Chapter

Aroma Profile of Arabica Coffee Based on Ohmic Fermentation

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Abstract

Aromatic components contained in coffee are the important components. Several technologies can be used to improve the aroma quality of coffee, for example with ohmic technology. This study established a specialty coffee processing system focused on ohmic-based fermentation technology. The aim of this study was to identify the aroma compound in coffee that fermented by ohmic technology. The SPME method by gas chromatography-mass spectrometry is used in this study. The temperatures (30, 35, and 40°C) and fermentation time were set for this study (2, 6, 12, and 18 h). The results of the sensory test of sample coffee from Indonesia with specification of areas of origins Enrekang and Gowa in comparison with a sample of coffee from Japan can conclude that the panelist provided a rating profile liking the sample coffee from Japan, but the overall results of the quantitative descriptive analysis (QDA) of the second sample are similar or nonsignificantly different. Compound pyrazine identified in GC-MS is earthy odor which has a correlation with the results of sensory taste QDA on sample coffee from Japan.

Keywords: coffee, sensory, aroma, flavor, fermentation

1. Introduction

Coffee is one of the world's most widely consumed beverages. Coffee is one of the most important agricultural commodities in the world and is the most traded commodity globally after petroleum [1]. In 2012, the total value of coffee industry was estimated at US $173.40 billion [2]. The world coffee production showed a slight increase from 8.21 million metric tons in 2007 to 8.3 million metric tons in 2011 [3]. Based on data from AICE and ICO [4], Indonesia accounted for approximately 8.9% of total production in 2013.

Aromatic components contained in coffee beverages are the important components, which are affected by several factors; the sensory characteristic of coffees depends on crop varieties, growing areas, and processing methods. The processing methods that can significantly affect sensory characteristic include the methods of fermentation of the coffee fruit (from the coffee cherry to the green coffee), roasting, grinding, and brewing. Some research have been done to find the volatile compounds associated with the aromas and flavors contained in coffee [5]. In addition to environmental and agronomic factors, flavors of coffee are also strongly influenced by the way of processing, especially the process of fermentation and roasting [6–11]. Coffee handling process in general can be distinguished as wet and dry handling. Differences in the processing of coffee will produce different flavors, mainly due to their effects on chemical composition of the processed coffee [12–14]. Fermentation is instrumental in the formation of flavor-forming precursor compound, while the roasting process is known to contribute to the formation of volatile compounds and nonvolatile compounds that produce to the distinctive flavor in coffee [15].

The quality of coffee flavor can be different perceived by consumers. According to Leroy et al. [16], taste can be measured with the senses and can be influenced by the physical, chemical, agronomic, and technological factors. Aroma and flavor are undoubtedly important hedonic aspects of a good coffee [17], and thus these two aspects should be carefully considered in coffee classification.

Flavor, which is composed of taste and aroma, is very important for the quality of coffee. Describing the flavor of coffee is a very complex task, because it is influenced by various factors including on farm factors [17]. Not surprisingly, the diversity of flavors available commercially in specialty coffee is amazingly spacious such that a generic description of "coffee flavor" is impossible. A variety of studies have been performed over the last decade to investigate the basic composition of coffee flavor and nonvolatile components using advanced technology and instrumentation [18–24] and volatile compounds [25–29]. These study the chemical components of coffee.

To better understand and explore the taste of coffee, much efforts should be focused on objectively measuring sensory properties of coffee using a scientific approach. Sensory evaluation was done to characterize the sensory properties of products through the measurement of human response with minimum bias [30] and because it is the most rigorous approach to any assessment of the quality of the coffee.

Sensory evaluation (organoleptic) is a method performed by humans using human senses, namely the eyes, nose, mouth, hands, and ears. Through reviews, these five basic senses, we can assess the sensory attributes of a product such as color, form, shape, taste, and texture.

Therefore, in this study, organoleptic evaluation of QDA method is conducted by using nine types of Arabica coffee samples with different fermentation treatments and originates from coffee-producing areas in Indonesia, namely Enrekang and Gowa, and compared it to the coffee samples from Japan. The QDA method is a method in which the panel chooses the words that express the characteristics of the sample and quantifies them, gives a score to each sensory characteristic, and allows the characteristics of the sample to be visualized.

This study was conducted to identify the aroma compound in coffee, as an ingredient of the most popular beverages in the world. The main method used to identify the volatile compounds that contribute to coffee flavor is solid-phase microextraction (SPME) method by gas chromatography-mass spectrometry (GC-MS).

Solid-phase microextraction (SPME) has been the preferred tool for many coffee aroma volatile analyses in recent decades [31–42], mainly due to its sensitivity, rapidness, and solvent-free properties [43]. The extraction of samples from the headspace (HS) was also recorded as the most accurate composition of the flavors [37]. The main purpose of this study was to analyze aroma profile of Arabica after fermentation in an ohmic heater.

2. Material and methods

Coffee samples used in the test were Arabica coffee from Indonesia, from two different growing areas in the province of South Sulawesi, namely Enrekang and

Gowa. The samples tested were fermented at different conditions, namely fermentation for 2, 6, and 18 h at temperatures of 30, 35, and 40°C. As comparison, we also can tests using commercial coffee samples from Japan.

Information to using symbol sample (E, M, J = Area sample, H (time fermentation), T (Temperature fermentation)) in QDA:

A = EH2T30
B = EH2T35
C = EH12T35
D = EH18T35
E = MH2T30
F = MH2T35
G = MH6T35
H = MH18Y40
I = JH0T0

Sensory testing was performed on the sample used in the study, with three replications for each sample, from a total sample of nine.

2.1 Sample preparation techniques

2.1.1 Sample sensory test

Sample coffee in the ground is by means of ground coffee types and coffee MORNING MATE MILL CO-10. Sample ground coffee, which has been prepared in a glass with each weighing 2 g/cup to test smile, was right to test the beverage weighed 2 g/cup by cup size used which is mixed with hot water 3 oz. The test results of sensory tests proceed with testing sensory quantitative descriptive analysis.

2.1.2 Preparation sample HS-SPME

HS-SPME Coffee Powder: 4 g of powder was weighed in a septic-sealed gas vial (20 mL); the resulting headspace was sampled for 40 min at 40°C with a 350 rpm agitation rate using a PDMS/DVB SPME fiber. By sampling 5 L of a 1000 mg/L solution of n-C13 in DBP in a 20 mL headspace vial and agitating it at 3 mL for 20 min at 50°C, the internal norm was preloaded to the fiber.

2.2 GC-MS analysis

GC-MS analysis was performed using a Hew Packard 6890 N (Agilent Technologies, Inc., Santa Clara, CA) HS-SPME-GC-MS at chromatographic conditions: injector temperature: 2300°C; injection mode: splitless; carrier gas: helium (2 mL/min); fiber desorption time and reconditioning: 5 min; column: SGE SolGelwax (100 percent polyethylene glycol) 30 m × 0.25 mm; ionization mode: EI (70 eV); scan range: 35–350 amu; ion source temperature: 2000 V with liquid carbon dioxide; MS conditions: ionization mode: EI (70 eV); scan range: 35–350 amu; and ion source temperature: 2000 V.

2.3 Volatile component identification

Aroma compounds were classified by comparing their measured linear retention indices and mass spectra to those of genuine samples or, provisionally, those obtained from home-made or commercial libraries (Wiley 7 N and Nist 05 ver 2.0 Mass spectral data) or published in the literature.

2.4 Quantitative descriptive sensory analysis

The approach of quantitative descriptive analysis (QDA) is based on the concept of the ability of panelists to verbalize impressions of the commodity in a reliable manner. The process embodies a systematic screening and training technique, the creation and use of a sensory language, and the labeling of items in a repeat test in order to achieve a complete, quantitative definition. We followed the method of stone and side, a panel of 10 assessors (5 males and 5 females, age range 20–50 years). Initially, 90 descriptive attributes to coffee beverage were Aroma (attributes, and to test beverage, get the six attributes after getting consensus among 10 assessors on the definition of terms as shown in **Figure 1**). The rating scale method shown below was evaluated by using a two-way analysis of variance (ANOVA).

2.5 Sensory test with a rating scale method

With a line scale, the members of the panel rated the strength of the coffee aroma by labeling the horizontal line. The marked point corresponded to the influence of the stimulus perceived. The length of the line was 14 cm with anchors on both ends. The left end of the scale corresponded to "none," while the right end corresponded to such descriptive terms. The panel consisted of 5 males and 5 females. Their ages ranged from 20 to 50 years with a mean of 24 years.

2.6 Statistical analysis

Analysis of variance (ANOVA) was applied for the determination of the main effects of the investigated independent factors (flavor and percentage) on the sensory attributes as they were rated during the QDA procedure. Duncan's multiple range test was used to separated means of sensory attributes when significant differences ($p < 0.05$) were observed.

A Shimadzu GC-MS solution of 2.5 SU1 and an Agilent ChemStation D.02.00.275 were used to collect data. To visualize sample groups and compare information provided by each sampling, Principal component analysis (PCA) was used. In normalized ISTD data, PCA based on Pearson correlation coefficient was

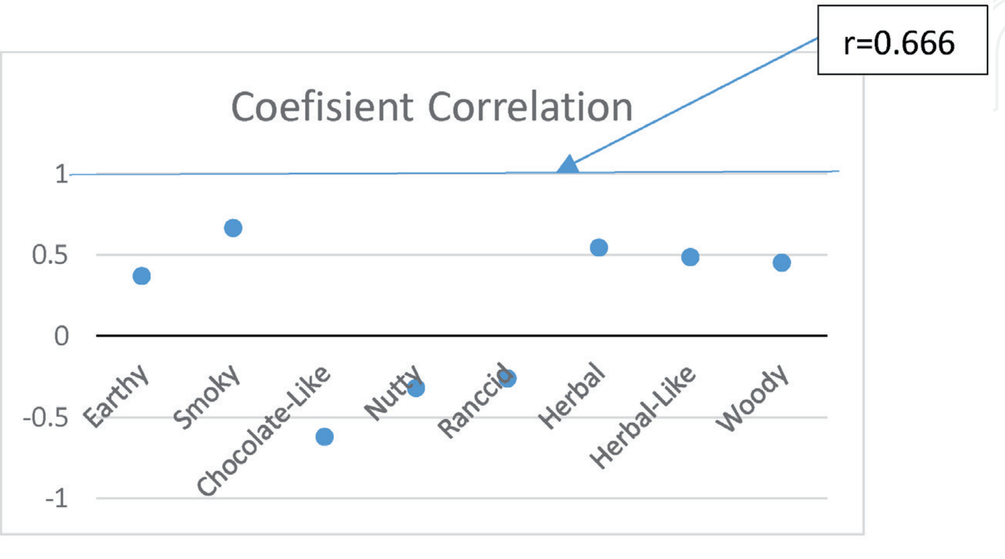

Figure 1.
Graphical representation of coefficient correlation characteristic attribute.

performed. XLSTAT (version 2015.5.01.23164) copyright Addinsoft 1995–2015 was used for statistical analysis, including one-way ANOVA and PCA. Non-polarity.

3. Results and Discussion

3.1 Quantitative descriptive analysis of various kinds of coffee brewed

A panel of 10 assessors was selected to evaluate 8 aroma attributes and 5 taste attributes of coffee beans. The aroma attributes tested are earthy, smoky, chocolate, caramel, nutty, rancid, herbal and woody. While the taste attributes tested are acidity, bitter, sweet, salt, and sour.

The strength of the correlation between the characteristic expression term and the taste (preference) that had a significant difference was calculated using the correlation function in Excel (**Table 1**).

From **Table 1**, when n = 9, from the correlation coefficient test table, it is judged that there is a significant positive correlation when r = 0.666 or more at 5% risk rate. So, it is shown from **Table 1** data of coefficient correlation result that all attributes have no correlation with the liking, because all the number of r is 0.05 from the table (n = 9 and r total sample = 0.666) which is bigger than the number of the correlation result (see **Figure 1**).

Figures 1 and **2** show the smell of sample coffee from Indonesia (sample difference treatment, fermentation) and Japan, so is the result is gaining attribute earthy, smoky, chocolate-like, caramel-like, nutty, herbal-like, and woody, like all sample are similar because the number from the result analysis, statistical (ANOVA), is low when compared to the number from q table, when total sample is 9 (q9 72 = 4.7937), and except the attribute rancid, only for sample A, C, G, I, and F is similar, then sample B, E, D, and H is not similar because the number from result ANOVA is bigger than number from q table.

Figure 3 shown is the taste of coffee sample from Indonesia (sample difference treatment, fermentation) and Japan, so is the result attribute bitterness, sweetness, saltiness, like all samples are similar because the number from result analysis, statistical (ANOVA), is low compared to the number from q table, when total sample is 9 (q9 72 = 4.7937), and except the attribute acidity for the sample D, I, and F are not similar because the number is bigger than number from table q, and then attribute sourness for the sample I, D, and F is same as the attribute acidity is not similar.

Attributes	Coefficient correlation
Earthy	0.37155974
Smoky	0.664932567
Chocolate-like	−0.617978767
Nutty	−0.316895337
Rancid	−0.263026567
Herbal	0.544261264
Herbal-like	0.486931132
Woody	0.451859838

Table 1.
Correlation coefficient of each characteristic expression term.

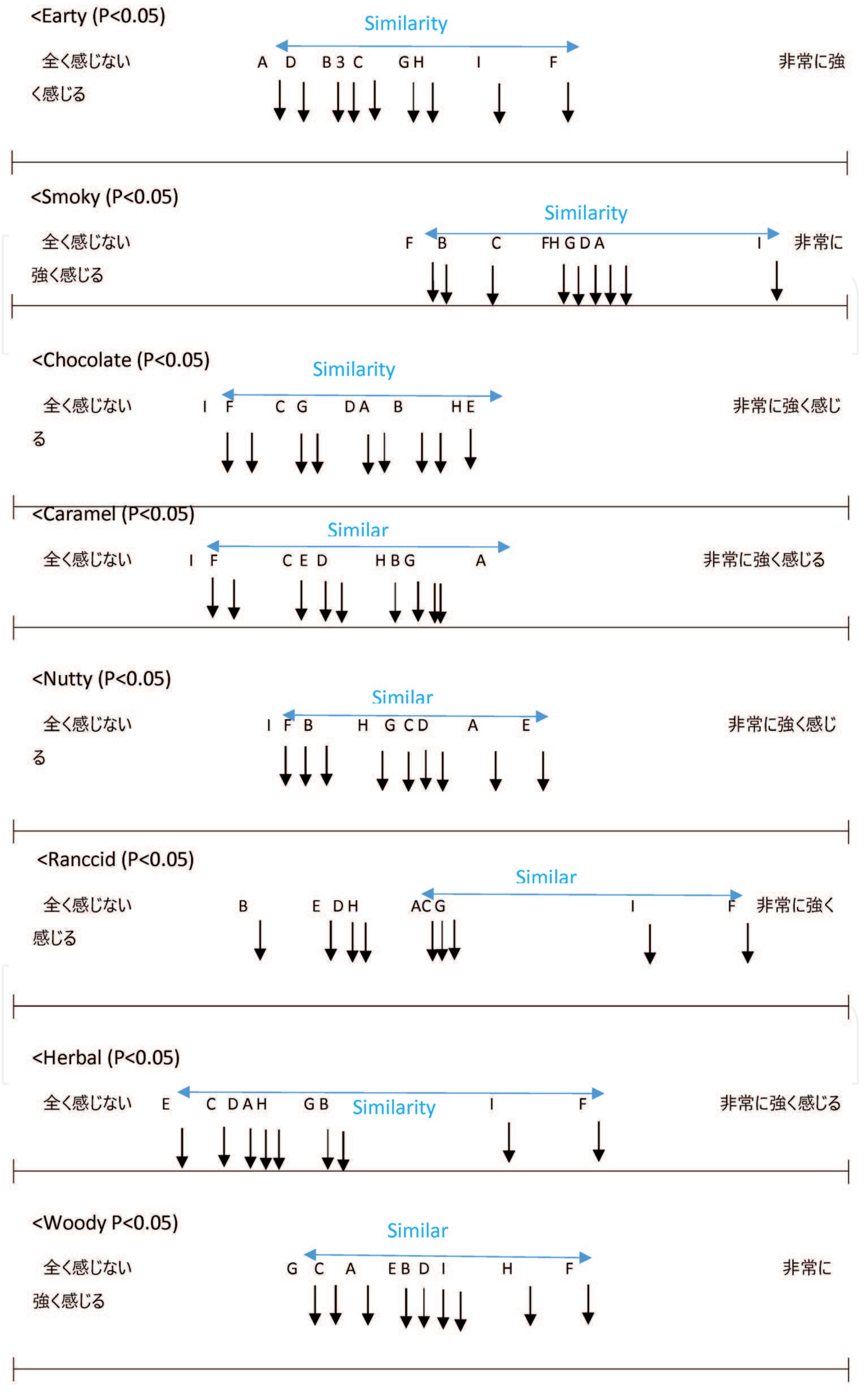

Figure 2.
Sensory analysis of coffee based on earthy, smokey, chocolate-like, caramel like, nutty, rancid, herbal-like, and woody-like odor flavor attributes.

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Figure 4(A) shows the results of sensory taste with QDA described in the sample A with smokey attribute panelist, giving the highest value in the sample compared with a sample of coffee from Japan than Indonesia. Attribute woody and liking panelist provide similar valuation between the two samples of the coffee, but the attribute rancid panelist provides high value, attribute nutty, caramel, and chocolate panelist, giving nonsimilarity to the second sample.

Based on the results, it can be seen that coffee with sample code A (EH2T30) has the highest value on the sour taste attribute, while coffee with code I (Japan) has the highest value on the sweet taste attribute. This shows that coffee A and coffee I have no similarities, and in general the panelists prefer coffee with sample code I.

Figure 4(A) and **(B)** can be explained that the sensory panelists' smell gives the highest value apart from all attributes except chocolate, caramel, and nutty, but at taste, sensory panelists provide the highest value of the sample A except attribute liking.

Based on the sensory analysis of the aroma of coffee beans, it shows that the woody and herbal aroma attributes in coffee sample I and B have similarities, but the smoke and rancid attributes in sample B have a higher value than coffee sample I. The taste attributes in both coffee samples show that sample B coffee has higher acidity and sour attributes than sample I coffee. There are similarities in the value of the sweet attribute in coffee I and coffee B.

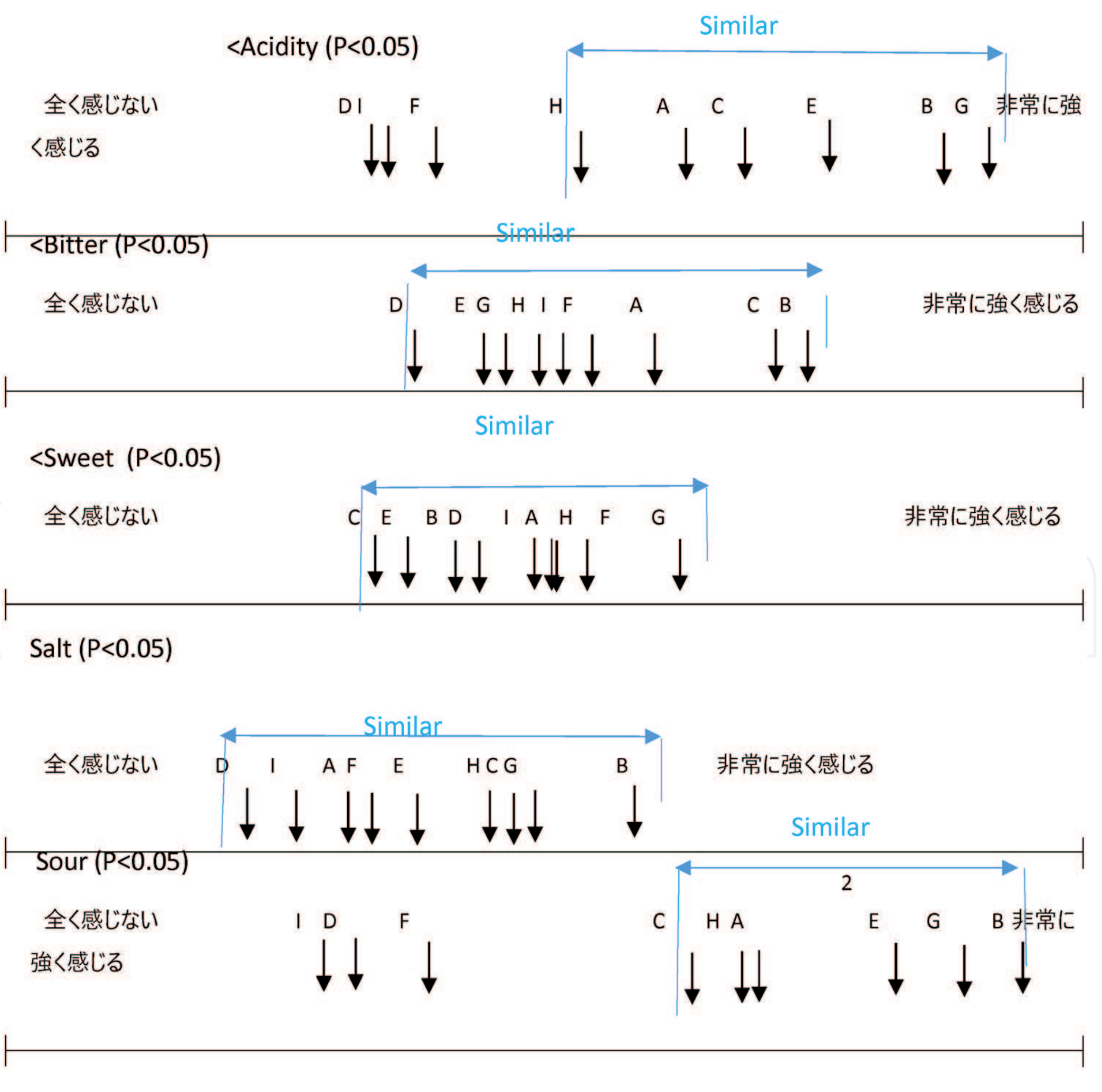

Figure 3.
Sensory analysis of coffee based on acidity, bitterness, sweetness, saltiness, sourness, and liking flavor attributes.

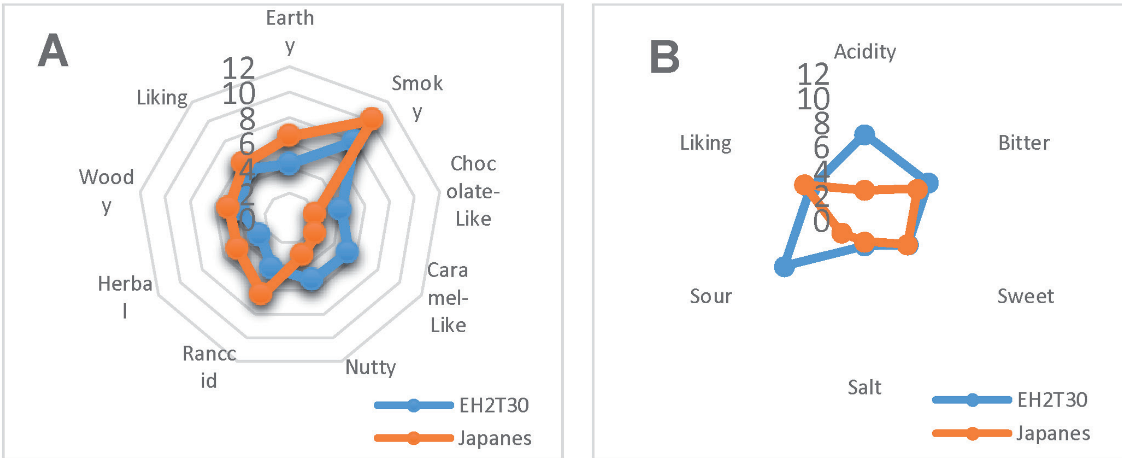

Figure 4.
(A) Result of sensory aroma sample a (EH2T30) with coffee from Japan (I) (JH0T0), and (B) result of sensory tastes sample a (EH2T30) with coffee from Japan (I).

Figure 5(A) showed the sample coffee B (EH18T35) than I result of QDA and sensory test is nonsimilar for the attribute smoky, rancid, and herbal, because the number of attributes is bigger than sample B (EH18T35), and the attribute that is similar is the nutty, caramel-like, and chocolate-like. And **Figure 5(B)** showed the sample B (EH18T35) and I being nonsimilar for attributes acidity, sourness, and saltiness.

Figure 6(A) showed the sample coffee B (EH18T30) than I result analysis for attribute sweetness and liking is similar, and all attributes for a sample coffee B (EH18T30) number is getting bigger than the sample I for the sensory tastes.

Figure 7(A) showed that the results of QDA and sensory aroma of sample coffee D (EH2T35) and I such as smokey and rancid is nonsimilar. High scores aroma smoke and rancid were also found in sample with I (Japan coffee).

The lowest aroma scores were found in sample D (EH2T35) as attributes being earthy, herbal, and rancid. **Figure 7(B)** showed the sensory tastes of coffee sample D (EH2T35) and I were found to be similar except the bitterness being lowest taste flavor.

Figure 8(A) from QDA of each attribute showed nonsimilar (significant difference) in smokey, rancid, herbal, nutty, and caramel-like when smelled directly. And **Figure 8** showed also non similar in acidity, sourness when tastes directly. Sample E (MH2T35) showed the lowest value in earthy, rancid, smoky, herbal and liking. No significant difference was noted by 10 panelists.

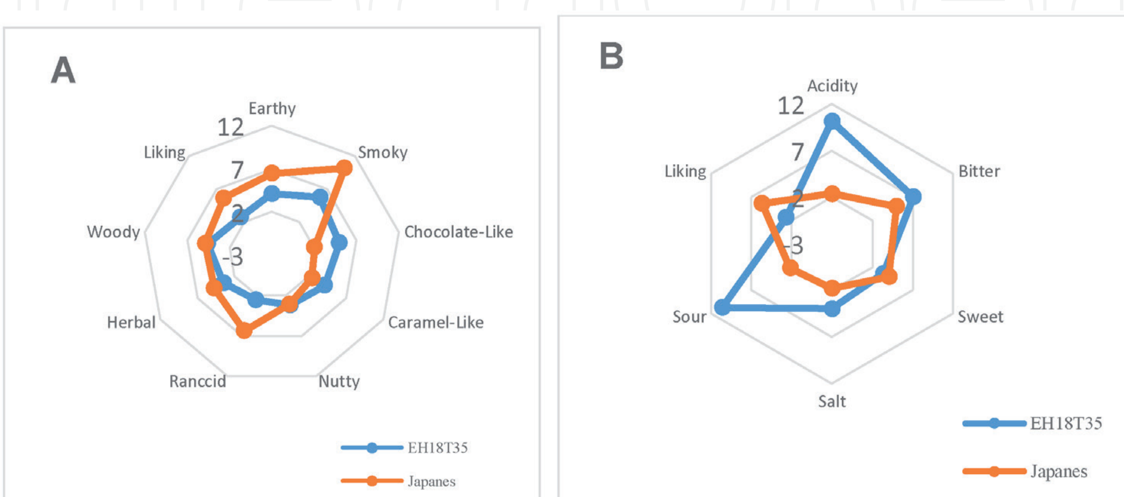

Figure 5.
(A) Result of sensory aroma sample B (EH18T35) with coffee from Japan (I), and(B) result of sensory tastes sample B (EH18T35) with coffee from Japan (I).

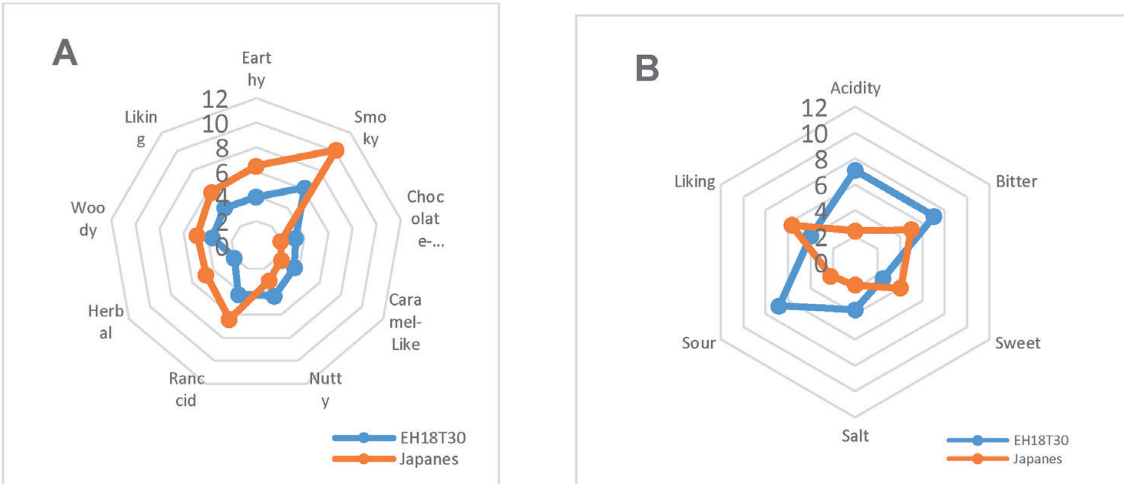

Figure 6.
(A) Result of sensory aroma sample C (EH18T30) with coffee from Japan (JH0T0), and (B) result of sensory tastes sample C (EH18T30) with coffee from Japan (I).

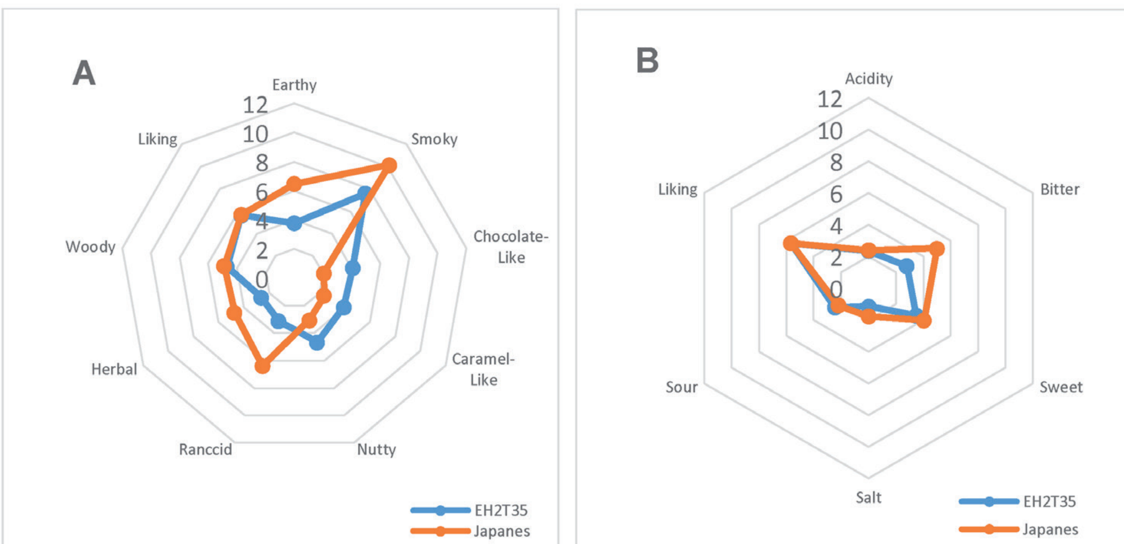

Figure 7.
(A) Result of sensory aroma sample D (EH2T35) with coffee from Japan (I), and (B) result of sensory tastes sample D (EH2T35) with coffee from Japan (I).

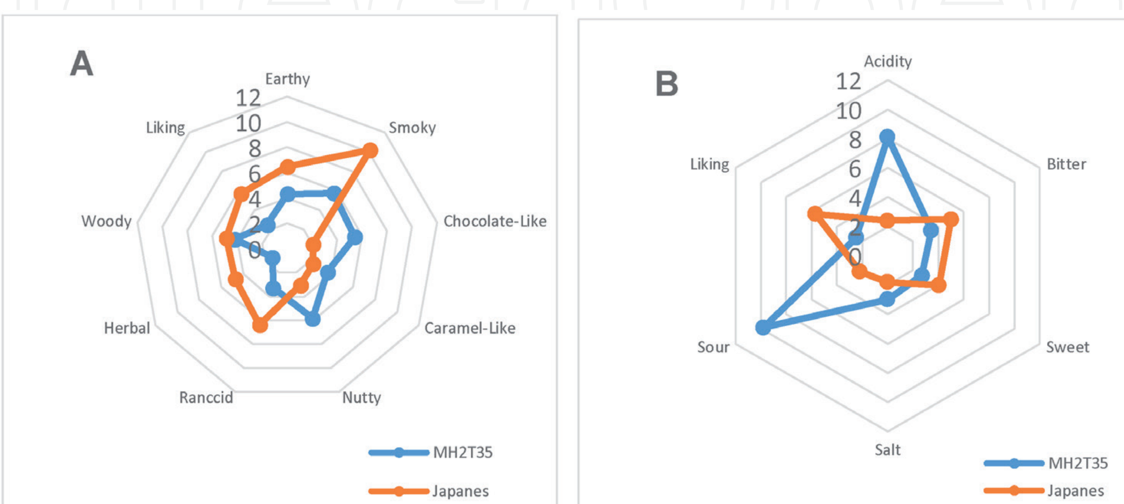

Figure 8.
(A) Result of sensory aroma sample E (MH2T35) with coffee from Japan (I), and (B) result of sensory tastes sample E (MH2T35) with coffee from Japan (I).

When comparing to type sensory analysis of coffee beverage, sample coffee E (MH2T35) has the lowest value than sample I (Japan), and with the other sensory tastes, the sample I (Japan) has higher preference and a higher liking attribute.

Figure 9(A), shows that all aroma attributes except the smoke attribute in sample F have similarities with the aroma attribute of sample I. The smoke attribute in sample I has a higher value than coffee sample F. **Figure 9(B)** showed all attributes of samples F and I are similar. When comparing the two types of sample coffees' smell and tastes, sample coffee F has higher value than sample I.

Figure 10(A), from QDA of each attribute, showed a nonsimilarity (significant difference) in smokey, rancid, herbal, nutty, and caramel-like when smelled directly. And **Figure 11** showed also nonsimilarity in acidity and sourness when tasted directly. Sample G showed the lowest value in earthy, rancid, smoky, herbal, and liking. No significant difference was noted by 10 panelists.

When comparing to type sensory analysis of coffee smell, sample coffee G has the lowest value than sample I, and with the other sensory tastes, sample G has

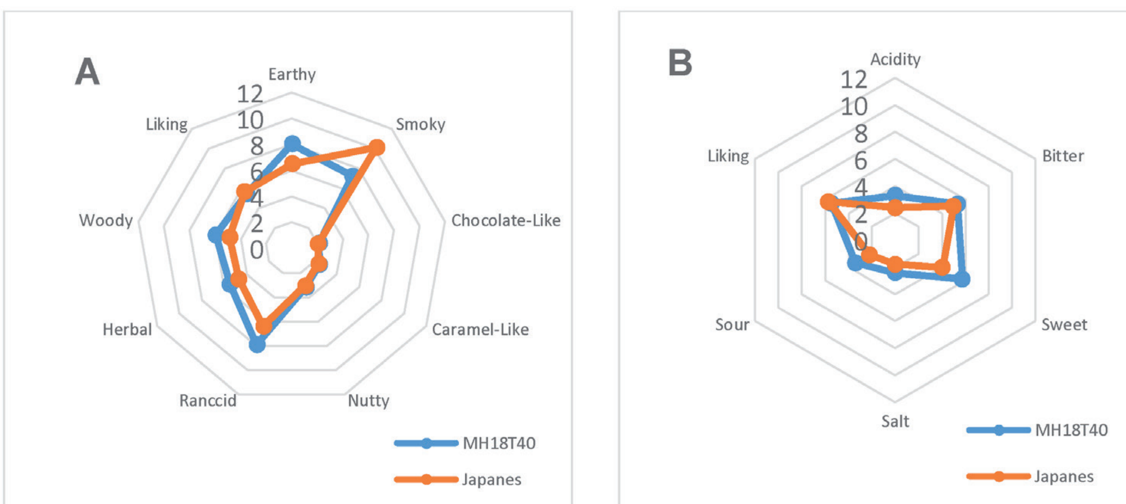

Figure 9.
(A) Result of sensory aroma sample F (MH18T40) with coffee from Japan (I), and (B) result of sensory tastes sample F (MH18T35) with coffee from Japan (I).

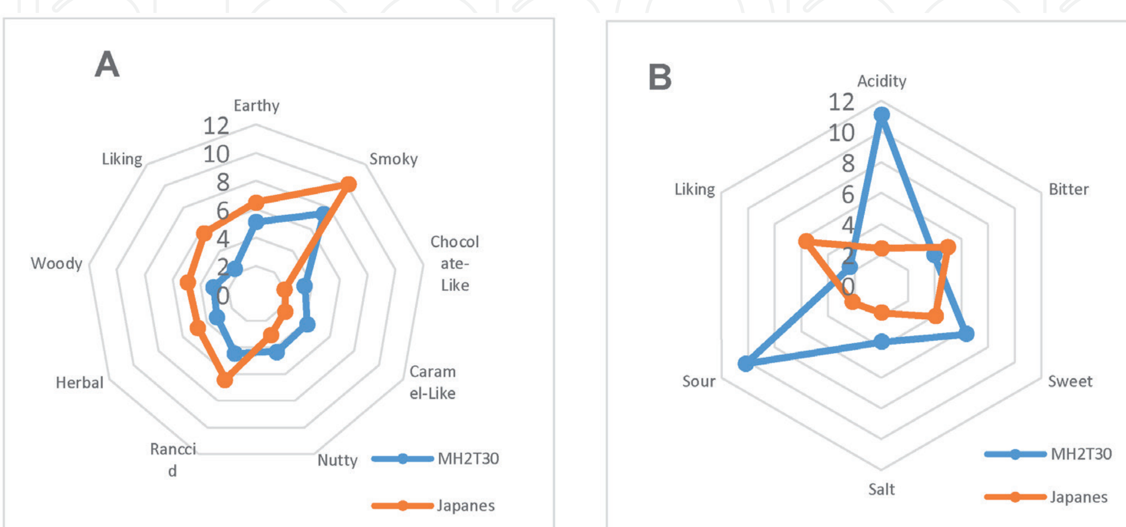

Figure 10.
(A) Result of sensory aroma sample G (MH2T30) with coffee from Japan (I), and (B) result of sensory tastes sample G (MH2T30) with coffee from Japan (I).

higher value preference for the attributes acidity and sourness than the sample I which has very lowest value due to a higher liking attribute.

Figure 11(A), from the results of QDA of each attribute, showed a nonsimilarity (significant difference) in smokey, rancid, and chocolate-like smell directly. Attribute smoke and rancid from the sample I showed higher value than sample H. **Figure 11(B)** also shows the non-similarity in the acidity, saltiness, and sourness attributes between sample H and sample I. These three attributes have higher values in sample H compared to sample I.

Based on **Figure 12**, it can be explained that the earthy aroma of coffee is the main attribute; the greatest compound that provides the earthy aroma is pyrazine; from nine samples tested, the largest sample from Japan coffee that has aroma earthy is identified. Furthermore, sample G (MH2T30) is a sample of the unidentified compound pyrazine, but the results of sensory taste panelists can identify the smell.

Based on **Figure 13**, it can be seen that the 2,2-Furanmethanol compound has the highest peak area of GC-MS result for the smoky attribute aroma. Based on the results of sensory taste, the panelist also found that smoky attribute is similar for all sample coffees, and gives no significant sample.

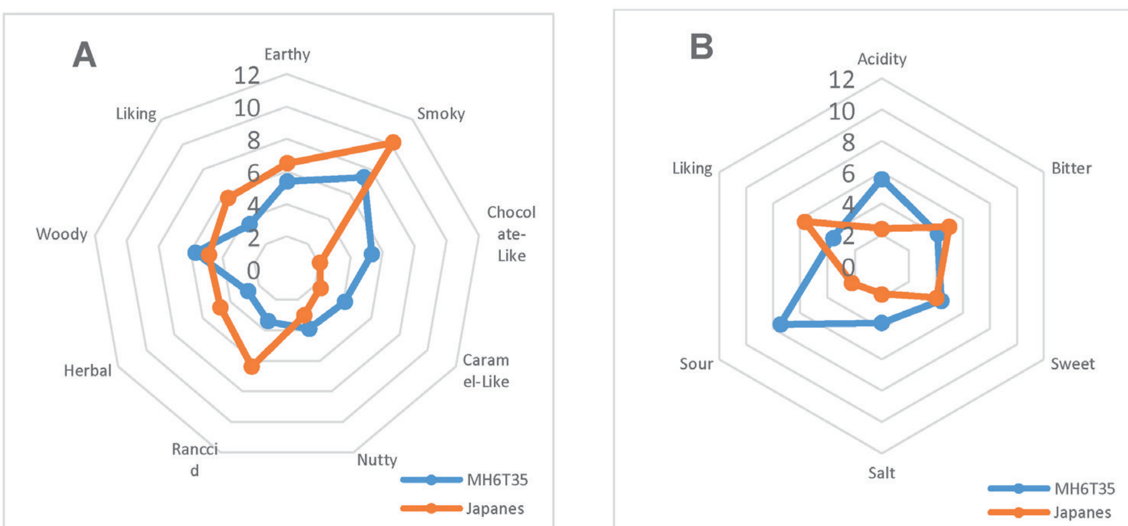

Figure 11.
(A) Result of sensory aroma sample H(MH6T35) with coffee from Japan (I), (B) Result of sensory taste sample H(MH6T35) with coffee from Japan (I).

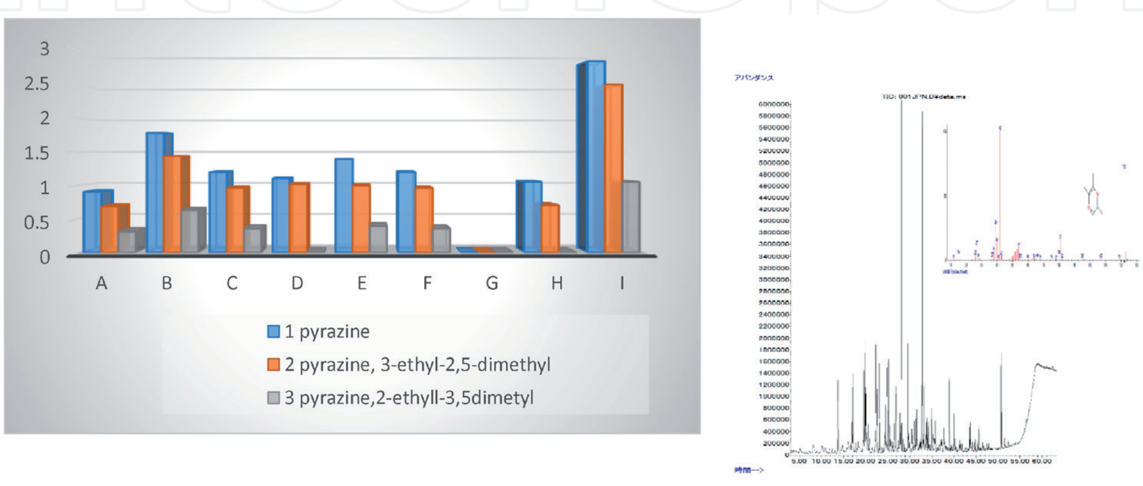

Figure 12.
Compound volatile aroma Arabica coffee by GC-MS compared with sensory taste attribute earthy.

Based on **Figure 14**, volatile compound identified from chocolate's aroma has five largest compounds, and the largest is compound pyrazine, 2,6-dimethyl in EH2T35 sample. Pyrazine-1,4-diazine compound is a compound which is identified

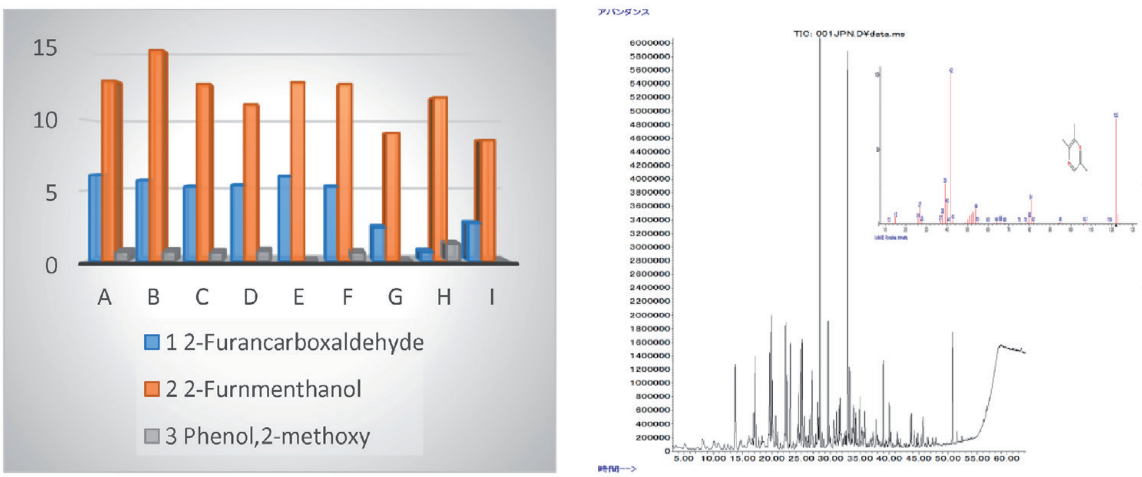

Figure 13.
Compound volatile aroma Arabica coffee bye GC-MS compare with sensory taste attribute smoky.

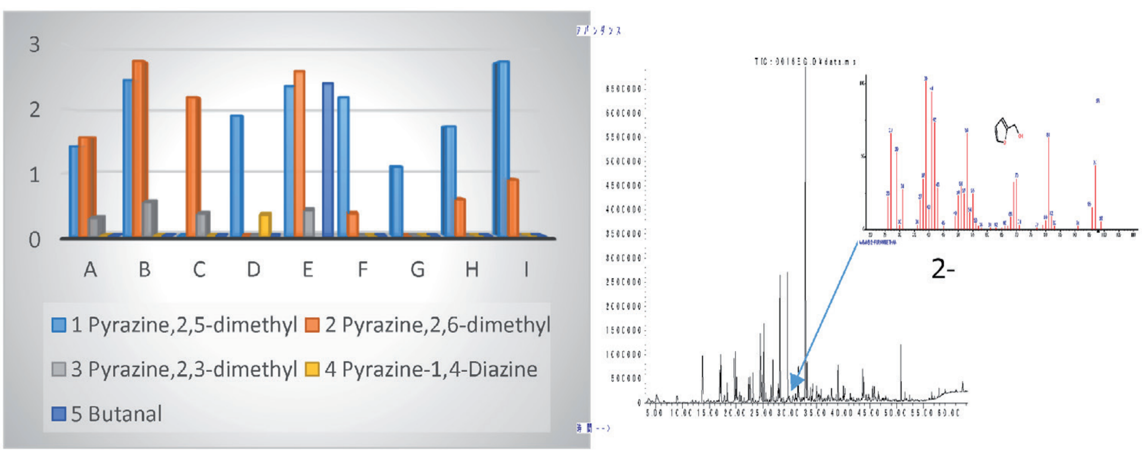

Figure 14.
Compound volatile aroma Arabica coffee by GC-MS compared with sensory taste attribute chocolate.

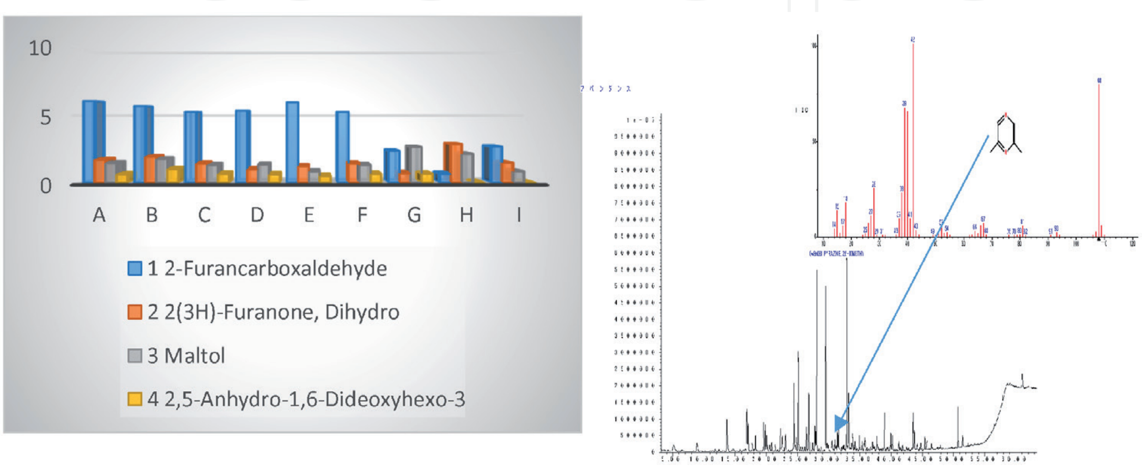

Figure 15.
Compound volatile aroma Arabica coffee by GC-MS compared with sensory taste attribute caramel.

only in the sample EH18T35, while the other sample was not identified. Sample G (MH6T35) is a compound sample that can identify only one type of its volatile compound which is pyrazine, 2,5-dimethyl.

Based on **Figure 15**, it can be explained that the volatile compound identified by GC-MS related to the results of sensory taste attributes aroma are 2-furancarboxaldehyde, 2(3H)-Furanone, Maltol, and 2,5-anhydro-1,6-dideoxyhexo. Volatile compound identified from the largest peak area is 2-Furancarboxaldehyde and is identified in sample A (EH2T30). Maltol compound is a compound which is identified in all kinds of samples of coffee with a peak area that is not too wide and not too small.

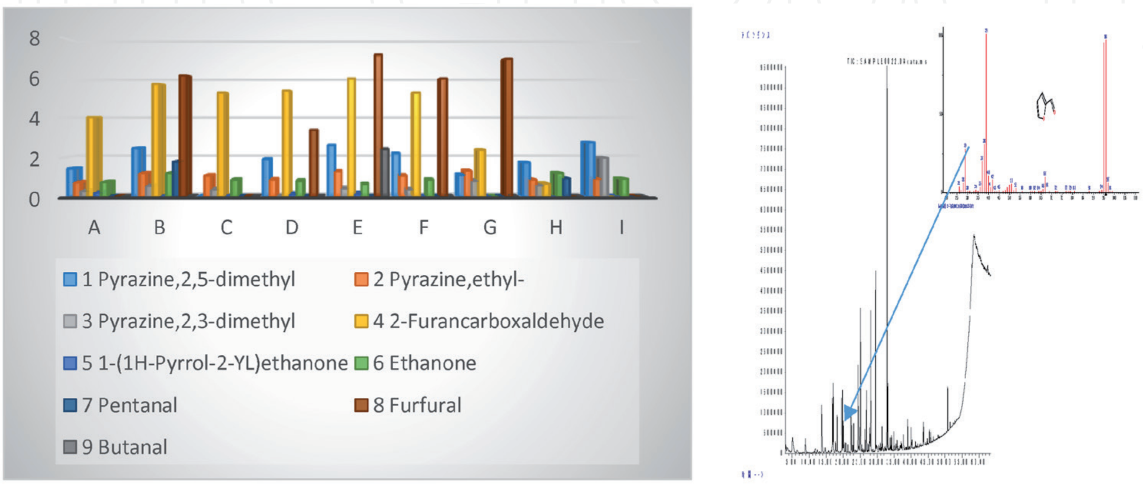

Figure 16.
Compound volatile aroma Arabica coffee by GC-MS compared with sensory taste attribute nutty.

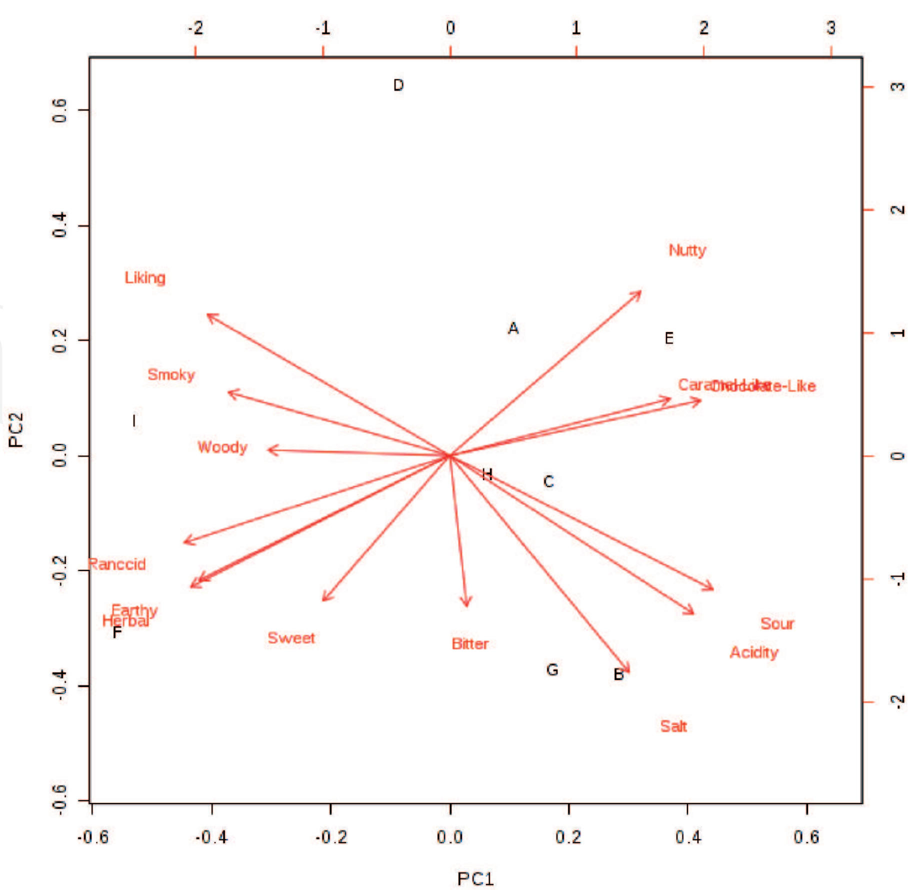

Figure 17.
Results of PCA attribute.

Attribute nutty coffee aroma in the studied sample identified by GC-MS can be seen in **Figure 16**. There are nine volatile compounds identified. The largest peak area of volatile compound identified is furfural; this compound is identified in samples F (MH2T35) with the area of the peak being 7.1846.

Based on the results of the sensory analysis in **Figure 17**, it can be seen that the panelists rated "like and have a correlation" on the smoky, woody, and rancid attributes. For the acidity attribute, the panelists assessed "dislike but have a correlation". In addition, the panelists assessed "dislike and no correlation" on the nutty, caramel-like, sweet, earthy, and herbal attributes.

4. Conclusions

From the results of sensory test, sample coffee from Indonesia with specification of areas of origins Enrekang (E) and Gowa (M) in comparison with a sample of coffee from japan (J), it can be concluded that the panelist provided a rating profile liking the sample coffee Japan, but the overall results of the QDA on the second sample are similar or nonsignificantly different. This means that the aroma profile as a whole does not provide too much difference. Pyrazine compound identified in GC-MS has an earthy odor, which has a correlation with the results of sensory taste based on the QDA on sample coffee from Japan. Reviewed nutty odor identified five compounds on GC-MS, and there is a correlation with the results of sensory taste of QDA which is similar to all coffee samples tested.

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