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Application of check-all-that-apply (CATA) in sensory profile assessment of arabica dark roast and black pepper mixed coffee

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Black pepper coffee is one of the innovations in Bangka Belitung Province, Indonesia, with a warm characteristic due to the naturally occurring piperine compounds. This study aimed to assess black pepper coffee's sensory profile using the CATA (check-all-that-apply) rapid analysis method and to find the formula and brewing technique liked most by consumers. The study consisted of two stages: determining the sensory attributes of black pepper coffee and obtaining sensory data from coffee-consumers with different coffee and black pepper powder ratios (98:2; 96:4; and 94:6) and brewing methods (cold brew, drip V60 brew, and tubruk). The analysis used in this CATA included the Cochran's Q test, correspondence analysis, principal coordinate analysis (PCoA), and penalty analysis using the XLSTAT 2019 software. The results showed a total of 14 sensory attributes, including bitterness, acidity, sweetness, spiciness, caramel, black tea, dark chocolate, smokiness, hints of black pepper, hints of cinnamon, hints of ginger, hints of lemongrass, brown sugar, and body/mouthfeel. Statistical analysis showed that the addition of black pepper and type of brewing had a significant effect (5% level) on the sensory attributes of black pepper coffee, except for bitterness, spiciness, and hints of black pepper based on the Cochran's test. According to the panellists, the ideal black pepper coffee had acidity, sweetness, body/mouthfeel, spiciness, hints of black pepper, and bitterness, and the attributes of acidity, sweetness, and hints of black pepper were included as must-have attributes. Based on the overall analysis, cold brew coffee with 4% black pepper was close to the ideal black pepper coffee.

1. Introduction

Indonesia is the fourth largest coffee producer and exporter globally. Indonesian coffee production, such as arabica and Robusta, is expected to increase from 2019-2023, with an average growth of 1.43% per year (Widaningsih, 2019). Arabica coffee is a coffee type that has a strong aroma that is higher in acidity, sweetness, and commercial value, which makes Arabica coffee of superior sensory quality compared to other types of coffee (Dias & Benassi, 2015; Vignoli et al., 2014). Coffee beans are generally processed into coffee powder through roasting, where degrees of roasting affect the composition and amount of volatile compounds in the coffee beans responsible for a more robust aroma and taste (Somporn et al., 2011). The higher the roasting temperature, the lower caffeine and phenolic compounds such as chlorogenic acid (Fuller & Rao, 2017; Somporn et al., 2011; Vignoli et al., 2014). Apart from roasting, brewing methods such as decoction, infusion, and pressure methods are also essential factors that affect coffee's sensory

quality (Lopez-Galilea et al., 2007; Moroney et al., 2015; Ludwig et al., 2012). Alan (2015) reported that the drip brew method resulted in higher intensity for coffee flavour. Also, Asiah et al. (2017) explained that the decoction method is an authentic Indonesian dish and used as a standard in assessing the taste of coffee internationally by several coffee experts.

One of the innovations in ground coffee processing products is adding black pepper powder, such as the Kola-N brand by a producer of Nibung Jaya Abadi in Bangka Belitong Province. As one of the bioactive compounds in black pepper, the piperine content produces coffee with a characteristic warm taste. This black pepper coffee product has been marketed in Bangka Belitung Province, Indonesia, and has become one of Bangka Belitung's signature products. This Province is a top source for pepper production; in 2019, production reached 33,810 tonnes (Dirjen Perkebunan, 2020). However, there is no information or documentation regarding the black pepper coffee products' sensory quality characteristics. Research on consumer profiling on coffee needs to be conducted to produce ground black pepper coffee and a serving method to approach consumer preferences.

Consumer-based sensory evaluation methods widely used today are free-choice profiling, projective mapping, flash profiling, sorting, and check-all-that-apply (CATA). The CATA method is a fast and simple method of collecting information about the sensory profile of a food product based on consumer perceptions by providing a checklist for the presence of the sensory attributes in question (Ares et al., 2010). Several studies have used this method to assess the sensory value of coffee products, such as Espitia-López et al. (2019), Heo et al. (2019), Khairunnisa (2019), and Marusiva (2019). Several others have assessed the sensory profile of various food products using the CATA method, including Belusso et al. (2016) on processed fish products, Adawiyah & Yasa (2017) on commercial sweeteners, Ares et al. (2010) on chocolate milk dessert, Dooley et al. (2010) on vanilla ice cream products, Jorge et al. (2015) on processed meat products, Adawiyah et al. (2019) on green tea, Pramudya & Seo (2018) on cooked rice, Alencar et al. (2019) on wine, and Gordon (2019) on Mexican sauce. Apart from food products, the CATA method was also used in cosmetic products (Parente et al., 2014). This study aims to obtain a sensory analysis through rapid consumer profiling using the CATA method (check-all-that-apply) and a selected coffee blend through this CATA profiling method with several specified parameters for dark roast Arabica and black pepper mixed coffee *tubruk*.

2. Materials and Methods

The main ingredients used in this study were dark roasted Arabica beans from Gunung Halu (West Bandung, West Java) and Bangka's black pepper powder. The treatments included a combination of the ratio of arabica coffee and black pepper powder (98:2 (A1); 96:4 (A2); and 94:6 (A3)) and the brewing method (cold brew (B1), drip V60 brew (B2), and *tubruk* (B3)) (modification of Fauzi et al., 2019). Dark roasted Arabica coffee beans were ground with a fine fineness. For brewing, the ratio of coffee used was 1:15, where 10 grams of coffee were brewed in 150 mL of water at 92 °C (Asiah et al., 2017).

Cold brew coffee was made as follows: ground black pepper coffee was poured into the container, followed by water. The mixture was covered tightly and stored at 10°C for 12 hours. The extract was filtered into another container using Hario VCF size 02 coffee filter paper and a glass funnel.

For drip brew coffee, ground black pepper coffee was put into coated V60 with a glass filter. Hot water at 92 ° C was poured in a circular motion to stir the coffee perfectly. The brewing time was 2-3 minutes.
And *tubruk* coffee was made by brewing hot water at 92 °C directly on the coffee grounds in a glass cup. After 4 minutes, the mixture was stirred evenly.

2.1. CATA (Check-All-That-Apply) method for sensory profiling

2.1.1. Determination of sensory attributes

The attributes determination used in the questionnaire list of the CATA method can be obtained by Focus Group Discussion (FGD) (Dooley et al., 2010). The FGD consisted of eight coffee baristas (five certified and three non-certified baristas) active in coffee cupping events with more than one year of experience, plus one moderator. The moderator only oversaw the discussion, acted as a facilitator, and prepared all the

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panellists' needs such as samples, mineral water, test sheets, and other necessities. All baristas tested the samples and used SCAA (2015) as a reference to set the attributes of the coffee. They performed organoleptic testing twice, and all the results were collected, then the obtained results were discussed again to determine the most likely attribute.

2.1.2. Data retrieval

The panellists used were 50 black pepper coffee-consumers(Moskowitz, 1997). In this study, some of the panellists did have training on sensory evaluations; therefore, there was a description of sensory attributes to facilitate the panellists' understanding of sensory testing. Before tasting the sample, the panellists were asked to check the sensory attributes that best described their perception of the ideal black pepper coffee's sensory profile. Then the panellists tasted the samples and rated the coffee samples' likeness intensity scores on a 9-point Likert scale (1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like or dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, 9 = like extremely). After that, the panellists tasted the sample once more and assessed sensory attributes in the coffee sample by placing a checkmark on the questionnaire. During testing, panellists were welcome to rest if needed and were not given a time limit.

2.2. Data Analysis

XLSTAT 2019 software with CATA analysis tools and preference mapping was used for data analysis in the CATA (Check-All-That-Apply) method. The resulting data analysis was in Cochran's Q test, correspondence analysis, Principal Coordinate Analysis (PCoA), and penalty analysis. The preference mapping tools in XLSTAT 2019 were used to obtain complementary data.

3. Results

3.1. Determination of sensory attributes in focus group discussion (FGD)

The FGD method is one of the most useful qualitative methods to obtain a sensory description of a food product. In this study, panellists determined the sensory attribute terminology to equate perceptions of the concept of sensory attributes between one another (Kemp et al., 2009). The decisions or discussion results were taken directly by the panellists, namely eight coffee baristas, without any intervention from the moderator, as shown in Table 1.

Table 1. Sensory attributes based on the results of the Focus Group Discussion

No	Sensory attribute	Description
1	Bitter	The bitter taste of coffee
2	Acidity	The sour taste of coffee
3	Sweetness	The pleasant sweetness of coffee
4	Spicy	Spicy taste that tends to be warm
5	Caramel	The taste and aroma is like caramel from the caramelization process
6	Black Tea	The taste and aroma of black tea
7	Dark Chocolate	The taste and aroma of bitter chocolate
8	Smoky	The taste and smell are similar to those found in baked goods, such as the smell of smoke produced when burning wood.
9	Hints of Blackpepper	The taste and aroma sensation of black pepper
10	Hints of Cinnamon	The taste and aroma sensation of Cinnamon
11	Hints of Ginger	The taste and aroma sensation of Ginger
12	Hints of Lemongrass	The taste and aroma sensation of lemongrass
13	Brown Sugar	The aroma of brown sugar
14	Body/Mouthfeel	Thick or full sensation in the mouth

3.1. Panellist profile in data retrieval

The panellist profile in this research can be seen in Figure 1. Fifty consumer panellists were included in this study, with a 60% male and 40% female ratio. According to Moskowitz (1997), at least 40-50 panellists are required to reduce bias in the obtained data in the sensory test. The panellists' were between 21 to 55 years old, with educations levels ranging from high school to master degree, with the majority possessing a bachelor education.

3.3. Sensory profile of black pepper coffee

The Cochran's Q test with Marascuilo multiple pairwise comparisons compares each sensory attribute in each sample with a test level of 5% (Meyners et al., 2013). This result is described in Table 2.

The Cochran's Q test with Marascuilo multiple pairwise comparisons is used to construct a correspondence analysis. The correspondence analysis represents the ideal black pepper coffee and black pepper coffee samples profile in a biplot map according to their sensory attributes (Meyners et al., 2013). This analysis can be seen in Figure 2.

Preference mapping is a technique that links acceptance data (hedonic data) with sensory characteristics of products (descriptive data) to determine product characteristics that affect consumer preferences (Martínez et al., 2002). Preference mapping data analysis in Figure 3 depicts the percentage of panellists who give preference values above average. The contour plot shows the regions corresponding to the various preference consensus levels on a chart with the same axes as the preference map. The preference level is expressed as a percentage (%), and each colour has a different percentage (Manik et al., 2016). In the regions with cold colours (blue), a low proportion of models give high preferences. The regions with hot colours (red) indicate a high proportion of models with high preferences.

The Principal Coordinate Analysis (PCoA) graph illustrates the correlation between the sensory attributes and the panellists' preferences for black pepper coffee samples. This analysis can be seen in Figure 4.

Penalty analysis on the CATA method can only be done if preferred data are available (Meyners et al., 2013). Based on the penalty analysis results on XLSTAT software, there are five sensory attributes: must-have, nice to have, must not have, does not harm, and does not influence. A sensory attribute has the potential to become a must-have sensory attribute if the sensory attribute has a condition P (No) | (Yes) of more than 20% and a positive mean drops value. The analysis curve of the must-have attributes can be seen in Figure 5.

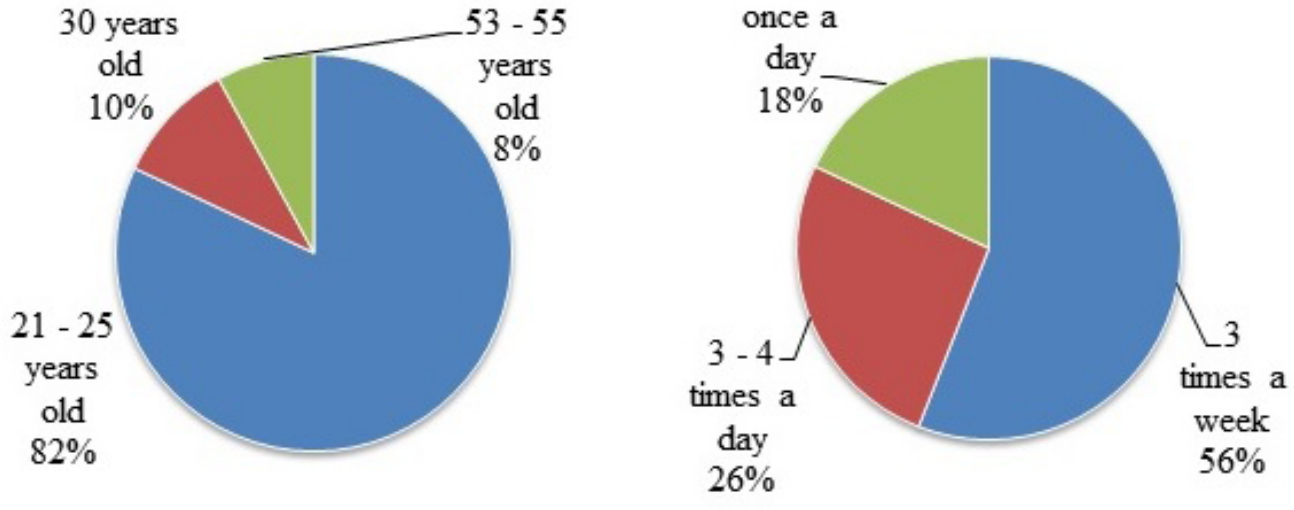

Figure 1. Profile of coffee-consumers based on (a) the panellists' age, and (b) frequency of coffee consumption

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Table 2. The Cochran's Q test with Marascuilo multiple pairwise comparisons

Attributes	A1B1	A2B1	A3B1	A1B2	A2B2	A3B2	A1B3	A2B3	A3B3
Bitter	0.920^{a}	0.960^{a}	0.960^{a}	1^{a}	1^{a}	1^{a}	1^{a}	1^{a}	1^{a}
Acidity	0.38^{ab}	1^{d}	1^{d}	0.540^{bc}	0.360^{ab}	0.180^{a}	0.780^{cd}	0.680^{bc}	0.160^{a}
Sweetness	0.500^{abcd}	0.920^{e}	0.740^{cde}	0.800^{de}	0.560^{bcd}	0.360^{ab}	0.480^{abc}	0.380^{ab}	0.180^{a}
Spicy	0.780^{a}	0.940^{a}	1^{a}	0.800^{a}	1^{a}	0.960^{a}	1^{a}	0.960^{a}	0.960^{a}
Caramel	0^{a}	0^{a}	0^{a}	0.800^{d}	0.740^{cd}	0.560^{bcd}	0.380^{b}	0.620^{bcd}	0.460^{bc}
Black tea	0.400^{abc}	0.180^{a}	0.880^{d}	0.680^{cd}	0.240^{a}	0.280^{ab}	0.840^{d}	0.640^{bcd}	0.740^{d}
Dark chocolate	0.100^{a}	0.200^{a}	0.460^{b}	0.700^{bc}	1^{d}	1^{d}	0.880^{cd}	1^{d}	0.860^{cd}
Smoky	0^{a}	0^{a}	0^{a}	0.440^{b}	0.660^{b}	0.760^{b}	0.760^{b}	0.840^{b}	0.500^{b}
Hints of black pepper	0.820^{a}	1^{a}	1^{a}	1^{a}	1^{a}	1^{a}	1^{a}	1^{a}	1^{a}
Hints of cinnamon	0.820^{d}	0.920^{e}	0.980^{e}	0.340^{ab}	0.500^{b}	0.220^{a}	0.140^{a}	0.140^{a}	0.100^{a}
Hints of ginger	0.520^{b}	0.180^{a}	0.560^{bc}	0.900^{d}	0.900^{d}	0.760^{bcd}	0.840^{bcd}	0.860^{cd}	0.620^{bcd}
Hints of lemongrass	0.540^{bc}	0.220^{a}	0.860^{cd}	0.480^{ab}	0.320^{ab}	0.240^{ab}	0.800^{cd}	0.860^{d}	0.540^{bc}
Brown sugar	0.680^{cde}	0.080^{a}	0.480^{bcd}	0.100^{a}	0.780^{e}	0.760^{de}	0.100^{a}	0.300^{abc}	0.200^{ab}
Body/Mouthfeel	0.140^{a}	0.620^{b}	0.940^{cd}	0.640^{bc}	0.580^{b}	0.940^{cd}	1^{d}	1^{d}	1^{d}

Note: A1B1: different letter in a line shows significant difference at 5% level
Arabica and black pepper ratio of 98:2 with cold brew method
A1B2: Arabica and black pepper ratio of 98:2 with drip V60 brew method
A1B3: Arabica and black pepper ratio of 98:2 with tubruk method
A2B1: Arabica and black pepper ratio of 98:4 with cold brew method
A2B2: Arabica and black pepper ratio of 98:4 with drip V60 brew method
A2B3: Arabica and black pepper ratio of 98:4 with tubruk method
A3B1: Arabica and black pepper ratio of 98:6 with cold brew method
A3B2: Arabica and black pepper ratio of 98:6 with drip V60 method
A3B3: Arabica and black pepper ratio of 98:6 with tubruk method

Meanwhile, a sensory attribute has the potential to become a nice-to-have or must-not-have sensory attribute if the sensory attribute has a condition P (Yes) | (No) of more than 20%, where positive mean drops are categorised as a nice-to-have sensory attribute, and negative mean drops is a must-not-have attribute. This curve analysis is described in Figure 6.

4. Discussion

Cochran's Q test results in Table 2 show that each sample's sensory attributes are significantly different at the 5% level, except for bitter, spiciness, and hints of black pepper attributes. Various brewing techniques and the addition of black pepper concentrations in coffee cause differences in each coffee brew's sensory characteristics. Pratama (2017) reported that black pepper, diluted at 1: 200000, still left a distinctive piperine flavour. Piperine has stable properties (Hamrapurkar et al., 2011) so that all black pepper coffee samples with the treatment combination left the attributes of spiciness and hints of black pepper. The darker the coffee roasting profile, the greater the bitter taste character produced; therefore, all treatment combinations still leave a bitter taste in dark roast Arabica coffee.

According to panellists, perceptions regarding the sensory profile of ideal black pepper coffee are illustrated by the correspondence analysis map in Figure 2. Ideal black pepper coffee in quadrant 1 has acidity, sweetness, spiciness, hints of black pepper and bitterness. The closest sample to the ideal black pepper coffee product is cold brew coffee with 4% and 6% black pepper concentrations. While cold brew coffee with 2% black pepper in quadrant 4 has dominant hints of a cinnamon attribute. *Tubruk* black pepper coffee with black pepper of 2%, 4%, and 6% and V60 coffee with 2% black pepper in quadrant 2 have dominant black tea, hints of lemongrass, dark chocolate, and body/

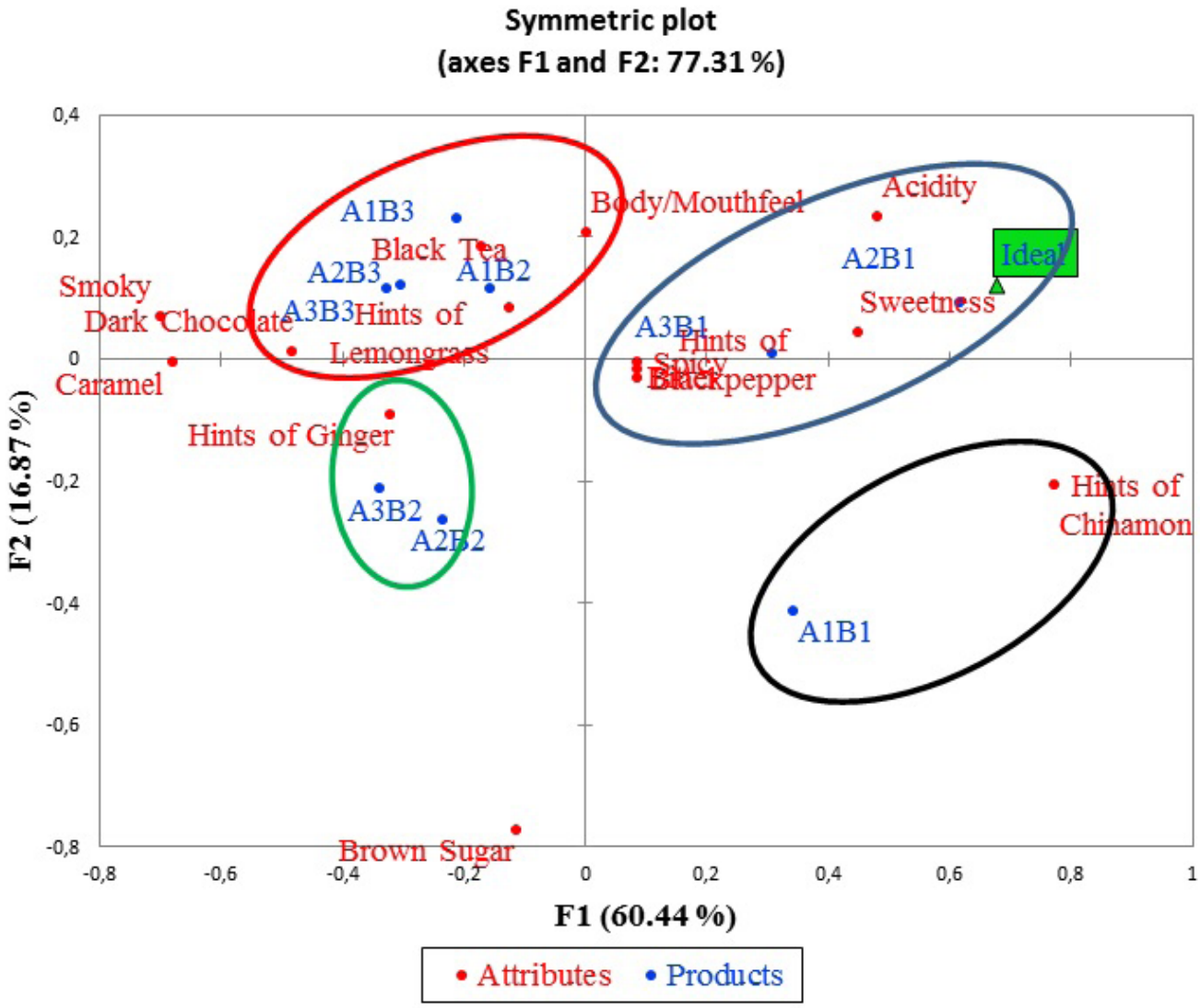

Figure 2. Representation of the ideal black pepper coffee sensory profile

Note: A1B1: Arabica and black pepper ratio of 98:2 with cold brew method
A1B2: Arabica and black pepper ratio of 98:2 with drip V60 brew method
A1B3: Arabica and black pepper ratio of 98:2 with tubruk method
A2B1: Arabica and black pepper ratio of 98:4 with cold brew method
A2B2: Arabica and black pepper ratio of 98:4 with drip V60 brew method
A2B3: Arabica and black pepper ratio of 98:4 with tubruk method
A3B1: Arabica and black pepper ratio of 98:6 with cold brew method
A3B2: Arabica and black pepper ratio of 98:6 with drip V60 method
A3B3: Arabica and black pepper ratio of 98:6 with tubruk method

mouthfeel attributes. V60 black pepper coffee with 4% and 6% black pepper in quadrant 3 have the dominant hints of a ginger attribute. Brown sugar, smokiness, and caramel are the minor attributes based on Figure 2. In addition, the quality of the analysis is sufficient (almost 80% of explained total inertia on the first two dimensions).

Figure 3 shows that many models (80% - 100%) give preference values above the average for cold brew black pepper coffee with black pepper concentrations of 2% in quadrant III and 4% and 6% in quadrant II. For black pepper coffee prepared in V60 and *tubruk* brewing techniques with a black pepper concentration of 2%, 4%, and 6%, a low proportion of models

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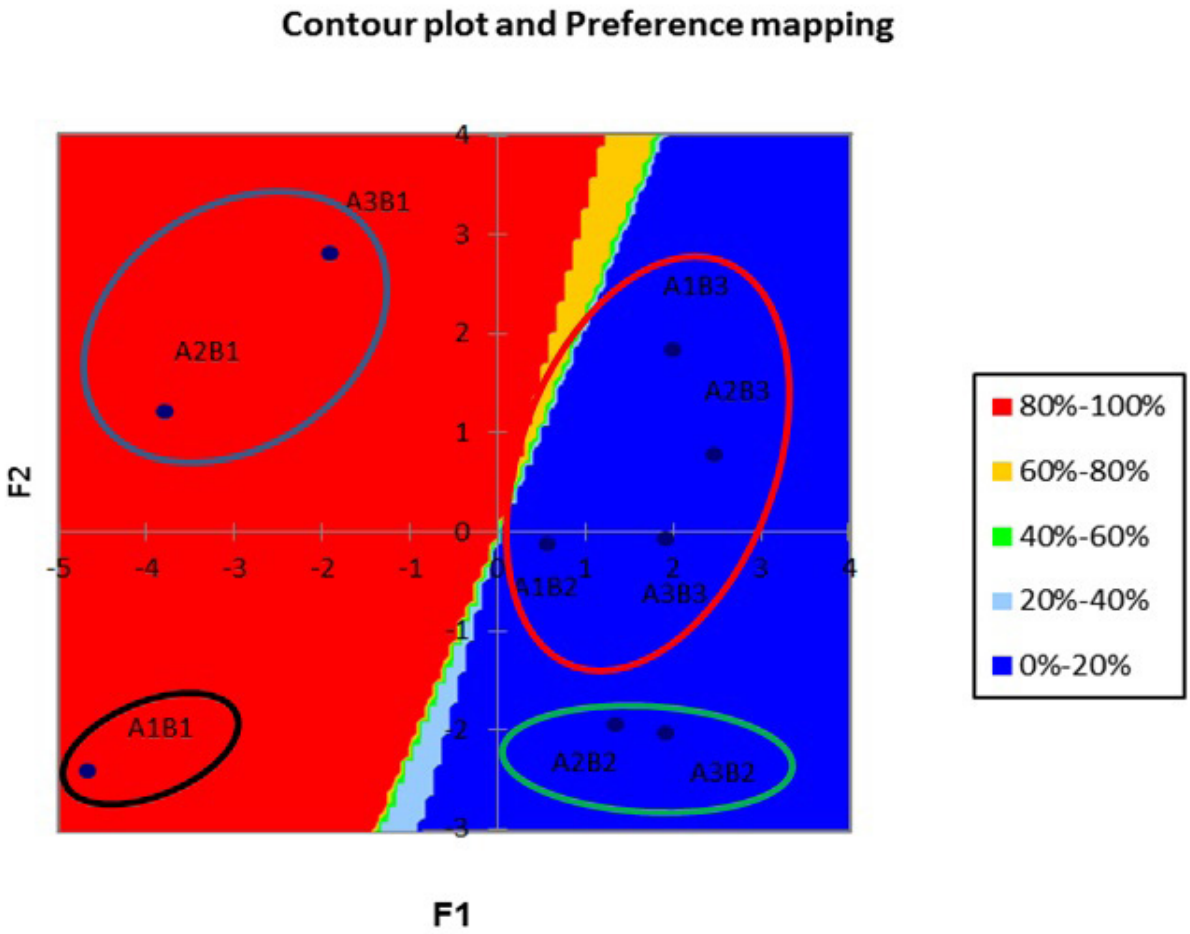

Figure 3. Panellists' preference map of black pepper coffee samples

Note: A1B1: Arabica and black pepper ratio of 98:2 with cold brew method
A1B2: Arabica and black pepper ratio of 98:2 with drip V60 brew method
A1B3: Arabica and black pepper ratio of 98:2 with tubruk method
A2B1: Arabica and black pepper ratio of 98:4 with cold brew method
A2B2: Arabica and black pepper ratio of 98:4 with drip V60 brew method
A2B3: Arabica and black pepper ratio of 98:4 with tubruk method
A3B1: Arabica and black pepper ratio of 98:6 with cold brew method
A3B2: Arabica and black pepper ratio of 98:6 with drip V60 method
A3B3: Arabica and black pepper ratio of 98:6 with tubruk method

(0% - 20%) give a preference value above average, where these coffees are in the blue areas in quadrants I and IV. This mapping analysis strengthens the correspondence analysis that the panellists prefer cold brew coffees with 4% and 6% black peppers. These coffees are the closest to the ideal black pepper coffee with the attributes of sweetness, acidity, spiciness, and hints of black pepper. Angeloni et al. (2019) reported that coffee's sensory characteristics with different extraction methods (drip, cold brewing, and French press) were different, and the extraction process and temperature influenced these different characteristics.

Based on the previous PCoA and the correspondence analysis, which is strengthened by contour plot and preference mapping, only the acidity, sweetness, and spiciness attributes have similarities to the ideal and affect the panellists' preferences. According to Figure 2 in the correspondence analysis results, the sample that closely matches the dominant attribute is cold brew coffee with 4% black pepper. Temperature is a factor in the brewing method that affects a suitable coffee extraction. Coffee, brewed at a low temperature, will tend to under-extract, so the resulting coffee has a bland to sour taste (Lingle, 2011). Also,

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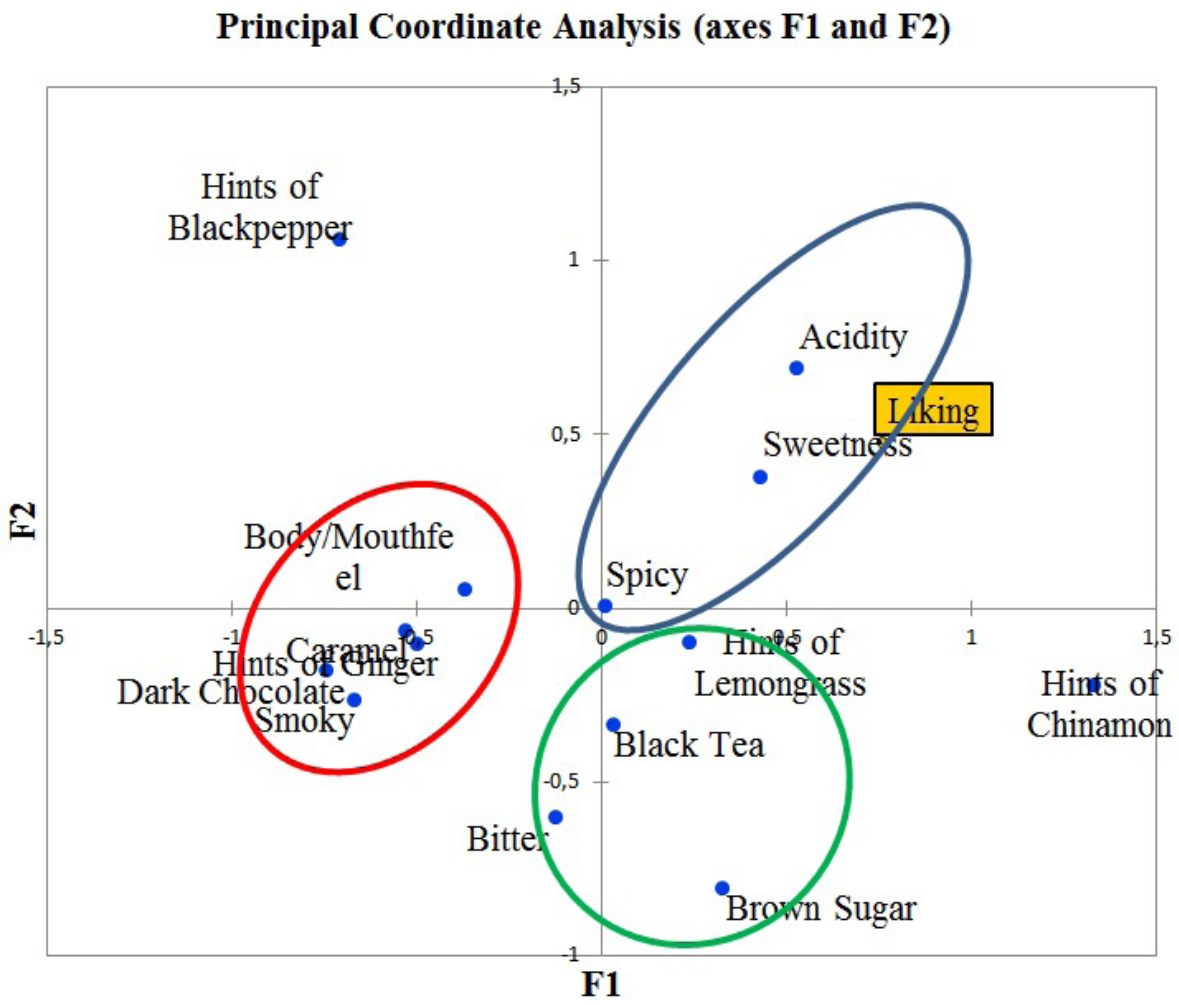

Figure 4.. Correlation plot of attributes and liking

cold-brew coffee has low acid and bitter characteristics (Baumann et al., 2012). The lower level of acidity in coffee with the cold brew method will result in a sweeter taste (Fuller & Rao, 2017; Angeloni et al., 2019). The addition of 4-6% black pepper makes for the right taste of spiciness.

Figure 5 shows three attributes are grouped as must-haves, namely the attributes acidity, sweetness, and hints of black pepper. According to the panellists, the attributes in this category must be contained in black pepper coffee products and have a positive impact on preferences. The must-have attribute is a sensory attribute that was not found in real market products, even though these sensory attributes were desired by panellists in ideal products (Meyners et al., 2013).

Figure 6 shows that the attributes of caramel, black tea, dark chocolate, smokiness, hints of ginger, hints of lemongrass, and brown sugar are classified as must-not-have; however, none of the attributes is classified as nice-to-have. The must-not-have attribute is undesirable in the development and has a negative impact on the Likert value.

Cochran's Q test, correspondence, and preference mapping analysis show an apparent relationship in black pepper coffee. It is a relationship that produces a selected black pepper coffee of 4% cold brew black pepper coffee with attributes of acidity, sweetness, and hints of black pepper.

5. Conclusion

Based on the research results, the differences in the concentration of black pepper and the brewing method significantly affected all sensory characteristics of black pepper coffee at the 5% level, except for the attributes of bitter, spiciness, and hints of black pepper. According to the panellists, the ideal black pepper coffee perception before tasting the sample was black

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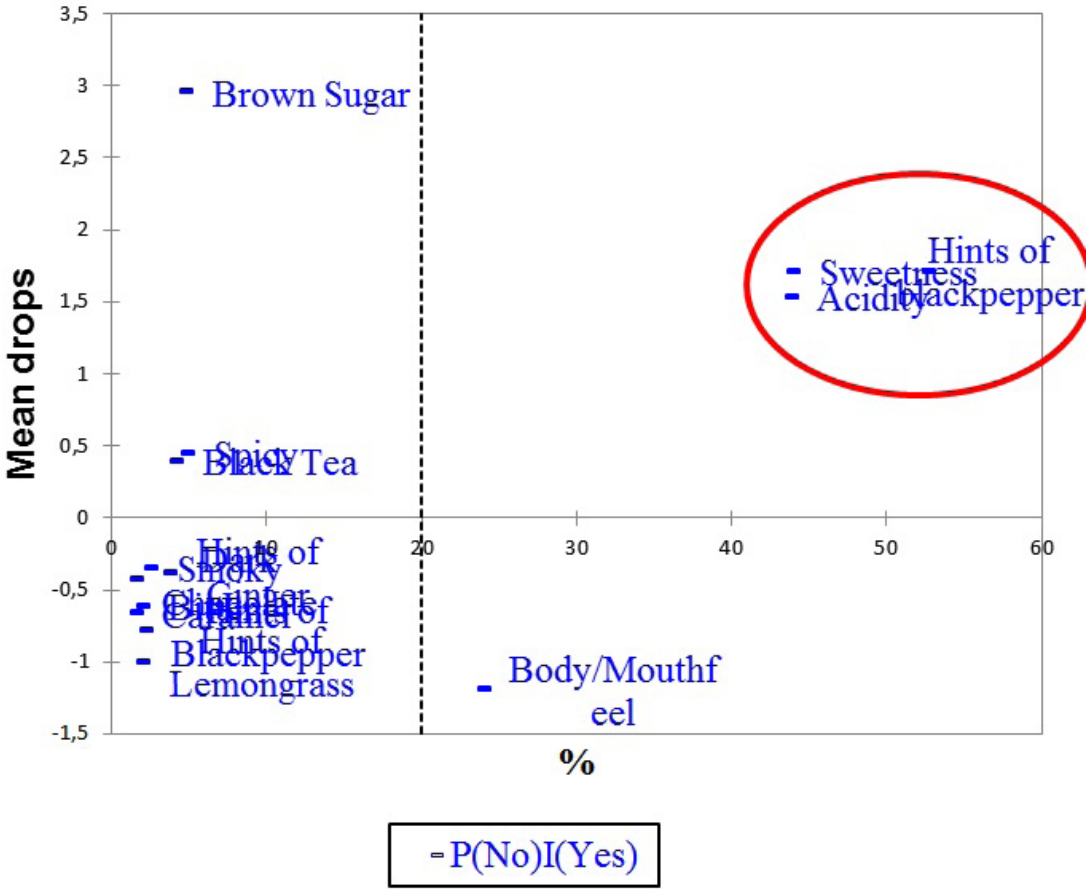

Figure 5. Analysis curve for must-have attribute

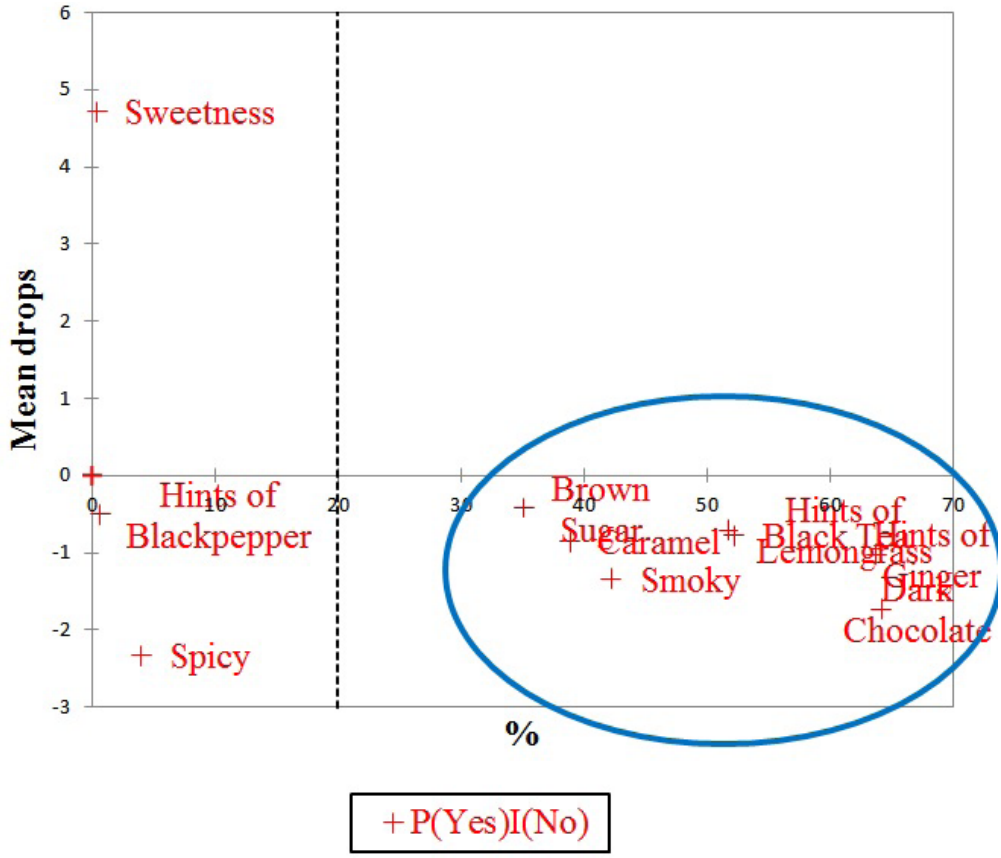

Figure 6. Analysis curve for nice-to-have and must-not-have attributes

pepper coffee with acidity, sweetness, body/mouth-feel, spiciness, hints of black pepper, and bitterness. The attributes that affected preference after tasting the sample were acidity, sweetness, and spiciness. Based on penalty analysis, the attributes of acidity, sweetness, and hints of black pepper were in the must-have category. The sample close to the ideal attribute and favourite was cold brew coffee with 4% black pepper.

Conflict of interest

The authors declare no conflict of interest.
The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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