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Identification, morphology of *Citrus* L. (Aurantioideae-Rutaceae Juss.) and its traditional uses in Riau Province, Indonesia

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Abstract. *Sofiyanti N, Iriani D, Wahyuni PI, Idani N, Lestari P. 2022. Identification, morphology of* Citrus *L. (Aurantioideae-Rutaceae Juss.) and its traditional uses in Riau Province, Indonesia. Biodiversitas 23: 1038-1047.* The genus *Citrus* (Rutaceae) is an important fruit crop in the world. The species of *Citrus* are extensively cultivated for fresh fruit and processed juice market. In addition, *Citrus* members have a great ability to cross and produce intra or intergeneric hybrids. Therefore, the taxonomic identification of the cultivars has been a serious challenge for botanists and agronomists. In Riau Province (Indonesia), the cultivars of this genus are grown for various uses. The aims of this study are to identify *Citrus* taxa in Riau Province, examine their morphological characters, and document their uses by local people. Samples were collected in the field. The result shows a total of 18 *Citrus* members were identified in this study. The *Citrus* morphologies vary among the members. Each *Citrus* identified in this study shows its morphological characteristic of vegetative and generative parts. Numerous local uses of *Citrus* are recorded in this study, e.g. fresh consumed, traditional drink, folklore, herb, spice and ornamental. The parts of *Citrus* used are whole plant, leaf, pericarp and pulp. The uses of *Citrus* recorded in this study are for herb and spice, dessert, traditional drink and treatment, folklore, and ornamental plant. This study provides the first record of the morphological characteristic of *Citrus* in this province and the uses of its members.

Keywords: *Citrus*, morphology, Riau

INTRODUCTION

Citrus L. is one of the members of the subfamily Aurantioideae (Rutaceae Family, from the bitter herb Rue) (Hamedi et al. 2019. The genus of *Citrus* is the most familiar aromatic group of plants (Morton and Telmer 2014)). This genus is one of the most important fruit crops in the world (Abouzar and Nafiseh 2016) and it is extensively cultivated for fresh fruit and processed juice market (Ollitrault and Luis 2012). The term *Citrus* came from Greek "*Kedros*" that was given to an unidentified tree similar to cedar, pine and cypress and had been later applied to the citron (Abouzar and Nafiseh 2016). *Citrus* species have a great ability to cross and produce intra or intergeneric hybrids. Apomixis is frequent in *Citrus* and permits the propagation of these hybrids via nucellar embryos (Rivera et al. 2022). Therefore, the identification of *Citrus* individuals and definition of *Citrus* taxa have been challenging botanists and agronomists for centuries (Araujo et al. 2003), because *Citrus* taxa overlap in their morphological characters and intermediate forms are frequent.

Indonesia is a very important center of diversity of the genus *Citrus* from which at least one species and several groups of hybrids originated in the area. *Citrus maxima* (Burm.) Merr., is the species described as *C. grandis* (L.) Osbeck by Swingle in 1943 originated in the Malay Archipelago and Indonesia (Ollitrault et al. 2020). *C.* × *amblycarpa* include all admixtures between *C. micrantha* and *C. reticulata* such as "Nasnaran," an Indonesian *Citrus* considered to be a direct *C. micrantha* × *C. reticulata* hybrid (Ollitrault et al. 2020). Furthermore, the type of *Citrus* ×*aurantiifolia* (Christm.) Swingle is based on the image of *Limo nipis* by Rumphius (1741) in his Herbarium Amboinense, from Amboina Island (Indonesia) (Tropicos 2021).

In Indonesia, a total of 255 *Citrus* varieties had been reported, with the highest proportion of varieties (44%) grouped within Mandarin (*Citrus reticulata* Blanco) (Yulianti et al. 2020). At the same time, the remaining varieties belong to tangerine, sweet orange, sour orange, pummelo and others (lime, lemon or C. *medica* L.). However, only limited knowledge on *Citrus* identification and morphology had been recorded from Sumatra Island. Nirmala and Hardiyanti (2017) had identified a total of 13 *Citrus* species from West Sumatra, with the common *Citrus* being *C. reticulata*. Identification of some *Citrus* in Sumatra Island was also reported from Aceh Province by Yulianti et al. (2016). Their study recorded a total of 15 *Citrus* taxa from this province. However, only limited record on *Citrus* taxa (Sofiyanti et al. 2021) and their morphological characteristics on the rest areas of Sumatra Island, including Riau Province.

The morphological characters of plants conform to their phenotype (Claben-BockHof 2001), including qualitative and quantitative characters. The morphological study of plant taxa is important to provide comprehensive information on their taxonomic status (Sofiyanti et al. 2015). It also gives an accurate way to determine the agronomical traits of plants (Purwanti and Prihanta 2017),

especially for crop plants (George 2007) such as *Citrus* taxa. Therefore in crop improvement, the understanding of its biodiversity is an essential resource (Dias 2015).

Based on our preliminary observation of *Citrus* in Riau Province, the different species of this genus are grown for various uses, e.g. fresh consumed, ornamental plant, herb and spice or folklore. The aims of this study are to identify *Citrus* samples in Riau Province, to examine their morphological characters as well as to document their uses by local people. This study is the first record of morphological characteristics of *Citrus* in this province.

MATERIALS AND METHODS

Sample collection

Samples were collected from the field using the purposive sampling method from April to August 2021. The sampled localities were chosen on the basis of the information provided by the guides or local fruit sellers. The vegetative and generative parts were photographed and labeled based on the location and name of the species. The information on uses of *Citrus* identified in this study was collected by direct observation in the field, interviews with local herb sellers as well as practitioners of folk medicine.

Identification and morphological description

The identification was carried out based on the morphological characters of collected specimens. The morphological description of *Citrus* followed IPGRI (1999). The herbarium specimens from virtual herbarium were also examined for the related taxa. We also use online identification by using the following website: www.gbif.org/species/search, citruspages.free.fr/limes.php; www.plantsoftheworldonline.org, identify.plantnet.org/; www.worldfloraonline.org, *Citrus* nomenclature follows GRIN (2021) and Ollitrault et al. (2020).

RESULTS AND DISCUSSION

Citrus species

A total of 18 *Citrus* members are identified in this study. Table 1 presents *Citrus* taxa identified in this study.

Morphological characteristics of *Citrus*

Figure 1 presents the habit, leaves and flowers of some *Citrus* examined in this study. The habit of Citrus species is usually a large shrub or small tree (Figure 1A), with spiny shoots. The spines are sharp-tipped and located laterally along with the shoot. However, the older shoots are commonly thornless. Generally, the leaves are subcoriaceous, alternately arranged, simple leaf or 1-foliolate laminae (also called unifoliate) and (Figure 1B-J presents leaf morphology of some *Citrus* in this study).

Table 1. *Citrus* taxa identified in this study

Species	Synonyms	Sample code	Local name
Citrus × *amblycarpa* (Hassk) Ochse		CAMB	Jeruk Saring; Kasturi sambal
Citrus aurantiifolia (Christm.) Swingle "Lemon Lokal"	*"Citrus acida* Pers." auct.	CACI	Lemon lokal
Citrus aurantiifolia (Christm.) Swingle "Jeruk Nipis"		CAUR	Jeruk Nipis
Citrus × *aurantium* L. "Jeruk Hantu"		CAHA	Jeruk Hantu
Citrus × *aurantium* L. "Jeruk Peras"		CAPE	Jeruk Peras
Citrus hystrix DC. "Purut"		CHPU	Jeruk Purut
Citrus hystrix DC. "Sundai"		CHSU	Jeruk Sundai, Limau Sunde
Citrus × *microcarpa* Bunge "Jeruk Kunci"	*Citrus japonica* Thunb. var. *madurensis* (Lour.) Guillaumin	CJAP	Jeruk Kunci
Citrus × *microcarpa* Bunge "Jeruk Kasturi"	"*Citrus microcarpa* Yu. Tanaka" auct.	CMIC	Jeruk Kasturi
Citrus longilimon Tanaka		CLON	Jeruk Lemon Medan; Jeruk timun
Citrus medica L. "Jeruk Hantu"		CMHA	Jeruk Hantu
Citrus medica L. "Jeruk Pagar"		CMPA	Jeruk Pagar
Citrus medica L. var. *sarcodactylis* (Hoola van Nooten) Swingle	*Citrus sarcodactylis* Hoola van Nooten	CMSA	Jeruk Cakar Harimau; Jeruk Jari Budha
Citrus maxima (Burm.) Merr.		CMAX	Jeruk Bali
Citrus × *aurantium* L. var. *nobilis* (Lour.) Ollitrault, Curk & R. Krueger	*"Citrus nobilis* L." auct.	CNOB	Jeruk Bangkinang; Jeruk Siam
Citrus reticulata Blanco × (*Citrus* × *aurantium* L. var. *unshiu* (Swingle) Ollitrault, Curk & R. Krueger × *Citrus* × *aurantium* L. var. *sinensis* L.)	*Citrus reticulata* Blanco × (*Citrus unshiu* (Yu. Tanaka ex Swingle) Marcow. × *Citrus sinensis* Osbeck)	CUSR	Jeruk Dekopon
Citrus sp. (1)		CSP1	Jeruk Kambing
Citrus sp. (2)		CSP2	Jeruk Pasir

Key identification

1 a. Leaf petiole wing present 2
b. Leaf petiole wing absent 11
2 a. Leaf petiole wing broad, almost as wide as leaf lamina *3*
b. Leaf petiole wing medium or narrow, much smaller than leaf lamina 4
3 a. Fruit slightly pyriform; fruit base concave collared; epicarp (flavedo) very bumpy ..... *C. hystrix* "Purut"
b. Fruit spheroidal; fruit base necked; epicarp bumpy ..... *C. hystrix* "Sundai"
4 a. Fruit weight < 250 gr, diameter < 7 cm; 5
b. Fruit weight > 400 gr, diameter > 9 cm; ..... *C. maxima*
5 a. Fruit shape spheroid or ellipsoid, fruit apex nipple-shaped or rounded; mesocarp (albedo) < 2cm thick; endocarp segments present 6
b. Fruit shape oblique (asymmetric), fruit apex fingered-shape; mesocarp (albedo) spongy, the thickness almost ½ of diameter; endocarp segments absent ..... *C. medica* var. *sarcodactylis*
6 a. Fruit apex rounded or truncate; pulp white, greenish yellow, whitish orange or orange 7
b. Fruit apex nipple-shaped; pulp light yellow ..... *C. aurantiifolia* "Lemon Lokal"
7 a. Fruit diameter < 4 cm; epicarp (flavedo) dark orange; yellow; light yellow 8
b. Fruit diameter > 4.5 cm; epicarp (flavedo) yellowish orange ..... *C.* × *aurantium* var. *nobilis*
8 a. Epicarp (flavedo) smooth 9
b. Epicarp (flavedo) rough 10
9 b. Fruit diameter 3.5-4 cm; epicarp (flavedo) light orange; pulp dark orange ..... *C*. x *aurantium* "Jeruk Peras"
b. Fruit diameter 2-2.9 cm; epicarp (flavedo) dark orange; pulp whitish orange ..... *C*. x *aurantium* "Jeruk Hantu"
10 a. Fruit base rounded, < 2cm length; epicarp (flavedo) dark green when young ..... *C.* × *amblycarpa*
b. Fruit base necked , > 2.5 cm length; epicarp (flavedo) light green when young ..... *C. aurantiifolia* "Jeruk Nipis"
11 a. Mesocarp (albedo) white and lightly spongy 12
b. Mesocarp (albedo) yellowish white, not spongy 13
12 a. Fruit length up to 10 cm, base rounded, apex nipple-shaped, shape ellipsoid; epicarp (flavedo) yellow, rough and vertically grooved ..... *C. medica* "Jeruk Pagar"
b. Fruit length 2.5-3.5 cm, base necked, apex rounded, shape pyriform; epicarp (flavedo) yellowish orange ..... *C. medica* "Jeruk Hantu"
13 a. Fruit shape ellipsoidal or slightly pyriform 14
b. Fruit shape spheroidal or obovate 15
14 a. Fruit shape ellipsoidal, fruit base rounded, fruit apex short nipple-shaped; epicarp (flavedo) slightly rough, bright yellow at maturity; pulp greenish white ..... *C. longilimon*
b. Fruit shape slight pyriform, fruit base necked, fruit apex short ; epicarp (flavedo) rough to slightly bumpy, bright orange at maturity; pulp orange ..... *Citrus reticulata* × (*Citrus* × *aurantium* var. *unshiu* × *Citrus* × *aurantium* var. *sinensis*)
15 a. Epicarp (flavedo) smooth 16
b. Epicarp (flavedo) rough 17
16 a. Fruit shape obovate; epicarp (flavedo) bright orange at maturity ..... *Citrus* ×*microcarpa* "Jeruk Kunci"
b. Fruit shape spheroidal; epicarp (flavedo) yellow at maturity ..... *Citrus* ×*microcarpa* "Jeruk Kasturi"
17 a. Fruit shape obovate; epicarp (flavedo) bright orange at maturity ..... *Citrus* sp. (1).
b. Fruit shape spheroidal; epicarp (flavedo) yellow at maturity ..... *Citrus* sp. (2).

The petioles of *Citrus* leaves in this study are green to dark green in color. Our observation shows that the petiole wings of *Citrus* taxa in this study are obcordate, obdeltate, obovate, slightly linear or absent. The largest winged petiole belongs to *C. hystrix* (Figure 1B and C); its size is almost as wide as the upper lamina. The shape of this wing is obcordate. Based on IPGRI of *Citrus* (1999), the petiole wing of *Citrus* is divided into three categories, i.e. narrow, medium and broad. *C. hystrix* shows the broadest petiole wing. The obdeltate wing is found in petioles of *C. maxima* and obovate wing in *C.* × a*mblycarpa*. The wing of both *Citrus* petiole is also distinguished by their size. *C. maxima* shows wider wing than in *C.* × a*mblycarpa*. The slight linear petiole wings are found in *C. aurantiifolia*, *Citrus* × *aurantium* var. *nobilis* "Bangkinang". On the other hand, the wing of the petiole is absent in other *Citrus* members identified in this study, such as *C. microcarpa*, *Citrus* × *microcarpa* "Jeruk Kunci", *C. medica*, *Citrus* sp.1, *Citrus* sp.2. According to Yunus et al. (2018), the wing characteristic of *Citrus* petiole may vary in a species. Their study indicated the high variation on this character on *C. maxima* from Aceh Province (Indonesia) from obcordata, obdeltate and obovate. The variations are also found in leaf blade size and thickness.

For *Citrus* with winged petiole, the junction between lamina and petiole presents two types, i.e. fused and articulate. The fused junction is formed by the elongation of the lamina base toward petiole, and shows continuous part, as found in *C. medica* "Jeruk Pagar". On the other hand, the articulate petiole wing shows the separation between leaf lamina and wing of the petiole (e.g. *C. hystrix* and *C. aurantiifolia*). The previous study on *Citrus* morphology by Yunus et al. (2018), recorded that both junction types (fused and articulate) can be found in the same species, *C. maxima* from Aceh, Indonesia.

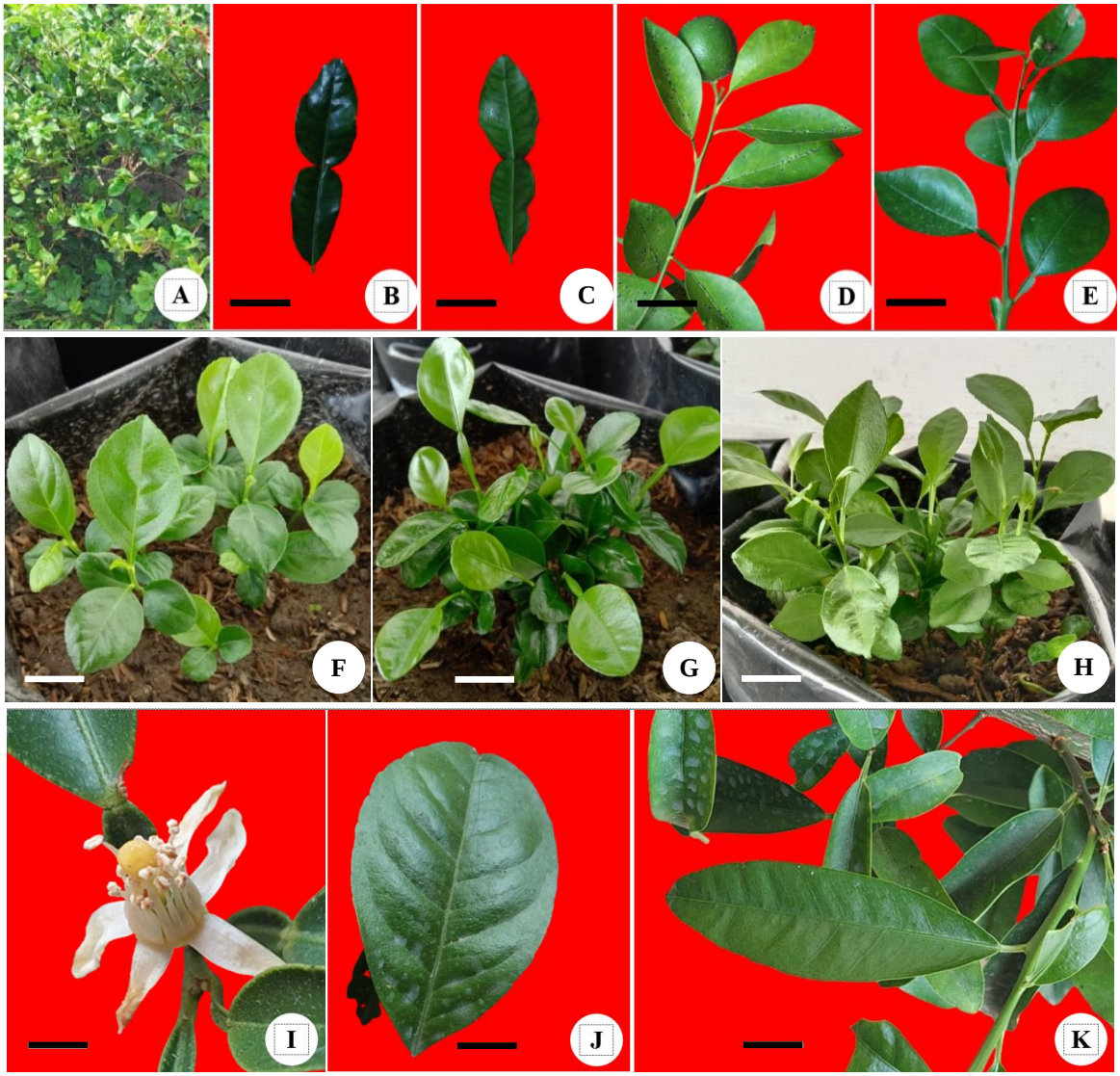

Figure 1. Morphology of some *Citrus* species from Riau Province. A. *C. aurantiifolia* "Jeruk Nipis", B-C. *C. hystryx* (B. adaxial and C. abaxial side of leaf), D. *C.* × *microcarpa* "Jeruk Kasturi", E. *C.* × *amblycarpa*, F. *C. medica* "Jeruk Pagar", G. *C. aurantiifolia* "Lemon Lokal", H. *C.* × *aurantium* var. *nobilis*, I-J *Citrus* × *microcarpa* "Jeruk Kunci", K. Flower of *C.* × *amblycarpa* (scale bar: B-E = 3 cm, F-H = 2.5 cm; I = 2 cm, J = 1.5 cm, K = 1 mm).

The leaf lamina shape of *Citrus* in this study varies from elliptic, oblong, obovate, ovate and obolanceolate. Elliptic leaf shape is found in *C.* × *microcarpa* (Figure 1 D), *C. aurantiifolia* (Figure 1G), *Citrus* × *aurantium* and *C. medica* var. *sarcodactylis*. Oblong leaf-shape is found in *C. medica* "Jeruk Pagar" (Figure 1F), *C.* × *aurantium* var. *nobilis* "Bangkinang" (Figure 1H), *C. longilimon*, and *C.* × *limon*. Obovate leaf shape is found in *Citrus* ×*microcarpa* "Jeruk Kunci" (Figure 1I). *C.* × *amblycarpa* (Figure 1E) has a slightly ovate leaf shape. The observation of leaf shape shows its variation in an individual, as found in *Citrus* × *microcarpa* "Jeruk Kunci" that has obovate (Figure 1I) and obolanceolate leaf shape (Figure 1J). The leaf variation is also found in other species such as *C.* × *aurantifolia* with an elliptic, oblong, or ovate leaf shape. The variation of *Citrus* leaf was also reported by Santos et al. (2015). The upper surface of leaves (adaxial) is green, usually darker than the lower surface (abaxial) (Figure 1B and C shows the leaves of *C. hystrix* on the adaxial and abaxial side). Most of the *Citrus* leaf has a green to dark green color. However, the variegated color of the leaf had been reported on few *Citrus* members, such as variegated pink-flushed lemon (*C.* × *limon*) (Hamdan et al. 2013), variegated true lemon (*C.* × *limon*) and variegated calamondin (*C.* × *microcarpa*) (Santos et al. 2015). These *Citrus* have a mix of leaf colors (light green, dark green and yellowish-green to yellow).

In this study, we observed a total of three textures of leaf surface, i.e. flat, slightly wavy and wavy. Most of the *Citrus* identified in this study have flat-leaf surfaces. The slightly wavy leaf surface is recorded on *C. aurantiifolia*, *C. medica* "Jeruk Pagar", *C. medica* "Jeruk Hantu", *C. medic*a var. *sarcodactylis*, *Citrus* × *microcarpa* "Jeruk Kunci" and *C. maxima*. While wavy leaf surface on *Citrus*

× *aurantium* L. "Jeruk Hantu". The leaf margins are entire (e.g. *C.* × *microcarpa* "Jeruk Kasturi", *C.* × *amblycarpa*), crenate (e.g. *C. hystrix, Citrus* × *microcarpa* "Jeruk Kunci"), and serrate (e.g. *C. medica* "Jeruk Hantu" and Jeruk Pagar").

The flowers of *Citrus* are axillary arranged, usually solitary or in small corymbs ca 1.5-2.5 cm in diameter. The petals are white to pinkish-white with numerous stamen and usually very strongly scented. Figure 1K shows a solitary flower of *C.* × *amblycarpa* "Jeruk Saring". The white petal's color is also observed in *C. aurantiifolia* and *C. histrix*, while the rest of the *Citrus* in this study have purple-tinged white petals. The stigma is usually rounded, and light yellow to yellow. The stylar column shows light green colour.

Figure 2 presents the fruit morphologies of *Citrus* identified in this study. *Citrus* presents a peculiar fruit type known as hesperidium, a modified berry fruit that results from one single ovary (Matheyambath et al. 2016). According to Pao and Feller (2003), *Citrus* fruits have a leathery rind and contain numerous seeds, and the epicarp contains abundant oil glands. Figure 2 present the fruit morphologies of *Citrus* identified in this study. The biggest fruit recorded belongs to *C. maxima* (Figure 2A), with up to 15 cm in diameter or more, while *C.* × *microcarpa* has the smallest fruit (ca. 2 cm in diameter). The fruit shapes observed in this study are spheroidal (e.g. *C. maxima, C.* ×*microcarpa, Citrus* × *aurantium* var. *nobilis, C. hystrix "*Sundai", *Citrus* Sp1), ellipsoidal (e.g. *C. longilimon, C. medica* "Jeruk Pagar"), pyriform (*C. medica* " Jeruk Hantu"), slightly pyriform (e.g. *C. hystrix* "Purut"), ovate (e.g. *Citrus* ×*microcarpa* Bunge "Jeruk Kunci") and oblique (asymmetric) (*C. medica* var. *sarcodactylis*). The most common fruit shape found I this study is the spheroidal fruit shape. The possibility of fruit variation in a species of *Citrus* had been reported by Hoque (2016). He recorded that pomelo shows great variation in fruit shape and size. Iqbal et al. (2015) also reported a similar result on sweet-lime fruit.

The shape of the fruit base observed in this study is necked, convex, truncate, concave, and concave collared. The necked fruit base has a narrower part toward the peduncle, as found in *C. medica* var. *sarcodactylis* (Figure 2Q) and *Citrus* × *microcarpa* "Jeruk Kunci" (Fiq. 2X1). The convex fruit base shows a rounded shape e.g. *C. longilimon, Citrus* × *aurantiifolia* (Christm.) Swingle "Lemon Lokal", *Citrus* sp. (2)., *C.* x *aurantium.* The truncate fruit base has a flat shape (e.g. *C. medica* "Jeruk Pagar, *Citrus* × *aurantium* var. *nobilis*). The concave fruit base is found in *C.* x *aurantium* "Jeruk Hantu", *C. aurantifolia* and *C.* × *amblycarpa.* In this study, only *C. hystrix* "Purut" shows a concave collared fruit base (Figure 2V).

The shapes of fruit apex also vary among *Citrus* in this study, i.e. nipple-shaped (*C. medica* "Jeruk Pagar", *C. hystrix* "Sundai", and *Citrus aurantiifolia* "Lemon Lokal"), rounded (e.g. *Citrus* × *aurantium* var. *nobilis* "Siam", *Citrus* ×*microcarpa* "Jeruk Kunci") and truncate (e.g. *Citrus* × *aurantium* var. *nobilis*, C. *hystrix*, C. x *aurantium* "Jeruk Hantu"). *C. medica* var. *sarcodactylis* has the most unique fruit apex, i.e. fingered-shape, and well-known as Finger *Citrus* due to this character (Zhang 2015). This character can be used to fast identification of this *Citrus*. The finger is up to 20 or more and arranged in two cycles, and the outer cycle has a higher number of fingers than the inner one.

The pericarp of *Citrus* is divided into three parts, i.e. epicarp, mesocarp and endocarp (Sadka et al. 2019). Epicarp is the outer part of the pericarp in *Citrus*. This part is also known as flavedo (Multari et al. 2021; Sharma and Tripathi 2006). Mesocarp is the inner part of the pericarp, located after epicarp, and also named as albedo in *Citrus* (Yerlikaya et al. 2016). In *Citrus* fruit, the endocarp is an internal tissue (Cebadera-Miranda et al. 2020) and usually is divided into segments. Endocarp contains juicy pulp. In this study, the fruit skin of *Citrus* (epicarp) color varies from light yellow (e.g *C. maxima*), yellow (e.g. *C. medica* var. *sarcodactylis, C.* × *amblycarpa*), orange (e.g. *Citrus* ×*aurantium* var. *nobilis, C.* × *aurantium*) to dark orange (e.g. *Citrus* Sp.1). The other characteristic of epicarp of each *Citrus* in this study is the epicarp surface texture, that varies form smooth (e.g. *Citrus* × *microcarpa* "Jeruk Kunci", *C.* × *aurantium* var. *nobilis*), pitted (e.g. *C.* × *amblycarpa, C.* × *aurantiifolia, C. maxima*), rough (*C. medica* " Jeruk Pagar, *C. medica* var. *sarcodactylis*) and bumpy or slightly bumpy (*C. hystrix* "Purut" and "Sundai").

The quantitative data of *Citrus* fruits in this study is presented in figure 3A-C. Figure 3A shows the fruit weight. *Citrus* with the lightest (ca. 15 gr) and heaviest fruit (ca. 475 gr) are *Citrus* × *microcarpa* "Jeruk Kunci" and *C. maxima*, respectively. Figure 3B presents the fruit size (width and height). Based on this figure, *C. maxima* has the highest measurement for both parameters. The thickness of the mesocarp (albedo) and a number of segments of *Citrus* fruit are presented in Figure 3C. The thickness of the mesocarp was measured from the inner part of the epicarp (flavedo) to the placenta in the center. The thickest mesocarp (albedo) (23 mm thick) belongs to *C. medica* supsp. *sarcodactylis.* This *Citrus* has a unique mesocarp that covers up to 95 % of the inner fruit part due to the absence of pulp. *C. maxima* also recorded thick mesocarp (ca. 21 mm thick). On the other hand, the thickness of the mesocarp of *Citrus* × *microcarpa* "Jeruk Kunci" is ca. 1-1.5 mm. The color of this part also varies from white (e.g. C. *hystrix, C. maxima, C. medica* "Jeruk Pagar, C. medica "Jeruk hantu"), light yellow (e.g. *C.* × *microcarpa*) and yellowish-orange (*C.* x *aurantium* "Jeruk Peras"). The number of endocarp fruit segments recorded in this study varies from 0 (in *C. medica* var. *sarcodactylis*) to 13 (C. *longilimon*) (Figure 3C).

The result of this study indicates great morphological of *Citrus* in Riau Province. Based on the explanation on *Citrus* morphology above, the members of this genus can be distinguished one to each other based on the laminae, petiole, flower and fruits characteristics. For example, the broad petiole wing and bumpy epicarp (flavedo) is the main characteristic of *C. hystrix. C. maxima* is characterized by having the largest fruit as well as a thick and spongy mesocarp (albedo). *C. medica* members show

rough epicarp and a large portion of mesocarp (albedo). In *C. medica* var. *sarcodactylis*, the mesocarp portion is up to 100% of the inner fruit parts. The characteristic of *C.* × *microcarpa* is its simple leaf and small fruit size. The result in this study provides the first morphological data from *Citrus* in Riau Province.

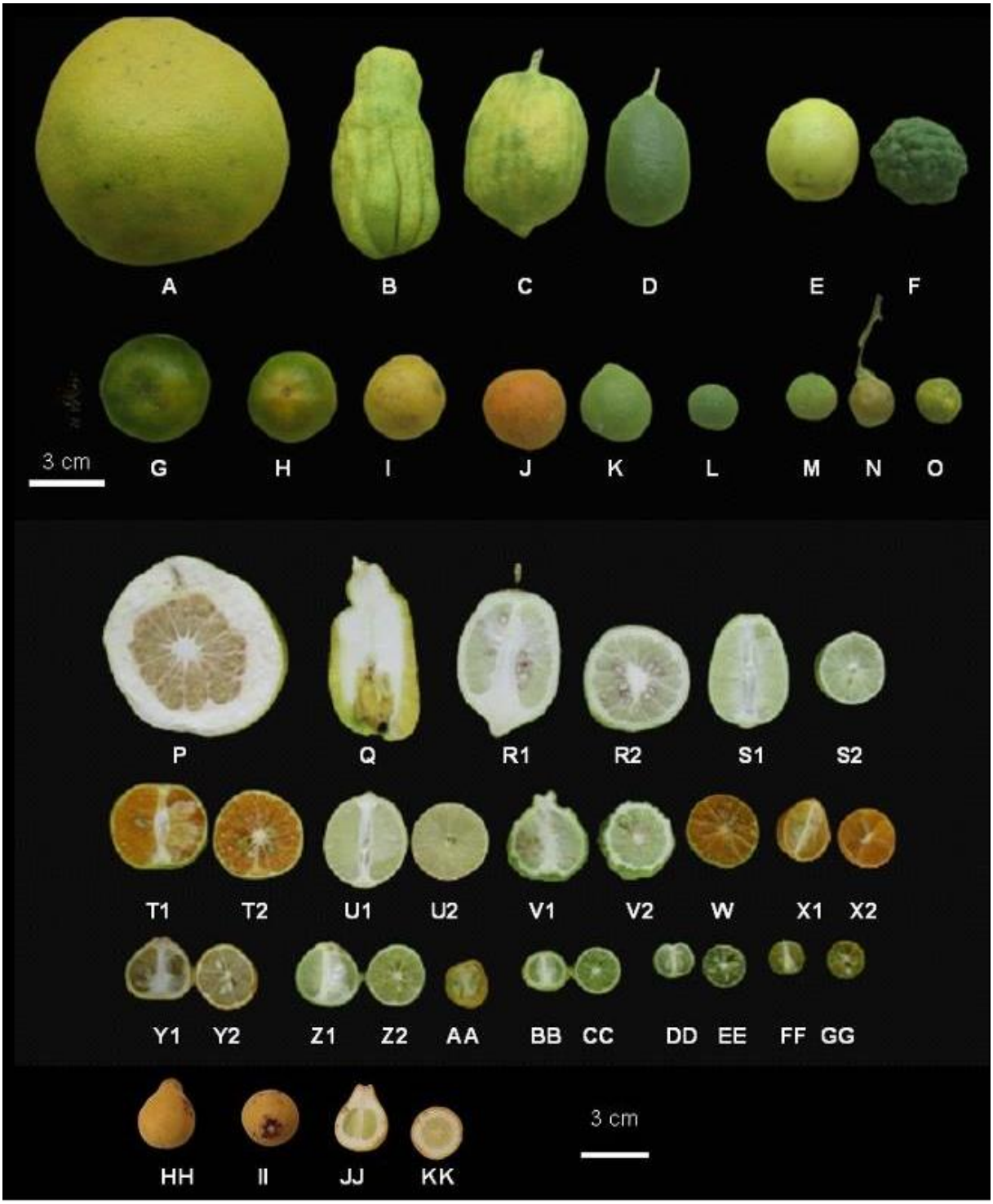

Figure 2. Fruit characteristic of *Citrus* from Riau Province. A & P. *C. maxima*; B & Q. *Citrus medica* var. *sarcodactylis*; C, R1, R2. *C. medica* "Jeruk Pagar"; D, S1 & S2. *C. longilimon*; E, U1 & U2. *Citrus aurantiifolia* "Lemon Lokal"*;* F, V1 & V2. *C. hystrix* "Jeruk Purut"; G, T1 & T2. *C.* × *aurantium var. nobilis*; H & W. *C.* x *aurantium* "Jeruk Peras"; I, Y1 & Y2. *C.* x *aurantium* "Jeruk Hantu"; J, X1 & X2. *Citrus* Sp.2; K, Z1& Z2. *C. aurantiifolia* "Jeruk Nipis"; L, DD & EE. *C.* × *amblycarpa*; M, BB & CC. *Citrus* s. (1); N & AA. *Citrus* × *microcarpa* "Jeruk Kunci"*;* O, FF & GG. *C.* × *microcarpa* "Jeruk Kasturi"*;* HH-KK. *C. medica* "Jeruk Hantu"

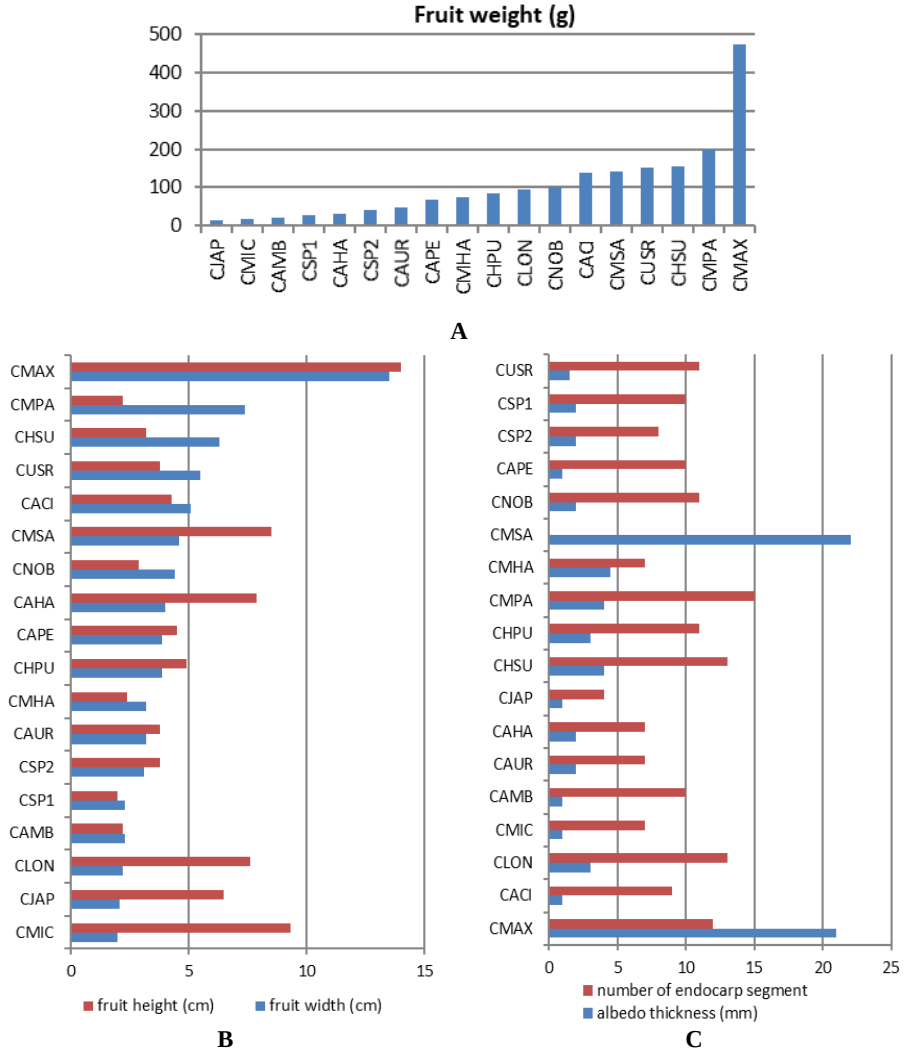

Figure 3. Quantitative data of *Citrus* fruits from Riau Province, Indonesia. A. Fruit weight, B. Fruit height and width, C. Number of endocarp segments and albedo thickness

The uses of *Citrus* in Riau Province

The *Citrus* members contain nutrients essential to the human diet (Sadka et al. 2019). According to Javadev and Athira (2017), *Citrus* fruits have a high content of Vitamin C that is very useful for protecting the human body from free radicals. Therefore, *Citrus* is outstanding among the most popular edible fruit crops in the world (Jose et al. 2014), but also for processed juice (Backer and Cameron 1999) or medicinal treatments (Chaudhari et al. 2016).

The uses recorded for *Citrus* identified in this study are presented in Table 2. The plant parts whose uses were recorded in this study are the whole plant, leaves, fruits, pericarps and pulp or juice, depending on the purpose of their uses. Usually, the whole plant is used for ornamental purposes, while leaf, fruit, pericarp and pulp are used for other aims, as presented in Table 2.

Traditional drink and juice

In this study, *Citrus* used for preparing traditional drinks is *C.* × *limon*, *C. aurantiifolia*, *C. longilimon* and *C.* × *microcarpa*. These *Citrus* are usually sliced and mixed with hot water before being drunk for an infused drink. Sometimes, the other ingredients e.g. ginger is mixed with this drink. *C.* × *microcarpa* is also used for a fresh drink, and is commonly sold by local people during hot days. *C.* x *aurantium* "Jeruk Peras" is usually prepared for fresh juice.

Dessert

Citrus used for dessert in this study is *Citrus* × *aurantium* var. *nobilis*, *C. maxima* and *Citrus* × *microcarpa* "Jeruk Kunci". However, the most common *Citrus* for freshly consumed dessert is *Citrus* × *aurantium* var. *nobilis* due to its sweet pulp. Furthermore, the price is more affordable for local people than *C. maxima* and *Citrus* × *microcarpa* "Jeruk Kunci". *Citrus* × *aurantium* var. *nobilis* is widely cultivated in Riau Province. Bangkinang, Kampar District is the agricultural center of this *Citrus* in Riau Province. *Citrus reticulata* × (*C.* × *aurantium* var. *unshiu* × *C.* × *aurantium* var. *sinensis*) is also used for fresh fruit dessert in other country (Japan, Korea, Brazil) (Reis et al. 2018). However, in Riau Province this Dekopon *Citrus* is only used for ornamental plant due to its high price.

Table 2. The uses of *Citrus* in Riau Province, Indonesia

Species	Plant part used	Uses	Preparation
Citrus aurantiifolia "Lemon Lokal"	Pulp	Diet drink, Traditional drink	Infusion
		Traditional treatment	Squashed
		Herb	Squashed
	Fruit	Face mask	Sliced and rubbed
		Herb	Sliced
Citrus × *amblycarpa*	Fruit	Herb	Crushed
*Citrus aurantiifolia "*Jeruk Nipis"	Pulp	Traditional drink	Infusion
		Traditional treatment	Squashed and boiled
		Herb	Squashed
Citrus × *aurantium* " Jeruk Hantu"	Fruit	Folklore	Sliced
Citrus × *aurantium* "Jeruk Peras"	Pulp	Juice	Squashed
Citrus hystrix "Purut"	Leaf	Herb and spice	Chopped
	Pulp	Herb	Infusion
	Pericarp	Herb, condiment	Ground
	Whole fruit	Folklore	Sliced
Citrus hystrix "Sundai"	Fruit	Herb	Sliced
Citrus × *microcarpa* "Jeruk Kunci"	Fruit	Traditional treatment	Sliced or squashed
	Whole plant	Ornamental plant	Grouwn in the pot
Citrus longilimon	Pulp	Traditional drink	Infusion in warm water
		Herb	Squashed
Citrus medica "Jeruk Hantu"	Fruit	Folklore	Sliced
Citrus medica "Jeruk Pagar"	Fruit	Folklore	Sliced
Citrus medica var. *sarcodactylis*	Fruit	Traditional Treatment	Sliced
	Pericarp	Traditional treatment	Sliced
	Whole plant	Ornamental	Grown in pot
Citrus × *microcarpa* "Jeruk Kasturi"	Fruit	Herb	Sliced
		Traditional or fresh drink	Sliced, squashed
	Pulp	Traditional treatment	Squashed
Citrus maxima	Pulp	Dessert	Freshly consumed
	Fruit	Traditional treatment	Sliced
Citrus × *aurantium* var. *nobilis*	Pulp	Dessert	Freshly consumed
		Fresh drink	Squashed
Citrus reticulata × (*C.* × *aurantium* var. *unshiu* × *C.* × *aurantium* var. *sinensis*)	Whole plant	Ornamental plant	Grown in a pot
Citrus sp1.	Fruit	Folklore	Sliced
Citrus sp2.	Fruit	Folklore	Sliced

Herb and spice

Herbs are plant parts for flavoring (Yang and Peppard 1999), seasoning and garnished for food (Motaleb 2011). Herb is used in fresh conditions while spice is dried plan part, e.g. seed, leaf, bark and flower (Kunnumakkara et al. 2009). The part used for herbs in this study are fruit (*Citrus aurantiifolia* "Lemon Lokal", *C.* × *amblycarpa*, *C. longilimon, C.* × *microcarpa*), leaf (*C. hystrix*), the pulp (*Citrus aurantiifolia* "Lemon Lokal", *C.* × *aurantiifolia*). The *Citrus* used as spice or condiment is *C. hystrix*. Usually, the dried leave of *C. hystrix* is used for flavoring meat-based food and traditional snacks.

Traditional treatment and folklore

The secondary metabolites and bioactivities of *Citrus* had been widely studied in order to examine their effectiveness as medicinal resources (Li et al. 2015; Chaudri et al. 2016). According to Ahmed and Azmat (2019), the bioactives of *Citrus* are suitable for a balanced diet and to keep humans healthy. In Indonesia, including in Riau Province, many people still rely on traditional practitioners to cure health problems. In this study, the species of *Citrus* are commonly used for traditional treatments for ulcer (*C,* × *aurantiifolia* (Christm.) Swingle "Lemon Lokal", *C.* × *microcarpa*), skin boil (*C.* × *aurantiifolia*), stamina booster for cancer patients (*Citrus* × *aurantiifolia* (Christm.) Swingle "Lemon Lokal", *C.* × *aurantiifolia* "Jeruk Nipis"), childbirth treatment (*C.* × *aurantiifolia*), and other diseases. The use of *C. aurantiifolia* for childbirth treatment to ease labor in this province was also reported by Susandarini et al. (2021). This species is also used to induce the production of breast milk. Traditional treatments with *Citrus* were also reported from other province in Indonesia. Silalahi and Nisyawati (2018) reported the uses of *Citrus* for treating cholesterol in South Sumatra Province. Furthermore, some species of *Citrus* (e.g. *C. hystrix*, *C.* × *aurantiifolia* and *Citrus* ×*aurantium* var. *nobilis*) are used for "oukup" (traditional steam-bathing) in this province. In East Java, *C.* × *aurantium* is used for treating respiratory-nose ad ear problems, as well as, oral/ dental and throat problems (Jadid et al. 2020). Besides traditional treatments, *Citrus* species are also used for folklore purposes, such as for

black magic treatment. *C. medica* "Jeruk Hantu", *Citrus* Sp1 and *Citrus* Sp2 are used in this treatment.

The result of this study is the first record on identification, morphology as well as the uses of *Citrus* members in Riau Province. The data obtained may complete the flora of Riau database that may support in identification and classification of vascular plants.

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