Physicochemical and color characteristic of the Bawakaraeng Forest Honey, South Sulawesi

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Abstract. Honey is a thick liquid produced by bees consisting of natural sugars derived from flower nectar or plant secretions. The content of monosaccharides and fructose causes the sweetness of honey, and glucose compounds are naturally found in honey derived from the juices of food carried by bees. This study aims to determine physicochemical and color characteristics of forest honey from Bawakaraeng Mountain with the quality of honey obtained in accordance with the Indonesian National Standard. Characterization of the physicochemical quality of total sugar content was measured using a refractometer, acidity by pH meter, and color characteristics by Hunter Methods using chromameter instruments. In the results, color characterization of forest honey L* 22.28-22.46; a* 3.30-3.37; b* 4.74-4.87, L value indicates a lightness level that tends to be dark and a yellow-red chromatic color range (YR). Then water content is 21.06%, total sugar content is 49.53%, and pH 4. Finally, physicochemical and color characteristics analysis of forest honey needs to be studied more rapidly on the content of bioactive compounds and their benefits for health. The potential of forest honey from the Sinjai Regency is a new functional food that provides high antioxidant content value and rich nutrients.

1. Introduction

Honey is a natural sweet substance produced by honeybees from the nectar of blossoms, the secretion of living parts of plants, or the excretion of plant-sucking insects on the living parts of plants. Honeybees collect, transform, and combine with specific substances of their own, store, and leave to ripen and mature in the honeycomb [1]. The nectar types used by honey bees, postharvest honey handling practices, and geographical ecology (climate and soil) all influence the physicochemical properties of honey. Honey's physicochemical properties are examined to determine its authenticity and to detect the presence of artificial ingredients [2,3].

Honey is produced primarily by Apis mellifera bees, the most important product obtained from beekeeping [4]. Nectar, a sugary secretion of flowers that contains 70-80% water, is used to make honey. Honey's flavor and taste are determined by the flower that provides the nectar. The bees add enzymes to the nectar and reduce the water content to about 19%, allowing the honey to last longer in the hive [5]. Fructose (38%) is the primary sugar, followed by glucose (31%), sucrose (1%), and water (18%) in the final product, and there are also proteins, vitamins, and enzymes [6,7]. There have been reports of phytochemicals like apigenin, pinocembrin, kaempferol, quercetin, galangin, chrysin,
hesperetin, ellagic, caffeic acid, p-coumaric, and ferulic acids [8]. It also contains minerals and elements, the composition of which is dependent on the honey's botanical and geographical origins [9].

Research [10] revealed that volatile compounds and honey aromas originating in Argentina that were analyzed using ethyl phenol and ethyl oxalate had a relationship with the level of ripeness of the fruit consumed by honeybees. The resulting honey has a spicy taste and a distinctive smell from the bee's food source, which consists mainly of 3-methylene and terpineol content. Another study, physicochemical and mineral analysis for 45 samples from three types of honeybees acacia, meadow, and sunflower in Vojvodina, Republic of Serbia. Most of the honey samples analyzed met the criteria based on physical and chemical quality, except for four samples that did not meet the requirements based on the parameters of moisture content and hydroxymethylfurfural (HMF) content [11]. Similar research, the effect of thermal treatment at 63°C for 10, 20, and 30 min on physicochemical quality in three types of Iranian honey, thyme (Zataria multiflora), multi-floral honey, and lotus (Ziziphus lotus). The influence of heating affects the decrease in phenolics content and antioxidant activity in honey, but there is an increase in hydroxymethylfurfural (HMF) content. Reduction in honey's antioxidant capacity is significant from a nutritional standpoint, impacting honey's health benefits [12]. Moreover, physicochemical, proximate, and antimicrobial activities analysis on 12 honey samples collected from three areas of Anfilo district (Yali, Yati, and Shebel sites), Southwest Ethiopia. Honey from all sites inhibited the growth of all reference pathogens, despite the varied concentrations. As a result, honey is a good source of nutrients and has antimicrobial properties against pathogens that cause food poisoning. Honey should be studied further as a nutritive therapeutic substance to prevent foodborne diseases [13]. The quality parameters can be used to determine whether honey is adulterated [14].

The sweet taste of honey is caused by the element of fructose monosaccharides so that it can be used as an alternative sweetener in place of sugar. Honey has been widely known as a food ingredient rich in benefits but does not yet have a high enough prestige in Indonesian society. This is due to the assumption that honey is still more viewed as a drug and supplement, and not yet guaranteed the quality of honey sold in the market is also one of the contributing factors to low levels of honey consumption. The quality of honey is related explicitly to its authenticity, assessed from quality indicators by consumers are color, flavor, taste, mineral content, and contaminants that affect the color of honey.

Indonesia is the largest honey exporter recognized worldwide. Some areas in Indonesia have become honey producers, including Sumbawa, East Kalimantan, Riau, Lampung, and Java. In South Sulawesi, there are several honey-producing areas but honey sourced from forests has a different nutritional content than honey that is bred. The great potential of forest honey found on Mount Bawakaraeng, Balakia Village, Sinjai Regency, has a sweet taste and is only consumed by the local people as a supplement because it is believed about its efficacy and authenticity for generations without knowing the chemical characteristics, especially its nutritional content. Based on this, the study aims to perform the aspects of the physicochemical and color of Bawakaraeng forest honey to inform the public and have the opportunity to market more widely that can potentially make it a top commodity product in Sinjai Regency.

2. Methodology
2.1. Bawakaraeng forest honey collection
Honey samples were collected directly from producers in Bawakaraeng Mountain, Sinjai Regency, South Sulawesi, Indonesia (Figure 1). Honey was obtained from Traditional beehives and was placed in trees or other places where predators couldn't get to them. Honey was extracted from the hives by hand with pressure or wooden presses. To conduct the study, researchers purchased approximately 1 kg of each honey sample directly from the collectors. Until the analyses, the samples were kept at room temperature and in a dark place.
2.2. *The moisture content of Bawakaraeng forest honey*
A refractometer (ATR-BR Schmidt and Haensch, Germany) was used to determine the moisture content. A few drops of honey were placed on the prism of the refractometer, and a reading was taken directly from the display (AOAC method number 969.38) [15].

2.3. *pH measurement of Bawakaraeng forest honey*
Dissolving a honey sample (10 g/75 mL distilled water) in standardized 0.1 M NaOH and titrating to pH 8.3 with a pH glass electrode attached to a pH meter (Consort C861, Belgium) as an endpoint indicator, free acid (meq of acid/1000 g) was determined. After calibration with standard buffer solutions pH 4, 7, and 10, pH was determined using a glass electrode (AOAC method number 962.19) [16,17].

2.4. *Apparent reducing sugar content of Bawakaraeng forest honey*
The apparent reducing sugar content was determined using a modified [1] procedure involving the reduction of Soxhlet's modification of Fehling's solution by titration at the boiling point against a solution of reducing sugars in honey solution (dissolving about 2 g homogeneous honey sample into 100 ml distilled water from which 50 ml was diluted to 100 ml) using methylene blue as an internal indicator.

2.5. *Colour characteristics of Bawakaraeng forest honey*
The Hunter method was used to analyze the colors of the samples using a Minolta Chroma CR-400 (Minolta Co, Osaka, Japan) (L, a, and b). The value of the nori snack's luminosity (L), Hue angle (°Hue), and chromaticity (C) will be visible as a parameter of the value L, a, b sample. The value (+) a stands for red, value (-) a for green, value (+) b for yellow, and value (-) b for blue [18].

![Figure 1. Sample Bawakaraeng forest honey. a) Packaging from traditional beehives, and b) Honey appearance.](image)

3. *Results and discussion*
Honey, regardless of its varied geographical origin, is generally acidic. Investigation pH value of honey confirms the acidity properties of honey, determined by the abundance of organic acids. The majority of acids found in honey are gluconic acid which is in the equilibrium of lactones and their esters, and inorganic ions such as phosphates and chloride. The result of the pH analysis was 4; indications of honey freshness are in the pH range of 3.4-6.1 [19]. The pH of honey strongly influences the flavor and aroma of honey; some aromatic acids cause it. It is found in forest honey, such as format acid, tartaric acid, maleic acid, citric acid, succinic acid, butyric acid, lactic acid, and
Oxalic acid [19]. Acidity characteristics of forest honey significantly affect antimicrobial activity; low acidity can inhibit the growth of bacteria so that it has a role in increasing the shelf life of honey [20]. Honey samples from Artisanal (Madrid) and Cordoba (Argentina) were found to have pH values ranging from 3.63-5.01 [21] and 3.14-5.05 [22]. Jars of honey with a pH of 3.5-4.5 are considered blossom honey, according to [23], while honey samples with a pH of more than five are regarded as low quality. As a result, Harenna forest honey is classified as blossom honey and has a pH of 3.5–4.5 [23].

Moisture content is one indicator of honey quality, the higher the moisture content and acidity, the lower the quality of honey. The water content of Bawakaraeng forest honey is 21.06%, this level is still following the quality requirements of 22% in Indonesian National Standard (SNI 8664:2018) and international honey standard limit (2001/110/EC) from the Council of the European Union, does not exceed 21%. Honey moisture content is influenced by several factors, harvest time, climate factors, postharvest handling of the type of nectar collected, and the maturity level of honey [22]. If the harvest time is done in the morning, where the conditions around the forest are filled with dew, honey with hygroscopic properties can draw moisture from the surrounding air until it reaches equilibrium. This condition takes place during the process of extortion, filtering, to packaging. Water content is strictly related to the botanical origin of the honey sample, harvesting techniques, extraction from the comb about the ripening process by bees, and degree of maturity in the hive [24].

Many European national beekeeping organizations, such as those in Belgium, Austria, Spain, Italy, and Germany, have set moisture content maximums of 17.50–18.50 g/100 g for certain types of honey. As a result, the moisture content of Harenna forest honey (17.89 1.02 g/100 g) satisfies the European beekeeping organization's unique class of honey.

The types of sugars found in honey are monosaccharides, namely glucose and fructose. The analysis of reducing sugar is 49.53%. This level is below the Indonesian National Standard (SNI 8664-2018), with a minimum content of 65% (b/b). Some factors that cause sugar content in honey to decrease are water content and harvest time. The sugar content in forest honey that has not been processed generally does not meet the requirements of the Indonesian National Standard. The Bawakaraeng forest's traditional hives were suspended from selected tallest trees 30–40 meters above the ground, while the frame hives were on the ground. There is a universal truth that as one's height rises above ground level, the likelihood of evaporation rises as well. As a result, the traditional hive's location aids in concentrating the honey's solid components, resulting in a decrease in sugar content. Furthermore, the differences in sugar content reduction methods between traditional and frame hives could be due to differences in the sugars in the nectar and enzymes in the bee and nectar.

Sugars are the main constituents of honey, consist of 95% of the dry weight of honey [1]. Research [25] discovered that honey is a concentrated monosaccharide solution containing 60–85% fructose and glucose. Bawakaraeng forest honey is blossom honey that has higher fructose than glucose content. The results of a sugar reduction analysis and a specific rotation proved this (levorotatory). Honeydew honey, or blends of honeydew honey and blossom honey, are classified by Codex Alimentarius as having about 45 g of reducing sugar per 100 g of honey [26]. The CA (Codex Alimentarius), EU (European Community), and Ethiopian standards were met in this study's sugar reduction results. The minimum limit for reducing sugar in honey is 65 g/100 g in the CA, EU, and Ethiopian standards.

The color of honey is an important quality indicator for consumers. The color classification of honey is commonly used for commercialization and affects the price of honey in the world market [27]. The color measurement of Bawakaraeng forest honey with chromameter is L* 22.28-22.46; a* 3.30-3.37; and b* 4.74-4.87. Based on the classification of L* value, Bawakaraeng forest honey is considered dark honey because of the value of L*<50 and has red and yellow components. Dark honey has a higher content of minerals and phenolic compounds than light-colored honey. Light-colored honey generally has a higher price, but dark-colored honey is more appreciated and preferred in certain areas [28]. The varied honey color is influenced by several factors: plant origin, mineral content, antioxidant pigments (carotenoids and flavonoids), temperature, and shelf life. Color
enhancement may be caused by a decrease in moisture content and, as a result, an increase in the concentration of the components responsible for honey's color, such as minerals.

4. Conclusion
The Bawakaraeng forest honey reducing sugar, pH, moisture, and color satisfied the Indonesian National Standard (SNI), Ethiopian Standards, Codex Alimentarius (CA), and European Community (EU). As a result, traditional honey harvesting and processing methods do not appear to have a negative impact on honey quality factors. Contrary to popular belief, honey harvested and processed using traditional methods are generally of low quality. The Bawakaraeng forest honey, which is largely sourced from traditional hives, met the quality parameters established by the Indonesian National Standard (SNI), Ethiopian Standards, Codex Alimentarius (CA), and European Community (EU).

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The authors declare no conflict of interest.

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