GC-MS analysis of essential oil of Kayu Papi (Exocarpus latifolius R. Br., Fam: Santalacea from East Nusa Tenggara

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Abstract. Exocarpus latifolius R.Br. known as Kayu Papi or shrub sandalwood, naturally occurred in East Nusa Tenggara. This species classified as fragrant wood and, on some occasions, has become sandalwood (Santalum album Linn) substitution. This species is beneficial as a medicine. A recent study indicated that Exocarpic acid isolated from Papua New Guinea origin empirically cures tuberculosis in the in vitro treatments. However, the study of the biological compound of this species from the region is little known. This research is aimed at elucidating chemical compounds in the Kayu Papi wood originating from East Nusa Tenggara. The method was using GCMS analysis of the essential oil through prior steam distillation. The result revealed that thirty-two compounds represent 99.94% of essential oils, with six major peaks in approximately 41 minutes’ retention in total. The six-dominant compound of oils were Benzeneethanamine, alpha-methyl-N-(phenyl methylene) 34.37%, Alpha-curcumen (14.05%), Tridecan, 2-methyl-2-phenyl (11.2%), Alpha-calacorene (6.40 %), Levomethamphetamine (4.46%), Benzene, (1-1-dimethylnonyl) (4.11%). Whereas the twenty-six remaining components were less than and just over 3% each. There was no exocarpic acid identified, but some compounds are identical to sandalwood or other fragrant wood. The study may complement Santalacea’s list of chemical compounds to distinguish sandalwood and other fragrant wood.

1. Introduction

Exocarpus latifolius R.Br. belongs to the Santalaceae family knows as kayu papi or shrub sandalwood. Kayu papi categorised as a minor fragrant wood, spreading naturally from Philippine, Indonesia, Australia, and Papua New Guinea (PNG) [1]. This species is a small tree up to 0.5 m in diameter and 10-20 m in tall, evergreen, drought resistant and adaptable growth in sandy soil at low altitude [1,2]. In Timor islands, East Nusa Tenggara, kayu papi naturally occurred at an altitude between 100-1200 m above sea level in loamy sand to sandy clay loam soil [3]. Kayu papi has many similarities with sandalwood (Santalum album Linn.), in terms of odour [4] and anatomical wood characteristics [5]. On some occasions, kayu papi can be used as a substitute for sandalwood or a mixture of sandalwood [1,3,6,7]. Thus, kayu papi considered as a high economic value wood. Since the nineties, where the demand for sandalwood has still high, but the production of sandalwood has decreased due to excessive
exploitation, the demand of *kayu papi* became increased [6,7]. Based on the results of a habitat survey of *kayu papi* on the Timor island in 2012 found that the practices of exploitation of *kayu papi* wood without compensating for conservation and cultivation efforts led to the threat of the existences of *kayu papi* in their natural habitat [3].

Moreover, *kayu papi* (*E. latifolius*) contains some active compounds that are useful as medicines. Recent studies showed that Exocarpic acid (*E-octadeca-13-ene-9, 11-diynoic-acid*) isolated from *E. latifolius* is a major active anti-mycobacterial compound that empirically cures tuberculosis [2,8-10]. Other studies also indicated some active compounds extracted from other *Exocarpus* species such as natural anti-oxidant and free radical scavenging activity in *E. longifolius* [11]; anti-bacterial and anti-inflammatory in *E. aphyllus* [12]; the acetylenic fatty acids that useful for pharmaceutical properties in the oils of *E. cupressiformis* [13].

Supply chain survey found that *kayu papi* traded together with other luxurious wood such as sandalwood and agarwood to fulfill market of fragrant wood and essential oil, locally and globally (survey). While *kayu papi*’s production from East Nusa Tenggara in 2014 outnumbered sandalwood at 276.8 m³ compared to 26.1 m³ [14], however, *kayu papi*’s production was missing in 2019 but sandalwood remained at 859.1 m³ [15]. In light of the importance of *kayu papi* as commercially fragrant wood products and potential medicinal ingredients, requires further research. Studies on ethnobotany, phytochemistry, and silvicultural aspects of this species remain few investigated. Therefore, this research is aimed at elucidating chemical compounds in the *kayu papi* wood originating from East Nusa Tenggara, Indonesia. The results of this study are expected to enhance the information regarding the content of active compounds in *kayu papi* and its potential use for medicine or other products.

2. Method

2.1. Plant Material
The wood of *Kayu papi* (*Exocarpus latifolius* R.Br) was collected from South Central Timor Regency, East Nusa Tenggara, Indonesia in 2014. The plant material was air-dried and stored at ambient temperature before extraction and analysis.

2.2. Sample Preparation and Extraction
The 3 kg of *kayu papi* wood were cleaned, chopped into small pieces and dried to produce 1.5 kg of dry wood chips. The 1.5 kg of dry wood chips were extracted by hydro-distillation (water-steam distillation) with a temperature of 100°C for 8 hours. The oil was dried over anhydrous sodium sulphate, kept in labelled bottles, and stored in the fridge before being analysed.

2.3. Gas Chromatography-Mass Spectrometry (GC-MS) Analysis
The sample was diluted with *diethy ether* (20µL in 1 mL). The sample injection volume was with a split ratio of 1:50. The sample was analysed by GC-MS QP2010S with HP-5 ms fused silica capillary column (30m x 0.25mm with a film thickness of 1.0 µm). The oil was analysed using GC-MS with a retention time of 60 minutes. The column temperatures were set at 70°C - 270°C for the injection, and helium was used as a carrier gas and ionizing EL 70 eV. The MS system was operated in scan mode with a mass range 50-800 m/z. The relative percentages of *kayu papi* oil were calculated from peaks total area in the chromatogram and chemical compound identified by comparing mass spectra and retention time with database Wiley 299 Library.

3. Result and Discussion
The gas chromatogram-mass spectrometry analysis of *kayu papi* oil was presented in Fig. 1. There were thirty-two identified compounds representing roughly 99.94% of *kayu papi* oil (table. 1). Among thirty-two compounds, there were six dominant peaks in nearly 41 minutes’ retention time in total. The six major compounds that have a quantity of more than 4%, namely Benzeneethanamine, *alpha*-methyl-*N*-(phenyl methylene) 34.37%, *Alpha*-curcumen (14.05%), Tridecane, 2-methyl-2-phenyl (11.2%), *Alpha*-

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calacorene (6.40 %), Levomethamphetamine (4.46 %), Benzene, (1-1-dimethylnonyl) (4.11 %). Whereas, the twenty-six other compounds were in small quantities.

| Number | Compounds                        | Retention time (min) | Molecular Formula | Area (%) |
|--------|----------------------------------|----------------------|-------------------|---------|
| 1      | Isopropylbenzene                 | 10.564               | C₈H₁₂             | 0.65    |
| 2      | Para cymene                      | 12.757               | C₁₀H₁₄            | 0.91    |
| 3      | D-limonene                       | 12.920               | C₁₀H₁₆            | 1.58    |
| 4      | Alpha, 4-dimethylstyrène         | 15.092               | C₁₀H₁₂            | 1.01    |
| 5      | 2-(4′-methylphenyl)-propanal     | 15.782               | C₁₀H₁₅O           | 0.20    |
| 6      | Benzene, (1-1-dimethylnonyl)     | 23.420               | C₁₇H₂₈            | 4.11    |
| 7      | 2,3-dibromo-8-phenyl-p-methane   | 24.408               | C₁₆H₂₂            | 0.23    |
| 8      | p-cymene                         | 24.597               | C₁₀H₁₄            | 0.31    |
| 9      | Isopropenyltoluene               | 25.064               | C₁₀H₁₂            | 0.68    |
| 10     | 2,3-dibromo-8-phenyl-p-methane   | 25.716               | C₁₀H₂₂            | 0.61    |
| 11     | Alpha-bergamotene                | 25.942               | C₁₅H₂₄            | 0.26    |
| 12     | Curcumene                        | 26.847               | C₁₅H₂₂            | 2.00    |
| 13     | Alpha-curcumene                  | 27.231               | C₁₅H₂₂            | 14.05   |
| 14     | 1-phenyl-2-(P-Tolyl)-propane     | 27.799               | C₁₅H₁₈            | 3.20    |
| 15     | Alpha-calacore                    | 27.885               | C₁₅H₂₀            | 6.40    |
| 16     | Zingiberene                      | 28.142               | C₁₅H₂₄            | 0.49    |
| 17     | 4-isopropenyl-1-methylbenzene    | 28.980               | C₁₀H₁₂            | 0.16    |
| 18     | 4,5,9,10-dehydro-isolongifolene  | 29.103               | C₁₅H₂₀            | 0.49    |
| 19     | 4,5,9,10-dehydro-isolongifolene  | 29.557               | C₁₅H₂₀            | 2.14    |
| 20     | Methyl 9-o xo stearate            | 29.742               | C₁₉H₃₆O₂          | 0.38    |
| 21     | Tridecane, 2-methyl-2-phenyl     | 30.076               | C₂₀H₃₄            | 11.2    |
| 22     | Benzeneethanamine, alpha-methyl-| 30.755               | C₁₂H₁₇N           | 34.37   |
|        | N-(phenylmethylene)              |                      |                   |         |
| 23     | 1-phenylcyclo pentylamine        | 31.253               | C₁₅H₁₅N          | 0.41    |
| 24     | Retinol acetate                  | 31.385               | C₂₀H₃₂O₂         | 2.21    |
| 25     | d-Nerolidol                      | 31.863               | C₁₅H₂₆O          | 0.50    |
| 26     | Beta-Bisabolol                   | 32.122               | C₁₅H₂₆O          | 0.96    |
| 27     | (R)-Cuparene                     | 32.250               | C₁₅H₂₂            | 1.27    |
| 28     | Cadalene                         | 32.392               | C₁₅H₁₈            | 1.60    |
| 29     | Levomethamphetamine              | 32.519               | C₁₉H₁₅N          | 4.46    |
| 30     | 3-phenyldecan-3-ol               | 32.804               | C₁₆H₂₅O          | 0.71    |
| 31     | Butyric acid, 2-methyl-4-(2,5-xy l) | 32.925               | C₁₃H₁₈O₂          | 0.27    |
| 32     | Dodecanolic acid, (2,2-dimethyl-1,3-dioxolan-4-y1) methyl ester | 40.608 | C₁₅H₃₂O₄ | 2.12 |
| Total Identified (%) |                        |                      |                   | 99.94   |

Based on the GC-MS analysis of kayu papi oil, there was no exocarpic acid compound detected. These results are different from previous studies which found exocarpic acid in the stem extract of E. latifolius origins Papua New Guinea (PNG), which acts as an anti-micro bacterial active against tuberculosis [2,8]. Exocarpic acid also identified in other Exocarpus species from Australia, e.g. eighty nine percent exocarpic acid in the oil root of E. cupressiformis and E. stricta [16] and the bark oil of E. aphyllus [12]. Undetected exocarpic acid in this study was probably due to the internal factors (genetic, the plant age, the physiology of plant); the environment or external factors (temperature, sunlight,
geography, water availability/rainfall, ecology of plant); also, the different extraction and analysis methods [17-19].

Similarly, the study on the GS-MS analysis of leaves and twigs extract of *E. longifolius* native to West Nusa Tenggara, also showed the absence of *exocarpic acid* compound [11]. Although in that study stated that *E. longifolius* not contain *exocarpic acid*, but it identified other chemical compounds that have the potential as a powerful natural antioxidant [11]. Likewise, in this study, among the thirty-two compounds identified in *kayu papi* (*E. latifolius*) oil by GCMS, several compounds have been revealed in previous studies of their biological activities.

Based on the literature review, three of the six dominant compounds identified in *kayu papi* oil have been known to have medicinal properties, e.g. *Alpha-curcumen, Alpha-calacorene* and *Levomethamphetamine*. *Alpha-curcumen*, including sesquiterpenes family [20] which is mostly contained in ginger (*Zingiber officiale*) rhizomes [21,22] and Curcuma xanthorrhiza [17]. This compound is useful as an antioxidant [21] and anti-mycobacterium [22]. *Alpha-calacorene* was forming about 4% in the *Teucrium montanum* essential oil which has anti-fungal and anti-bacterial effects [23]. Whereas, *Levomethamphetamine* with *dextromethamphetamine* are two chemical compounds that formed the Methamphetamine drug for the first time in 1893. It is used to treat a nasal decongestant and bronchial inhalers [24,25].

Furthermore, there were twenty-six remaining compounds in *kayu papi* oil in small amounts, some of them were also reported to be found in other species and have biological activities that are useful for medicinal properties. These prevalent small quantities compounds in *kayu papi* oil were *Retinol acetate* (2.21%), *Curcumene* (2%), *D-limonene* (1.58%), *(R)-Cuparene* (1.27%), *Beta-Bisabolol* (0.96%), *Isopropylbenzene* (0.65%), *d-Nerolidol* (0.50%), *Zingiberene* (0.49%), *Para cymene* in minute 12.76 and *p-cymene* in minute 24.59 determining 0.91% and 0.31% respectively, and *Alpha-bergamotene* (0.26%).

*Retinol acetate* is a natural compound that exhibiting the function of vitamin A. Besides being essential in fulfilling nutrients to overcome vitamin A deficiency, this compound is important in pharmacological fields for anti-cancer and dermatological applications [26,27]. *Curcumene* and *Zingeberene*, along with *Alpha-curcumen* performs as an antioxidant and antibacterial [17,21,22], further *Zingeberene* inhibits cancer cells growth [28]. *D-limonene* has biological activities widely, involving anti-diabetic [29], anti-carcinogenic, anti-oxidant, and anti-inflammatory effects [30]. *Isopropylbenzene* (cumene) is also identified in *Cuminum cyminum, Cinnamomum verum, and Zingiber officinal* [31]. Studies reported that although Isopropyl Benzene (cumene) is not a dominant compound

![Figure 1. GC-MS chromatogram of *E. latifolius* oils.](image-url)
in *Cuminum cyminum*, it has antifungal and antibacterial activities [32-35]. *P-cymene* as anti-fungal [36,37], anti-oxidant [38] and anti-bacterial effects [39].

Meanwhile, other minor compounds identified in *kayu papi* oil also detected in other species in small quantity, have biological activities. There were (R)-*Cuparene* has anti-bacterial and anti-tumour activities [40]; *Beta-Bisabolol* also shows anti-oxidant and anti-bacterial activities [41,42]; *d-Nerolidol* has anti-virulence activities [43]; and *Alpha-bergamotene* as anti-inflammatory and anti-oxidant [44,45]. Furthermore, several compounds in *Exocarpus latifolius*, also present in the other plants which are often used as sandalwood substitution or fake sandalwood. For instance, *Isolongifolene* (2.14%) usually used as an agent or synthetic fragrance, also present in *Osyris lanceolata* (Fam. Santalaceae) or African sandalwood at a minor concentration [48]. Also, *a-curcumene* that presence in *E. latifolius* at 14% was a minor component of sandalwood (*Santalum album*) at less than 1% [48].

4. Conclusion

In conclusion, there were thirty-two compound identified in *kayu papi* (*Exocarpus latifolius*) oil origin East Nusa Tenggara. However, there were no *exocarpic acid* compounds in the GCMS chromatogram, among the 32 compounds identified, most of them have biological activities that are useful for medicinal properties such as antioxidant, anti-cancer, anti-microbial, anti-fungal, anti-inflammatory and anti-viruses. Thus, future research needs to be undertaken to isolate its pharmacological profile from *E. latifolius*. There was no *exocarpic acid* identified through GC MS analysis, but some compounds are identical to sandalwood or other plants that used as sandalwood substitution which often so-called fake sandalwood.

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