UNIVERSITI PUTRA MALAYSIA

FREEZE DRYING OF STINGLESS BEE HONEY

HALIMATON AIMAN TAUFIC EFFANDI

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ABSTRACT

A stingless bee honey (*Heterotrigona Itama*) has a distinctive sweetness mixed with a sour and acidic taste. This honey is also known to have a more liquid consistency compared to the usual sweet and sticky honey. The consistency has become an issue since the high moisture content promotes microbial activities that can cause fermentation process to occur in the honey. Freeze drying, a process of water removal through sublimation is mainly use to preserve and extend the shelf-life of material. Before freeze drying, the stingless bee honey was frozen at two different temperatures (-20°C and -70°C) and with two different quantity (15ml and 1ml). The honey were analysed for their characteristic during freeze drying. During freeze drying, the sample started to bubble and spilled over. Only the honey frozen at a temperature of -70°C with a quantity of 1ml had settled. Upon observation, the stingless bee honey was seen to be more viscous than before freezing and moves at a slower rate. The stingless bee honey could not be produce to become a powdered honey as it could not freeze properly.

ABSTRAK

Madu kelulut (*Heterotrigona Itama*) mempunyai rasa yang tersendiri iaitu rasa masam dan manis. Madu ini juga dikenali dengan konsistensi yang lebih cair berbanding dengan madu biasa yang sifatnya melekit dan manis. Madu kelulut ini mempunyai kandungan kelembapan yang tinggi. Oleh sebab itu proses fermentasi di dalam madu boleh terjadi akibat aktiviti mikrobial. Proses pengeringan beku (freeze drying) sering digunakan bagi mengelakkan proses fermentasi dari terjadi dan juga untuk memanjangkan jangka hayat penyimpanan madu, Proses ini menyingkirkan kandungan air menerusi kaedah pemejalwapan. Madu kelulut dibekukan pada dua suhu berbeza (-20°C dan -70°C) dan dua kuantiti berbeza (15ml dan 1ml). Kemudian, sampel ini melalui proses pengeringan beku. Ciri-ciri sampel ini deperhatikan semasa proses ini berlangsung, Sampel-sampel tersebut mula berbuih dan melimpah keluar dari tiub, tetapi hanya sampel yang dibekukan pada suhu -70 dengan kuantiti 1ml sahaja yang yang menetap di dalam tiub *falcon*. Hasil permerhatian mendapati bahawa konsistensi madu kelulut menjadi lebih ligat selepas pengeringan beku dan megalir pada kadar yang lebih perlahan. Justeru, madu kelulut tidak dapat diproses kepada serbuk kerana madu tersebut tidak dapat di beku dengan sepatutnya.

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CHAPTER 1: INTRODUCTION

1.1 Background

The project of introducing freeze drying onto stingless bee honey had been studied. Currently, honey in present form is rather inconvenient to transport for everyday use as generally in its viscous state, handling honey can be quite a hassle. By introducing freeze drying to honey, the physical form of honey shall be changed into powdered honey. Although raw honey can be kept for a long time, powdered honey will seem more engaging to consumers whilst still having the same life expectancy, especially if it were to be introduced to those who have not heard of stingless bee honey. Stingless bee honey is more fluid if compared to the usual sticky honey sold at the moment. From first glance, a more fluid honey might not seem appetizing not to mention, the distinct sour fragrant and taste but the nutritional value stingless bee honey possess should consume and used for the benefits itself. The freeze drying of stingless bee honey will be frozen using two methods. The first using a freezer and secondly using dry ice. Between both methods there is about a 50°C difference in temperature. Both methods of stingless bee honey will undergo freeze drying after 24hour.

1.2 Introduction of Stingless Bee Honey

They are each three to five millimetres in size but the tiny kelulut (stingless bees) or meliponines hold huge potential of making Malaysia a major player in the global honey market. Thriving in tropical and sub-tropical countries, there are over 500 species of stingless bees in the world, with 40 species found in Malaysia. Stingless bees have short flight ranges of about 500m – making it easier to keep them among crops for pollination – compared to honey bees which have a flight range of 2km and thus, may fly to other farms. Unlike honey bees, stingless bees are generally harmless to humans and domesticated animals. Another plus point is that they are resistant to the diseases and parasites that affect honey bees (bees that can sting).

The following is an extract from an article entitle "A Potential Treasure Trove is Found in Malaysia's Stingless Bees" by Wong Liza from The Star dated 14th September 2017, Malaysian stingless bees can be divided into two groups; one group can be farmed and kept in boxes while the other needs to be left in their natural habitat. Beekeepers here need to choose species that grow well in boxes. Two species that thrive in boxes in Malaysia are the *Geniotrigona thoracica* and *Heterotrigona itama*. Researchers from Mardi have already tried it and it is successful, shared Dr Cristiano Menezes, bee biology and bee management researcher, Brazilian Agricultural Research Corporation (Embrapa).

In another article entitled "Malaysia Eyes Global Honey Market with Kelulut Bee" from The Star dated 25th February 2020, Assoc. Prof. Dr. Wan Iryani Wan Ismail a lecturer with the Faculty of Science and Marine Environment of Universiti Malaysia Terengganu says that the stingless bee are more docile than the ordinary honey bee and can easily breed on a large scale at the same time, a pain, if any, from the sting of

the stingless bee is negligible and had no side effects. It is estimated that there are between 750 to 1000 people nationwide that are engaging in bee farming and Prof Wan Iryani is reassuring the kelulut honey business can grow into a huge industry over the next 10 years. Prof Wan Iryani, head of committee that drew up the National Kelulut Honey Industry Development Plan 2020-2030, aims to make the kelulut honey industry as a new source of stable and sustainable income. Prof Wan Iryani states that their first challenge is that the international market has yet to award the stingless bee honey the recognition given to ordinary honey because some of its feature does not meet the standards set by market. A reason for this is that stingless bee honey is a little sour and the texture is more of a liquid while honey in accordance with the international standards must be sweet and sticky.

An article with given tittle of "Stingless Bee Honey Products to Be Exported to Middle East by The Star dated on the 27th June 2020, the Farmers Organisation Authority (FOA), chairman Dr Nik Muhammad Zamawi Salled said that their results of a study by FOA showed local stingless bee honey was a good quality and suitable for export since there have been request for Malaysian products to be sold in the Middle East. Terengganu FOA director Mohd Saupee Sudin noted that the stingless bee honey fetched a higher price than the other type of bee honey. In Malaysia, stingless bee honey are largely farmed for their honey, which contributes RM200m annually to the economy. Sarawak currently ranks the highest in its production, followed by Sabah and Peninsular Malaysia.

1.3 Problem Statement

Whilst having a very distinctive sweet and sour flavour, raw stingless bee honey (*Heterotrigona Itama*) has a much higher moisture than that of honey produce by *Apis Mellifera* which is a type of western honey bee mainly preferred for its production of honey. Shelf-life of honey is greatly affected by the moisture content as it promotes fermentation (Silva T.M.S. et al., (2013), Wang J., et al. (2011)). A much needed care in handling stingless bee honey is vital. One of the ways to remove moisture is to introduce heat, unfortunately direct heat degrades the quality of honey and causes the decrease of diastase activity and increases its hydroxymethylfulfural (HMF) content. A proposal to freeze dry the stingless bee honey is introduce. At low temperature, no heating element is needed to reduce the moisture content and the quality of the honey shall be persevered.

1.4 Objectives

The objective of this study are:

1) To investigate the application of freeze drying of stingless bee honey.

1.5 Scope of Study

The study covers the basic layer of introducing the freeze drying technique onto raw stingless bee honey and the usage of readily available materials and equipments. Several method of initial freezing on the stingless bee honey were introduced. The process of freeze drying stingless honey bee is purely the honey itself without any additives being added.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In this chapter, we discuss the main topic that encompass the whole thesis starting from the sample used stingless bee honey, and the process of freeze drying.

2.2 Stingless Bee and Honey

Stingless bees, as they are referred to, do not sting per se, instead, the stings are greatly reduced and are unable to penetrate human skin. By looking at the position of its hind leg during flight, (see Figure 2.2.1: Stingless Bee) which would hang loosely downwards, it's a prominent way of differentiating between a stingless bee and other bees (Wu Yuwei et al., 2019). Amongst the most diverse and useful of all insect groups, the stingless bees are both fascinating as well as captivating. They are found in the tropical and sub-tropical regions including Brazil, Australia, Africa, and of course, Malaysia. This is because they are adaptive to different types of vegetation forests, savannah, fields and mountains. (Andreia et al., 2005). One of the most common stingless bees found in the region of Southeast Asia is the *Heterotrigona itama*.

Figure 2.2.1: A diagram of Stingless Bee (Source: Chui Shao Xiong, 2014, National University of Singapore)

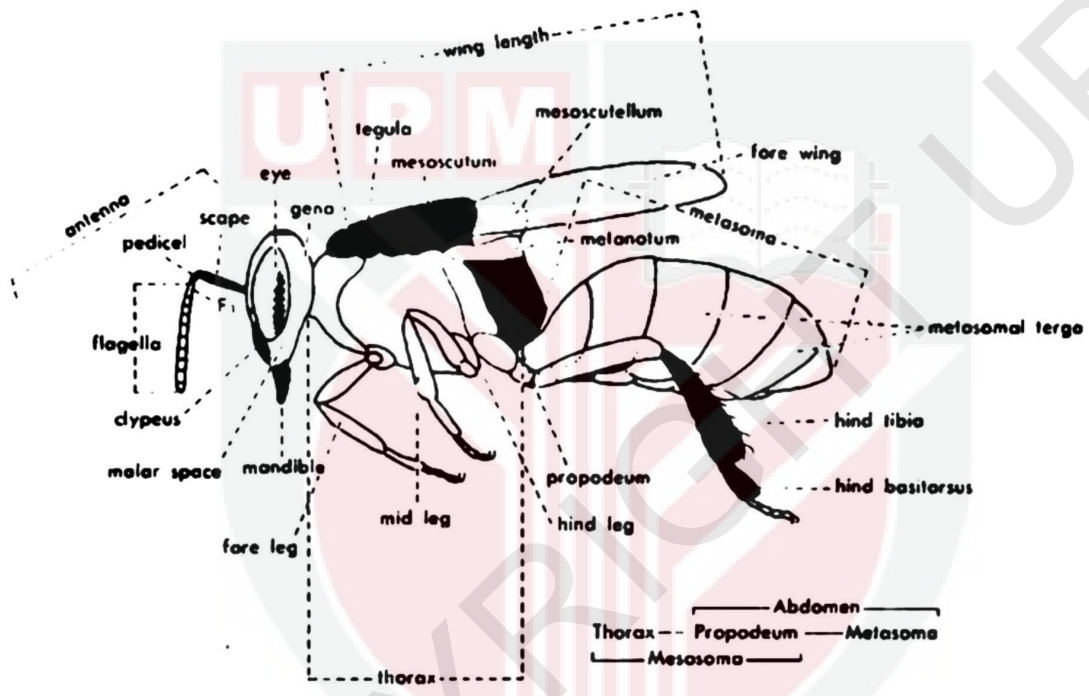

Figure 2.2.2: Side view diagram of a typical stingless bee. (Source: Sakagami et al., (1990), Natural History of Social Wasps and Bees in Equatorial Sumatra)

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 (Abd. Jalil et al., 2017). They act as the main pollinators for many wild and cultivated tropical plants. Honey compositions depend greatly on

the botanical origin of honey, thus further research is essential to explore in depth the usefulness of honey as functional foods and its benefits to health.

The stingless bees are not over-particular in building their hives. It is easier for them to build an artificial hive in order to manipulate the colony and increase honey production (Abd Jalil et al., 2017). They are unique as the honey originates from the rich vegetation found in native environments. Stingless bee are easier to handle compared to honey bees that are often lost, always abandoning their hive and are vulnerable to diseases (Khairunnisa, 2011).

Stingless bee honey has a distinctive sweetness mixed with a sour and acidic taste. Honey is a supersaturated sugar solution from the nectar or secretion of plant that was converted into honey from the enzyme produced by bees. Honey contained around 80 to 85 % of carbohydrates, 15- 17 % of water, 0.3 % of proteins, and 0.2 % of ashes (Lim D.C.C., 2019). Honey consists of high concentration of fructose and glucose, with low levels of amino acids, phenolic acids, organic acids, vitamins, minerals, enzyme and other phytochemicals (Cantarelli et al., 2008, Silva et al., 2013).

Hydroxymethylfurfural (HMF) content and diastase activity are parameters used to evaluate freshness and/or overheating of honey (Gomes et al. 2011). At first, the formation of HMF is thought due to poor handling, storage or processing, honey degradation and also prolonged exposure of high temperature or hitting. But as stated by Gomes S. et al. (2010), Spano N. et al. (2006), Fallico B. et al. (2006), fructose in the honey is decomposed and reacts with acid since HMF is a cyclic aldehyde formed by decomposition of fructose in the presence of acid where HMF increases with

heating, time of storage or adulteration with invert sugar syrup (Almeida-Muradian 2013). Studies had shown that due to the 5-HMF which can be cytotoxic, mutagenic, carcinogenic, and genotoxic (Capuano & Fogliano, 2011) it is imperative to observe its concentration in food products as honey.

Research on honey showed that active compound in honey such as flavonoids, phenolic compounds and certain enzymes (glucose oxidase and catalase) has beneficial effects to our health. Similaryly, stingless bee honey has such benefits including antimicrobial, antioxidant and anti-inflammatory activities, treatment of eye diseases and as a supplement for consumers' health (Rao et al., 2016).

Honey has been reported to improve metabolic abnormalities such as lowering hyperglycemia (Rashid et al, 2019). Stingless bee honey has been consumed traditionally in Malaysia with beliefs on its anti-ageing effects enhancing libido and immune system, killing bacteria, treating bronchial phlegm, and relieving sore throat, cough, and cold (Barakhbah, 2007). Aside from its ability to heal wounds as well as potential adjuvant, several studies had shown honey to possess various pharmacological properties such as anti-inflammatory, antioxidant, anti-cancer, anti-ulcer, antimicrobial, anti-nociceptive and antibacterial properties (Hassan & Abdul Karim 2018; Machado De-Melo et al. 2018; Martinotti et al. 2018; Martinotti & Ranzato 2018; Putri Shuhaili et al. 2016; Sawazaki et al. 2018; Stagos et al. 2018; Sabir et al. 2005; Kek et al. 2014; Zainol et al. 2013). It was further observed that there was a decrease in body weight of diabetic patients stated by Bahrami et al. (2009). Such observations serves to make honey a suitable supplement in the daily diet.

As stated by the Malaysian Agricultural Research and Development Institute (MARDI), stingless bee honey contains up to ten times more antioxidants than regular honey and is twice as nutritious. Based on the research done by Budin et al. (2017) on streptozotocin-induced diabetic rats, the antioxidant property of stingless bee honey has been shown to prevent sperm and testicular oxidative damage. High content of phenolics and flavonoids are mainly responsible for the antioxidant properties of honey. Having low pH and enzymatic glucose oxidation reaction contributes to the antibacterial property of honey (Hassan & Abdul Karim 2018; Putri Shuhaili et al. 2016). In addition, slow absorption of honey leads to the formation of short-chain fatty acid fermentation agents by gut microbiota (Hassan & Abdul Karim 2018) which are essential for health and wellbeing of the host (LeBlanc et al. 2017; Mohan et al. 2017).

According to Malaysian Standard (MS 2683:2017) Kelulut (Stingless Bee) Honey- Specifications, the moisture content of raw unprocessed Malaysian stingless bee honey shall not be more than 35%. The water content in honey specifically in stingless bee honey in general, has become a major issue since the high water content promotes microbial activities that causes fermentation process as reported by Stephen (1964) . Biluca et al. (2014) further proves the statement which states that the honey's fluidity derives from its high water content, which can undergo undesirable fermentation either caused by the yeast of nectar micro-flora or introduced by apiary management, resulting in the formation of organic compounds that can affect taste and colour, as well as decrease shelf life (Abramovic, Jamnik, Burkan, & Kac, 2008).

The production of honey mainly depends on various factors such as fruit or flower season, the geography that affects the temperature, bee species and maturity of the honey. Moreover, honey is considered to be a heat sensitive material generally,

with most of its content can be altered due to certain amount of excessive heat especially the antimicrobial antioxidant in it as explained by Fauzi et al. (2014). The thermal treatment of honey is a practical method for preventing or postponing crystallisation and to ease filling by viscosity reduction, however it destroys micro-organisms (Tosi et al., 2002; Turhan et al., 2008).

As such, freeze drying is found to be one of the effective method in ensuring the colour, smell, flavour and any heat-sensitive nutrients are retained without adding any additives. Though the process can be costly, freeze dried honey has a relatively small density, easy to transport, and can be eaten directly.

2.3 Freeze Drying

Drying is a common method since water removal restrains microorganism's growth, enzyme activity and decreases the weight of product, making it easier for transportation as well as storage (de Brujin et al, 2016). By contrast, the dried material should be possible to recuperate the properties of the fresh material by rehydrating. Freeze drying, is the removal of water by freezing the material, then reducing the pressure and add heat to allow the frozen water in the material to sublimate. Sublimation is the transformation of ice directly into a gas without passing through a liquid phase (see Figure 2.3.1). This technique allows to retain food quality and

structure better than other dehydration process, however, high energy costs and long processing times restricts its relevance to a high-value product (Karam, et al, 2016).

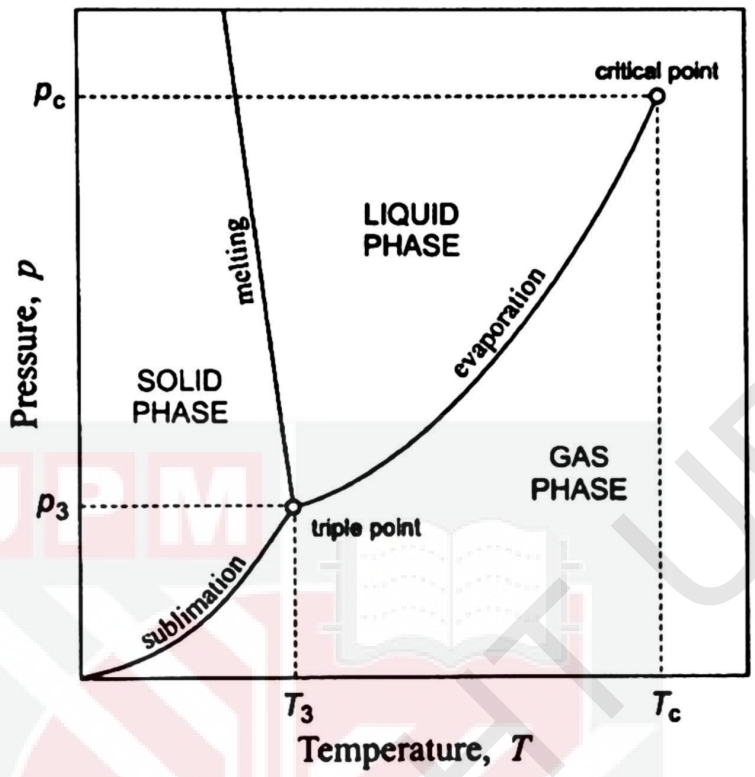

Figure 2.3.1: Sublimation according to a Phase Diagram (Source: E. Generalic)

Freezing is the first step of a freeze-drying process. During freezing, the liquid suspension is cooled and ice crystals of pure water are formed. As more and more water contained in the liquid freezes, it increases the concentration of the remaining liquid. As the liquid suspension becomes more concentrated, its viscosity increases including inhabitation of further crystallization (Abdelwahed W. et al 2006). This highly concentrated and viscous liquid solidifies, yielding an amorphous, crystalline phase. The small percentage of water that remains in liquid state and does not freeze are consider as bound water.

At low temperatures, honey becomes a glassy amorphous solid that is non-crystalline. Most freezers available are maintain a temperature of between -4°C and -20°C. These temperatures are not adequate to completely freeze honey to its glassy

state. They are however adequate to make honey stay fresh for a long period of time. Frozen honey should not experience large temperature fluctuations as changes in temperature causes the structure of ice particles to change and it will slowly degrades the frozen honey. It is also recommended that honey to be frozen needs space to give the honey room for expansion.

After freezing, the primary drying stage involves the sublimation of ice from the frozen material. At the beginning, heat is transferred from the shelf to the frozen material through the tray and the vial, and conducted to the sublimation front. The ice then sublimes and the water vapour formed passes through the dried portion of the material to the surface of the sample. The water vapour is transferred from the surface of the product through the chamber to the condenser and the water vapour condenses. At the end of the sublimation step, a porous plug is formed. Its pores represents the space that were occupied by ice crystals. Secondary drying involves the removal of absorbed water from the material. This is the water which did not separate as ice during freezing and did not sublimate. Figure 2.3.2 shows a single-cycle freeze drying process for both primary and secondary drying (Ratti C., 2013)

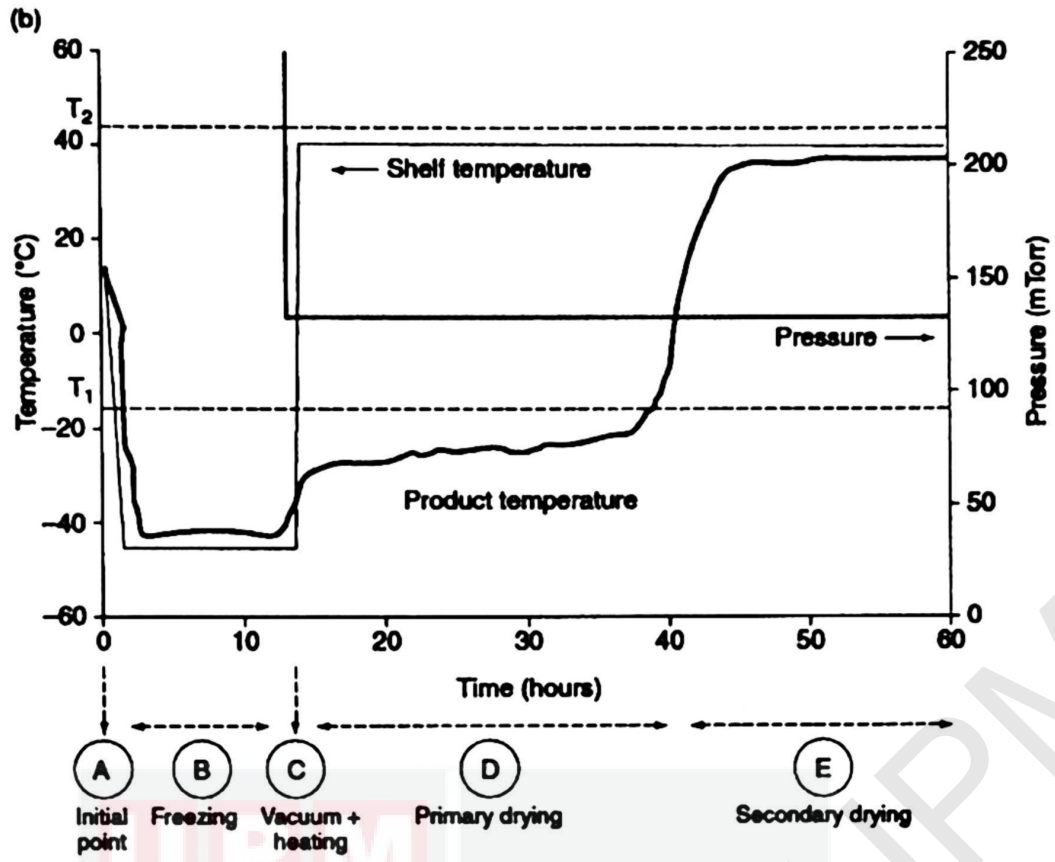

Figure 2.3.2: Product temperature profile during freeze drying. (Source Freeze Drying for Food Powder Production, Handbook of Food Powders)

Sagar et al (2019) had introduced a two-step protocol for freeze drying of a dark grade maple syrup by using glass transition temperatures to determine the primary and secondary drying temperature and using an online shelf and product temperature reading with thermocouples to determine the end of primary drying. Maple sugar powder were produced under two drying times of 25 and 30 hour. The powder exhibits fair to poor flow characteristic owing to its cohesiveness but have an instant-like properties with dissolution times shorter than 14s.

Products and material that have undergone freeze drying are of a much higher quality because most of the deterioration actions are slowed down or practically stopped. Which in turn, minimises flavour and aroma losses, maximizes nutrient retention and have porous structure due to the absence of liquid water, the absence of oxygen under vacuum and the use of low temperatures. (Ratti, 2001). Freeze dried products have high structural rigidity, high rehydration capacity, low density, and they

retain the initial raw material properties such as appearance, shape, taste, and flavour. This process is generally used for the dehydration of products of high added value and sensitivity to heat treatments (Welti-chanes J. et al 2004).

CHAPTER 3: METHODOLOGY

3.1 Introduction

In this chapter, the method and materials needed to produce a freeze dried stingless bee honey is described. In addition, raw stingless bee honey and freeze dried stingless bee honey are analysed in terms of moisture content, viscosity and dissolution. The project that started early on March 2020 is done at the laboratory of Halal Products Research Institute. The stingless bee honey that were used for the project was taken from the University Agricultural Park. Stingless bee honey is mainly consumed for its health benefits by groups of people who are in favour of organic goods.

3.2 Raw Material

The stingless bee honey used for the experiment is harvest and taken from the University Agriculture Park Division. The stingless bee honey is then kept in a vacuum glass bottle and stored inside a chiller before using.

3.3 Freezing

Before starting the process of freeze drying, the stingless bee honey must undergo primary freezing to ensure that the honey is completely frozen and

sublimation can occur during the process. Stingless bee honey however, could not be frozen in a domestic refrigerator. Using the falcon tube, about 15 ml of stingless bee honey is frozen inside the freezer with a temperature of -20°C for 24 hours.

Figure 3.3.1: Falcon tube

Another way of freezing stingless bee honey is by using dry ice. 15ml of stingless bee honey poured inside the falcon tube is frozen using dry ice which has a temperature of -70°C for 24 hours. The box containing dry ice and sample of stingless bee honey is placed in cool, dim-lit space as to not speed up the evaporation of dry ice. In ensuring the process is not reversed by having thawed stingless bee honey once the dry ice has evaporated, the timing between freezing the stingless bee honey and freeze drying process shall be accounted for.

Figure 3.3.2: Stingless bee honey inside dry ice

3.4 Freeze Drying

With the freeze stingless bee honey still inside the falcon tube, it is then placed inside the freeze dryer which is set at a temperature of -104°C. The process of freeze drying will be done once all the water from the stingless bee honey has turned into vapour and all that is left is dried stingless bee honey, in any case, a powder form.

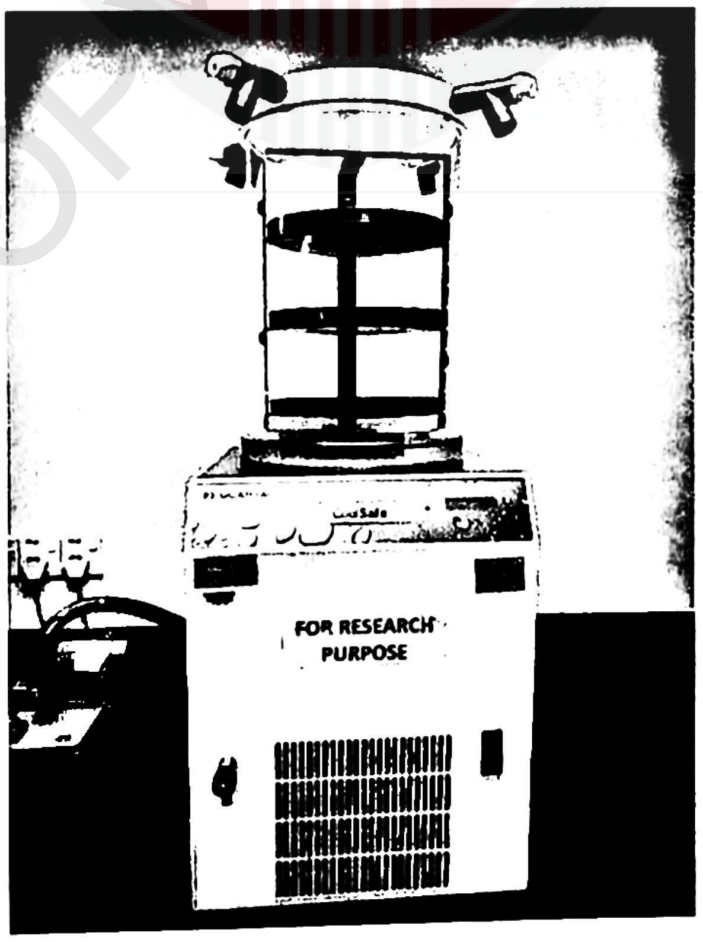

Figure 3.4.1: Freeze Dryer

3.5 Characterisation of Stingless Bee Honey

Raw stingless bee honey and freeze dried stingless bee honey are tested to characterise the honey before and after freeze drying occurred. The stingless honey bee does not, unfortunately, turns into a powder form. And due to poor time management, only observation of the stingless bee honey was done.

CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 Introduction

In this chapter, the way the stingless bee honey behaves during and after freeze drying are observed and recorded will be discussed.

4.2 Primary Freezing

Initially, 15ml of stingless bee honey was poured into a falcon tube. With an amount of 15ml, there was only a little gap between the honey and the top of the falcon tube. This space inside the falcon tube play an important role during freeze drying. After 24 hours, the honey however was not completely frozen, it flows but at a slower rate than being at room temperature.

Figure 4.2.1: 15ml Stingless bee honey (freezer)

Secondly, with the 15ml stingless bee honey inside the falcon tube, the samples were placed inside a container filled with dry ice as shown in Figure 4.2.2. Dry ice with a temperature of - 70°C, were able to freeze the sample but the honey flows at a much slower rate than that of using a freezer after 24 hours. The gap between the top of the falcon tube and honey were still narrow.

Figure 4.2.2: 15ml Stingless bee honey (dry ice)

Thirdly, with an amount of 1ml, the stingless bee honey was poured into the falcon tube and was frozen with dry ice for 24 hours as seen in Figure 4.2.3. The small amount of honey provided ample space between the honey and the top of the falcon tube. It was observed that the 1ml honey did not freeze completely but flows at a slower rate between the three freezing conditions. At lower temperatures, honey becomes a glassy amorphous solid that is non-crytalline.

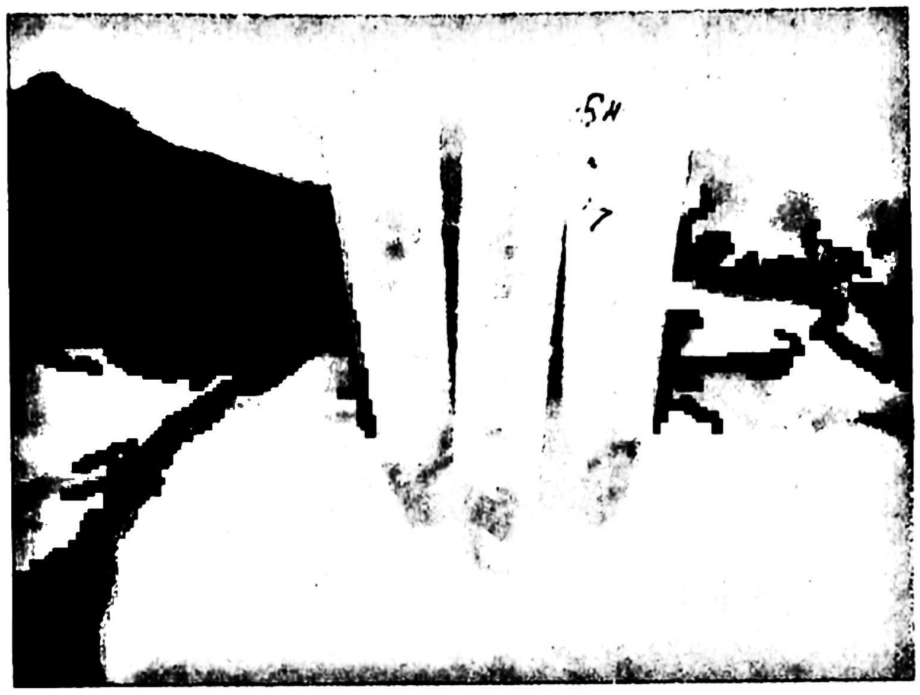

Figure 4.2.3: 1ml of Stingless bee honey (dry ice)

4.3 Freeze Drying

The freeze drying of stingless bee honey was done using a freeze dryer that was provided by the Laboratory of Halal Services, Halal Products Research Institute.

To begin with, the 15ml stingless bee honey freeze with a freezer was placed inside the freeze dryer. During observation, it can be clearly seen that the honey did not freeze completely. Upon placing the sample inside the freeze dryer, the sample started to bubble and honey started to spill out of the falcon tube and into the container that contained all three samples. (Figure 4.3.1). The experiment was cut short due to the dismay that this may have a negative impact on the freeze dryer. The bubbling and spilling of the honey were mainly due to the honey being not properly frozen. It produced bubbling effects when exposed to vacuum condition, due to the presence of air pockets in the honey.

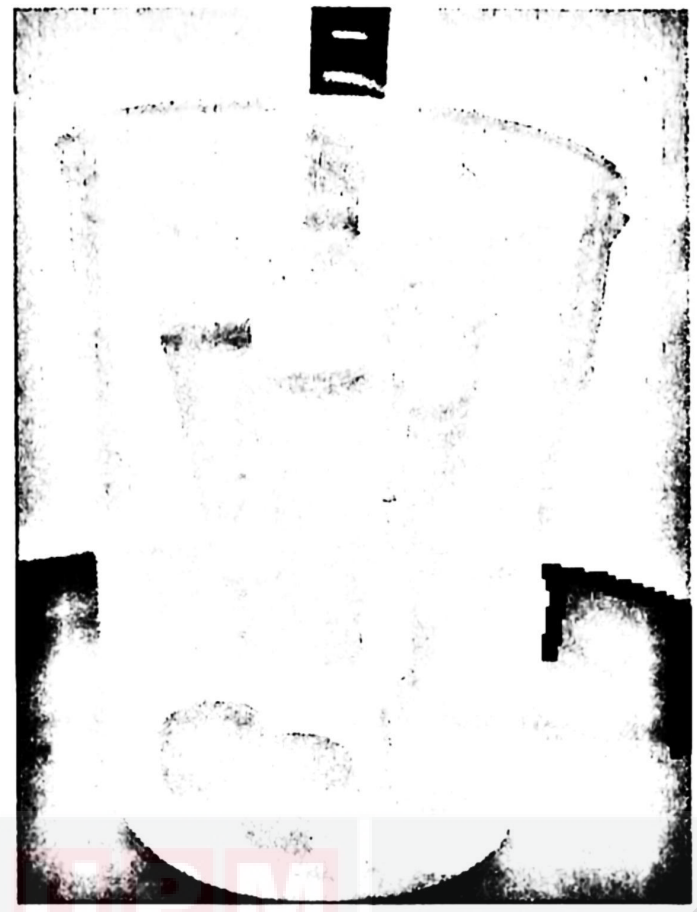

Figure 4.3.1: Stingless bee honey initial freeze drying

Secondly, with 15ml of stingless bee honey freeze with dry ice, that is, on placing the honey in the freeze dryer, there were no signs of any activity however after a few minutes, the honey started to form bubbles thus overflowed beyond the falcon tube. This may be due to freezing the honey in dry ice which caused it to be colder and flow at a slower rate than compared to before. Figure 4.3.2 shows the bubbling effect on honey.

Figure 4.3.2: Stingless bee honey second freeze drying

Thirdly, with a 1ml of stingless bee honey freeze in dry ice, the bubbling effect also occurred but due to the smaller amount, the bubbled honey does not spill over the falcon tube. In Figure 4.3.3, it can be seen that all the honey were still contained.

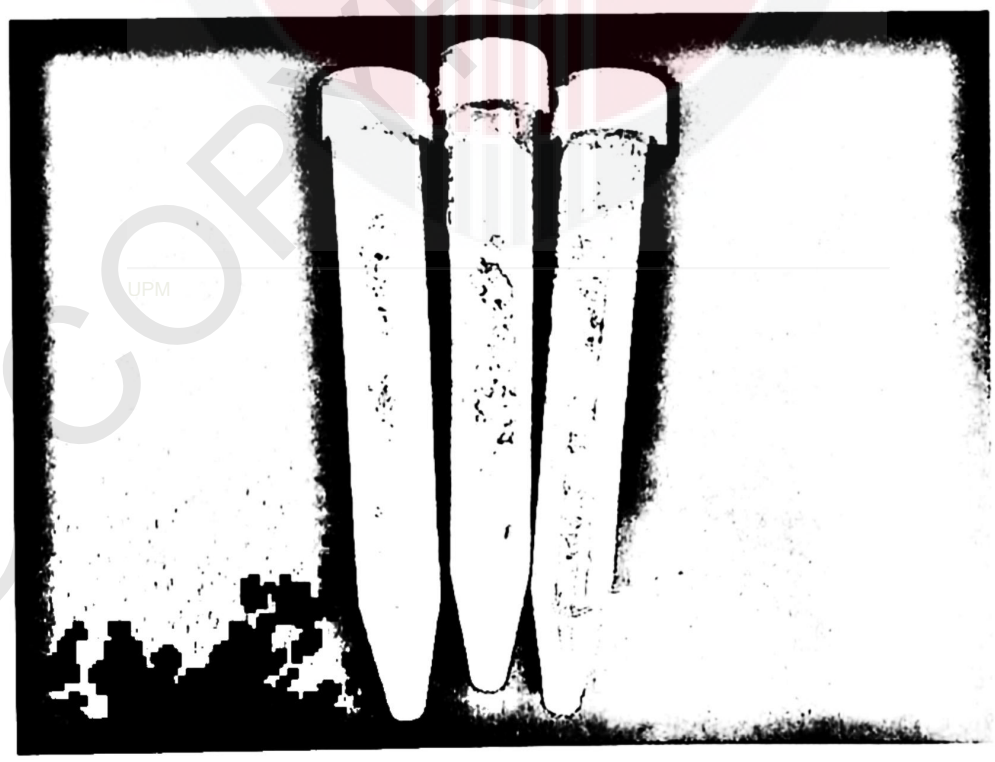

Figure 4.3.3: Stingless bee honey third freeze drying

It is the utmost important to know the freezing point of stingless bee honey in order to carry out the experiment accordingly and safely without hindrance to the user and the equipment used.

The results taken from the freeze drying were done through observation of the third and final freezing condition of stingless bee honey which is the 1ml of honey freeze with dry ice. For both the 15ml honey, the amount of spillage that occurred caused less honey inside the falcon tube and makes it a bit difficult to use the honey for data collection.

The Figure 4.3.4 shows the state of honey that has just been taken out of a chiller and just before freezing it with dry ice. It can be seen that the honey was less viscous and flows in accordance to the position the falcon tube placed on its side.

Figure 4.3.4: Chilled stingless bee honey

After freeze drying had occurred, the sample with the bubbling effect still within the falcon tube was capped and stored at a cool, low light area for observation. The stingless bee honey began settling and only a few of the bubbles can be seen

situated at the sides of the falcon tubes. The main difference that can be seen was the way the stingless bee honey acts. Based on figure 4.3.5, the falcon tubes were positioned the same way as before freeze dried but the stingless bee honey had become more viscous and flows at a much slower rate. Although, the stingless bee honey inside the falcon tube has not been tampered with, it seems that the honey has harden as it refuses to dribble down even when the falcon tube was placed upside down.

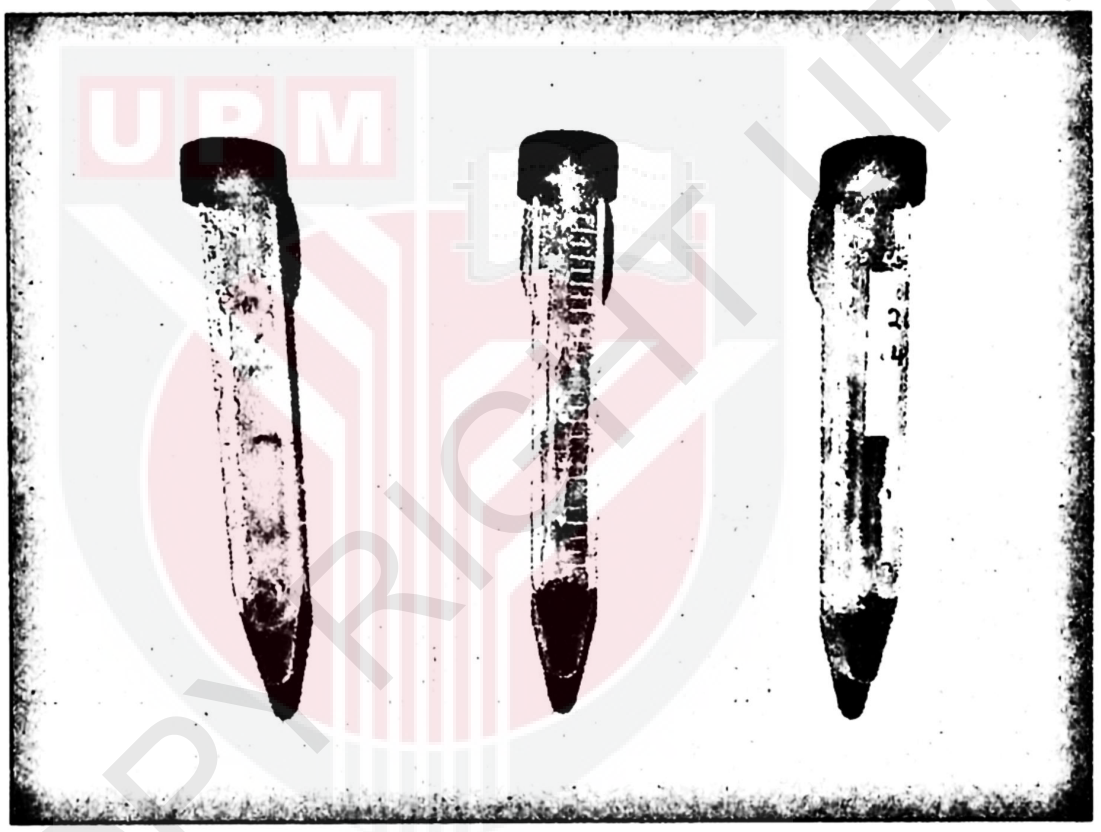

Figure 4.3.5 (a): Freeze dried stingless bee honey

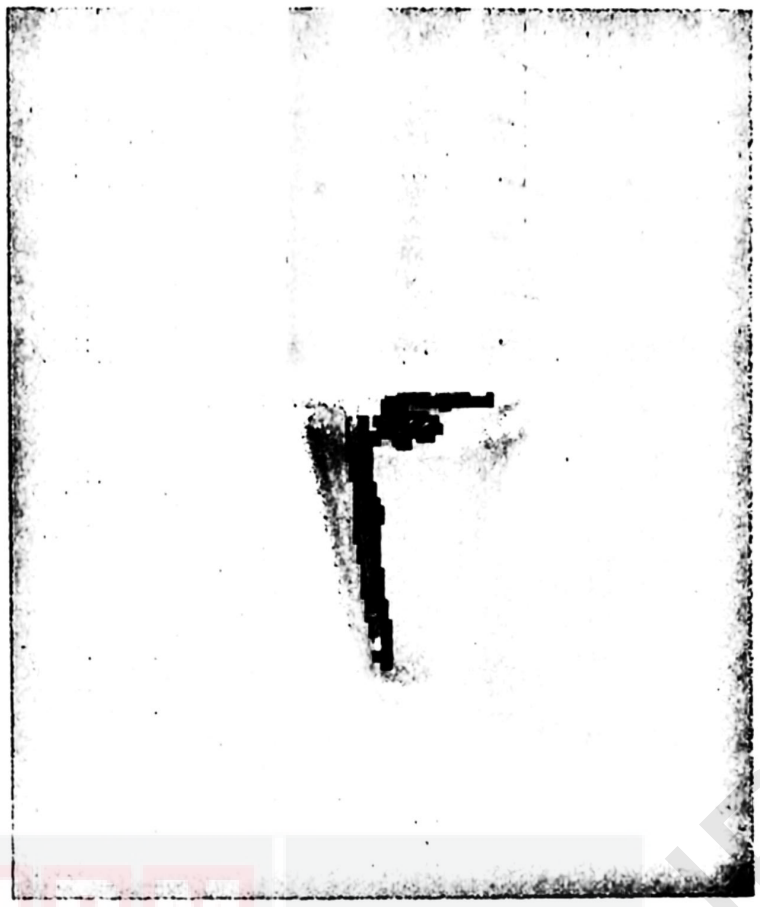

Figure 4.3.5 (b): Freeze dried stingless bee honey

Although a more viscous and harder to flow stingless bee honey might be easier to transport and would not cause any spill damage while in storage, for consumption, it would be a hassle to be poured and inconvenient to be taken daily as it take a long time for the stingless bee honey to flow out.

Nurhadi et al (2016), mentioned that honey could not be dehydrated into powder without an addition of other materials mainly filler materials of a high glass transition temperature. Glass transition temperature is defined as a temperature which amorphous food material enters from solid glassy state to rubbery state, which means that a significant change in molecular mobility and physical properties occur at this critical temperature (Ratti, 2001). The glass transition temperature were dependant on the water content and composition. The reported glass transition temperature of honey are low and vary according to several studies. Starch, modified starch, maltodextrins,

and Arabic gum are some of the available filler materials for drying of honey. Nurhadi et al (2012) also mentioned, a combination of high drying rate (low temperature at low absolute preassure) and use of the filler materials enabled the production of powder with a high level of natural solids. The use of water as an aid to enhance homogenous mixing of honey and maltodextrin affected the total solid content of the liquid honey mixture. The total solids content of the liquid being dried is an important factor in determining the success of the drying process.

CHAPTER 5: CONCLUSIONS

Stingless bee are bees commonly found in tropical areas. They are great pollinators for a variety of floras found within the tropical areas. As of now, more and more people are interested in stingless bee and its honey but it is mainly known locally as the species are more abundant. The stingless bee honey are at a rise but due to its low production and high demand, the cost of buying a stingless bee honey are rather steep. The popularity of the stingless bee honey gained the term "Super Food" by certain consumers because of its benefits such as anti-oxidant, anti-inflammatory and anti-microbial. As stingless bee honey are rather sour than sweet compared to existing honey such as Manuka honey, stingless bee honey could not act as a sugar substitute or as an ingredient to be added or even as a topping for certain dishes. The stingless bee honey can be catered to groups of people who prefers organic foods instead of processed supplements. These health benefits can impact a consumer's dietary consumption. However, it is in the nature of stingless bee honey to have a high moisture content. The shelf-life of honey will be greatly affected by the moisture content as it will promote fermentation. Ways to prolong the shelf-life of stingless bee honey while at the same time keeping its nutritional benefits are greatly needed. The idea of freeze drying is introduced since it is performed with a low temperature, the nutrition can be retained and only the physical form of stingless bee honey is changed. Unfortunately, having a greater viscosity causes the stingless bee honey to not freeze properly. Hence the study does not end with a final outcome of producing powdered stingless bee honey.

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