DISTRIBUTION AND COMPOSITION OF THE MAIN ACTIVE COMPONENTS FOUND IN STINGLESS BEE PROPOLIS FROM VARIOUS REGIONS IN INDONESIA

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ABSTRACT

Objective: The aim of this study is to map out the distribution and composition of the main active components found in stingless bee propolis from various regions in Indonesia.

Methods: The stingless bee propolis used was obtained from ten different provinces in Indonesia and the active components analysis using Gas Chromatography-Mass Spectrometer (GC-MS) pyrolyzer.

Results: This study found 85 main types of active components with concentrations ≥1%. The most frequently found active component was alpha-d-glucopyranoside, which had an average concentration of 28.20%.

Conclusion: There were differences between the main active components found in 14 samples of stingless bee propolis obtained from 10 provinces in Indonesia, which was due to the variety of bee species and plant origin.

Keywords: Active components, Concentration, Distribution, Plant resin, Stingless bee propolis

INTRODUCTION

Bees are one of Indonesia’s fauna that can be used for many advantages. Species of bees are divided into two main types: stingless bees and stinging bees. Indonesia has approximately 46 stingless bee species spread around Sumatra and Borneo [1]. The 12 species commonly found are the Heterotrigona itama (H. itama), Geniotrigona thoracica (G. thoracica), T. apicalis, T. terminata, T. respani, T. melanocephala, T. valdezi, T. collaris, T. atropipes, T. canifrons, T. iridepennis, and T. laeviceps [2].

Most stingless bee species have the potential to cultivate and produce high-quality propolis in large quantities, as much as 2,243 tons per 4 mo or 6,729 tons per year [3]. Propolis is a mixture of resin substances (plant sap), gum tree bark, and shoots of plants which are collected by bees, mixed with beeswax and bees saliva [4]. Propolis can strengthen the structural stability of bees hive to prevent decomposing of the inside. Currently, propolis is mainly used in the health industry as an anti-inflammatory and antibacterial treatment and also as antioxidant serum [5]. Stingless bee propolis can provide health benefits including the prevention and treatments of diseases and consumed in prescribed dosage [6, 7]. Propolis has more than 300 different active components [8], with polyphenols (flavonoid, phenolic acid, and ester) as the main active components found in propolis, which are known to have antibacterial and antioxidiant activities [9].

There are plenty of unidentified active components in stingless bee propolis due to various geographic locations, plant resins, and bees species [10]. Therefore, it is essential to discover the distribution and composition of the main active components found in stingless bee propolis from different regions in Indonesia.

MATERIALS AND METHODS

Materials

The stingless bee propolis used were obtained from 10 different provinces in Indonesia, namely Tetragonula minangkabau and Sundastrigona moorei from North Sumatra, Tetragonula laeviceps from Banten, Tetragonula laeviceps from West Java, Tetragonula laeviceps from Central Java, Heterotrigona itama from West Borneo, Heterotrigona itama from East Borneo, Heterotrigona itama, Geniotrigona thoracica, Tetragonula laeviceps from South Borneo, Wollastrigona incisa and Tetragonula biroi from South Sulawesi, Tetragonula fuscoablatea from West Nusa Tenggara, and Tetragonula fuscoablatea from North Maluku. These bees were harvested by bee farmers and delivered to Jatinangor, Sumedang. Materials for extraction and GC-MS Analysis, such as alcohol, ethanol, paraffin were obtained from Sigma-Aldrich, USA. Propylene glycol was obtained from Merck, USA.

Propolis extraction

The first step was mixing 1 kg of raw propolis (still in the process of glass transition) with ethanol 70% at a ratio of 1:2.5 (propolis: ethanol). Then, propolis was mashed into propolis pulp and filtered using a 30-mesh filter before being left for 12 h. The filtrate was separated while the rest of the propolis pulp was mixed with ethanol 70% at a ratio of 1:1.5 (propolis: ethanol), which was repeated 3 times. Afterward, the filtrate was condensed using a rotary evaporator at a maximum temperature of 50 °C, which was preceded until the color of propolis extract turned dark brown, then it was mixed with propylene glycol and filtered using Whatmann 50 filter paper.

GC-MS analysis

This study used the GC-MS QP equipped with pyrolyzer, with the oven temperature set at 50 °C for 5 min, then raised up to 280 °C, with a pressure of 101 kPa, column flow 0.85 ml/min. MS detector was set at ion source temperature (200 °C), interface temperature 280 °C, detector temperature 280 °C, pyrolyser temperature 300 °C. When stable, 1 μg/1 drop liquid propolis was injected into the pyrolyzer, and GC-MS started to operate for 50 min.
RESULTS AND DISCUSSION

Distribution and composition of main active components of stingless bee propolis

The study found 85 types of main active components with concentrations of ≥ 1% in 14 propolis samples obtained from 10 provinces in Indonesia. Table 1 shows alpha d-glucopyranoside as the most frequently found substance, which was observed in 8 different propolis samples: *H. itama* from East Borneo, *H. itama, T. laeviceps*, and *G. thorascia* from South Borneo, *W. incisa* and *T. biroi* from South Sulawesi, *T. fuscobalteata* from West Nusa Tenggara, and *T. fuscobalteata* from North Maluku. This finding aligns with a previous study which found alpha d-glucopyranoside as the sugar component in propolis [11].

Table 1: Main active components of stingless bee propolis

| No. | Name of components | Province/Species | Avera ge | Regio ns |
|-----|--------------------|-----------------|---------|---------|
| 1   | Formamide          |                 | 8.26    | 3.11    | 5.69 | 2 |
| 2   | Limonene           |                 | 4.09    | 2.85    | 1.16 | 1 |
| 3   | 2,3 butanedione    |                 | 5.17    | 1.62    | 1.07 | 1 |
| 4   | 2 methyl furan    |                 | 9.48    | 1.18    | 7.17 | 4 |
| 5   | Acetoin            |                 | 9.48    | 1.18    | 7.17 | 4 |
| 6   | Acetic acid        |                 | 1.18    | 1.18    | 7.17 | 4 |
| 7   | Carbamic acid      |                 | 1.18    | 1.18    | 7.17 | 4 |
| 8   | Methoxymethyl acetate |                 | 1.18    | 1.18    | 7.17 | 4 |
| 9   | 2 propanone        |                 | 1.18    | 1.18    | 7.17 | 4 |
| 10  | Propanal/Pyrvaldehyde |               | 1.18    | 1.18    | 7.17 | 4 |
| 11  | Propanoic acid     |                 | 1.18    | 1.18    | 7.17 | 4 |
| 12  | Butanone           |                 | 1.18    | 1.18    | 7.17 | 4 |
| 13  | 2,3 Dimethylenebutane 1,4 diaceta te | | 1.18 | 1.18 | 7.17 | 4 |
| 14  | Cyclobutabenzenes |                 | 1.18    | 1.18    | 7.17 | 4 |
| 15  | Cyclopentanone     |                 | 1.18    | 1.18    | 7.17 | 4 |
| 16  | Cyclopentene       |                 | 1.18    | 1.18    | 7.17 | 4 |
| 17  | Cyclohexanone      |                 | 1.18    | 1.18    | 7.17 | 4 |
| 18  | Isoosorbid        |                 | 1.18    | 1.18    | 7.17 | 4 |
| 19  | Hydroquinone       |                 | 1.18    | 1.18    | 7.17 | 4 |
| 20  | Cyclohexane        |                 | 1.18    | 1.18    | 7.17 | 4 |
| 21  | Methylpyrazine     |                 | 1.18    | 1.18    | 7.17 | 4 |
| 22  | Dodecanone         |                 | 1.18    | 1.18    | 7.17 | 4 |
| 23  | Dodecanoic acid    |                 | 1.18    | 1.18    | 7.17 | 4 |
| 24  | Dodecanoic acid/lauric acid | | 1.18 | 1.18 | 7.17 | 4 |
| 25  | N-(2-hydroxyethyl) dodecanamide | | 1.18 | 1.18 | 7.17 | 4 |
| 26  | Tetradecanoic acid/Myristic acid | | 1.18 | 1.18 | 7.17 | 4 |
| 27  | Tetraacanoic acid  |                 | 1.18    | 1.18    | 7.17 | 4 |
| 28  | Tetracontane       |                 | 1.18    | 1.18    | 7.17 | 4 |
| 29  | Octadecanoic acid  |                 | 1.18    | 1.18    | 7.17 | 4 |
| 30  | Undecanoic acid    |                 | 1.18    | 1.18    | 7.17 | 4 |
| 31  | Pentadecanoic acid |                 | 1.18    | 1.18    | 7.17 | 4 |
| 32  | Octanoic acid      |                 | 1.18    | 1.18    | 7.17 | 4 |
| 33  | Undecadecanoic acid |                 | 1.18    | 1.18    | 7.17 | 4 |
| 34  | Hexadecanoic acid  |                 | 1.18    | 1.18    | 7.17 | 4 |
| 35  | Hexadecanoic acid |                 | 1.18    | 1.18    | 7.17 | 4 |
| 36  | Hexanoic acid butyl ester | | 1.18 | 1.18 | 7.17 | 4 |
| 37  | Tricosanoic acid   |                 | 1.18    | 1.18    | 7.17 | 4 |
| 38  | Oxalic acid        |                 | 1.18    | 1.18    | 7.17 | 4 |
| 39  | Acetol             |                 | 1.18    | 1.18    | 7.17 | 4 |
| 40  | Oxiraneundecanoic acid | | 1.18 | 1.18 | 7.17 | 4 |
| 41  | 1,6 anhydro beta d |                 | 1.18    | 1.18    | 7.17 | 4 |
| 42  | Nondecane          |                 | 1.18    | 1.18    | 7.17 | 4 |
| 43  | 1,4 Anhydro d mannitol |            | 1.18    | 1.18    | 7.17 | 4 |
| 44  | Citronella         |                 | 1.18    | 1.18    | 7.17 | 4 |
| 45  | Alpha D            |                 | 1.18    | 1.18    | 7.17 | 4 |
| 46  | Glucopyranoside    |                 | 1.18    | 1.18    | 7.17 | 4 |
| 47  | Alpha L            |                 | 1.18    | 1.18    | 7.17 | 4 |
| 48  | Mannoturanoside    |                 | 1.18    | 1.18    | 7.17 | 4 |
| 49  | Ionisol            |                 | 1.18    | 1.18    | 7.17 | 4 |
| 50  | Styrene oxide      |                 | 1.18    | 1.18    | 7.17 | 4 |
| 51  | Isopentane         |                 | 1.18    | 1.18    | 7.17 | 4 |
| 52  | Ditryl L2          |                 | 1.18    | 1.18    | 7.17 | 4 |
| 53  | Diisopropyl diacetate |             | 1.18    | 1.18    | 7.17 | 4 |
| 54  | 1,2,4 tri acetyl di methyltribitol | | 1.18 | 1.18 | 7.17 | 4 |
| 55  | Methylisobutythioanilide | | 1.18 | 1.18 | 7.17 | 4 |
Every bee species has its own plant source based on its region; thus the active propolis component varies. The variety is caused by the every bee species has its own plant source based on its region; thus the active propolis component varies. The variety is caused by the place of origin and the climatic conditions. The active components of stingless bee propolis are influenced by the raw materials utilized by the stingless bees. For example, a study conducted by Mahani et al. (2017) identified a total of 85 active compounds in the propolis samples collected from various regions in Indonesia, with the highest concentration of 77.84% found in Bantul, Central Java. The study also found that the active components of stingless bee propolis vary depending on the region and the species of the bees. For instance, the propolis from T. laeviceps and T. biroi contained different active compounds, with T. laeviceps having a higher concentration of active compounds than T. biroi. The active components of stingless bee propolis are important for their medicinal properties, which include anti-inflammatory, antioxidant, anti-microbial, and anti-cancer activities. Therefore, the study by Mahani et al. (2017) highlights the potential of stingless bee propolis as a source of natural compounds with therapeutic potential.
was from mango plant; this was due to the high flavonoid content in

| No. | Province         | Type of stingless bee | Number of active components | Plant origin                                                                 |
|-----|------------------|-----------------------|-----------------------------|------------------------------------------------------------------------------|
| 1   | North Sumatra    | T. minangkabau        | 14 components               | Mangifera indica, Artocarpus heterophyllus, Durio zibethinus, Masa paradisiaca L. |
| 2   | Banten           | T. laeviceps          | 17 components               | Coffeea, Anacardium occidentale, Durio zibethinus, Gnetum gnetom, Saccharum, Nephelium lappaceum, Avverhoa carambola, Artocarpus heterophyllus, Anonna muricata, Cocos nucifera, Mangifera indica, Garcinia mangostana, Theobroma cacao, Swietenia madagasi, Tectona grandis, Garcinia mangostana, Artocarpus heterophyllus, Amaranthus spinosus |
| 3   | West Java        | T. laeviceps          | 8 components                | Mystica Pragrans, Garcinia mangostana, Artocarpus heterophyllus, Swietenia madagasi, Tectona grandis, Garcinia mangostana, Artocarpus heterophyllus, Amaranthus spinosus |
| 4   | Central Java     | T. laeviceps          | 9 components                | Swietenia madagasi, Tectona grandis, Garcinia mangostana, Artocarpus heterophyllus, Amaranthus spinosus |
| 5   | West Borneo      | H. itama              | 4 components                | Hevea brasiliensis |
| 6   | East Borneo      | H. itama              | 6 components                | Mangifera indica, Artocarpus heterophyllus, Durio zibethinus, Masa paradisiaca L. |
| 7   | South Borneo     | T. laeviceps          | 6 components                | Mangifera indica, Artocarpus heterophyllus, Durio zibethinus, Masa paradisiaca L. |
| 8   | South Sulawesi   | W. incisa             | 7 components                | Manihot glaziovii, Garcinia mangostana, Mangifera indica, Artocarpus heterophyllus, Artocarpus heterophyllus, Durio zibethinus, Citrus maxima, Masa paradisiaca L, Ricinus communis |
| 9   | West Nusa Tenggara | T. fuscohalteata      | 14 components               | Manihot glaziovii, Garcinia mangostana, Manihot glaziovii, Swietenia madagasi, Tectona grandis, Garcinia mangostana, Artocarpus heterophyllus, |
| 10  | North Makiku     | T. fuscohalteata      | 6 components                | Myristica fragrans, Syzygium aromaticum, Manihot glaziovii, Tectona grandis, Garcinia mangostana, Artocarpus heterophyllus, |

Based on table 2, the most frequent plant origin found in Indonesia was from mango plant; this was due to the high flavonoid content in the plant and its bark [19]. The other plants origin were Persea americana, Acacia, Michelia champaca, Artocarpus integer, Erythrina variegata, Agathis dammara, Ricinus communis, Archidendron pauciflorum, Citrus maxima, Citrus limon, Theobroma cacao, Hevea brasiliensis, Mangifera odorata, Manihot glaziovii, Garcinia mangostana, Cordyline fruticos, Leucaena leucocephala, Michelia champaca, Albizia chinensis, Artocarpus altiss, Baccacrea racemosa, Dillenia, Manihot glaziovii, Annona muricata, etc. [20]. The difference of plants origin aligns with a study which proved the active propolis components were affected by the plants origin [21]. The higher resins in the plant, the stronger biological activity in the propolis.

### Biological activities of the main active components in stingless bee propolis

Active components in stingless bee propolis have the potential to be further developed in Indonesia’s healthcare sector. Based on the GC-MS analysis and library, there were 16 main active components with different biological activities (table 3).
Details:
1) North Sumatra Tetragonaun minangkabau, 2) North Sumatra Sundatrigona moorei, 3) Banten T. laeviceps, 4) West Java T. laeviceps, 5) Central Java T. laeviceps, 6) West Borneo Heterotrigona itama, 7) East Borneo H. itama, 8) South Borneo H. itama, 9) South Borneo T. laeviceps, 10) South Borneo Geniotrigona thoracica, 11) South Sulawesi Wallacetrigona incisa, 12) South Sulawesi T. biroi, 13) West Nusa Tenggara T. fuscobalteata, 14) North Maluku T. fuscobalteata.

Based on table 3, the biological activities of the active components found were very diverse and complex. The main active component was the glycoside derivate alpha-D-glucopyranoside, which is a flavonoid compound. The role of this component is to inhibit bacterial DNA synthesis [37], inhibit receptor signals, neutralize micro-toxin, and inhibit virulent factor secretion [38]. Another advantage of alpha-D-glucopyranoside is its ability to act as an antiemetic substance by reducing gastrointestinal hyperactivity. In a previous study, which was conducted by giving vomiting agents to chicks, flavonoid compounds showed an effect of reduction of the stomach’s excessive movement [39].

One of the components which act as an immunostimulator is 1,6-Anhydro-Beta-D-Glucopyranose, which functions as an immune system inducer to increase T cells, which will release granules to hydrolyze the Mycobacterium tuberculosis (M. tuberculosis) cell wall [27]. This component is also hepatoprotective, which means it can protect the liver from the toxic effect of antibiotics drugs and maintain the liver’s function, which in turn will result in the maintenance of appetite. The main two active components, alpha-D-glucopyranoside and 1,6-Anhydro-Beta-D-Glucopyranose, act as antioxidants which can reduce the radical compound 2,2-diphenyl-1-pircilylhydrazyl (DPPH) [24].

Tetradecanoic acid and hexadecanoic acid are long-chain fatty acid compounds, an essential oil that works by damaging bacterial cell membranes [37]. Both of these components can also reduce the radical compound 2,2-diphenyl-1-pircilylhydrazyl (DPPH) [40]. The component of dodecanoic acid/lauric acid acts as an antibacterial, which has more antibacterial effects on gram-positive bacteria compared to gram-negative bacteria [29].

2-methyl-furanocarboxaldehyde has the ability to be anti diabetic, which was proven in a previous study by screening 2.4 derivatives of substitution of furan for its anti diabetic activity and compared it to standard Acarbose drugs (diabetes medications). The result showed that most of the active components were equal to those of Acarbose drugs [13]. Cycloartenol is found in Brazilian red propolis, which has been identified as having antibacterial, antymycotic, and antiradical activities, independently of its plant origin and chemical composition. Plenty of studies have shown that propolis has antimicrobial and antioxidant activities due to the role of stingless bee in the hive, which uses these active components to protect themselves against pathogenic microorganisms and weather elements [34].

The component octadecatrienoic acid, the main component of Bauhinia purpurea leaf extract, has shown the presence of antibacterial activity against two gram-positive bacteria (S. aureus and B. subtilis) and also has the potential to be used in the treatment of infectious diseases caused by microorganisms resistant to commercial antibiotic drugs [35].

The biological activities of some active components identified, namely the Hexanoic acid butyl ester and Acetoin, has yet to be known.

CONCLUSION
In this study, each of the 14 stingless bee propolis samples from 10 provinces in Indonesia had different main active components. The differences of the propolis LTS samples were caused by the variety of bee species and plant resins. The most frequently found active component was alpha-D-glucopyranoside, with an average concentration of 28.20%. The component can be utilized for its antimicrobial, antibacterial, hepatoprotective, and antifungal activities.

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AUTHORS CONTRIBUTIONS
All the authors have contributed equally.

CONFLICT OF INTERESTS
The authors declare no conflict of interest associated with this study.

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