JPPIPA 10(SpecialIssue) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Sugar Content Composition of Various Types of Honey Produced by Apis Mellifera L.: A Review

Juniarny Silfana Waworuntu[1*]

[1] Klabat University, Airmadidi, Indonesia

Received: June 21, 2024
Revised: July 27, 2024
Accepted: August 25, 2024
Published: August 31, 2024

Corresponding author:
Dally Rahman
dallyrahman@nrs.unand.ac.id

DOI: 10.29303/jppipa.v10iSpecialIssue.8199

Abstract: The purpose of this review is to determine the sugar content profile in various types of honey produced by Apis mellifera, such as monofloral, unifloral, extra-floral, and honeydew. Generally, the goal is to assess the average sugar content parameters within acceptable ranges set by SNI, Codex, and EU as quality and sugar content requirements. Among the honey types studied, monofloral honey met the sugar standards but some samples were found to have low sugar content, ranging from 21.77% to 58.95%, below SNI and Codex standards. In contrast, unifloral, extra-floral, and honeydew honeys exhibited higher sugar levels, in accordance with established standards, ranging from 73.40% to 83.9%. The differences in sugar content among the types of honey produced by A. mellifera are influenced by nectar sources, geography, climate, and vegetation. Monofloral honey tends to have lower sugar content, while unifloral, extra-floral, and honeydew honeys are richer in sugar, making them more compliant with honey quality standards. Further research should focus on identifying plant species and the quantity of nectar that can consistently produce honey with sugar content meeting established quality standards.

Keywords: Apis mellifera L.; Honey; Sugar

Introduction

Apis mellifera is a native bee of Europe, and in Indonesia, it was seriously developed in the 1970s (Widiarti & Kuntadi 2012). A. mellifera has a high adaptability to various climatic conditions, allowing it to produce a large amount of honey and not be overly aggressive (Gojmerac 1983). Approximately 25% of the total honey production in Indonesia comes from A. mellifera bees (Kuntadi 2008).

Honey is utilized by humans due to the health benefits it offers; 100 grams of honey contains about 306 kcal of energy. Twenty grams of honey provides 61.2 kcal, or 3% of the daily energy requirement, absorbed into the bloodstream without prior digestion (Bogdanov et al., 2008; Blasa et al. 2006; Ajibola et al., 2012). Other benefits of honey include its excellent glucose tolerance compared to other sugar solutions for cardiovascular health, chemoradiotherapy, cough relief in children, wound healing, and other diseases (Morales et al., 2023).

Carbohydrates are essential macro-nutrients in metabolic pathways that provide the energy required for the proper functioning of human organs. Sugar intake needs to be controlled for energy balance in the body; however, excessive consumption of sweet products at various ages, from children to adults, can lead to health vulnerabilities to diseases in the present or future (Witek et al., 2022).

A. mellifera is a type of honeybee capable of producing honey with a better natural sugar content compared to artificial sugars.The amount of nectar produced is a sweet liquid secreted by the nectar glands of plants, which can develop on flowers, leaves, and stems. Nectar is mostly water with dissolved sugars. The sugar content varies significantly based on the flower source and environment (Olaitan et al., 2007). Nectar undergoes physical and chemical processes until it matures into honey. Honey consists of various types of sugars, with fructose and glucose being the main components. The composition criteria for honey according to Codex and EU regulations are: sucrose content $\leq 10\%$, total fructose dan glucose ≥ 45g, acidity $\leq$

How to Cite:
Waworuntu, J. (2024). Sugar Content Composition of Various Types of Honey Produced by Apis Mellifera L.: A Review. *Jurnal Penelitian Pendidikan IPA*, *10*(SpecialIssue), 98–106. https://doi.org/10.29303/jppipa.v10iSpecialIssue.8199

50meq/kg, Hydroxymethylfurfural (HMF) $\leq 40mg/kg$, *kandungan air* $\leq 0.1g/100g$(Bogdanov et al., 1999).

Various factors influence the composition and physicochemical properties of honey, including nectar source, geographical location, bee species, harvesting processes, climate, and vegetation type (Lazaridou et al., 2004).

Based on the source of nectar and pollen, honey from A. mellifera is categorized into four groups: extra-floral honey, monofloral honey, multifloral honey, and honeydew. Extra-floral honey is produced from nectar collected from parts of the plant other than flowers, such as leaves, branches, or stems. Monofloral honey is produced from a single flower species. Multifloral honey comes from a variety of flowers. Honeydew is produced by bees from a honey-like liquid secreted by certain insects, often found on plants or flower petals, or from sap that is consumed by other insects.

Method

This study employs a qualitative descriptive research model, guided by an extensive literature review, to explore the role of carbohydrate intake in maintaining glycogen stores and enhancing physical performance during prolonged exercise. The methodology begins with a comprehensive search of reputable scientific databases, including Scopus, ScienceDirect, and Google Scholar. The search utilizes specific keywords such as "Carbohydrates," "Glycogen Stores," and "Prolonged Exercise" to identify relevant literature.

A systematic approach is then taken to select articles that meet the inclusion criteria, focusing on their authors, publication years, study designs, research objectives, sample characteristics, methodologies, and summaries of findings.

Data collection is performed through a systematic documentation method, wherein pertinent information is gathered and organized from the selected literature. Subsequently, content analysis is employed to evaluate the relevance and contributions of each study, synthesizing the findings into a cohesive document that addresses the research questions related to carbohydrate intake, glycogen maintenance, and physical performance during prolonged exercise.

Results and Discussion

Physicochemical Characterization Of Monofloral Honey In Java

Holt et al. (2002) stated that the differences in sugar content in honey are due to the nectar source from flowers. According to SNI 3545: 2013, the quality requirement for honey has a minimum reducing sugar content of 65% b/b. The reducing sugar content that does not meet SNI standards includes randu honey (R1) and coffee honey (KP1). Generally, sugar content is influenced by moisture and acidity levels. Chasanah (2001) noted that high moisture content in honey can stimulate yeast activity, leading to the degradation of sugars (glucose and fructose) into alcohol and CO2, which causes the honey to become more acidic, thereby reducing the glucose and fructose content. Low reducing sugar content can also be caused by the decomposition of reducing sugars due to an increase in HMF. HMF is a cyclic aldehyde formed during the decomposition of fructose and glucose. Factors such as acidic conditions, high temperatures, high moisture content, and metal containers can affect its formation (Wang & Li, 2011).

Chayati (2008) reported on research conducted with four honey samples from the DIY region and Central Java: kaliandra honey (DIY), longan, rambutan, and randu (Central Java). The results showed moisture content ranging from 18.95% to 26.52%, red color values from 2.23 to 4.13, yellow color values from 10.00 to 40.33, pH ranging from 3.87 to 4.48, and glucose content between 14.63 and 18.82 mg/100ml, fructose 28.82 to 41.30 mg/100ml, and maltose 6.71 to 28.82 mg/100ml. These results are below the honey quality standards. Conversely, research by Adalina et al. (2024) on the physicochemical properties of monofloral and multifloral honey, using four samples—rubber honey, rambutan honey, randu honey, and mango honey—from Java and Kalimantan—showed that monofloral honey had a Pfund intensity of 47 to 143 mm, while multifloral honey had a Pfund value of 74 to 100 mm. The HMF content of monofloral honey was 0.47 to 0.64 mg/kg, while multifloral honey had HMF levels of 0.43 to 0.55 mg/kg. The acidity of monofloral honey was 4.93 ml NaOH 0.1N/kg, while multifloral honey had 2.79 ml NaOH 0.1N/kg. The pH of monofloral honey ranged from 4.1 to 4.5 with an average of 4.3, while multifloral honey ranged from 3.5 to 4.5 with an average of 4.0. The reducing sugar content of monofloral and multifloral honey was 79.03% to 94.88%. The sugar content in both monofloral and multifloral honey met the SNI 8664-2018 standards, with a minimum quality requirement of 65%.

Extra-Floral Honey

Different foraging areas for honey bees (Apis mellifera) will produce honey of varying quality based on reducing sugar content (glucose). Prasetyo (2014) found that glucose levels in rubber honey and rambutan honey indicated that the quality of honey foraged in rubber areas is superior to that of honey foraged in rambutan areas. The glucose content of rubber plants is 66.6 ± 0.9 b/b, while rambutan is 64.5 ± 0.7 b/b. The glucose content in rambutan honey is below the established standard. The main factor is the source plant that produces nectar. Sihombing (2005) stated that rubber and rambutan plants are nectar sources, but the nectar produced by rubber plants is greater compared to that from rambutan plants, leading to a difference in glucose content. Rubber plants produce nectar through extra-floral nectariferous glands secreted via stipules,

leaves, petioles, and stems, whereas nectar from rambutan plants is secreted by floral nectariferous glands through flowers, which are the precursors to fruit and have a high sucrose content.

In the study by Erwan et al. (2020), the reducing sugar content of A. mellifera honey from the sap of Cocus nucifera (73.69 ± 0.21%) was significantly higher ($P < 0.05$) than that from Arenga pinnata sap (60.15 ± 2.13%). The acidity was also lower for Cocus nucifera (22.00 ± 2.14) compared to Arenga pinnata (43.00 ± 7.48). These differences depend on the geographical origin of the flowers, the season, environmental factors, and management practices in beekeeping.

Unifloral Honey

Nayik et al. (2019) studied unifloral honey with four samples (saffron honey, apple honey, cherry honey, and P. rugosus honey) in India, finding that all tested honey samples were acidic (pH 3.01-4.35). The highest sugar content was in apple honey at 78.45%, while saffron honey had the lowest at 73.89%. Cherry honey and P. rugosus honey had sugar contents of 75.60% and 74.58%, respectively. These results were similar to those of Tariq et al. (2022), who tested 12 samples of A. mellifera in the Islamabad and Mardan regions, finding acidity levels of 10-30 meq/kg and sugar contents ranging from 76.2% to 78.8%. Although these results were not significantly different from those of Nayik, the acidity levels in Tariq's study were still high.

Meanwhile, research conducted by Khalil, Motallib, Anisuzzaman, Sathi, Hye, and Shahjahan (2001) presented a table analyzing the biochemical properties of various unifloral honey brands available in Northern Bangladesh.

Table 1. Total Sugar Content of Authentic Honey Brands

Test Honey	Total Sugar content (%)	Reducing Sugar content (%)
Litchi	80.30	65.02
Mustard	79.80	63.20
Plum	77.70	62.30
Til	78.60	64.20
Kadom	78.40	64.40

Source: Khalil, Motallib, Anisuzzaman, Sathi, Hye,dan Shahjahan (2001)

The total sugar content of unifloral honey tested from five different brands—Litchi, Mustard, Plum, Til, and Kadom—showed that Litchi honey had the highest sugar content at 80.3%, while Plum honey had the lowest at 77.7%. These results indicate that unifloral honey from these five brands has high sugar content and can be considered a good source of sugar.

Monofloral Honey

Conti, Medrzycki, Argenti, Meloni, Vecchione, Boi, and Mariotti (2016) conducted research on the sugar and protein content in monofloral pollen, analyzing 40 different pollen samples. The study results showed that the total sugar content ranged from 21.77% (Zea mays) to 58.95% dry matter (Apiaceae f. A <25 µm). This data is consistent with findings from other researchers (Todd and Bretherick, 1942; Szczesna, 2007), except for four types that exceeded the 50% threshold (Apiaceae f. A <25 µm, Linum, Ranunculus arvensis, and Rubus f.). In this study, the minimum and maximum sugar values mentioned align with the nitrogen content in corbiculae, but the estimated nitrogen in pollen antennae dry matter was 8.83% and 4.14%, respectively (> twice as high).

Another study conducted by Fasasi (2012) on the physicochemical attributes of natural honey from Nigerian honeybees showed a mean sugar content of 28.3 ± 2.4% (26.0-30.7%), which only slightly differs from results obtained from honey samples studied in Aragon, Spain (Prez-Aguillue et al., 1994). Lower results were found in Libya (Mohamed et al., 1981), with a sugar content of 25.0 ± 0.5%. The study concluded that naturally harvested honey, when done hygienically, has stable water content with minimal variation in sugar composition, diastase activity, and HMF (Hydroxymethylfurfural), while maintaining EEC and Codex Alimentarius standards with constant viscosity at room temperature for up to two years. This study also indicated that honey can retain its stability without significant physicochemical changes for at least two years if harvested, extracted, and stored hygienically at room temperature without undue disturbances during processing and storage. This is supported by Lazaridou et al. (2004), who noted that the composition of honey depends not only on the plant source and geography but also on processing and storage conditions.

Belay, Haki, Birringer, Borck, Lee, Cho, Kim, Bayissa, Baye, and Melaku (2017), as shown in Table 2, conducted a study on the sugar profile and physicochemical properties of monofloral honey from Ethiopia. They stated that sugars are the main components that regulate honey properties, and their content is closely related to the ripeness and botanical origin of the honey. The results for six sugars—fructose, glucose, sucrose, maltose, turanose, and isomaltose—indicated that the maximum concentration of fructose (43.1 ± 0.4 g/100 g) was found in Acacia honey, while the minimum (35 ± 4 g/100 g) was in Becium grandiflorum. A significant difference ($p < 0.01$) was observed between Acacia and other monofloral honeys in fructose content. The maximum glucose content was found in Leucas abyssinica (37.2 ± 0.4 g/100 g) and the minimum in Becium grandiflorum (29 ± 3 g/100 g). A significant difference ($p < 0.01$) in glucose content was noted between Leucas abyssinica and other monofloral honeys.

This study showed that the average total sugar content of honey ranged from 72.4 to 79.7 g/100 g, with monosaccharides being dominant. Among the monosaccharides, fructose was found to be higher than glucose. This aligns with findings from other researchers

regarding monofloral honey. The higher concentration of fructose found in Acacia honey could serve as an indicator for Acacia honey. This is consistent with the findings of León-Ruiz et al. (2011), which noted that sugar composition has discriminating capacity as a marker for honey. Glucose was the second most abundant sugar in this study, and similar values for glucose have been reported by different researchers. In contrast, findings by Münstedt et al. (2008) and Swallow & Low (1990) indicated that in canola honey, glucose composition was higher than fructose.

Sucrose is an important sugar for detecting and screening honey quality. The contribution of sucrose to the total sugar in honey can increase if the honey is harvested before it ripens. During the ripening process, in the honeycomb, the level of sucrose decreases due to the action of the enzyme invertase. The highest concentration of sucrose (2.8 ± 0.7 g/100 g) was found in Becium grandiflorum, while the lowest (1.1 ± 0.1 g/100 g) was in Syzygium guineense. A significant difference ($p < 0.01$) was observed between Becium grandiflorum and other monofloral honeys in sucrose content. Sucrose was found to be the third most dominant sugar in Ethiopian monofloral honey. In this study, sucrose levels were observed to be lower than the maximum limit (5 g/100 g honey) set by Codex Alimentarius (CA), the European Union (EU), and Ethiopian standards.

Table 2. Sugar composition (g/100g) mean + for monofloral honey

Sample name	Fructose	Glucose	Sucrose	Maltose	Turanose	Isomaltose
Acacia	43.07 ± 0.37a	33.28 ± 0.58c	1.22 ± 0.10e	1.20 ± 0.49de	0.43 ± 0.30e	0.01 ± 0.01c
Becium grandiflorum	35.30 ± 3.53d	29.34 ± 2.75e	2.75 ± 0.65a	1.78 ± 0.16ab	1.03 ± 0.25c	1.52 ± 1.02a
Croton macrostachyus	38.86 ± 0.82c	31.65 ± 1.37d	2.57 ± 0.22b	1.41 ± 0.96cd	0.82 ± 0.37d	0.01 ± 0.03c
Eucalyptus globulus	40.26 ± 0.25b	30.56 ± 0.32def	1.93 ± 0.14d	2.04 ± 0.45a	1.73 ± 0.36a	0.16 ± 0.09bc
Hypoestes	38.14 ± 0.53c	36.17 ± 0.60ab	1.85 ± 0.03d	1.27 ± 0.08ce	0.87 ± 0.05cd	0.49 ± 0.04b
Leucas abyssinica	38.64 ± 0.23c	37.20 ± 0.35a	1.33 ± 0.06e	1.36 ± 0.29bce	0.92 ± 0.24cd	0.19 ± 0.10bc
Schefflera abyssinica	38.81 ± 1.18c	30.55 ± 2.69f	2.14 ± 0.16c	0.55 ± 0.34f	0.33 ± 0.36e	0.00 ± 0.0c
S. guineense	41.01 ± 0.30b	34.33 ± 0.38bc	1.13 ± 0.02e	1.77 ± 0.33ac	1.34 ± 0.11b	0.13 ± 0.09bc

Means in a column, for monofloral honey, with different letters were significantly different
Sumber: Belay, Haki, Birringer, Borck, Lee, Cho, Kim, Bayissa, Baye, dan Melaku (2017)

Table 2, the results of the study by Belay et al. (2017) show that maltose content ranges from 0.55 ± 0.34 g/100 g (Schefflera abyssinica) to 2.04 ± 0.45 g/100 g (Eucalyptus globulus). A significant difference ($p < 0.01$) was observed between Eucalyptus globulus and other monofloral honeys, except for ($p > 0.01$) for Syzygium guineense and Becium grandiflorum. The turanose content ranged from 0.33 ± 0.36 g/100 g (Schefflera abyssinica) to 1.7 ± 0.4 g/100 g (Eucalyptus globulus). A significant difference ($p < 0.01$) was also noted between Eucalyptus globulus and other monofloral honeys. The isomaltose content in Ethiopian monofloral honey ranged from undetectable levels (Schefflera abyssinica) to 1.5 ± 1.0 g/100 g (Becium grandiflorum). A significant difference ($p < 0.01$) was observed between Becium grandiflorum and other monofloral honeys. Maltose, turanose, and isomaltose were found in all monofloral honeys. The maltose values align with the report by Ouchemoukh et al. (2010), and the results for turanose and isomaltose are also similar to findings by Ouchemoukh et al. and De la Fuente (2011). Isomaltose can serve as a marker for Schefflera abyssinica honey.

De Sousa, de Souza, Marques, Benassi, Gullon, Pintado, and Magnani (2015) conducted a study on the sugar profile, physicochemical aspects, and sensory characteristics of monofloral honey produced by various stingless bee species in Brazil, as shown in Table 3.

Table 3. Physicochemical Parameters (n: 3, mean ± standard deviation) and Sugar Profile of Monofloral Honey Produced by Various Stingless Bees (jandaíra and uruçu) in the Semi-Arid Northeast Region of Brazil from Different Floral Sources

Psychochemical parameter	Stingless bee/monofloral honeys							
	Jandaira (M. Subnida Duke)				urugu (M. scutellaris Latrelle)			
	juazeiro	Malicia	velame branco	Jurema branca	juazeiro	Malicia	velame branco	Jurema branca
Water (g/100gr)	23.9Ad±0.4	27.2±0.2	25.6±0.4	28.9±0.2	24.3±0.3	26.5±0.8	25.8±0.4	25.4±0.6
Brix	74.7Aa ±0.2	71.1±0.2	72.4±1.2	72.0±1.0	74.3±0.5	73.0±0.6	72.5±0.5	72.8±1.2
pH	5.3Aa±0.4	3.1±0.2	3.8±0.01	3.6±0.02	4.2±0.05	4.0±0.02	3.5±0.4	3.6±0.1
TA (mmol H+/L)	28.2Ac±0.9	86.8±0.4	17.8±1.0	37.8±0.8	30.4±1.2	66.1±2.4	32.1±0.4	42.4±0.7
Protein (g/100 g)	0.5Aa±0.1	0.4±0.1	0.3±0.0	0.2±0.1	0.5±0.0	0.4±0.0	0.3±0.0	0.3±0.0
Proline (mg/kg)	20.5Aa±3,7	11.9±2.1	5.9±0.8	10.8±1.1	17.4±0.9	7.5±0.5	4.6±1.0	8.9±0.7
EC (	598Bb±2.6	636±1.0	300±3.1	520±0.2	670±5.1	514±2.3	340±1.5	571±3.4
Ash (g/100 g)	0.52Aa±0.0	0.04±0.0	0.11±0.0	0.12±0.0	0.41±0.0	0.03±0.0	0.12±0.0	0.1±0.0
Color (nm Pfund)	95.4Ba±0.2	55.6±0.02	35.8±0.3	54.1±0.1	103.4±0.6	82.8±0.4	55.9±0.4	57.2±1.1
HMF	nd	nd	nd	nd	nd	nd	nd	nd

Psychochemical parameter	Stingless bee/monofloral honeys							
	Jandaira (M. Subnida Duke)				urugu (M. scutellaris Latrelle)			
	juazeiro	Malicia	velame branco	Jurema branca	juazeiro	Malicia	velame branco	Jurema branca
Sugars (g/100 g)								
Glucose (g/100 g)	37.7Aa±0.4	45.4±0.3	42.1±0.6	45.7±0.4	38.1±0.3	42.6±0.2	43.3±0.1	41.4±0.5
Fructose (g/100 g)	59.2Aa±1.1	50.0±0.9	55.7±1.9	52.6±2.5	57.6±1.5	55.5±1.0	53.8±0.9	53.6±0.7
Sucrose (g/100 g)	1.6Ab±0.2	3.9±0.2	0.7±0.0	1.2±0.2	2.6±0.5	1.9±0.3	2.0±0.3	3.0±0.5
Maltose (g/100 g)	nd	nd	nd	nd	nd	nd	nd	nd
Arabinose (g/100 g)	nd	0.5±0.0	1.0±0.1	0.4±0.1	0.3±0.0	0.4±0.1	0.7±0.1	0.2±0.0
TS	68.2Aab±0.7	63.1±1.0	67.9±1.9	71.2±1.4	67.6±1.6	62.7±1.4	68.0±2.3	71.2±1.5
F/G	1.5Aa±0.2	1.1±0.0	1.3±0.0	1.1±0.0	1.5±0.0	1.3±0.0	1.2±0.0	1.2±0.0

Source: De Sousa, de Souza, Marques, Benassi, Gullon, Pintado, dan Magnani (2015)

Table 3, the study by De Sousa et al. (2015) shows that the predominant sugar present in honey is fructose, followed by glucose and sucrose. Except for honey from juazeiro, honey from the same floral source produced by different bee species varied significantly ($p < 0.05$) in the amounts of each detected sugar; this difference was also found for different floral sources. In floral honey, the glucose content corresponds to the nectar characteristics of the dominant flowers and varies among plant species (Escuredo, Dobre, Fernández-Gonzalez, & Seijo, 2014). The levels of glucose and fructose in the studied honey were higher than those reported in previous studies, with multifloral honey produced by stingless bees in Ecuador showing 25.5 g/100 g total sugar for glucose and 25.2 g/100 g total sugar for fructose (Guerrini et al., 2009), and in southern Brazil showing 8.2–35.39 g/100 g total sugar for glucose and 31.88–45.46 g/100 g total sugar for fructose (Rizelio et al., 2011).

The fructose/glucose (F/G) ratio in the honey evaluated ranged from 1.1 to 1.5, similar to the ratio found by Oddo et al. (2008) (1.4) in samples of honey produced by stingless bees in Australia. The F/G ratio directly affects the sweetness of honey since fructose is sweeter than glucose. The sucrose content was found to be lower than reported in previous studies for multifloral honey produced by jandaíra bees (3.7 g/100 g total sugar) and uruçu bees (5.3–8.8 g/100 g total sugar) (Campos et al., 2010; Sousa et al., 2013). These results indicate a lack of adulteration and honey collection at the ideal maturation time, as high sucrose content can result from the addition of commercial sugars or may be linked to early honey collection.

Dew Honey

Golan and Najda (2011) conducted a study on the differences in sugar composition of dew honey. The research found significant differences in the total sugar content of dew honey collected from three different host plants. The highest total sugar content was recorded in dew honey excreted by C. hesperidum fed on F. benjamina (4.833 mg/ml^{-1}), while the lowest was from C. limon (1.159 mg/ml) (Figure 1).

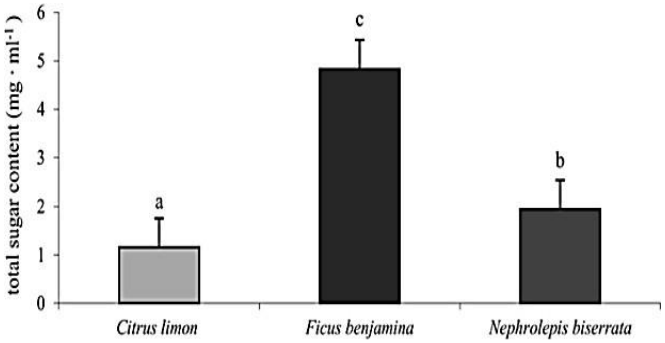

Figure 1. Total Sugar Content (mg/ml^{-1})
Source: Golan dan Najda (2011)

A similar relationship was also noted in the total sugar content of plant extracts. More than 20 sugars were recorded in dew honey from aphids (Wool et al., 2006). According to many researchers, glucose and fructose are the primary components of dew honey from sap-sucking insects (Wilkinson et al., 1997; Fischer et al., 2005; Wool et al., 2006). These sugars are present in dew honey in varying proportions depending on the insect species and the host plant. Research on *C. hesperidum* found that dew honey from this scale insect contained three monosaccharides (glucose, fructose, and arabinose) and one disaccharide (sucrose). The highest glucose content was 83.9% in the extract from *N. biserrata*, sucrose was 46.2% in the extract from *C. limon*, and fructose was 17.9% in the extract from *C. limon*, while the highest concentration of arabinose (69.5%) was found only in the extract from *F. benjamina*. As in the study by Wool et al. (2006), the dominating sugar in honey, regardless of the host plant, is glucose. This occurs in varying concentrations but is highly abundant in dew honey collected from insects feeding on *N. biserrata*. However, these results contrast with those of Bogo et al. (1999) for an unspecified species of scale insect closely related to *Stigmacoccus asper*. In the honey from this species, glucose was found to be lower compared to sucrose and fructose.

Research by Shaaban et al. (2021) collected dew honey samples from silver fir (Abies alba Mill) and spruce (Picea abies L.) at the Apicultural State Institute, University of Hohenheim (Stuttgart, Germany). The samples were classified based on the botanical and

zoological sources of the bees. The results indicated that the monosaccharides fructose and glucose were the dominant sugars in all samples, averaging around 60 g/100 g of honey, with fructose content being higher than glucose in the tested samples.

Unifloral honey types have a high sugar content in Northern Bangladesh, where the total sugar content of tested unifloral honey from five different brands—Litchi, Mustard, Plum, Til, and Kadom—showed that Litchi honey had the highest total sugar content at 80.3%, while Plum honey had the lowest at 77.7%. Similarly, research on four types of samples in India, including apple honey, saffron honey, cherry honey, and P. rugosus, found that apple honey had the highest sugar content at 78.45%, while saffron honey had the lowest at 73.89%. Other samples of A. mellifera tested in the Islamabad and Mardan regions showed sugar content ranging from 76.2 to 78.8%.

Monofloral honey in some areas has sugar content below the standard values, as observed in acacia plants in Ethiopia, where the maximum glucose content was found in Leucas abyssinica (37.2 ± 0.4 g/100 g) and the minimum in Becium grandiflorum (29 ± 3 g/100 g). Similarly, the maximum glucose content of 45.7 ± 0.4 g/100 g was found in jurema branca honey, while the minimum was 37.7 ± 0.4 g/100 g in juazeiro honey from four types of honey produced in Brazil.

Another study (Conti et al., 2016) analyzed the sugar and protein content in monofloral pollen, where 40 different pollen samples showed total sugar content ranging from 21.77% (in Zea mays) to 58.95% dry matter. In contrast, research by Adalina (2024) on four samples taken in Java—rubber honey, rambutan honey, randu honey, and mango honey—indicated that the monofloral honey produced by A. mellifera met the quality standards for honey set by SNI 8664-2018 (minimum 65%), along with HMF and acidity parameters.

Dew honey has varying total sugar content based on the feeding scale of insects on three different host plants. The highest total sugar content was recorded in dew honey excreted by C. hesperidum feeding on F. benjamina, while the lowest was observed when feeding on C. limon. The sugars in dew honey are present in different proportions depending on the species of the insect and the host plant. Research on C. hesperidum revealed that dew honey from this insect contains three monosaccharides (glucose, fructose, and arabinose) and one disaccharide (sucrose). According to the study by Wool et al. (2006), the dominant sugar in dew honey, regardless of the host plant, is glucose. The highest glucose content was 83.9% in the extract from N. biserrata, while sucrose was 46.2% in the extract from C. limon, and fructose was 17.9% in the extract from C. limon. The highest concentration of arabinose was 69.5% in the extract from F. benjamina.

Shaaban et al. (2021) obtained dew honey samples from silver fir (Abies alba Mill) and spruce (Picea abies L.) at the Apicultural State Institute, University of Hohenheim (Stuttgart, Germany). The monosaccharides fructose and glucose were the dominant sugars in all samples, averaging around 60 g/100 g, with fructose content being higher than glucose.

Extrafloral honey from rubber trees is produced through extrafloral nectariferous glands secreted through stipules, leaves, petioles, and stems. In contrast, the nectar produced by rambutan trees is secreted by floral nectariferous glands through flowers, which are the ovary structures with high sucrose content. The glucose content from rubber trees is 77.14% b/b, while that from rambutan is 73.40% b/b.

Erwan et al. (2020) found that the reducing sugar content of A. mellifera honey from coconut sap (73.69 ± 0.21%) was significantly higher ($P < 0.05$) than that from Arenga pinnata sap (60.15 ± 2.13%). The quality standards for honey based on SNI 3545:2013 and CODEX STAN 12-1981 are a minimum of 65 g/100 g (> 65%) and a minimum of 60 g/100 g (> 60%), respectively.

Differences in sugar content among various types of honey produced by A. mellifera can be influenced by several factors, including the amount of nectar and pollen produced by the plants, the type of plant, the bees' ability to produce invertase (which converts sucrose into glucose and fructose), altitude, and humidity. Additionally, the composition of honey is not only dependent on the botanical and geographical origin but also on processing and storage conditions (Lazaridou et al., 2004).

Conclusion

The type of honey produced by A. mellifera generally meets quality standards for honey. However, some findings indicate that monofloral honey has a sugar content ranging from 21.77% to 58.95%, which is still below the SNI and Codex standards. Meanwhile, unifloral honey has a sugar content between 73.89% and 80.30%, extrafloral honey ranges from 73.40% to 77.14%, and dew honey has glucose content ranging from 60% to 83.90%.

Acknowledgements

In the course of this research, I would like to express my deepest gratitude to my beloved family for their unwavering support, love, and encouragement. I am also profoundly thankful to the esteemed lecturers at the Faculty of Sports Science for their exceptional guidance, knowledge, and inspiration. Additionally, I wish to acknowledge my fellow students in the Master of Sports Education Program, whose camaraderie has been a continual source of inspiration and motivation.

Author Contributions

This article was written by seven contributors, Ismardi contributed to the writing of the introduction, methodology, literature review, results, and conclusions. Muhamad Sazeli Rifki, Wilda Welis, Ardo Okilanda contributed to the process

of conceptualization, methodology, review, and finalization of articles. Yovhandra Ockta contributed to the finalization and improvement of the content of the article and reviews in different thought sections.

Funding
This research was not funded by any party. The funding comes from the author of this article.

Conflict of Interest
The content of this article does not create a conflict of interest.

References

Ajibola, A. Chamunorwa, J. P., Erlwanger, K H. (2012) Nutraceutical Vales of Natural Honey and its Contribution to Human Health and Wealth. Nutrition & Metabolism. 9(61). https://doi.org/10.1186/1743-7075-9-61

Adalina, Y. dan Kuntadi. (2019). The Sucrose Contents of Four Honey Types from Apis Mellifera Beekeepers in Java, El-Hayah, 7(2) 55-61. https://doi.org/10.18860/elha.v7i2.8244

Adalina, Y., Mulyati, A. H., Oktasari, D. and Prayoga, P. (2024). Physico-chemical Properties of Multifloral honey Apis dorsata and Monofloral honey of bees *Apis mellifera*. IOP: Earth and Environmental Science. https://doi.org/10.1088/1755-1315/1315/1/012065

Belay, A., Haki, G. D., Birringer, M., Borck, H., Lee, Y., Cho, C., Kim, K., Bayissa, B., Baye, K., & Melaku, S. (2017) Sugar profile and physicochemical properties of Ethiopian monofloral honey. *International Journal of Food Properties*, 20(11), 2855-2866. https://doi.org/10.1080/10942912.2016.1255898

Blasa, M., Candiracci, M., Accorsi, A., Piatti, A. dkk (2006) Raw Milefiori Honey is Packed Full of antioxidant. Food chemistry 97(2):p 217-222. https://doi.org/10.1016/j.foodchem.2005.03.039

Bogdanov, S., Jurendic, T., Sieber, R., Galman, P. (2008) Honey for Nutrition and Health; a review. Dec;27(6):677 89. https://doi.org/10.1080/07315724.2008.10719745

Bogdanov S., Lüllmann C., Martin P., von der Ohe W., Russmann H., Vorwohl G., Oddo L.P., Sabatini A.-G., Marcazzan G.L., Piro R., Flamini C., Morlot M., Lhéritier J., Borneck R., Marioleas P., Tsigouri A., Kerkvliet J., Ortiz A., Ivanov T., Vit P. Honey quality and international regulatory standards: review by the International Honey Commission. Bee World. 1999;80(2):61–69. https://doi.org/10.1080/0005772X.1999.11099428

Bogo, A., Watson G. W., Mantle, P. G. & Mottana, G. M. (1999). Honeydew sugars eliminated by Stigmacoccus sp. nr. Asper Hempel (Hemiptera: Margarodidae) feeding on Leguminous trees in Brazil. Entomologica 33: 275–278. https://doi.org/10.15162/0425-1016/846

Campos, F. S., Gois, G. C., & Carneiro, G. G. (2010). Physico-chemical parameters of the honey of stingless bee Melipona scutellaris produced in the Paraíb*a*. *Zootecnia, 7*, 186-190. https://doi.org/10.18551/rjoas.2022-01.21

Chasanah, N. (2001). *Kadar dekstrosa, levulose, maltose, serta sukrosa madu segar dan madu bubuk dengan bahan pengisi campuran gum Arab dan dekstrin.* FakultasPeternakan, Institut Pertanian Bogor.

Chayati, I. (2008) Sifat Fisikokimia Madu Monoflora dari Daerah Istimewa Yogyakarta dan Jawa Tengah. AgriTech: Jurnal Fakultas Teknologi Pertanian UGM Vol. 28(1). https://doi.org/10.22146/agritech.9779

Conti, I., Medrzycki, P., Argenti, C., Meloni, M., Vecchione, V., Boi, M., &Mariotti, M. (2016). Sugar and protein content in different monofloral pollens - Building a database. *Bulletin of Insectology* 69(2).

De La Fuente, E., Ruiz-Matute, A.I.,Valencia-Barrera,R.M., Sanz, J., Castro, I. M. (2011). Carbohydrate Composition of Spanish Unifloral Honeys. *Food Chemistry, vol. 129*(4), 1483–1489. https://doi.org/10.1016/j.foodchem.2011.05.121

Erwan, E. , Harun, M. , Muhsinin, M. (2020). The Honey Quality of Apis mellifera with Extrafloral Nectar in Lombok West Nusa Tenggara Indonesia. JoSSEd, Journal of Science and Science Education. https://doi.org/10.29303/jossed.v1i1.482

Escuredo, O., Dobre, I., Fernandez-Gonzalez, M., & Seijo, M. C. (2014). Contribution of botanical origin and sugar composition of honeys on the crystallization phenomenon. FoodChemistry, 149, p. 84-90. https://doi.org/10.1016/j.foodchem.2013.10.097

Fasasi, K. A. (2012). Physicochemical attributes of Nigerian natural honey from honeybees (*Apis mellifera adansonii*) (Hymenoptera: Apidae) and its shelf life in storage at room temperature. Pakistan *Journal of Biological Sciences 15*(21), 1027-1033. https://doi.org/10.3923/pjbs.2012.1027.1033

Fischer M.K., Völkl W. & Hoffmann K. H. (2005). Honeydew production and honeydew sugar composition of polyphagous black bean aphid, Aphis fabae (Hemiptera: Aphididae) on various host plants and implications for ant-attendance. European Journal of Entomology. 102(2): 155-160, https://doi.org/10.14411/eje.2005.025

Gojmerac, W.L. 1983. Bees, Beekeeping, *Honey and Pollination*. Publishing. Connecticut: AVI

Golan, K., & Najda, A. (2011). Differencesin the sugar composition of the honeydew of polyphagous brown soft scale Coccus hesperidum (Hemiptera: Sternorrhyncha: Coccoidea) feeding on various host plants. *European Journal of Entomology*, 108(4): 705-709, https://doi.org/10.14411/eje.2011.090

Holt, S. H., A., de Jong, V., Miller, J. C., & Arcot, J. (2002). The glycaemic and insulin index values of

a range of Australian honeys. *Asia Pacific Journal of ClinicalNutrition (Supll),* 11, 310.

Khalil, Md. I., Motallib, Md. A., Anisuzzaman, A. S. Md. (2001) Biochemical Analysis of Different Brands of Unifloral Honey Available at the Northern Region of Banglades. *Journal of Medical Sciences*. https://doi.org/10.3923/jms.2001.385.388

Kuntadi (2008) Langkah-langkah memaksimalkan produksi dan produktivitas koloni lebah madu. Pusat Peneltian dan Pengembangan Hutan dan Konservasi Alam.

Lazaridou, C.G., Biliaderis, C., Bacandritsos, N., Sabatini, A. G. (2004) *Composition, thermal and rheological behavior of selected Greek honeys. Journal of Food* Engineering. Vol. 64(1) pp. 9-21. https://doi.org/10.1016/j.jfoodeng.2003.09.007

León-Ruiz, V., Vera, S., González-Porto, A.V., & Andrés, M.P.S. (2011). Vitamin Cand Sugar Levels as Simple Markers for Discriminating Spanish Honey Sources. *Journal of Food Science*, *76*(3), 356–361. https://doi.org/10.1111/j.1750-3841.2011.02041.x

Morales, M. P., Huertas, J. R. and Rodriguez-Perez, C. (2023). A Comprehensive Review of the Effect of Honey on Human Health. *Nutrients* 15(13) 3056. https://doi.org/10.3390/nu15133056

Münstedt, K., Sheybani, B., Hauenschild, A., Brüggmann, D., Bretzel, R. G., & Winter, D. (2008). Effects of Basswood Honey, Honey-comparable Glucose- fructose Solution, and Oral Glucose Tolerance Test Solution on Serum Insulin, Glucose, and C-peptide Concentrations in Healthy Subjects. *Journal of Medicinal Food*, *11*(3), 424–428.

Mohamed, M. A., Amed, A. A., and Mazid, M. M. (1981) Studies on Libyan Honeys. *Journal of Food Qual*., 4. 185-201. https://doi.org/10.1111/j.1745-4557.1981.tb00727.x

Nayik,G. A., Dar, B. N. dan Nanda, V. (2019)Physico-chemical, rheological and sugar profile of different unifloral honeys from Kashmir valley of India. Arabian Journal of Chemistry.Vol. 12 (8)p.3151-3162. https://doi.org/10.1016/j.arabjc.2015.08.017

Oddo, P. L., Heard, T. A., Rodríguez- Malaver, A., Perez, R. A., Fernandez-Mui no, M. A., Sancho, M. T., et al. (2008). Composition and antioxidant activity of trigona carbonaria honey from Australia. Journal of Medicinal Food, *11*, 789-794. https://doi.org/10.1089/jmf.2007.0724

Olaitan, P.B.,Adeleke, O.E., Iyabo, O.O. Honey. A Reservoir for Microorganisms and An Inhibitory Agent for Microbes. African Health Sciences 2007, 7(3), 159–165. https://doi.org/10.5555/afhs.2007.7.3.159

Ouchemoukh, S., Schweitzer, P., Bey, M.B., Djoudad-Kadji, H., & Louaileche, H. (2010). *HPLC Sugar Profiles of Algerian Honeys*. *Food Chemistry, 121*(2), 561–568. https://doi.org/10.1016/j.foodchem.2009.12.047

Perez-Aguillue, C., Pillar, C. Agustin, A., Teresa, J., dan Antonio, H. (1994). Quality Evaluation of Spanish Rosemary (Rosemarinus officinalis) Honey. *Food Chem.,* 51:207-210.

Prasetyo, B. A. (2014) Perbandingan Mutu Madu Lebah Apis Mellifera Berdasarkan Kandungan Gula Pereduksi Dan Non Pereduksi Di Kawasan Karet (Hevea Brasiliensis) Dan Rambutan (Nephelium Lappaceum). Retrieved from http://repository.ub.ac.id/id/eprint/137107

Sihombing, D. T. H. (2005). *Ilmu ternak lebah madu*. Cetakan ke 2. Gajah Mada University Press, Jogjakarta.

Shaaban, B., Seeburger, V., Schroeder, A., Lohaus, G. (2021) Suitability of Sugar, amino acid, and Inorganic ion Compositions to Distinguish Fir and Spruce Honey. E*uropean food research and Technolgy*. Vol. 247 p 879-888

Sousa, J. M. B., Aquino, I. S., Magnani, M.,Albuquerque, J. R., Santos, G. G., & Souza, L. S. (2013). Physicochemical aspects and sensory profile of stingless beehoneys from Serido region, State of Rio Grande do Norte, Brazil. *Semina: Ciencias Agrarias, 34*, 1763-1772

Sousa, J. M. B., Souza, E. L., Marques, G., Benassi, M. T., Gullon, B., Pintado, M. M.,Magnani, M. (2016). Sugar profile, physicochemical and sensory aspects of monofloral honeys produced by different stingless bee species in Braziliansemi-arid region. *LWT – Food Science andTechnology*, 65, 645-651. https://doi.org/10.1016/j.lwt.2015.08.058

Swallow, K. W., & Low, N. H. (1990). Analysis and quantitation of the carbohydrates in honey using high-performance liquid chromatography.*Journal of Agricultural and Food Chemistry,* 38(9), 1828–1832.

Szczesna, T. (2007). Study on the sugar composition of the honeybee-collected pollen. *Journal of Apicultural Science*, 51(1), 15-22.

Tariq, K., Iqbal, S., Ali, M. F. (2022) Quantifying Physicochemical Properties of Honey Collected from different Floral Sources of Islamabad and Mardan Regions. *Jurnal Agroteknologi dan Perkebunan.* 5(1). https://doi.org/10.36490/agri.v5i1.195

Todd, F. E., & Bretherick, O. (1942). *The compositions of pollens. Journal ofEconomic Entomology*, 35, 312-317. https://doi.org/10.1093/jee/35.3.312

Wang J., Li Q.X. Advances in Food and Nutrition Research. Volume 62. Elsevier; Amsterdam, The Netherlands: 2011. Chemical Composition, Characterization, and Differentiation of Honey Botanical and Geographical Origins; pp. 89–137. https://doi.org/10.1016/B978-0-12-385989-1.00003-X

Widiarti, A., dan Kuntadi, K. (2012) Budidaya Lebah Madu Apis mellifera L. oleh Masyarakat Pedesaan

Kabupaten Pati, Jawa Tengah. *Jurnal Penelitian Hutan dan Konservasi Alam*. 9(4): 351-361. https://doi.org/10.20886/jphka.2012.9.4.351-361

Wilkinson T. L., Ashford D. A., Pritchard J. & Douglas A. E. (1997). Honeydew sugars and osmoregulation in the pea aphid Acyrthosiphon pisum. *J. Exp. Biol.* 200,2137–2143.

Witek, K., Wydra, K., Filip, M. (2022) A High-Sugar Diet Consumption, Metabolism and Health Impacts with a Focus on the Development of Substance Use Disorder: A Narrative Review. *Nutrients* 14(14): 2940. https://doi.org/10.3390/nu14142940

Wool D., Hendrix D. L. & Shukry, O. (2006). Seasonal variation in honeydew sugar content of galling aphids (Aphidoidea: Pemphigidae: Fordinae) feeding on Pistacia: host ecology and aphid physiology. *Basic Appl. Ecol.* 7: 141–151