, (*Z*)-β-Ocimene, (*E*)-β-Ocimene, *trans*-Sabinene hydrate, *cis*-Linalool oxide, *trans*-Linalool oxide, Fenchone, α -*p*-Dimethyl styrene, Terpinolene, *cis*-Sabinene hydrate, α-Fenchol, Phenylethyl alcohol, Nonanal, *cis*-*p*-Menth-2-en-1-ol, β-Thujone, *trans*-Pinocarveol, β-Terpineol, Isoborneol, Isopulegol, *p*-Cymen-8-ol, Myrtenal, Verbenone, *trans*-Carveol, α-Fenchyl acetate, *cis*-Carveol, Carvone, Pulegone, Linalyl acetate, Isopulegyl acetate, *cis*-Sabinyl acetate, 2-Hydroxy-1,8-cineole, Isobornyl acetate, Bornyl acetate, Terpinen-4-yl acetate, pinocarvone, (*Z*)-Methyl cinnamate, Eugenol, (*E*)-Methyl cinnamate, α-Cubebene, α-Copaene, β-Patchoulene, β-Bourbonene, β-Elemene, α-Gurjunene, β-Caryophyllene, β-Gurjunene, α-Bergamotene, (*E*)-β-Farnesene, α-Guaiene, Alloaromadendrene, α-Humulene, Germacrene D, *Ar*-Curcumene, β-Selinene, Viridiflorene, γ-Muurolene, Valencene, α-Muurolene, α-Selinene, γ-Elemene, β-Bisabolene, γ-Cadinene, σ-Cadinene, Elemol, (*E*)-Nerolidol, β-Chamigrene, Carotol, Spathulenol, Caryophyllene oxide, Globulol, Ledol, Viridiflorol, Cubenol, Cuaiol, γ-Eudesmol, Cadinol, Muurolol, α-Cadinol, β-Eudesmol, α-Bisabolol, β-Bisabolol, α-Eudesmol, (*Z*)-α-Bergamotol, (*Z,E*)-Farnesol, (*E,E*)-Farnesol, Nootketone[F], trans-Caryophyllene, Zingiberene[J], Methyleugenol, Eugenol acetate, Chavicol (4-allylphenol), Chavicol acetate[K].
Citrus hystrix DC.	α-Pinene[L,M,N,O,P,Q], β-Pinene[L,N,O,P,Q,R,S,T,U], α-Terpineol[L,O,P,Q,R,S,T], Sabinene[L,M,N,O,P,T,U], Terpinene-4-ol[N,O,P,R,T], Linalool[M,N,O,P,S,T], γ-Terpinene[L,M,N,O,S], Citronellol[P,R,S,T], Limonene[O,P,Q,R], *cis*-Linalool oxide[M,O,Q,T], p-Cymene[M,N,O], Citronellal[L,M,P,S], Geranyl acetate[L,M,N,T], l-Limonene[L,M,N,S], α-Terpinolene[L,M,N,Q], γ-Cardinene[L,M,N,O], Terpinolene[O,P], 2, 6-Dimethyl-5-heptenal[N,T,U], Citronellyl acetate[L,N,O], α-Terpinene[M,O], α-Phellandrene[L,M,O], β-Citronellol[L,N,T], Neryl acetate[L,N,O], Nerolidol, β-myrcen[L,N,T], α-Thujene[L,O,P], Geraniol[M,N,T], Myrcene, Camphene[M,O,P], Bicyclogermacrene, (-)-Isopulegol, Germacrene-D[L,M], *trans*-Sabinene hydrate[L,N], b-Cubebene[L,O], α-Muurolene[M,N], α-Humulene, α-Copaene[L,M], β-Terpinene[P,Q], 1,8-Cineole[Q,R], Isopregol[Q,T], Geranial, *trans,trans*-α-Farnesene, α-Guaiene, d-Guaiene, Hexanal, *trans*-2-Hexenal, *trans*-Geraniol, 1H-Indole,

(*Continued*)

Appendix 1. (Continued)

Species	Content of the essential oils
	Neral, *cis*-β-Ocimene, *trans*-β-Ocimene, 1-Penten-3-ol, 4-Pentenal, cis-2-Pentenol, Octanol, Neoiso(iso)pulegol, α -Terpinen-4-ol, δ-3-Carene, (+)-Aromadendrene, Diethyl phtalate, Decanal, (+)-Cycloisosativene, *trans*-4,8-Dimethyl-1,3,7-nonatriene, d-Cadinene, Epi-bicyclosesquiphellandrene, 2-(2-Hydroxyl-2propyl)-5-*m*-cyclohexanol, *trans*- β –Farnerene, *trans*-β-Caryophyllene[L], cis- β-Terpineol, T-Muurolol, trans β-Terpineol, α-Terpineol, Isoborneol, Ledene, Linalool oxide, 2-β-Pinene, γ-Selinene, β-Selinene, Terpineneol, 1,4,6-Trien-3-ol, α-Ylangene, Octyl phenyl acetate, δ-Cardinene, Cadina-1,4-diene, Elemol, l-Citronellol, α-Eudesmol, γ-Eudesmol (Selinenol), α-Fenchene, Citronellyl acetate, Benzoic acid, Cyclofenchene, Cyclohexene; D-Fenchyl alcohol, Caryophyllene[M], Epoxy-linalool oxide, trans-Linalool oxide, Guaiol, Nerol, *l*-α-Terpineol, cis-Ocimene, *p*-Menthan-3,8-diol, 4-*p*-Menthene, *iso*-Pulegol, trans-Caryophyllene, Caryophyllene oxide, α-Bergamotene, Δ-3-Carene, β-Bisabolene, *l*-Citronellal, Eugenol, *d*-Citronellal, β-Elemene, 2,6 Dimethyl-5-heptenol[N], (*Z*)-Caryophyllene, Borneol, Germacrene, *neo*-Isopulegol, *iso*-Isopulegol, *exo*-Fenchol,α-Cubebene, β -Citronellol[O], δ-2-Carene[P], α-Caryophyllene[Q], Cyclohexanol, Cyclohexanol[S], 5,9-Dimethyl-1-decanol, *Cis*-2,6-Dimethyl-2,6-octadiene, 8-Dimethyl-1,7-nonadien-4-ol, (*E*)-2,5-Dimethyl-1,6-octadiene, 2-(2-Hydroxy-2-propyl)-5-methyl-cyclohexanol, Methyl citronellate, 2-Methyl-7-oxabicyclo-heptane, 4-Methyl-6-hepten-3-ol, 3-Hexen-1-ol, Isopulegol, 1,8-Terpine, (E)-Furanoid,Linalool oxide, Tetrahydro-4-methyl-2-(2-methyl-1-propenyl)-2*H*-pyran, 3-Undecanol[T], Citronellic acid, (-)-Citronellal[U].
Cymbopogon citratus (DC.) Staft.	Geranial[V,W,X,Y,Z], Neral[V,W,Y,Z], α-Gurjene, β-Eudesmol, Citronellal, δ-Cadinene[V,X,Z], Geranic-acid[V,W,Y], Linalool[V,X,Y], Citronellol[V,Y,Z], Myrcenol, α-Bergamotene[V,W], β-Myrcene, Nerol[V,X], Citral[V,Y], Germacrene-D, α-Farnesene, α-terpineol[V,Z], Geraniol, Elemol[X,Z], Myrcene[Y,Z], Methyl-n-nonyl-ketone, 1-Octyn-3-ol *trans*-Chrysanthemal, α-Pinene oxide, Burneol, α-Amorphene, 3-Undecyne, 3-Carvomenthenone, Valencene, β-*O*-Cimene, Allo-*o*-cimene, Viridiflorol, *t*-Cadinol, *trans*-(-)-Carveol, Dextro-carvone, α-Elemol, α-Gurjunene, Humulene, *t*-Muurolol, Levo-β-elemene, γ-Muurolene, α-Muurolene, β-Sesquiphellandrene, α-Selinene[V], α-Phellandren-8-ol, α-Pinene, β-Pinene, τ-Gurjunene, β-Caryophyllene, β-Caryophyllene oxide, α-Terpinolene, trans-3(10)-Caren-2-ol, β-Citronellol, p-Cymenec, cis-Verbenol, 2-Undecanone, β-Bourbonene, cis-Geraniol, Geranyl acetate, β-Linalool, β-Citronellal, p-Mentha-1(7),8(10)-dien-9-ol; cis-p-mentha-2,8-dienol, Eudesm-7(11)-en-4-ol, Nopol, Neric acid, (Z)-β-Ocimene, (E)-β-Ocimene[W], 6-Methyl-5-hepten-2-one, Naphthalene, cis-β-Farnesene, α-Muurolene, σ-Muurolol, β-Citral, E-Eitral, β-Bisabolene, Caryophylene oxide, β-Chamigrene, cis-Ocimene, β-z-Ocimene, Germacrene B, β-Panasinsene[X], Citronellyl tiglate, Bicyclogermacrene, Limonene, Methyl-5 epten- 2one, γ-Eudesmol, Sabinene hydrate, β-Elemene[Z].
Andropogon nardus L.	Geranyl acetate[W,Z,AA,AB,AC,AE], Limonene[W,Z,AA,AB,AD,AE], Nerol[W,AA,AB,AD,AE], Geranial[W,Z,AB,AC,AD], Geraniol[Z,AB,AC,AD,AE], Citronellyl acetate[AA,AC,AD,AE], Germacrene-D, β-Elemene[W,Z,AA,AB], Eugenol[W,AA,AB,AC], Neral[W,Z,AB,AC], Citronellol[Z,AB,AC,AE], Citronellal[AA,AB,AC,AD,AE], Elemol[Z,AA,AB], α-Cadinol, δ-Cadinene[W,AA,AB], Linalool[AA,AB,AD], Myrcene[Z,AB,AE], β-Eudesmol[Z,AA], Isopulegol, α-Eudesmol[AA,AB], β-Myrcene, α-Muurolene, τ-Cadinol[W,AA], Citral[AA,AE], Bicyclogermacrene, α-Farnesene[Z,AB], α-Terpineol[Z,AE], trans-β-Caryophyllene[AB,AC], 4-Nonanona[AC,AD], Isoeugenol[W,AE], 7-Acetil-2-hidroksi-2-metil, 5-Nitrobenzofuran-2-carboksil acid, Bisiklo(4,4,0) dec-1-en, 2 isoprophy, Endo-1-bourbonanol, Siklobutene, 1,2,3,4-Tetrametil, Z-Citral, Geranil, Geraniol formate, 2,6-Dimetil-5-heptenal, α-Copaena, (-)-Isopulegol, Patchouli alcohol, β-Patchoulena, δGuaiena, T-Muroolol[AA], γ-Eudesmol, Citronellyl tiglate, Cis Citronellal[Z], Citronnellyle acetate, β-Cadinol, D-Germacrene-4-ol[AB], γ-Cadinene, 1-Ethyl-2-methylcyclopentene[AC], τ-Eudesmol, β-Caryophyllene, β-Citronellal, β-Citronellol, Cubenol, β-Cubebene, τ-Gurjunene, α-Humulene, β-Linalool, Ledol, Melonal, (Z,E)-Farnesol, Seychellene, τ-Muurolene[W], 6-Metil-5-hepten-2-ona, (Z)-β-Ocimene, (E)-β-Ocimene, Caryofilenol[AD], cis-Citral, trans-Citral, α-Pinene, β-Pinene, Menthone[AE].
Ocimum basilicum L.	Linalool[AF,AG,AH,AI,AJ,AK,AL,AM,AN,AO,AP,AQ], Camphor[AG,AH,AI,AJ,AM,AN,AO,AP,AQ,AR], Eugenol[AG,AH,AJ,AL,AM,AO,AP,AQ], Methyl eugenol[AF,AH,AK, AL,AN,AO,AP,AQ], Methyl chavicol[AG,AI,AJ,AK,AL,AM,AN,AO,AP], α-Pinene[AF,AJ,AL,AM,AN,AO,AP,AQ], 1,8-Cineole[AG,AH,AJ,AK,AM,AN,AP,AQ], β-Pinene[AF,AH,AJ,AL,AM,AN,AO,AP,AQ], Myrcene[AF,AL,AM,AN,AO,AP,AQ,AR], α-umulene[AF,AG,AH,AI,AJ,AN,AQ], *trans*-α-Bergamotene[AF,AG,AI,AM,AN,AQ,AR], Sabinene[AF,AM,AN,AO,AP,AQ], Terpinene-4-ol[AG,AH,AM,AN,AP,AR], Bornyl acetate[AF,AH,AI,AJ,AN,AR,AS], Bicyclogermacrene, Camphene[AJ,AM,AN,AO,AP,AQ], Germacrene-D[AF,AG,AH,AM,AN,AO,AP,AQ], γ-adinene[AG,AH,AM,AN,AP,AQ,AR], β-Elemene[AF,AH,AM,AN,AP,AR], γ-Terpinene[AF,AJ,AM,AN,AP,AQ], β- α-Terpinene[AF,AL,AM,AO,AP,AQ], α-Terpineol[AF,AH,AL,AN,AP,AR], Spathulenol[AG,AM,AN,AP,AQ,AR], Limonene[AF,AH,AM,AP,AQ], Borneol[AM,AN,AP,AQ,AR], Geraniol[AF,AM,AN,AO,AP,AR], β-Cubebene[AF,AH,AM,AN,AP], α-Cubebene, α-Copaene[AF,AM,AN,AP,AS], Eudesmol[AG,AM,AP,AQ,AS], Fenchone[AG,AM,AN,AP,AQ], Cadinol[AH,AM,AN,AQ,AR], α-Bulnesene[AM,AN,AP,AQ,AR], α-Guaiene[AF,AM,AN,AP], Caryophyllene oxide[AG,AM,AP,AQ], 1,8 Cineol[AL,AO,AR], Neral, Geranial[AF,AG,AQ], Linalyl acetate[AF,AL,AO], β-Caryophyllene[AF,AJ,AK], *cis*-Sabinene hydrate, *cis*-Linalool oxide (furanoid), *cis*-Muurola-4(11),5-diene[AF,AN,AQ], β-Bourbonene[AF,AM,AP], Geranyl acetate[AF,AN,AR], α-Thujene, Nerol[AF,AO,AQ], P-cymene[AF,AP,AQ], 1,10-di-*epi*-Cubenol[AG,AN,AQ], Terpinolene, (*E*)-β-Ocimene, (*E*)-Caryophyllene, (*E*)-β-Farnesene, α-Cadinene[AM,AN,AP], α-Bisabolol[AM,AP,AQ], Phytol[AM,AP,AR], Ocimene[AO,AS], Carvacrol[AF,AH], Eucalyptol[AF,AI], Cadina-3,9-dien[AF,AJ], Endo-fenchyl acetate[AF,AN], *trans*-β-Ocimene, *trans*-Myroxide, Terpinen-4-ol, Chavicol, Exo-2-hydroxycineole acetate[AF,AQ], Germacrene-A, *epi*-α-Cadinol[AG,AN], Methyl cinnamate[AH,AJ], *trans*-α-Bisabolene[AG,AQ],

(*Continued*)

Appendix 1. (Continued)

Species	Content of the essential oils
	Caryophyllene[AH,AO], α-(Z)-Bergamotene, α-Amorphene, Δ-Cadinene[AH,AP], Estragole[AH,AQ], 3-Carene[AJ,AS], Farnesol[AL,AO], (*Z*)-β-Ocimene, (*Z*)-Sabinene hydrate, Aromadendrene, *α*-Zingiberene, (*Z*)-Nerolidol, (*Z*)-Calamenene, Alloaromadendrene[AM,AP], *trans*-Calamenene[AN,AQ], Benzaldehyde, cis-hex-3-Enyl acetate, *cis*-β-Ocimene, *trans*-Linalool oxide, Neo-allo-ocimene, Menth-2-en-1-ol, Pinocarvone, 3,7-Dimethyloct-1,5-dien-3,7-diol, *n*-Octyl acetate, Bicycloelemene, 3,7-Dimethylocta-1,7-dien-3,6-diol, α-ylangene, β-Copaene, δ-Muurolene, β-Acoradiene, α-Acoradiene, Bicylogermacrene, Benzaldehyde, Octen-3-ol, cis-3-Hexenyl acetate, β-Phellandrene, *n*-Octanol, Octan-3-yl acetate, Cyclopentanal-1,2-dimethyl-3(1-methylethenyl), cis-Menth-2-en-1-ol, Plinol, Methyl calicylate, *n*-Octyl acetate, cis-3-Hexenyl valerate, Myrtenyl formate, β-Cycloelemene, Exo-2-hydroxycineole acetate[AF], Octen-3-ol, 6-Methyl-5-hepten-2-one, *trans*-Caryophyllene, Humulene epoxide II[AG], Aloaromadendrene, Carvone, *β*-Burbonene, Calamenene, *β*-Farnesene, *α*-Bisabolene, (Z)-(E)-Spatulenol, Torreyol, Chavicol[AH], trans-Carvophyllene, Cadinol[AI], 1–4-Hexen-1-ol, 2-Hexenal, β-Myrcene, *α*-Phellandrene, D-Limonene, Terpinen-4-acetat, Bergamotene, β-Muurolene[AJ],β-Terpinene, β-Terpineol, Iso eugenol[AL], β-Selinene, σ-Cadinene[AM], Exo-fenchyl acetate, Guaiene, cis-β-Guaiene, Viridiflorene, δ-Amorphene, 10-Epi-cubebol[AN], 1,4-Terpineol, Methyl chavicol, Geroniol, Cadinene, cis-Bisabolene, Nerolidole, Selinene, t-Cadinol[AO], *β*-Phellandrene, *α*-Longipinene, *α*-Cedrene, (E)-*α*-Farnesene,β-Sinensal[AP], Ethyl 2-methyl butyrate, Ethyl isovalerate, Octen-3-yl acetate, 4-Acetyl-1-Methylcyclohexene, σ-Terpineol, Octanol acetate, Fenchyl acetate, *cis*-Methyl cinnamate, Neryl acetate, *trans*-Methyl cinnamate, β-Elemene, Sesquithujene, β-Caryophyllene, α-Quaiene, *trans*-β-Farnesene, 10-*epi*-β-Acoradiene, *trans*-Muurola-4(11),5-diene, β-bisabolene, β-Sesquiphellandrene, Salviadienol, *trans*-Nerolidol, Maaliol, Guaia-6,10(11)-diene-4-β-ol, α-Muurolol, Aromadendran-12-ol, Aromadendran-11-ol, *cis*-Lanceol, *trans*-Phytol, *trans*-Phytol acetate[AQ], β-(Z)-Ocimene, Cubenol[AR], 1,2,3,4,5 Pentamethyl-1,3-cyclopentadiene, P-Menth-2-en-1-ol, 6-methyl-5-(1-methylethylidene)-6,8-nonadien-2-one, 3,6-Dimethyl-4,5,6,7-tetrahydrobenzofuran, 1-Ethenyl-1-methyl-2-(1-methylethenyl)- 4- (1- methylethylidene) cyclohexane, 1, 7, 7-Trimethlbicyclo [2.2.1] heptan-2-ol, 4-methyl-1-(1-methylethyl) cyclohexene, γ- Elemene, 1-Ethenyl-1-methyl-2-(1-methyl) cyclohexane, Eugenyl acetate, Copaene, 1,4-Dimethyl-7-(prop-1-en-2-yl)-1,2,3,4,5,6,7,8-octahydroazulene, 2,4,5,6,7,8- Hexahydro-1,4,9,9-tetramethyl-3H-3a, 7-Methanoazulene, 2,2,4,8 Tetramethyltricyclo [5.3.1.0(4,11)]undecan-7-ol, γ -Himachalene, 9-β-Acetoxy-3α-hydroxy-3,5 α,8 trimethyltricyclo [6.3.1.0(1, 5)]dodecane, Isoeugenyl acetate, Uncineol, Rosifoliol, 6,10,11-trimethyl-2-pentadecanone, Tricyclo[6.3.0.0(3,7)]undec-1(8)-en-3-ol, Farnesylacetone, Isophytol, Thunbergol, 1,5,6,7-Tetramethylbicyclo [3.2.0] hept-6-en-3-one[AS].
Zingiber officinale Roscoe	Zingiberene[AT,AU,AV,AW,AX,AY,AZ,BA], 1,8-Cineole[AT,AV,AW,AX,AZ,BB], β-Sesquiphellandrene[AT,AW,AX,AY,AZ,BB], Neral[AT,AW,AX,AZ,BB], Geranial[AT,AW,AZ,BA,BB], Camphene[AU,AX,AZ,BA,BB], γ-Terpinene[AV,AW,AX,AZ,BB], α-Pinene[AV,AW,AX,AY,AZ,BB], β-Bisabolene[AT,AW,AX,AZ], Copaene[AX,AY,BA,BB], Terpinen-4-ol, α-Terpineol, Geraniol[AW,AX,AZ,BB], β-Pinene[AV,AY,AZ,BB], Nerol[AW,AX,AZ], Limonene[AW,AZ,BB], α-(E,E) Farnesene, Ar-curcumene, Linalool[AW,AX,BB], Sabinene, 6-Methyl-5-hepten-2-one, 2-Heptanol, Myrcene, δ-Cadinene, Germacrene-D, Geranyl acetate, 2-Undecanone, Bornyl acetate, Camphor, Borneol[AX,AZ,BB], β-Phellandrene, α-Zingiberene, Neryl acetate[AW,BB], γ-Eudesmol, β-Caryophyllene, β-Eudesmol, β-Elemene, α-Muurolene, (E)-β-Ocimene[AZ,BB], (E, Z)-Farnesol, (Z)-Lanceol, (Z, Z) Farnesol, Eudesma-3,7(11) diene, Zingerone, z-α-Bergamotol, β-Bisabolol, Sesquisabinene hydrate, Epi-α-cedrenol, β-Guiacol, Cubenol, Elemol, (E)-Nerolidol, (Z)-Nerolidol, δ-Elemene, Undecanal, trans-Linalool oxide[AX,AZ], σ-3-Carene, p-Cymene, Linalyl acetate, Citronellal, Tricyclene[AX,BB], e-Citral, z-Citral, Ocimene[AU], α-Phallendrene, Citral[AV], Octanol, trans-Carveol, Cis-caryophyllene, α-Caryphyllene, E-Ethyl cinnamate, G-Epi-caryophyllene, γ-Curcumene, Apo farnesal-2-dihydro, α-(Z) Bisabolene[AW], Octenal, β-Myrcene, α-Phellandrene, α-Terpinene, d-Limonene, 2-Nonanol, Undecanone, Citronellol, Sabinol, Iso borneol, Myrtenol, Carveol, Gerania, Neric acid, Neryl acetate, Geranic acid, σ-Elemene, β-Elemene, γ-Elemene, α-Bergamotene, (E)-β-Farnesene, Thujopsene, α-Guaine, Germacrene-d, α-Muurrolene, Cedre-8-en-13-ol, α-Muurolol, Eudesma-7(11)-en-4-ol, trans-α-Bisabolene epoxide, Farnesene epoxide, Curcumenyl acetate, Cinnamyl cinnamate[AX], Santolina triene, α-Curcumene, β-Sesquiphellandrene[AY], Hexanal, Hexanol,o-Xylene, Amyl acetate, Undecane, Menthone, Menthol, Decanal, trans-Carvone oxide, β-Cubebene, α-Copaene, α-Bergamotene, β-Farnesene, γ-Muurolene, Zingiberenol, α-Murrolol, α-Eudesmol, (E, E)-Farnesol[AZ], 2-Heptyl acetate, trans-β-Ocimene, Terpinolene, 2-Nonanone, trans-Sabinene hydrate, Camphene hydrate, Isoborneol, Terpinen-4-ol, Myrtenal, Linalyl formate, β-Citronellol, trans-2-Decenal, Myrtenyl acetate, Isocaryophyllene, α-Humulene, Allo-aromadendrene, α-Selinene, α-Elemol, trans-Nerolidol, Caryophyllene oxide, Caryophyllenedienol, α-Bisabolol, cis,cis-Farnesol, trans,trans-Farnesol, trans,trans-Farnesal, Phytol[BB].

[A]Abdelwahab *et al*. 2010; [B]Abdelmageed *et al*. 2011; [C]Jaafar *et al*. 2007; [D]Wong *et al*. 1993; [E]Maimulyanti and Prihadi 2015; [F]Jirovetz *et al*. 2003; [G]Wu *et al*. 2014; [H]Raina *et al*. 2014; [I]Raina *et al*. 2002; [J]Phanthong *et al*. 2013; [K]de Pooter *et al*. 1985; [L]Tinjan and Jirapakkul 2007; [M]Srisukh *et al*. 2012; [N]Nor 1999; [O]Hongratanaworakit and Buchbauer 2007; [P]Kasuan *et al*. 2013; [Q]Kerdchoechuen *et al*. 2010; [R]Waikedre *et al*. 2010; [S]Suri *et al*. 2002; [T]Loh *et al*. 2011; [U]Sato *et al*. 1990; [V]Ekpenyong *et al*. 2014; [W]Kpoviessi *et al*. 2014; [X]Subramanian *et al*. 2015; [Y]Ranitha M *et al*. 2014; [Z]Koba *et al*. 2009; [AA]Setiawati *et al*. 2011; [AB]Abena *et al*. 2007; [AC]Hazwat *et al*. 2014; [AD]Fuselli *et al*. 2010; [AE]Nakahara *et al*. 2013; [AF]Ozcan and Chalchat 2002; [AG]Sajjadi 2006; [AH]Politeo *et al*. 2007; [AI]Zheljazkov *et al*. 2008; [AJ]Klimánkova *et al*. 2008; [AK]Werker *et al*. 1993; [AL]Kandil *et al*. 2009; [AM]Hassanpouraghdam *et al*. 2010; [AN]Dzida 2010; [AO]Said-Al Ahl and Mahmoud 2010; [AP]Hassanpouraghdam *et al*. 2011; [AQ]Beatovic *et al*. 2015; [AR]Carvalho Filho *et al*. 2006; [AS]Unnithan *et al*. 2013; [AT]Ekundayo *et al*. 1988; [AU]Raina *et al*. 2005; [AV]Sultan *et al*. 2005; [AW]El-Baroty *et al*. 2010; [AX]Nampoothiri *et al*. 2012; [AY]Wang *et al*. 2012; [AZ]Barman and Kumar 2013; [BA]Kumari *et al*. 2014; [BB]Sivasothy *et al*. 2011.