Physicochemical characteristics of west Sumatera's forest honey

M D E Wiratmoko and A Pribadi

*Research and Development of Forest Fiber Technology Institute, Ministry of Environment and Forestry, Kampar Regency, 28401, Indonesia

*E-mail: michael.enggar@gmail.com

Abstract. Asian giant honeybees (Apis dorsata) have an important economic role for the community around the forest and forest’s health. However, degradation and conversion of forest are the main threats for its existence and distribution. Thus, the conservation strategy needs to be developed to maintain their honey production. Moreover, natural landscapes in West Sumatera province makes some unique characteristics of the honey since in each bioregion has its vegetations. This study aimed to characterize the physicochemical characteristics of West Sumatra’s forest honey. Observation and survey were used as the research method. SNI 3545:2013 was used as a reference for making the comparison between bioregions. The result showed that physicochemical characteristics of West Sumatra’s forest honey taken from many bioregions have already met the standard required by SNI 3545:2013. Furthermore, the physicochemical characteristics are not significantly different between its bioregions.

1. Introduction

Asian giant honey bees (Apis dorsata) has an important key for supporting the economic sector for people who lived around forests. Most local people who lived around forest hunt for their honey for their livelihood and daily needs. The study revealed that in one tree can be inhabited by more than 50 colonies of A. dorsata and can produce up to 10 kg honey [14]. However, most of these local people are using the unsustainable technique to obtain its honey. As a result, it destroys their nest and migrates to other trees. Furthermore, they do not want to inhibit the trees anymore. Hence, the better and sustainable technique to gather honey should be promoted to maintain the productivity and the quality of the honey.

Deforestation that happens to sialang tree (a local term defined by local people to call trees inhibited by A. dorsata) and landscape fragmentation and conversion into plantations are main factors that considerably disturb the existence and habitat of A. dorsata. The good environment holds the essential keys for the sustainability of honey production. One of parameter used for calculating the environment quality is the condition of surrounded forest (hutan kepungan) around sialang tree and the availability of nectarous plants. The main factor that makes declining in the honey bee population in west India was decrease of Dalbergia sissoo trees population [19]. Thus, it shows that honey bees depend on the forest as their habitat and sources for their food. Moreover, trees need A. dorsata to be
one of the pollinators. Thus, conservation strategies are required to be developed in order to maintain the sustainability of honey production and its habitat.

Indonesia is one of the countries that have a great potential in producing honey in the world. Honey production in Indonesia reached 492.60 tons distributed on the five biggest islands [3]. However, the study reported that the total demand for honey in Indonesia reaches up to 3600 – 4000 tons per year [4]. It means that Indonesia still in honey deficit problems or about 80% of honey demand is not covered by our production. This condition supposed to lead to challenges and opportunities for many beekeepers in Indonesia to boost their productivity. In related to that, the lack of honey production can initiate many frauds of honey. Based on these problems, it is required to find better and effective ways to detect any frauds potential toward honey products.

West Sumatera province is one province in Indonesia that have a great honey production. West Sumatera provinces can produce up to 680 kg/year [2]. This amount is smaller than honey production that only reached 26.25 ton/year in 2002. Many districts that are known as the center of honey production, namely Solok, Dharmasraya, Sijunjung, dan Pesisir Selatan. Those districts have unique landscapes and effect on the vegetation structure of lowland to highland. These variations are assumed to give significant effects on honey characteristics. In other words, the differences between the vegetations and environment in each landscape or bioregion are presumably affecting the physiochemistry characteristics of the origin bio-regions.

This study used some parameters on SNI 3545:2013 as a reference to examine the characteristics of honey gathered from West Sumatera province. SNI 3545:2013 was used as a reference since it accommodates all physics and chemistries parameters and officially used to standardize all honey products in Indonesia [11]. Furthermore, there is no guarantee and assurance in the originality and quality of honey in West Sumatera province. Hence, the prejudice toward the originality of West Sumatera’s honey will always be questioned [15]. Thus, the objective of this study is to examine and determine some physic and chemistry parameters of West Sumatera province’s honey-based on SNI 3545:

2. Materials and Methods

2.1. Location

This study was conducted in West Sumatera province from March 2016 to November 2016. Six locations were represented by the characteristic of the landscapes structure, namely (1) natural forest, (2) *Acacia mangium* plantations, (3) rubber plantations, (4) oil palm plantations, (5) mangrove forest, and (6) mixed heterogenic horticulture plantations.

2.2. Methods

This study was used observation method. The survey was conducted to select the appropriate *A. dorsata*’s colonies that represent its bioregions. For each bioregion, samples were gathered using three replications from different *A. dorsata* colonies that inhabited different sialang trees at same bioregion. Samples were processed and analyzed based on the work procedure stated in SNI 3545:2013.

Parameters that were observed in this study i.e. Hydroxsimetilfurfural (HMF), water content, reduction sugar content, sucrose content and color.
3. Results and Discussion
The results of the analysis of variance on the five quantitative parameters contained in SNI 3545: 2013 indicate that all honey samples obtained from 6 bioregions in West Sumatra did not have any significant difference except for the parameters of sucrose content.

3.1. Water content
The result showed no statistical differences among the bioregion (Table 1). The honey samples from natural forest and rubber plantations have higher value than is stated on SNI 3545:2013 which required not more than 22% although all honey samples were wax-sealed already. Thus, it is categorized as mature honey.

Water is one of the constituent elements of honey in addition to reducing sugars [16]. Moreover, honey has hygroscopic properties and easily absorbs water [6]. The water content of honey can be affected by weather conditions, initial nectar moisture content, and post-harvest handling [5]. Wet weather conditions and high air humidity can give significant effect to honey produced by *A. dorsata* and it causes the honey cannot meet the SNI requirement. Hence, this condition leads the honey to have high water content.

Moisture is one of the most relevant characteristics of honey because it influences viscosity, specific weight, maturation, crystallization, taste, and conservation of this food. Furthermore, after extraction process, moisture changes according to storage due to water transfer [20]. A high-water content in honey facilitates the proliferation of yeasts, causing fermentation process, which decreases the quality of product and sometimes is categorized as fraud [12].

Figure 1. Research locations
3.2. *Hidroksimetilfurfural (HMF)*

The test of Hydroximetilfurfural showed no statistical differences among the bioregions (Table 1). The results showed that samples taken from mangrove forest had a high HMF content compared to other samples which were 49.58 mg/kg. Nevertheless, most samples gathered from all bioregions have already met the SNI 3545:2013 which required level below 50 mg/kg. HMF is the result of decomposition of glucose, fructose, and other monosaccharides which have six C atoms in an acidic atmosphere and their formation can be accelerated with the help of heat [1]. HMF is usually found in foods that experience excess of processing such as heating. The presence of HMF in honey is usually used as an indicator of the quality level of honey. The higher the value of HMF (more than 50 mg/kg), the lower the quality of honey or it can be indicated that honey is exposed to excess heating during honey processing.

3.3. *Ash content*

ANOVA test (P-value) shows that the value of ash content in the honey samples did not show any significant differences between bioregions. Furthermore, the results revealed that there were only two bioregions that have ash content above 0.5%, namely natural forest and rubber plantations. Also, all honey samples obtained have significant difference values with the minimum standard values required by SNI 3545: 2013. The ash content in honey is influenced by the source of nectar and harvesting techniques [8]. Harvesting techniques by squeezing can increase the ash content in honey. Moreover, the existence of pollen also contributes to ash content although it increases the honey quality since it has various minerals such as K, Na, Ca, B, Cl, I, Mn with the value is 3 - 4%. In other words, when the ash content in honey is high, it can be considered if honey is mixed with pollen during the extraction process.

Table 1. Average of the physico-chemical parameters of the giant honeybee’s honey from bioregion in west Sumatera province

| Bioregions                  | n   | Moisture (%) | HMF (mg/kg) | Ashes (%) | Reducing Sugar (%) | Sucrose (%) | Color (Pfund Scale) |
|-----------------------------|-----|--------------|-------------|-----------|--------------------|-------------|---------------------|
| Natural forest              | 3   | 23.35<sup>a</sup> | 37.65<sup>a</sup> | 0.52<sup>a</sup> | 75.65<sup>a</sup> | 4.25a | 110                 |
| A. mangium plantations      | 5   | 20.75<sup>a</sup> | 30.67<sup>a</sup> | 0.14<sup>a</sup> | 86.64<sup>a</sup> | 7.67bc | 90                  |
| Rubber plantations          | 2   | 24.70<sup>a</sup> | 37.07<sup>a</sup> | 0.61<sup>a</sup> | 73.97<sup>a</sup> | 5.21ab | 50                  |
| Palm oil plantations        | 5   | 20.85<sup>a</sup> | 30.09<sup>a</sup> | 0.40<sup>a</sup> | 87.60<sup>a</sup> | 9.49c | 120                 |
| Mangrove forest             | 2   | 15.49<sup>a</sup> | 49.58<sup>a</sup> | 0.9<sup>a</sup>  | 86.09<sup>a</sup> | 15.85d | 60                  |
| Mixed heterogenic horticulture plantations | 3   | 20.26<sup>a</sup> | 43.06<sup>a</sup> | 0.02<sup>a</sup> | 85.18<sup>a</sup> | 4.53a | 100                 |

Remarks: Means followed by the same letter(s) in the same column are not significantly different at the 5% probability level according to Duncan test.

3.4. *Reduction sugar*

The analysis showed that all samples originated from oil palm plantations have the highest reduction in sugar levels compared to other samples which are equal to 87.6%. Meanwhile, samples obtained from rubber plantations have the lowest reducing sugar levels as 73.97%. However, in general, honey samples from all bioregions have met SNI 3545:2013 standard, which required level above 65%. In related to that, the dominant type of sugar in honey is fructose, which is pure and simple sugar from fruit extracts, while white sugar is made from sucrose which is processed by a human from sugar cane.
Measurement of reducing sugar levels is important to determine if there are any additional contents in honey. If sugar has been diluted in honey, the reduction of sugar content contained will be below SNI standard.

3.5. Sucrose content
Sucrose content is one of the parameters that can be used to determine the originality of honey products. This happens because sucrose is a compound sugar that has not been broken down by the enzyme amylase or invertase which is only owned by bees. During the ripening process of nectar into honey, sucrose derived from nectar will be broken down by the activity of invertase enzymes into simple forms of sugar which are glucose and fructose. Immediately after the broken down of sucrose, simple sugars (fructose and glucose) will be formed [17]. These two simple sugars are not found in nectar [17].

The results of the F test (P value) showed the value of sucrose levels in honey samples showed significant differences between bioregions. The results of the honey sample test showed that there were four bioregions which had sucrose level greater than it is required in SNI 3545: 2013 which is only 5%. Furthermore, there are only natural forests and mixed gardens that meet the requirement in SNI 3545:2013. Meanwhile, all honey samples taken from other bioregions were significantly different from what is required on SNI 3545: 2013. The results of the analysis showed that all samples of honey had a smaller value than is required, as it gives as 5%. In related to that, The Swiss Bee Research Center [18] states that there are three groups of honey based on their sucrose levels, namely (1) general honey which has a maximum sucrose content of 5%, (2) honey from the flowers of Robinia, Lavandula, Hedysarum, Trifolium, Citrus, Mediacago Eucalyptus camaludensis, and Eucryphia have a maximum sucrose content of 10%, and (3) honey derived from Calomanthus flowers, Eucalyptus scabia, Banksia, Xanthorrhoea, and honeydew have a maximum sucrose content of 15%.

3.6. Honey color
The color level of honey depends on the source of nectar and the composition of minerals from the soil where the nectar-producing plants grow. Some people assume that the bright color of honey shows better quality than honey which is darker. However, honey has darker colors have more mineral content than light-colored honey (Table 2) [13]. In addition to the mineral content, honey which has a darker color also shows a higher content of phenolic compounds than bright color honey [7]. In addition to that matter, honey color from all honey samples are vary which range from extra light amber and light amber to dark amber. This shows that the color of honey samples originating each bioregion cannot be used as a distinctive marker because it has a wide range of colors.

| Mineral | Dark Colored Honey (Dark Amber), mg/kg | Light Colored Honey (Light Amber), mg/kg |
|---------|----------------------------------------|----------------------------------------|
| Ca      | 227                                    | 107                                    |
| Cu      | 1                                      | 1                                      |
| K       | 1241                                   | 441                                    |
| Mg      | 132                                    | 40                                     |
| Mn      | 10                                     | 1                                      |
| Na      | 23                                     | 251                                    |
| P       | 123                                    | 129                                    |
| Zn      | 2                                      | 3                                      |
4. Conclusion
The physicochemical characteristics of West Sumatra forest honey did not show significant differences between bioregions except for sucrose level. Some honey taken from certain bioregions showed did not meet the requirement in SNI 3545: 2013, particularly on parameters of water content, ash content, and sucrose. However, in general, based on the physicochemical properties, honey from West Sumatra had met SNI 3545: 2013.

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