The Potential of Production and Characteristic of Oleoresin Tapped from *Dipterocarpus verrucosus* as Natural Ingredient for Multi Purposes

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ABSTRACT
Keruing (Dipterocarpus) is one of the Dipterocarpaceae family which produces oleoresin. Dipterocarpus species diversities will give the difference in oleoresin obtained from tapping, and its physical and chemical properties. This research aimed to determined the distribution of tapped oleoresin of D verrucosus trees in Labanan, Berau, East Kalimantan, and its physical properties identified, i.e. specific gravity and color characteristics, and chemical component analized as natural ingredients for multi-purposes. Oleoresin was produced from the *Dipterocarpus verrucosus* tree with two triangulars tapping opened at a height of ± 130 cm. Harvesting was carried out 7 days after tapping, then the tapping wound was renewed and oleoresin was harvested a second time in the following 7 days. Oleoresin specific gravity tested by using pycnometer method and oleoresin color analysis using PC vision analysis. Chemical components were identified using GC-MS method. The results showed that in Labanan, eight *D. verrucosus* trees tended to grow spread out with a diameter of more than 50 cm. The greater diameter of the *D. verrucosus* tree tended to be higher in oleoresin produced. The highest total tapping yield was on trees with a diameter of 77 cm, which amounted to 1155.53 ml. Oleoresin has a specific gravity of 1.18-1.22. According to PC vision analysis, oleoresin colored L* = 48.75, a* = 6.0, and b* = 11.75. Oleoresin contained the largest chemical component of caryophyllene 54.17%, isolongifolic acid 13.8%, α-humulene 12.07%, and caryophyllene oxide.

Keywords: *Chemical content, Dipterocarpus verrucosus, , GC-MS, Oleoresin, Tapping.*

1. INTRODUCTION

Keruing (Dipterocarpus) is one genera of Dipterocarpaceae family which has enormous potential for oleoresin as non-timber forest products [1]. Oleoresin of Dipterocarpus is a thick or semi-solid liquid with a distinctive smell obtained from tapping Dipterocarpus tree trunks. Dipterocarpus oleoresin can provide revenue for residents around the forest in Southeast Asia [2]. Traditionally, Dipterocarpus oleoresin has been used as lights, putty, and boat coatings by residents around the forest [3]. Today, Dipterocarpus oleoresin is a significant raw material for various medications [4] and is also utilized as a bio cosmetic material [5].

Each Dipterocarpus species has a specific tapping method and produces a specific oleoresin. Oleoresin has a variety of physical properties, including specific gravity and color of oleoresin. Oleoresin also has a different chemical content variation for each species [6]. For example, *D. alatus* oleoresin dominated by α-gurjune, *D. baudii* dominated by caryophyllene, and *D. dryobalanops* dominated by berginin [7].

Not all Dipterocarpus species produce oleoresin. There are 69 species of Dipterocarpus, but only 20 species of Dipterocarpus that produce oleoresin in Kalimantan, Indonesia, one of which is Dipterocarpus verrucosus [8]. *D. verrucosus* can be found in KHDTK (Special Purpose Forest Area) Labanan, Berau district, East Kalimantan province, Indonesia. Unfortunately, there are no sufficient data on the tapping and chemical content of oleoresin from the *D. verrucosus* tree. This research aimed to determine the distribution of tapped oleoresin of *D. verrucosus* trees in KHDTK Labanan, Berau, East Kalimantan, Indonesia, and its physical properties identified, i.e. specific gravity and color characteristics, as well as chemical component properties as natural ingredients for various benefits and purposes.

2. MATERIALS AND METHODS

2.1. Dipterocarpus verrucosus Trees Exploration and Distribution

The exploration was begun by searching for a *D. verrucosus* tree with a diameter at breast height of more than 50 cm in KHDTK (Special Purpose Forest Area) Labanan, Berau District, East Kalimantan, Indonesia. The trees were recorded with GPS points and measured for their total height using haga meters. GPS tree points are corrected using a global mapper. The updated GPS points were used to make treemaps using ArcGIS software.

2.2. Dipterocarpus verrucosus Oleoresin Tapping

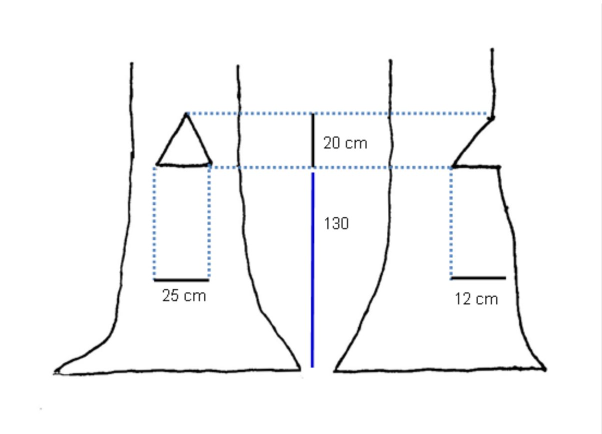


Figure 1 Oleoresin tapping opening sketch.

Making tapping openings in the *D. verrucosus* tree at tallness of ± 130 cm. Each tree is made with two tapping openings. The tapping opening is made in the shape of a triangle with a width of 25 cm, a height of 20 cm, a profundity of 12 cm with an incline of 45^0 [3]. Illustration of making tapping openings can be seen in Figure 1. Oleoresin was collected in bottles and harvested after seven days. The oleoresin collected in the bottle is then measured in volume using a measuring cup. The volume of oleoresin averaged from the two tapping openings of each tree. After seven days, the tapping openings were renewed and the catch bottles were replaced. Oleoresin was harvested after the second seven days, oleoresin was measured in volume. The yields of the two tapping times were added together to determine the total oleoresin yield and averaged to determine the production of each tapping from each tree.

2.3. Oleoresin Physicals Properties

Oleoresin specific gravity and color were tested as oleoresin physical properties. Oleoresin-specific gravity testing utilized the pycnometer method [9]. Empty pycnometer weighed. Then, the pycnometer was filled with oleoresin according to the volume and weighed. Specific gravity calculated as in Equation (1), where *W1* is the weight of empty pycnometer, *W2* is the weight of pycnometer filled with oleoresin, and *V* is the pycnometer volume.

$$Specific\ gravity = \frac{W2 - W1}{V} \quad (1)$$

Oleoresin color analysis utilized PC vision analysis [10]. Oleoresin was put into the Petri dish. Furthermore, the Petri dish is scanned. Scanning image results opened using Adobefotoshop software to see the L*, a*, and b* value.

2.4. Oleoresin Chemicals Properties

Oleoresin was dissolved in 96% ethanol with a proportion of 1:20 and tested using GC-MS to recognize the chemical components [11]. GC-MS utilized by Shimadzu QP 2010, column type is RTx-5MS (Restek Corp.) with a length of 30 m, injector and identifier temperature 250^0C, and working temperature 50-300^0C, helium carrier gas, the total retention time of one hour and chemical database NIST Library [12].

3. RESULTS AND DISCUSSIONS

3.1. Dipterocarpus verrucosus Trees Distribution

This study showed that KHDTK Labanan had eight *D. verrucosus* trees with more than 50 cm dbh. *D. verrucossus* tree distribution can be seen in Figure 2.

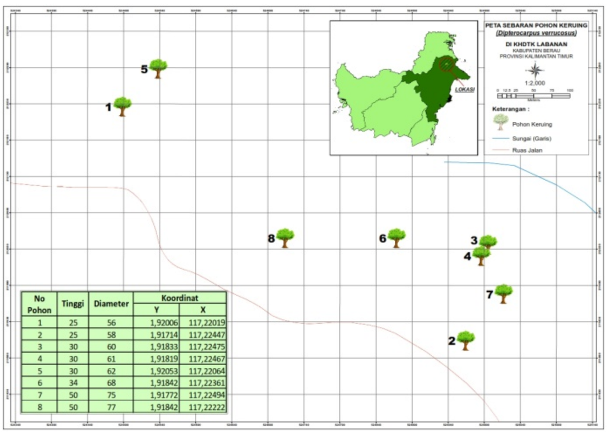


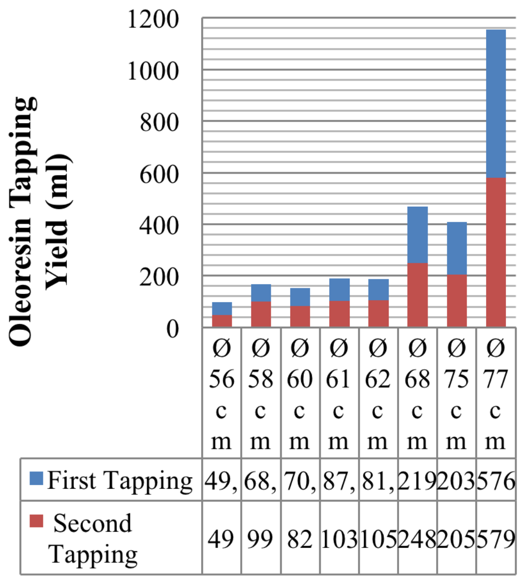
Figure 2 *D. verrucosus* trees distribution.

High precision tree maps could be produced by ArcGIS software, and the tree maps can be used to make the best decision in forest management [13]. Making treemaps with detail attribute is faster using ArcGIS compared to manual ways. From the tree maps created, *D. verrucosus* trees tend to grow independently and spread out in the forest. In general, dipterocarps tend to grow individually [14]. Most of the Dipterocarpus trees grow scattered [15]. Dipterocarpus seeds and seedlings have a lot of predators, which only large trees remain [16].

The results showed that the smallest diameter of tapped *D. verrucosus* tree was 56 cm and largest was 77 cm. Making a tapping opening into tree trunk until heartwood. In the Philippines, Dipterocarpus oleoresin tapping is carried out on trees with a minimum diameter of 40 cm at a stature between 50 cm above ground level to the first branches of trees [17]. Making tapping openings until heartwood will injure the resin channel cells in tree trunk. The resin channel cells in the injured tree trunk will produce oleoresin [18].

3.2. Dipterocarpus verrucosus Oleoresin Tapping

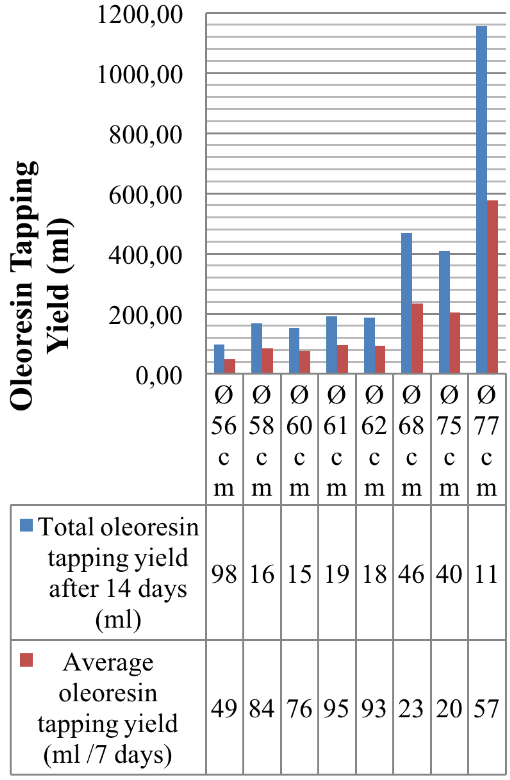
Simple and effective *D. verrucosus* tapping techniques that it reported in this study can be shown in 7 days, and 14 days harvested. The *D. verrucosus* oleoresin tapping yields can be seen in Figures 3 and 4, respectively.



	Ø 56 cm	Ø 58 cm	Ø 60 cm	Ø 61 cm	Ø 62 cm	Ø 68 cm	Ø 75 cm	Ø 77 cm
First Tapping	49,	68,	70,	87,	81,	219	203	576
Second Tapping	49	99	82	103	105	248	205	579

Figure 3 *D. verrucosus* oleoresin tapping yield.

Figure 3 shown the results of first tapping (first 7 days) produced less oleoresin than the re-tapping at second 7 days (14 days). It can be seen that larger diameter of *D. verrusosus* trees, then more higher in total yield of *D. verrucosus* oleoresin tapping.



	Ø 56 cm	Ø 58 cm	Ø 60 cm	Ø 61 cm	Ø 62 cm	Ø 68 cm	Ø 75 cm	Ø 77 cm
Total oleoresin tapping yield after 14 days (ml)	98	16	15	19	18	46	40	11
Average oleoresin tapping yield (ml /7 days)	49	84	76	95	93	23	20	57

Figure 4 Average and total yield oleoresin tapping each 7 days.

From Figure 4, the *D. verrucosus* tree with a tree diameter of 56 cm has a total yield of 98.63 ml and an average oleoresin yield of 49.32 ml / 7 days. The highest tapping yield was on trees with a diameter of 77 cm with a total tapping yield of 1155.53 ml and an average oleoresin yield of 577.77 ml / 7 days. As a comparison, the results of tapping Keruing Kipas (*Dipterocarpus spp*) origin from Dusun Benua (West Kalimantan, Indonesia) showed that Dipterocarpus trees with a diameter class of 30-39 cm produce Dipterocarpus oil 73.1 grams and diameter classes 40-49 to produce 112.18 grams [19]. The results of Dipterocarpus oleoresin tapping was affected by tree diameter [2].

3.3. Oleoresin Physicals Properties

Visually, *D. verrucosus* oleoresin is pale light brown, and opaque. Oleoresin has a milky white color and not transparent which is derived from *D. grandiflorus* species [5], and *D. gracillis* species [3]. The color characteristic of *D. verrucosus* oleoresin based on PC vision analysis can be seen in Table 1.

Observation of color by humans' eyes directly is very subjective and tends to be biased; therefore, digital image processing is utilized to produce detailed color elements [20]. Oleoresin *D. verrucosus* has an average color number of L* = 48.75, a* = 6.0, and b* = 11.75. L* if it is 0 then the object is black or has no light reflection, if

L* = 100 then the object is white or has reflected light. a* is positive means that the object tends to be red and b* is positive, the object tends to be yellow [21]. For comparison, the oleoresin of *Myristia fragrans* fruit that is dried in the sun has a yellowish red color, with values of L* 63.55, a* 13.01, and b* 28.96 [22].

Table 1. Physical properties of *D. verrucosus* oleoresin

Tree diameter (cm)	Specific gravity	Colour		
		L*	a*	b*
56	1.19	49	9	14
58	1.18	49	5	11
60	1.20	52	5	12
61	1.18	45	6	10
62	1.19	48	7	14
68	1.20	49	5	10
75	1.22	51	5	11
77	1.21	47	6	12
Average	1.20	48.75	6	11.75

From Table 1, oleoresin *D. verrucosus* has a specific gravity of 1.18-1.22. For comparison, oleoresin from *D. grandiflorus* species has a specific gravity of 0.95 [5], *Myristia fragrans* fruit oleoresin 0.453-1.417 [23], ginger oleoresin 0.891-0.916 [24], and Cinnamon bark oleoresin 1.0179 [25].

3.4. Oleoresin Chemicals Properties

D. verrucosus oleoresin GC-MS test result can be seen in Table 2.

Table 2. *D. verrucosus* oleoresin GC-MS test result

	R-time (min.)	Area (%)	Chemical compound
1	17.71	1.58	Caryophyllenol
2	18.57	0.59	5-Benzofuranacetic acid, 6-ethenyl-2,4,5,6,7,7a-hexahydro-3,6-dimethyl-.alpha.-methylene-2-oxo-, methyl ester
3	18.73	7.34	Caryophyllene oxide
4	20.38	0.83	Caryophyllene oxide
5	20.80	0.45	Caryophyllene oxide
6	21.03	54.17	Caryophyllene
7	21.66	0.53	Longipinocarveol, trans-
8	21.88	12.07	α-humulene
9	24.91	0.44	Caryophyllenol
10	25.25	1.58	Caryophyllene oxide
11	49.32	0.5	2,4a,8,8-Tetramethyldecahydrocyclopropa[d]naphthalene
12	49.36	0.52	6.beta.Bicyclo[4.3.0]nonane, 5.beta.-iodomethyl-1.beta.-isopropenyl-4.alpha.,5.alpha.-dimethyl-,
13	49.50	4.43	Squalene
14	54.07	13.8	Isolongifolic acid
15	54.85	1.17	Pinoresinol

From table 2, *D. verrucosus* oleoresin contains the largest chemical component of caryophyllene as much as 54.17%. In comparison, oleoresin *D. gracilis* contains 51.21% caryophyllene [3], oleoresin *D. grandiflorus* contains 69.14% β-bisabolene [5], and oleoresin *D. alatus* contains 30.31% α-gurjunene [26].

Caryophyllene was detected at the sixth peak, the retention time of 21.03 minutes, which has the chemical formula $C_{15}H_{24}$. Caryophyllene belongs to the terpene group [27]. Caryophyllene is also called β-caryophyllene, which has been used since 1930 in the fields of food and beauty care products, including as a food added substances, food flavoring, scent, shampoo, and various other uses [28]. β-caryophyllene has a distinctive and strong woody odor [29]. β-caryophyllene has various biological uses, including as an antioxidant, anti-tumor, anti-inflammatory, and neuroprotective agent [30].

The second most abundant compound in *D. verrucosus* oleoresin was isolongifolic acid at 13.8% which was detected at the fourteenth peak with a retention time of 54.07 minutes. Isolongifolic acid ($C_{15}H_{24}O_2$) has bioactivity as an anti-fungal [31] and an anti-termite [32]. The third-largest chemical compound detected is α-humulene, as much as 12.07% at the eighth peak at the retention time of 21.88 minutes. α-humulene ($C_{15}H_{24}$) belongs to the terpene group, one of which functions as bio-insecticide [33]. α-humulene has anti-inflammatory bioactivity [34], anti-proliferation [35], anti-bacterial and biofilm medicinal ingredients [36].

The fourth most abundant chemical compound at 7.34% was caryophyllene oxide which was detected at the third peak at the retention time of 18.73 minutes. Caryophyllene oxide ($C_{15}H_{24}O$) was also detected at the fourth peak at 0.83%, the fifth peak at 0.45%, and the tenth peak at 1.58%. The total caryophyllene oxide in *D. verrucosus* oleoresin was 10.15%. Caryophyllene oxide is also called β-caryophyllene oxide which is included in the terpene group and has anti-bacterial bioactivity [34]. Caryophyllene oxide has a distinctive woody odor and can be utilized in cosmetics, food added products [29], and an anti-allergic substance on the skin [37].

The fifth-largest chemical compound detected was squalene at the thirteenth peak, with a retention time of 49.5 minutes of 4.43%. Squalene ($C_{30}H_{50}$) belongs to the triterpene group which functions as a strong natural antioxidant [38]. Squalene is currently widely utilized in the food, cosmetic and drug industries [39]. Squalene is odorless, colorless, easy to spread, and has a low consistency so that it can be used in lipsticks, cream formulations, nail dyes and facial make-up purposes [40]. In the pharmaceutical field, squalene is used for vaccines, cancer drugs, skin disease drugs, and drugs to reduce blood lipid levels [41].

Caryophyllenol detected at two peaks, the first peak with a retention time of 17.71 minutes having an area of 1.58%, and the ninth peak with a retention time of 24.91 having an area of 0.44%. Caryophyllenol ($C_{15}H_{24}O$) is included in the sesquiterpene group which has sedative agent activity [42]. In plants, caryophyllenol helps increase growth hormone in plants [43].

At the fifteenth peak, with a retention time of 54.58 minutes, 1.17% pinoresinol compounds were detected. Pinoresinol ($C_{20}H_{22}O_6$) has various bioactivities such as antioxidants, anti-cancer, anti-inflammatory, and hepatoprotective [44]. Pinoresinol also functions as anti-leukemia and has the potential as an HIV drug [45].

At the seventh peak, with a retention time of 21.66 minutes, Longipinocarveol compounds, trans- as much as 0.53% were detected. Longipinocarveol, trans- ($C_{15}H_{24}O$) has antioxidant, anti-malaria, anti-depressant, and anti-convulsant bioactivity [46]. Anti-convulsants are drugs to restore the stability of nerve cell stimulation [47].

In KHDTK (Special Purpose Forest Area) Labanan, Berau district, East Kalimantan, Indonesia, eight *Dipterocarpus verrucosus* trees were found which tend to grow individually and are scattered in the forest. *D. verrucosus* trees that produce oleoresin from the smallest diameter of 56 cm to the largest is 77 cm. The highest tapping yield was on trees with a diameter of 77 cm with a total tapping yield of 1155.53 ml and an average oleoresin yield of 577.77 ml / 7 days. This study demonstrated that the larger of *D. verrucosus* tree diameter might improve oleoresin obtained from the tapping process. This proved that tree diameter is one of the most influential factors on oleoresin tapping.

The color characteristic of *D. verrucosus* oleoresin based on PC vision analysis showed that *D. verrucosus* oleoresin is pale light brown, and opaque. Oleoresin has a milky white color and not transparent which is derived from others species. Meanwhile, *D. verrucosus* oleoresin through GC-MS analysis showed that it contained the largest chemical component of caryophyllene, and others important chemical components. However, all of these chemical components are natural ingredients with various bioactivities that can be used as basic ingredients in the food, cosmetic, and drug (pharmaceutical) industries.

AUTHORS' CONTRIBUTIONS

All authors had the same contribution in this paper.

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