Physicochemical properties of honey produced by the Indonesian stingless bee: *Tetragonula laeviceps*

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Abstract. The present study was undertaken to evaluate the physicochemical properties of honey produced by the Indonesian stingless bee: *Tetragonula laeviceps*. Sample of honey was obtained from three meliponiculture origins: Faculty of Animal Science Universitas Gadjah Mada (UGM), Gunungkidul (Yogyakarta) and Klaten (Central Java) and analysed for physical (flavour) and chemical properties including water content, dry matter (DM), ash, fat, protein, carbohydrate, and organic matter. The electrical conductivity (EC) was determined by the equation of \( EC = 0.14 + 1.74 \times A \) (\( A \) = ash content). Data were statistically analysed using one-way analysis of variance followed by honestly significant difference test. The results showed that the flavour of honey from the Faculty of Animal Science UGM and Klaten were sweet and those from Gunungkidul were bitter. The results showed that the geographical origins had a highly significant effect (\( P<0.01 \)) on water content, protein, DM and carbohydrate. Furthermore, geographical origins had a significant difference (\( P<0.05 \)) on ash, organic matter, and EC, but not on fat (\( P>0.05 \)). There was great variability in the composition of honey across different geographical origins. Thus, the chemical properties of honey from the Faculty of Animal Science UGM and Klaten were higher than honey from Gunungkidul.

1. Introduction

The *Tetragonula laeviceps* is a group of stingless bees that using propolis to protect colonies in the hive. The stingless beekeeping is more familiar called as *meliponiculture*. In Indonesia, the stingless bees can be found nesting in a bamboo, sugar palm stalk, tree trunk or wood, and in the ground. The stingless bee *Tetragonula laeviceps* like honeybees can produce main products consists of honey, bee pollen (bee bread), and propolis [1–3]. Honey is defined as a natural food made from the nectar of plant flowers, honeydew or excretions of plants sucking insects that produced by honeybees or stingless bees [4,5].

Honey is mainly composed by sugars and other constituents, such as enzymes, amino acids, organic acids, carotenoids, vitamins, minerals, and aromatic substances [4,6]. The chemical composition of honey from stingless bees in several countries have been studied by those former researchers [7–13]. Honey produced by Indonesian stingless bees has been commercialized by beekeepers but has not been studied on the chemical composition, except the recent report of sugar content profile of stingless bee *Tetragonula laeviceps* from Indonesia [7]. This study was aimed to evaluate the physicochemical properties of honey produced by the Indonesian stingless bee: *Tetragonula laeviceps*. 
2. Material and methods

2.1. Material
The honey sample was obtained from the Indonesian stingless bee *Tetragonula laeviceps* from three geographical origins i.e. the Faculty of Animal Science Universitas Gadjah Mada (UGM) (Yogyakarta), Ngliantar Gunungkidul (southeast part of Yogyakarta) and Klaten (Central Java).

2.2. Methods
The physical properties (flavour) of honey was determined by tasting a spoonful of honey sample. The chemical composition of honey was analysed by proximate analysis [14], including water content, dry matter, protein, ash, organic matter, fat, and carbohydrate. The electrical conductivity (EC) was determined by the equation of EC = 0.14 + 1.74 A (where A is the ash content) [15]. For all analyses, the chemical composition was performed in three replicates each in duplet.

The chemical composition and EC of honey were analysed using one-way analysis of variance (ANOVA) operated by SPSS (version 23). Significant differences between the means were identified by honestly significant difference (HSD) test [16].

3. Results and discussion
The results showed that the physical properties (flavour) of honey from the Faculty of Animal Science UGM and Klaten were sweet and those from Gunungkidul were bitter. The different geographical origins of *meliponiculture* had a highly significant effect (P<0.01) on the water content, DM, carbohydrate, and protein. In addition, the geographical origins had a significant effect (P<0.05) on the ash content, organic matter, electrical conductivity, and but not on fat (P>0.05) (Table 1).

The water content of honey among areas were significantly different, which might be affected by the different plant flowers as the source of nectar, climate, temperature and humidity, the maturity level of honey [4,17,18]. The water content is one of the very important parameters that influencing honey physical properties such as crystallization, colour, flavour, taste, and solubility [4,18]. Honey water content in the study was lower to those previously reported [9–13,19]. The honey moisture in this study was acceptable by Indonesian (27.5%) [20], but not accepted by international standard (20 %) [5]. The dry matter content of honey depends of water content. In addition, the dry matter content is affected by the different plant flowers as the source of nectar, climate, temperature and humidity, the maturity level of honey [4,17,18].

| Table 1. Chemical composition of honey stingless bee *T. laeviceps* from different geographical origins |
|---------------------------------------------------------------|
| **Parameters** | Faculty of Animal Science UGM | Klaten, Central Java | Ngliantar, Gunungkidul |
| Water content (%)** | 24.30±0.42<sup>b</sup> | 26.81±0.07<sup>c</sup> | 21.21±0.47<sup>a</sup> |
| Dry matter (g/100 g)** | 75.70±0.42<sup>b</sup> | 73.19±0.07<sup>a</sup> | 78.79±0.47<sup>c</sup> |
| Protein (g/100 g)** | 0.72±0.03<sup>b</sup> | 0.72±0.05<sup>b</sup> | 0.18±0.03<sup>a</sup> |
| Ash (g/100 g)* | 0.49±0.01<sup>b</sup> | 0.49±0.27<sup>b</sup> | 0.07±0.03<sup>a</sup> |
| Fat (g/100 g) | 0.55±0.26 | 0.50±0.16 | 0.18±0.05 |
| Carbohydrate (g/100 g)** | 73.95±0.62<sup>b</sup> | 71.48±0.25<sup>a</sup> | 78.36±0.39<sup>c</sup> |
| Organic matter (g/100 g)* | 99.51±0.01<sup>a</sup> | 99.51±0.27<sup>a</sup> | 99.93±0.03<sup>b</sup> |
| Electrical conductivity (mS/cm)* | 0.99±0.02<sup>a</sup> | 0.99±0.47<sup>b</sup> | 0.27±0.05<sup>a</sup> |

<sup>a,b,c</sup> Different superscripts within rows indicate significant differences at P<0.05 (*) and highly significant differences at P<0.01 (**) 

The protein contents of honey from the Faculty of Animal Science UGM and Klaten were similar 0.72 g/100 g and were higher than protein content of honey from Gunungkidul 0.18 g/100 g. The different protein content in this study was affected by different plant flowers as the source of nectar or pollen. Protein and amino acids of honey are attributed to the animal (secretion of the salivary glands and pharynx of honeybees) and vegetable source [4,21] but the main source of protein and amino acids...
in honey is the pollen [4]. The protein content of honey is varied depends on honeybees species, *Apis cerana* honey contains 0.1 to 3.3% protein, while *Apis mellifera* honey 0.2 to 1.6% protein [4]. In this study, protein contents were ranged from 0.18 to 0.72 g/100 g. In addition, the fat content of honey did not differ across geographical regions.

The ash contents of honey from the Faculty of Animal Science UGM and Klaten were similar 0.49 g/100 g and were higher than ash content of honey from Gunungkidul 0.07 g/100 g. The ash content indicates the mineral content present in honey and as the geographical origins marker [4,9]. The different ash content of honey might be affected by the different soil nutrients from each region for *meliponiculture*, influencing mineral and ash of nectar from plant flower, although in our study there was no analysis for chemical composition of nectar for each plant. The ash content of honey in the study was differ from those previously reported [8–10,12,13,19]. Mineral content is related to the colour and flavour of honey, with a higher mineral content leading to a darker and stronger flavour [4,18,22]. Honey from the Faculty of Animal Science UGM and Klaten were darker in colour and stronger in flavour than honey from Gunungkidul which was bright and normal in flavour. The ash content of honey in the study was acceptable by Indonesian and international standards with ash content not exceed 0.5 g/100 g [5,20]. The organic matter contents of honey from the Faculty of Animal Science UGM and Klaten were similar 99.51 g/100 g and were lower than organic matter of honey from Gunungkidul 99.93 g/100 g. The organic matter was in contrast with ash content.

The EC of honey in the Faculty of Animal Science UGM and Klaten were similar 0.99 mS/cm, but were not acceptable by international standard which should be not exceed 0.80 mS/cm [5] for blossom honey and were higher than the EC of honey from Gunungkidul 0.27 mS/cm, but was acceptable by international standard. The EC is a linear relationship with the ash content [15]. The EC of honey is related to ash content (mineral content), acidity, revealing presence of ions, organic acids, and protein [4].

The carbohydrate content of honey in the study (from the highest to lowest, respectively): were honey from Gunungkidul (78.36 g/100 g), Faculty of Animal Science UGM (73.95 g/100 g) and from Klaten (71.48 g/100 g). The different of honey carbohydrate contents in each origin were affected by the different plant flowers as the source of nectar to produce honey, climate, temperature and humidity, the maturity level of honey [4,17,19].

4. Conclusion

The results showed that there was great variability in the composition of honey across different geographical origins. Thus, the chemical properties of honey from the Faculty of Animal Science UGM and Klaten were higher than honey from Gunungkidul. These variations are existed due to different plant flower types, as stingless bee food, in each geographical origin.

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