



## Research article

# Ethnobotany and diversity of *Citrus* spp. (Rutaceae) as a source of “Kem-kem” traditional medicine used among the Karo sub-ethnic in North Sumatra, Indonesia

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## ABSTRACT

The Karo sub-ethnic is one of five Batak sub-ethnicities in the Karo Regency, North Sumatra Province, Indonesia. They are famous for their local knowledge about the traditional use of medicinal plants to treat various diseases. The “Kem-kem” traditional medicine is one of the traditional healing practices that involve using plants passed down through generations from their ancestors. One of the plant genus group in the Rutaceae family utilized in the traditional “Kem-kem” healing practice is a citrus known as “Rimo”. This study aims to document the local knowledge about the diversity of *Citrus* spp. as Kem-kem’s herbal medicinal plant. This study was conducted from April to July 2023 in the Kabanjahe and Berastagi districts, Karo Regency, North Sumatra. Data was collected using interviews with traditional healers, herbal medicine vendors, and direct observations at traditional markets, involving a total of 8 *Citrus* spp. The Karo uses “Rimo” with different local names as sources of traditional medicinal ingredients in practicing “Kem-kem”. There are 15 local names comprising eight species of *Citrus*. Four are hybrids, i.e., *Citrus x aurantiifolia* (Christm.) Swingle, *Citrus x aurantium* L, *Citrus x junos* Siebold ex Yu.Tanaka, and *Citrus x taitensis* Risso. Two of the remaining species are recognized in infraspecific rank, one variety (*Citrus medica* var. *sarcodactylis* (Hoola van Nooten) Swingle) and one form (*Citrus x aurantium* f. *deliciosa* (Ten.) M.Hiroe). They were used as material sources for Kem-kem traditional medicine to treat at least nine health problems. There are two species with six local names included in the Least Concern (LC) category, namely *C. medica* (Rimo Gawang, Rimo Hantuantu, Rimo Kayu), *C. medica* var. *sarcodactylis* (Rimo Kuku Harimau), and *C. medica* (Rimo Telur Buaya), *C. maxima* (Burm.) Merr. (Rimo Malem). Nine local names are included in the Not Evaluated (NE) category, namely *C. x junos* (Rimo Kejaren), *C. x taitensis* (Rimo Jungga), *C. x aurantium* f. *deliciosa* (Rimo Keling), *C. x aurantium* (Rimo Kersik), *Citrus hystrix* DC. (Rimo Mukur), *C. x taitensis* (Rimo Puraga), *C. x aurantium* (Rimo Kalele), *Citrus swinglei* Burkill ex

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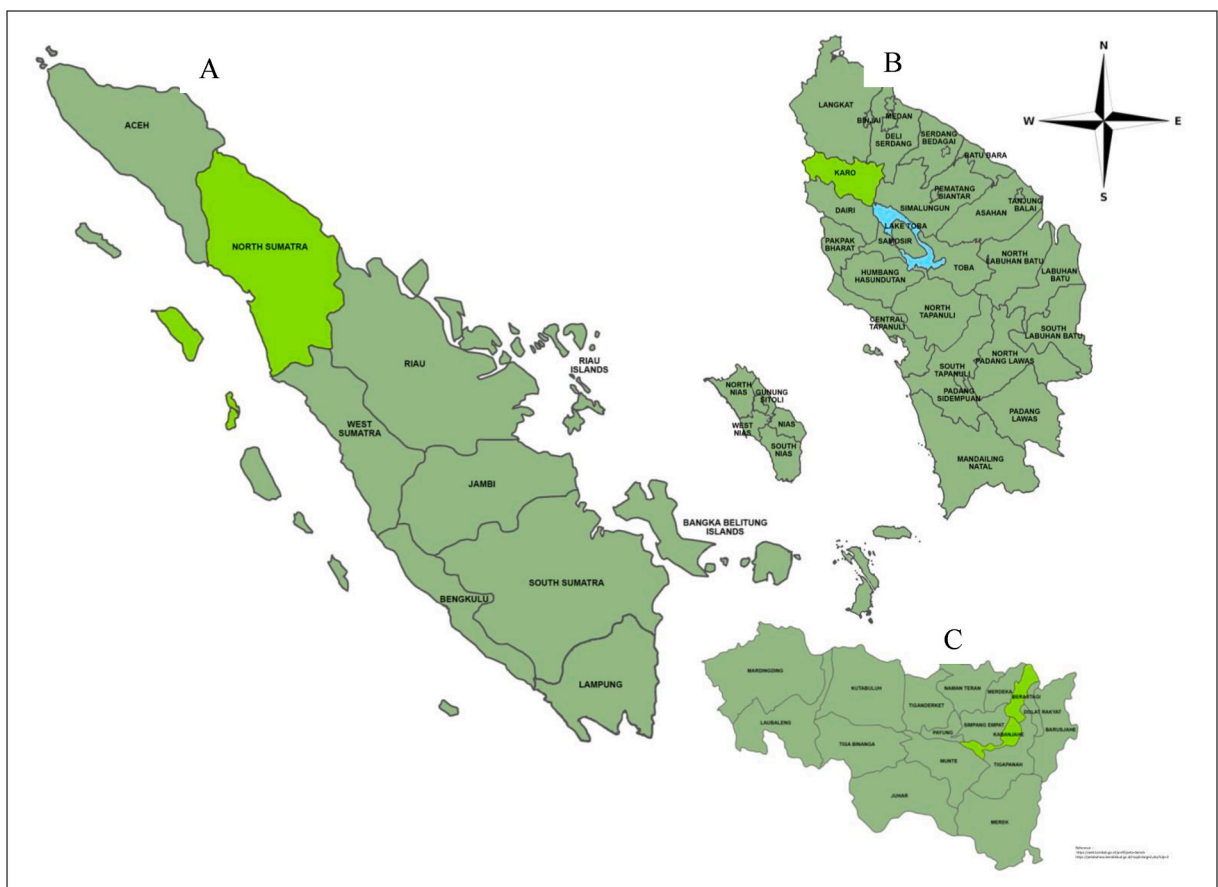
Harms (Rimo Pagar), and *C. x aurantiifolia* (Rimo Bunga). Rimo Kejaren (*C. x junos*) is a species that has the most benefits.

## 1. Introduction

Indonesia has the second-biggest biodiversity in the world, with a high amount of indigenous medicinal plant diversity [1]. Most Indonesians, especially ethnic groups in inland areas, still use traditional herbal medicines to treat various diseases because of the rich source of medicinal plants and limited access to modern medicine [2]. Also, traditional medicine is a part of the ethnic culture in Indonesia [3] because it is simple to use, easy to obtain, and plentiful [4]. Each ethnic group has local knowledge about using medicinal plants, passed down from generation to generation. The Karo sub-ethnic is one of the ethnic groups in Indonesia living in inland areas on Sumatra Island. They are famous for their local knowledge of traditional medicine using diverse medicinal plants and possess wisdom and knowledge in traditional herbal medicine known as Kem-kem. One of the plant genus groups they use is *Citrus* spp. from Rutaceae. Kem-kem's traditional herbal medicine uses the diversity of *Citrus* spp. and other medicinal plant species.

The Karo sub-ethnic is one of five Batak sub-ethnicities in North Sumatra that live in the highlands, called the Karo Gugung [5]. They are the ancestors of the Proto-Malay and have been living there since 500–600 years ago [6]. They are located at the Karo Regency, North Sumatra Province. They are famous for their local knowledge about the traditional use of medicinal plants from the forest to treat various diseases [4]. However, along with the modernization and development of science and technology, the traditional use of medicinal plants has been abandoned [4]. Their rich local knowledge of medicinal plants will be lost gradually [7]. Lifestyle changes result in fewer medicinal plants being grown, and fewer people knowing how to use them. The rate of local knowledge loss is greater than the rate of plant diversity decline. Furthermore, the location of the Karo sub-ethnic in North Sumatra is close to neighboring Singapore and Malaysia, which has the potential to degrade this local knowledge.

Moreover, several species are endangered and have not been well documented. Therefore, it is important to conduct ethnobotanical studies that can document all local knowledge to determine the diversity of species used, how they are used, the preparation process,



**Fig. 1.** The study site in shade: A. North Sumatra Island; B. Regency of Karo in the Province of North Sumatra; C. Berastagi and Kabanjahe in the Regency of Karo [11].

and possible implications of medicinal plants for human health [3,8]. This study aims to document local knowledge about the diversity of *Citrus* spp. as medicinal plants for use in Kem-kem's traditional herbal medicine by the Karos.

## 2. Material and methods

### 2.1. The study area

This study was conducted from April to July 2023 in Kabanjahe and Berastagi sub-districts, Karo Regency, North Sumatra, Indonesia. The trade and preparation of traditional herbal remedies are still widely practiced in Berastagi and Kabanjahe, North Sumatra. It is approximately 2° 50' – 3° 19' North Latitude and 97° 55' – 98° 38' East Longitude (Fig. 1). The area of Karo Regency is 2127.25 km<sup>2</sup> or 2.97 % of the North Sumatra Province [9]. Kabanjahe and Brastagi are sub-districts in the Karo Regency in the highlands of the Barisan Mountains and is an Upper River Region [10]. Kabanjahe comprises 13 villages, while Brastagi comprises 9 villages; both are considered rural. The main livelihood of the population is food agriculture, horticulture products, and smallholder plantations.

### 2.2. Data collection and identification of medicinal plants

An ethical clearance and research permit were obtained before conducting the study. The interviews were carried out using the participatory observation method [12–14] through in-depth interviews and semi-structured questionnaires [15] that were ethically reviewed and approved by the Directorate of Research and Innovation Licensing Governance Committee, National Research and Innovation Agency. Interviews were undertaken with 60 key informants: 14 males and 46 females with an average age of 40–70 years old. Inequality in knowledge also occurs within a society where gender and age influence the value assigned to knowledge [16]. Therefore, data collection from key informants was conducted based on gender and age categories to understand knowledge variations or decline among generations. Key informants were selected using a purposive sampling approach [17]. More than 33 % of key informants in Berastagi were approximately 40 years old. At least 37 % of Kabanjahe were aged 50 years and above. The key informants were interviewed in an open-ended discourse about their local knowledge of the citrus medicinal plants used to make Kem-kem, a traditional herbal medicine used to treat various health-related problems. The key informants were asked for an open-ended discourse about their local knowledge of the citrus medicinal plants that they used when they experienced health problems. The key informants were also asked about the local name of the citrus used, its utility, part of the plant they use, mode of preparation, form of administration, and their population in nature.

The collections of specimens were conducted with the help of the key informants if the plants were available at the research location. The scientific name of each species was identified and validated using the online POWO website [18]. The most commonly used plant part for identification is the leaves and fruits by using taxonomic books and diversity of citrus "Teknologi Inovatif Jeruk Sehat Nusantara" [19], Journal of *Citrus* spp. and matching herbarium specimens available in the Herbarium Bogorienze before validating it with POWO. The citrus herbarium specimens voucher was accessed and deposited in the Herbarium Bogorienze (BO) Directorate of Scientific Collection Management, National Research and Innovation Agency of the Republic of Indonesia, for future study and reference.

### 2.3. Literature study method of chemical constituents

A literature study was conducted using electronic databases, including Medline (PubMed) (<http://www.ncbi.nlm.nih.gov/pubmed>), ScienceDirect (<http://www.sciencedirect.com/>), Scopus (<http://www.scopus.com/>), Web of Science (<https://apps>).

**Table 1**  
Demographic profile of the key informants.

Social group	Variable	Number of Person	
		Berastagi Sub-District	Kabanjahe District
Gender	Male	9	5
	Female	21	25
Age (years)	≤40	8	9
	41–49	9	6
	50–59	9	11
	60–69	4	3
	≥70	0	1
Occupation	Farmer	5	11
	Housewife	7	8
	Trader	13	5
	Civil Servant	5	6
Education	Elementary	10	12
	High School	13	9
	Collage	2	6
	No Education	5	3

webofknowledge.com/), recognized books, and thesis/dissertation to retrieve online publications. We used the following search terms or keywords: “ethnopharmacology”, “chemical compound of the plant species certain looking for”, “ethnomedicine of plant species certain”, “ethnobotany of plant species certain”, “chemical contain of plant species certain”, “Phytochemical of plant species certain”, and “pharmacology of plant species certain”. A keyword mix was used to search for chemical compounds contained in medicinal plant species. The relevant articles from the list of references were also used to search the databases about chemical compounds of the plant species.

### 3. Results and discussion

#### 3.1. Demographic profile of the informants

Table 1 shows the demographic profile (gender, age, and education) of the key informants. There were 9 (30 %) male and 21 (70 %) female informants in the Berastagi Sub-District. There were 5 (17 %) male and 25 (83 %) female informants in the Kabanjahe District. The total number of key informants was 14 (23 %) males and 46 (77 %) females. They were between 39 and 86 years old, and the majority of them (33 %) were fifty years old. Most were medicinal plant traders, including local healers or experts in traditional medicine who use medicinal plants 30 % (18), followed by farmers 27 % (17), housewives 25 % (15), and civil servants 18 % (11).

#### 3.2. History of traditional medicine “Kem-kem” among the Karo sub-ethnic

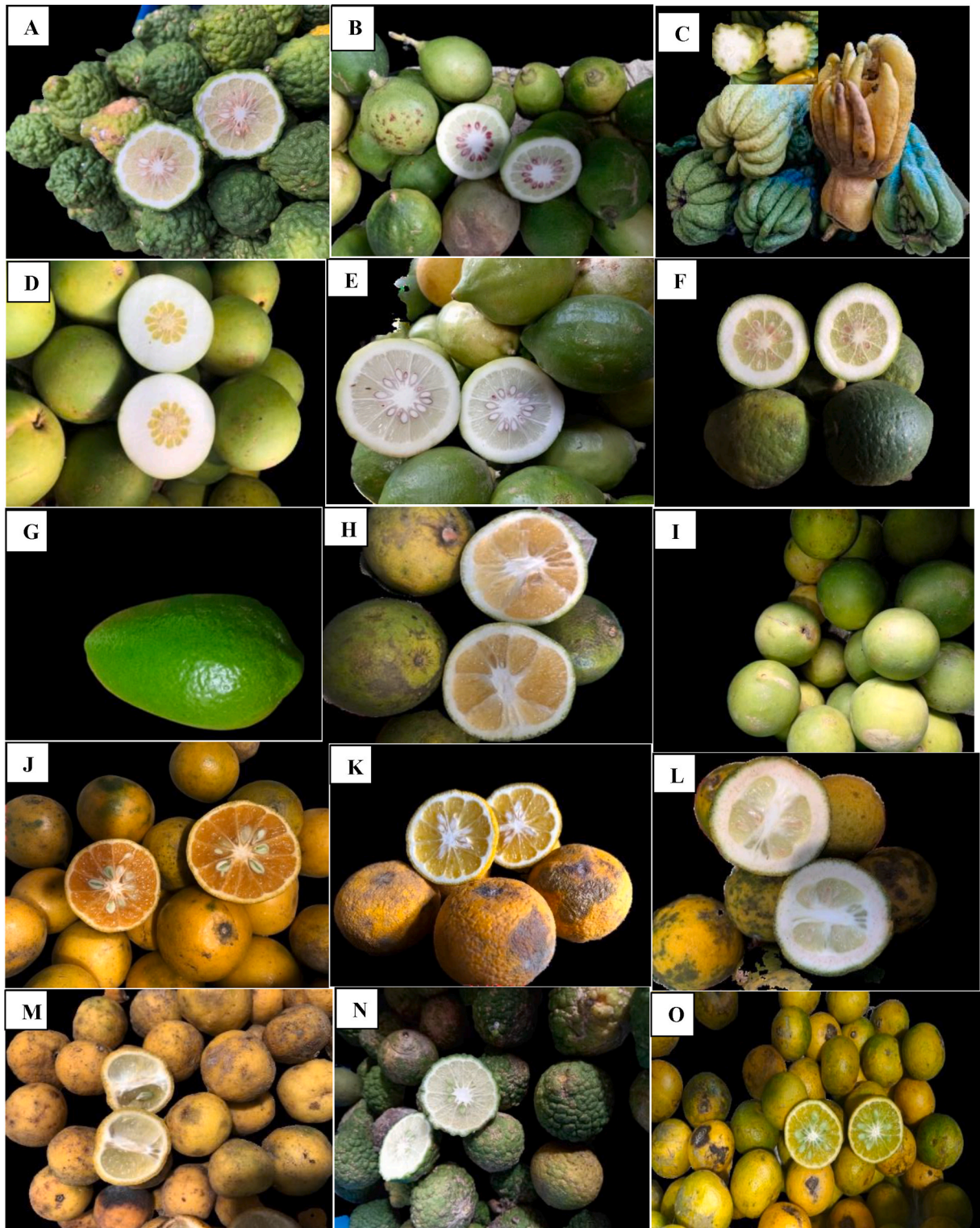
The Karo sub-ethnic is one of five Batak sub-ethnics in North Sumatra. The other four are Phakpak, Simalungun, Toba, and Angkola-Mandailing [20]. Silalahi et al. (2015) stated that among the five groups of Batak sub-ethnics, two still use traditional medicinal ingredients, namely the Karo and Simalungun [21]. The Karo is well-known for using plants to concoct Kem-kem traditional medicine [22] which is inherited from generation to generation. Kem-kem traditional medicine is unique, including the materials used, preparation mode, and usage.

However, the practice of Kem-kem traditional medicine is not well documented. It tends to be inherited from generation to generation and is a family secret. Therefore, there is a potential to become extinct. Based on interview results with the traditional Kem-kem healer (called “Sebeso” in their language), the treatment has been carried out by the eighth generation. According to the “Sebeso”,

**Table 2**

Diversity of citrus medicinal plant species used by the Karo sub-ethnic as sources of “Kem-kem” traditional medicine.

Local name	Scientific name	Use plants	Part of plants	Mode preparation
Rimo Bunga	<i>Citrus x aurantifolia</i> (Christm.) Swingle, NMR 1056	Flu-cough, sore throat	Fruits juice	Mix with other ingredients
Rimo Kalele	<i>Citrus × aurantium</i> L., NMR 1058	Warding off negative, black magic energy, or supernatural	Fruits juice	Mix with other ingredients
Rimo Keling	<i>Citrus × aurantium f. deliciosa</i> (Ten.) M. Hiroe, NMR 1055	Warding off negative, black magic energy, or supernatural	Fruits juice	Mix with other ingredients, add water, use for bathing
Rimo Kersik	<i>Citrus × aurantium</i> L., NMR 1054	Strain and smooth skin	Fruits juice	Mix with other ingredients, add oil, and use to massage the affected part
Rimo Mukur	<i>Citrus hystrix</i> DC., NMR 1059	Myalgia	Fruits juice	Mix with other ingredients and add oil to massage the sore body parts
Rimo Kejaren	<i>Citrus × junos</i> Siebold ex Yu.Tanaka, NMR 1068	Smooth skin	Fruits juice	Mix with other ingredients, add oil, then rub on the body part
		Cough and Dyspnea		Mix with other ingredients, add boiled water, and drink
Rimo Malem	<i>Citrus maxima</i> (Burm.) Merr., NMR 1057	Warding off negative, black magic energy or supernatural	Fruits juice	Mix with other ingredients and add water for bathing
Rimo Antu	<i>Citrus medica</i> L., NMR 1061	Warding off negative, black magic energy or supernatural	Fruits juice	Mix with other ingredients, add water, use for bathing
Rimo Gawang	<i>Citrus medica</i> L., NMR 1064	Strain and smooth skin	Fruits juice	Mix with other ingredients, add oil, then rub on the sick
Rimo Kayu	<i>Citrus medica</i> L., NMR 1062	Fracture and bruise	Fruits juice	Mix with other ingredients plus oil, and massage the affected area
Rimo Telur buaya	<i>Citrus medica</i> L., NMR 1063	Warding off negative, black magic energy or supernatural	Fruits juice	Mix with other ingredients plus water for bathing
Rimo Kuku Harimau	<i>Citrus medica var. sarcodactylis</i> (Hoola van Nooten)Swingle, NMR 1065	Warding off negative, black magic energy or supernatural	Fruits juice	Mix with other ingredients, add water for bathing
		Myalgia		Mix with other ingredients, add oil, and use to massage the affected part
Rimo Pagar	<i>Citrus swinglei</i> Burkill ex Harms, NMR 1060	Smooth skin and myalgia	Fruits juice	Mix with other ingredients
Rimo Jungga	<i>Citrus × taitensis</i> Risso, NMR 1067	Strain and smooth skin	Fruits juice	Mix with other ingredients, add oil, and massage on the affected part
Rimo Puraga	<i>Citrus × taitensis</i> Risso, NMR 1066	Smooth skin	Fruits juice	Mix with other ingredients plus oil, massage on the affected part of the body



**Fig. 2.** Fruit characteristic of citrus that is used by Karo ethnic. A. *C. hystrix* (Rimo Mukur); B. *C. maxima* (Rimo Malem); C. *C. medica* var. *sarcodactylis* (Rimo Kuku Harimau); D. *C. medica* (Rimo Antu); E. *C. medica* (Rimo Gawang); F. *C. medica* (Rimo Kayu); G. *C. medica* (Rimo Telur Buaya); H. *C. swinglei* (Rimo Pagar); I. *C. x aurantiifolia* (Rimo Bunga); J. *C. x aurantium* f. *deliciosa*. (Rimo Keling); K. *C. x aurantium* (Rimo Kalele); L. *C. x aurantium* (Rimo Kersik)"; M. *C. x junos* (Rimo Kejaren); N. *C. x taitensis* (Rimo Jungga); O. *C. x taitensis* (Rimo Puraga).

Kem-kem traditional medicine was initially used to treat fever, fracture, and disease caused by invisible beings due to their actions or diseases sent by others due to resentment. In their language, this disease is called “tersambar”. The word “Kem” means “silent/in here”, meaning that all materials needed for the medication process come from its location. It refines and beautifies the word “Kem-kem”.

About 30 years ago, many species of local plants were used as medicinal ingredients. However, there has been a change in their use in medicine. It was estimated because the types of plants used for treatment have become rare in nature, e.g., *C. medica* L. var. *sarcodactylis*, which is native to India [23]. It is known as “Rimo Kuku Harimau” in the Karo language, and *C. medica* is already rare. The number of species used for each Kem-kem traditional medicine is odd. They have faith and assume that God Almighty knows exactly how much is enough for use in Kem-kem traditional medicine. The part used is the fruit juice. The “Sebeso” states that there are two types of diseases: disease of attack from others (in the Karo language is called “bahen bahanen kalak”) and disease due to a virus, bacteria, and other. The “Sebeso” suggests that patients first conduct Erpangir Ku Lau rituals for “bahen bahanen kalak” diseases, i.e., a bath ritual involving washing the body using the squeezed juice of five or seven local citrus. Four of these are essential main components that must be present in the bathwater, namely Rimo Mukur, Rimo Malem, Rimo Keeling, and Rimo Kalele. The other three local citrus, Rimo Kersik, Rimo Hantuantu, and Rimo Telur Buaya, are optional. The ritual “Erpangir Ku Lau” is a treatment to ward off evil spirits, assisted by traditional healers or shamans. “Erpangir” means “bathing”, “Ku Lau” originates from the word “Maba Ku Lau”, meaning “Taking the child downstairs for a bath”.

Traditional communities in Tanzania [24,25] and Kenya [26] believe that certain clinical symptoms are associated with supernatural powers and consult traditional healers. The “erpangir” tradition is taught by ancestors and carried out from generation to generation. Currently, the “Bahen bahanen” kalak treatment process is rarely carried out. Consequently, some varieties used for bathing rituals, such as Rimo Kuku Harimau, Rimo Antu, and Rimo Kalele, are becoming increasingly rare.

### 3.3. Diversity and local knowledge of the citrus medicinal plant composition

This study documented eight citrus medicinal plant species of Rutaceae with 15 local names. They are a traditional medicine unique to the Karo sub-ethnic. The family Rutaceae listed one genus, eight species, and fifteen local names used as “Kem-kem” traditional medicine materials to treat at least nine health problems (Table 2). Four of the fifteen local names comprising eight citrus species are hybrids, such as *C. x aurantiifolia*, *C. x aurantium* L., *C. x junos*, and *C. x taitensis*. The other two species are recognized in infraspecific rank: one variety, namely *C. medica* var. *sarcodactylis*, and one form, namely *C. x aurantium* f. *deliciosa*.

The citrus medicinal plant species is used for medicine purposes and consumed as fruits, such as *C. x aurantium* (Rimo Keling), *C. x junos* (Rimo Kejaren), and *C. x taitensis* (Rimo Puraga). *C. x aurantium* var. *nobilis* is commonly consumed as a dessert due to its sweet pulp [27]. The Karo also consumes *C. x taitensis* (Rimo Jungga) as cooking spices in the traditional Batak food, called “Naniura”. There are fifteen local names for the eight species, but they have the same scientific name (Table 2 and Fig. 2. A - O). The *C. medica* species has five local names, namely Rimo Gawang, Rimo Antu, Rimo Kayu, Rimo Kuku Harimau, and Rimo Telur Buaya. They serve different purposes. The *C. x aurantium* species has three local names: keeling, kersik, and kalele. Traditional communities in the Riau Province know the cultivars of *C. x aurantium* (jeruk Antu) as a slice of fruit used for folklore and “jeruk peras” whose squashed pulp is drunk as a juice [27].

*Citrus x taitensis* has two local names: Rimo Puraga and Rimo Jungga. It occurs because of the great ability of citrus species to cross and produce intra or intergeneric hybrids [27]. Rivera et al. (2022) explained that citrus occurs frequently due to apomixis and propagation of hybrids via nucellar embryos [28]. These have posed a challenge to botanists and agronomists in identifying individuals and taxa definition of citrus for centuries [29], because their morphological characters overlap and intermediate forms are frequent. The Karo has differentiated local names for each cultivar of citrus based on the fruit’s morphological characteristics, although their scientific names are the same. Advanced research in molecular taxonomy is required to determine their characteristics and distinguish cultivar citrus from the original.

There are fifteen local names, one genus, and eight species of citrus medicinal plant to treat nine health problems (Fig. 2. A - O). The most useful plant for Kem-kem traditional medicine is *C. x junos* Siebold (Rimo Kejaren). This species is possibly a hybrid of *C. Cavaleriei* and *C. reticulata*. It has three uses: smooth skin, cough, and dyspnea. The other species have two and one use (Table 1). Adhikari et al. (2017) extracted a callus from *C. junos* and assessed its utility as a source of topical anti-aging ingredients [30]. *C. x junos* Siebold has also been used as an aromatic stomachic and sweating medicine in Chinese traditional medicine [31]. A hot bath using *C. x junos* can improve blood circulation and prevent colds [32]. It is effective in preventing certain diseases because it is anti-inflammatory [32], anti-oxidant [33], and anti-carcinogenic [34,35]. Traditionally, It has been used in cuisines, cosmetics, and perfumery in China [31].

Most citrus medicinal plant species are used to ward off negative, black magic or supernatural energy; they can also make the skin smooth. There is one genus, three species, and three local names to ward off negative, black magic or supernatural energy. They have six local names: Rimo Antu (*C. medica*), Rimo Keling (*C. x aurantium* f. *deliciosa*), Rimo Kuku Harimau (*C. medica* var. *sarcodactylis*), Rimo Malem (*C. maxima*), Rimo Telur Buaya (*C. medica*), and Rimo Kalele (*C. x aurantium*). Each local name was given based on the emic characterization from the community’s perspective. The name that differs in the local perspective has characteristics that should be described (Fig. 2. A - O). The “Rimo Telur Buaya” is thus named because its shape resembles crocodile eggs (Fig. 2. G). The “Rimo Malem” because it is commonly used in ritual ceremonies at night (Fig. 2. B). “Rimo Keling” means black because it was brought from India (Fig. 2. J). “Rimo Kalele” means deviating from negative things that enter the body (Fig. 2. K).

The *C. medica* species is used to ward off the negative black magic energy in Kem-kem traditional medicine and has three local names. *C. medica* is known by traditional communities in the Riau Province as “Rimo Antu”, “Rimo Pagar”, “Rimo Kuku Harimau” [27]. It is called “Rimo Kuku Harimau” because its shape resembles tiger claws (Fig. 2. C); “Rimo Antu” because it is used to ward off

evil spirits or negative energy within the body (Fig. 2. D); “Rimo Pagar” because it is commonly used as a garden boundary or fence (Fig. 2. H).

There are four species used to create smooth skin: Rimo Gawang (*C. medica*), Rimo Kejaren (*C. × junos* Siebold), Rimo Jungga (*C. × taitensis*), Rimo Kersik (*C. × aurantium*), and Rimo Puraga (*C. × taitensis*). It is called “Rimo Gawang” because the tree has many thorns, making it suitable as a guard (Fig. 2. E). It is called “Rimo kersik” because the fruit surface is rough or not smooth (Fig. 2. L). “Rimo Kejaren” means pursuing livelihood and maintaining enthusiasm (Fig. 2. M), while “Rimo Jungga” means rejecting anything negative from entering the body (Fig. 2. N). “Rimo Puraga” means all negative energies harmful to the body will disappear (Fig. 2. O). “Rimo Kayu” means sturdy and strong like wood (Fig. 2. F), while “Rimo Bunga” signifies that there will always be abundant results or outcomes (Fig. 2. I).

Strain and myalgia recorded three species successively: *C. medica* (Rimo Gawang), *C. × taitensis* (Rimo Jungga), *C. × aurantium* (Rimo Kersik), *C. medica* var. *sarcodactylis* (Rimo Kuku Harimau), *C. hystrix* (Rimo Mukur), and *C. swinglei* Burkill (Rimo Pagar). “Rimo Mukur” means shampooing or washing the hair because it is used for that purpose (Fig. 2. A). Flu-cough noted two species: *C. × junos* Siebold (Rimo Kejaren) and *C. × aurantiifolia* (Rimo Bunga). Fracture and bruise recorded one species, i.e., *C. medica* (Rimo Kayu). Dyspnea and sore throat recorded two species: *C. × junos* Siebold (Rimo Kejaren), and *C. × aurantiifolia* (Rimo Bunga). Fig. 3 records the information on citrus medicinal plant species with a high number of species and local names.

### 3.4. Distribution and conservation status

*Citrus* spp. originated in Southeast Asia and was introduced to Europe [36]. Specific areas include the Yunnan province in southwest China, north-eastern India in the foothills of the Himalayas, and Myanmar [37]. The native range for *C. medica* is thought to span from the western-central Himalayas to Myanmar [18]. All citrus forms are thought to have originated from South East Asia. Still, it has been suggested that the citron may have had a comparatively westerly origin in the central Himalayan foothills [38]. Citron has been observed to grow well, up to 1300 m asl in the tropics [39]. Further research focused on identifying wild populations across the historic native range is necessary to evaluate the contemporary distribution status of the species precisely. *C. × junos* Siebold is an artificial cross-hybrid formula of *C. cavaleriei* × *C. daoxianensis* × *C. maxima*. *Citrus x junos* originated from Cina and was cultured in Japan and Korea. *C. junos* is a traditional medicine distributed in Asia, especially in Korea, Japan, and China [40–42]. *C. × taitensis* is distributed in China, India, and Malesia [42]. *C. × aurantium* most probably originated in north-eastern India and adjoining Burma (Myanmar) and China areas. It is distributed in all continents except Antarctica [43]. It became especially common in Spain, hence its vernacular name, Seville orange. It was one of the first citrus species taken to South America in the 16th century, where it soon escaped from cultivation

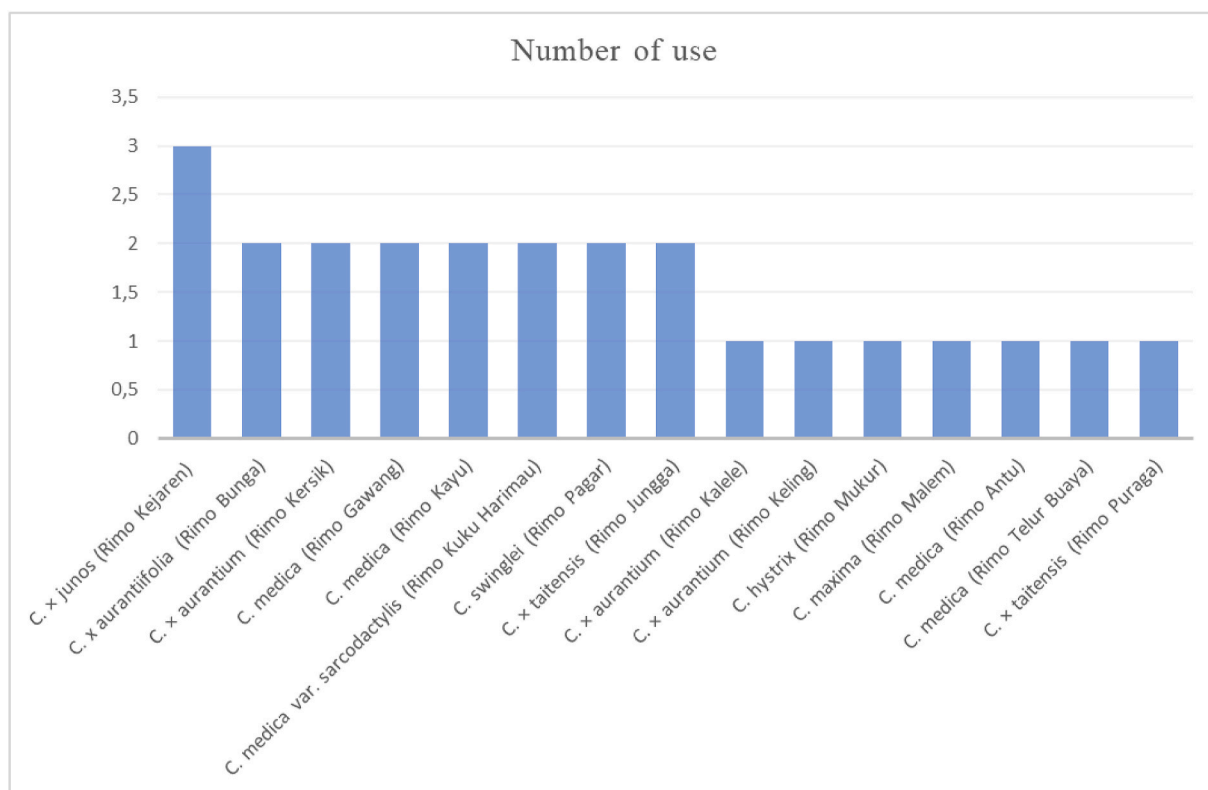


Fig. 3. Number of medicinal plant species used to treat for each kinds of health conditions.

and was naturalized in many areas. It is now cultivated in many tropical and subtropical countries but rarely in South East Asia [44].

*C. medica* var. *sarcodactylis* is commonly distributed in South and South East Asia. The plant is cultivated in the tropics and subtropics, such as India, Sri Lanka, Thailand, Vietnam, China, Japan, and Taiwan [45]. The native range of *C. swinglei* is from Hainan, Peninsula Malaysia. It is a shrub or tree and grows primarily in the wet tropical biome [18]. The origin of *C. maxima* distribution is Southeast Asian island (Malesia), which then spreads to Indo-China, South China, South Japan, West India, the Mediterranean, and Tropical America, while *C. hystrix* distribution is from mainland Southeast Asia to Island Southeast Asia. *C. aurantiifolia* originates from the tropics throughout the Malay Archipelago and has limited distribution in the tropics and subtropics [46].

There are eight species of citrus used as the source of traditional medicine for the Karo sub-ethnic. Based on the classification of IUCN [47], six local names for two species are included in the Least Concern (LC) category, namely *C. medica* (Rimo Gawang, Rimo Antu, Rimo Kayu, and Rimo Telor Buaya), *C. medica* var. *sarcodactylis* (Rimo Kuku Harimau), and *C. maxima* (Rimo Malem). Meanwhile, nine local names for seven species are included in the Not Evaluated (NE) category: *Citrus × junos* (Rimo Kejaren), *C. × taitensis* (Rimo Jungga and Rimo Puraga), *C. × aurantium* (Rimo Keling, Rimo Kersik, and Rimo Kalele), *C. hystrix* (Rimo Mukur), *C. swinglei* (Rimo Pagar), and *C. x aurantiifolia* (Rimo Bunga).

A least-concern species is one that has been evaluated against the Red List criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Threatened. It is not a focus of species conservation because the specific species is still plentiful in the wild [47]. Species cannot be assigned the “Least Concern” category unless their population status has been evaluated. Adequate information is needed to directly or indirectly assess its extinction risk based on its distribution or population status.

These species are of lesser concern than species in other threatened categories. It does not imply that these species are of no conservation concern. Meanwhile, a not-evaluated species has not been evaluated against the criteria. Not-evaluated species are not published in the IUCN Red List [47]. However, an urgent determination of its conservation status is still necessary for monitoring the conditions and populations of the species in the wild. Additionally, conservation efforts are the foundation to prevent excessive utilization of the *Citrus* spp. Diversity [48,49]. Conservation efforts for one of the citrus species, namely *C. Junos*, have been carried out through species conservation techniques involving active cultivation and reproduction development in Japan and Korea over the last 40–50 years [50]. The increasing prevalence of modern medicine can pose an extinction threat to medicinal plant species. We can contribute to the preservation of plant species that are becoming scarce through traditional medicinal practices that involve a diverse range of plants, including the Kem-kem traditional medicine [51–53].

### 3.5. Medicinal plant part and form of preparation and administration

According to Law No. 36/2009 on traditional medicine and health, traditional treatment encompasses substances or formulations consisting of plant materials, extracts, or mixtures of these materials that have been traditionally used for medicinal purposes from generation to generation [54]). Traditional medicine sources have been proven effective and safe for use. The government ensures and guarantees their sustainability for the development and preservation of raw materials [54]). The forms of traditional medicinal preparations used to treat illnesses are based on a traditional medical system that first seeks to identify the cause or etiology of the illness. This etiology concept is crucial for diagnosing the disease, which is necessary to determine the treatment methods [55].

The personalistic system attributes illnesses to interventions, which can involve supernatural entities (e.g., ghosts, ancestral spirits) or human beings (e.g., sorcerers, shamans, or witch doctors). Illnesses caused by supernatural factors are referred to as “uncommon illnesses” within the Karo community, and they are believed to be caused by people.

A part of the citrus medicinal plants is used as fruit juice, mixed with water, and for bathing. According to the Karo community, other common and usual illnesses are those related to bones, such as rheumatism, lower back pain, sprains, and nerve pain. A traditional bone-setting healer treat these by massaging the affected area with a mixture of *C. medica* fruit juice “Rimo Kayu” mixed with oil, applied, and massaged onto the affected area [56]. The Karos commonly use the juice of *C. medica* fruit (Rimo Antu) mixed with water, which is then used for bathing to ward off illnesses caused by black magic or supernatural forces. They use the juice of *C. medica* (Rimo Antu) mixed with essential oil and apply it to the entire body to smooth the skin [50].

Rostiyati (2010) stated that the knowledge of the etiology of illness is based on traditional cultural concepts and not on observations, research, and experiments [56]. Instead, it relies on the experiences of previous generations that have been passed down orally. In traditional medicine systems, cultural and ecological aspects provide dominant characteristics. Furthermore, Yang & Kang (2013) reported that *C. medica* alleviates inflammatory diseases, providing a scientific basis for using essential oil from *C. medica* fruit to reduce inflammation symptoms [57]. According to Kim et al. (2013), essential oil from *C. medica* var. *sarcodactylis* is used as an anti-inflammatory. *C. junos* (Rimo Kejaren) results from artificial crossbreeding between *C. cavaleriei* × *C. daoxianensis* × *C. maxima* [58]. It has a sour taste; even more sour than grapefruit. The fruit is rarely consumed, but is often used as a flavoring agent in Japanese and Korean cuisine and pastries due to its strong aroma.

Currently, the scent of “Rimo Kejaren” is also widely used in perfumery and fragrances. Typically, this aroma is employed in bath products and used in inhalers and aromatherapy for spa massages. The skin of “Rimo Kejaren” can be used as an essential oil with many benefits. Rimo Kejaren is also often found in traditional rituals.

In traditional medicine, the juice of the leaves and fruits of Rimo Mungkur is used for hair care and to maintain a stable blood sugar, prevent diabetes, treat influenza, scaly, and peeling skin [59]. The Karos use Rimo Mungkur as a material for various ritual events and as a medicinal ingredient. They use the fruit of Rimo Kalele (*C. x aurantium*) to ward off diseases caused by negative energy, black magic, or the supernatural. The traditional medicinal preparation for healing typically involves using the juice extracted from Rimo Kalele (*C. x aurantium*) and *Citrus × aurantium* f. *deliciosa*.

Singh et al. (2010) reported that monoterpenic essential oil is a natural anti = oxidant [60]. The juice of *Citrus x aurantiifolia* is



beneficial for treating cough, constipation, hemorrhoids, irregular menstruation, dysentery, acne, headaches, hoarseness, body odor, increasing appetite, preventing hair loss, sudden dizziness, dandruff, flu, fever, tonsillitis, urinary tract infections, and nosebleeds [59]. Its juice is widely used as a remedy for cough and respiratory issues.

The Karos has long harnessed the benefits of *C. aurantifolia* as an additive and main ingredient in various traditional treatments. Razak et al. (2013) reported that the juice of the *C. aurantifolia* fruit is used to treat acne and heal wounds to prevent abscess formation [61]. The juice of *C. aurantifolia* is used to address hypertension and other cardiovascular diseases [62] and is anti-cholesterol [63,64]. The juice of *C. x taitensis* fruit is mixed with essential oil to soften the skin. The local community in western China (Yunnan) uses *C. x taitensis* fruit as vinegar and shampoo [37]. Ethnobiological studies conducted by the Creole community in the northern part of the Misiones province show the significance of the *C. x taitensis* plant as a traditional medicine. It is the primary plant used in the base ingredients of honeybee products to treat flu and various respiratory conditions [65,66].

The entry and proliferation of modern culture may potentially erode the local community's knowledge in gathering and utilizing plants as medicine, especially in the case of "Kem-kem" traditional medicine. Therefore, positive local knowledge must be explored, researched, published, and passed down to the next generation. The fundamental factors influencing the local knowledge of traditional medicine, specifically "Kem-kem" among the Karo ethnic, include customs, beliefs, and worldviews [67]. Traditional Karo medicine has existed since ancient times, indicating that their traditional customs and worldview are closely related to the tradition of using plants in medicine. In addition to the influence of customs, traditions, and worldview, the persistence of "Kem-kem" traditional medicine until today is also due to their belief in its efficacy as a consequence of its use for generations. Other supporting factors are the economic factor and ease of access. Many Karo people consider traditional medicine to be more affordable than modern medicine, creating a high demand in the traditional medicine market and making it a potential business opportunity. Some of these markets can be found in the central areas of Kabanjahe and Berastagi traditional markets. The role of mass media is also important in maintaining the ongoing use of "Kem-kem" traditional medicine.

However, currently, globalization allows the entry of modern technology that can influence the mindset of the younger generation to view the future of modern life distant from traditional aspects. As a result, the interest of the younger generation in pursuing knowledge about traditional medicine may decline. The degradation of knowledge about "Kem-kem" traditional medicine will accelerate due to a lack of motivation from those involved in herbal medicine crafting businesses. The knowledge in "Kem-kem" traditional medicine may be at risk of extinction due to a lack of development efforts. One effort that can be undertaken is promoting and enhancing knowledge among practitioners. The reduced supply of raw materials can also threaten local knowledge. High forest exploitation, monoculture plantation practices, and the lack of cultivation efforts can diminish the raw material supply.

Currently, there is no cultivation effort in creating gardens to collect plants used in "Kem-kem" traditional medicine. Policy recommendations and development strategies for medicinal plants to achieve competitive, sustainable forestry agribusiness and agro-industry enhance the well-being of medicinal plant farmers and traditional healers. Cultivation techniques for plant species need to be taught and disseminated to farmers to prevent extinction in the wild and simultaneously develop potential plants, especially those used in "Kem-kem" traditional medicine.

The local knowledge of communities in utilizing medicinal plants must be preserved because it serves as capital in developing the pharmaceutical field amid the increasing complexity of various diseases today. Government efforts are required to explore the potential knowledge of communities, especially traditional medicinal plant gatherers, through activities such as increasing insights, benchmarking, cultivation efforts, and sharing experiences with parties interested in traditional medicine. This is necessary so that the knowledge of traditional medicine gatherers and promotion can increase, the availability of raw materials can be maintained, and the transfer of knowledge to the next generation can occur.

### 3.6. Phytochemicals of citrus fruits

Citrus fruits are a rich source of vitamin C. They are also abundant in other macronutrients, including sugar, fiber, potassium,

**Table 3**  
IUCN red list status of citrus medicinal plant species.

Local Name	Scientific Name	IUCN Red list Status
Rimo Gawang	<i>C. medica</i> L.	Least Concern
Rimo Antu	<i>C. medica</i> L.	Least Concern
Rimo Kayu	<i>C. medica</i> L.	Least Concern
Rimo Kejaren	<i>C. x jumos</i> Siebold ex Yu.Tanaka	Not evaluated
Rimo Jungga	<i>C. x taitensis</i> Risso	Not evaluated
Rimo Keling	<i>C. x aurantium</i> f. <i>deliciosa</i> (Ten.) M.Hiroe	Not evaluated
Rimo Kersik	<i>C. x aurantium</i> L.	Not evaluated
Rimo Kuku Harimau	<i>C. medica</i> var. <i>sarcodactylis</i> (Hoola van Nooten) Swingle	Least Concern
Rimo Mukur	<i>C. hystrix</i> DC.	Not evaluated
Rimo Puraga	<i>C. x taitensis</i> Risso	Not evaluated
Rimo Malem	<i>C. maxima</i> (Burm.) Merr.	Least Concern
Rimo Telur Buaya	<i>C. medica</i> L.	Least Concern
Rimo Kalele	<i>C. x aurantium</i> L.	Not evaluated
Rimo Paga	<i>C. swinglei</i> Burkill ex Harms	Not evaluated
Rimo Bunga	<i>C. x aurantifolia</i> (Christm.) Swingle	Not evaluated

folate, calcium, thiamin, niacin, vitamin B6, phosphorus, magnesium, copper, riboflavin, and pantothenic acid. However, secondary metabolites are an especially popular topic in the present research. These constituents, also known as phytochemicals, are small molecules that are not strictly necessarily for the survival of the plants but represent pharmacological activity. Citrus fruits contain secondary metabolites, such as phenolic compounds, terpenoids, alkaloids, coumarins, and essential oils (Table 3). These active secondary metabolites show several bioactivities of vital importance to human health, including anti-oxidative, anti-inflammatory, anti-cancer, antibacterial, anti = fungal, etc. [68]. Table 4 summarizes the phytochemical group contained in fruit of *Citrus* spp.

### 3.6.1. Phenolic compound

Flavonoids in *Citrus* spp. have bioactivities such as anti-oxidant, anti = diabetic, anti-inflammatory, and anti-atherosclerosis [100, 101]. Sun et al. (2023) found that flavonoids such as sypnephine and stachydrine (choline) have many bioactivities that affect tissues, organs, or systems, such as the cardio-cerebrovascular system, blood system/sugar, respiratory system, digestive system, uterine contraction for pregnancy, and pharmacokinetics [77]. *C. aurantium* contains eight compounds in the flavonoid group, namely isonaringin, naringin, hesperidin, neohesperidin, naringenin, hesperitin, nobiletin, and tangeritin [71]. *Citrus medica* L. var. *sarcodactylis* Swingle has a high phenol content, increasing its anti-oxidant capacity [102]. The compound *trans*-ferulic acid was found in the extract of *C. aurantiifolia* [69].

### 3.6.2. Terpenoid

Gao et al. (2020) conducted a study on *C. medica* var. *sarcodactylis* and found 113 compound components dominated by terpenoid compounds [98]. The content of D-limonene is a major compound, around 40 %. Other compounds found in high percentages include a-pinene, terpinene, and myrcene. These compounds play an active role as anti-biofilms. lan-phi et al. (2009) made a similar discovery when studying *C. junos*, where as many as 69 compound components were identified, dominated by terpenoid compounds [88]. The highest percentage is limonene at 63.1–68.1 %, followed by c-terpinene (11.4–12.5 %), b-phellandrene (4.6–5.4 %), myrcene (3.0–3.2 %), and a-pinene (2.3–2.7 %). Limonene is an important compound with potential anti-cancer activity [103].

### 3.6.3. Alkaloid

Alkaloid were found in some species of *Citrus* spp., such as *C. x aurantiifolia*, *C. x aurantium f. deliciosa*, *C. x aurantium*, *C. maxima* [70,73,78,80](Anmol et al., 2021; Gunwantrao et al., 2016; Sormin et al., 2023; Sun et al., 2023). Sormin et al. (2023) reported that it has potential anti-microbial activity against *Propionibacterium acnes* and *Staphylococcus epidermidis* [70].

### 3.6.4. Coumarins

Coumarins were found in some species of *Citrus* spp., such as *C. x aurantiifolia*, *C. hystrix*, and *C. maxima* [73,80,84,85,89]. Coumarins from the peel of *C. x aurantiifolia* dominantly consists of 5-geranyloxy-7-methoxycoumarin; 5,7-dimethoxycoumarin (syn. limettin); 5,8-dimethoxypsoralen (syn. isopimpinellin); 5-methoxypsoralen (syn. bergaptene); 5-geranoxypsoralen (syn. bergamottin), and 5-(2,3-dihydroxy-3-methylbutoxy) psoralen (syn. Oxy-peucedanin hydrate) based on liquid chromatography analysis with potential antifungal activity [73].

### 3.6.5. Essential oils

Essential oils are commonly found in *Citrus* spp. fruits and were reported to be a natural anti-oxidant [32,74,76,79,82,88,89,99, 104]. The peel of ripe fruit *C. aurantiifolia* contained 0.266 % v/w of essential oils with R-(+)-limonene as the majority of bioactive compound with potential anti-oxidant and cytotoxic activity [74]. The recycling waste derived from peels and seeds of *C. x aurantium f. deliciosa*. contained bioactive compounds in its essential oils such as flavonoids, limonoids, and terpenoid with D-limonene as the predominant compound and a potential anti-oxidant [76]. The essential oil of *C. maxima* also contained Limonene as a dominant compound with anti-oxidant activity [89].

**Table 4**

The phytochemical group contained in fruit of *Citrus* spp.

Scientific Name	Local Name	Chemical Compounds				
		Phenolic Compound	Terpenoid	Alkaloid	Coumarins	Essential Oil
<i>Citrus x aurantiifolia</i>	Rimo Bunga	[69–71]	[72]	[70]	[73]	[74]
<i>Citrus x aurantium f. deliciosa</i>	Rimo Keling	[75]		[75]	–	[76]
<i>Citrus x aurantium</i>	Rimo Kalele; Rimo Kersik	[77]	[77]8	[78]	–	[79]
<i>Citrus hystrix</i>	Rimo Mungkur	[80]	[81–83]	–	[80,84, 85]	[82]
<i>Citrus x junos Siebold ex Yu. Tanaka</i>	Rimo Kejaren	–	[32, 86–88]	–	–	[32,89]
<i>Citrus maxima</i>	Rimo Malem	[89–91]	[89,90,92]	[89]	[89]	[89,93]
<i>Citrus medica</i>	Rimo Antu; Rimo Gawang; Rimo Kayu; Rimo Telur Buaya	[94,95]	–	–	–	[96]
<i>Citrus medica</i> var. <i>sarcodactylis</i>	Rimo Kuku Harimau	[97]	[98]	–	–	[99]
<i>Citrus swinglei</i> Burkill ex Harms	Rimo Pagar	–	–	–	–	–
<i>Citrus x taitensis</i> Risso	Rimo Jungga; Rimo Puraga	–	–	–	–	–

Further studies should be performed to explore more phytochemical compounds in *Citrus* spp., including saponin, tannin, and other secondary metabolites. We identify that *C. × aurantium*, *C. medica*, and *C. × taitensis*. have several varieties with different morphologies as explained in Fig. 2. Further phytochemical study should be conducted to analyze the phytochemical compounds and bioactivities in each variety because the current study does not accommodate identifying phytochemical compounds for each variety of *Citrus* spp. used by the Karos. We also recommend that a genomic study is performed to understand the characteristics of *Citrus* spp. varieties at the molecular level.

#### 4. Conclusion

We conclude that:

1. This study reports the quantitative ethnomedicinal survey in the Berastagi and Kabanjahe districts of the Batak sub-ethnics in the Karo Regency, North Sumatra, Indonesia. The Karo use eight species of citrus for “Kem-kem” traditional medicine to treat nine health problems. Four hybrids are *C. × aurantiifolia*, *C. × aurantium*, *C. × junos* Siebold, and *C. × taitensis*. Two of the remaining four species are acknowledged in infraspecific rank, specifically as one variety, such as *C. medica* var. *sarcodactylis*, and one form (*C. × aurantium* f. *deliciosa*)
2. The most useful plant for Kem-kem traditional medicine is *C. × junos* (Rimo Kejaren). It has many benefits, including anti-aging, aromatic stomachic and sweating medicine, blood circulation improvement, prevents colds, anti-inflammation, anti-oxidant, and anti-carcinogenic. It can also be used in cosmetics and perfumes. The Karos have differentiated local names for each citrus based on fruit morphological characteristics, although the scientific name is the same. Citrus plant species can be used for the “Kem-kem” traditional medicine because it contains phenolic compounds, terpenoids, alkaloids, coumarins, and essential oils as bioactivities vital to human health. It contains anti-oxidative, anti-inflammatory, anti-cancer, anti-oxidant, antidiabetic, anti-atherosclerosis, antibacterial, and antifungal compounds.
3. Six local names for two species such as *C. medica* (Rimo Gawang, Rimo Antu, Rimo Kayu, and Rimo Telor Buaya), *C. medica* var. *sarcodactylis* (Rimo Kuku Harimau), and *C. maxima* (Rimo Malem) have Least Concern (LC) conservation status. Nine cultivars with different local names of seven species such as *C. × junos* (Rimo Kejaren), *C. × taitensis* (Rimo Jungga and Rimo Puraga), *C. × aurantium* (Rimo Keling, Rimo Kersik, and Rimo Kalele), *C. hystrix* (Rimo Mukur), *C. swinglei* (Rimo Pagar), and *C. × aurantiifolia* (Rimo bunga) have Not Evaluated (NE) conservation status. The increasing prevalence of modern medicine can threaten the extinction of medicinal plant species. Through traditional medicinal practices involving a diverse range of plants, we can contribute to preserving plant species that are becoming scarce.
4. This research implicates preserving traditional medicine culture and adding the local community’s knowledge in gathering and utilizing plants as medicine, especially in the case of “Kem-kem” traditional medicine, so that the knowledge can be passed down to posterity. Policy recommendations and development strategies must be developed for medicinal plants to achieve competitiveness and sustainable forestry agribusiness and agroindustry, enhancing the well-being of medicinal plant farmers and traditional healers. The Karos’ local knowledge of utilizing medicinal plants for “Kem-kem” traditional medicine can serve as capital in developing the pharmaceutical field amid the increasing complexity of various diseases today.
5. This study did not identify the phytochemical compounds in each variety of *Citrus* spp. used by the Karos. Therefore, additional phytochemical studies should be carried out to analyze compounds and bioactivities in each variety. Furthermore, we recommend a genomic study to understand the characteristics of *Citrus* spp. varieties at the molecular level.

#### Declaration

##### Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

##### Data availability statement

This manuscript does not contain data availability, due to the data is included in the article/supp. material/referenced in the article.

##### CRedit authorship contribution statement

**Mulyati Rahayu:** Writing – review & editing, Writing – original draft, Validation, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Titi Kalima:** Writing – review & editing, Writing – original draft, Validation, Resources, Methodology, Investigation, Formal analysis, Data curation. **Merry Meryam Martgrita:** Writing – review & editing, Writing – original draft, Resources, Project administration, Investigation, Funding acquisition, Formal analysis, Data curation. **Christine Sembiring:** Writing – original draft, Visualization, Software, Resources, Project administration, Investigation, Formal analysis, Data curation. **Lianty Simangunsong:** Writing – original draft, Visualization, Software, Resources, Project administration, Investigation, Formal analysis, Data curation. **Sion Elisabeth:** Writing – review & editing, Writing –

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## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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