January 2022

THE SECOND INTERNATIONAL CONFERENCE ON GENETIC RESOURCES AND BIOTECHNOLOGY: Harnessing Technology for Conservation and Sustainable Use of Genetic Resources for Food and Agriculture

Committees: The Second International Conference on Genetic Resources and Biotechnology

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Preface: The Second International Conference on Genetic Resources and Biotechnology

The Second International Conference on Genetic Resources and Biotechnology, which is the continuation of the first event held in 2018, focuses on topics related to advances in biotechnology to create more opportunities for effective conservation and sustainable utilization of genetic resources for food and agriculture. This year conference's theme is Harnessing Technology for Conservation and Sustainable Use of Genetic Resources for Food and Agriculture. The conference was organized by Indonesian Agency for Agricultural Research and Development (IAARD), Ministry of Agriculture, Indonesia, in collaboration with Indonesian Biotechnology Consortium and held on 24th-25th of May 2021virtually due to the pandemic of COVID-19.

The conference aims to share and exchange current scientific information and technological developments on biotechnology and their applications for conservation and sustainable use of genetic, to encourage and promote quality, efficiency, and modernization of management and utilization of genetic resources, and to facilitate national and international collaboration among participants. There are five scopes discussed in this conference. They are effective management of conservation and sustainable use of genetic resources for food and agriculture, application of genomics and molecular markers for genetic resource conservation and crop adaptation to climate change, application of innovative crop improvement techniques for conservation and sustainable use of plant genetic resources for food and agriculture, plant cell and tissue culture for conservation and effective utilization of genetic resources, and the use of microbial genetic resources as biological control agents of agricultural pests and diseases, and for soil bioremediation.

Five speakers from the United States of America, Japan, India and Indonesia were invited to discuss about their expertise and knowledge on relevant subjects in the plenary sessions. This conference was attended by more than 100 participants including 75 presenters and 44 listeners worldwide. They came from diverse governmental, private, or academic institutions and also scientific communities. The presented materials have undergone peer review processes and only qualified papers were selected. Furthermore, all papers were subjected to double blind peer-review and expected to meet the scientific criteria of significance and academic excellence to be published in a conference proceedings indexed in a well-known, reputable service.

We would like to express our sincere gratitude to our speakers, presenters and all participants for their contributions in this conference. We would also like to express our appreciation for the generosity of our sponsors that support this conference: PT CropLife, PT ITS Science Indonesia, PT Fajar Mas Murni and PT Prima Instrument Analitika. Lastly, special thanks to all committee members for their exceptional work and contributions in the conference and publication.

Chair of Organizing Committee

Dr. Toto Hadiarto

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Morphological identification of underutilized local fruits in Kutai Barat Regency to support their conservation and sustainable use

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Fitri Handayani, Nurbani and Asep Pebriandi

Morphological Identification of Underutilized Local Fruits in Kutai Barat Regency to Support Their Conservation and Sustainable Use

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Abstract. Kutai Barat Regency has huge genetic resources of local fruit plants. However, most of them are still underutilized and even some species are threatened with extinction. Those fruits generally grow in secondary forests and traditional orchards called lembo. The aims of this study were to identify and morphologically characterize underutilized local fruits found in several lembo in Kutai Barat Regency in order to support their conservation efforts. The study was carried out in March 2020 in several lembo in Tering and Linggang Bigung Districts. Observation for plant characterization was carried out on the characters of trees, leaves, fruits, and seeds consisted of qualitative and quantitative characters. Seven species of underutilized local fruits have been identified and characterized, that were ihau, keramuq, rekeep, hivauu, kapul, ruuiq, and jentiq'an. As part of the culture and local wisdom, lembo plays an important role in genetic conservation of underutilized local fruits in Kutai Barat. Furthermore, lembo also plays role in support regional economic development. Registration of local varieties for superior accessions needs to be done as part of the initial efforts of conservation based on legal protection. Registration of horticultural varieties is also needed to support its direct utilization through large scale plant development.

INTRODUCTION

Kutai Barat Regency has huge genetic resources of fruit plants. Majority population of Kutai Barat Regency are indigenous people consisted of various Dayak tribes with diverse languages, customs, and culture. One of the well preserved local cultural heritages of Dayak community in Kutai Barat Regency is the existence of traditional fruit orchards called *lembo*. *Lembo* is a traditional garden in Dayak community consisting of various types of plants, but usually dominated by fruit species [1].

Ethnic groups usually have their own traditional knowledges related to conservation, utilization, and management of local genetic resources, as well as source of food, medicine, and various materials needed in daily life. *Lembo* is a way of traditional Dayak communities in Kutai Barat Regency to manage land use spatial planning so that village space can be utilized optimally and to conserve local plant species [2]. *Lembo* is a traditional garden that has very high economic and ecological values [1].

Kutai Barat Regency is very rich regarding local underutilized fruit species that potential to be explored and developed. Unfortunately, the utilization and empowerment of the genetic potential is still insufficient. Furthermore, with high rate of deforestation and land use change, many species of local fruits in Kutai Barat Regency are threatened with extinction. *Lembo* plays an important role in genetic conservation of local fruit plants which are mostly forest-derived plants, such as the relatives of these well-known fruits, e.g. durian (*Durio* sp.), *kapul-rambai* (*Baccaurea* sp.), rambutan (*Nephelium* sp.), *duku*/langsat (*Lansium* sp.), and mangoes (*Mangifera* sp.).

Compared with fruits commonly consumed, underutilized local fruits also contain nutritional values that are quite complete and varied. Local fruit species of Kalimantan, such as *balangkasua*, mangosteen, and *gitaan*, has high fiber and vitamin C content relatively, so they are potential to be used as source of food and functional food [3].

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However, consumption level of underutilized local fruit species is still low due to limited supply which caused by short harvest periods, less commercially cultivated, and inaccessible production centers. Farming system in Kutai Barat Regency, especially in small scale/narrow land farming, is intended to meet their own needs (self-sufficiency, subsistence) [4].

Generally, problems faced in the development of underutilized local fruit are low productivity, low quality compared with commercial fruit, and product continuity because of its seasonal nature [5]. Local fruit is mainly consumed as fresh fruit [6] due to its short shelf life which in turn causes the limited distribution range.

In addition to regional comparative advantage and regional specialization, economic potential of a region is a very influential factor in its economic growth. Therefore, utilization and development of all economic potentials should be top priority in implementing sustainable regional economic development [7]. In line with the opinion of Martini *et al*. [8] and Suryawan *et al*. [9], genetic resource of underutilized local fruits is one of the economic potencies of Kutai Barat Regency that should be employed to support regional economic development. To support the development efforts of underutilized local fruits, information about identity and characters of the fruits is needed to compose varietal description as one of requirement in regards to plant variety registration. The aims of this study were to identify and morphologically characterize underutilized local fruits found in several *lembo* in Kutai Barat Regency in order to support their conservation efforts.

MATERIALS AND METHODS

Identification of underutilized local fruits in Kutai Barat Regency was carried out in March 2020 in four *lembo* in Tering and Linggang Bigung Districts (Fig. 1). The accessions were selected by purposive sampling with several conditions, such as have superior characters, and the plants were bearing fruit. Information about plants that fulfill these conditions had been collected beforehand from field extension officers (*Penyuluh Pertanian Lapangan*/PPL). Based on the information, the study was focused on two locations, namely Jelemuq Village, Tering District and Linggang Mapan Village, Linggang Bigung District. Observation, identification, and characterization were carried out at each location of the selected plants.

FIGURE 1. Exploration sites of local fruits in Kutai Barat Regency.

Observations for plant characterization were carried out on the qualitative and quantitative characters of trees, leaves, fruits, and seeds. Tree characterization was carried out to determine the shape of the canopy, branch type, and the character of the trunk. Leaf characterization was carried out to determine the shape of the leaf, the size and color of the leaf and the petiole, the leaf edge, and the leaf texture. Fruit characterization was carried out to determine the shape and size of the fruit, the color and texture of the fruit skin, as well as characters of fruit flesh

such as color, thickness, taste, texture, and aroma. For seed, characters observed were the shape, color, and size. Quantitative data, such as leaf length/width, fruit length/diameter, fruit flesh thickness, etc., were measured from 10 samples, then the average values were calculated. Photographs of plants and plant organs were taken using a Sony Alpha A5000 camera.

RESULTS AND DISCUSSIONS

Kutai Barat Regency is located between 1°31'35"–1°10'16" South and 113°45'05"–116°31'19" East. Kutai Barat Regency with total area 20,384.6 km^2 consisted of 16 districts dominated by flat to wavy topography (64.48%), very steep (17.20%), and steep (18.32%). There are 14 large rivers with tens of kilometers in length, the shortest is Barong River (28.5 km) and the longest is Mahakam River (229.42 km). Kutai Barat is a regency in East Kalimantan with the largest percentage of number of villages located in valleys or watersheds (66.39%). The rest are villages located on the plains (26.89%) and on mountain or hill slopes (6.72%) [10]. So, agriculture become sector with great potential to be developed, where one of the sub-sectors is fruit crops [11].

Commercial local fruits in Kutai Barat Regency are durian, banana, rambutan, *duku*/langsat, and mango [12] which have been cultivated intensively or semi-intensively. Besides these commercial fruits, this regency also has an immense germ plasm of exotic local fruits. These local fruits generally still underutilized, grow in secondary forests and in traditional orchards called *lembo*. Although *lembo* has begun to be displaced as a result of regional development, it is still easy to find it around the settlements or farmland of Dayak community in the regency. Several local fruit species were found in exploration and identification carried out in four *lembo* in Tering and Linggang Bigung Districts (Table 1). These underutilized local fruits are forest plants that have been domesticated by the community in their own orchards. Economically, these local fruits contribute an income for the owner during harvest period, while some are consumed to meet their own need. These fruit species are source of useful genes for related crop species in breeding program [13]. The plant characters of the fruit species is described on Table 2 and leaf characters is on Table 3.

TABLE 1. Identified local fruit species of Kutai Barat Regency.

Local name	Common name	Species	Plant location
Ihau	*Lengkeng/mata kucing*	*Dimocarpus longan* ssp. *malesianus* var. *malesianus*	Jelemuq Village, Tering District
Hivauu	Rambutan	*Nephelium sp.*	Jelemuq Village, Tering District
Rekeep	Rambutan	*N. cuspidatum* var. *eriopetalum*	Linggang Mapan Village, Linggang Bigung District
Kapul	*Kapul*	*Baccaurea macrocarpa*	Jelemuq Village, Tering District
Ruuiq	*Kapul*	*Baccaurea sp.*	Linggang Mapan Village, Linggang Bigung District
Jentiq'an	*Kapul*	*Baccaurea sp.*	Jelemuq Village, Tering District
Keramuq	*Dabai/Kembayau*	*Canarium odontophyllum/ Dacryodes rostrata*	Linggang Mapan Village, Linggang Bigung District

TABLE 2. Plant characters of the local fruits of Kutai Barat Regency.

Local name	Cross-section of stem	Bark color	Trunk surface	Branch type
Ihau	Round	Brown	Rough	Pointing up
Hivauu	Round	Brown	Rough	Pointing up
Rekeep	Round	Brownish grey	Rough	Horizontal
Keramuq	Round	Greyish brown	Rough	Pointing up
Jentiq'an	Round	Brownish grey	Rough	Irregular
Kapul	Curved	Greyish brown	Rough	Horizontal
Ruuiq	Round	Greyish brown	Rough	Horizontal

TABLE 3. Leaf characters of the local fruits of Kutai Barat Regency.

Local name	Leaf blade shape	Leaf blade margin	Leaf upper surface color	Leaf lower surface color	Length (cm)	Width (cm)	Petiole color	Petiole length (cm)
Ihau	Oblong	Entire	Dark green	Green	42.6	15.5	Brown	2.0
Hivauu	Elliptic	Entire	Dark green	Green	23.7	8.1	Green	1.4
Rekeep	Linear oblong	Entire	Dark green	Greenish grey	25.1	7.4	Brown	0.9
Keramuq	Oblong	Entire	Dark green	Green	13.1	5.6	Light green	2.2
Jentiq'an	Elliptic	Entire	Dark green	Green	17.0	6.9	Green	3.1
Kapul	Elliptic	Entire	Dark green	Green	19.5	8.4	Green	4.6
Ruuiq	Elliptic	Entire	Dark green	Green	28.9	10.9	Brownish green	7.2

Ihau (*Dimocarpus longan* ssp. *malesianus* var. *malesianus*)

Ihau or often called as *mata kucing* is a fruit plant originated from Southeast Asia, while the highest genetic diversity was found on Kalimantan Island, where 30–40 diverse landraces have been found [13, 14]. *Ihau* has many similarities with commercial longan, so it is called as longan fruit of Kalimantan. *Dimocarpus longan* Lour. consisted of two subspecies, namely subspecies *longan* and subspecies *malesianus*. Commercial longan belongs to subspecies *longan* (*D. longan* ssp. *longan*), while *ihau* belongs to subspecies *malesianus* (*D. longan* ssp. *malesianus*). Each subspecies consisted of several varieties. Varieties of subspecies *malesianus* were var. *malesianus* and var. *echinatus* [14, 15].

TABLE 4. Fruit and seed characters of *ihau, hivauu, keramuq,* and *rekeep*.

Characters	*Ihau*	*Hivauu*	*Rekeep*	*Keramuq*
Fruit rind/skin surface	Warty	Covered by soft spines with 3 mm in length	Covered by soft spines with 5–6 mm in length	Flat, thin powdery
Fruit shape	Circular	Oblong	Oblong	Elliptic
Length of pedicel (cm)	0.9	0.3	0.2	1.2
Rind/skin color of mature fruit	Light brown	Purplish red	Red	Dark purple
Thickness of rind/skin (cm)	0.13	0.2	0.3	0.04
Fruit size (cm)	2.4 (diameter)	3.4 (length) 2.6 (diameter)	3.5 (length) 2.8 (diameter)	3.3 (length) 2.2 (diameter)
Fruit weight (g)	8.5	11.0	13.2	8.9
Thickness of flesh (cm)	0.4	0.5	0.5	0.2–0.3
Main color of flesh	Clear white	Milky white	Milky white	Brown beige
Taste of flesh	Sweet	Sweet and sour, seed taste is savory and crispy	Sweet and sour	Savory with a little sour
Flesh texture	Soft	Soft	Soft	Soft
Flesh juiciness	Juicy	Juicy	Juicy	Non-juicy
Flesh aroma	Weak	Weak	Weak	Unscented
Seed shape	Oblong	Ellipsoid	Oblong	Oblong
Seed color	Dark brown	White with brown stripe	Beige	Reddish brown
Seed size (cm)	1.9 (length) 1.4 (diameter)	1.9 (length) 1.1 (diameter) 0.8 (thick)	2.0 (length) 1.2 (diameter) 1.0 (thick)	2.7 (length) 1.6 (diameter)

Taxonomic status of *ihau* and commercial longan is still debatable. Some literatures stated that *ihau* and commercial longan are subspecies of *D. longan* Lour., but in fact there are differences in their chromosomes arrangement. The number of chromosomes of *ihau* is 2n = 2x = 14 and no satellites are found. On the other hand, the number of chromosomes of commercial longan is 2n = 2x = 30 with satellite chromosome located on

chromosome number 12 [16]. Study of the genome size and trichome morphology of subspecies *malesianus* and *longan* found that *malesianus* is not a subspecies of *D. longan* Lour. [17].

The main difference between fruit of *ihau* and commercial longan is the texture of fruit skin surface. Commercial longan fruit has a leathery flat skin surface, while the fruit skin of *ihau* is warty (Table 4). The proportion of fruit flesh and seeds is also different. Commercial longan has thick fruit flesh (about 60–75% of its total weight is edible) which wraps a small-sized seed [15], while *ihau* has thin flesh with relatively large seed (Table 4). The flesh of *ihau* contains 76.75% of water, 27.27% of carbohydrates, 3.83% of crude fat, 1.75% of crude protein, 10.80% of crude fiber, total acid 11.67 mg/g, and vitamin C 66.9 mg/100 g [3]. The fruit content is similar to commercial longan, but lower in carbohydrate and energy values as well as higher mineral content [13].

Although the quality of fruit is inferior to commercial longan, the subspecies *malesianus* is potential to be developed as commercial fruit varieties or used as gene bank in longan breeding programs. However, its genetic potential has not been exploited optimally. One of the superior characters of subspecies *malesianus* is highly adaptive to tropical climates, especially in the equatorial zone, in contrast to commercial longan which is only adaptive in subtropical regions [15].

By-product of the fruit of family Sapindaceae can be transformed into novel products. The seed and peel of *D. longan* are rich in phenolic compounds, such as gallic acid, ellagic acid, corilagin, and geraniin. These compounds are potential to be applied in food and pharmaceutical industries and developed into functional food as well as preservatives in food and health care products [18].

Keramuq (*Canarium odontophyllum/Dacryodes rostrata*)

Canarium odontophyllum is a native plant of Kalimantan and can be found in all regions of the Kalimantan Island (Brunei, Indonesia, and Malaysia) [19, 20]. This species is known as different local names, including *keramuq* (Dayak, Paser), *rukam* (Kutai), *kumbayau* (Banjar), *kamayau* (West Kalimantan), and *dabai* (Malaysia). In its natural habitat, *keramuq* fruit is a food for various species of birds, primates, and rodents mammals. However, *keramuq* is also planted by local people in their orchards to be consumed [20].

The shape of *keramuq* fruit is oval to ellipsoid. Pericarp (fruit skin) is dark purple to black, surrounds pale yellow to bright yellow thin mesocarp (fruit flesh), which wraps a large size seed (endocarp) [19, 21]. The seed of *keramuq* is relatively big (Table 4), contributes to 61% of the fruit weight [22].

Keramuq fruit is not consumed as a fresh fruit, but must be processed first. The fruit must be steeped in warm water (60°C) for 15–20 min, drained, added a little salt and/or sugar, and then served [19], similar to the way of Dayak community in Kutai Barat Regency. Unsteeped *keramuq* flesh is hard and unpalatable. Steeping *keramuq* fruit will decrease the firmness of the flesh by 92%, increasing the soluble solid concentration up to 58%, and decreasing the pH [22]. The taste of *keramuq* flesh is similar to an avocado, which is savory with fine creamy texture.

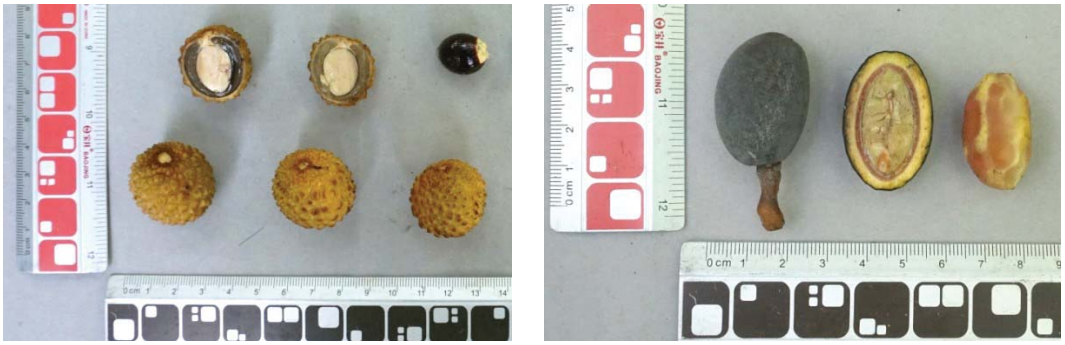
Keramuq fruit is a source of minerals (calcium, magnesium, and phosphorus), protein, carbohydrates, and fat [21]. Lipid is the main nutrient contained in *keramuq* fruit, while the main mineral contents are calcium, sodium, and potassium. Protein content of *keramuq* fruit is rich in glutamic acid and aspartic, about 45–49% of the total amino acids [23].

Keramuq fruit can be recommended as a major source of natural antioxidant [24, 25]. Antioxidant activity in *keramuq* fruit is highly correlated with total phenol content [23, 24]. *Keramuq* fruit contains two phenol acids, five flavonoids, three anthocyanidins, and four anthocyanins. Plant variety affects the profile of anthocyanidin and anthocyanin, but has no influence on phenol and flavonoid acids. Meanwhile, the diversity of environmental growth affects the content of phenol compounds quantitatively [26]. Fruit performance of *ihau* and *keramuq* are shown in Fig. 2.

Azlan *et al*. [27] compared the fatty acid content and physicochemical characteristics between *keramuq* oil, olive oil, and palm oil, and concluded that *keramuq* oil (derived from fruit flesh and seeds) has a good composition of fatty acids and potential to be developed into healthy oil. Besides the fruit, the useful part of *keramuq* plant is the bark. Acetone extract from *keramuq* stem bark was potential to be used in development of anticancer agents for colon cancer treatment [28].

Postharvest processing of *keramuq* fruit is an alternative way to increase its economic value, providing the economic benefits for the local community. Rahman and Thajudin [21] processed *keramuq* flesh into a sauce which contains 45% fruit puree, 30% sugar, 18% water, 0.9% salt, 1.53% modified corn starch, 0.1% xanthan gum, 0.4%

citric acid, 4% margarine as an emulsifier, and 0.07% sodium benzoate. According to the results of proximate analysis, the nutrient content was 35.5% of carbohydrate, 1.4% of protein, 0.75% of fat, and 0.92% of crude fiber.



(a) (b)

FIGURE 2. Fruits of *ihau* (a) and *keramuq* (b).

Kapul (*Baccaurea sp.*)

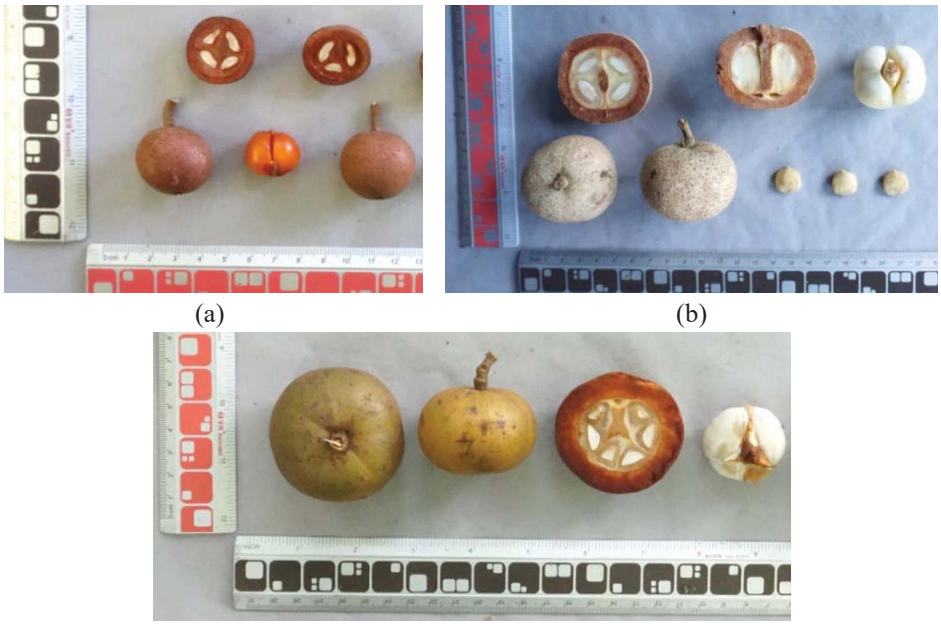
Baccaurea is a genus of the family Phyllantaceae which consisted of about 80 species of fruit trees spread from Indonesia to the Pacific Islands. In general, the genus *Baccaurea* is divided into two groups based on their fruit character, namely the *rambai* group (thin-skinned) and the *tampoi* group (thick-skinned) [29]. *Kapul* or *tampoi* is a type of fruit plant of the genus *Baccaurea*. The name *kapul* usually refers to *B. macrocarpa* species. However, *kapul* is also used as a common name for several local species of *Baccaurea sp*. which has similarities to *B. macrocarpa*, for example *jentiq'an* and *ruuiq*.

TABLE 5. Fruit and seed characters of *kapul, ruuiq*, and *jentiq'an*.

Characters	*Kapul*	*Ruuiq*	*Jentiq'an*
Fruit rind surface	Flat and smooth	Flat and rough	Flat and smooth
Fruit shape	Oblate	Oblate	Globose
Fruit stalk length (cm)	1.2	1.0	1.7
Rind color of mature fruit	Greenish light brown	Greyish beige	Reddish brown
Thickness of rind (cm)	0.8	0.8	0.4
Fruit size (cm)	3.7 (length) 5.2 (diameter)	4.1 (length) 4.9 (diameter)	2.7 (length) 2.8 (diameter)
Fruit weight (g)	46.8	42.4	10.7
Number of locules	3	2	2
Number of seed in each locule	1–2	1–2	1–2
Locule partition	Brown beige color, perfectly partitioned by thin wall	Beige, imperfectly partitioned by wall which only exist in the middle of the fruit cavity	Beige to orange, perfectly partitioned by thin wall
Thickness of flesh (cm)	0.3	0.5	0.3
Flesh color	Milky white	Milky white	Orange
Taste of flesh	Sweet and sour	Sweet and sour	Sweet and sour
Flesh texture	Smooth	Smooth	Smooth
Flesh juiciness	Juicy	Juicy	Juicy
Flesh aroma	Weak	Weak	Unscented
Seed shape	Elliptical	Oblong, with acute apex	Elliptical, thicker in the middle
Seed color	Beige	Beige	Beige
Seed size (cm)	1.4 (length) 0.6 (diameter) 0.4 (thick)	1.5 (length) 1.4 (diameter) 0.5 (thick)	1.0 (length) 0.9 (diameter) 0.3 (thick)

Jentiq'an and *ruuiq* are local names in Kutai Barat Regency for local fruit plants of genus *Baccaurea* with characteristics that similar to *kapul* (Table 5). *Kapul* and *ruuiq* have many similarities in characters of tree, leaf, and fruit. The most noticeable differences are the color and texture of fruit skin, and the number of locules (cavities containing seeds). The fruit cavity of *kapul* is divided into 3 locules which are perfectly partitioned by thin walls, while the fruit cavity of *ruuiq* is only divided into 2 locules partitioned by imperfect wall which only exists in the middle of the fruit cavity (Table 5). Each locule contains 1–2 seeds which wrapped by flesh. *Jentiq'an* fruit is smaller than *kapul* or *ruuiq*. The fruit cavity is divided into 2 locules like *ruuiq*, but perfectly partitioned like *kapul*. *Jentiq'an* has orange flesh, while the flesh of *kapul* and *ruuiq* is white (Table 5).

Three types of *kapul* plants was found in Kutai Barat region, namely white *kapul*, yellow *kapul*, and small *kapul* [30]. Based on the morphological characteristic and comparing with Table 5, small *kapul* refers to *jentiq'an*, while white *kapul* refers to *kapul*. *Kapul* (*B. macrocarpa*) is a species that potential to be developed on a large scale because it has good quality fruit with a fairly large market demand and early fruiting [29]. Fruit performace of *jentiq'an*, *ruuiq*, and *kapul* are shown in Fig. 3.



(a) (b)

(c)

FIGURE 3. Fruits of *jentiq'an* (a), *ruuiq* (b), and *kapul* (c).

Rambutan (*Nephelium sp.*)

Kalimantan Island is center of origin and center of diversity of rambutan relatives (genus *Nephelium*). Sixteen species of *Nephelium* can be found in Kalimantan Island, and eight of them are endemic plants [31]. *N. cuspidatum* var. *eriopetalum* is one of local rambutan species of Kalimantan that naturally grows in the forest, and has been domesticated by the community in gardens or yards [31]. It is called as *rekeep* or *lempukat* by Dayak tribes in Kutai Barat [1], and called as *bakuel* in Sanggau District, West Kalimantan [32], while also known as rambutan *kabung* or *ranggung* in other place [31].

Rambutan *hivauu* (*Nephelium* sp.) has a slightly smaller fruit than *rekeep*, with darker fruit skin color (Table 4). Another difference is the part of fruit that can be consumed. Generally, flesh (mesocarp) is the only part of rambutan fruit that can be consumed, but *hivauu* has edible seed. *Hivauu* has savory taste with crispy texture of seed, so it can be chewed directly with the flesh.

Information about genetic diversity of wild rambutan relatives is very useful in genetic improvement of cultivated species. The farther the genetic distance, the higher the genetic diversity. Genetic diversity analysis of rambutans in Sanggau District, West Kalimantan using ISSR markers showed that *N. cuspidatum* var. *eriopetalum* had farthest genetic distance to other species [32]. Cluster analysis based on variation in stomata types, anticlinal wall patterns, and stomata types on leaf surfaces of the family Sapindaceae showed that *N. cuspidatum* var.

eriopetalum grouped in the same cluster with *N. cuspidatum* var. *robustum*. They were separated with *N. costatum*, *N. cuspidatum* var. *multinerve*, *N. cuspidatum* var. *ophoides*, *N. hamumalatum*, *N. lappaceum*, *N. laurinum*, *N. ramboutan-ake*, and *N. uncinatum* [33]. Fruit performace of *hivauu* and *rekeep* are shown in Fig. 4.

(a) (b)

FIGURE 4. Fruits of *hivauu* (a) and *rekeep* (b).

Efforts of Conservation and Utilization of Underutilized Local Fruits

All of underutilized fruit species observed in this study did not contribute to fruit production figures in Kutai Barat Regency [10]. Two species that has possibility to contribute to fruit production data are *hivauu* and *rekeep* as part of rambutan relatives, with total rambutan production was 251 tons in 2018.

Fruits can be grouped based on their usability and economic value, i.e. group of commercial fruits, rare fruits, *upakara* fruits, and medicinal fruits. Rare fruit is a fruit that is hard to find on the market, annual, rarely cultivated, and grows wild. Based on those criteria, these seven underutilized local fruits can be included in category of rare fruit. These fruits have many benefits, still well known by the community especially in rural areas, and their existence must be protected in order to keep their remains sustainable [9].

The easiest way to conserve local plants is by using these plants sustainably. Optimal utilization will help maintaining the sustainability of a plant species. For local species with high economic value such as durian and their relatives, conservation through sustainable use can be carried out easily. But for local fruits that are less popular and less economical (underutilized), such as *ihau*, *kapul*, *ruuiq*, *jentiq'an*, *hivauu*, *rekeep*, and *keramuq*, some other ways of conservation are required so that the species will not extinct.

Kutai Barat is one of regencies in Indonesia that accommodates conservation regulations at local level and arranges it in Local Regulation of Community Forestry, in which local conservation situated. Activities of community that support conservation can be found easily in Kutai Barat Regency. Usually, those activities are passed down from generation to generation. One of them is *lembo* in Dayak culture [34].

Lembo is a traditional garden of Dayak community in East Kalimantan Province. The term *lembo* is thought originated from the Dutch "landbouw" which means agriculture [35]. In terms of Dayak Benuaq and Dayak Tunjung, its traditional fruit garden is called as *simpukng* or *munaan* [1, 34], or *simpukng runukng* in terms of Dayak Bentian [1], while Kutai tribe called it as *rondong* [34]. Generally, *lembo* is dominated by fruit trees combined with other beneficial plants, even animals [1, 35], so it becomes an ideal way to conserve the genetic resources.

Lembo can be classified into four types, namely field *lembo*, *lamin lembo*, house *lembo*, and road *lembo* [35]. Field *lembo* usually located far from residential areas, in secondary forest that previously was a paddy field. *Lamin lembo* is located around *lamin*, Dayak traditional longhouse that is inhabited by several families in each chamber. Every family has the right to use and control *lembo* plot behind or in front of their chamber. House *lembo* is located around single house, owned by a family so it develops faster. Road *lembo* is a communal property along the road leading to the river, fields, or road between settlements.

Plants in the *lembo* can be divided into two large groups, that are fruit plants which usually deliberately planted and non-fruit plants that mostly grow naturally and are not maintained [1]. Based on its cultivation status, plants in *lembo* can be divided into three groups, that are uncultivated species or wild species (55%, which generally are non-fruit plants), semi cultivated species (23%), and cultivated species (22%) [35]. In *lembo* there is no plant spacing. Group of cultivated species is just planted on a part of land that is still empty, and has growing space without any special treatment. Minimum maintenance is done when fruit season arrives [36].

Rapid development in Kutai Barat Regency causes a change in community lifestyle, and also affects the sustainability of *lembo* as a traditional cultural heritage of the Dayak tribe. The main threat to the sustainability of

lembo is the expansion of rubber plantations, oil palm plantations and coal mining [1]. High investment of multinational oil palm companies in East Kalimantan Province is closely related to the low cost of land acquisition, because most of them are forest areas and customary land. Therefore, Risal [37] argues that the presence of multinational oil palm companies in this province has serious consequences related to threats to local cultural wisdom, including biodiversity decline and loss of endemic species due to logging and burning practices for land clearing. Decreasing area of *lembo* in Kutai Barat Regency continues to occur due to the conversion of traditional and customary lands, including *lembo* lands, into rubber plantations, oil palm plantations and mining areas [1].

Therefore, the government of Kutai Barat Regency initiates to repromote *lembo* through the activities of the adat leader (ethnic group leader) in each village supported by government budget. To support the policy, technical instruction was arranged as a guideline for adat leaders to build custom *lembo* that economically productive and still uphold traditional values as a cultural heritage [1].

Matius *et al*. [1] suggested to plant various types of local fruits and other useful plants to build the custom *lembo*. The diversity of plant species in *lembo* forms multilayer canopy structures which serves to maintain the humidity of the microclimate, store carbon, produce oxygen, and protect land surfaces from erosion. Canopy structures can be grouped into four layers, which is layer A (large trees with height >30 m), layer B (rather large trees with height of 20–30 m), layer C (medium trees with height of 10–20 m), and layer D (plants <10 m tall including shrubs, herbs, and creeping plants on the forest floor). Based on the structure of the canopy, *keramuq* tree can occupy layer B, while *hivauu*, *rekeep*, *kapul*, *ruuiq*, *jentiq'an*, and *ihau* occupy the layer C [1].

Vegetation of traditional *lembo* in Kutai Barat Regency is dominated by underutilized local fruit species, so its utilization is still suboptimal. Local community just take the fruit in harvest season to be sold and consumed themselves. Economically the fruits can provide additional income which is around IDR 10,000 per kg (*rekeep*, *hivauu*, and *keramuq*) up to IDR 15,000 per kg (*kapul*, *ruuiq*, *jentiq'an*, and *ihau*). Harvest period of those seven fruit species is at the end of the fruit season (around February–March), when harvest time of favorite fruits such as relatives of durian, *duku*/langsat, and mango has finished. Therefore, those seven underutilized local fruits are relatively easy to sell.

Genetically, the presence of local fruits with high biodiversity and high genetic diversity offers availability of gene sources for long-term breeding program of a fruit species. *Ihau* is very potential to be source of genes in breeding programs of commercial longan plant, especially for its adaptivity in tropic region even in equatorial zone [15]. *Rekeep* has far genetic distance with other species of *Nephelium* sp. [32, 33], so they can contribute good characters in rambutan breeding programs.

In short-term, for appropriate utilization of genetic resources of local fruits, exploration are needed to find local accessions with superior fruit character (taste, aroma, fruit size, flesh thickness, nutrient content, etc.) which potential to be developed as commercial varieties. Furthermore, the superior accessions could be utilized directly through development in large scale. However, the development of a plant variety must be supported by the availability of quality seeds which propagated through seed certification system. In accordance with Rules of Agricultural Ministry No. 8 of 2012 concerning the production, certification, and supervision of horticultural seed distribution, quality seed of horticultural commodities can be produced for registered varieties only.

Registration of horticultural varieties is a procedure to obtain government recognition for a variety that has superior characters, so that the seeds can be produced and distributed under supervision of seed certification agencies. To support its development, a superior accession/variety of local fruits must be legalized through registration of local variety and continued by registration of horticulture variety. The aims of local variety registration are to collect data of local plant varieties (national database) and to confirm the ownership of the local varieties by certain region (regency/city or province). Registration of local varieties is part of the initial efforts of conservation based on legal protection. In addition, the registration of horticultural varieties is needed as a legalization for seed propagation and distribution. As an early step in process of local varieties registration and horticultural varieties registration, plant identification and characterization need to be done to obtain taxonomic data, information about the presence and distribution of the variety, variety description, and photo documentation of plant and its organs.

CONCLUSION

Seven local fruit species have been identified and characterized from several *lembo* in Tering and Linggang Bigung Districts, namely *ihau* (*D. longan* ssp. *malesianus* var. *malesianus*), *keramuq* (*C. odontophyllum*), *rekeep* (*N. cuspidatum* var. *eriopetalum*), *hivauu* (*Nephelium* sp.), *kapul* (*B. macrocarpa*), *ruuiq* (*Baccaurea* sp.), and *jentiq'an*

(*Baccaurea* sp.). All of them are underutilized fruit species, so the utilization is still inadequate for local community. High rate of deforestation and land use change threaten the extinction of many local fruit species. Conservation effort that potential to be implemented is by utilizing *lembo* as part of the culture and local wisdom of Dayak community in Kutai Barat Regency. Registration of local varieties for superior accessions needs to be done as part of the initial efforts of conservation based on legal protection. Registration of horticultural varieties is also needed to support its direct utilization through large scale plant development.

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