PHYSICAL AND CHEMICAL PROPERTIES OF LOCAL HONEY FROM EAST KALIMANTAN
(Sifat Fisis dan Kimia Madu Lokal Kalimantan Timur)

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ABSTRACT

Most of the local honey production in East Kalimantan is managed traditionally, thus honey quality, particularly its physical and chemical properties, are unknown. However, the honey analysis provides a comprehensive composition profile and potentially gives hints to improve the quality of local honey from East Kalimantan. This research aimed to analyse the properties of two local honey from East Kalimantan. The methods used in this study were gravimetric, volumetric, spectroscopy, spectrophotometry, and chromatography. Honey A was produced by *Apis cerana* whereas *Apis dorsata* produced honey B. The color intensities were 560±5.66 and 947.5±27.58 mAu for honey A and B, respectively. Honey A and B a had moisture content of 22.7 and 25.8% w/w, respectively. Other proximate analysis parameters were also reported. Fructose and glucose content for honey A were 30.65±2.35% w/w and 30.08±0.58% w/w, while honey B gave different pattern with fructose at 28.06±1.04 and higher glucose instead at 32.74±1.13% w/w. Reducing sugar and total sugar for both samples were higher than 60% w/w while sucrose in honey A and B were 2.8 and 1.4% w/w respectively, thus indicating no adulteration. Vitamin C content measurement showed negligible result with total phenolic content of honey A was lower than honey B. Honey B had higher Na, Ca, Fe and Zn than those of honey A. This study reported thorough chemical composition of local honeys from East Kalimantan in which some could have significant nutritional value. However, quality improvement particularly on moisture and reducing sugar content is necessary to meet Indonesian National Standard 8664:2018.

Keywords: Color, proximate, carbohydrate, phenolic, vitamin C, minerals

ABSTRAK

Sebagian besar produksi madu lokal di Kalimantan Timur dikelola secara tradisional sehingga kualitas madu, terutama secara fisik dan kimia, tidak diketahui secara pasti. Analisis sifat fisis dan kimia madu dapat memberikan profil komposisi yang lengkap dan petunjuk berharga untuk peningkatan kualitas dan produksi madu lokal Kalimantan Timur. Penelitian ini menganalisis dua madu lokal Kalimantan Timur dengan kombinasi metode gravimetri, volumetri, spektroskopi, spektrofotometri, dan kromatografi. Madu A yang dihasilkan Apis cerana berwarna kuning-jingga terang sementara madu B yang dihasilkan Apis dorsata berwarna kuning-jingga. Kedua madu memiliki kesegaran yang baik berdasarkan hasil uji Fiehe, masing-masing memiliki nilai intensitas warna berturut-turut 560±5,66 dan 947,5±27,58 mAu untuk madu A dan B. Analisis proksimat menunjukkan kadar air madu A dan B masing-masing 22,7 dan 25,8% b/b. Parameter analisis proksimat lain juga dilaporkan. Kadar fruktosa dan glukosa madu A adalah 30,65±2,35% b/b dan 30,08±0,58% b/b sementara madu B memberikan pola berbeda yakni fruktosa sebesar 28,06±1,04 dan glukosa yang lebih tinggi sebesar 32,74±1,13% b/b. Gula

pereduksi dan gula total kedua sampel lebih tinggi dari 60% b/b dan kadar sukrosa madu A dan B adalah 2,8 dan 1,4% b/b yang menunjukkan tidak ada penambahan gula. Kadar vitamin C pada kedua madu sangat kecil sementara kadar fenolik madu A lebih rendah dari madu B. Madu B memiliki kadar Na, Ca, Fe and Zn lebih tinggi dari madu A. Penelitian ini melaporkan komposisi kimiawi madu lokal Kalimantan Timur secara lengkap dan sebagian komposisinya dapat memiliki nilai gizi yang signifikan. Namun, peningkatan kualitas madu terkait kadar air dan gula pereduksi dibutuhkan untuk memenuhi SNI 8664:2018.

Kata kunci: Warna, proksimat, karbohidrat, fenolik, vitamin C, mineral

I. INTRODUCTION

Honey is one of the most complicated carbohydrate present naturally (Soga, 2002). Indonesia produces local honey up to 1,500 tons annually (Muslim, 2014). Some regions which are well-known as a honey producer in Indonesia include Kalimantan, Sumatera, Sulawesi and Nusa Tenggara Islands. Natural honey gives a lot of health benefit and has been popular since Egypt civilization (Nayik, Shah, Muzaffar, Wani, Gull, Majid, & Bhat, 2014). Nowadays, people use honey for its nutrient and medication and industrial purposes (Buba, Gidado, & Shugaba, 2013).

The use of honey in Indonesia is common. The markets, recently, offer various types of honey, such as the pure ones, black honeys, and bitter honeys. With the presence of e-commerce, consumer could even purchase honey from other regions easily. The large demand along the year should be accompanied by efforts to improve honey quality.

The quality of honey is obviously determined from its physical and chemical properties. Various reports about local honey in Indonesia have been published, yet a comprehensive study of local honey from East Kalimantan is limited. Its complex composition would be the cause. Most local honey from East Kalimantan is produced traditionally, makes it's chemical composition unrecorded, which leads to uncertain quality, and consequently the low price.

Though no honey has an identical composition, the physical and chemical analysis will provide thorough composition profile and direct improvement to meet national even international standard. This research reported the actual physical and chemical properties of local kinds of honey from East Kalimantan including, color intensity, freshness, proximate analysis, carbohydrate profile, total phenolic, vitamin C, and mineral content.

II. MATERIAL AND METHOD

A. Location and Time

All determination was carried out at Laboratory of Pharmacy, University of Nahdlatul Ulama Kalimantan Timur except for proximate and mineral analysis which were undergone at Center for Agro-Based Industry (CABI) Bogor. This research was undertaken from April to October 2019.

B. Materials

Honey samples were collected from two sources. Honey A was obtained in April 2019 from honey bee-hunter located at Bumi Harapan Village, Sepaku IV, Penajam Paser Utara Municipality. Honey B was purchased from a distributor in Balikpapan and also originated from Balikpapan region.

Reagents used in this study were fructose (Merck), glucose, maltose (Merck), resorcinol, $CuSO_4$ (Merck), K-Na-Tartrate (Merck), sucrose, Na2CO3 (Merck), methylene blue, glucose oxidase reagent DiaSys, TLC silica gel 60 F254 plates (Merck), N*(1-naphtyl) ethylenediamine dihydrochloride (Merck), methanol (Merck), pyridine (JT Baker), butanol (Merck), ethanol (Merck), Folin-cioucalteau, gallic acid, 2,6-dichlorophenolindophenol (DCPIP) (Merck), metaphosphoric acid (Merck), and ascorbic acid (Merck).

C. Methods

1. Color intensity

Color intensity was measured using a method described by Beretta, Granata, Ferrero, Orioli, & Facino (2005) with slight modification. Samples were filtered through a cloth and then diluted 50%w/w in warm aqua dest (45-50°C). The honey solution then was filtered, and the absorbances of the filtrate were read in 450 nm and 720 nm. The gap of the absorbance was then calculated and reported in mAu. All measurements were done in triplicate.

2. Fiehe's test

Detection of honey freshness was conducted using Fiehe's test (Kavapurayil, Karalam, & Chandran, 2014). Five grams of each honey sample was diluted in 10 mL ether and decanted, the step was repeated, and the filtrates were left dry in room temperature. A significant drop of resorcinol was then added, and cherry red color is considered as a positive result of Hydroxymethylfurfural (HMF) presence.

3. Proximate analysis

Analysis of water content, ash, protein, fat, and crude fiber was conducted using laboratory service of Center for Agro-Based Industry (CABI) Bogor. CABI conducted water content analysis according to SNI 3545:2013 (Standar Nasional Indonesia, 2013) and the other parameters according to SNI-01-2891-1992 (Standar Nasional Indonesia, 1992).

4. Fructose content

Fructose content was measured using the resorcinol method according to AOAC (2000) (as cited in Buba et al., 2013). Briefly, samples were diluted 40 times in aqua dest. A hundred microlitre of sample was diluted with aqua dest to 2 mL, whereas 2 mL of 0.1; 0.2; 0.3; 0.4; and 0.5 mg/mL fructose was prepared using 1 mg/mL fructose stock solution. Accurately 0.5 mL resorcinol and 3.5 mL concentrated HCl was added. The mixture was then heated in 80°C for 10 minutes and cooled in water for 5 minutes. Samples were then appropriately diluted, and the

absorbances were measured at 520 nm within 30 minutes. The measurement was done in triplicate.

5. Glucose content

Glucose content was determined using Glucose GOD FS Diasys according to manufacture's instruction. Three grams of honey sample was diluted into 250 mL aqueous solution. Ten microlitres of each sample and standard glucose were mixed with 1000 µL reagent. Aqua dest was used as blank. The mixtures were left for 20 minutes in 20°C, and the absorbances were then read at 500 nm. The measurement was done in triplicate.

6. Reducing sugar and sucrose content

Reducing sugar and total sugar were determined using Lane-Eynon method, and sucrose content of honey was calculated indirectly. First, total reducing sugar content of honey was determined through titration with standardized copper sulphate solution using methylene blue as indicator. Secondly, honey samples were hydrolyzed with HCl, and total sugar content of honey was obtained with similar titration method. Finally, sucrose content was calculated from substracting total sugar with total reducing sugar multiplied with sucrose factor.

7. Oligosaccharides analysis

Oligosaccharides of honey were analyzed qualitatively using thin-layer chromatography method by Aso, Watanabe, and Yamao (1960) (as cited in Karimah, Anggowo, Falah, & Suryani, 2011). Briefly, a 5% w/v honey solution in 50% v/v ethanol was prepared and eluted in TLC silica plate using pyridine: butanol: H_2O (4:6:3) as eluent. TLC silica plate then was soaked in N*(1-napthyl) ethylenediamine dihydrochloride solution. Lastly, TLC silica plate was heated until spots appeared.

8. Total phenolic content

Phenolic compounds content was measured using gallic acid equivalence method as described in Kek, Chin, Yusof, Tan, & Chua (2014). Samples were diluted by 20% w/v in aqua dest. A

set of gallic acid standard solution consisted of 50, 100, 150, 200, and 250 µg/mL of gallic acid were prepared. One hundred microlitres of each solution were mixed with 0.4 mL Folin-Ciocalteau reagent, 1 mL Na_2CO_3 7.5% w/v solution, and 3.5 mL H_2O. All mixtures were incubated for two hours, and the absorbance was measured in 765 nm. The measurement was done in triplicate.

9. Vitamin C content

Vitamin C extraction and measurement were conducted using metaphosphoric acid and DCPIP solution (Ferreira, Aires, Barreira, & Estevinho, 2009). Five grams of each honey sample was diluted up to 25 mL with metaphosphoric acid 1% w/v solution. The solutions were incubated for 45 minutes and then filtered. Vitamin C standard solution of 200, 400, 600, 800 µg/mL were prepared. Five hundred microlitres of sample and standard were mixed with 4.5 mL DCPIP solution. The absorbance of each mixture was read immediately after mixing at 515 nm. The measurement was done in triplicate.

10. Mineral analysis

Some primary mineral content in honey were measured. Analysis of potassium (K), sodium (Na), iron (Fe), zinc (Zn), calcium (Ca), and copper (Cu) was conducted using laboratory service of Center for Agro-Based Industry (CABI) Bogor. The analysis used flame atomic absorption spectroscopy (AOAC, 2005). The result was reported in mg/100g honey sample.

III. RESULTS AND DISCUSSION

A. Preliminary Examination of Honey Sample

According to the honey bee-hunter, honey harvest season starts in February until May during the dry season. Furthermore, the honey bee-hunter stated that honey bees collect nectar from the acacia tree. This emphasizes the report that acacia tree (*Acacia mangium*) is considered to be a species with the highest important value index at Forest Area with Special Purpose (*Kawasan Hutan dengan Tujuan Khusus*, KHDTK) Rantai Kalimantan Selatan (Adalina, 2018).

Through amateur examination toward honey bee collected together with honey A, honey bee species is similar to *Apis cerana*. This species has a common name as Asian honey bee and indigenous to Asia. The presence of this species in Indonesia is known and varies in size with a smaller size for tropical races (Bradbear, 2009).

Honey B from Balikpapan is commercial honey and has obtained legal permission from Health Agency P-IRT No 1094471010.48X-XX, a halal label from LPPOM MUI 10120000360XXX, and registered brand IDM 000511XXX. From the label of the honey package, honey B is produced by *Apis dorsata*. This species is known as rock bee, the giant honey bee, or the cliff bee (Bradbear, 2009).

Early examination to color of honey samples showed that honey A and B appeared to have light amber and amber color, respectively. Through color intensity Abs450 measurement, color intensity of honey A and B were 560.0±5.66 and 947.5±27.58 mAu, respectively (Table 1). These values are similar in pattern with a report that honey from *Apis cerana* has lower color intensity than honey from *Apis dorsata* (Kek, Chin, Yusof, Tan, & Chua, 2017). The same report showed heterogeneous data because no significant difference observed from various honey except for honey Kelulut with 990.3±380.0 and Manuka honey which has highest color intensity up to 7296.7±15.3 (Kek et al., 2017). There is a positive correlation between color intensity and phenolic compounds content (Ahmed et al., 2016; Kek et al., 2014) which indicates antioxidant potential as well (Khalil et al., 2012).

Table 1. Color intensity and Fiehe's test of honey sample
Tabel 1. Intensitas warna dan hasil uji Fiehe pada sampel madu

Samples (*Sampel*)	Color intensity (*Intensitas warna*, $(Abs_{450}-Abs_{720})$ mAU)	Fiehe's test (*Uji Fiehe*)
Honey A (*Madu A*)	560.0±5.66	Negative (*Negatif*)
Honey B (*Madu B*)	947.5±27.58	Negative (*Negatif*)

Table 2. Proximate analysis of honey sample
Tabel 2. Analisis proksimat sampel madu

Parameters (*Parameter*)	Unit (*Satuan*)	Honey A (*Madu A*)	Honey B (*Madu B*)	SNI 8664:2018
Moisture (*Kadar air*)	%	22.7	25.8	max. 22
Ash (*Kadar abu*)	%	0.29	0.29	max. 0.5
Protein (*Protein*)	%	0.43	1.07	-
Fat (*Lemak*)	%	0.37	0.20	-
Crude fiber (*Serat kasar*)	%	0.11	0.008	-

Hydroxymethylfurfural (HMF) content can be analyzed qualitatively through Fiehe's test using resorcinol reagent. HMF can indicate old honey or the occurrence of contamination during extraction, processing, or storage (Kavapurayil et al., 2014). Fiehe's test result of honey A and B showed a negative effect (Table 1), which indicate honey were fresh and still had good quality. Both honeys were analyzed within months after harvested. Though honey is well-known for its durability during prolonged storage, many types of researches used different storage method. Since storing honey in low temperature can influence honey quality significantly (Wulandari, 2017), it is best to store honey at room temperature in the airtight-sealed package and analyse honey soon after harvest.

B. Proximate Analysis

Proximate analysis was conducted to determine moisture, ash, protein, fat and crude fiber parameter, and the result is shown in Table 2. The moisture content of honey A and B were 22.7% and 25.8% w/w, respectively, and these values are consistent with typical moisture content for honey produced by *Apis dorsata* and *Apis cerana* (Kek et al., 2017; See, Manila-Fajardo, Fajardo, & Cervancia, 2011). However, these results are higher than Indonesian National Standard (SNI) Number 8664:2018 (Standar Nasional Indonesia, 2018) about honey quality particularly for moisture parameter which is 22% w/w and for international standard even lower at 20% w/w (Buba et al., 2013).

Moisture content of both samples are similar to some local Indonesian honey reported (Adalina, 2018; Evahelda, Pratama, Malahayati, & Santoso, 2017; Savitri, Hastuti, & Suedy, 2017) and Indian honey which ranged from 22.6–26.2% w/w (Kavapurayil et al., 2014). The values obtained in this study were higher than rubber honey and rambutan honey from Indonesia (Harjo, Radiati, & Rosyidi, 2015), Nigerian honey (Buba et al., 2013), Algerian honey (Khalil et al., 2012), Saudi Arabia honey (Mohammed et al., 2017), and Pakistan honey (Ahmed et al., 2016).

Moisture content is influenced by season and geographical origin (Kavapurayil et al., 2014) which partially explains the reason why honey from tropical countries such as India and Indonesia may have higher moisture values and honey from the region with dry climate may have very low moisture as low as around 10% w/w. Low moisture content is essential to extend storage period of honey since it will inhibit fermentation and the growth of osmotolerant yeast (Ahmed et al., 2016) for example Zygosaccharomyces (Harjo et al., 2015). Honey with moisture higher than 19% with only one yeast spore per gram will spoil (White & Doner, 1980). Early harvesting also can cause high moisture content (Harjo et al., 2015). Based on the result, honey moisture content should be reduced, for example, through drying or determining the exact harvest time.

Darker honey has higher ash and nitrogen content. Ash content related to mineral composition, whereas nitrogenous compound in honey mostly is protein (White & Doner, 1980). Honey B was darker than honey A. Although the ash content of both kinds honey showed a similar result of 0.29% w/w, protein content reported seems to confirm that typical comparison. Still, this study showed ash content of both samples conform to Indonesian National Standard (SNI) Number 8664:2018 (Standar Nasional Indonesia, 2018) which is less than

Table 3 Carbohydrate analysis of local honeys from East Kalimantan
Tabel 3 Analisis karbohidrat madu lokal Kalimantan Timur

Carbohydrate parameters (Parameter karbohidrat)	Honey A (Madu A)	Honey B (Madu B)	SNI 8664:2018	International standard (Standar Internasional berdasarkan Buba et al., (2013))
Fructose (Fruktosa, %b/b)	30.65±2.35	28.06±1.04	-	No fixed limit (Tidak ada nilai khusus)
Glucose (Glukosa, %b/b)	30.08±0.58	32.74±1.13	-	No fixed limit (Tidak ada nilai khusus)
Reducing sugar (Gula pereduksi, %b/b)	60.48	63.86	Min. 65	Not less than 60 (Tidak kurang dari 60)
Total sugar (Gula total, %b/b)	63.45	65.35	-	No fixed limit (Tidak ada nilai khusus)
Sucrose (Sukrosa, %/b)	2.83	1.42	Max. 5	Not >5 (Tidak lebih dari 5)

0.5% w/w, and international standard which is less than 0.6% w/w (Buba et al., 2013). Protein and fat content have no particular international standard. Protein in honey consists of enzymes (White & Doner, 1980). Different enzymes work during the process of honey ripening such as diastase (amylase), invertase (saccharase or α-glucosidase), glucose oxidase, and catalase. The range of protein content reported here is similar to the report from Amabye (2017), which ranges from 0.46 to 1.04 gram/100 g honey.

C. Carbohydrate Analysis of Honey Sample

Carbohydrate analysis determined fructose, glucose, reducing sugar, total sugar, sucrose, and oligosaccharides content. All carbohydrate composition, except oligosaccharide, are shown in Table 3. Honey A and B had fructose content

of 30.65±2.35 g/100g and 28.59±1.04 g/100 g respectively. While fructose and glucose of honey A were similar, honey B had higher glucose content than its fructose. Although it is rare to find a honey with higher glucose content than fructose, the result of this study is similar to Ng & Reuter (2015).

Fructose and glucose content do not have international standard value, but their sum should be at least 60 g/100g (Buba et al., 2013), except honeydew honey with the lower standard at 45 g/100g (Ahmed et al., 2016). The reducing sugar contents of both samples did not conform to SNI 8664:2018 (Standar Nasional Indonesia, 2018) yet fulfilled the international standard of not less than 60% w/w. Measurement of total sugar resulted in sucrose content of honey A and B were 2.83% and 1.42% w/w respectively, which conformed to both SNI 8664:2018 and
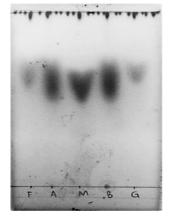

Figure 1. TLC result of honey A and B showed monosaccharides and disaccharide spots yet oligosaccharide spot was not detected. F: fructose, G: glucose, M: maltose.
Gambar 1. Kromatogram madu A dan B menunjukkan totol monosakarida dan disakarida namun totol oligosakarida tidak terdeteksi. F: fruktosa, G: glukosa, M: maltosa

Table 4. Ascorbic acid and total phenolic content
Tabel 4. Kandungan asam askorbat dan fenolik total

Samples (*Sampel*)	Ascorbic Acid content (g/100g) from extraction of honey at 10% b/b (*Kandungan asam askorbat dalam g/100 g dari ekstraksi madu pada kadar 10%b/b*)	Ascorbic Acid content (g/100g) from extraction of honey at 20% b/b (*Kandungan asam askorbat dalam g/100 g dari ekstraksi madu pada kadar 20%b/b*)	Total Phenolic content (mg GAE/100 g honey) (*Kandungan fenolik total (mg/ GAE/100 g madu*)
Honey A (*Madu A*)	0.0183±0.0040	0.0129±0.0037	42.00±0.79
Honey B (*Madu B*)	0.0326±0.0026	0.0307±0.0047	65.92±2.34

Remarks (*Keterangan*): GAE: Gallic acid equivalent (*Ekuivalen asam galat*)

international standard (Table 3). These sucrose values indicated that local honey used in this study are considered natural. This study shows natural honey without adulteration are available for customers since so many honey are on the market without certainty about non-adulteration. Although it is stated that sucrose content larger than 5% w/w is an indication of sucrose adulteration, interestingly one study reported that even addition of sucrose sugar up to 100 L/colony could only result in 3.05 % sucrose content (Guler et al., 2017).

This study analyzed oligosaccharides qualitatively. Chromatogram showed streaked spot with distance comparable with standard monosaccharides and disaccharides, indicating very high content of respective carbohydrate (Figure 1). No spots indicating oligosaccharides was observed and this probably due to low oligosaccharides content which exceeds the detection limit of thin layer chromatography method.

D. Vitamin C and Total Phenolic Content

This study reports that vitamin C or ascorbic acid content in both honeys were negligible and predicted the result as false positive. This is due to the extraction of ascorbic acid from honey using metaphosphoric acid at 10% and 20% w/w gave similar result (Table 4). Unlike this report, many other previous reports stated that the content of ascorbic acid was 18.52-25.16 mg/100g (Buba et al., 2013), 126.78-147.28 mg/kg honey (Ahmed et al., 2016), and 0.19-3.70 mg/100g honey (Guler et al., 2017). Considering the meager result reported on those studies, this probably also came out from false positive due to linear regression calculation. Based on the value obtained, this study assumed that honey is not a source for vitamin C.

Phenolic compounds in honey include phenolic acids and flavonoid (Cianciosi et al., 2018). High level of pigments such as carotenoids and flavonoids darken honey color moreover these two pigments involve in honey antioxidant potential (Ahmed et al., 2016). Total phenolic content of honey A and B were consecutively 42.00±0.79 mg GAE/100g and B 66.92±2.34 mg GAE/100 g (Table 4), and give a comparable result with typical phenolic content of honey produced by Apis genus (Kek et al., 2014). The highest phenolic content was from Kelulut honey produced by *Trigona* spp. with 105.88 mg GAE/100g (Kek et al., 2014). Honey B, as indicated with a darker color than honey A has proven to have higher phenolic content and

Table 5 Some mineral contents of local honey from East Kalimantan
Tabel 5 Kandungan beberapa mineral pada madu lokal dari Kalimantan Timur

Parameters (*Parameter*)	Unit (*Satuan*)	Honey A (*Madu A*)	Honey B (*Madu B*)
Sodium (*Natrium*, Na)	mg/100g	3.76	6.55
Potassium (*Kalium*, K)	mg/100g	137	135
Calcium (*Kalsium*, Ca)	mg/100g	11.1	15.1
Iron (*Besi*, Fe)	mg/100g	<0.0017	0.15
Copper (*Tembaga*, Cu)	mg/100g	<0.0008	<0.0008
Zinc (*Seng*, Zn)	mg/100g	<0.0004	0.09

confirm the report by (Kek et al., 2014) about the positive correlation between color intensity and phenolic content.

E. Mineral Content

Mineral content of honey is related to ash content. Dark honey has higher ash (mineral) (White & Doner, 1980). From previous proximate analysis section, it is known that both honey have the same ash content of 0.29% w/w. However, mineral composition pattern of each honey regarding types of mineral measured in this study were different (Table 5). Overall, Honey B contained higher mineral than Honey A, particularly Na, Ca, Fe, and Zn. Beyond the minerals measured in this study, according to Ahmed et al. (2016), honey also contain significant amount of magnesium.

IV. CONCLUSION

A thorough examination of physical and chemical properties of local honey from East Kalimantan was conducted. Moisture and reducing sugar content were outside the range set in SNI 8664:2018; however, ash and sucrose content conformed to the standard. The carbohydrate analysis showed fructose and glucose content are comparable to the international standard, however, one sample showed a distinct pattern with its glucose content higher than fructose. Both samples had sucrose content less than 5% w/w and fulfilled both SNI 8664:2018 and international standard, and considered natural. Local honey showed a negligible amount of vitamin C but a comparable amount of phenolic content typical for honey produced by Apis genus. Local kinds honeys had similar ash content but different pattern in mineral composition. Local honeys had good quality, but decreasing the water content and increasing reducing sugar content through drying or determining the correct harvest time is necessary to be able to meet the national standard of SNI 8664:2018.

ACKNOWLEDGEMENT

AUTHOR CONTRIBUTIONS

UK and RM conducted the ideas, designs, and experimental designs; trials and test treatments are carried out by UK and AA; UK and AA collected and analyzed the data; UK, RM, and AA wrote the manuscript; UK, RM, and AA edited and finalized the manuscript.

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