International Journal on Advanced Science Engineering Information Technology

Vol.9 (2019) No. 6
ISSN: 2088-5334

The Application of Clay Pot for Moisture Reduction of *Geniotrigona thoracica* Stingless Bee Honey

Nashratul Shera Mohamad Ghazali[#], Yus Aniza Yusof[#,*], Chin Nyuk Ling[#], Siti Hajar Othman[#], Yanty Noorzianna Abdul Manaf[*], Syahrul Anis Hazwani Mohd Baroyi[#]

[#]*Department of Process and Food Engineering, Faculty of Engineering, Universiti Putra Malaysia, Selangor, Malaysia*
E-mail: nashratulshera@gmail.com; yus.aniza@upm.edu.my; chinnl@upm.edu.my; s.hajar@upm.edu.my; anishazwani45@yahoo.com

[*]*Laboratory of Halal Services, Halal Products Research Institute, Universiti Putra Malaysia, Selangor, Malaysia*
E-mail: yus.aniza@upm.edu.my, yanty@upm.edu.my

***Abstract*— *Geniotrigona thoracica* (*G. thoracica*) stingless bee honey contained high moisture that can easily lead to fermentation process. The high moisture content of stingless bee honey could lead to unwanted fermentation and crystallization form. Hence, it will affect the quality of honey in terms of acidic taste and undesirable appearance. To make sure stingless bee honey meets the standard set by IHC, some methods have been carried out to reduce its moisture content. This study investigates the moisture reduction during storage of *G. thoracica* stingless bee honey in a clay pot. The *G. thoracica* honeys were stored in clay pot with the inner volume of 75.4cm^3 and glass bottle (as control) at 25˚C for 21 days. Physicochemical analysis of honey such as moisture content, total soluble solid, water activity, viscosity, pH, free acidity, electrical conductivity, colour (L*, a* and b*) and colour intensity were investigated during storage. The result obtained indicated that the honey stored in a clay pot was significantly reduced the moisture content from 28.03% to 16.51%. The water activity (a_w) of honey in a clay pot was also reduced from 0.779 to 0.601. The free acidity of honey stored in a glass bottle increased significantly compared to honey stored in a clay pot, which was initially 106.7meq/kg to 146.3meq/kg and 121.7meq/kg, respectively. In conclusion, the application of clay pot as a storage medium was capable to reduce water content and preserved the quality of honey from *G. thoracica*.**

***Keywords*— physicochemical; moisture; honey; *Geniotrigona thoracica;* clay.**

I. INTRODUCTION

Honey is an important product of stingless bees because of its advantages to the consumers for medicine and food purposes. The chemical and physical compositions of honey are enriched with various nutritional and medicinal values that had been used in traditional medicine since ancient times. The ancient Egyptians, Chinese, Greeks, and Romans utilized honey to cure the diseases of the intestine and skin wounds [1]. The previous study showed that honey can act as antioxidant, antimicrobial and anti-inflammatory [2].

Nowadays, *meliponiculture* has become popular among beekeepers in Malaysia. *Meliponiculture* is an activity of beekeeping with stingless bees to obtain honey, pollen, resin, and ecological services [3]. Beekeepers of stingless bees can increase honey production by building a human-made hive to control the colony. This is since they are not revolt in picking the spot to construct hive [2]. There are around 500 species of stingless bees have been identified [4]. These bees are abundant in tropical and subtropical regions worldwide, including Australia, Africa, Southeast Asia, and tropical America [5].

Geniotrigona thoracica (*G. thoracica*) is a type of stingless bee commonly found in Malaysia. *G. thoracica* belongs to the family of Hymenoptera in subfamily level of Meliponinae [6]. The average body size of *G. thoracica* is 7.44±2.05 mm. *G. thoracica* has brownish body with dark brown wings and white tips at the apex of the wings [7]. Monsoon seasons and floral abundance in the perimeter where bees live are the factors that influence the taste of honey produced by *G. thoracica* stingless bee which is sweet-sour in nature [8].

Honey composition varies depending on the species of bee and the types of plants from which the bee consumes nectar [9]. When comparing the organoleptic and physicochemical properties of stingless bee honey with Apis mellifera honey, there are some notable differences which stingless bee honey has greater moisture content and acidity [10]. For instance, *P. tobagoensis* stingless bee honey has a very high-water content which can reach up to 42% [11] and

Partamona epiphytophila stingless bee honey contained 45.8% moisture [12].

The high moisture content of stingless bee honey could lead to unwanted fermentation and crystallization form. Hence, it will affect the quality of honey in terms of acidic taste and undesirable appearance [13]. The International Honey Commission (IHC) has set the standard for good quality of honey; should have a moisture content that is not more than 20 g/100 g [14]. However, this standard only can be applied to *Apis mellifera* honey since stingless bee honey contains high moisture in nature.

To make sure stingless bee honey meets the standard set by IHC, some methods have been carried out to reduce its moisture content. The conventional method is to heat the honey first before storage to eliminate yeast and reduce the moisture content. However, the increase of hydroxymethylfurfural (HMF) content and enzyme activity unfavorably could happen when uncontrolled heating applied to honey. HMF has become an indicator of the freshness of honey and consider as overheating if the content is high [15].

The clay pot is made up of clay as suggest by its name. Clay is a geologic product of the earth that is readily available and the process of making clay pot does not require extensive processing [16]. Previous researchers proved that clay pot can be used as a water filter because of the fact that water will flow out through the wall of the clay pot and left the unwanted material in it ([17] – [19]). With this mechanism, the clay pot can be applied to store stingless bee honey for the reduction of moisture content in order to meet the standard set by IHC [14]. The uses of clay pot as a medium for moisture content reduction of honey to avoid rapid fermentation can also benefit the beekeeper since it is convenient and economical.

The objective of this work was to investigate the application of clay pot as a storage medium for moisture reduction of *G. thoracica* stingless bee honey. The physicochemical properties were also examined in terms of total soluble solids (TSS), viscosity, water activity (a_w), pH, free acidity, electrical conductivity (EC), color parameter and color intensity.

II. Material and Method

A. Clay pot design

Clay pots were custom designed by Belipot Craft Ceramic Sdn. Bhd. in a cylindrical shape with lids (Fig. 1). The wall thickness of the clay pots was 0.5 cm. After shaping the clay into the desired design mold, the pots were dried and subsequently placed in a furnace at 1100˚C for 7 hr. Each clay pot was having a volume of approximately 75 cm3. The surface roughness, Ra, of the clay pot (7.31 ± 2.82 μm) was identified using a portable surface roughness tester (Mitutoyo, SJ-201P, Japan). The clay pots were sterilized in an autoclave at 121˚C for 15 min.

B. Material and sampling

A 2500g of raw G. thoracica stingless bee honey were obtained from University Agricultural Park, Universiti Putra Malaysia. Each cylinder clay pots and glass bottle (as control) were filled with 50g of G. thoracica stingless bee honey. Then, all cylinder clay pots and glass bottles were stored in an incubator at 25˚C and analyses on the honey were done during the storage time of 21 days (Day 0, 1, 3, 5, 7, 14 and 21).

Fig. 1 Front view of cylindrical clay pot

C. Physicochemical determinations

1) Moisture content and total soluble solids: The moisture content and total soluble solids of *G. thoracica* honey were determined using an Abbe refractometer (Digital ABBE Refractometer AR2008, A.Kruss, Germany) at 20˚C. According to Reference [20], the refractive index (RI) reading obtained from the Abbe refractometer was inserted in the Equation (1) to get the value of moisture content.

$$W\ (g/100g) = [-0.2681 - \log(RI - 1)] / 0.002243 \qquad (1)$$

The total soluble solid of honey was recorded from the reading obtained from the Abbe refractometer and expressed in ˚Brix.

2) Viscosity: A rheometer (AR-G2, TA Instruments, New Castle, USA) provided with a software (TA Instrument Advantage TM software) was used to determine the rheological properties of *G. thoracica* stingless bee honey at room temperature (25°C) [13]. To determine the viscosity of the honey, a 60 mm diameter plate geometry and 1° steel cone angle was used. Circulated water system was responsible to control the temperature. Steady state measurement was conducted with shear rate of 1-1000 s^{-1} at 20°C. About 2 g of honey was slowly loaded onto the sample dish to avoid any possible bubble. The plate gap was set to 1000µm. The average viscosity of honey was calculated based on the 30 points data given by the software.

3) Water activity: The measurement of the water activity (a_w) of honey was took place by a water activity meter (Aqualab CX2, Decagon Devices Inc, WA, USA) at room temperature (25°C). A saturated salt solution was used to calibrate the equipment in the water activity range of interest.

2g of honey was placed in the sample dishes for the water activity measurement.

4) pH and free acidity: For the determination of pH and free acidity of honey samples, AOAC Official Method 962.19 was applied [21]. pH was determined by using a pH meter (Sartorius, PB-10) at room temperature. Buffer solutions of pH 4.00 and pH 7.00 were used to calibrate the pH meter. The honey solution that consists of 10g of *G.thoracica* honey dissolved in 75 mL of distilled water was prepared and the pH reading was recorded. Then, the titration of the honey solution by 0.1 M NaOH was carried out until the solution achieved pH 8.30 and the amount of NaOH used was recorded. The free acidity of honey was calculated by multiplying the volume (mL) of 0.1 M NaOH used in titration with 10. The free acidity was expressed as milliequivalent acid per kg of honey (meq/kg).

5) Electrical conductivity: To determine the electrical conductivity of honey, honey solution of 20% (w/v) was prepared by mixing 20g of honey in distilled water. Prior to the measurement, the electrical conductivity electrode (EC-5061, Taiwan Gaoji EZDO, Taiwan) was dipped into the calibrating solution. The results were reported in milliSiemens per centimetre ($mS.cm^{-1}$) [14].

6) Colour parameter and color intensity: Colour parameter which *consist* of L* (lightness), a* (red/green (+a*/-a*)), and b* (yellow/blue (+b*/-b*)) were measured using a spectrophotometer (UltraScan Pro, HunterLab, USA) equipped with EasyMatch QC software. Before beginning the color measurement of the samples, the instrument was standardised using a light trap followed by white tile. A port plate of 0.780 inches is used. For the color measurement, a clear glass cell (20mm depth x 55 mm width x 57 mm height) was used as a honey holder. Glass cell filled with samples was then ready to be measured for the color parameter. According to Reference [23], the colour intensity of *G. thoracica* stingless bee honey was measured using the Pfund method; honey was diluted to 50g/100ml (w/v) in ultrapure water. The absorbance of the honey was determined using UV-VIS spectrophotometer at 636 nm and then converted to the Pfund scale according to the Equation (2):

$$mmPfund = -38.7 + 371.39xAbs \quad (2)$$

7) Statistical analysis: All data were conducted triplicate and the data expressed as mean ± standard deviation. The data were analysed by analysis of variance (ANOVA) using Minitab Statistical Software (Version 17, Minitab Inc.), and the difference among means at a significance level of 5% was performed by Tukey's range test.

III. Results and Discussion

The physicochemical properties of *G. thoracica* honey stored in a glass bottle (as control) and clay pot for 21 days at 25˚C are shown in Table 1. Moisture content is practically the most essential quality specification, as it affects the storage life of honey. Honey fermentation caused by osmotolerant yeasts potentially happened when honey contains high moisture [24]. According to Table 1, the moisture content of *G. thoracica* honey on Day 0 (28.03±0.18g/100g) was in the range of 26.5-31.8 g/100g for stingless bee honey from Malaysia as reported by Reference [25]. The moisture content of *G. thoracica* honey stored in a clay pot for 21 days showed a significant decrease from 28.03±0.18g/100g on Day 0 to 16.51±0.10g/100g on Day 21 while for the control, the moisture content slightly decreased from 28.03±0.18g/100g to 27.25±0.15g/100g. In between Day 7 to Day 21, the value of moisture content of *G. thoracica* honey has achieved to the standard set by IHC which was not more than 20% [14]. The water was absorbed into the wall of the clay pot since clay characteristic is porous substance [26]. This result indicated that the moisture content of *G. thoracica* honey was reduced within a week by using a clay pot as a storage medium which stored at an ambient temperature of 25˚C.

Total soluble solid is related to the moisture content and sugar content of honey. Therefore, the higher the water content, the lower the soluble solid content [6]. On Day 0, the TSS value for *G. thoracica* honey was 70.5±0.1 °Brix. Previous studies found that the TSS value for stingless bee honey from Malaysia was in the range of 60.85-72.25 °Brix [27] and these values were slightly higher (71.1 to 74.7 °Brix) for stingless bee honey from Brazilian semiarid region [23]. The variation of TSS value between Malaysia and Brazil honey might be affected by the type of stingless bees as well as climatic and geographic factors [28]. TSS of *G. thoracica* honey stored in a clay pot was increased from 70.5±0.1 °Brix on Day 0 to 81.9±0.0 °Brix on Day 21. On the other hand, the total soluble solid of the control was slightly increased from 70.5±0.1 °Brix on Day 0 to 71.3±0.1 °Brix on Day 21 (Table 1).

The initial (Day 0) viscosity of *G. thoracica* honey was 0.125 Pa.s which was lower (0.29 Pa.s) than that of *Heterotrigona itama* honey as reported by Reference [29]. In our study, the moisture content of honey stored in a clay pot was decreased and subsequently, the viscosity of honey was increased throughout the storage duration. Reference [30] also found that honey with the highest viscosity (23.4 Pa.s) had the lowest moisture content (15g/100g). Reference [31] stated that the higher dehydration temperature and longer duration which resulted in higher moisture loss and produced more viscous honey due to the caramelization process. No significant difference in this parameter was observed for honey stored in a glass bottle during storage. The viscosity of honey stored in a clay pot on Day 21 was 16.46 Pa.s. When the honey is too viscous, it would affect the storage, handling, and processing of honey.

To date, there is no available standard has been set for water activity of stingless bee honey. The higher value of a_w which is above 0.60 represents a critical threshold for microorganisms to grow [32]. In this study, the initial (Day 0) a_w value of *G. thoracica* honey was 0.78. The previous study found that the water activity of *Trigona carbonaria* honey was ranging from 0.73 to 0.75 [33]. Lower a_w value was obtained from Turkish blossom honey with a range of 0.50 to 0.69 [34]. The water activity values for honey stored in a

TABLE I

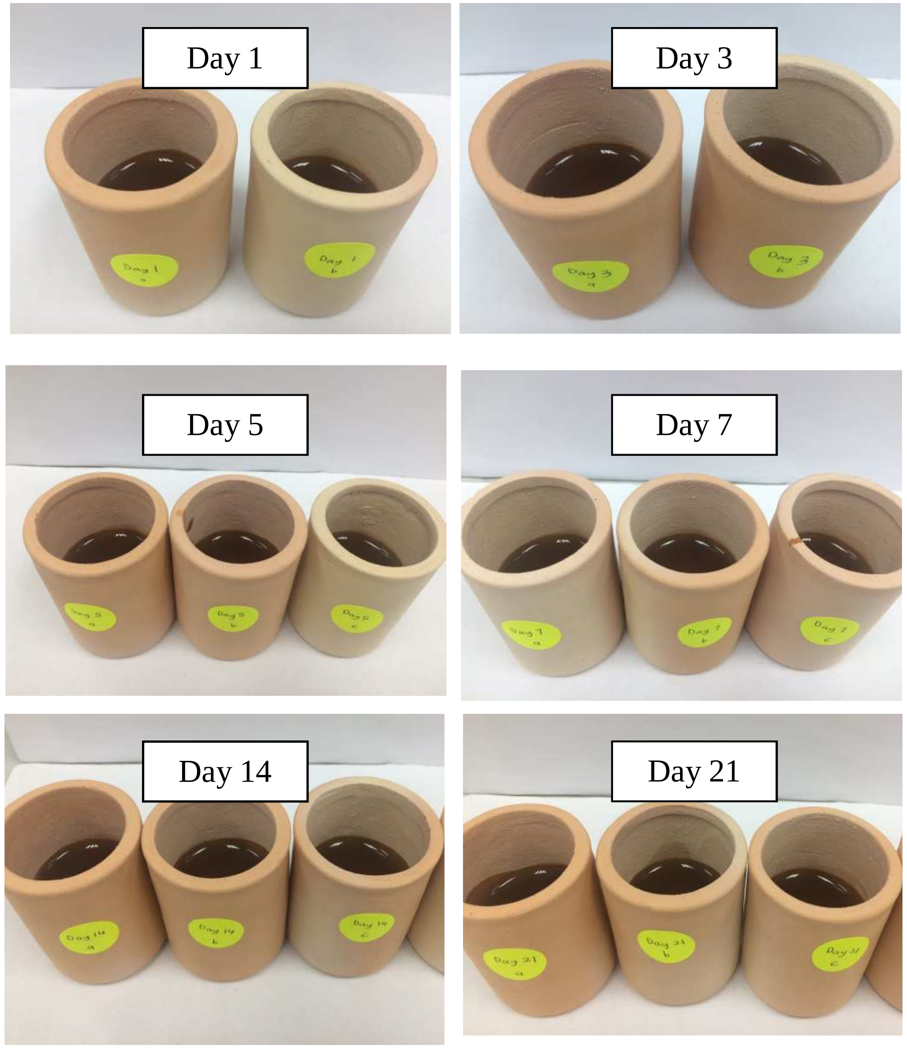
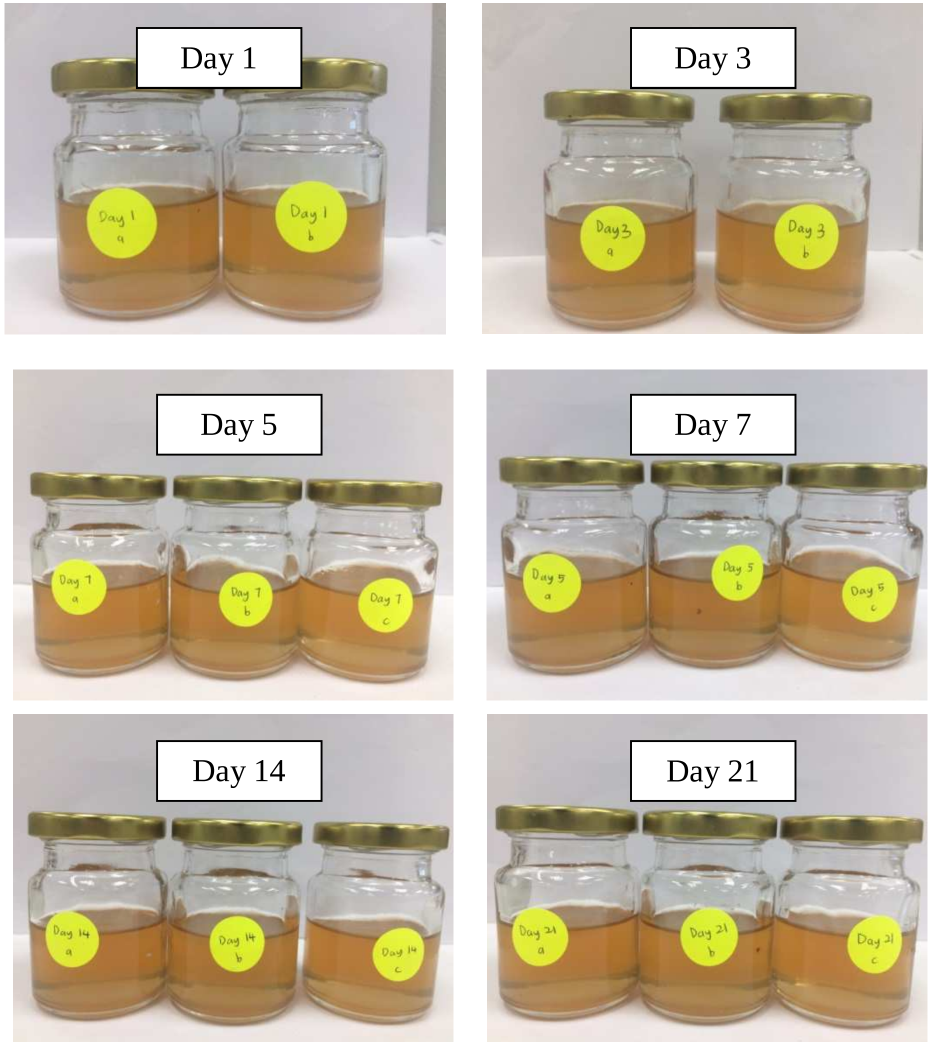
PHYSICOCHEMICAL PROPERTIES OF G. THORACICA STINGLESS BEE HONEY IN A GLASS BOTTLE (GB) AND CLAY POT (CP) DURING 21 DAYS OF STORAGE

Physicochemical properties	Samples	Storage time (days) at 25˚C						
		0	1	3	5	7	14	21
MC (g/100g)	GB	28.0±0.2^{Aa}	28.3±0.3^{Aa}	28.2±0.4^{Aa}	27.3±0.3^{Ba}	27.3±0.1^{Ba}	27.0±0.1^{Ba}	27.3±0.1^{Ba}
	CP	28.0±0.2^{Aa}	26.2±0.1^{Bb}	24.1±0.0^{Cb}	21.8±0.1^{Db}	20.2±0.1^{Eb}	18.0±0.0^{Fb}	16.5±0.1^{Gb}
TSS (˚Brix)	GB	70.5±0.1^{Ba}	70.3±0.2^{Bb}	70.3±0.4^{Bb}	71.2±0.3^{Ab}	71.2±0.1^{Ab}	71.5±0.1^{Ab}	71.3±0.2^{Ab}
	CP	70.5±0.1^{Ga}	72.3±0.1^{Fa}	74.4±0.2^{Ea}	76.7±0.1^{Da}	78.2±0.1^{Ca}	80.4±0.0^{Ba}	81.9±0.0^{Aa}
Viscosity (Pa.s)	GB	0.125±0.007^{Ba}	0.285±0.088^{Aa}	0.179±0.004^{ABb}	0.188±0.003^{ABb}	0.194±0.006^{ABb}	0.184±0.002^{ABb}	0.191±0.003^{ABb}
	CP	0.125±0.007^{Da}	0.284±0.018^{Da}	0.820±0.016^{Da}	1.224±0.068^{Da}	3.171±0.100^{Ca}	6.742±0.402^{Ba}	16.468±0.65^{Aa}
a_w	GB	0.779±0.001^{Aa}	0.693±0.001^{Ca}	0.683±0.007^{Ca}	0.745±0.004^{Ba}	0.723±0.006^{Ba}	0.777±0.008^{Aa}	0.774±0.000^{Aa}
	CP	0.779±0.001^{Aa}	0.673±0.008^{Ba}	0.640±0.011^{BCb}	0.665±0.004^{Bb}	0.642±0.004^{BCb}	0.608±0.031^{Cb}	0.601±0.006^{Cb}
pH	GB	3.43±0.01^{Aa}	3.40±0.01^{Bb}	3.40±0.00^{Bb}	3.35± 0.01^{Cb}	3.36±0.00^{Db}	3.30±0.00^{Eb}	3.16±0.01^{Fb}
	CP	3.43±0.01^{Aa}	3.42±0.01^{Ba}	3.42±0.01^{ABa}	3.37±0.01^{Ea}	3.40±0.00^{Ca}	3.38±0.00^{Da}	3.27±0.00^{Fa}
FA (meq/kg)	GB	106.7±0.6^{Fa}	106.7±0.6^{Fa}	114.7±0.6^{Ea}	117.7±0.6^{Da}	121.7±0.6^{Ca}	131.7±0.6^{Ba}	146.3±1.5^{Aa}
	CP	106.7±0.6^{Eb}	103.7±0.6^{Fb}	105.7±1.5^{EFb}	111.0±1.0^{Db}	114.0±1.0^{Cb}	119.0±0.0^{Bb}	121.7±0.6^{Ab}
EC(mS cm^{-1})	GB	0.20±0.00^{Aa}	0.20±0.00^{Aa}	0.20±0.00^{Aa}	0.20±0.00^{Aa}	0.20±0.00^{Aa}	0.20±0.00^{Aa}	0.20±0.00^{Aa}
	CP	0.20±0.00^{Aa}	0.15±0.07^{Aa}	0.15±0.07^{Aa}	0.15±0.07^{Aa}	0.20±0.00^{Aa}	0.15±0.07^{Aa}	0.20±0.00^{Aa}
L* parameter	GB	26.48±0.03^{Aa}	26.53±0.04^{Aa}	26.02±0.03^{Ba}	25.74±0.02^{Ca}	25.37±0.03^{Db}	25.04±0.05^{Eb}	24.98±0.07^{Eb}
	CP	26.48±0.03^{Ba}	26.46±0.02^{BCa}	25.86±0.05^{Db}	25.70±0.03^{Ea}	25.93±0.01^{Ea}	26.69±0.05^{Aa}	26.38±0.04^{Ca}
a* parameter	GB	2.25±0.01^{BCa}	2.35±0.12^{Ba}	2.76±0.19^{Aa}	2.40±0.11^{Ba}	2.33±0.05^{Ba}	1.95±0.17^{CDb}	1.86±0.05^{Db}
	CP	2.25±0.02^{Da}	2.44±0.05^{CDa}	2.80±0.09^{Aa}	2.50±0.09^{BCa}	2.35±0.07^{CDa}	2.49±0.12^{BCa}	2.69±0.03^{Aba}
b* parameter	GB	2.93±0.08^{Ba}	3.43±0.15^{Aa}	2.49±0.05^{Ca}	2.20±0.14^{Ca}	1.80±0.02^{Db}	1.14±0.24^{Eb}	0.90±0.15^{Eb}
	CP	2.93±0.08^{ABa}	3.07±0.16^{Ab}	2.52±0.14^{CDa}	2.17±0.07^{Da}	2.26±0.06^{CDa}	2.60±0.17^{BCa}	2.32±0.23^{CDa}
CI (mmPfund)	GB	121.6±1.2^{Da}	123.5±1.1^{Db}	125.5±1.6^{Db}	131.3±1.4^{Cb}	132.4±1.9^{Cb}	138.1±1.3^{Bb}	146.3±1.0^{Ab}
	CP	121.6±1.2^{Ea}	126.6±0.7^{Da}	135.2±0.8^{Ca}	142.5±1.1^{Ba}	140.7±1.0^{Ba}	147.2±1.0^{Aa}	149.5±0.6^{Aa}

MC: moisture content; TSS: total soluble solid; a_w: water activity; FA: free acidity; EC: electrical conductivity; CI: color intensity. Different capital letters in the same row indicate significant differences ($p \leq 0.05$) of a particular sample on different days of analysis. Different lowercase letters in the same column indicate significant differences ($p \leq 0.05$) between the samples on a particular day of analysis.

TABLE IIIII

THE STORAGE OF G. THORACICA STINGLESS BEE HONEY STORED IN CLAY POTS AND GLASS BOTTLES FOR 21 DAYS AT 25˚C

G. thoracica stingless bee honey stored in clay pots	*G. thoracica* stingless bee honey stored in glass bottles
	

clay pot reduced substantially compared to that of honey stored in a glass bottle. Honey stored in a clay pot has achieved the value of aw of 0.60 after 14 days but for honey stored in a glass bottle, the a_w value was still beyond 0.77 up to Day 21 (Table 1).

pH values, which are of great importance parameter during the extraction and storage of honey, as they influence the texture, stability and shelf life [35]. Honey is known for its acidic characteristics. According to Table 1, the pH of *G. thoracica* honey was initially 3.43±0.01 on Day 0. Reference [36] stated that the pH value for stingless bee honey is ranging between 3.2 and 4.5. Reference [37] reported the pH value for stingless bee honey from Thailand is ranging from 3.3 to 4.1. After 21 days of storage in the clay pot and glass bottle, the honey became more acidic with pH of 3.27 and 3.16, respectively (Table 1). The acidic pH range in the honey samples prevents the honey from constant contamination by various species of microorganisms and thus helps to ensure longer shelf life. A similar result was obtained for *G. thoracica* honey from Malaysia which decreased gradually throughout the storage of 42 days [38].

According to Reference [25], free acidity of honey is a parameter correlates with the organic acid present in the honey. Honey tends to ferment by converting sugars to organic acid thus increasing the acidity of the honey. According to Table 1, the free acidity value of *G. thoracica* honey on Day 0 was 106.7±0.6 meq/kg which fall in the range of free acidity for *G. thoracica* reported by Reference [27] (101.83 to 170.50 meq/kg). Our result also in the range of free acidity of fresh *Tetragonalu laeviceps-pagdeni* (78.5 to 118.0 meq/kg) from Thailand [37]. Honey stored in a clay pot increased to 121.7±0.6 meq/kg on Day 21 while the free acidity value of the control sample was increased to 146.3±1.5 meq/kg on Day 21. The free acidity value of honey in the clay pot and glass bottle was found to be significantly different on Day 21.

The electrical conductivity of honey is directly related to the concentration of mineral salts, organic acids and proteins, which are being very useful in the determination of the floral origin [39]. According to Table 1, the value of electrical conductivity on Day 0 was 0.20 mS cm^{-1} which found to be in the range of the electrical conductivity of stingless bee honey from Brazil that ranging from 0.15 to 1.34 mS cm^{-1} [9]. No significant difference was observed in the electrical conductivity value of honey between honey stored in a glass bottle with honey stored in a clay pot throughout 21 days of storage. The electrical conductivity values of honey obtained in this study were acceptable according to international standards (< 0.8 mS cm^{-1}) [40].

The type of nectar used in honey production [41] and the minerals present [42] could be influenced the color of the honey. The changes in color parameters of *G. thoracica* honey during storage at 25˚C for 21 days are shown in Table 1. The * value of *G. thoracica* honey stored in a clay pot was increased while the control sample was decreased during the storage period. In the meantime, *G. thoracica* honey in both storage containers showed decreased values of b* and L*. On the other hand, the colour intensity of *G. thoracica* honey in both containers was found to be increased during storage. On Day 0, the color intensity of *G. thoracica* was 121.6±1.2 mmPfund. The result obtained was in the range of 39 to 150 mmPfund for blossom honey and honeydew honey from Northwest Spain, respectively [41]. At the end of the storage period (Day 21), both *G. thoracica* honey stored in the clay pot and glass bottle had dark color in which the value of Pfund was higher than 114mm. USDA (1985) mentioned that honey with the Pfund value greater than 114mm had a darker color [43]. The darker color of honey could be due to the breakdown of volatile substances, the caramelization of the sugar, and the production of brown melanoidin [44].

IV. Conclusion

In this work, the physicochemical properties of *G.thoracica* stingless bee honey originated from Malaysia during 21 days of storage in the clay pot and a glass bottle has been studied. Storage of *G.thoracica* stingless bee honey in a clay pot does make a significant reduction of moisture content within a week since water can penetrate through its wall. Therefore, the clay pot can be used as a storage medium to reduce the moisture content of honey in order to meet the standard. *G.thoracica* stingless bee honey in a clay pot was still retained good quality compared to the control sample (honey in a glass bottle) even though there were many changes in the physicochemical properties of honey during storage. The low water activity and pH with a high sugar concentration of honey stored in a clay pot could prevent the growth of many microorganisms. Therefore, the deterioration of stingless bee honey can be minimized and would help the entrepreneurs to sustain the quality of honey before the product distribution.

Acknowledgment

We would like to express our gratitude to the Ministry of Education Malaysia for the Transdisciplinary Research Grant Scheme (TRGS/1/2016/UPM/01/5/3) for the research funding. The author also would like to thank UPM for the facilities provided and University Agricultural Park, UPM for honey sample collection.

References

[1] P. V. Rao, K. T. Krishnan, N. Salleh, and S.H. Gan, “Biological and therapeutic effects of honey produced by honey bees and stingless bees: a comparative review”, *Brazilian Journal of Pharmacognosy*, vol. 26, pp. 657–664, 2016.

[2] M. A. Abd Jalil, A. R. Kasmuri, and H. Hadi, “Stingless bee honey, the natural wound healer: a review”, *Skin Pharmacology and Physiology*, vol. 30, pp. 66–75, 2017.

[3] M. Halcroft, R. Spooner-Hart, and L. A. Dollin, “Australian Stingless Bees,” in *Pot Honey: A Legacy of Stingless Bees*, P. Vit, S. R. M. Pedro, D. W. Roubi, Eds. New York, NY, USA: Springer, 2013.

[4] C. D. Michener, “The Meliponini,” in *Pot Honey: A Legacy of Stingless Bees,* P. Vit, S. R. M. Pedro, D. W. Roubi, Eds. New York, NY, USA: Springer, 2013

[5] B. Chuttong, Y. Chanbang, K. Sringarm, and M. Burgett, “Physicochemical profiles of stingless bee (Apidae: Meliponini) honey from South East Asia (Thailand),” *Food Chemistry*, vol. 192, pp. 149–155, 2016b.

[6] A. Nordin, H. Q. A. V. Sainik, S. R. Chowdhury, A. Saim, and R. B. H. Idrus, “Physicochemical properties of stingless bee honey from around the globe: A comprehensive review”, *Journal of Food Composition and Analysis*, vol. 73, pp. 91–102, 2018.

[7] W. A. Azmi, R. Ghazi, and I. S. Nasharuddin, “Morphological, Nest Architecture and Colony Characteristics of Stingless Bees (Hymenoptera; Apidae; Meliponini) from Tasik Kenyir, Terengganu”, *Greater Kenyir Landscapes; Springer: Cham*, pp.111–121, 2019.

[8] N. F. M. Saufi, and K. Thevan, “Characterization of nest structure and foraging activity of stingless bee, Geniotrigona thoracica (hymenopetra: apidae; meliponini)”, *Jurnal Teknologi*, vol. 77(33), pp. 69–74, 2015.

[9] F. C. Biluca, F. Braghini, L. V. Gonzaga, A. Carolina, O. Costa, and R. Fett, “Physicochemical profiles, minerals and bioactive compounds of stingless bee honey (Meliponinae)”, *Journal of Food Composition and Analysis*, vol. 50, pp. 61–69, 2016.

[10] P. Vit, S. Bogdanov, and V. Kilchenmann, “Composition of Venezuelan honeys from stingless bees (Apidae: Meliponinae) and Apis mellifera L”, *Apidologie*, vol. 25, pp. 278–288, 1994.

[11] Bijlsma, L., Bruijn, L. L. M. de, Martens, E. P., & Sommeijer, M. J. (2006). Water content of stingless bee honeys (Apidae, Meliponini): interspecific variation and comparison with honey of Apis mellifera*. *Apidologie*, *37*, 480–486.

[12] A. J. Rodríguez-Malavera, C. Rasmussen, M. G. Gutiérrez, F. Gild, B. Nieves, and P. Vit,“Properties of honey from ten species of Peruvian stingless bees”, *Natural Product Communications*, vol. 4 (9), pp. 1221–1226, 2009.

[13] K. Y. Chong, N. L. Chin, and Y. A. Yusof, “Thermosonication and optimization of stingless bee honey processing”, *Food Science and Technology International*, vol.23(7), pp. 608–622, 2017.

[14] International Honey Commission, 2009. Harmonised Methods of the International Honey Commission, 63 pp. Swiss Bee Research Centre, Bern: FAM, Liebefeld

[15] R. Subramanian, H. U. Hebbar, and N. K. Rastogi, “Processing of honey: a review”, *International Journal of Food Properties*, vol. 10, pp. 127–143, 2007.

[16] D. Rhodes, *Clay and Glazes for Potter*. Philadelphia: Chilton Book Company, 1957.

[17] Y. Dah-traoré, L. Zerbo, M. Seynou, and R. Ouedraogo, “Mechanical, Microstructural and Mineralogical Analyses of Porous Clay Pots Elaborated with Rice Husks”, *Journal of Minerals and Materials Characterization and Engineering*, vol. 6, pp. 257–270, 2018.

[18] A. J. Varkey, and M. Dlamini, “Point-of-use water purification using clay pot water filters and copper mesh”, *Water SA*, vol. 38(5), pp. 721–726, 2012.

[19] W. Wongsakoonkan, T. Prechthai, and K. Tantrakarnapa, “Suitable types and constituent ratios for clay-pot water filters to improve the physical and bacteriological quality of drinking water”, *EnvironmentAsia*, vol. 7(2), pp. 117–123, 2014.

[20] G. Sesta, and L. Lusco, “Refractometric determination of water content in royal jelly*”, *Apidologie*, vol. 39, 2008.

[21] Association of Official Analytical Chemist (AOAC). In: W. Horwitz (Ed.) (18. ed.). Gaithersburg, MD, USA: Association of Official Analytical Chemists, 2005.

[22] J. M. B. de Sousa, E. L. de Souza, G. Marques, M. de T. Benassi, B. Gullón, M. M. Pintado, and M. Magnani, “Sugar profile, physicochemical and sensory aspects of monofloral honeys produced by different stingless bee species in Brazilian semi-arid region”, *LWT - Food Science and Technology*, vol. 65, pp. 645–651, 2016.

[23] A. Abdulkhaliq, and K. M. Swaileh, “Physico-chemical properties of multi-floral honey from the West Bank , Palestine”, *International Journal of Food Properties*, vol. 20(2), pp. 447–454, 2017.

[24] M. F. Abu Bakar, S. B. Sanusi, F. I. Abu Bakar, O. J. Cong, and Z. Mian, “Physicochemical and antioxidant potential of raw unprocessed honey from Malaysian stingless bees”, *Pakistan Journal of Nutrition*, vol. 16(11), pp. 888–894, 2017.

[25] M. P. Mathai, and A. Simon, “Water diffusion through pottery discs of varying porosity”, *Journal of Tropical Agriculture*, vol. 42(1–2), pp. 63–65, 2004.

[26] S. Shamsudin, J. Selamat, M. Sanny, S. Abd, N. N. Jambari, Z. Mian, and A. Khatib, “Influence of origins and bee species on physicochemical, antioxidant properties and botanical discrimination of stingless bee honey”, *International Journal of Food Properties*, vol. 22(1), 239–264, 2019.

[27] C. A. Fuenmayor, A. C. Díaz-Moreno, C. M. Zuluaga-Domínguez, M. C. Quicazán, “Honey of Colombian stingless bees: nutritional characteristics and physicochemical quality indicators”, in *Pot Honey: A Legacy of Stingless Bees*, P. Vit, S. R. M. Pedro, D. W. Roubi, Eds. New York, NY, USA: Springer, 2013, pp. 3-17.

[28] S. P. Kek, N. L. Chin, Y. A. Yusof, S. W. Tan, and L. S. Chua, “Classification of entomological origin of honey based on its physicochemical and antioxidant properties”, International *Journal of Food Properties*, pp. 1–16, 2017.

[29] S. Yanniotis, S. Skaltsi, and S. Karaburnioti, “Effect of moisture content on the viscosity of honey at different temperatures”, *Journal of Food Engineering*, vol. 72, pp. 372–377, 2006.

[30] S. K. Yap, N. L. Chin, Y. A. Yusof, and K. Y. Chong, “Quality characteristics of dehydrated raw Kelulut”, *International Journal of Food Properties*, vol. 22(1), pp. 556–571, 2019.

[31] P. M. da Silva, C. Gauche, L. V. Gonzaga, A. C. O. Costa, and R. Fett, “Honey: chemical composition, stability and authenticity”, *Food Chemistry*, vol. 196, pp. 309–323, 2016.

[32] L. P. Oddo, T. A. Heard, A. Rodríguez-malaver, R. A. Pérez, M. Fernández-muiño, M. T. Sancho, G. Sesta, L. Lusco, P. Vit, “Composition and Antioxidant Activity of Trigona carbonaria Honey from Australia”, *Journal of Medicinal Food*, vol. 11(4), pp. 789–794, 2008.

[33] F. Tornuk, S. Karaman, I. Ozturk, O. S. Tokera, B. Tastemur, O. Sagdic, M. Dogan, and A. Kayacier, “Quality characterization of artisanal and retail Turkish blossom honeys: Determination of physicochemical, microbiological, bioactive properties and aroma profile”, *Industrial Crops & Products*, vol. 46, pp. 124–131, 2013.

[34] A. Terrab, A. F. Recamales, D. Hernanz, and F. J. Heredia, “Characterisation of Spanish thyme honeys by their physicochemical characteristics and mineral contents”, *Food Chemistry*, vol. 88, pp. 537–542, 2004.

[35] M. Solayman, A. Islam, S. Paul, Y. Ali, M. I. Khalil, N. Alam, and S. H. Gan, “Physicochemical properties, minerals , trace elements , and heavy metals in honey of different origins : a comprehensive review”, *Comprehensive Reviews in Food Science and Food Safety*, vol. 15, pp. 219–233, 2016.

[36] B. Chuttong, Y. Chanbang, K. Sringarm, and M. Burgett, “Effects of long term storage on stingless bee (Hymenoptera: Apidae: Meliponini) honey”, *Journal of Apicultural Research*,2016a.

[37] M. N. Lani, A. H. Zainudin, S. B. Abdul Razak, A. Mansor, and Z. Hassan, “Microbiological quality and pH changes of honey produced by stingless bees, Heterotrigona itama and Geniotrigona thoracica stored at ambient temperature”, *Malaysian Applied Biology*, vol. 46(3), pp. 89–96, 2017.

[38] L. B. de Almeida-Muradian, K. M. Stramm, A. Horita, O. M. Barth, A. da S. de Freitas, and L. M. Estevinho, “Comparative study of the physicochemical and palynological characteristics of honey from Melipona subnitida and Apis mellifera”, *International Journal of Food Science and Technology*, vol. 48, pp. 1698–1706, 2013.

[39] Codex Alimentarius Commission (2001). Alinorm 41/10: Revised standard for honey, Alinorm 1, 19–26.

[40] E. Olga, F.-G. María, and S. M. Carmen, “Differentiation of Blossom Honey and Honeydew Honey from Northwest Spain”, *Agriculture*, pp. 25–37, 2012.

[41] A. S. Alqarni, A. A. Owayss, A. A. Mahmoud, and M. A. Hannan, “Mineral content and physical properties of local and imported honeys in Saudi Arabia”, *Journal of Saudi Chemical Society*, vol. 18, pp. 618–625, 2014.

[42] USDA. 1985. United states standards for grades of extracted honey. May 23. Washington, DC: USDA, Agricultural Marketing Service

[43] L. D. Sant’Ana, A. B. B. Ferreira, M. C. A. Lorenzon, R. L. L. Berbara, and R. N. Castro, “Correlation of total phenolic and flavonoid contents of Brazilian honeys with colour and antioxidant capacity”, *International Journal of Food Properties*, vol. 17, pp. 65–76, 2014.