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Effect of change in moisture content of Sumatra Forest Honey on total sugar, electrical conductivity and color

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Abstract. Sumatra forest honey is a type of forest honey produced by *Apis dorsata*. High humidity in forest environments and the type of open nest can increase the moisture content of honey because of its hygroscopic. The high moisture content has the potential for fermentation cause a decrease in the physicochemical quality of honey and can cause damage to packaging in long-term storage. This research was to know the effect of reducing the moisture content of Sumatran forest honey from 25% to 22% using a vacuum evaporator. The method used an experimental method with a completely randomized design consisting of four treatments and four replications. The results of these parameters are the total sugar content between 72.5% to 76% which has a very significant effect, electrical conductivity between 0.92 and 1.08. ms/cm which gave a significant effect as well as the color intensity of $L * a * b *$ between 14.67 to 17.93 which did not affect the moisture content level of honey. The conclusion of this research showed that decreasing the moisture content of honey using a vacuum evaporator was able to improve the physical and chemical quality of honey.

1. Introduction

Sumatran forest honey is honey produced by wild bees *Apis dorsata*. Sumatra has vast forests scattered in various districts such as Solok, Dharmasraya, Sijunjung, and Pesisir Selatan [1]. Each district has different vegetation characteristics and altitude so it is assumed that it will have an influence on the quality of the honey produced. Unlike honey that comes from grazing bees, Sumatran forest honey has the character of honey which is dark in color, smells slightly sour and watery. The quality of honey is influenced by the surrounding environment because honey is easy to absorb water or hygroscopic. Sumatran forests have a variety of plant vegetation as well as high levels of humidity between 60-90% which can affect the quality of the honey produced.

The form of an open forest honeycomb accompanied by high humidity affects the physical and chemical quality of forest honey, one of which is moisture content. Moisture content greatly affects the quality of honey because it can determine its shelf-life. The moisture content that has been determined by the Indonesian National Standard (SNI of Honey 8664 - 2018) is 22%, while the Codex Alimentarius 2001 that the moisture content of honey is not more than 20%. Sumatran forest honey has a moisture content of between 24-26% so that the potential for fermentation is caused by yeast. Yeast will degrade the sugar content in honey and will produce alcohol which will turn into acetic acid and oxalic acid when interacting with oxygen so that this can affect sensory quality and decrease nutrition in honey [2].



Various types of Sumatran forest plant vegetation will produce various types of flower nectar and the mineral content from the soil will determine the mineral content in honey. Soil mineral content in forests is thought to affect the mineral content of honey and color produced.

Efforts to reduce the moisture content of honey can help maintain the physical and chemical qualities of honey during the storage period. One of the methods used is through a heating process using a vacuum evaporator. The reduction in moisture content by the vacuum method can reduce the moisture content and prevent granulation by the sugar content of honey. The use of a vacuum evaporator can maintain the quality of honey because the heating process uses the optimum temperature and the appropriate pressure so as not to damage the physical and chemical qualities of honey. This study aims to determine the effect of levels of levels in honey on the total sugar content, electrical conductivity and color intensity of honey.

2. Material and methods

2.1. Location

This research was conducted at the Laboratory of Animal Products Technology, Faculty of Animal Science, Brawijaya University and PT. Kembang Joyo Sriwijaya. This research was conducted from 15th June to 23th August 2020.

2.2. Method

This study used an experimental method with a Completely Randomized Design (CRD) consisting of 4 treatments and 4 replications. The treatments consisted of honey moisture content of 25%, 24%, 23% and 22%, each of which consisted of 4 replications. The data obtained will be analyzed with Analysis of Variance (ANOVA) and followed by the Duncan's Multiple Range Test (DMRT) test if a significant difference is produced ($P < 0.05$). The honey quality parameters observed were total sugar content, electrical conductivity and honey color intensity.

2.3. Collect and preparation sample

Samples are taken from the same drum container with the amount of honey equal to 50 kg for each time the evaporation process is carried out. The tools used are a digital sitting scale with a capacity of 500 kg, a large pot, a cloth filter and a vacuum evaporator machine. Evaporation of honey is carried out by pouring 50 kg of honey which has been weighed into a vacuum machine. Then the honey is heated with a moisture content of 26% until it reaches a temperature of 600 C and the pressure is at 60 atm. Check the moisture content every 10 minutes until it matches the desired moisture content for sampling. The evaporation process is continued when the sample with a certain moisture content has been obtained until it reaches a moisture content of 22%.

2.4. Total sugar

The method of testing total sugar in honey was carried out using a brix refractometer [3]. The refractometer used is the manual Atago refractometer by measuring the refractive index of honey and regularly cleaning aquadest. How to use a honey refractometer is to open a light plate and then drop a few drops of honey until the honey covers the entire blue area. The result is the value on the sweetness scale shown in the viewfinder. Sweetness value expressed in percent brix (% brix).

2.5. Electric conductivity

The honey conductivity test method is carried out using an EC meter. The tool used is a professional 2 in 1 pH meter EC meter. Determination of the electrical conductivity value of honey is carried out by weighing a sample of 10 grams (20% w/v) using a digital scale, the honey sample is dissolved with 50 ml of distilled water in a beaker glass and homogenized. Electrical conductivity measurements are carried out by immersing the EC meter electrode in the honey sample solution [3]. In this study, the

sample volume was used according to the existing ratio, namely 1: 5, 2 mL of honey was used and 10 mL of aquadest was used.

2.6. Color intensity

The color intensity of honey is determined in the L*, a*, b* system. Measurement of color intensity is done by attaching the CS-10 colorimeter sensor to the sample that has been placed in a 20 mL volume film pot 3 times and the average values of L*, a* and b* are taken. L is the brightness (lightness) coordinate of the light which has a value range of 0-100. The value of a is the saturation of the red-green axis, if positive indicates red and negative a indicates green. A positive b value indicates yellow and a negative b value indicates blue [4]. Instrumental color grading can be calculated by the formula:

$$\Delta E^* = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2}$$

3. Results and discussion

3.1. Total sugar

The results of the total sugar test can be seen in table 1. The results of the Duncan test showed that the decrease in moisture content in Sumatran forest honey had a very significant effect on the total sugar content of honey ($P > 0.01$). Based on the results of sample testing, it shows that the decrease in moisture content in honey is accompanied by an increase in the total sugar content. The highest total sugar content was 76% brix in the treatment with a decrease in the moisture content of honey to reach 22% in accordance with SNI 8664 2018. The lowest sugar content was 72% brix in the treatment of reducing the moisture content of honey to 25%. The average total sugar content in all treatment samples exceeds the standards set by Codex Alimentarius 2001, namely by not exceeding 60 of 100 g.

The main components of honey are sugar and water. Carbohydrates that dominate honey are from reducing sugars, namely glucose and fructose by 70–80%, moisture content of 10-20% and other components, namely organic acids, organic minerals, minerals, vitamins, proteins, enzymes, volatile components and flavonoids [6]. Total sugar is influenced by the sucrose content, which is the main type of sugar from nectar. The components of sucrose can be broken down by the invertase enzyme into simple sugars, namely fructose and glucose, which are reducing sugars [5]. The Indonesian National Standard 8664-2018 has determined that the minimum total reducing sugar content in honey is at least 65%, so that all samples have been categorized as meeting the standard. The total sugar content in honey is influenced by the type of plant origin (nectar), geographical origin, climate, processing and storage [6].

Table 1. Results of average Sumatran Forest Honey sugar total.

Moisture content of honey (%)	Total sugar (% brix)
25	72.75±0.50 ^a
24	73.98±0.05 ^b
23	74.93±0.29 ^c
22	75.53±0.33 ^d

The total sugar content and water content in honey can be used to control the honey granulation process [7]. Crystallization in honey occurs in honey which has high sugar content. Sugar will become crystals of glucose monohydrate and crystals then separate from the water and fructose [6]. The lowest percentage of total honey sugar brix is found in honey with the highest moisture content, namely 25%. The moisture content in honey can trigger yeast activity to grow and develop, causing the fermentation process. Yeast that causes fermentation in honey comes from the genus *Zigosac charomyces* which is resistant to high sugar concentrations so that it can live and thrive in honey. The presence of yeast in honey can degrade sugars such as dextrose and levulose into alcohol and CO₂ so that it affects the total sugar content of honey [8].

3.2. Electric conductivity

The results of the electrical conductivity test can be seen in table 2. The moisture content level has a significant effect on the conductivity or electric power of honey ($P>0.05$). The lowest average conductivity value is owned by Sumatran forest honey with the highest moisture content, namely 25%. The value of electrical conductivity in this study continues to increase along with decreasing moisture content. The value of honey's electrical conductivity is standardized on Codex Alimentarius 2001 which states that the electrical conductivity, not more than 0.8 m/s. The electrical conductivity values for all honey samples exceed the established limits. However, the state of honey after dilution with aquadest solvent cannot be related to these provisions because of the many properties and compositions in honey. The use of a solvent such as purified water to dissolve honey can increase the conductivity to a value of 1.1 $\mu\text{S}/\text{cm}$ which is equivalent to pure water with a NaCl content of 0.48 ppm. Honey has the highest electrical conductivity value with a moisture content of 23% and 22%, namely (1.037 ± 0.017 m/s) and (1.035 ± 0.043 m/s). Electrical conductivity varies depending on geographic location and botanical conditions. Electrical conductivity is influenced by levels of ash and acidity, the higher the ash and acid content, the higher the value of the electrical conductivity [7].

Table 2. Results of average electrical conductivity of Sumatra forest honey

Moisture content of honey (%)	Electrical conductivity (m/s)
25	0.96 ± 0.04^a
24	1.01 ± 0.02^b
23	1.03 ± 0.01^{bc}
22	1.03 ± 0.04^b

Electrical conductivity is also influenced by the mineral content and organic acids in honey [9]. The acidity of honey is related to the presence of organic acids in it and the mineral content of honey characterizes the plant from which honey is derived. Forest honey is thought to have advantages, namely high mineral content so that it will affect the value of electrical conductivity. The mineral content of honey is obtained from flower nectar which is influenced by mineral conditions in the soil, forest environmental conditions can increase the solid content and the electrical conductivity of honey.

3.3. Color intensity

The results of the $L^* a^* b^*$ color intensity test can be seen in table 3. The level of moisture content does not have a significant effect on the color intensity of honey, but the highest color intensity is owned by honey with the lowest moisture content, namely 22% with a color intensity of 16.51 ± 1.02 . Notation L^* indicates the level of brightness on the honey object, the a^* notation shows the level of redness and greenness of the object with a positive value indicating that the object tends to be red while the negative value shows the object tends to be greenish, the b^* notation shows a yellow blue color on the object, if the value is positive shows that the object tends to be bluish and if the value is negating it indicates that the object tends to be bluish [10]. Honey sample images can be seen in figure 1.

Table 3. Average color intensity of Sumatran Forest Honey.

Moisture (%)	L^*	a^*	b^*	ΔE
25	14.84	-2.12	2.86	15.27 ± 0.711
24	15.71	-2.61	2.74	16.16 ± 0.731
23	15.20	-2.41	2.74	15.80 ± 0.540
22	15.34	-2.66	4.39	16.51 ± 1.023



Figure 1. Color of Sumatran forest honey based on the Moisture content.

The difference in color in honey is caused by the presence of pigments such as carotenoids and flavonoids which are influenced by the type of plant and the geographical origin of the honey. Harvest age and consistency of honey also affect the resulting color. The color and consistency of honey also depend on the moisture content, saccharides, and pollen of honey. Sumatran forest honey has a darker color and is indicated to have a high phenolic value compared to light-colored honey [11].

The L^* value will decrease or get closer to zero along with the browning process that occurs due to the heating process in honey. The level of browning is stated in the Browning Index (BI). Browning index is influenced by the length of time heating honey, this is due to the presence of non-enzymatic reactions by reducing sugar carbonyl groups, aldehydes, ketones, protein amino acid groups, and other compounds that will produce dehydrated products due to the heating process. The heating temperature used in the evaporation process was 60°C and balanced with the pressure applied so that the boiling point of honey can be reached in a short time, a point which did not cause denaturation of some bioactive components in honey. In addition, a negative a^* value in all samples indicates that the Sumatran forest honey sample has a higher value of red color and the b^* value indicates a positive value indicating that Sumatran forest honey as a sample is more yellowish in color.

4. Conclusion

The quality of honey is maintained in terms of total sugar content, electrical conductivity, and color intensity with the process of reducing its moisture content using a vacuum evaporator.

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