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Sensory Profile of Cocoa Powder Using Analytical Hierarchy Process

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Abstract

Cocoa powder comes with various attributes in its taste affecting consumer acceptance. The analytical hierarchy process (AHP) approach can be used to identify the effect of each attribute on the sensory profile of cocoa powder. This present study used the AHP approach to determine the degree of importance of sensory attributes on several types of cocoa powder and find the type with the best sensory profile. Cocoa powder comes from cocoa beans made through fermentation and non-fermentation process. In addition, we used non-fermented cocoa powder treated with water and incubated at 45°C for 4, 8, and 16 hours later named as incubated cocoa powder. Then, the sensory attributes of fermented cocoa powder were used as the reference in assessing the sensory profile of incubated cocoa powder, including the one going through the treatment. The sensory analysis performed by 14 trained panelists revealed 11 attributes that made up the flavor profile of cocoa powder. Of these 11 attributes, only 4 were considered primary attributes with a high degree of importance, including chocolate (23.7%), sweet (19.9%), caramel (11.8%), and nutty (10.9%). Other attributes had a lower degree of importance, including creamy (7.4%), fruity (6.5%), green (5.4%), flowery (4.8%), astringent (4.5%), bitter (3.1%), and acid (2.2%). AHP also ranked the incubated cocoa powder based on the similarity of the flavor profile with fermented cocoa powder. Non-fermented cocoa powder without treatments fell into the lowest rank, while non-fermented cocoa powder with treatments fell into a higher category in the following order: 8 hours > 16 hours > 4 hours. To summarize, AHP can be used in decision-making affected by many factors. AHP has been proven effective in determining the sensory profile of cocoa powder, especially in choosing the attribute with the highest effect. In addition, AHP helps determine the best treatment for incubated cocoa powder to produce the most similar sensory profile to fermented cocoa powder.

Keywords: cocoa powder, fermentation, incubation, sensory, analytical hierarchy process

INTRODUCTION

Cocoa powder is one of Indonesia's most important export commodities; its export value reached USD 194 million in 2020 (BPS, 2020). Cocoa powder comes from dried cocoa beans after the cocoa pods have been removed and compressed to remove some fat (cocoa butter). Processing cocoa beans start with fermentation, yet many cocoa farmers in Indonesia skip this step (Schaad & Fromm, 2018). Fermentation is a crucial step in forming the distinctive flavor of chocolate. During the fermentation process, precursor compounds are produced, which become the forerunner of flavor. Unfermented cocoa beans will have an excessive astringent and bitter taste due to unoxidized polyphenolic compounds. The polyphenol oxidation process occurs due to the action of the polyphenol oxidase enzyme in the beans. This enzyme loses its activity after the beans are dried. Misnawi *et al.* (2002a) report that polyphenol oxidation can also be triggered by incubation of cocoa powder in water at 45°C for 2-16 hours. Furthermore, incubation with water can also restore other enzymes involved in forming flavor precursors, such as invertase and carboxypeptidase enzymes (Misnawi *et al*., 2002b).

The quality of the cocoa powder is determined based on physical parameters in addition to heavy metal and microbial contamination, as described in SNI 3747:2013 (BSN, 2013). Flavor characteristic has not been widely used as quality parameter. However, several studies have employed sensory properties as the quality parameter for choosing planting materials (Sari *et al.,* 2022) and product formulation (Cempaka *et al*., 2021). The challenge of sensory analysis in the cocoa products is the occurence of undetermined flavor attributes that can describe the sensory profile. The quantitative descriptive analysis (QDA) method can be applied to determine the flavor attributes of cocoa powder. This method requires a product assessor called a panelist. Not all panelists have the same flavor perception in determining the sensory profile of cocoa powder; therefore, a decision is needed to determine the selected sensory profile based on panelist acceptance (Kusumaningrum *et al*., 2014).

Analytical hierarchy process (AHP) is a decision-making process by hierarchically setting priorities from various complex alternatives or alternatives with more than one criterion (Saaty, 2008; Melia, 2013). In this study, AHP was used to make decisions by considering the criteria of the sensory profile and the best treatments for incubated cocoa powder. AHP has previously been used in decision-making in determining consumer preferences based on several attributes of coffee drinks (Ramírez-Rivera *et al*., 2020) and analysis of factors that influence consumer decisions in choosing the type of egg (Baba *et al*., 2017).

This study aimed to evaluate the effectiveness of AHP in selecting attributes that significantly influence the sensory profile of cocoa powder. In determining the sensory profile, fermented cocoa powder was used as a reference to determine the quality of the incubated cocoa powder. Furthermore, in this study, AHP was also used to determine the best treatment for non-fermented cocoa powder based on the proximity of the sensory profile to fermented cocoa powder.

MATERIALS AND METHOD

Preparing Cocoa Beans

We used Forastero cocoa beans from the Kaliwining Experimental Station of Indonesian Coffee and Cocoa Research Institute. Some cocoa beans were fermented, and some were not. Cocoa beans for fermentation were prepared by squeezing 40 kg of wet cocoa beans in a perforated wooden box (40 cm long, 40 cm wide, and 60 cm high). The tops of the beans were covered with burlap sacks, and the beans were allowed to ferment for four days (96 hours). The beans were stirred at the beginning of day 3. The fermented beans were then dried in the sun until the moisture content reached 7%. Non-fermented cocoa beans were not ripened but were directly dried under sun until the moisture content reached ±7%.

Dried cocoa beans, fermented and non-fermented, were then processed into cocoa powder; the process included peeling the pods shell, making the cocoa paste, pressing the fat (cocoa butter), and refining. The cocoa powder was then stored in a plastic container at room temperature.

Incubating Non-Fermented Cocoa Beans

The treatment of non-fermented cocoa powder is described in detail in a separate study (Sari *et al*., 2022). In this study, non-fermented cocoa powder was first added with distilled water at concentration 1.5 mL g^{-1} cocoa powder and then incubated at 45°C for 4 hours, 8 hours, and 16 hours (Misnawi *et al*., 2002b). The cocoa powder that had been incubated was then dried in an oven at 40°C for 20 hours, then ground and sieved through a 100 mesh sieve.

Preparing Cocoa Powder Samples for Sensory Profile Analysis

Cocoa powder, both from incubated and fermented beans, was roasted using an oven at 130°C for 15 minutes (Voigt *et al*., 1994). Before being presented to the panelists, 5 g of cocoa powder samples were given 125 mL of distilled water at 55°C and stirred (ADM Cocoa, 1997).

Sensory analysis with QDA

Panelists for quantitative descriptive analysis (QDA) were selected with the following criteria: age 18-50 years, able to distinguish primary flavor, and have no history of allergies to cocoa powder. After selection, 14 panelists (5 women and 9 men) attended training on identifying and scoring flavor and aroma intensity for two months, followed by analyzing and assessing samples for flavor and aroma identification. Samples for flavor identification were presented in various concentrations to produce variations in intensity, including weak, medium, and strong intensity. As for the samples for aroma identification, variations in intensity were achieved by dissolving the reference compound in propylene glycol with different ratios. Panelists were considered successfully trained if they could distinguish the aroma and flavor of samples consistently without difficulty (Kusumaningrum *et al*., 2014). Panelists were then asked to determine the order of attributes based on the degree of importance. Samples for the aroma and flavor identification are listed in Table 1 and 2.

Table 1. Solution concentration for flavor description with variations in intensity

Flavor identification	Test compound*	Concentration (g L^{-1})		
		Weak	Medium	Strong
Alkali	Na_2CO_3 solution	0.375	0.5	0.625
Sour	Citric acid solution	0.225	0.3	0.45
Salty	NaCl solution	1.875	2.5	3.125
Sweet	Sucrose solution	11.25	15	18.75
Bitter	Kina (quinine) solution	0.070	0.094	0.117
Astringent	$KAlSO_4$ solution	0.56	0.75	0.94
Umami	Monosodium glutamate solution	1.9	2.5	3.1

(*compound dissolved in distilled water)

Table 2. Ratios of test compound with propylene glycol for flavor description with variations in intensity

Flavor identification	Test compound	The ratio of test compound: propylene glycol (g g^{-1})		
		Weak	Medium	Strong
Sour	Acetic acid solution	0.5:9.5	1:9.0	1.5:8.5
Caramel	Phenyl ethyl alcohol solution	0.2:9.8	0.5:9.5	1:9.0
Floral	Cempaka essence solution	0.2:9.8	0.35:9.65	0.5:9.5
Chocolate	Chocolate essence solution	0.2:9.8	0.5:9.5	1:9.0
Creamy	2,3-pentandion solution	0.5:9.5	1:9.0	1.5:8.5
Green	Cis-3-hexenon solution	0.2:9.8	0.5:9.5	1:9.0
Orange	Orange essence solution	0.2:9.8	0.5:9.5	1:9.0
Ambon banana	Essence solution	0.5:9.5	1:9.0	1.5:8.5
Ylang-ylang (*Cananga odorata*)	Ylang essence solution	0.5:9.5	1:9.0	1.5:8.5
Nutty	Nutty solution	7.5:100	15:100	30:100
Smokey	Smoke oil solution	0.01:9.99	0.075:9.925	0.2:9.8

After panelist selection and training, a focus group discussion (FGD) was conducted to establish consensus on terms for the identification of the sensory attributes of cocoa powder. The assessment criteria were based on the intensity of the attributes perceived by the panelists, with scores including 0 (not detected), 1 (very weak), 2 (weak), 3 (moderate), 4 (strong), and 5 (very strong).

Data Analysis

AHP started with collecting assessment data from all panelists for each attribute. Then, the degree of importance of each attribute was determined by dividing the total value of one attribute by the total value of other attributes. The degree of importance was then normalized using the value of each attribute with the total value of each column. Next, against the normalization value, the eigenvalues of the sample and attribute were sought. The eigenvalue of the attribute was determined by dividing the normalization value by the total normalization value for one attribute and the number of attributes. After that, the eigenvalue of the sample was determined by dividing the sample normalization value by the total normalization value for one sample and the number of samples. Finally, the eigenvalue of the attribute was multiplied by the eigenvalue of the sample—attributes and samples with the largest eigenvalue were placed at the top.

The consistency ratio value indicates the consistency of the attribute's degree of importance (consistency ratio, CR), which should not be more than 10% for a matrix of more than 4x4 (Saaty, 1994; Melia, 2013). CR is determined by dividing the consistency index (CI) value by the random index (RI) value. The RI value is obtained from the predetermined value for AHP: RI value for 11 attributes is 1.51 and RI value for 4 samples is 0.9 (Saaty, 1994). The CI value is obtained from the lambda max value minus the number of attributes divided by number of attributes minus 1. Lambda max is total value of the eigenmatrix divided by number of attributes. CR value of our samples was obtained by the same calculation method. The panelist's assessment is valid if the attribute's degree of importance and the sample are consistent. AHP data processing was conducted using Microsoft Excel and Expert Choice 11 software.

RESULTS AND DISCUSSION

Sensory Analysis of Incubated Cocoa Powder

Previous studies have reported the results of flavor analysis using QDA (Sari *et al.,* 2022). These attributes are consistently found in various kinds of cocoa powder, both fermented cocoa powder and non-fermented cocoa powder, including those treated with incubation. The appearing flavor attributes include sour, sweet, bitter, and astringent. The aroma attributes include caramel, chocolate, creamy, flowery, fruity, green, and nutty. The sensory test of cocoa paste also reports attributes of chocolate, caramel, nutty, bitter, astringent, and sour (Kusumaningrum *et al*., 2014).

The sensory profile of fermented cocoa powder is characterized by caramel, chocolate, creamy, flowery, fruity, and nutty aroma attributes with stronger intensity when compared to non-fermented cocoa powder and incubated one. Fermented cocoa powder is also characterized by a weak intensity of bitter and astringent taste. Furthermore, the study also showed that non-fermented cocoa powder treated with water incubation for 8 hours had several attributes with an intensity score close to that of fermented cocoa powder. Both types of cocoa powder show strong intensity for caramel, chocolate, creamy, flowery, fruity, and nutty attributes (Sari *et al*., 2022).

Selecting Priority of Attribute Criteria and Alternative Treatments

The flavor attribute in the sensory test of cocoa powder is the basis for decision-making to determine the quality of cocoa powder. AHP can be used by involving several criteria, taking into account human judgments, experiences, perceptions, and feelings in the decision-making process (Dos Santos *et al*., 2019). Several sequences of basic principles must be understood and applied to AHP: compiling a hierarchy of problems encountered, making a pairwise comparison matrix, and continuing with the synthesis of priority using the eigenvector method to obtain relative weights for alternatives for decision-making and assessment of consistency (Leal, 2020).

The relative degree of importance, as shown in Table 3, confirms that the attributes of sweet and chocolate have a high degree of importance, as shown by the score that is smallest than compared to other attributes. This is contrary to the attributes of sour and bitter, with a lower degree of importance than other attributes. The attribute of green is more important than the attributes of sour and bitter.

Table 4 shows that the CR is valid because the values do not exceed 10%. This supports Saaty (1994) and Melia (2013) that a consistency ratio of ≤ 10% or ≤ 0.1 means that the alternative strategy is acceptable.

Table 3. Comparison of the degree of importance of cocoa powder sensory attribute

Attribute Criteria	A	M	P	S	Ca	Ch	Cr	Fl	Fr	G	N
Sour (A)	1.000	0.166	0.343	0.286	0.249	0.166	0.320	0.369	0.325	0.334	0.272
Sweet (M)	6.023	1.000	4.268	3.548	3.118	0.778	3.639	3.835	3.236	3.381	2.141
Bitter (P)	2.912	0.234	1.000	0.554	0.284	0.195	0.325	0.382	0.340	0.406	0.258
Astringent (S)	3.498	0.282	1.805	1.000	0.360	0.203	0.424	0.704	0.519	0.891	0.452
Caramel (Ca)	4.017	0.321	3.524	2.779	1.000	0.266	2.792	2.904	2.242	2.663	1.393
Chocolate (Ch)	6.023	1.286	5.117	4.934	3.765	1.000	3.806	4.621	3.997	3.565	2.874
Creamy (Cr)	3.129	0.275	3.077	2.358	0.358	0.263	1.000	2.232	1.768	1.340	0.423
Flowery (Fl)	2.712	0.265	2.692	1.420	0.344	0.216	0.448	1.000	0.494	0.834	0.383
Fruity (Fr)	3.077	0.309	2.945	1.928	0.446	0.250	0.566	2.025	1.000	1.396	0.435
Green (G)	2.990	0.296	2.464	1.123	0.390	0.280	0.746	1.199	0.716	1.000	0.396
Nutty (N)	3.670	0.467	3.873	2.213	0.575	0.338	2.364	2.611	2.296	2.524	1.000
Total	39.051	4.900	31.108	22.142	10.888	3.955	16.430	21.882	16.932	18.333	10.029

Table 4. Measuring alternative consistency against the criteria

Alternative Treatments	λ max	CI	RI	CR	Note
Sour	4.118	0.039	0.9	0.043	Consistent
Sweet	4.017	0.006	0.9	0.006	Consistent
Bitter	4.039	0.013	0.9	0.014	Consistent
Astringent	4.254	0.085	0.9	0.094	Consistent
Caramel	4.011	0.004	0.9	0.004	Consistent
Chocolate	4.134	0.045	0.9	0.049	Consistent
Creamy	4.026	0.009	0.9	0.010	Consistent
Flowery	4.031	0.010	0.9	0.012	Consistent
Fruity	4.011	0.004	0.9	0.004	Consistent
Green	4.002	0.001	0.9	0.001	Consistent
Nutty	4.031	0.010	0.9	0.012	Consistent

Notes: Consistent because ≤ 0.1 or 10%.

Decision-Making based on AHP

The assessment data on the sensory attribute of the incubated cocoa powder is shown in Table 5. The inconsistency value of the 14 panelists' combined assessment is 0.03. An inconsistency value of less than 0.01 shows that the processed data of the criteria has been consistent so that it can be considered in determining the sensory profile of the incubated cocoa powder (Saaty, 2008; Melia, 2013).

The attribute with the highest score was chocolate, with a weight of 23.7%, followed by sweetness (19.7%), caramel (11.8%), and nutty (10.9%). Therefore, the four attributes are considered the main attributes. Other attributes have a degree of importance ranging from 2.2% to 6.5%. Based on the results of the priority selection above, the attributes of chocolate, sweet, caramel, and nutty get top priority in selecting cocoa powder according to the panelists' preferences. The sensory attributes with the lowest degree of importance are astringent, bitter, and sour.

The next step after selecting the priority attributes was the selection of the priority treatment of non-fermented cocoa powder. The sample with the highest priority was the 8-hour treatment, followed by the 16-hour and 4-hour treatments. The lowest priority was non-fermented cocoa powder without treatment (Table 5). Furthermore, the relationship between attributes and priority is formulated in a graph (Figure 1). Figure 1 illustrates the sensitivity of the attributes to the quality and overall value of a sample of cocoa powder.

The 8-hour treatment was assigned the highest rank, scoring the highest for key attributes, including chocolate, sweet, caramel, and nutty. The 16-hour treatment came in

Table 5. The selection results of priority attributes and treatments of cocoa powder

Attributes	The degree of importance (%)	Treatments of non-fermented cocoa powder	Score
Sour	2.2	Without treatment	12.0
Sweet	19.7	4-hour incubation	23.3
Bitter	3.1	8-hour incubation	37.7
Astringent	4.5	16-hour incubation	27.1
Caramel	11.8	Inconsistency	0.03
Chocolate	23.7		
Creamy	7.4		
Flowery	4.8		
Fruity	6.5		
Green	5.4		
Nutty	10.9		
Inconsistency	0.03		

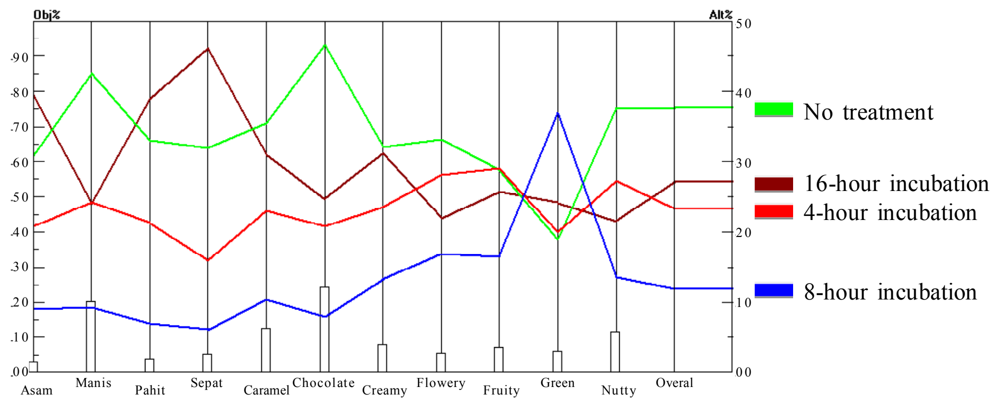

Figure 1. Sensitivity in the selection of priority attributes and treatments of non-fermented cocoa powder

second because of a high score for the main attribute. The scores for the bitter and astringent attributes were very high, but the 8-hour incubated cocoa powder was still considered better than the cocoa powder that was treated for 4 hours and without treatment. This was because the degree of importance of the bitter and astringent attributes was not too high compared to the degree of importance of the chocolate and caramel attributes. Non-fermented cocoa powder without treatment and 4-hour incubation treatment were in the lower rank because it had a low score for the main attributes; however, the bitter and astringent attributes were quite weak.

Non-fermented cocoa powder without treatment also had a very high score for the green attribute. The green attribute is described as the taste of unripe beans. This attribute had a fairly low degree of importance at 5.4%. Non-fermented cocoa powder incubated for 16 hours also had a fairly high score for this attribute, yet, it was still considered better than non-fermented cocoa powder without treatment and with 4-hour incubation treatment. This shows that the presence of the green attribute in cocoa powder does not significantly affect the overall score, especially if there is a high score for the chocolate, caramel, sweet, and nutty attributes.

The high degree of importance of chocolate, sweet, caramel, and nutty indicates that these attributes are important components in shaping the perception of chocolate aroma. Pyrazine is a compound known to play an important role in forming the aroma of chocolate. The threshold value of pyrazine compounds is very low, which means that the sense of smell can detect even a small concentration of the compound. For example, the compound 2-methylpyrazine has a strong aroma intensity, which can be detected at a concentration of 60 g L^{-1}, described as the aroma of chocolate and nutty. Other pyrazine compounds have different threshold values and aroma descriptions, including 5-ethyl-2-methylpyrazine (100 g L^{-1}; caramel, cocoa), 2,5-dimethylpyrazine (1700 g L^{-1}; cocoa, roasted peanuts), and 2,3,5-trimethylpyrazine (1800 g L^{-1}; cocoa, roasted peanuts, peanuts). The compound 2,3,5,6-tetramethylpyrazine, described as the aroma of chocolate, cocoa, and coffee, has a high threshold value (10000 g L^{-1}), although this compound is present in cocoa powder at a high concentration of 4.65 mg kg^{-1} (Bonvehi, 2005; Kusumaningrum, 2014).

The flowery and fruity aroma is due to the presence of ester compounds, which can appear in cocoa powder in the concentration range of 0.188-1.33 mg kg^{-1}. Ethyl valerate and ethyl hexanoate compounds produce apple and banana aromas at very low concentrations, 1.5 and 1.9 g L^{-1}, respectively. Other ester compounds produce different fruity aromas with higher threshold values, including ethyl heptanoate (2.2 g L^{-1}; wine, brandy), ethyl laurate (19 g L^{-1}; flower, fruit), and ethyl decanoate (19 g L^{-1}; pears, grapes, brandy). Aldehydes, ketones, and terpenoids are other compounds associated with flowery and fruity aromas. The aldehyde compound with a very strong effect is 2-phenyl acetaldehyde, with a threshold value of 4 g L^{-1} and is described as having a berry aroma. The ketone compound, 4-methyl acetophenone, has a strong fruity and floral aroma with a threshold value of 0.027 g L^{-1}. The important terpenoid compound in cocoa powder is linalool, which gives a nutty, sweet, floral, and green aroma (Bonvehi, 2005; Kusumaningrum, 2014).

Alcohol compounds may probably cause the green aroma that appears with high intensity in non-fermented cocoa powder. This aroma arises due to pentyl alcohol and hexyl alcohol compounds. In addition, ethyl palmitate, linalool, and 2,6-dimethyl pyrazine compounds can also cause a green aroma (Bonvehi, 2005).

Polyphenolic compounds and alkaloids cause bitter and astringent attributes. The astringent attribute arises due to the denaturing reaction of proteins in saliva with polyphenolic compounds (Huang & Cu, 2021). Polyphenols are present in large concentrations in non-fermented beans, yet conversely, the concentration decreases in fermented cocoa beans. Polyphenols have also been reported to reduce the intensity of the chocolate taste (Misnawi *et al*., 2004), the sweet taste, and the fruity aroma (das Virgens *et al*., 2021).

AHP has been used to determine the sensory profile of coffee drinks (Ramiréz-Rivera, of the chocolate taste (Misnawi *et al*., 2004), 38 attributes, and through AHP weighting, only 15 attributes were considered important. For example, bitter and spicy are considered attributes that greatly affect consumer acceptance. AHP is also used in assessing the sensory characteristics of eggs and determining the attributes that influence consumer decisions in choosing one of three types of eggs, including conventional, free-range, and omega-3 enriched eggs (Baba *et al*., 2017). The study reported that the main attributes were price, origin, and size of eggs.

Determining the degree of importance of attributes through AHP allows the formulation of strategies to improve the profile of cocoa powder. The flavor of cocoa powder can be improved with a focus on increasing the intensity of the chocolate, caramel, sweet, and nutty attributes. Pyrazine, the main aromatic compound related to these attributes, is formed through the Maillard reaction while roasting cocoa powder. The Maillard reaction requires reducing sugars as a carbon source and amino acids as a nitrogen source (Oracz & Nebesny, 2019). Therefore, the sensory profile of cocoa powder can be improved with treatments that can increase the concentration of reducing sugars and amino acids in cocoa beans.

The main strategy for forming precursor compounds is to carry out fermentation. The fermentation process kills cocoa beans. In turn, the bean's death causes cell walls within the bean to break down, allowing enzymes to come into contact with their substrates. For example, the invertase enzyme will interact with sucrose and convert it into reducing sugars, glucose and fructose. In addition, endoprotease and carboxypeptidase enzymes can react with proteins and peptides to be further converted into amino acids. Furthermore, polyphenol enzymes can oxidize polyphenolic compounds to form polymers that do not cause astringent taste (El Kiyat *et al.,* 2018; De Vuyst & Leroy, 2020).

Incubation with water is an alternative method to increase the concentration of precursor compounds in cocoa beans that have already been dried without going through the fermentation process; this method is based on a previous study by Misnawi *et al.* (2002) reporting that enzymes in dry cocoa beans, such as invertase, endoprotease, and polyphenol oxidase, could be restored to their activity by incubation in water for 2-16 hours. Enzyme activity then produces precursor compounds which will form pyrazine compounds during roasting. The increasing intensity of chocolate, caramel, and nutty attributes indicates the presence of pyrazine compounds in rather large concentrations after the incubation treatment.

Other attributes, such as bitter, astringent, green, flowery, and fruity, rank lower in priority, so they can be left in the cocoa powder. However, flowery and fruity attributes distinguish bean quality, i.e. cocoa beans with these attributes are considered to have higher quality. Furthermore, cocoa beans of Criollo type are known to have flowery and fruity attributes with fairly strong intensity (Castro-Alayo *et al*., 2019). Therefore, Criollo beans generally have a higher selling price than Forastero beans (Gockowski *et al*., 2011; Cadby & Araki, 2021).

CONCLUSIONS

The analysis results of cocoa powder showed that the sensory profile of cocoa powder could be described by 11 attributes, including sour, sweet, bitter, astringent, caramel, chocolate, creamy, flowery, fruity, green, and nutty. AHP could be used to determine the main attributes, namely chocolate, caramel, sweet and nutty, which determine the panelists' preferences. The other attributes were considered to have a lower priority level. The non-fermented cocoa powder had a low score on the panelists' preference because the score for the main attribute was also low. Scores for the main attributes increased in the non-fermented cocoa powder, which was treated with water incubation for 4-16 hours. The highest increase in the main attribute scores was observed in the non-fermented cocoa powder incubated for 8 hours, followed by the cocoa powder incubated for 16 hours and 4 hours. Determining the priority attributes also helps improve the quality of cocoa beans by increasing the concentration of pyrazine precursor compounds, namely reducing sugars and amino acids.

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