



**INTERNATIONAL JOURNAL OF CURRENT
NATURALSCEINCE AND ADVANCE
PHYTOCHEMISTRY**

journal homepage: www.ijcnap.com



**A REVIEW ON PHYSICOCHEMICAL PROPERTIES OF HONEY AND EFFECTS
ON HEALTH**

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ARTICLE INFO

Keywords

*Composition of
honey,
Physicochemical
Properties,
Antimicrobial,
Antioxidant,*

ABSTRACT

Honey, a functional food material collected by honey bees from different types of plants and left to mature in honeycombs. Honey has an important share in the market in terms of production and consumption due to its physical and chemical properties as a food product. The chemical composition of honey approximate; It consists of macro and micro components such as 82% carbohydrates, 17% water, 0.7% mineral substances, 0.3% protein, vitamins, organic acids, phenolic compounds and free amino acids. The chemical structure of honey varies depending on the type and type of nectar secreted by flowers and plants in the region where it is located. The positive effects of honey on human health, such as antimicrobial and antioxidant, are an important criterion in choosing honey. In this review, the physical (color, smell, taste and aroma of honey, electrical conductivity, viscosity and crystallization), chemical (moisture amount, acidity, protein and enzyme amount) and health effects (antimicrobial and antioxidant) of honey are mentioned. In this context, it is aimed to inform consumers about the food product honey.

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Received 25 December 2023; Received in revised form 28 December 2023; Accepted 28 December 2023

Available online 30 December 2023

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Introduction

According to the Turkish Food Codex honey community, honey is “found in the flowers or other living parts of plants.” It is defined as “a sweet product resulting from the collection by honey bees (*Apis mellifera*) of the nectar secreted from the nectar glands and the secondary substances secreted by some insects living on the plant by taking advantage of the living parts of the plants, changing their composition in their bodies, storing them in the honeycomb cells and maturing there” (Honey Communiqué)., 2020)

The color, sensory properties and composition of honey vary depending on the climatic conditions of the region where honey is collected, and the diversity of bee species and plant species (Bogdanov et al., 2008). The composition of honey consists of approximately 80% carbohydrates, including 35% glucose, 40% fructose and 5% sucrose. The remaining content consists of 17% water and 3% enzymes, amino acids, phenol compounds, minerals and various vitamins (Ouchemoukh et al., 2007)

Physical Properties of Honey

Physical properties are the basic criteria for honey classification as they are simple to measure and provide information about the composition of honey. Colour, taste and aroma, electrical conductivity, Crystallization, and viscosity are among the measurable physical properties of honey (Abu-Jdayil et al., 2001; Pridal et al., 2002).

The Color of Honey

The color of honey is evaluated according to the Pfund scale. Honey generally starts from transparent to dark red; It comes in yellow,

amber, brown, greenish and reddish colors. Honey according to their colors; It is divided into four groups water white, extra white, extra light amber and dark color. Substances that give color to honey: Chlorophyll, carotene, xanthophyll and their unknown composition are plant pigments that create yellow and green colors. The reasons for the different colors of honey vary depending on the region where the honey is collected and the type of plant. Additionally, temperature is effective in darkening the color of honey. Therefore, storage conditions must be ensured thoroughly. Gomez et al. (2010) stated in their study that the color of honey is related to the total mineral (ash) content. Accordingly, a light color was observed in honey with low ash content, while a dark color was observed in honey with high ash content.

Taste and Aroma

The taste and aroma of honey is a delicious and sweet product produced from the nectar and sap collected by bees. It is a food product with a unique aroma and high nutritional value. Many factors that affect the taste and aroma of honey. Depending on the type of plant from which the honey is collected, products with a different aroma are obtained. Additionally, aroma compounds can be created during heat treatment or storage of honey (Bonvehí and Coll, 2003). The taste and aroma of honey an important criterion for applications in the food industry and consumer preference. According to the Turkish Food Codex Communiqué, there should be no foreign substance that will negatively affect the taste and aroma of honey (Honey Notification, 2020).

Electrical Conductivity

Electrical conductivity is an important criterion in honey. It is an important criterion used to distinguish flower honey collected by honeybees from flowers and honey obtained from secretions. Electrical conductivity varies depending on the acid and mineral substances contained in honey. According to the Turkish Food Codex notification, the electrical conductivity in secretion honey is accepted as at least 0.8 mS/cm, and this value is accepted as a maximum 0.8 mS/cm in flower honey (Bilgen et al., 2010; Batu et al., 2013).

Viscosity

The viscosity of honey is one of the most important sensory and physical properties. The viscosity of honey is affected by temperature, humidity and colloid contents in the product. For this reason, studies have been conducted on the humidity and temperature on which the viscosity of honey depends. Studies have shown that viscosity decreases as humidity and temperature increase (Yanniotis et al., 2006; Gómez-Díaz, et al., 2009). Viscosity depends on the content of honey; The composition of sugars (disaccharides) in its structure gives it more viscosity (Kayacier and Karaman, 2008). The viscosity of honey is important for the processing of the product. Because it is an important criterion for the filtering, processing and packaging of honey. Because honey is a product with high viscosity. Therefore, its applicability is increased by applying heat to honey. However, the deterioration of the structure of the sugars in the honey due to the effect of the applied heat, causes the amount of HMF in the honey to increase, which the Turkish food codex determines as a maximum of 40 mg/kg. Honey containing high HMF is dangerous for health (Honey communiqué, 2020).

Crystallization

The Crystallization of honey causes it to appear in an irregular structure. Crystallization occurs as a result of the sugars in honey separating from the water phase and precipitating. Crystallization shows that the honey is pure and natural. However, it has some disadvantages. Honey spilling and the formation of an unpleasant crystal structure on the palate make it not preferred. Additionally, after crystallization, the color of honey changes and it turns into a waxy appearance. Therefore, manufacturers apply processes such as heat treatment, microwave ultrasound, ultrafiltration and the addition of food additives to correct the texture (Amariei et al., 2020). Heat treatment applied at high temperatures increases the hydroxymethylfurfural (HMF) content, darkens the color, and changes in taste and aroma negatively affect the health and quality of honey (Alias et al., 2018).

Chemical Properties of Honey

The chemical structure of honey varies depending on the region where honey is produced and the variety of nectar collected. Structurally, honey consists of approximately 80% carbohydrates, including 35% glucose, 40% fructose and 5% sucrose. The remaining content consists of 17% water and 3% enzymes, amino acids, phenol compounds, minerals and various vitamins (Ouchemoukh et al., 2007).

Amount of moisture

Moisture is one of the most important parameters in honey. The amount of water in honey accelerates fermentation stability and crystallization. Therefore, heat treatment is applied to prevent yeast fermentation and

crystallization (Fallico et al., 2004). It must be worked under suitable conditions to avoid the formation of undesirable color, taste and HMF during heat treatment. In addition, the environment, climatic conditions during the harvest period and adverse storage conditions increase the moisture content in honey (Anupama et al., 2003).

Acidity of Honey

The acids found in honey foodstuff are of great importance in preserving the chemical structure of honey. The acidity of honey has properties that prevent aroma, chemical reaction, antibacterial, antioxidant and development and formation of microorganisms that cause spoilage (Gheldof et al., 2002). Gluconic acid and other organic acids, the most abundant acids in honey, create acidity (Cavia et al., 2007). In addition to preserving the chemical structure of acids in honey, formic acid, which ensures the maturation of honey, is added to nectar by honey bees and allows it to ripen. Ph value in honey should be between (3.5-5.5) and free acidity should be at most 50 meq/kg according to the food communiqué (Honey communiqué, 2020). In addition, honey with an acidity of more than 0.4% is considered suspicious and unsafe.

Protein Content of Honey

Although the amount of protein in honey is not high, its amount is an important criterion. The most important proteins in honey include important protein types such as proline, phenylalanine, butyric acid, serine and aspartic acid (Pérez et al., 2007). The most abundant amino acid in honey is proline. Proline formation in honey occurs from the nectar collected by honey bees. Therefore, the

amount of proline in fake honey produced by feeding sugar syrup and similar types of sugar to honey bees has an important place in the detection of fake and real honey, as the amount is lower than the amount of honey produced by honey bees naturally. According to the Turkish Food Codex data, the minimum amount of proline required in honey is accepted as 300 mg/kg (Honey communiqué, 2020).

Enzyme Content of Honey

Enzymes found in honey are an important parameter for quality. Because enzyme activity is important in the ripening of honey. Under the influence of the Invertase enzyme, the nectar collected by honey bees breaks down sucrose into glucose and fructose and produces honey. Another enzyme found in honey is the diastase enzyme. The diastase enzyme breaks down the starch in honey and turns it into small sugars (Lichtenberg-Kraag, 2014). The number of diastases in honey must be a certain number in national and international regulations. According to the Turkish Food Codex honey communiqué, this number is determined as 8 (Honey communiqué, 2020).

Effect of Honey on Health

Antimicrobial effect

Due to the influence of microorganisms in food, products spoil very quickly and pose a health problem. Therefore, foods with antimicrobial effects have an important place in food production and processing. The antimicrobial activity of honey is due to the presence of hydrogen peroxide, aromatic acids and phenolic compounds. In addition, the low water activity, low pH, low protein and high amount of sugar in honey prevent the

proliferation of yeast and molds (Patton et al., 2006; Samarghandian et al., 2017). In the study, four different flower honeys were used and their antimicrobial activities against bacteria, yeast and mold were examined. In the study, *Acinetobacter baumannii* AYE, *Bacillus cereus* DSM 4312, *Klebsiella pneumoniae* ATCC 700603, *Listeria monocytogenes* ATCC 7644, *Pseudomonas aeruginosa* ATCC 35032 as bacteria, *Staphylococcus aureus* ATCC 25923, *Candida albicans* ATCC 10351, *Schizosaccharomyces po* as yeast. *Alternaria alternata* and *Penicillium italicum* were used as mbe molds. As a result of the study, it was stated that all honey showed antimicrobial and antifungal activity (Çınar, 2020).

Antioxidant Effect

Oxidation is the deterioration of the food's properties such as color, taste and smell as a result of the reaction of food with oxygen. Additionally, free radicals are formed as a result of certain reactions. Free radicals cause damage to the human body. Antioxidants ensure the removal of these radicals from the body (Akan, Bagatur, & Karaogul, 2023; Alwazeer, Elnasanelkasim, Çiçek, Engin, Çiğdem, & Karaoğul, 2023; H.Balaky, Karaogul, Altuntas, Hammadi, Galalae, & Alma, 2020; Hamad, Alma, Gulcin, Yilmaz, & Karaogul,

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2017; İkinci, Dursun, & Karaogul, 2021; Ugurtay & Karaogul, 2022). For this reason, antioxidant-rich herbal products are preferred in nutrition and diet products. Natural antioxidants are phenolic compounds, flavonoids, nitrogen compounds, carotenoids and phenols (Halliwell, 1990; Aruoma, 1994). Studies have shown that honey collected from flowers by bees has antioxidant properties. The antioxidant content of honey depends on the plants from which bees collect nectar, seasonal conditions and environmental factors. In the study conducted to investigate the antioxidant properties of honey, phenolic and antioxidant analyzes of honey with different properties were performed and the results were evaluated. Accordingly, it has been stated that all honeys have phenolic and antioxidant content (Al-Mamary et al., 2002).

Conclusion

Honey is an energizing food with a high sugar content. Honey is highly preferred by consumers due to its physical, chemical and positive health effects. Additionally, its long shelf life is another reason for preference. Having four seasons in our country and having a rich plant population is important for honey diversity. The purpose of this review is to inform consumers about the properties of honey and to increase consumer awareness.

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