DETERMINATION OF ELECTRICAL CONDUCTIVITY AND PH FROM THE DIFFERENT TYPE HONEY SUCTION PUMP

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SITI NUR ATIKAH BINTI MOHD NOOR

Thesis submitted in fulfillment of the requirements
for the award of the
Bachelor Degree in Energy and Environment with Honors

Faculty of Engineering Technology

UNIVERSITI MALAYSIA PAHANG

JANUARY 2019

Dedication to My Beloved Family and Friends

ACKNOWLEDGEMENTS

I would like to express my gratitude to those who gave me the possibility to complete this report. Special thanks to my supervisor Dr Shamil Shaari whose help, recommended suggestion and encourage me in the project and writing this report. I also sincerely thank for my supervisor for the time he spends to proofreading and correcting my mistakes. Many thanks also goes to all lecturer and staffs who has given their full effort in guiding the team especially En. Joharizal Johari in achieving the goal and as well as keeping and maintain the project in track. I also want to express my gratitude toward my teammates during the project for their team works and passion to succeed the project.

I also indebted to my parent, En. Mohd Noor Said and Pn Siti Noor Haizat Mohd Ishak and siblings, Nur Athifah Najwani, Nur Athilah Amirah and Muhammad Azri Najmi for giving me fully support and also for their love, dream and sacrifice throughout my life. There no word could describe my appreciation toward their devotion and faith in my success and goals. Specially thank also to my grandparents who also giving me continuous support to me.

Lastly, sincerely thank for all my friends in University Malaysia Pahang especially in course Energy and Environment and all others. Thank for being my sunshine when the sky is grey. I would like to thanks any person which contributes to my final year project directly or indirectly. I would like to acknowledge their comments and suggestions, which was impaortant for the successful completion of this study.

ABSTRACT

In this thesis presents the electrical conductivity and pH values of stingless bee honey samples collected from two different suction circulation; diaphragm vacuum pump and peristaltic pump was investigated. The honey samples were collected from the area of Bukit Goh, Kuantan, Pahang. Physicochemical analyses of parameters such as electrical conductivity and pH values have an important part in defining the overall properties of the honey and acquiring the quality of stingless bee honey in both type of pump. The data from the electrical conductivity shows that the honey samples from the diaphragm vacuum pump and peristaltic pump are 0.48 – 0.95 mS/cm and 0.25- 0.80 mS/cm respectively. Meanwhile, the data from the pH shows that the honey samples from the diaphragm vacuum pump and peristaltic pump are in range of 3.32 – 3.53 and 3.39 – 3.5 respectively. From the research, the value of electrical conductivity of honey sample from diaphragm vacuum pump is slightly higher than peristaltic pump but the pH values of the both pump are same in values. In conclusion, the peristaltic pump can maintain the physicochemical characteristics of stingless bee honey eventhough the both pumps have different in many ways.

ABSTRAK

Thesis ini membentangkan nilai kekonduksian elektrik dan nilai pH daripada madu kelulut yang telah dikumpul menggunakan dua jenis aliran pam yang berbeza iaitu pam diafragma vakum dan pam peristaltik telah diselidik. Sampel madu kelulut ysng dikaji adalah dikumpulkan daripada Bukit Goh, Kuantan, Pahang. Analisis faktor fizikokimia seperti nilai kekonduksian elektrik dan pH sangat penting dalam menentukan sifat madu tersebut secara keseluruhan serta menetukan kualiti madu kelulut dengan menggunakan dua pam yang berbeza. Data menunjukkan bahawa nilai kekonduksian elektrik dari sampel madu yang dikumpulkan melalui pam vakum diafragma dan pam peristaltik adalah 0.48 - 0.95 mS / cm dan 0.25- 0.80 mS / cm. Sementara itu, nilai pH daripada sampel madu dari pam vakum diafragma dan pam peristaltik berada dalam lingkungan 3.32 - 3.53 dan 3.39 - 3.50. Daripada kajian, nilai kekonduksian elektrik sampel madu dari pam vakum diafragma lebih tinggi daripada pam peristaltik tetapi nilai pH bagi kedua- dua jenis pam adalah sama. Kesimpulannya, pam peristaltik dapat mengekalkan ciri-ciri fizikokimia madu kelulut walaupon kedua-dua pam ada banyak perbezaan.

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g	Gram
ºC	Celsius
µS/cm	Electric conductivity value in micro-Siemens per centimeter
mS/cm	Electric conductivity value in meter-Siemens per centimeter
±	Plus- minus sign
nm	Measurement of wavelength
V	Volume
ml	Millimeter

LIST OF ABBREVIATIONS

sp.	species
T.	*Trigona*
H.	Habenaria
MARDI	Malaysia Agricultural Research and Development Institute
CAC	Codex Alimentarius Commission
PDP	Positive displacement pump
w/v	Weight/volume
EC	Electrical conductivity
pH	Potential of hydrogen
™	Trademark
NaOH	Sodium hydroxide
5-HMF	5-Hydroxymethylfurfural

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter is discussed about the project background, the problem statement of the project, the objectives of the project and project scope.

1.2 PROJECT BACKGROUND

Honey is a natural food, mainly composed of sugars and other constituents such as enzymes, amino acids, organic acids, carotenoids, vitamins, minerals, and aromatic substances. It is rich in flavonoids and phenolic acids that exhibit a wide range of biological effects and act as natural antioxidants (Alqarni et. al., 2012). The composition, colour, aroma and flavour of honey depend mainly on the flowers, geographical regions, climate and honeybee species involved in its production, and are also affected by weather conditions, processing, manipulation, packaging and storage time (Escuredo et. al., 02014; Tornuk et al., 2013). various There are various types of honey in Malaysia such as Acacia, Pineapple, Borneo, Gelam, Kelulut, and Tualang honeys (Chong et. al., 2017). These honeys usually will be classified by the type of bee produced the honey which are, *Apis mellifera* (honey bee) honey and stingless bee honey.

Honey that produced by honeybees (*Apis sp.*) and stingless bees (*Meliponini sp.*) exhibits tremendous medicinal properties such as anti-microbial, anti-carcinogen and antioxidant. Honey is also specially highlighted as a natural remedy in the Holy Quran, as implied in Surah An-Nahl ('the Bees') in chapter 16, verse 69. Bees act as plant pollinators for the plants, indirectly resulting in improved plant pollination and increased crop production by up to 40% (Biluca et.al, 2016), thus potentially providing additional income to beekeepers and their neighbourhoods, while increasing national agriculture products (Mustapa et. al, 2018).

In Malaysia, production of honey by honeybees, such as *Apis melifera*, has not been profoundly successful due to the *Varroa dectructor* mite outbreak of 1996 (Azmi,2016). Thus, availability of local honey is completely dependent on honey hunters who obtain feral honey from stinger honeybees, such as Tualang bees (*Apis dorsata*). The Tualang bees, which mainly nest in the jungle and far off the ground, limit the implementation of standard production procedures. Meanwhile, stingless bees (*Meliponini sp.*) or lebah kelulut which do not have stingers, build nests in already existing cavities or hollowed out areas of trees, buildings and hives. This nesting behaviour provides the opportunity for stingless bees to be cultivated in intensive farms with controlled environmental conditions or in homes in rural areas that implement standard operating procedures. Thus, empowerment of today's stingless bee industry would have direct impact on production of high-quality honey, while also sustaining pollination of crops and other plants, particularly to maintain biodiversity.

In this thesis, the type of bee that would be highlighted is stingless honey bee. Stingless honey bees (also known as stingless bees or meliponines) are a socialize large groups of bees. The tribe Meliponini comprising about 500 species of the stingless bees (Michener, 2007). Although Meliponines have stingers at their back, the stingers are highly reduced and not suitable for defense against the enemy. Usually, stingless bees bite their enemy to protect them from any harm.

In the Southeast Asia, our country; Malaysia is known as one of high biodiversity and one of the indicators for this category is pollinator species according to Malaysian Agricultural Research and Development Institute (MARDI) in 2016. The reports shown that a total of 29 stingless bee species was recorded in Peninsula Malaysia and out of this 17 species were known to inhibit the old-growth forest (virgin forest). The researchers from MARDI believe that there will be more than 50 new species of stingless bees to be discovered in Malaysia (Jaapar & Jajuli, 2016).

Stingless bee breeding had become very commercial in Malaysia since it has been introduced in 2012. The demand for stingless bee honey had been increased from the times to times and the market values for these honey become more precious toward communities. As stated in Borneo Post newspaper on 31st August 2014, the stingless bee honey was actually contained twice nutritious as honey that produced by normal bees according to the Malaysian Agricultural Research and Development Institute (Mardi).

There are various ways that had been used by the beekeepers to collect the honey from the stingless bees' nest. The most conventional method that recorded that had been used was by using syringes. Unfortunately, this method is very high time- consuming for the user and the volume of honey collected over the time was very low in the quantity. The non-effectiveness of the usage of the syringe to collect the honey leads to the invention of the suction pump honey collector. The suction pump on the present market is using diaphragm vacuum pump.

In this thesis, the type of pumps that suitable for the system will be reviewed and discussed based on its advantages and disadvantages. The peristaltic pump will be using as the final product of the thesis project. The quality of the honey in both suction pump which are vacuum and peristaltic will be compared in pH and electrical conductivity of the honey. This is to make sure the changing in suction would not change the quality of the honey.

1.3 PROBLEM STATEMENT

The thesis was done based on many difficulties and challenges that the stingless honey harvesters faced during their activities by using the conventional methods. There are a few of limitations in the present honey vacuum suction pump that had been identified during the project. The type of suction pump used in the conventional suction pump is diaphragm vacuum pump which is a reciprocating-type positive displacement type of pump. The limitations are high power requirements, noisy pump operation and complicated designs such as the height and arrangement of the parts in the machine.

Firstly, the vacuum suction pump for honey collector required high power to operate. High power usage of the vacuum suction pump leads to the higher voltage of batteries for installation to collect honey. The causes of the high power usage in the vacuum suction pump can be various. One of the causes is pump running at the speed above the limit speed or motor problems.

Secondly, the vacuum suction pump has a loud noise during its operation. The loud sound in the machine maybe due to overloaded honey carryover to the pump because of the high power usage in vacuum suction pump. There could also be some foreign objects trapped on the tubing line such as bee pollens, bee breads or the bee itself as the bee is small in size. The clogged check valve where located at discharge and intake point of the pump (Global Pump. 2013) also contribute to the loud noise in the suction pump.

Next, the size of the vacuum suction pump for honey is different on both the size of the bottle used to collect the honey and the vacuum pump casing. The bottle used to collect the honey always build separately from the vacuum pump part. The type of the pump used in the machine is reciprocating positive displacement type which is diaphragm pump. The volume of the liquid moved by the pump depends on the bottle volume. This type of pump is more suitable to pump clean and free particle liquid or gas like oil compared to honey (Global Pump, 2013). This also caused the pump to put on higher pressure as the long tube that connect from the pump to the bottle collector.

In addition, the separation in the vacuum pump casing and the bottle collector make the design look complex by the wiring and the tube tangled each other. The design also exposes the user to electric shock if handling the machine during the rains. The machine also not portable and have to be carried in the basket all the time which is become inconvenient to the user.

Figure 1.1: The vacuum pump honey harvester

Source: Kerisasli, 2012

In conclusion, the design of conventional vacuum pump honey has a lot of disadvantages for the harvester even though with high pressure pump. These unused parts in the pump are financially unbenefited and loss to the manufacturer.

1.4 OBJECTIVES

The objective of the project is to compare the pH and the electrical conductivity of different circulation pumps (vacuum pump and peristaltic pump) and evaluate the type of pumps suitable for the system.

1.5 PROJECT SCOPES

To achieve the project objectives, an experimental study was also conducted to know the pH and electrical conductivity properties in the honey from stingless bee from the two different usage of pump which is peristaltic and vacuum pump.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will provide the review from previous research that is related to this final year project. There are previous researches on the properties of pH and electricity conductivity in the stingless bees' honey.

2.2 HONEY

Honey is a sweet liquid made by bees using the nectar from flowers. Honey is also one of the complex food stuffs produced by nature, and certainly the only sweetening agent that can be used by humans without processing It is graded by colour, with the clear, golden amber honey often fetching a higher retail price than the darker varieties. The flavour of a particular type of honey will vary based on the types of flower from which the nectar was harvested. Both raw and pasteurized forms of honey are available. Raw honey is removed from the hive and bottled directly, and as such will contain trace amounts of yeast, wax, and pollen. Consuming local raw honey is believed to help with seasonal allergies, due to repeated exposure to the pollen in the area. Pasteurized honey has been heated and processed to remove impurities. Honey has high levels of monosaccharides, fructose, and glucose, and it contains about 70 to 80 percent sugar, which provides its sweetness. Honey also has antiseptic and antibacterial properties (Nordqvis, 2018).

Therefore, both predisposition and the commercialization probabilities depend on sensory properties (colour, flavour and texture). These properties are a complex function of physicochemical parameters, which are over time, determined by the botanic and geographic origins. Therefore, the characterization of honeys is a hard task in response to consumer's demands. International honey standards allow specific denominations for honey produced from particular nectar.

The international standard for honey (CODEX, 2001) does not included the stingless bee or meliponine honey due to the scant knowledge. The meliponine honey also is not control by any food control authorities so, there is no assurance for the consumers. Mostly the honey standards that had been established was only for honey bee (Apis melifera) following the guidelines of international standards of the Codex Alimentarius Commission, CAC (CODEX, 2001). The honey produced by the stingless bee is very different from the honey bee in its physiochemical characteristics.

According to MARDI in 2006, honey from stingless bees not only low in sugar level but also high in antioxidant level. The antioxidant level in stingless bees' honey is four to ten times higher than honey that produce by normal bees.

Currently, the demands for stingless bee products such as honey, pollen and cerumen (Abd Jalili et. al, 2017) multiply very quickly in such short time. Hence, the interest in dominance stingless bee farming spread widely among people in the countryside residence especially in Kelantan, Terengganu, Perak and Kedah to suffice the high demand on crude honey and honey-based products (Fatima, 2015) and the interest had become the source income for these harvester.

2.3 STINGLESS BEE

Stingless bees are classified in the division Animalia, filum Arthopoda, class Insecta, ordo Hymenoptera, family, Apidae (Sihombing, 1997). Stingless bee belongs in the family Apidae which is closely related to common honey bees, carpenter bees, orchid bees and bumblebees (Roubik, 1989). Like honey bees, stingless bees also collect pollen and contribute considerably to flower pollination (Heard, 1999). There are others bee's family such as Andrenidae also have the same 'stingless' characteristics as Meliponines. Most of this bee species can be found in tropical or subtropical areas such as South America, Australia and Southeast Asia (Michener, 2007).

There are approximately 64 genera and 500 species within the stingless bee genus in the worldwide (Heard, 1999), with the majority of these species being located in Latin America, the mainland of Australia, Africa, and Eastern and Southern Asia (Rasmussen and Cameron, 2010). Two genera of stingless bee that usually used in farming are the *Melipona sp.* and the *Trigona sp.* especially in South East Asia such as Malaysia, Thailand and Indonesia. Comparing both genus in the stingless bee, the *trigona* genus is smaller in size compared to *melipona* genus. Meanwhile, the *Melipona* genus is numerically large, even larger than that of the common honey bee (*Apis mellifera* Linnaeus) (Michener, 2013).

a) Melipona type bee (Melipona

b) Trigona type bee (Trigona Itama).

c) Honey Bee (Apis Mellifera

Figure 2.1: Stingless bee and honeybee

Source: USGS,2014, Mohd Noor, 2018 and Lotz, 2007.

Stingless bees also play an important role in the ecology, economy, and culture. They act as the main pollinators for many wild and cultivated tropical plants (Slaa et. al., 2006). Their products such as honey, pollen, and cerumen have been used as a source of income for generations. In addition, stingless bees are attached to the culture of indigenous people, especially the Mayan, in rural areas of America (Ayala et. al., 2012)

According to a research officer in the Malaysian Agricultural Research and Development Institute (MARDI), the specialty of the stingless bees is the ability to pollinate small-sized flowers due to their diminutive figure which cannot be achieved by the relatively big honey bee. Besides, the stingless bees are not choosey in building a colony hive. As a result, it is easier to build an artificial hive to manipulate the colony and increase the honey production. As the name suggests, the stingless bees do not sting; thus, it is easier to extract the honey, pollen, and propolis frequently. Furthermore, stingless bees are easier to handle compared to honey bees that are often lost, always abandon their hive, and are vulnerable to disease (Khairunnisa, 2011). Likewise, stingless bee honey is unique as it originates from the rich vegetation in native environments.

The honey that produced by stingless bee has a distinctive sweetness mixed with a sour and acidic taste. In contrast to the stingless bee population, the distribution of this honey is lower compared to that of the common honeybee. This is due to the limited knowledge about this honey, which has resulted in it being less popular in terms of its industrial production, shelf life, and quality standard (Dos Santos, 2009). Therefore, stingless bee honey should be further explored due to its mass production and convenience of management.

2.4 PHYSICOCHEMICAL COMPOSITION OF HONEY

According to English Oxford dictionaries, physicochemical means something that relating to physics and chemistry properties or to physical chemistry. Every natural occurring substance has its own unique characteristics that confer its specialty in the ecosystem. Honey also add up to considerable amount of unique factors give away to a variable bioactivity into nature. The diversity of honey physicochemical components has been reported widely by several researchers emphasizing that different honey exhibits different patterns of physicochemical properties (Bogdanov, 1997). Generally, all honey shares similar physical properties such as high acidity, low pH value, low water content or moisture and electrical conductivity. Molecules like reducing sugar, phenolic compounds, flavonoids, hydrogen peroxide, proteins, enzymes, minerals and vitamins are ubiquitously present in all types of honey. The concentrations of these components differentiate the level of bioactivity of one honey to another. Table 2.1 shown comparisons between physicochemical properties of tualang honey (after Erejuwa et al., 2010) and stingless bee honey (after Souza et al., 2006).

Table 2.1 The comparisons physicochemical properties of bees

Physicochemical Properties	**Stingless Honey**	**Tualang Honey**
Appearance	Amber brown	Dark Brown
Moisture content	25.02%	23.30%
pH	3.05 – 4.55	3.55 – 4.00
Fructose	31.11 – 40.20	29.60%
Glucose	8.20 – 30.98	30.00%
Sucrose	0.31 – 1.26%	0.60%
Total Reducing sugars	55.00 – 86.00%	67.50%
Electrical Conductivity (mS/cm)	0.49 – 8.77	0.75-1.37
HMF (mg/kg)	8.80 – 69.00	46.17
Ash Content	0.01 -0.12	0.19

Source: Pasupuleti et. al. (2016)

From the Table 2.1, the previous researchers had concluded that the values and ranges of physicochemical parameters of honey produces by stingless bee and honeybee is different. The physicochemical properties of stingless bees cannot be compared using the normal standards which are European Standards; The International honey standards Codex Alimentarius standards (Bogdanov, 1999) and Malaysia Standard according to Food Act & Regulation 1985 for Honey.

The laws regarding honey are developed by considering the requirements to standardize the processing of products, and to ensure equal conditions and full transparency in their development and marketing. The authenticity of honey is defined internationally by the Codex Alimentarius, which establishes the identity and the essential quality requirements of honey intended for direct human consumption. These standards are applied to honey produced by bees and cover all styles of honey presentations, which are processed and ultimately intended for human consumption (Codex Standard for Honey, 2001).

The purpose of these laws is to establish the identity and minimum quality requirements for honey. Among other factors, these regulations take into account the sensory and physicochemical properties of honey by setting the colour and the minimum or maximum amount related to maturity, purity and deterioration parameters for honeys. With respect to maturity, the regulation evaluates sugar content and moisture; for purity, it analyses ash content, electrical conductivity and insoluble solids in water; and for maturity, it verifies HMF content, acidity and diastase activity (Codex Standard for Honey, 2001).

Due to the insufficient knowledge about stingless bee honey composition, there is a lacking of identification and qualification standards for the honey made by stingless bees, since this differs from the standards set by the international honey standards (Codex Alimentarius Commission, 2001) that the values and ranges of physicochemical characteristics that specific to the *Apis mellifera* honey (Silva et al., 2013 & Chuttong et al., 2016).

Therefore, the characterization of honeys is a hard task in response to consumer's demands. The International honey standards allow specific denominations for honey produced from particular nectar. One of the way of handling scientific analyses of various honeys must have three aims: quality control, purity control, and identification of adulterations. Honey quality test is important task to be done in order to measure and evaluate the product manufactured locally as well as commercially. Hence the study makes its attention on the determination of conductivity and acidity of honey collected from products manufactured locally (Kropf et. al. (2008) and Acquarone et. at. (2002)).

2.4.1 Colour

The colours of honey made by the stingless bee can be varies from light coloured to dark coloured, which is the main attractive for sensory quality for its consumption besides flavour and aroma. The existent of multi-coloured honey caused by the mineral content in the honey which is dependent on the natural absorption of minerals by plants from the soil and the environment (Gonzalez- Miret et. al., 2005; Vanhanen et. al., 2011). The absorption of mineral by bees can also happens artificially by altered the composition of the artificial sources such as feeding the bees with sugar or syrup. For this reason, the higher the mineral content in the honey, the stronger the flavour of the honey.

2.4.2 PH

One of important physical analysis for honey is its pH value. The pH (potential of hydrogen) scale is used for measurement of acidity or alkalinity of water soluble substances. The pH scale can be categorized into three values which are, acid, neutral and alkaline. The pH scale in range of the 1 to 6 is acidic, 7 is neutral and 8 to 14 is alkaline. The lower the number in pH scale, the higher the acidity of the water soluble substances and vice versa.

According to Prica et. al. (2014), the main physiochemical characteristic of pH value of honey in all species of bees is naturally highly acidic. The pH is extremely low that ranging in between 3 and 4.5. As the result, the low pH values in honey supress the growth of bacteria and other spoil-ready organisms (Geiling, 2013). The acidity of any honey is directly related to the floral sources that created it. Honey contains a number of different acids, including about 18 amino acids, many different organic acids, as well as aliphatic and aromatic acids. The aromatic acids greatly contribute to the flavour of honey (Jamnik, 2008).

2.4.3 Acidity

The purpose of acidity analysis is to measure the amount of hydrogen ion (H^+) concentration relative to hydroxide ion (OH^-) concentration in aqueous solution. Honey consist of wide range of organic acid as example, formic acid, oxalic acid, butyric acid, citric acid, 2,3-dihydroxybutanedioic acid, malic acid, pyroglutamic acid, lactic acid, benzoic acid, maleic acid, gluconic acid, isobutyric acid, succinic acid, pyruvic acid, α-ketoglutaric acid and glycolic acid. Some of the acids are introduced into honey via the nectar, i.e., their contents depend on the type of the honey, whereas some are produced during storage process and are influenced by storage temperature and processing conditions. The acidity of honey can range from 8.7 to 59.5 meq/kg, with an average of 29.1 meq/kg. Increased acidity of honey is an indicator for a fermentation process and transformation of alcohol into organic acid (Rogulja et al., 2009).

According to the data from the literature, the content of organic acids in honey ranges between 0.17 and 1.17% (average range 0.57%). Most of organic acids are present in honey in the form of esters, which contributes to its characteristic flavour and aroma. The influence of acid content on fermentation processes, flavour and aroma as well as bactericidal properties of honey make the total acidity an important indicator of quality of honey (Prica, 2014).

The acidity of honey maybe determined by titration with sodium hydroxide (free acidity) or directly measuring the pH value. The natural acidity of honey can be increased by the storage and ripening of honey, as well as during the fermentation of honey. Honey that is adulterated with sugar syrup has very low acidity (<1), while honey that is adulterated with invert sugar has a pronounced high acidity (Yadata, 2014). The acidity value related to the balance of organic acids naturally present in honey varies according to the floral source and the bee species (Sousa et. al., 2016).

Acidity was obtained by performing the neutralization of acidic solution of honey (10 g of honey dissolved in 75mL of distilled water) using a sodium hydroxide solution 0.1 N and 1% of phenolphthalein indicator solution until a pink colour was obtained for 10 seconds The reading of the sodium hydroxide volume 0.1 N required in the titration was recorded. The result is expressed in meq kg-1 using the equation:

Acidity = V (NaOH) x P_A, where: -

V (NaOH) = NaOH volume (mL)

P_A = sample weight (g)

Titration of the acidity has the major drawback that the endpoint of the titration is not well defined because of lactone hydrolysis, which leads to a constant drift in the endpoint. Theoretically the equivalence point titration is the correct method for determination of honey acidity, as the equivalence point of the titration is fixed for each honey. While the endpoint titration method has been officially used in most countries, in France the equivalence point titration with automatic titrators is used.

Thus the reproducibility of these methods is very poor and unsatisfactory in both cases. This very high interlaboratory variation throws some doubt on the usefulness of this measurement to determine the quality of honey. However, one should bear in mind the poor precision of the method when interpreting acidity results close to the limit (International Honey Commission, 2009).

2.4.4 Electrical Conductivity

Electric conductivity (EC) is an ability of electric current to flow through a material. In food especially liquid type can conduct electricity. However, the charge carrier in foods are ions instead of electrons (Zhang, 2009). The ions of water (H+ and OH-) are able to move by proton hopping from one water molecule to another with direct movement of a particular ion. Other ions need to diffuse under the influence of the applied electrical field and hence the solution viscosity is very influential (Balaji et. al., 2015).

Electrical properties are important in food processing with Pulsed Electric, ohmic heating, induction heating, radio frequency and microwave heating. It follows that electrical conductivity is important in detection processing conditions or in determining the quality of foods. The electrical conductivity of foods is relatively recent interest to researcher. This topic had not become critical in food applications until late 1980s. Hence, there just a little literature exists on this subject (Zhang, 2009).

Electrical conductivity is influenced by the source of the honey, acidity, salt content, moisture and viscosity. The conductivity is also very often used in routine honey quality control. This property of honey is considered very good criterion for assessment of botanical origin and purity of honey. Among other things, honey contains components such as organic acids and minerals, which in an aqueous solution have the ability to dissociate into the ions or to conduct an electric power. The bright colour of honey usually points to a lower conductivity than dark colour of honey (Kropf et al., 2008).

The conventional method used to conduct the measurement of the conductivities of undiluted honey samples were measured using a conductivity cell connected to an LCR meter. The conductivities were predicted using a fundamental chemical approach to physical properties.

With known constant values of the sugars and acid, known ion conductance values or estimated ion mobilities, and solution viscosity the electrical conductivity was calculated (Balaji et. al, 2015). However, the value of electrical conductivity in honey is extremely variable, it is difficult to predict many of its physical properties or relate these to composition. Similar to other properties of honey, the conductivity varies depending on the geographical and botanical conditions. The conductivity can be used to distinguish whether honey is from honeydew or floral nature (Belay et al., 2013; Chefrour et al., 2009).

In addition, the measurement of electrical conductivity in the honey also points indirectly to the ashes content of honey (Accorti et al., 1987). The electrical conductivity of the honey is related to the concentration of mineral salts, organic acid and proteins and proved to be useful for discriminating honeys of different floral origins (Acquarone et al., 2007).

Other factors, such as floral source, amount of organic acids and proteins, and storage time can also influence the electric conductivity of honey (Karabagias et al., 2014). High electric conductivity values do not necessarily correspond to higher amounts of ash in the honey (Escuredo et al., 2014).

2.4.5 5-Hydroxymethylfurfural

5-Hydroxymethylfurfural (5-HMF) is an important bio-sourced intermediate (Armaroli, 2000), formed from carbohydrates such as glucose or fructose. 5-Hydroxymethylfurfural (5-HMF) is a furanic compound that can be formed by Maillard reaction or hexose dehydration in acid media (Tosi et al., 2002). 5-HMF also can be formed in low temperatures over long storage period of storage, but in lower concentrations once Maillard reaction slows in these conditions. Aside from temperature, 5-HMF concentration formation depends on the kind of sugar, pH, water activity, and divalent cations concentrated in the media. In vitro studies indicate that 5-HMF can be cytotoxic, mutagenic, carcinogenic, and genotoxic (Capuano & Fogliano, 2011), and due this toxicity is important to monitor its concentrations in food products as honey.

The method for determination of hydroxymethylfurfural (HMF) was based on the readings in different absorbance scales (284 and 336 nm wavelengths) in a spectrophotometer (A.O.A.C.,1990). The HMF is expressed in mg/kg in the equation:

$$HMF = (A284 - A336) \times 149.7 \times 5 \times D/W, \text{ where:}$$

A284 = absorbance at 284 nm

A336 = absorbance at 336 nm

D = dilution factor, if necessary

W = weight of honey sample (g)

2.4.6 Ash Content

The ash content is a measure of the total amount of minerals present in the food content. The several important reasons in determination of ash content of honey. Firstly, ash content is a part of direct physicochemical analysis for nutritional labelling. The concentration and type of minerals present must often be stipulated on the label of the food. Next, the quality of many foods depends on the concentration and type of minerals they contain, including taste, appearance, texture and stability. The ash content also important for nutrition control as some minerals are essential to healthy diet meanwhile others can be toxic. Lastly, it is important to check up the ash content of the foods during processing because this will affect the physicochemical properties of the foods The ashes of honey also give an indication of environmental pollution and hence also an indication of geographical origin (Sonkamble and Phandure, 2017).

Every different food has different physicochemical properties, so the drying method that used to collect the ashes content will be different. For instance, the drying methods that had been used for this function are sun drying, oven drying and shade drying (Sonkamble and Phandure, 2017). Typically for honey, the oven drying method was used as honey has high melting point of crytallized honey which is in between 40 and 50 º depending on its composition. The ash content in the samples was determined by performing the incineration of 1 g of honey (crucible) in a muffle at 550°C for 3 hours (Pregnolato,1985).

The result is expressed in percentage (%) according to the equation:

Ashes = [(m1-m2)/m3] x 100, where:

m1 = weight of the crucible with the ash (g).

m2 = weight of the crucible (g)

m3 = weight of honey sample (g)

2.5 HARVESTING HONEY

The two most significant ways to collect stingless bee honey are by using syringe or using suction pump (vacuum pump).

The usage of syringe is the most conventional method to collect honey from the stingless bee 'pot'. This method handling is manually and required human-power to do the jobs. The honey was pump to the inside of the syringe by different pressure that had been created when the user squeezes the top of the syringe. The honey inside the syringe was then collected and put together a little by little into the container. Unfortunately, this method is very high time- consuming for the user and the volume of honey collected over the time was very low in the quantity. Therefore, the method of usage of the syringe is not effective to collect the honey from the stingless bees' nest.

Figure 2.2: Using Syringe to Collect Honey

Source: *Little Green Bee*, 2017.

The non-effectiveness of the usage of the syringe to collect the honey leads to the invention of the suction pump honey collector. The type of pump that had been used for the honey collector is vacuum pump. The vacuum pump uses a vacuum or compressor to provide the vacuum and pressure to move the honey from the stingless bees' nest inside one-side of the tubes. The other side of the tubes was attached into the bottle and the bottle was used to store the honey collected. The compressor forces air into the bottle, purging it and the intake hose of fluid, then draws honey into the bottles until it is full. The honey is then deposited inside the bottles (Gregorski , 2003).

2.6 PUMPS

A pump is a device which moves fluids by mechanical action, from one place to the other. It is, essentially, the earliest form of machine, dating back to ancient Egypt. The shaduf is the first device used for lifting water in several civilisations such as Egypt and India and thus the earliest form of pump. Pumps are divided into two broad categories, dynamic pumps and positive displacement pumps (All Pumps, 2016).

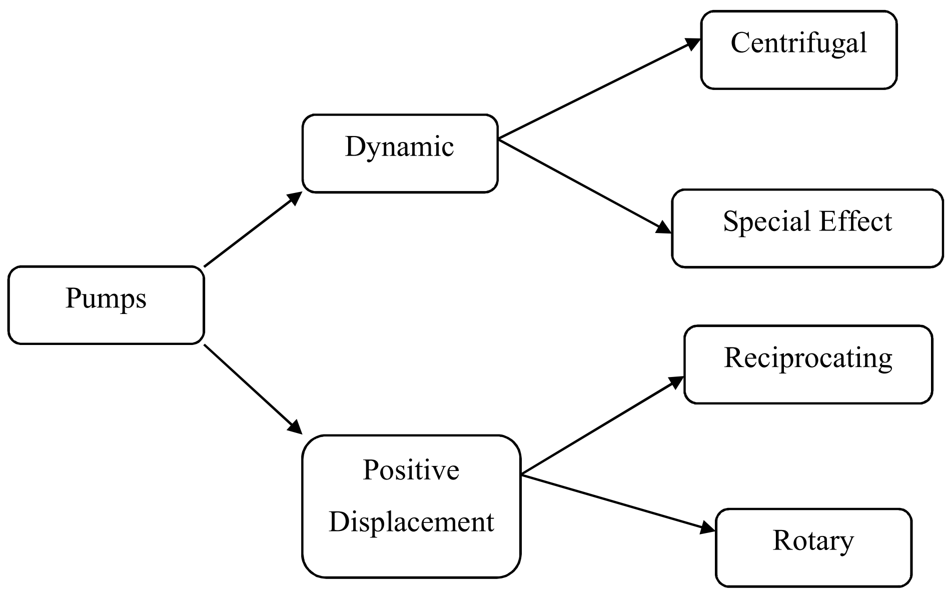


Figure 2.3: Classification of Pump

Source: All Pumps, 2016

The both categories of pumps, dynamic and positive displacement pump has itself advantages and applicability in field. Working principle and applications of the pump had to be carefully study when choosing the right pump type.

The most common type of dynamic pump (or rotodynamic pumps) that had been used is centrifugal pump. The centrifugal pump transfers the kinetic energy of the motor to the liquid by spinning impeller, as the impeller rotates the pumps draws in fluid causing increased velocity that moves the fluid to the discharge point. On the other hand, positive displacement pumps are characterised by an operation that moves fluid by trapping a fixed volume, usually in a cavity, and then forces that trapped fluid into the discharge piping system.

For this reason, positive displacement pump is used inside the suction pump for collecting the honey. There are several reason why positive displacement pump is more favoured that dynamic pump; the effect of pump on pressure and viscosity, efficiency, suction lift and shearing.

In positive displacement pump, the flow rate of the pump remains constant with a change in pressure. Due to internal clearances high viscosities are handled easily and flow rate increases with increasing viscosity. The efficiency of the positive displacement pump is less affected by pressure, with the external helps to increase as pressure increases and the pump can be run at any point on their curve without damage or efficiency loss. The positive displacement pumps also create a vacuum on the inlet side, making them capable of creating suction lift. The low internal velocity in the positive displacement pump means little shear is applied to the pumped medium which is ideal for shear sensitive fluids. The shear sensitive liquid tends to change viscosity when under stress of pressure especially in non-Newtonian fluid such as honey (Nelik, 2011).

On the contrary, the dynamic pump flow rate varies with the change in the pressure. The flow rate of the dynamic pump also decreases with increasing viscosity, even any moderate thickness, due to frictional losses inside the pump. The efficiency of the dynamic pump peaks only at specific pressure causing any changes of pressure can affect the efficiency of the pump dramatically and the dynamic pump does not operate well when run off the middle of the curve; that can cause damage and cavitation easily. The standard models cannot create suction lift, although self-priming designs are available and manometric suction lift is possible through a non-return valve on the suction line. Lastly, high speed motor of dynamic pump leads to shearing of liquid which is not suitable for shear sensitive mediums (The Process Piping, 2017).

In conclusion, the positive displacement pump is suitable choices compared to dynamic pump to extract honey. The positive displacement pump is able to handle the high viscosity and shear sensitive fluids such honey and it capability to handle rations in pressure is more likely preferred compared to dynamic pump.

2.6.1 Positive Displacement pump

The positive displacement pump (PDP) is a type of pump in which a certain amount of fluid is captured inside the cavity, then discharge the same. The PDPs can be categorized into three more different type, rotary, reciprocating and linear.

The rotary positive displacement pump type of working by the rotation of the rotary displaces the fluid from the reservoir to the discharging pipe. Some of the example of this type of pump is internal gear, screw pump and flexible impeller.

Next, the reciprocating positive displacement pump works by moving the reciprocating part backward and forward to helps the fluid to move forward the reservoir. The pumps contain several valves including inlet and outlet ones. During the suction process of liquid, the inlets open and the outlets remain closed. The opposite happens during discharge of the liquid. As piston moves to the right, the cavity expands and the fluid is sucked into the cavity. The example for this type of pump are plunger, piston and diaphragm.

Lastly, linear positive displacement type of pump. This type of pump perform the displacement of the fluid takes place linearly, which means in a straight line. For example, rope pump and chain pumps. In addition, this type of pump does not require calibration and can be set in a static location.

To sum up, the type of positive displacement pump that had been choose in this study is reciprocating type which is diaphragm pump and linear type which is peristaltic pump. The both pump can be analyse from the several parameters with respect to diaphragm and peristaltic metering pump system and comparing their reliability to the system.

2.6.2 Comparing pumps for honey collector.

The typical present technology in honey suction pump used diaphragm pump as the main pump for the system. In this project, the comparisons of diaphragm pump and peristaltic pump will determine which pump is suitable for the system.

Diaphragm pumps typically employ a large number of “wetted” components such as suction strainer with check valve, suction tubing or piping, pump head with inlet/outlet valves, discharge tubing or piping and injection fitting with check valve. Meanwhile, the peristaltic pumps employ much fewer “wetted” components for instance, suction tubing or piping, peristaltic pumping tube, discharge tubing or piping and injection fitting with check.

In addition, the peristaltic pumps are very efficient in pumping fluids with un-dissolved solids. These “dirty” fluids, or “slurries,” tend to clog valves in a diaphragm pump head.

Some fluids tend to release, absorbed or occluded gasses when subjected to a vacuum or changes in temperature. For examples of this effect are noticeable in chemicals such as chlorine and hydrogen peroxide. Diaphragm pumps often lose their prime and fail when gasses build up in the pump head area. However, the peristaltic pumps are capable of pumping both fluid and gas and, therefore, cannot lose its prime.

Moreover, the forces created during the pumping action can be adversely effected some fluids. As a consequence, the diaphragm pumps can damage delicate fluids, particularly if the pump employs a high velocity stroke action such as in a solenoid type pump. The peristaltic pumps utilize a gentle squeezing action that will not damage these types of fluids.

On the other hand, the peristaltic pump output volume does not change due to changes in the system pressure and the diaphragm pumps output will vary with system pressure changes.

The honey is delicate fluid, thus selection of pump in the system must be determine based on its physicochemical characteristics. The pump type that had been chosen for comparing in this project is peristaltic pump (refer Appendix B

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter will explain about the material and method that had been used in experimental process.

3.2 MATERIALS

3.2.1 Honey Samples

Trigona honey samples were obtained from a bee farm located in Breeding and Production Center (Pusat Pembiakan dan Pengeluaran Benih, Felda Bukit Goh, Kuantan, Pahang. The type of the stingless bee is *Itama Mega*. Konsortium Penyelaras Koperasi Negeri Pahang Berhad (Kospen) bred the stingless bees at the located place due to the degraded environment and covered with a lot of fruit type trees such as mango, rambutan, durian and forest flowers according to Harian Metro in 2016.

The stingless bees honey samples were obtained from sealed honey pots from the colonies. The honey sample acquired was 75g (refer to Appendix A). The honey samples obtained were covered in aluminium foil and were stored in the dark area at room temperature to keep the freshness of the honey quality.

Figure 3.1: Location of the honey sample obtained.

Source: Mariana et. al., 2010

The other materials used for fabrication and wiring of peristaltic honey suction pump were bought and the cost of bill (refer to Appendix C) is listed. The total of materials was included the damaged and the incorrect materials that were bought during the project.

3.3 METHODOLOGY

3.3.1 Experiment Design

The overview of this study was designed as shown in Figure.

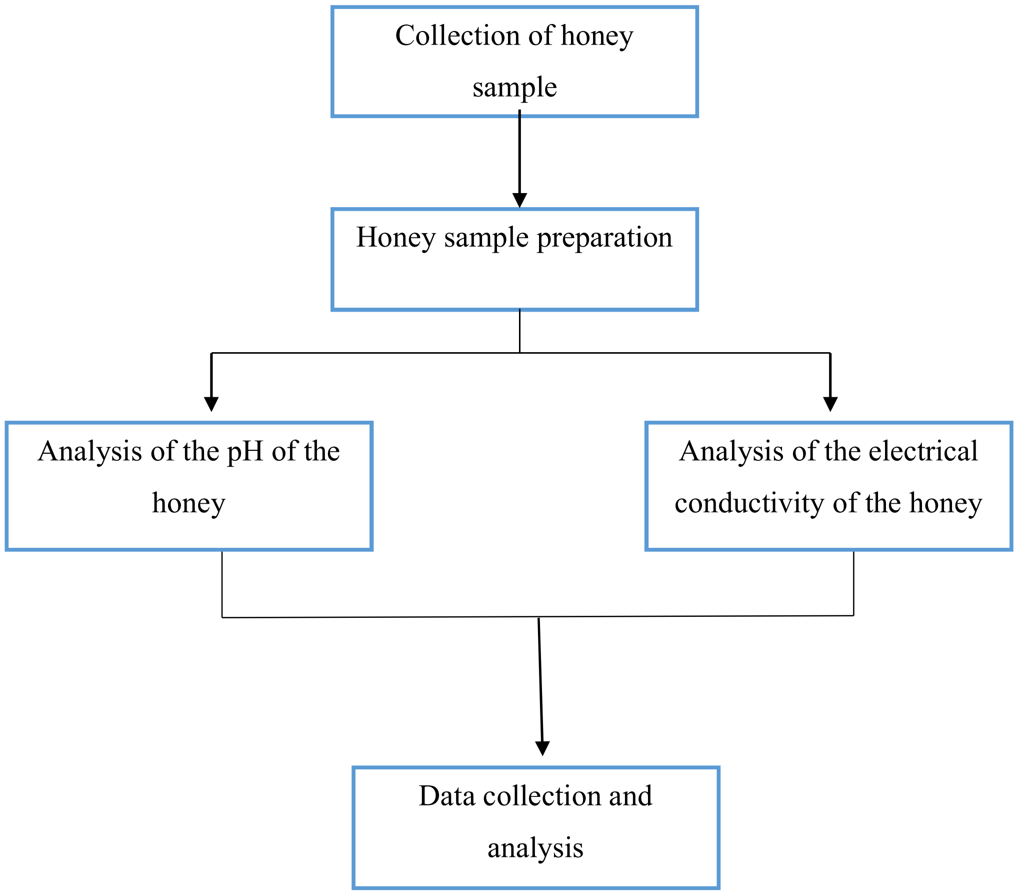


Figure 3.2: Experimental design of this study

3.4 Preparation of Honey Solution

3.4.1 Calculation of Weight/Volume Percentage Concentration

Weight/volume percentage is a measurement of the concentration of a solution. The weight/volume percentage concentration is usually abbreviated as w/v (%). The concentration of honey was prepared using this calculation was the method that is prescribed by International Honey Commission Methods (2009).

To calculate w/v (%) concentration:

$$\mathrm{w/v(\%)} = \frac{\text{mass of solute (g)}}{\text{volume of solution (m1)}} \times 100$$

$$= \frac{2\mathrm{g}}{10\mathrm{ml}} \times 100$$

$$= 20\% \text{ (w/v)}$$

3.4.2 Electrical Conductivity

According to International Honey Commission Methods (2009), a honey was weight in 50 ml beaker by using the electronics balance equivalent to 2.0 g anhydrous honey, in distilled water (refer Appendix A). The 20% (w/v) solution quantitatively transferred to a 10 ml and make up to volume with distilled water.

3.4.3 pH

According to International Honey Comission Methods (2009), a honey was weight in 50 ml beaker by using the electronics balance equivalent to 2.0 g anhydrous honey. A distilled water was measured in 10 ml measuring cylinder equivalent to 10 ml. The 10 ml of distilled water was mixed inside the beaker contains the honey. The 20% (w/v) solution was stir with magnetic stirrer for an hour with magnetic stirrer to make sure it is homogenous.

3.5 PROCEDURE

3.5.1 Electrical Conductivity

The determination of the electrical conductivity is based on the measurement of the electrical resistance, of which the electrical conductivity is the reciprocal. The conductivity meter was calibrating by using the conductivity standards solution which are 1413 µS/cm and 12.88 mS/cm. The conductivity cell was connected to the conductivity to the conductivity meter. The electrical conductivity was measured at 20 °C in solutions of honey samples using a Mettler-Toledo SevenGo™ Conductivity Meter. The method of measuring is prescribed by International Honey Commission Methods (2009). The reading of the conductivity was repeated for three times and the average of conductivity reading of honey samples was taken.

Figure 3.4: Mettler-Toledo SevenGo™ Conductivity Meter.

Source: Mohd Noor, 2018

3.5.2 pH

The pH meter (Mettler-Toledo SevenCompact™) was calibrate before use at pH 3.0, 7.0 and 9.0. The pH measurements were performed at 20ºC using a pH-meter Mettler-Toledo SevenCompact™ in a 20% (w/v) solution of honey in freshly boiled distilled water according to method prescribed by International Honey Commission Methods (2009). The reading of pH measurement had been repeated for three times and the average pH reading of honey samples was taken.

Figure 3.5: pH meter (Mettler-Toledo SevenCompact™)

Source: Mohd Noor, 2018

3.6 ETHICAL CONSIDERATION

Safety and precaution when conducting the experiment inside the lab is the main concerns during the data collection processes. The person handling the lab should always maintain a right personal protection equipment such as wearing lab coat or apron, closed-toe shoes and gloves if necessary to protect the wearer from the specific hazards and hazardous. The samples taken should be keep in clean, dark and in room temperature.

CHAPTER 4

DATA COLLECTION AND ANALYSIS

4.1 INTRODUCTION

This chapter will discuss the data collection from the experiment and the analysis from the data that gained from the experiment.

4.2 RESULTS

The tables below show the results from the experiment that had been done on both type of honey.

Table 4.1: The average reading of pH and conductivity value of honey sample from diaphragm vacuum pump

Sample	pH	Electrical Conductivity (mS/cm)
1	3.32	0.90
2	3.33	0.73
3	3.35	0.76
4	3.46	0.95
5	3.53	0.48
6	3.40	0.92

Six samples of honey that taken using the conventional system which is diaphragm suction pump were investigated during the experiment. The investigated honey samples taken from the diaphragm vacuum pump shown the pH values; 3.32, 3.33, 3.35, 3.46, 3.53 and 3.40. All the honey samples taken shown high number of values pH and acidic characteristics. Meanwhile, the range electrical conductivity of the honey samples taken shown values of 0.90 mS/cm ,0.73mS/cm, 0.76 mS/cm, 0.95 mS/cm, 0.48 mS/cm and 0.92 mS/cm. All the electrical conductivity in the honey taken are varied from each other. The highest electrical conductivity value is from sample number six (6) which is 0.92mS/cm and the highest pH value is 3.53 from the sample number five (5).

Table 4.2: The average reading of pH and conductivity value of honey sample from peristaltic pump

Sample	pH	Conductivity (mS/cm)
1	3.42	0.31
2	3.39	0.25
3	3.40	0.75
4	3.46	0.70
5	3.53	0.80
6	3.40	0.58

In the other hand, six samples of honey that taken by using peristaltic suction circulation pump were also investigated during the experiment. The honey samples taken with the peristaltic pump shown the pH values; 3.42 mS/cm, 3.39 mS/cm, 3.40 mS/cm, 3.46 mS/cm, 3.53 mS/cm and 3.40 mS/cm. The samples shows acidic behaviour and low number of pH values. Meanwhile, the range electrical conductivity of the honey samples taken shown values of 0.31. 0.25, 0.75, 0.70, 0.80 and 0.58. All the electrical conductivity in the honey taken were varied from each other. The highest electrical conductivity values and pH values are from honey sample number five (5) which is 0.80 mS/cm and 3.53 from the sample five.

The figure 4.1 and figure 4.2 show the values of pH against electrical conductivity that obtained during the experiment.

Figure 4.1: The electrical conductivity against pH values of honey samples from the vacuum pump

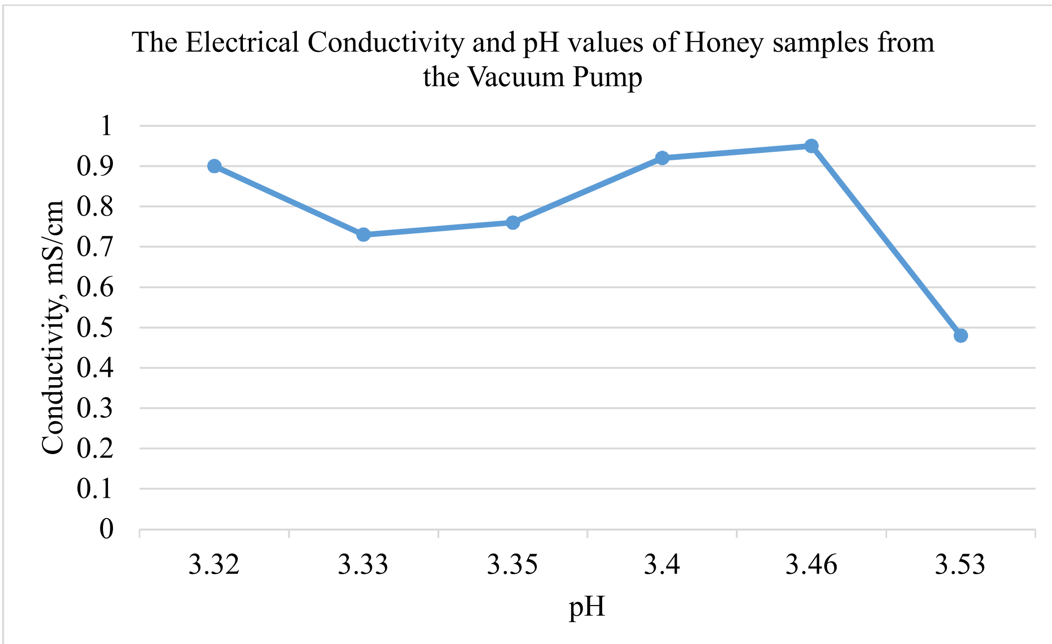
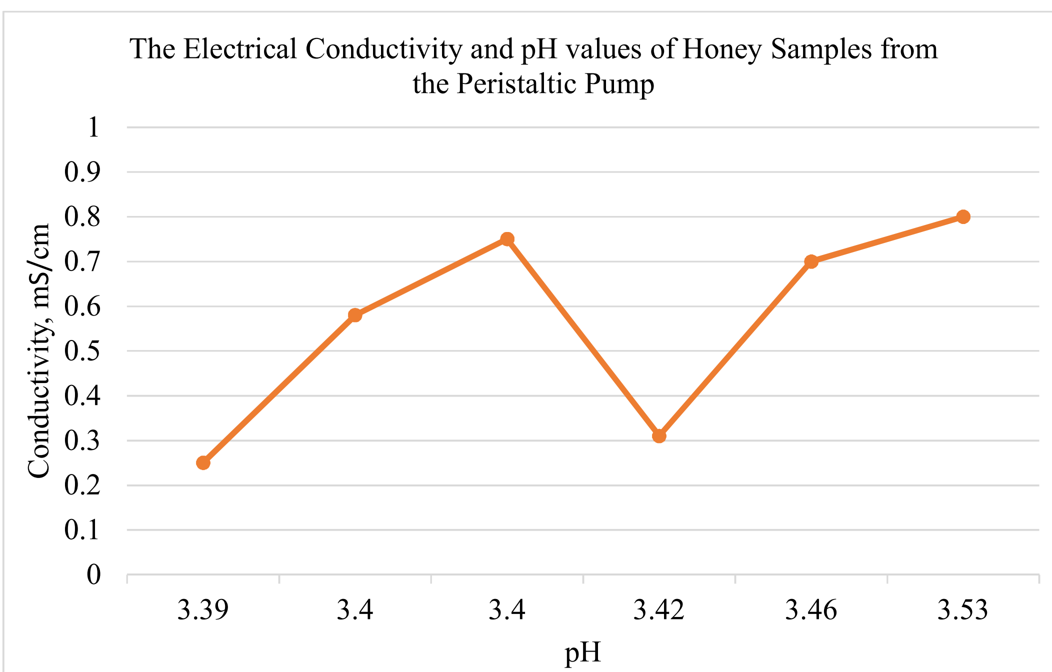


Figure 4.2: The electrical conductivity against pH values of honey samples from the peristaltic pump



4.3 ANALYSIS

4.3.1 Electrical Conductivity

From the experiment, the electrical conductivity values in the investigated honey samples from diaphragm vacuum pump varied in the range of 0.48 – 0.95 mS/cm. Meanwhile, the electrical conductivity values in the honey samples from the peristaltic pump varied in the range of 0.25- 0.80 mS/cm. The highest electrical conductivity value of the samples from the diaphragm vacuum pump and peristaltic pump are 0.92 mS/cm and 0.80 mS/cm. The value of electrical conductivity from the honey sample taken by diaphragm vacuum pump is higher than peristaltic pump maybe due to the day experiment was conducted.

In comparing to Fatima et. al. (2015) journal, the electrical conductivity results ranges from 0.47 mS/cm to 0.55 mS/cm for stingless bee honey and 0.23 mS/cm for Tualang honey from honey bee (*Apis Dorsata*). These values of reading are quite similar to our results.

However, the electrical conductivity values from Chuttong et. Al. (2016) who reported in the journal that the average electrical conductivity of stingless bee from South Asia from the 28 samples is 1.1 ± 0.780 mS/cm. The honeys from three of the 11 stingless bee species possessed conductivity reading of >2 (*T. apicalis*, 3.1 and 2.1 ms/cm; *T. melanoleuca,* 2.8 ms/cm; *H. fimbriata*, 2.6 mS/cm). Excluding these 4 honey samples from these species, the average conductivity is 0.794 ± 0.413 mS/cm. The values of electrical conductivity in Chuttong et. al (2016) is quite high compared to our conductivity values eventhough the study take place in Thailand which is also located in South East Asia. This is also comparable to the report of Suntiparapop et al. (2012) which is also take place in Thailand who reported electrical conductivity of *T. laeviceps* from Chanthaburi and Trat provinces as 0.71 and 0.5 mS/cm.

In the stingless bee honey literature originating from South America only one study (Guerrini et al., 2009) provided any information regarding electrical conductivity. This research reported an electrical conductivity of 0.48 ± 0.06 mS/cm calculated from three honey samples whose species origins were not given. In addition, Wanjai et al.

(2012) reported electrical conductivity for A. mellifera from Thailand to be 0.26 ± 0.04 mS/cm, which is lower than electrical conductivity for stingless bee honey.

Based on the Yadata (2014), the conductivity analysis was done based on two seasons which is summer and winter but the type of bee is not stated inside the journal. The conductivity measurement collected from analysis of 40mL of different honey samples solution at 200C±0.5, from different location with respect to Tepi; is in the range of 0.09-0.1, 0.15-0.16, 0.1-0.13 and 0.32-0.35mS/cm in case of Korcha, Mexi, Shako and Gobito respectively in summer. In winter season 0.11-0.14, 0.17-0.21, 0.08-0.13 and 0.24-0.26mS/cm in Korcha, Mexi, Shako and Gobito have been determined.

In Biluca et. al. (2016), the values for electrical conductivity found in the thirty-three samples of honey from stingless bees studied, ranged from 0.150 to 1.34 mS/cm, the lowest value was found in the *M. scutellaris* species and the largest was found in the *T. angustula* species, showing great variability among species.

In conclusion, the values of electrical conductivity of honey samples in this research is comparable to the other research. The variations in the reading of electrical conductivity values might be due to influenced of the source of floral origin and botanical origin. Hence, determination of electrical conductivity in honey is important because it effect the purity and quality of the honey retrieved from the stingless bee.

4.3.2 pH

The pH values in honey samples obtained by vacuum pump is varied from the ranged 3.32 – 3.53. Meanwhile, the pH values in the honey samples obtained by peristaltic pump is varied from the ranged 3.39 – 3.5. All the honey samples that had been investigated in the study were found acidic characteristic. The results showed that although with different type of pump used to retrieved the honey samples, their pH were almost within the same range. The highest pH value of the honey sample taken by both diaphragm vacuum pump and peristaltic pump are 3.53.

According to Fatima et. al. (2015), the pH values of the stingless bee honey (Trigona thorasica and Trigona itama) from Kelantan and Terengganu ranged between 2.79±04 to 2.95±0.02, while the pH of honey bees from Apis Dorsata was 3.64±0.04.

The pH values of stingless bee honey in Fatima et. al. (2015) journal is lower compared to the pH value in the honey samples that had been investigate in this study.

According to Chuttong (2016), the 28 honey samples examined from 11 stingless bee species in the study, the average pH is 3.6 ± 0.198, with a range of 3.1–3.9. Ten honey samples were examined from the most commonly encountered stingless species (Tetragonula laeviceps-pagdeni complex) in Thailand and the species most frequently 'managed' by meliponiculturists. From the ten samples of this specie's honey an average pH of 3.6 ± 0.195 is revealed. The pH values in this study is comparable to the pH values in the study conducted in this project.

Meanwhile in Vit et al. (2013), the comparison to neo-tropical stingless bee species in Venezuela, South America has find out from 18 honey samples have an average pH of 3.9 ± 0.601.

According to the result in Yatada (2014), the acidity in the honey samples is tested with pH meter and the results are all less than 7, which is in range 3.95 to 4.30. In Korcha the pH value of honey sample is 4.18, in Mexi sample 3.96, in Shako sample 3.96 and in Gobito sample 4.00. In winter the pH values of honey sample in Korcha, Mexi, Shako and Gobito are 3.36, 4.1, 4.26 and 3.37 respectively.

In Biluca et. al. (2016), thirty-three samples have been analyzed and all the data of pH values in the honey samples are between 3.33 and 6.56. From the research, the lowest value was found in the Meliponinae quadrifasciata species and the largest was found in the Meliponinae mondury species, indicating an average value of 3.80 ± 0.440.

In conclusion, the pH reading of the honey sample is similar to other researches. Commonly, all the honey samples will show the acidic properties and show the pH values under 7. The high pH inhibits the presences and growth of microorganisms. Its low pH also makes honey compatible with many food products in terms of pH and acidity.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

This chapter will conclude the overall the study and gives the recommendation for the future study.

5.2 RELATIONSHIP OF PH AND ELECTRICAL CONDUCTIVITY OF HONEY

The project aimed to investigate on the study comparing the pH and the electrical conductivity of different circulation pumps (vacuum pump and peristaltic pump) was achieved

Eventhough using the different pump, both honey samples show a very high similarity to each other. The study of electric conductivity and pH of honey collected in the Felda Bukit Goh, Kuantan, Pahang was determined.

The data from the electrical conductivity shows that the honey samples from the diaphragm vacuum pump and peristaltic pump are 0.48 – 0.95 mS/cm and 0.25- 0.80 mS/cm respectively. The high reading of electrical conductivity is maybe because of the honey origin and botanical environment. The reading of electrical conductivity of the *Trigona sp.* is also disturb by the shear sensitivity of the fluid by the pump suction method as honey is delicate fluid.

The data from the pH shows that the honey samples from the diaphragm vacuum pump and peristaltic pump are in range of 3.32 – 3.53 and 3.39 – 3.5. This demonstrate that there no significant effect on changing the circulation of the pump. The honey is still maintained on its original physicochemical characteristics.

The data gathered from the research in this project was also compared to previous data from the other researcher's study and most of the data of electrical conductivity and pH of the stingless bee honey are likely similar to the data gathered during this project.

The finalize product was also included the Honeybee Apps (refer Appendix A) to control the circulation of the pump so that it easier to clean inside the tube the product also used

In conclusion, the usage of peristaltic pump can maintain the physicochemical characteristics of stingless honey as diaphragm vacuum pump eventhough both the system has different working principle, efficiency, effect on the pressure and viscosity and shearing.

5.3 RECOMMENDATIONS

For the future study, the collection of stingless honey should be taking place during the full productive month of the stingless bees producing honey so that more honey samples can be obtain and observe for further analysis which is staring in March. In the wet monsoon season, the stingless bee becomes low in productivity of honey and honey collected was just enough for the bees to go through the season.

The honey sample must be stored in the completely dark place with a room temperature to avoid any damage to the honey samples quality. The honey sample also cannot be stored in the refrigerator as the crystallization of the honey will take place and damage the quality of honey and increase the moisture inside the honey that will leads to active microbial activity.

A multiple type of honey can also be applied to the research in this project and not only limited to one type of stingless bee honey only so, more values of electrical conductivity and pH values of stingless bee in Malaysia can be gathered.

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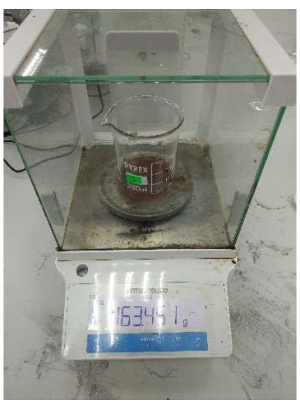
APPENDIX A

THE EXPERIMENTAL PROCEDURE

Figure 7.1: The honey sample

Figure 7.2: Weighing the honey sample



APPENDIX B

FARBRICATION OF PERISTALTIC PUMP AND HONEYBEE APLICATION

A) Design structure of the Peristaltic Honey Pump case.

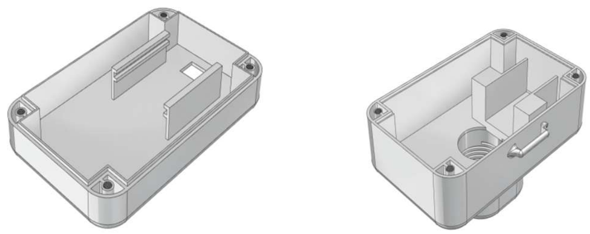


Figure 7.3: Isometric view of the top part and bottom part of the case.

B) The interface of application for controlling the pump.

Figure 7.4: Interface of Honeybee Apps

C) Final product

Figure 7.5: The peristaltic honey pump

APPENDIX C
BILL OF MATERIALS

No.	Item	Quantity	Price (RM)	Total (RM)
1.	ABS for 3D printing	-	200.00	200.00
2.	Arduino Nano	1	121.90	121.90
3.	Breadboard/PCB	1	20.20	20.20
4.	Wire	1 set	10.00	10.00
5.	IR Sensor	1	59.00	59.00
6.	Resistor	2	0.50	1.00
7.	Peristaltic pump	1	38.96	38.96
8.	Silicone Tubing 3350	1 set	18.25	18.25
9.	Battery lithium 12v & 5v	1	56.90	56.90
10.	Android charging port	1	13.00	13.00
11.	Bottle	1	14.00	14.00
12.	Bluetooth Receiver HC-05	1	25.00	25.00
13.	Motor Driver L293D	1	12.50	12.50
14.	Selector switch	1	10.00	10.00
			Total	600.71