Honey Sensory and Compositional Properties

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The basis of honey sensory evaluation is the description and quantification of a variety of factors relating to the perception of visual, olfactory, gustatory, and tactile characteristics. It is an essential process in improving the understanding of consumer requirements, preferences, or aversions for the evaluated honey products. This research evaluates the relationships between the sensory and compositional characteristics of a range of commercially available honeys.

Keywords: commercially available honey ; sensory analysis ; antioxidant ; physicochemical ; likeability

1. Overview

Honey's composition and appearance are largely influenced by floral and geographic origins. Australian honeys are frequently sourced from supermarkets; however, properties associated with consumer preference and likeability remain relatively unknown. This study aimed to complete sensory and compositional analyses on a selection of commercially available Australian honeys. Samples (n = 32) were analysed for visual, olfactory and taste characteristics, with overall likeability assessed by a trained sensory panel (n = 24; M = 12). Compositional analysis included colour intensity (mAU); phenolic content; antioxidant characteristics (DPPH, CUPRAC); and physicochemical properties (pH, viscosity, total soluble solids). The likeability of honey was positively associated with perceived sweetness ($p < 0.01$), and it was negatively associated with crystallisation; odour intensity; waxy, chemical, and fermented smell; mouthfeel; aftertaste; sourness; bitterness and pH (All p's < 0.05). The price (AUD/100 g) was not associated with likeability ($p = 0.143$), suggesting price value potentially does not influence consumer preferences. Conclusively, differences in likeability between honey samples demonstrate that consumer perception of sampled honeys is diverse. Honey preference is primarily driven by the organoleptic properties, particularly perceived negative tastes, rather than their antioxidant capacity or phenolic content.

2. Honey Sensory Evaluation

Honey is a naturally produced product made from a combination of the nectar of plants and bees own secretions, which is deposited into honeycomb for maturation [1]. It is primarily composed of sugars, predominantly fructose (~36%) and glucose (~30%) [2], in addition to over 200 different nutritionally relevant compounds [3]. Among these other constituents, honey includes several enzymes, vitamins, minerals, organic acids, and a range of phytochemical compounds, such as polyphenols and carotenoids [3]. The composition of honey is largely influenced by several factors, such as its botanical origins and geographic location, as well as climate and storage conditions [2].

A variety of health benefits of honey have been identified relating to honey's antioxidant characteristics, antibacterial properties, and anti-inflammatory effects. Honey consumption was shown to increase plasma antioxidant levels in healthy humans [4][5], and to reduce the circulating reactive oxygen species (ROS) by-products of oxidative stress in both animal [6] and human models [4]. These antioxidant characteristics of honey can be attributed to its composition, predominately its bioactive compounds, such as phenolic acids. The antibacterial effects of honey are ascribed to its physicochemical properties (including pH and viscosity), which have the ability to prevent the growth of bacterial species [7], and the production of hydrogen peroxide as a by-product of the breakdown of glucose caused by glucose oxidase [8]. The combined effects of the antioxidant and antibacterial properties can further lead to their synergistic anti-inflammatory effects [9][10].

The global production of honey is approximately 1.2 million tons, with the average annual consumption of honey in Australia per capita averaging 0.6–0.8 kg/year [11]. Furthermore, supermarket purchases represent 70% of honey retail in Australia [12], highlighting the acceptance of commercially available honey. The majority of commercially available honeys are exposed to a variety of different treatments and processing techniques. These include straining and filtering of the honey (to remove pollen and other plant constituents), heating (liquefication to prevent crystallisation), and pasteurisation (to destroy potential pathogens) [13]. These processes commonly include heating honey to 45 °C for 8 h, followed by filtration (100 μm) [14] in order to maintain the quality and consistency of the products and for adherence to consumer expectations of the overall product [13].

The sensory evaluation of food products traditionally involves human panellists characterising, quantifying, and interpreting the properties of a particular food product [15]. Although some laboratory analysis can quantify many characteristics of a food product, sensory evaluation is often completed when a new food product is developed or when there is an interest in the consumer's perception of an existing food product [16]. The sensory analysis of a food product represents an essential tool in determining a variety of the product's organoleptic properties, evaluating a products quality, and assessing the consumer opinion of the product [15].

The basis of honey sensory evaluation is the description and quantification of a variety of factors relating to the perception of visual, olfactory, gustatory, and tactile characteristics [15]. Additionally, the sensory analysis of honey can provide information relating to the botanic origin of the honey and the identification of any potential defective qualities, such as crystallisation. It is also an essential process in increasing the understanding of consumer requirements, preferences, or aversions for the evaluated honey products [17].

Desirable characteristics responsible for the overall consumer preference in the selection of honey include flavour, appearance, price/value, local origin, and convenient environmentally friendly packaging [18][19][20][21]. However, whether the composition and physical properties of honey influence consumer preference is still relatively unexplored. This could occur by multiple mechanisms, including the presence of phenolic compounds that are known to produce a bitter taste sensation [22] or levels of sugar associated with the onset of crystallisation [23]. The present study performed a sensory analysis of a range of commercially available Australian honeys to determine the likeability and the factors that contribute to this, considering both organoleptic and compositional attributes.

3. Associations between honey composition, sensory properties, and likeability

3.1. Honey Samples

A total of 32 commercially available honey samples were purchased from various large commercial suppliers across the Australian Capital Territory (ACT; Australia). Honey samples were stored in darkness at room temperature (26 ± 3 °C) following recommended guidelines [24]. For the analytical analysis, if honey samples were required to be diluted based on preliminary analysis and validation, it was completed with warm deionised (DI) water (<50 °C to prevent compound degradation) [24].

3.2. Honey Sensory Analysis

3.2.1. Visual, Olfactory, and Taste Characteristics of Selected Honeys

Trained panellists were provided with a de-identified honey sample in closed glass jar to determine the visual characteristics of colour intensity, texture, and the presence of crystallisation [15]. Additionally, olfactory characteristics, including odour intensity and odour attributes (OA) (flowery, fruity, waxy, caramelised, acidic, chemical, and fermented), were evaluated immediately after opening the sample jars [15]. The taste characteristics of perceived mouthfeel, sample aftertaste, and specific taste intensities (sweetness, sourness, bitterness, and astringency) were also assessed [17]. Finally, panellists were asked to provide the overall acceptability and likeability, or preference, of each honey based on the olfactory, visual, and taste characteristics to assess consumer acceptability of the commercially available samples.

3.3. Antioxidant and Physicochemical Characteristics of Selected Honeys

3.3.1. Antioxidant and Total Phenolic Composition

The antioxidant scavenging capacity was determined using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay according to Thaipong et al. [25]. The absorbance was measured at 515 nm (Multiskan Go, Thermo Scientific, Waltham, MA, USA), and the results were expressed as millimoles of Trolox equivalents (TE) per gram of honey (mmol TE/g). The cupric ion reducing capacity (CUPRAC) was determined according to Apak et al. [26]. The absorbance was measured at 450 nm (Multiskan Go, Thermo Scientific, USA) and expressed as millimoles of Trolox equivalents per gram of honey (mmol TE/g).The total phenolic content (TPC) was determined using the Folin–Ciocalteur method [27]. The absorbance was measured at 765 nm (Multiskan Go, Thermo Scientific, USA), and the results were expressed as milligram Gallic Acid equivalents (GAE) per gram of the sample (mg GAE/g). All assays were completed in triplicate.

3.3.2. Colour Analysis

The International Commission on Illumination (CIE) L^*, a^*, b^* colour measurements (Color Reader CR-20, Konica Minolta, Tokyo, Japan) provide information regarding the honey's lightness (L^*; 99 = white, 0 = black), redness (+a^*)/greenness (-a^*), and yellowness (+b^*)/blueness (-b^*) [28]. The colour intensity (ABS_{450}) of the honey samples was determined by diluting each of the samples to a 50% concentration (*w*/*v*) [24]. The spectrophotometric absorbance was then determined in triplicate at 450 nm and 720 nm (Multiskan Go, Thermo Scientific, USA), with the difference between the two wavelengths reported as mAU.

3.3.3. Physicochemical Properties

The pH of the undiluted honey samples was determined using a pH meter (Mettler Toledo, Port Melbourne, Australia) [29]. The total soluble solids (TSS), expressed as °Brix, was determined in 50% honey dilutions using a handheld digital refractometer (Opti Brix 54, Bellingham + Stanley, Kent, UK) [30]. The viscosity of the undiluted honey samples was expressed in pascal seconds (Pa s) and was determined using a viscometer (Smart Series, FungiLab, Barcelona, Spain) at 5, 10, or 20 rpms depending on the percentage torque of the sample [31]. All samples were analysed in triplicate.

3.4. Relationships Between Sensory and Compositional Characteristics

To determine relationships between compositional and sensory characteristics, including the likability (Table 1), a Kendall's Tau correlation was completed (IBM SPSS Statistics version 25; IBM Corp:Armonk, NY, USA; the level of significance was defined as $p < 0.05$). The likeability of honey samples was only positively correlated with sweetness ($\tau = 0.353$, $p < 0.01$); all other associations were negative. These included: crystallisation ($\tau = -0.260$, $p < 0.05$), odour intensity ($\tau = -0.297$, $p < 0.05$), the odour attributes of waxy ($\tau = -0.255$, $p < 0.05$), chemical ($\tau = -0.374$, $p < 0.01$), fermented ($\tau = -0.324$, $p < 0.01$), mouthfeel ($\tau = -0.288$, $p < 0.05$), aftertaste ($\tau = -0.435$, $p < 0.01$), the taste attributes of sourness ($\tau = -0.277$, $p < 0.05$) and bitterness ($\tau = -0.252$, $p < 0.05$), and pH ($\tau = -0.437$, $p < 0.01$). In a relatively recent study by Cosmina et al. [18], the presence of crystals in honey were found to be disliked by Italian consumers. In addition, a preference for honeys that are more liquid in texture has been reported [18][20], supporting the data collected in this analysis. However, preference for the mouthfeel of honey is conflicting in the literature, as a study by Murphy et al. [21] reported a preference for thick honey. Further, there were no associations between the perceived likeability and the compositional data, except for pH. This suggests that these potential health properties did not influence the sensory characteristics of the honeys reported by panellists in this study.

The perceived sweetness, which was associated with likeability, was inversely related to the bitter ($\tau = -0.271$, $p < 0.05$) and sour ($\tau = -0.385$, $p < 0.01$) tastes and a honey's aftertaste ($\tau = -0.260$, $p < 0.05$), which were all also negatively associated with the likeability, highlighting how important the panellists considered this taste characteristic to be. A sweet taste in food is commonly associated with its sugar content, with soluble solids also generally being correlated with sugar [2], and soluble solids comprising 80% of the sugar content [32]. Despite this, the perceived sweet taste of the samples in this study was inversely associated with the TSS ($\tau = -0.315$; $p < 0.05$).

Table 1. Kendall's Tau correlations between a selection of the sensory attributes, antioxidant characteristics, and physicochemical properties of a range of commercially available Australian honeys.

	Crystallisation	Odour Intensity	Mouthfeel	Aftertaste	Sweetness	Bitterness	Likeability	DPPH Inhibition (%)	CUPRAC	TPC
Crystallisation	1									
Odour Intensity	0.135	1								
Mouthfeel	0.550**	0.148	1							
Aftertaste	-0.039	0.256*	-0.004	1						
Sweetness	-0.176	-0.218	-0.104	-0.260*	1					
Bitterness	0.289*	0.262*	0.221	0.203	-0.271*	1				
Likeability	-0.260*	-0.297*	-0.288*	-0.435**	0.353**	-0.252*	1			
DPPH Inhibition (%)	-0.162	0.059	-0.077	0.379*	-0.059	0.028	-0.202	1		
CUPRAC	-0.125	0.276*	-0.089	0.315*	-0.131	0.118	-0.177	0.476**	1	

TPC	-0.141	0.147	-0.077	0.234	-0.042	0.057	-0.105	0.468**	0.677**	1
ABS_{450}	-0.113	0.139	-0.012	0.290*	0.006	0.061	-0.097	0.500**	0.556**	0.573
pH	0.181	0.415**	0.165	0.311*	-0.224	0.149	-0.437**	0.169	0.339**	0.270

Note** Correlation is significant at the 0.01 level; * Correlation is significant at the 0.05 level.

4. Conclusions

While the sweetness of honey was positively associated with the likeability, a greater range of visual, olfactory, and taste attributes, in addition to honey's pH, were identified to be inversely correlated, which could potentially drive consumer purchasing decisions. The dislike of crystallisation could inform retailers that their honey may not be selected for purchase in comparison to non-crystallised types. These negative associations could potentially drive consumer purchasing decisions in opposition of the selection of these honeys in comparison to the likeability of sweetness encouraging honey selection. Interestingly, the antioxidant profile had no influence on the consumer perception of the honey samples, which could be due to the blinded nature of the study design and should be investigated further. There should be a focus in future research on investigating further influences on consumer honey selection, including the influence of packaging and product origin. Consumer understanding of the potential medicinal benefits of honey should also be examined, and if this knowledge would influence honey purchasing decisions.

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