



The physicochemical properties and nutritional value of Stingless bee honey at Gelam Forest in Telaga Papan, Terengganu, Malaysia

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ABSTRACT

Honey's compound is differ depending on the types and origin of bees' food; which are flower nectar and plant honeydew. These differences then influenced the quality and nutritional value of honey as a superfood. This research accesses the physicochemical properties and nutritional value of stingless bee honey at Gelam forest. Honey of *Heterotrigona itama* was collected at Telaga Papan in Terengganu, Malaysia. The location of hives is surrounded and dominant by Gelam trees. The physicochemical analysis, antioxidant properties, total phenolic and flavonoid compounds, and minerals content of stingless bee honey were investigated. The physicochemical parameters in terms of moisture, pH, and Brix were measured. The result obtained shows that the Gelam honey produced by *H. itama* has a moisture content of 27.28%, the pH is 3.30, and the total soluble solid or Brix value is 75.88. Meanwhile, for total phenolic and total flavonoid content, both recorded a quite higher value which was 10.68 mg GAE/g and 6.64mg CE/g respectively. In terms of antioxidants, Gelam honey shows a promising 1,1-diphenyl-2-picrylhydrazil (DPPH) inhibition. The four major minerals as potassium, sodium, calcium and magnesium recorded values are 2036.04mg/L, 101.31mg/L, 41.51mg/L, 7.88mg/L respectively. In general, Gelam honey has a good quality and nutritive as similar to other stingless bee honey produced from another botanical origin.

Keywords: Stingless bee, Gelam honey, physicochemical properties, nutritional value

INTRODUCTION

Honey is a complex food substance, which makes up of approximately 200 different components such as fructose, glucose, water, proteins, vitamins, minerals, polyphenolic compounds and plant derivatives (Nolan et al., 2019). A wide range of phenolic compounds present in honey has encouraged people since ancient times to use honey for medicinal purposes. However, during that time, most of the health advantages of honey were based solely on eye observations without any supporting evidence (Bobiş et al., 2018). Honey's nutritional value, therapeutic properties, and healing capabilities have now been scientifically validated over time. These days, more of its functional properties are being highlighted. Stingless bees use cerumen, a combination of propolis

and wax, to make pots for their nests that store floral and non-floral nectar and honeydew before it is processed into honey. Due to various amounts of potential sources, coming from an enormous diversity of plants, no honey is equivalent and wholly the same as another one (Ramly et al., 2021). There is a great variety of honey in this world. As indicated by Codex Alimentarius, honey types usually referred to the honey origin, that it may be nominated by the name of the geographical or topographical region where the honey was produced exclusively within the referred area or maybe according to the botanical or plant source (Bogdanov, 2011).

The constitution of stingless bee honey and *Apis* species honey is identical in terms of ash and nitrogen levels (Alvarez-Suarez et al., 2012). They differ, however, in terms of moisture content, acidity, viscosity, sugar content, and mineral composition (Kek et al., 2017). Gelam honey is a Malaysian wild monofloral honey. The tree *Melaleuca jupati* Powell, often known as the Gelam tree, provides the bees with the majority of their nectar and pollen. This plant species is a member of the Myrtaceae family. The log of Gelam is known as Kayu Putih in Malaysia, and it has a tall evergreen tree. Melaleuca species thrive in mud woods behind sandy beaches and mangroves in the Malaysian states of Kedah, Melaka, Negeri Sembilan, Kelantan, and Terengganu (Putri Shuhaili et al., 2016). Gelam honey is traditional Malaysian honey that is frequently utilized in traditional medicine.

However, the discrepancy in the quality of honey available at the market is always a rising problem. The differences in terms of color and taste make it questionable either it is pure or fake honey. As the qualities of stingless bee honey vary based on the bee species and location of the beehives, confirming the purity and authenticity of stingless bee honey has proven difficult. According to Fatima et al. (2018) and Karabagias et al. (2014), the stingless bees produce different honey compositions due to their foraging activity hence they forage on diverse bunches of flowers that grow at a variety of habitats. Razali et al. (2018) stated that honey's purity can only be determined by looking at its physicochemical features, such as moisture, pH, total soluble solids, color characteristics and intensity, antioxidant content, and minerals, while its originality may be determined by looking at its origin.

To date, there is still a scarcity of literature emphasis on the quality of Gelam honey and its nutritional value. The purpose of this work is to analyze the physicochemical and phytochemical features of stingless bee honey collected at Gelam forest in Telaga Papan, as well as its mineral values, which may lead to future research on the therapeutic properties of Gelam honey. The establishment of the physicochemical correlation improves the understanding of honey characteristics which benefits the honey industry.

MATERIALS AND METHODS

Sample collection

Honey of *H. itama* was collected at stingless bee apiary, Telaga Papan in Terengganu, Malaysia. The location of beehives is surrounded and dominated by approximately 50 acres of Gelam trees (Fig. 1). Hives with a perfect condition, free from any disease, and has active and healthy colonies were selected for this experiment. The honey samples were obtained from sealed honey pots, transferred into a sterilized bottle, and kept at 4°C chiller (Sun-tech LC-213LD, Taiwan) before further analysis.



Fig. 1. Location of stingless bee apiary at Telaga Papan Terengganu Malaysia.

Physicochemical analysis

Determination of pH

The pH of the honey samples was analysed using a pH meter (Thermo Scientific Orion 2-Star Benchtop). The pH meter electrode was inserted in 6 g of the honey sample that had been diluted with 45 mL of distilled water, and the reading was taken. The measurement was performed quintuplicate for each sample to obtain the mean value (Omar et al., 2019).

Determination of total soluble solids

A simple handheld refractometer (HANNA instrument-96801) was used to identify the total soluble solid of stingless bee honey. Two droplets of concentrated honey were put and dispersed throughout the whole surface of the refractometer's prism. The values obtained were recorded as °Brix. To achieve the mean value, the readings were recorded in quintuplicate on average (Moniruzzaman et al., 2013).

Determination of moisture

The AOAC approved method for measuring moisture content was used as suggested by Nielsen (1998). The crucible was cleaned and dried in an oven (Mettler) at 105°C for 4 hours before being used to remove the excessive moisture. After the cooling process in the desiccator, the crucible was weighed as W1. The honey samples were then weighed in the crucible for approximately 2 g and weighed as W2. Following that, the crucible was placed in a 105°C oven for 24 hours. After 24 hours, the crucible containing the dried sample was transferred into the desiccator to let it cool down and then being weighed as W3. For each sample, the measurement was repeated quintuplicate to get the average value. Finally, the percentage of moisture content was calculated using the formula:

$$\% \text{ Moisture} = (W2-W3)/(W2-W1) \times 100$$

Where:

The crucible's weight, W1
Before drying, W2 was the weight of the sample plus the crucible.
After drying, W3 was the weight of the sample plus the crucible.

Phytochemical and antioxidants analysis

Determination of total phenolic content

With slight modifications, the Folin-Ciocalteu test as suggested by Moniruzzaman et al. (2013) was used to determine the total phenolic content. One gram of honey was diluted with 9 ml of methanol; which yielded a honey solution with a ten percent concentration (99.99 percent, HmbG). After that, 0.5 mL of that solution was combined with 2.5 mL of Himedia's 0.2N Folin & Ciocalteu's Phenol reagent for 5 minutes. The mixture was then mixed with 2 mL of 7.5 percent Na₂CO₃ (Bendosen) solution and incubated at room temperature for 2 hours in the dark. After that, the samples were analysed at 760 nm using a UV-Visible Spectrophotometer (Shimadzu UV mini -1240) against a mixture of methanol, 0.2N Folin & Ciocalteu's Phenol Reagent, and 7.5 percent Na₂CO₃ as a blank using a UV-Visible Spectrophotometer (Shimadzu UV mini -1240). A calibration curve was then generated by using a standard solution of gallic acid (Merck) (0, 25, 50, 125, 250, 377, 500, 1000, and 1500 mg/L). The total phenolic content in mg of Gallic acid equivalents (GAE) per gram of honey was calculated.

Determination of total flavonoid content

The total flavonoid content of the honey sample was assessed using a modified version of the method as reported by Moniruzzaman et al. (2013). A standard solution of catechin (Santa Cruz) was used to generate a calibration curve (0, 0.04, 0.08, 0.12, 0.16, 0.20, 0.24, and 0.28 mg/ml). A millilitre of honey was diluted in four millilitres of methanol (99.99 percent, HmbG). After that, 0.3 mL of 5% NaNO₂ (Merck) was added. After 5 minutes, 2 mL 1M NaOH (Bendosen) and 0.3 mL 10% AlCl₃ (HmbG) were added, followed by 2 mL 1M NaOH (Bendosen) after 6 minutes. To make a 10 mL solution, 2.4 mL distilled water was added to the mixture. Results obtained were used to analyse its absorbance at 510 nm by using a UV-Visible Spectrophotometer (Shimadzu UV mini -1240) against a blank sample consisting of a solution consisting of methanol, 5 % NaNO₂, 10 % AlCl₃, and NaOH (1M) without the honey sample. Finally, the data was converted into mg catechin equivalents (CE) per gram of honey.

DPPH radical scavenging activity (% RSA)

With slight modifications, the scavenging activity against the 1,1-diphenyl-2-picrylhydrazil (DPPH, Sigma Aldrich) radical was measured using the approach described by Chua et al. (2013) and Shamsuddin et al. (2019b). In a nutshell, 0.75 mL of honey solution in methanol was combined with 1.5 mL of 0.02 mg/mL DPPH in methanol at various doses ranging from 20 to 40 mg/ml. The mixture was then incubated for 15 minutes at room temperature in the dark. After that, the absorbance was measured at 517nm against a methanol blank sample. Using 0.75 mL of methanol and 1.5 mL of DPPH solution, the absorbance of the control was measured. Honey's DPPH inhibition was measured in terms of percentage inhibition of DPPH radical and was calculated as below:

$$I = [1 - (A_A / A_B)] \times 100,$$

where:

I = Inhibition of DPPH (%)

The absorbance of the control is denoted by the letter AB.

AA denotes the honey sample's absorbance.

Mineral's analysis

The concentrations of calcium (Ca), magnesium (Mg), sodium (Na), iron (Fe), zinc (Zn), copper (Cu), aluminum (Al), phosphorus (P), manganese (Mn), and sulfur (S) in honey samples were determined using an inductively coupled plasma atomic emission spectroscopy, ICP-OES (Thermo Scientific iCAP 7000 Series, UK). As followed by Yücel & Sultanoğlu (2013) the sample preparation and the methodology were improved with slight modification. First, the sample needs to be digested before being used as the final sample for the ICP-OES. Honey samples were subjected to a microwave digestion technique. Using a microwave digestion machine, five milligrams of each honey sample were digested with 9 ml of 65 percent HNO₃ (65 percent, Merck) (Anton Paar -Multiwave GO). Then, to be diluted, the digested sample was mark up until 25 ml with ultra-pure water. A blank digest was carried out in the same way. After that, approximately 10ml of the digested sample was poured into the test tube and get ready to be used as the sample for the ICP-OES. The result obtained was expressed as mineral content in mg per kg of honey.

Data analysis

All statistical analyses were carried out using R statistical software version 4.0.3 (R Core Team, 2020). For the significant difference at a 95% confidence level ($P \leq 0.05$), the data was completed using one-way ANOVA (Analysis of Variance). LSmeans were used to determine the significance of variations in mean values, and post-hoc Tukey tests were used to determine the location of stingless bee hives as explanatory variables.

RESULTS AND DISCUSSION

Physicochemical characteristics of Gelam Honey

Physicochemical characteristics of honey samples was represented in Table 1. We found that the moisture content, pH, and Brix value of Gelam honey collected at Telaga Papan Terengganu is nearly similar to the Gelam honey reported in other studies. In addition to that, the quantity of phenolic and flavonoids compounds also has a relatively high value. Our Gelam honey also displays a good antioxidant activity and has a good amount of minerals content.

The moisture content of honey

We found that the moisture content of the Gelam honey falls at 27.28%. According to the International Honey Commission (IHC), good-quality honey should only contain less than 20% of moisture. In a study by Shamsudin et al. (2019), the stingless bee honey collected at the beehives in the Gelam forest has a moisture content of 25.49%. In addition to that, the moisture content of stingless bee honey collected from the beehives at the acacia forest and starfruit farm were 21.52% and 24.24% respectively. Many researchers reported that stingless bee honey has a high moisture content; thus, it does not fulfil the IHC requirement to be classified as good-quality honey. As an example, Majid et al. (2019) reported that the moisture content of stingless bee honey collected from different botanical origins (acacia, coconut, mangrove, starfruit, multi-floral, and multifruit) ranged from 27.00 percent to 31.00 percent. Meanwhile, a study by Fatima et al. (2018) found that the moisture content of stingless bee honey from monofloral and multi-floral sources ranged from 28.30%-33.70%. Last but not least, Kek et al. (2018) found that *H. itama* honey had the maximum moisture level of 33.24 %, with the nectar primarily from acacia trees. The water content in honey is influenced by several factors such as the nectar's botanical and geographical origins, soil, and climate conditions (Pontara et al., 2012). If compared, the moisture of stingless bee honey is greater than *A. mellifera* honey. This moisture value is characterized by a high hygroscopicity of stingless bee honey (Do nascimento et al., 2015), emphasizing that the moisture content of honey is affected by intrinsic bee species characteristics and the material used to build the honey pot. In fact, stingless bees construct their honey pots using unique cerumen made up of wax, propolis, and plant resins; which may contribute to high moisture content. On the other hand, *Apis* sp. honeycombs are mainly composed of only beeswax (Kek et al., 2017). As the moisture content in stingless bee honey is quite high and may lead to

the fermentation process, it is advisable to keep honey in the fridge to minimize deterioration or fermentation (Gela et al., 2021).

The pH value of honey

Honey with lower pH was good in terms of its stability against microbial damage and preventing the growth of microbes (²Da silva et al., 2013). In our study, the pH value of Gelam honey was 3.30, which is within the permissible range underlined by the Malaysian Standard for stingless bee honey (ranged from 2.5 to 3.8). In another study by Wong et al. (2018), the pH values of stingless bee honey collected from the beehives at acacia forest ranged from 3.23 to 3.38. Meanwhile, Majid et al. (2019) reported that the pH value of stingless bee honey collected at six different botanical origins in Johor Malaysia ranges from 3.17 to 3.44. In addition to that, ²Shamsudin et al. (2019) reported that the pH of honey collected from Gelam forest, acacia forest, and starfruit farm are 3.38, 3.35, and 3.19 respectively. These findings show that most stingless bee honey has a pH value that is categorized as good quality of honey as outlined by the Malaysian Standard of Stingless Bee Honey. Pauliuc et al. (2020), stated that the pH of honey is determined by the organic acid compositions, which are chemical components that give the honey aroma while also preventing it from bacterial harm. As a result, the pH may be used as a prediction of possible microbial growth; as a pH of 7.2 to 7.4 is ideal for most bacteria' development.

The Brix value of honey

The value of total soluble solids (Brix) calculated in this study was 75.88 °Brix. ²Shamsudin et al. (2019) reported that the Brix value of *H. itama* honey ranges from 66.25 – 72.25 °Brix; where the honey collected from the beehives at acacia jungle had the lowest value while the highest value was found from the honey samples collected at starfruit farm. ²Shamsudin et al. (2019) also reported that the Brix value of stingless bee honey collected from the beehives at Gelam forest was 70.30°Brix. Another research, ¹Shamsudin et al. (2019) found that Gelam honey indicates 74.50 °Brix, while acacia honey was 74.65°Brix, and starfruit honey was 73.88°Brix. In comparison with our finding, the Brix value reported in the research mentioned above is quite lower compared to ours. Honey with a high total soluble solid content has a high sugar content and a low moisture content in general. Total soluble solid just roughly calculates the sugar value as it's representing the value of sugars, organic acids, and minerals in the solution. This concludes that it was not a definite method for quantifying the exact sugar content in honey (Biluca et al., 2016). In the food business, the Brix scale is used to determine the expected quantity of sugars. Total soluble solids (TSS), which are proportional to sugar concentration, may be a great indicator of adulteration (Anguebes et al., 2016).

Total phenolic content (TPC) in Gelam Honey

We found the TPC of Gelam honey was 10.68mg GAE/g. In comparison with us, ¹Shamsudin et al. (2019), documented a lower value of TPC produced by Gelam honey which valued 52.25mg GAE/100g. The TPC of honey is differed depending on its botanical and geographical origin (Moniruzzaman et al., 2014). As an example, ¹Shamsudin et al. (2019) mentioned that the TPC of acacia and starfruit honey was 33.12mg GAE/100g, and 40.44mg GAE/100g respectively. In addition to that, Wong et al. (2019) reported the TPC of acacia honey collected from the beehives at Sarawak was 477.40mg GAE/kg. Previously, Wong et al. (2018) investigate two sources of honey from acacia trees, where both give the value of 435.38mg GAE/kg and 509.20mg GAE/kg. In other research by Hazirah et al. (2019), the phenolic content of multi-floral *H. itama* honey was 844.45mg RE/kg. It is important to quantify the amount of TPC as the honey's biological activities are determined by the concentration and the type of phenolic compounds (Al-mamary et al, 2002). Flavonoids are the most common type of phenolic compound found in plants, and they are thought to be the most useful and effective antioxidants (Cheng et al., 2019). Flavonoids are low-molecular-weight phenolic chemicals that contribute to honey's fragrance and antioxidant potential (Moniruzzaman et al., 2014). On top of that, flavanols are the most prevalent flavonoid in honey samples (Iurlina et al., 2009).

Total flavonoid content (TFC) in honey

The total flavonoid content in our Gelam honey was 6.64 mg CE/g. In comparison with that, the Gelam honey analyzed by ¹Shamsudin et al. (2019) and ²Shamsudin et al. (2019) gives the value of 6.53 mg QAE/100g and 8.41mg QAE/100g respectively. This value was much lower when compared to our findings. In another study by Ali et al. (2020), the TFC values for stingless bee honey samples obtained from six botanical origins, including acacia, mangrove, coconut, multi flower, multifruit, and starfruit, are 29.42 mg RE/100g, 44.66 mg RE/100g, 51.33 mg RE/100g, 19.42 mg RE/100g, 41.33 mg RE/100g, and 32.28 mg RE/100g, respectively. Last but not least, research by Hazirah et al. (2019) on *H. itama* honey that was collected from the beehives at multi-floral sources recorded a lower value of TPC compared to our finding where the value was 78.29mg RE/kg. Khalil et al. (2011) stated that the differences in polyphenol compounds in honey were largely correlated with their floral nectar sources as well as the type of bee species. Many researchers believe that the quality of honey is influenced by the nectar and honeydew sources acquired by bees, the climate in the honey botanical origin, and storage and processing conditions (¹Ramly et al., 2021).

Table 1. The physicochemical characteristics of Gelam honey produced by the stingless bee in Telaga Papan.

Parameter (Unit)	Gelam Honey
Moisture content (%)	27.28 ± 0.098
pH	3.30 ± 0.006
Brix (°Brix)	75.88 ± 0.020
TPC (mg GAE/g)	10.68 ± 0.163
TFC (mg CE/g)	6.64 ± 0.062

*Values expressed as mean ± standard error.

DPPH radical scavenging activity (%RSA)

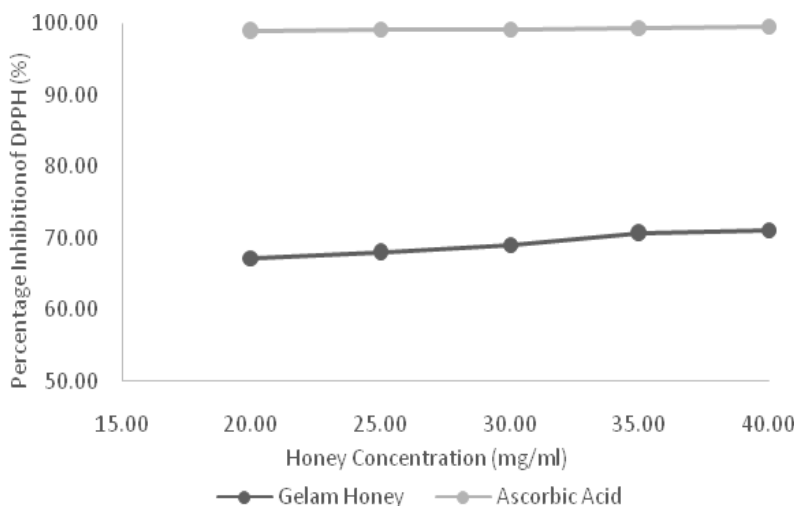


Fig. 2. The percentage of 2,2-Diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity of stingless bee honey at different concentrations of honey samples

According to Katalinic et al. (2006), the DPPH method is probably to be the most reliable technique for determining honey's antioxidant activity because it generates stable free radicals for analysis. From Fig. 2, at the highest concentration of 40mg/ml, Gelam honey can inhibit until 71% of the DPPH while at the lowest concentration, 20mg/ml it can inhibit 57%. Ascorbic acid was a common water-soluble vitamin c that acts as an amazing antioxidant. Due to that, it was used as the reference standard in comparison to the antioxidant capacity of the percentage inhibition of DPPH by Gelam honey. As predicted, the DPPH inhibition of ascorbic acid is close to 100%, where at a concentration of 40 mg/ml it inhibits 99.50% of DPPH in the solution. In comparison with Majid et al. (2020), six different honey samples with a concentration of 50mg/ml each, tend to scavenge 26.67-74.03% of the DPPH radicals which are the highest scavenging activity was from *H. itama* from mangrove sources while the lowest was from multi-floral origin. Coconut honey was observed to give a quite higher DPPH inhibition value, 66.30% at a concentration of 50mg/ml (Majid et al., 2020). In another hand, Mahmood et al. (2021) reported that honey collected from stevia plants listed lower DPPH inhibition, 72.12% compared to multi-floral honey, 86.03%. *H. itama* honey at Serapi Garden where the nectars are mainly from the floral sources showed higher antioxidant property as indicated at 50% of the DPPH inhibition, the concentration values were ranging from 12.55 – 33.78 mg/L of honey (Ngaini et al., 2021). Honey's functional qualities are correlated to the abundance of natural antioxidants present in pollen and flower nectars obtained by bees. The presence of phenolic acids, flavonoids, ascorbic acid, carotenoids, catalase, peroxidase, and Maillard reaction products in honey's composition has been linked to its antioxidant capacity (Pauliuc et al., 2020).

Minerals

Even though minerals and heavy metals are considered insignificant components, they play a vital role in establishing the authenticity and quality of honey (Rosidi Sujanto et al, 2021). Our finding shows the identified minerals in Gelam honey as listed in Table 2. Potassium (K), sodium (Na), calcium (Ca), and magnesium (Mg) are the four primary elements, followed by phosphorous (P), iron (Fe), zinc (Zn), manganese (Mn), and copper (Cu) as minor elements in descending order of concentration. When compared to other minerals, potassium has the highest content (2036.04mg/L). According to Solayman et al. (2016), among the major and minor elements claimed to be present in honey, K is found in the highest amounts, followed by Na, with Mg, Ca, Fe, Zn, and Cu in intermediate concentrations. Kek et al. (2017) reported that the *H. itama* honey collected from the beehives at acacia forest recorded a lower potassium content that gives the value of 732.2mg/L but higher in sodium, calcium, and magnesium content at 598.7mg/L, 191.9mg/L, and 33.81mg/L respectively. Meanwhile, for minor elements, it was recorded to have a range of variation between each other (Kek et al., 2017; Ngaini et al., 2021). It can be concluded that the amount of minerals in honey is depending on the botanical and geographical origins of the honey (Vincivia-gaile, 2010; ¹Da Silva et al., 2013). It agrees with Solayman et al. (2016), that the amount of different minerals and heavy metals in honey is strongly influenced by the soil composition, as well as the different types of floral plants, because minerals are carried into plants via the roots, passed to the nectar, and then into the honey.

Each of the four major minerals has its own specialties to our body. The most common inorganic compounds in plant cellular media are potassium (K⁺) and calcium (Ca²⁺), both of which are seldom mentioned (Sardans & Peuelas, 2021). A higher potassium consumption is associated with better blood pressure control. High potassium diets, in fact, lower blood pressure in hypertensive individuals, improve blood pressure control in normotensives, and lessen the risk of stroke (Mazzaferro et al., 2021). According to Solayman et al. (2016), calcium is an essential mineral because it plays a significant role in various biological functions in the cardiac, neurological, and musculoskeletal systems, including bone and tooth production. Another crucial item to remember is that sodium (Na) is essential for maintaining healthy blood pressure, renal function, and nerve and muscle function, while magnesium (Mg) is a cofactor for up to 300 enzymes, the majority of which are involved in antioxidant reactions.

Table 2. The minerals content of Gelam honey from stingless bee in Terengganu

Minerals (mg/L)	Gelam Honey
Potassium (K)	2036.04 ± 927.105
Sodium (Na)	101.31 ± 19.183
Calcium (Ca)	41.51 ± 16.323
Magnesium (Mg)	7.88 ± 2.971
Phosphorus (P)	7.79 ± 1.265
Iron (Fe)	6.11 ± 1.615
Zinc (Zn)	1.64 ± 0.563
Manganese (Mn)	0.97 ± 0.545
Copper (Cu)	0.78 ± 0.193

*Values expressed as mean ± standard error.

CONCLUSION

Heterotrigona itama honey was harvested from Gelam forest in Telaga Papan, Terengganu, and its physicochemical activities, antioxidant capacities, and mineral content were studied. Moisture, pH, and Brix analysis reveal acceptable values within the established tolerable standard range. Meanwhile, for total phenolic and total flavonoid content, our findings exhibit a higher value compared to most reported studies. The TPC and TFC contents of stingless bee honey samples were greatly affected by sources of botanicals. In addition, the DPPH inhibition analysis shows a promising potential of honey from this Gelam source as an antioxidant. For minerals content, the highest concentration was showed by potassium (K) among all the other minerals and had an agreement with most works of literature. The botanical origin of the honey samples can be concluded to influenced the physicochemical, phytochemicals, and minerals content. However, a detailed study with a large number of samples is needed to get further insight into the effect of botanical origin on the parameters being evaluated, and this data can be used to supplement that knowledge in this field.

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