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# Indonesian Honey Consumers' Behavior and Sensory Preference for Commercial Trigona Honey

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## *ABSTRACT*

*Consumption of honey has increased in recent years. This included trigona honey as a new market that is developing. This research was conducted to (1) identify the consumption patterns for Indonesian honey, and (2) identify the sensory attributes of honey considered ideal by consumers which influence consumer acceptance and satisfaction. There were 2 stages of activity in this study, including a consumption online survey by 225 respondents and a sensory testing of honey samples using the CATA (check-all-that-apply) method involving 64 untrained panelists. Data analysis was carried out using SPSS and XLSTAT 2022 software. There were 4 honey samples used in this study: 2 Apis bee honey samples and 2 trigona honey samples. The study showed that the consumption pattern of Indonesian honey consumers is influenced by the consumers' age and income. Health benefits, brand awareness, and taste of honey were the important factors in consumer behavior. Apis bee honeys were perceived as the ideal honey by consumers as they were very familiar with the taste. The sweet aroma, sweet aftertaste, caramel flavor, and viscous attributes of Apis bee honey were the attributes that the consumers like. The floral flavor and fruity aroma found in trigona honey were appealing. However, the strong sour aroma, taste, and aftertaste found in trigona honeys decrease the Indonesian consumers liking.*

***Keywords:*** *CATA, honey bee honey, ideal attributes, ideal honey, stingless honey*

## INTRODUCTION

Honey-based products have the potential to be developed as local products in Indonesia. Indonesia can produce a diverse range of honey due to its diverse bee population, which includes eight *Apis* bee species and more than 40 stingless bee species (Gratzer *et al.,* 2019). Honey consumption has increased in recent years due to increased health consciousness and COVID-19 outbrake. The demand for stingless bee honey, known as trigona honey, is increasing because trigona honey has medicinal properties such as being high in flavonoid and phenolic content (Majid *et al.,* 2020; Syam *et al.,* 2016), inhibiting LDL oxidation (Rahma *et al.,* 2014), and anti-diabetic effect (Amin *et al.,* 2018). However, trigona honey is a new emerging market in Indonesia compared to the forest honey and beekeeping honey. This can be an opportunity as well as a challenge to the beekeepers considering the honey market competition.

Although honey sensory profile is one of the parameters that determine the honey quality, there is no global agreement on honey criteria. Each honey has a unique sensory profile due to its composition, which is influenced by honey's origin, maturity, season, bee type, plant source of nectar, bee lifestyle, harvesting method, and post-harvest handling (da Silva *et al.,* 2016). It is important for the beekeepers to understand the honey sensory quality and find out the consumers preference in order to increase consumer acceptance and satisfaction, also well as sales. Different buyers will have different honey quality requirement.

Currently, there has been no study regarding the sensory profile of honey sold in Indonesia and the sensory profile that considered as ideal according to Indonesian honey consumers. Analysis of consumer behavior need to be carried out to determine consumer characteristics, consumption pattern, and factors that influence consumer decisions to buy honey products, both extrinsic and intrinsic factors.

Check-All-That-Apply is a simple, fast, and easy method to identify the sensory profile of a product based on consumer perceptions (Ares *et al.,* 2014b). Consumers as panelists are asked to choose attributes that are considered appropriate to the sample from the list provided. Data obtained from the CATA test for sensory evaluation were then analyzed with Cochran's Q test, correspondence analysis, principal coordinates analysis (PCoA), penalty analysis, and visualized into a biplot diagram to see the similarities and differences of each sample and the sensory attributes that compose the sample sensory profile.

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Therefore, the purpose of this study is to identify consumption patterns of Indonesian honey and the sensory attributes of honey that are considered ideal by consumers as well as the sensory attributes of honey that can affect consumer acceptance and satisfaction. This study contributes to the knowledge of sensory quality of Indonesian honey to raise the honey industry competitiveness and further development of honey products.

## MATERIALS AND METHOD

### Materials

This study used four samples of commercial honey which produced by different types of bees, including stingless bee and honey bee (*Apis* sp.). The honey samples were all obtained from local markets. Commercial trigona honey and trigona farm honey were produced by stingless bee. The trigona farm honey is originated from Central Java stingless bee honey farm. Commercial X honey and commercial Z honey were produced by *Apis* bee. The stingless bee honey was the main focus with *Apis* bee honey served as the comparison.

### Methods

This study was divided into two stages: an online survey and a sensory evaluation of commercial honey using the CATA method. The data collected from the online survey will be further analyzed with SPSS software, while sensory evaluation data will be further analyzed with XLSTAT 2022.

### Online survey

Online survey was conducted using Google Form and the link was shared through social media (Whatsapp, Facebook, Instagram, and Twitter). The questions given in the online survey aim to collect consumer background information: gender, age, education level, income, and consumers habit in consuming honey (frequently consumed honey products and frequency of honey consumption). The online survey respondents were chosen using convenience sampling, with the following criteria: honey consumer (has consumed honey twice within the last 2 week) and age range of 15 to 65 years. The required number of online survey respondents was determined by G*Power software. G*Power can be applied to many analytical statistics, including exact statistics, t-test, F-test, and ANOVA when the effect of population size or behavior distribution is unknown (Kyonka, 2019; Uakarn *et al*., 2021). The sample size was estimated using the exact test-correlation bivariate normal model on G*power software and the parameters used were two tails, Pearson's r value of 0.3 at a significance level of 5% and statistical power of 0.95, which resulted in 138 respondents (Figure 1), but 225 were obtained.

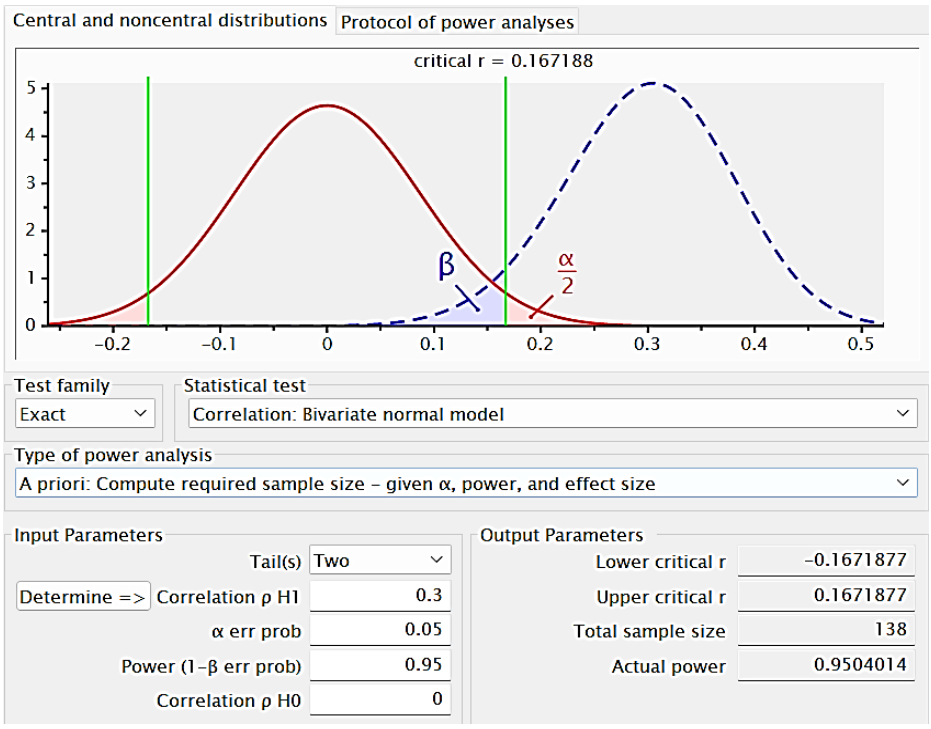


Figure 1. The sample size for the online survey calculated using G*Power at α level 5%, power 0.95, and effect size 0.3 is 138

**Honey profile sensory evaluation with CATA**

Sensory evaluation of commercial honey samples was performed using check-that-all-apply (CATA) method, involving 64 untrained panelists from IPB University. The honey sensory profile was evaluated using the nine-point hedonic scale for aroma, flavor, taste, trigeminal sensation, color, and overall acceptability (1- extremely disliking to 9- extremely liking).

A focus group discussion (FGD) was held to gather information about honey sensory attributes that will be used to evaluate the sensory profile of honey with CATA method. The selected ten participants in the FGD should be honey consumers aged 15 to 60 years who consume honey at least four times per month.

Samples for sensory evaluation were prepared by pouring 7g of honey sample into a 30 mL plastic cup (Marcazzan *et al.,* 2017). Then, the plastic cup was labeled with a random three-digit code, covered with plastic wrap, and served to the panelists at room temperature 20-25°C. Each panelist will receive four honey samples, cracker, and mineral water. Before tasting the four honey samples, the panelists were asked to answer questions about their perception of ideal honey by ticking the characteristics that ideal honey must have. The panelists were then asked to identify the perceived attributes of the honey samples while tasting them and assign a preference value to each honey sample.

**Online survey and CATA data analysis**

The results of the online survey are processed using SPSS and displayed with diagrams and correlation analysis to identify the factors that influence consumer behavior. Meanwhile, CATA analysis data were processed using the XLSTAT 2022 software which was then interpreted using Cochran's Q test at 5% significance value, correspondence analysis, principal coordinate analysis (PCoA), and penalty analysis.

**Measurement of Brix and pH value**

Measurement of sugar content (°Brix) in honey samples was carried out using a Brix refractometer (ATC, Bellingham+Stanley, UK) at room temperature 22-25°C according to Karabagias *et al*. (2020). Following that, the sample pH was determined by dissolving 10 g of each honey samples in 75 mL distilled water and the pH value was measured using a calibrated pH meter (Thermo Orion 410, USA).

## RESULTS AND DISCUSSION

**Online survey respondent profile**

Table 1 shows the profile of respondents in the online survey, with a total of 225 people responding, 69% of whom were female and 31% of whom were male. The majority of respondents (51%) were between the ages of 16 and 25, followed by those between the ages of 26-35 years (32%), 36-45 years (8%), 46-55 years (7%), and 56-65 years (1%).

Table 1. Profile of online survey respondents

| | Total | Percentage (%) |
|---|---|---|
| Gender | | |
| Male | 70 | 31 |
| Female | 155 | 69 |
| Age | | |
| 16-25 | 115 | 51 |
| 26-35 | 73 | 32 |
| 36-45 | 18 | 8 |
| 46-55 | 16 | 7 |
| 56-65 | 3 | 1 |
| Education level | | |
| High School/Equivalent Level | 15 | 7 |
| Bachelor's degree/Diploma | 200 | 89 |
| Graduate School | 10 | 4 |
| Job | | |
| Student | 98 | 44 |
| Civil servants | 14 | 6 |
| Employees | 80 | 36 |
| Enterpreneur | 20 | 9 |
| Others | 13 | 6 |
| Monthly income | | |
| ≤ Rp. 2.500.000 | 92 | 41 |
| Rp. 2.500.001 - Rp. 5.000.000 | 31 | 14 |
| Rp. 5.000.001 - Rp. 10.000.000 | 50 | 22 |
| > Rp. 10.000.000 | 52 | 23 |

The majority of respondents (89%) had taken undergraduate/diploma degree, while the remainder had completed high school/vocational school/equivalent level (7%) and postgraduate masters/doctoral degree (4%). Respondents were classified as students (44%), private employees (36%), entrepreneurs (9%), civil servants (6%), and others (6%), based on their occupation. According to the data, the respondents' monthly income varies depending on their field of work. Because the majority of respondents are students, the majority of respondents (41%) have a monthly income of less than Rp 2.500.000. Meanwhile, other respondents with incomes above Rp 10.000.000 reached 23%, respondents with incomes between Rp 5.000.001 and Rp 10.000.000 reached 22%, and respondents with incomes between Rp 2.500.001 and Rp 5.000.000 reached only 14%.

**Honey consumption pattern analysis**

Based on the data collected from the online survey, the majority of respondents had consumed honey before (Figure 2A). More than half of the respondents (57%) consume honey at most 1-2 times per week, 26% consume honey 3-5 times per week, 12% of respondents consume honey 5-7 times per week, and only 5% of respondents consuming honey more than 7 times per week.

A correspondence analysis was performed to understand the relationship between the consumer profile and the frequency of honey consumption. In this study, the respondent's gender, age, and occupation had no effect on the frequency of honey consumption. However, the respondent's monthly income influences how frequently they consume honey weekly. Figure 2B shows that consumers with a monthly income greater than Rp 10.000.000 are more likely to consume honey more than once per day on a daily basis. The monthly income per person remains the limiting factor to honey purchase and consumption frequency in many countries (Brščić *et al.,* 2017; Vapa-Tankosić *et al.,* 2020).

According to Figure 3, the most popular honey is commercial honey from brand Madu TJ (31%), followed by Madurasa (27%), Madu Nusantara (7%), Madu Trigona (7%), Madu Manuka (7%), Madu Pramuka (5%), Madu Uray (4%), Madu Alshifa (4%), and the rest is a mix of various honey brands (9%). Both Madu TJ and Madurasa are leading brands with market sizes of 10.4 and 59.5% (TBI, 2022). This shows that brand recognition and reputation influence Indonesian consumers' choices.

**Consumers' motivation**

Understanding consumer motivation can help increase honey acceptance and satisfaction (Verain *et al.,* 2016). Figure 4 shows that the majority of consumers (44.9%) consume honey for health reasons. Furthermore, respondents were motivated to consume honey due to their liking toward honey (21.9%), the use of honey as a sugar substitute (17%), and the antioxidant content (16.2%). The result of this study is in accordance with research conducted by Purnomo *et al.* (2021). There are four main reasons why consumers consume honey: honey is widely known as a natural medicine, a part of a lifestyle, a nutritional supplement, and a food additive (Purnomo *et al.,* 2021).

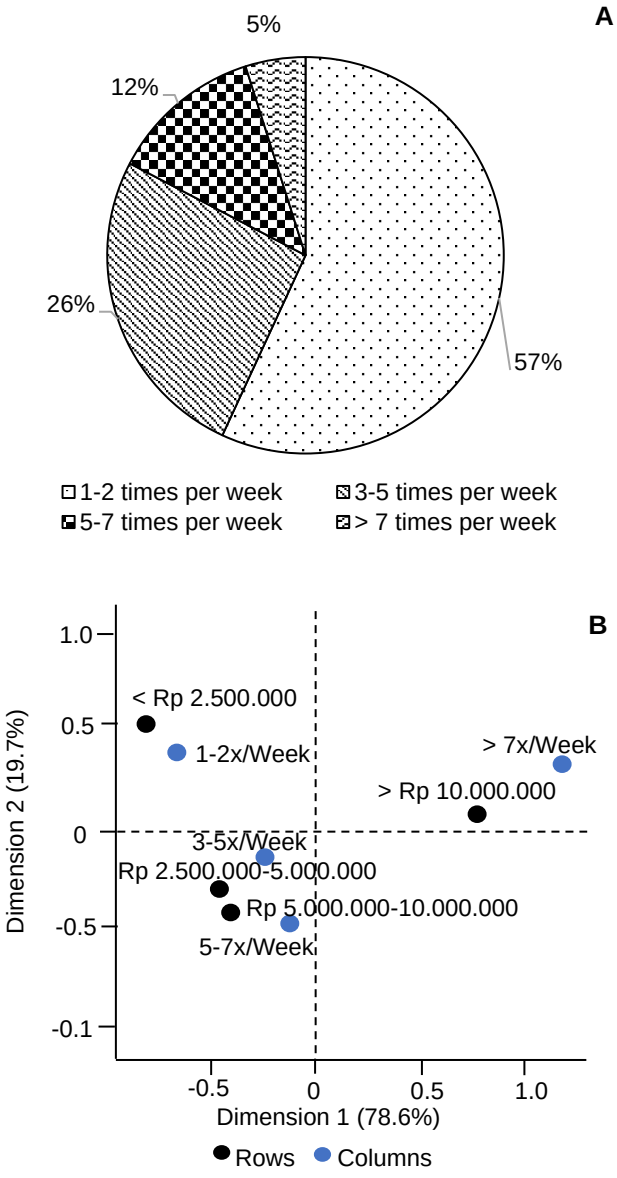


Figure 2. Consumption frequency of 225 online survey respondents (A) and correspondence analysis of respondents' monthly income and consumption frequency (B)

In addition, the COVID-19 breakout had greatly affected the consumers' behaviour. According to the

Protection Motivation Theory, consumers consider taking precautions against potential health risks such as COVID-19 as important (Rad *et al.,* 2021). This coping mechanism motivate consumers to consume trigona honey, which has medicinal properties and is beneficial to the lifestyle of health-conscious people.

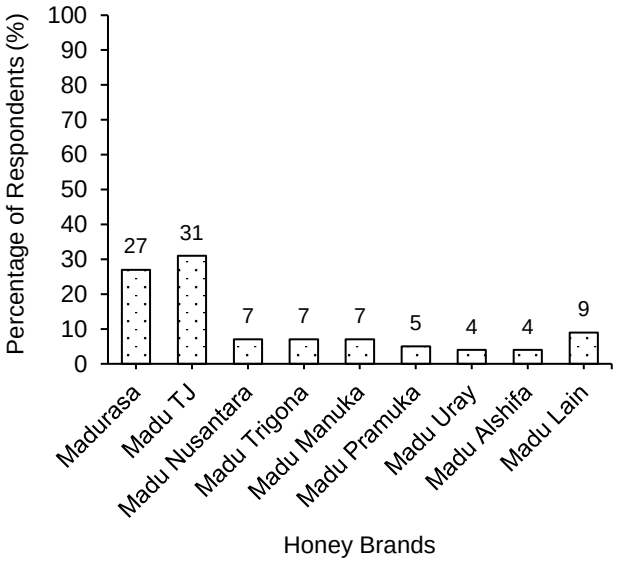


Figure 3. Brands of honey consumed by 225 online survey respondents

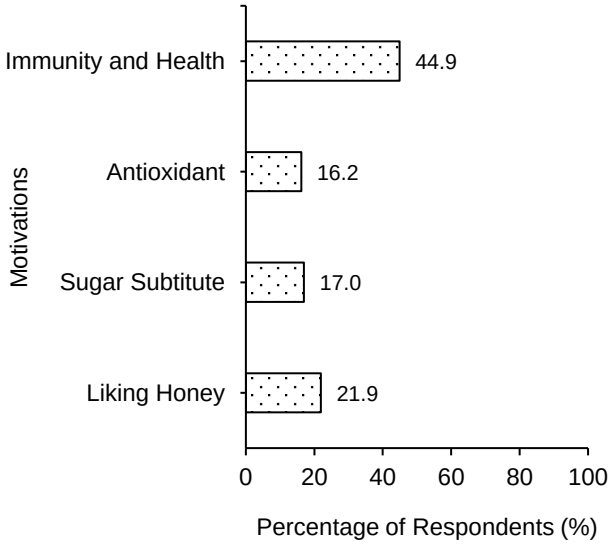


Figure 4. Motivation for consuming honey

**Attributes of importance**

Honey consumers make a purchase by evaluating the qualities of honey due to the large variety of honey products available on the market. Brand, price, origin of honey, quality of organic honey, health benefit, type of honey, and sensory qualities of honey such as taste and texture are all factors that honey consumers evaluate (Šánová *et al.,* 2016). According to the online survey responses (Figure 5), taste or sensory aspects (37.9%) are the most essential attributes for most Indonesian honey consumers when purchasing honey. This result was related to consumers' motivation to consume honey due to liking (21.9%) and as a sugar substitute (17%). Aside from flavor, consumers consider health benefits (27.7%), price (19.3%), ingredient content (14.1%), and consumption temperature (1.2%) when purchasing honey. In the study of Brščić *et al.* (2017), the Croatian honey consumers also value intrinsic honey attributes such as taste, aroma, consistency, and type of honey more than brand, label, packaging, and honey's color.

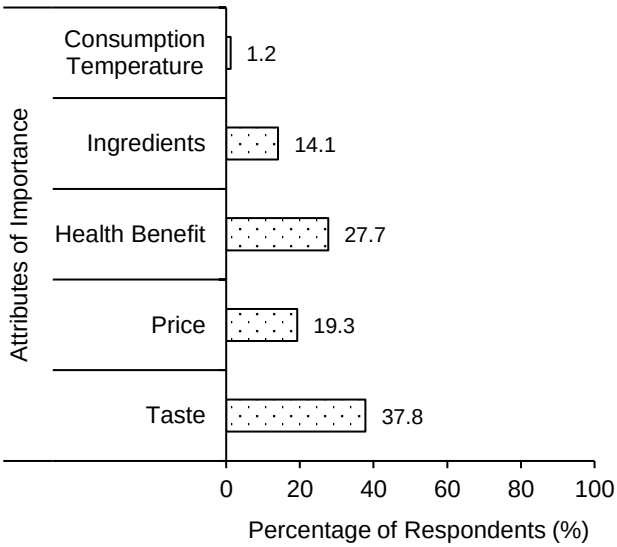


Figure 5. Honey attributes that considered as important

Consumer preferences for certain types or brands of honey are closely related to consumers' socio-demographic conditions (Purnomo *et al.,* 2021). There is a correlation between the age and monthly income towards attributes of importance (Figure 6). Consumers around aged 26 to 35 years with earning Rp 5.000.001-10.000.000 has a positive correlation to the attributes of taste (sensory) and price. Consumers around 46 to 65 years old with earning above Rp 10.000.000 has a stronger correlation with health effect attributes and ingredient composition. Meanwhile, the consumer group aged 16 to 25 years and whose income is below Rp 2.500.000 has correlation to consumption temperature. It can be seen from Figure 2B and Figure 6 that there is a possible segmentation based on the level of income of consumers: 1) people with high income, who consume honey frequently and pay attention to the quality of honey; 2) people with moderate income,

who consume honey moderately and pay attention to the taste and price; and 3) people with low income, who consume less and tend to consume based on consumption temperature influenced by the environment.

**Honey profile sensory evaluation with CATA**

Data obtained from honey sensory evaluation was analyzed using Cochran's Q test, correspondence analysis, principal coordinate analysis (PCoA), and penalty analysis. List of attributes for sensory evaluation obtained from FGD can be seen in Table 2.

**Honey sensory profile**

A total of 64 panelists assessed four honey samples. The commercial X honey sample and the commercial Z honey sample were *Apis* bee honey, while trigona honey sample from Central Java bee farm and commercial trigona honey sample were stingless bee honey.

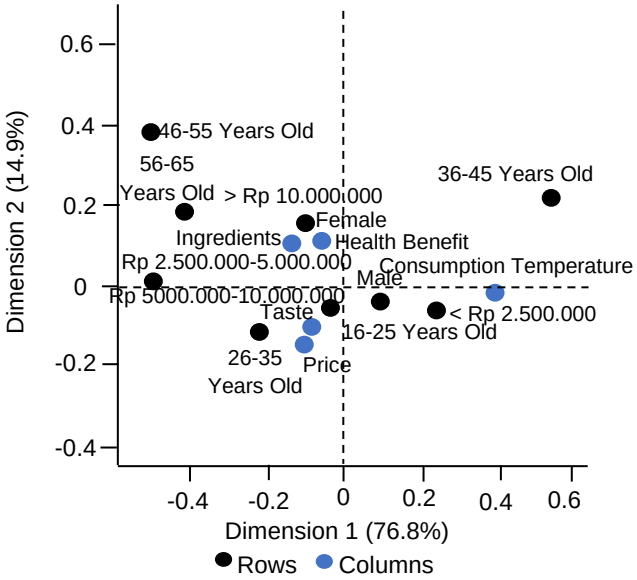


Figure 6. Correspondence analysis of consumers' profile (gender, age, and monthly income) and attributes of importance

Table 2. Honey sensory attributes based on *focus group discussion* (FGD) by 10 selected consumer panelists

| No. | Sensory Attributes | Description | Reference |
|---|---|---|---|
| | Aroma | | |
| 1 | Sweet | Aroma of sugar solution | |
| 2 | Sour | Aroma of acid solution | |
| 3 | Bitter | Aroma of solution contains quinine or caffeine | Galán-Soldevilla *et al*., 2005; Marcazzan *et al*., 2017 |
| 4 | Fruity | Aroma associated with fruit, such as lemon or apple | |
| 5 | Floral | Aroma associated with flower | |
| 6 | Caramel | Combination of sweet aroma after cooked or burned | |
| 7 | Fermented | Aroma associated with beer | Galán-Soldevilla *et al*., 2005 |
| 8 | Waxy | Aroma associated with wax or resin | |
| | Flavor | | |
| 9 | Fruity | Taste associated with fruit | Galán-Soldevilla *et al*., 2005; Marcazzan *et al*., 2017 |
| 10 | Floral | Taste associated with flower | |
| 11 | Caramel | Sweet taste after cooking or toasting | Galán-Soldevilla *et al*., 2005 |
| 12 | Fermented | Taste associated with beer | |
| | Taste | | |
| 13 | Sweet | Taste of sugar solution | |
| 14 | Sour | Taste of acid solution | Galán-Soldevilla *et al*., 2005; Marcazzan *et al*., 2017 |
| 15 | Bitter | Taste of solution contains quinine or caffeine | |
| | Aftertaste | | |
| 16 | Sweet | The sweet taste that lingers after being swallowed | |
| 17 | Sour | The sour taste that lingers after being swallowed | Marcazzan *et al.*, 2017 |
| 18 | Bitter | The bitter taste that lingers after being swallowed | |
| | Trigeminal sensation | | |
| 19 | Astringent | Sensation produced from the mixture of sour and bitter taste | Galán-Soldevilla *et al*., 2005 |
| | Mouthfeel | | |
| 20 | Pasty | Texture that causes a paste-like feeling in the mouth | Marcazzan *et al*., 2017 |
| 21 | Viscous | Texture related to the thickness of the product | Galán-Soldevilla *et al*., 2005; Marcazzan *et al*., 2017 |
| | Color | | |
| 22 | Yellow color | | |
| 23 | Orange color | | |
| 24 | Darker orange color | | |

According to Cochran's Q test, the four honey samples had significantly different sensory profiles for 22 attributes at the $p<0.05$ level, except for the floral aroma ($p=0.770$) and orange color ($p=0.303$) attributes (Table 3). It appears that the ideal honey is characterized with sweet aroma, waxy aroma, sweet taste, sweet aftertaste, and viscous. In contrast, the honey samples sensory profile is more varied.

Commercial X honey and commercial Z honey samples characterized with highly sweet profile, dominated by caramelic flavor, sweet aroma, sweet taste, sweet aftertaste, and viscous texture, which are common attributes of *Apis* bee honey. Caramel aroma was weakly identified in commercial X samples. *Apis* bee honey is sweeter than stingless bee honey due to its higher fructose content (32-44%) (Machado De-Melo *et al.,* 2017), whereas stingless bee honey contains less fructose (7.79-22.92% w/w) (Agus *et al.,* 2021). Trigona farm honey samples and comercial trigona honey samples showed a typical stingless bee honey profile. The trigona farm honey has sweet and sour taste, while the commercial trigona honey sample is less sweet with sour and bitter taste. Both honey samples have a strong sour taste due to the presence of organic acids and acid sugar (lactonic acid) (do Vale *et al.,* 2018; Sousa *et al.,* 2016). Organic acid was produced from the degradation of 5-HMF (5-hydroxymethylfurfural) compounds as a result of fermentation process that occurs to honey during the storage (Braghini *et al.,* 2021; Habib *et al.,* 2014).

The stingless bee honey has rich aroma with fruity aroma, floral aroma, fermented aroma, and waxy aroma. Volatile compounds found in stingless bee honey, such as aldehyde, ketone, benzeneacetic acid (floral aroma), and esters (honey aroma), contributed to the complex honey aroma (Sharin *et al.,* 2021). In addition, the stingless bee honey is high in polyphenol, such as flavonoids, phenolic acids, and tannin which cause honey to have an astringent sensation (Kek *et al.,* 2014; Liu *et al.,* 2023).

The color of honey is influenced by the content of water-soluble color compounds (polyphenols, carotenoids, anthocyanins), sugars, minerals, and amino acids (Machado De-Melo *et al.,* 2017; Moniruzzaman *et al.,* 2013). Commercial X honey and trigona farm honey samples showed a yellow or bright color. Meanwhile, commercial Z honey and commercial trigona honey samples showed a dark orange honey color. Dark-colored honey contains higher polyphenolic compounds than light-colored honey (Machado De-Melo *et al.,* 2017).

Table 3. Cochran's Q Test analysis of honey sensory attributes obtained from honey sensory evaluation CATA method with 64 untrained panelists

| Attributes | *p*-values | Commercial X Honey | Commercial Z Honey | Commercial Trigona Honey | Trigona Farm Honey |
|---|---|---|---|---|---|
| Sweet aroma | <0.0001 | 0.828$^{a}$ | 0.953$^{a}$ | 0.547$^{b}$ | 0.844$^{a}$ |
| Sour aroma | <0.0001 | 0.078$^{c}$ | 0.516$^{b}$ | 0.797$^{a}$ | 0.641$^{ab}$ |
| Bitter aroma | <0.0001 | 0.031$^{b}$ | 0.172$^{b}$ | 0.516$^{a}$ | 0.078$^{b}$ |
| Fruity aroma | <0.0001 | 0.266$^{b}$ | 0.312$^{b}$ | 0.281$^{b}$ | 0.703$^{a}$ |
| Floral aroma | 0.770 | 0.375$^{a}$ | 0.359$^{a}$ | 0.297$^{a}$ | 0.359$^{a}$ |
| Fermented aroma | <0.0001 | 0.047$^{b}$ | 0.125$^{b}$ | 0.641$^{a}$ | 0.078$^{b}$ |
| Caramelic aroma | 0.025 | 0.312$^{b}$ | 0.500$^{a}$ | 0.359$^{ab}$ | 0.344$^{ab}$ |
| Waxy aroma | <0.0001 | 0.281$^{c}$ | 0.766$^{a}$ | 0.719$^{ab}$ | 0.547$^{b}$ |
| Sweet taste | <0.0001 | 1$^{a}$ | 1$^{a}$ | 0.469$^{b}$ | 0.859$^{a}$ |
| Sour taste | <0.0001 | 0.109$^{b}$ | 0.297$^{b}$ | 0.812$^{a}$ | 0.969$^{a}$ |
| Bitter taste | <0.0001 | 0$^{b}$ | 0.031$^{b}$ | 0.844$^{a}$ | 0.047$^{b}$ |
| Fruity flavor | <0.0001 | 0.281$^{b}$ | 0.422$^{b}$ | 0.281$^{b}$ | 0.875$^{a}$ |
| Floral flavor | 0.022 | 0.531$^{a}$ | 0.484$^{ab}$ | 0.297$^{b}$ | 0.359$^{ab}$ |
| Fermented flavor | <0.0001 | 0.016$^{b}$ | 0.031$^{b}$ | 0.641$^{a}$ | 0.172$^{b}$ |
| Astringent sensation | <0.0001 | 0.141$^{b}$ | 0.109$^{b}$ | 0.719$^{a}$ | 0.547$^{a}$ |
| Caramelic flavor | <0.0001 | 0.531$^{a}$ | 0.562$^{a}$ | 0.328$^{b}$ | 0.172$^{b}$ |
| Sweet aftertaste | <0.0001 | 0.969$^{a}$ | 0.969$^{a}$ | 0.234$^{c}$ | 0.578$^{b}$ |
| Sour aftertaste | <0.0001 | 0.047$^{b}$ | 0.234$^{b}$ | 0.594$^{a}$ | 0.812$^{a}$ |
| Bitter aftertaste | <0.0001 | 0.016$^{b}$ | 0.047$^{b}$ | 0.844$^{a}$ | 0.031$^{b}$ |
| Pasty | <0.0001 | 0.406$^{b}$ | 0.562$^{ab}$ | 0.719$^{a}$ | 0.125$^{c}$ |
| Viscous | <0.0001 | 0.891$^{a}$ | 0.938$^{a}$ | 0.906$^{a}$ | 0.328$^{b}$ |
| Yellow/light | <0.0001 | 0.766$^{a}$ | 0.078$^{b}$ | 0.016$^{b}$ | 0.734$^{a}$ |
| Orange/medium | 0.303 | 0.203$^{a}$ | 0.297$^{a}$ | 0.234$^{a}$ | 0.156$^{a}$ |
| Darker orange/dark | <0.0001 | 0.031$^{b}$ | 0.625$^{a}$ | 0.750$^{a}$ | 0.078$^{b}$ |

Note: Numbers in the same row followed by the same letter are not significantly different at the 5% test level

**Consumers' honey preference**

Correspondence analysis data shows that ideal honey has the attributes of sweet aroma, caramel aroma, sweet taste, floral flavor, caramel flavor, sweet aftertaste, and viscous. The ideal attributes were identified in all honey samples as the intensity varied (Table 3). Both commercial X and commercial Z honey samples are the ideal honey in consumers preference since they are as the clostest to the ideal honey in Figure 7. This could be due to consumers are more familiar with the sensory profile of *Apis* bee honey than trigona honey, which is relatively new and may not appeal to all consumers. Instead of highly varied aromatic honey, highly sweet and low acidity was portrayed as more familiar and acceptable for consumer (Kortesniemi *et al.,* 2018). The "liking" or prefered attributes of honey were investigated further using principal coordinate analysis (PCoA). Figure 8 depicts the preferences of Indonesian honey consumers for sweet aroma, caramel aroma, sweet taste, floral flavor, caramel flavor, and sweet aftertaste, which previously appeared on the ideal attribute. Caramel, floral, and fruity attributes were also favored in the study by Kortesniemi *et al.* (2018).

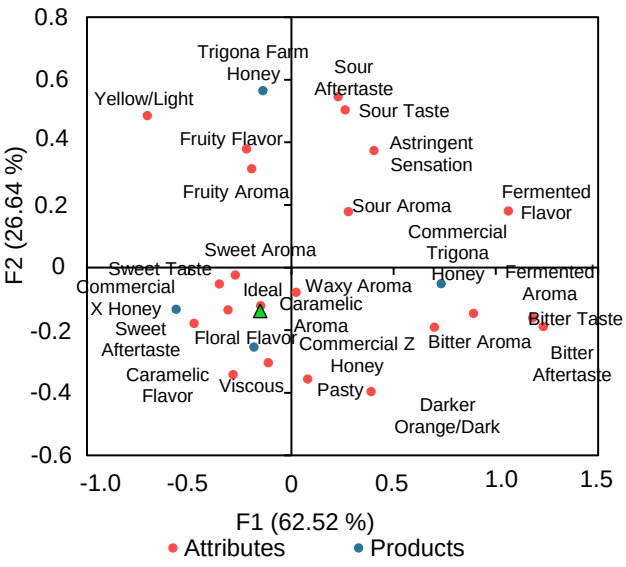


Figure 7. Correspondence analysis of honey attributes and honey samples

Penalty analysis was used in CATA to identify the attributes that reflect the preferences of honey consumers considering that there is a discrepancy between the ideal product and the actual product. Attributes are classified into must have, nice to have, and must not have attributes based on how much the preference value is reduced (Ares *et al.,* 2014a). Penalty analysis adopts the Pareto principle, which states that 80% of effects result from 20% of causes. As a result, the penalty analysis employs a 20% cutoff rule (Narayanan *et al.,* 2014). Must-have attributes should have a value of more than 20% for the condition % P(No)I(Yes) (attributes only detected in ideal product) and positive mean drops. Attributes with a value of more than 20% for the condition % P(Yes)I(No) (attributes only detected in real product) and a positive mean drop value are considered nice to have, whereas those with a negative mean drop value are considered must not have (Adawiyah *et al.,* 2019).

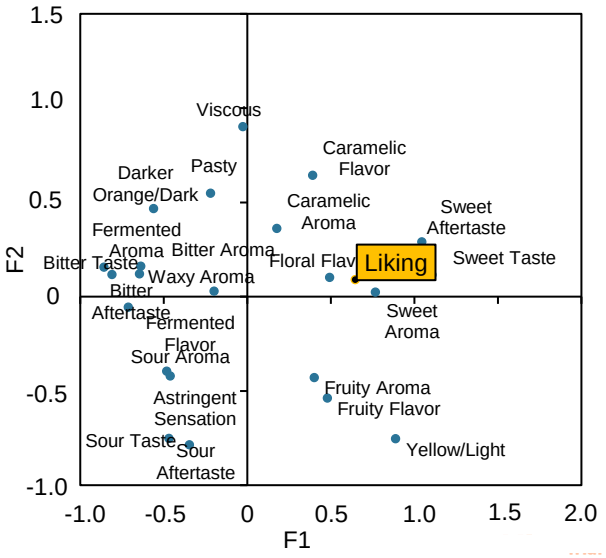


Figure 8. Principal coordinate analysis of honey attributes

Caramel flavor and sweet aftertaste fulfil the >20% P(Yes)I(No) and positive mean drop value condition. However, sour aroma, sour taste, fermented flavor, astringent sensation, sour aftertaste, and bitter aftertaste fulfil the >20% P(Yes)I(No) and negative mean drop value. These are attributes that should be noted to improve consumers satisfaction and acceptance (Figure 9 and 10).

Based on this, the sensory attributes detected in honey are classified, as shown in Table 4. The presence of caramel flavor and sweet aftertaste in honey can significantly improve the consumer satisfaction and acceptance. While the presence of sour aroma, sour taste, fermented flavor, astringent sensation, sour aftertaste, and bitter aftertaste in honey should be avoided or the consumer satisfaction and acceptance will be greatly reduced. These attributes may appear if honey is not handled properly during the processing and storage (Najeeb *et al.,* 2022). Also, consumers have a favorable attitude toward fruity aroma, caramel aroma, waxy aroma, fruity flavor, floral flavor, pasty, and viscous, though these do not have a significant impact on consumer preferences.

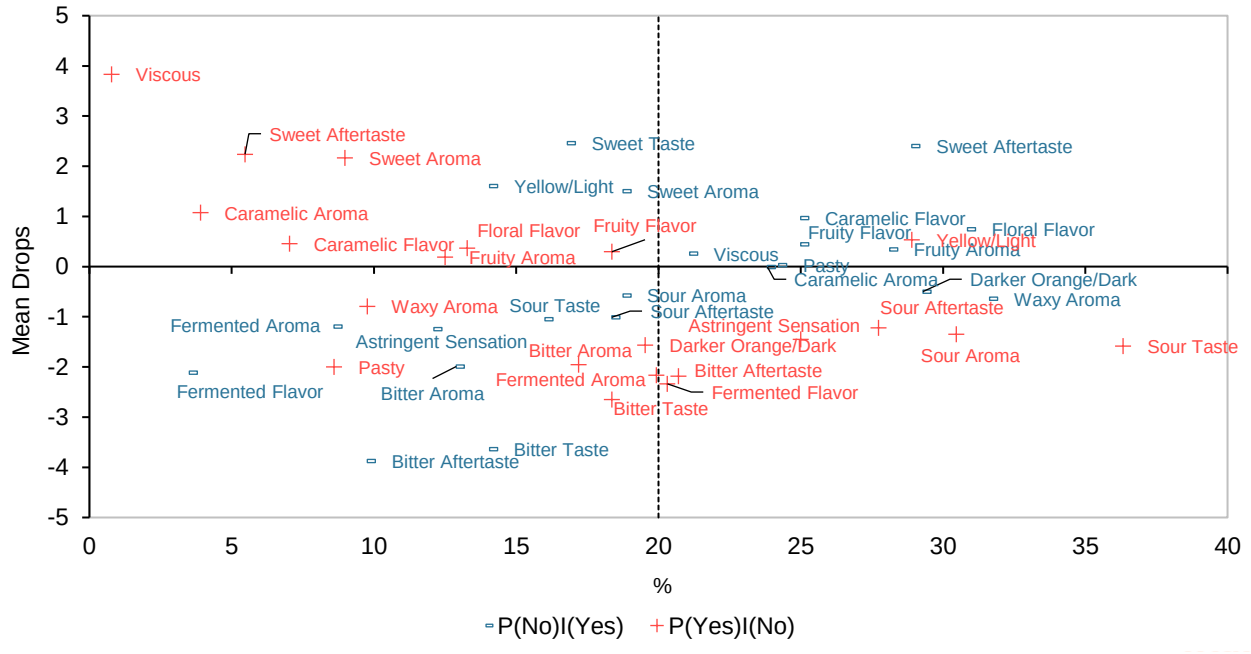


Figure 9. Penalty analysis summary of %P(No)I(Yes) and %P(Yes)I(No)

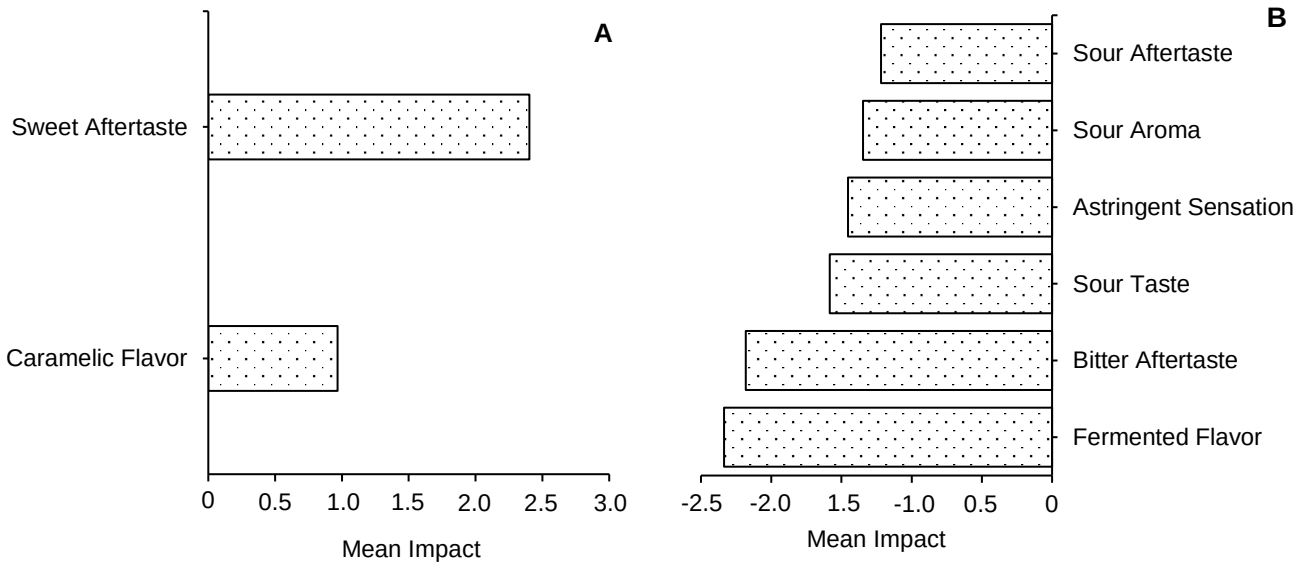


Figure 10. Mean impact of must have attributes (A) dan must not have attributes (B)

Table 4. Honey sensory attribute categories based on penalty analysis

| Must Have | Nice to Have | Does Not Influence | Does Not Harm | Must Not Have |
|---|---|---|---|---|
| Caramelic Flavor | | Fruity Aroma | Yellow/Light | Sour Aroma |
| Sweet Aftertaste | | Caramelic Aroma | | Sour Taste |
| | | Waxy Aroma | | Fermented Flavor |
| | | Fruity Flavor | | Astringent Sensation |
| | | Floral Flavor | | Sour Aftertaste |
| | | Pasty | | Bitter Aftertaste |
| | | Viscous | | |

In this study, honey color did not influence Indonesian honey consumers' preference. The yellow color attribute is included in the does not harm attribute as the value for % P(No)I(Yes) and % P(Yes)I(No) are nearly identical. This result is in accordance to Brščić *et al.* (2017), that consumers have neutral attitude toward honey color. Nonetheless, yellow color can increase consumer perceptions of sour tastes that are less preferred (Fateminia *et al.,* 2020). Ligther colored honey indicates the lower levels of antioxidants than other honey, whereas according to online survey data, consumers' motivation to consume honey is to increase immunity and health, partly because honey contains antioxidants.

**Results of pH and Brix measurements**

The °Brix value reflects the sugar composition (fructose, sucrose and glucose) in honey. Commercial X honey samples and commercial Z honey have a °Brix value of 80 (Table 5), where generally honey produced by honey bees (*Apis* spp.) has a °Brix value ≥ 75 (Habib *et al.,* 2014). In the stingless bee honey group, the trigona farm honey sample had a °Brix 72, while the commercial trigona honey sample had a °Brix 80 (Table 5). Stingless bee honey has higher water content, resulting in lower °Brix value within range 61.8-76.1 (do Vale *et al.,* 2018). The low °Brix value in trigona farm honey from the stingless bee honey group also indicated that the honey has lower sugar content than the other three honeys, resulting in the least sweet tasting honey (Table 3).

Table 5. pH and °Brix value of honey samples

| Honey Samples | pH | °Brix |
|---|---|---|
| Commercial X honey | 2.32 | 80 |
| Commercial Z honey | 3.62 | 80 |
| Commercial trigona honey | 2.69 | 80 |
| Trigona farm honey | 2.33 | 72 |

Note: pH was analyzed by pH meter and °Brix was analyzed by Brix refractometer at room temperature 22-25°C

The pH of honey samples was determined since the pH number indicates whether the acidity is increasing or decreasing, which can affect the sensory profile. All honey samples have a low pH, which is 2.32-3.62 (Table 5), where the pH of honey can range from 3.2-6.5 (Sousa *et al.,* 2013). Low honey pH indicates that honey is rich in organic acids, including citric acid, malic acid, oxalic acid (Sousa *et al.,* 2016). All honey samples should have sour taste due to the low pH. Interestingly, the sour taste was only detected in stingless bee honey samples, while it was not detected in *Apis* bee honey samples. *Apis* bee honey has higher fructose content, which allows the perceived sweet taste to mask the sour taste of honey (Wang *et al.,* 2019; Kortesniemi *et al*., 2018).

## CONCLUSIONS

The consumption pattern of Indonesian honey consumers is influenced by the consumers' age and income. The major motivation for Indonesian honey consumers to consume honey is to get health benefits, while brand awareness and taste of honey have an important role in purchasing decision. Honey sensory profile is important since honey is used as sugar substitution. The commercial X honey and commercial Z honey (*Apis* bee honey) have the same characteristic and perceived as the ideal honey by consumers as they were very familiar with the taste. *Apis* bee honey was identified by the sweet aroma, sweet taste, sweet aftertaste, caramel flavor, and viscous attributes. The stingless bee honey was identified by the strong sour aroma, taste, and after taste, which was reducing the consumers liking. However, consumers found caramelic aroma, fruity aroma, waxy aroma, fruity flavor, and floral flavor in trigona honey appealing. These attributes can improve consumer acceptance, albeit not as significant.

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