Current Research in Nutrition and Food Science

Sensory Profilesof Chocolate Drinks Made from Commercial Fermented Cocoa Powder and Unfermented Cocoa Beans

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Abstract

Polyphenols are the major bioactive compounds of cocoa beans. The addition of unfermented cocoa beans powder is used to enhance the functional properties of the chocolate drink. This study aimed to analyze the sensory profile of chocolate drinks made from a mixture of commercial cocoa powder and non-fermented cocoa beans by the projective mapping method. Seventy-five naive paneliststested four types of chocolate drink formulations and one benchmark (BM). The beverage formulations based on commercial cocoa powder consist of Formulations 1 (F1), F2, F3, F4 namely with the addition of 0, 10%, 20%, and 30% unfermented cocoa powder, respectively. The result showed that samples F1, F2, F3, and F4 had the dominant attributes of chocolate aroma, bitter taste, and bitter aftertaste. Whereas, BM has a dominant sensory profile of chocolate aroma, sweet taste, and sweet aftertaste. The highest value elevation (95°) is thebenchmark (commercial chocolate powder drink). The next height value is in sample F1 which is located at an altitude of 20°-30°. Samples F2, F3, and F4 are the samples that have the lowest elevation (20°). Thus, the addition of cocoa powder from unfermented cocoa beans has not been accepted by consumers due to its bitter taste and bitter aftertaste.

Introduction

Cocoa (*Theobroma Cacao* L) is a plantation crop that is a leading commodity in Indonesia.[1] As one of the top five cocoa producing countries in the world, Indonesia has the potential to create and develop high quality chocolate final products.[2,3] The national cocoa production in 2016 amounted to 639.14 thousand tons. These data show an increase in cocoa production of 7.72% or 45.8 thousand tons compared to cocoa production in 2015 which amounted to 593.331 thousand tons.[4]

The processing of cocoa beans greatly affects the quality of the final chocolate product. One of the processes that contribute to the aroma of chocolate is the fermentation step. This process

can produce a precursor to chocolate taste and aroma.[5,6] Typical flavor found in chocolate is formed from the processing of cocoa beans such as fermentation, drying, and roasting.[7] One of the parameters of cocoa that becomes a value for consumers in consuming cocoa powder is flavor attributes.[8] During the fermentation process, there are microbial metabolic activities take place in the pulp and the seeds. The process might reduce the levelof polyphenols ofthe beans. These compounds diffuse when there is an increase in temperature due to microbial activity. Hence, fermented cocoa beans have lost some of polyphenol which are functional properties in chocolate.[9]

There have been studies on potential health benefits of polyphenols including of the cocoas, both in vitro or in vivo levels.[10,11] There are three groups of polyphenols in cocoa beans: proanthocyanins, catechin and anthocyanins.[6,9] The content of polyphenol compounds in cocoa beans varies depending on the level of fruit maturity, variety, andthe environment in which to grow and process.[12] Unfermented cocoa has a higher total polyphenol content compared to grapes, black tea, and green tea.[13]

In Indonesia, cocoa is consumed in the form of processed chocolate and instant chocolate powder. In the year 2002-2015, the consumption of instant chocolate increased by 22.16% per year, while the consumption of powdered chocolate increased 57.77% per year. Cocoa consumption is expected to increase in 2016-2020 with an average growth of ± 1.17% per year14.In addition to using fermented cocoa, processed cocoa products on the market generally also contain high calories because it is mixed with other ingredients during theprocessing such as sugar and milk.[15,16] The high content of sugar and milk in the product is one of the risk factors of obesity.[17] If there is an imbalance between energy intake and energy expended, there will be excess energy. Excess energy will be stored in the form of fat in adipose tissue. Not only in conditions of excess fat, but also in the distribution of fat in the body. Fat distribution can increase the risk of developing degenerative and metabolic diseases such as diabetes.[18]

In contrast to its unpleasant taste, the unfermented cocoa is believed to have more health benefits compared to the fermented one.[20] The use of unfermented cocoa as a food ingredient in beverage making is still not popular. Most of the available chocolate drink products, both chocolate powder drink and ready to drink chocolate, use fermented cocoa beans. Through the substitution of sources of chocolate, sugar, and other ingredients, chocolate drink products that are healthier and more acceptable to consumers are still not available on the market. Hence, the development of unfermented cocoa beans-based chocolate drinks should be pursued. This study aims to analyze the sensory profile of cocoa-based drinks with a mixture of commercially fermented cocoa powder with unfermented cocoa powder.

Table 1: Cocoa Beverage Formulations

Material Composition	BM	F1	F2	F3	F4
Commercial Fermented Cocoa Powder (g)	Commercial	4.2	3.78	3.36	2.94
Unfermented Cocoa Powder (g)	instant	-	0.42	0.84	1.26
Stevia (sweetener) (g)	chocolate	2.2	2.2	2.2	2.2
Vegetable Cream (g)	drinks	8.5	8.5	8.5	8.5
Flavor (g)		0.1	0.1	0.1	0.1
Water (ml)		85	85	85	85
Total (g)		100	100	100	100

*BM = Benchmark
F 1 : 100% (F)
F 2 : 90% : 10% (F : UF)
F 3 : 80% : 20% (F : UF)
F 4 : 70% : 30% (F : UF)
F= Fermented Cocoa Powder; UF= Unfermented Cocoa Powder

Materials and Methods

The ingredients used for the formulation of chocolate drinks are unfermented cocoa beans obtained from the Small Medium EnterpriseSumedang, West Java, fermented cocoa powder"Oh Java", vegetable creamer "Ellenka", sweetener stevia "Tropicana Slim" and vanilla flavor "KoepoeKoepoe". Besides the four formulations (Table 1), there is a benchmark, namely instant cocoa powder with the brand 'Delfi'. Equipment used for projective mapping are 60x60 cardboard for placing samples according to the level of closeness to each other according to the panelists.
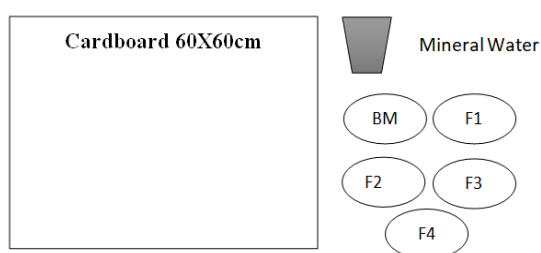

Fig. 1: Chocolate drink sample presentation

Sensory Analysis

Sensory analysis in this study was conducted using the Projective Mapping method. This method is used to study consumer testing with the sensory properties of food products based on their attributes.[21] Panelists place samples according to the similarity of their attributes.[22] Seventy-five naive panelists aged 19-22 years (range age=19-22) contributed to this study.

They were selected based on their willingness to participate and time availability. They were mainly undergraduate students in Food Science and Technology at Universitas Bakrie. Panelists were briefed about the study but they were not informed about the products detail. The initial step of testing is that the entire sample is provided in front of the panelists. The sample is given consists of five samples with three different digit codes. Then the 60x60 cm cardboard paper was given to the panelists as a base to position the sample on it. The arrangement is based on grouping the samples according to the similarity level of the sensory attributes (Fig. 1). Similar samples are placed close together and different samples are placed far apart. After that, the panelists were asked to write down the sample code on the cardboard and add information about the aroma, taste, after taste, and overall sample acceptance.

Data Analysis

Data from Projective Mapping sensory analysis was processed with R v3.6.0 software.Statistical analyses were conducted to assess the link between consumer preferences and perceptions of the product being tested. Apart from numbers, the sample descriptions from the panelists can also explain why the panelists put the sample positions. Table 2 shows the terms for the taste, aroma, aftertaste attributes of the entire sample by the panelists.

Table 2: Terms used in descriptive analysis of Chocolate Drink Sample

Attribute	Sensory Type	Definition
Sweet	Flavor, aroma, aftertaste	Taste elicited by table sugar
Chocolate	Flavor, aroma, aftertaste	Chocolate flavor and aroma
Sour/ acid/ tamarind	Flavor, aroma, aftertaste	Sour flavor
Salty	Flavor, aroma, aftertaste	Taste elicited by table salt
Vanilla	Flavor, aroma, aftertaste	Taste elicited by vanilla extract
Milk	Flavor, aroma, aftertaste	Flavor of whipping milk
Peanut/ bean	Flavor, aroma, aftertaste	Taste elicited by nuts
Caramel	Flavor, aroma, aftertaste	Aroma from heating the sugar to golden brown and producing a
distinctive deep flavor		
Astringent	Flavor, aroma, aftertaste	Taste that puckers the mouth, numbs the tongue, and constricts the throat
Bitter	Flavor, aroma, aftertaste	Having a sharp, pungent taste or smell; not sweet
Creamy	Flavor, aroma, aftertaste	Soft and melts in the mouth

Roasted/ burnt/ wood	Flavor, aroma, aftertaste	Smell of smoke from the wood burning
Fresh/floral/ flower	Flavor, aroma, aftertaste	Energizing fresh taste from floral/ flower
Roasted/ baked	Flavor, aroma, aftertaste	Smells of baked aroma
Soil/ground/ grassy/earth	Flavor, aroma, aftertaste	Smell of earth
Fruit	Aroma, aftertaste	Smell of sweet fruits
Tobacco	Aroma	The smell of cigarettes
Molasses	Aroma	The strong smell of sugar
Winey/ alcohol	Aroma	Strong aroma of alcoholic beverage
Herbs and spices	Aroma, aftertaste	Taste elicited by herbs and spices
Coffee	Aroma	Taste elicited by coffee
Wheat	Aroma, aftertaste	The aroma of flour
Candy	Aroma	Aroma of confectionary product
Savory	Aftertaste	Full of flavor, delicious and tasty

Results and Discussion

Sensory analysis is an analysis to determine the description of sensory attributes, characteristics, and differences between products that can affect consumer acceptance. This purpose is also used in product development such as product reformulation.[23] The sample used consisted of four formulations with increased amounts of unfermented cocoa powder. The benchmark used is chocolate powder drink that is already on the market.The four samples were added with stevia sugar, this sweetener is considered to have a higher level of sweetness compared to sugar cane.However, it has lower calories.[24]

Fig. 2 shows the sample chocolate drink used in the study.From the picture, it can be seen that there are differences in color and texture between the samples.
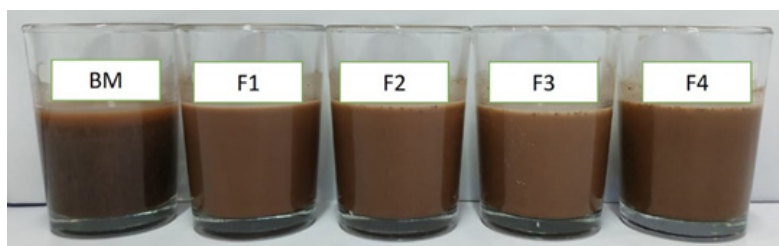

Fig. 2: Chocolate drink samples with mixed formulations of fermented and unfermented cocoa powder

Sensory Profile of Fermented and Non-Fermented Cocoa-Based Drinks

Evaluation of this sensory profile produces a dominant sensory description in each sample which can be seen in Table 2. In the benchmark, it has the dominant attributes of sweet taste, chocolate taste, chocolate aroma, and sweet aftertaste. However, the samples F1, F2, F3, and F4 have dominant attributes of a bitter taste, sweet taste, chocolate taste, chocolate aroma, sweet aroma, and bitter aftertaste. The aroma and taste of chocolate are the characteristic sensory attributes of fermented cocoa beans. In this process, there is a breakdown of polyphenol compounds, proteins, and sugars by enzymes to form precursors for the distinctive taste of chocolate.[25] Furthermore, the sample descriptions are analyzed related to similarities and differences between samples. The similarity of aroma attribute between BM and F3 samples are chocolate, sweet, milk, nuts, coffee, vanilla, bitter, cream, wheat, and candy aroma. As for the difference, the BM sample has the aroma of roasting, coffee, grass, soil, and wood and the F1 sample has a burnt aroma. In samples F2, F3 and F4 have the same aroma, namely having the aroma of chocolate, sweet, milk, peanuts, cream, roasted, bitter, earth, and vanilla. The difference between the three samples is that the F2 sample has a smell of grass, fruit, and is tasteless. Sample F3 has a brownie and salty aroma

and sample F4 has an aroma of wheat, leaves, and tamarind.

These aromas are formed due to the volatile components of the ingredient. Apart from the materials used, that can also be formed because of the processing of the product. For example, the fermentation process which involves microbial activity and Maillard reactions from sugar and protein.[26] In the taste attribute, the similarities between BM and F1 samples were both sweet, bitter, chocolate, earth, milk, baked, vanillin, fresh, salty, wood, sour, cream, wheat, peanuts, fruit, and astringent. However, different attributes include the BM sample having a taste of smoke, grass, coffee, burnt and tobacco, while the F1 sample has a taste of alcohol. Samples F2, F3, and F4 have the same taste attributes, namely bitter, sweet, chocolate, baked, milk, sour, cream, wood, peanut, salty, smoked, and ground. As for the difference, the F2 sample has a vanilla, spicy, and savory taste. Sample F3 had a fresh taste and F4 had floral, wheat, fruity, and burnt flavors.

The distinctive taste of chocolate is formed from a combination of basic bitter, sour, and sweet tastes which are composed of unique components in chocolate.[26] The sweet taste generally comes from the sweetener added to cocoa powder, usually, the sweetener used is sugar cane. While in the sample, the sweetener used was stevia. The purpose of using stevia sugar is to reduce calories but still be able to provide an appropriate sweet taste.

The bitter taste which is the characteristic taste of chocolate comes from alkaloid components such as caffeine and theobromine, pyrazine, phenolics as well as some peptides and amino acids.[8,27] The creamy taste that is formed is thought to come from a combination of a sharp chocolate taste with a soft texture.[28,40] The vanilla flavor that is present in the product comes from the additional of the flavor essence. The identified milk flavor may come from the vegetable creamer used. The herb is a characteristic taste of the unfermented cocoa beans. It comes from the high polyphenol content in the cocoa beans. Unfermented cocoa have a higher polyphenol content than those of fermented beans.[29]

The sour taste comes from the high content of lactic and acetic acids. It contributes to the distinctive chocolate flavor. However, if the sour taste is too high, this indicates the low quality of the cocoa beans. The taste of the beans identified comes from fermented cocoa bean components such as 2-Methylpyrazine, 2,5-Dimethylpyrazine, 2,6-Dimethylpyrazine, 2-Ethylpyrazine, and 2,3,5-Trimethylpyrazine. The identified taste of coffee comes from components 2,3,5,6-Tetramethyl-pyrazine and 2,6-Dimethylpyrazine8. The fruit flavors identified were derived from Benzyl alcohol, Ethyl acetate, Ethyl dodecanoate, while floral flavors derived from 1- Phenylethanol and ethyl dodecanoate.[30,41]

Similarities between the F1 and the benchmark weresweet, bitter, chocolate, sour, astringent, grass, peanut, and milk aftertaste. Meanwhile, the BM samples also haveearthy, smoked and salty aftertaste. While the other three groups have the same attributes including the bitter, sweet, sour, astringent, chocolate, peanut, and caramel aftertaste. Whereas the difference is that the F2 sample has a vanilla, for the F3 sample it has a grass and for the F4 sample there is milk, soil, and salty aftertaste.

Individual Factor Map, Confidence Ellipses for the Napping and Sensory Descriptions
Individual factor maps are points that indicate the existence of each sample determined by the 75 panelists (Fig. 2). The points are then made Euclidean distance to be combined into one, which means that the panelists indirectly agree on the existence of the position of each sample.[31]

In addition to the individualfactor map, the results of confidence ellipses for the napping are a matrix containing coordinates of different frequencies and variables determined by panelists indirectly.[32] Confidence ellipses for napping in Fig. 3 shows the results of the analysis of the sensory profile evaluation of beverage formulations based on a mixture of fermented and unfermented cocoa powder with variations in the percentage of the mixture. The ellipses section shows the alleged virtualization position determined by the panelists by 375 points. Based on the results of the plot, the first dimension up to the second dimension MFA explains 70.02% diversity.
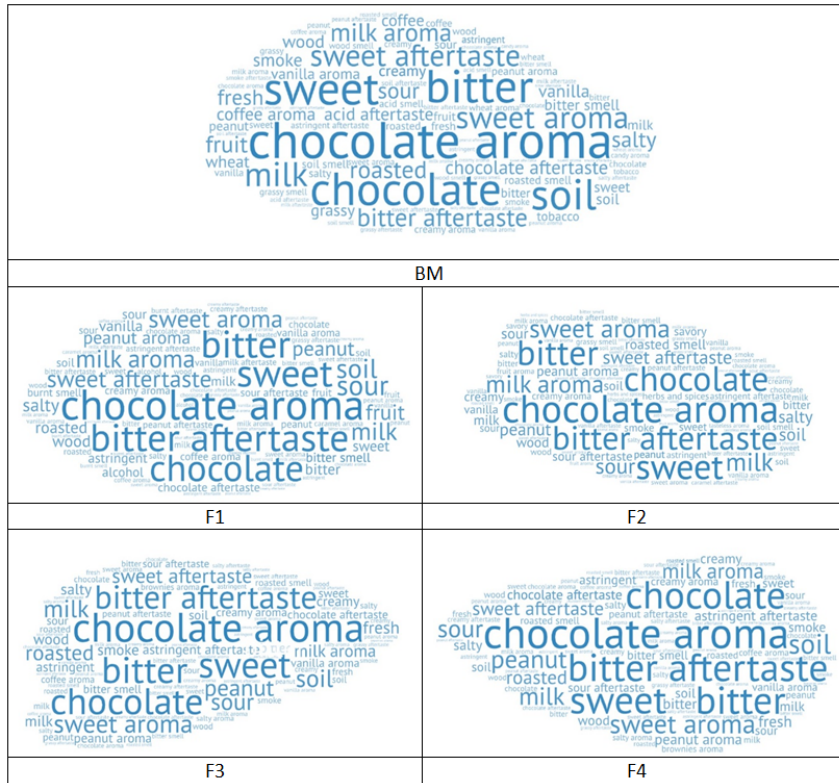
Fig. 3: Description of Sensory Attributes of Chocolate Drink Samples with Mixed Formulations of Fermented and Unfermented Cocoa Powder
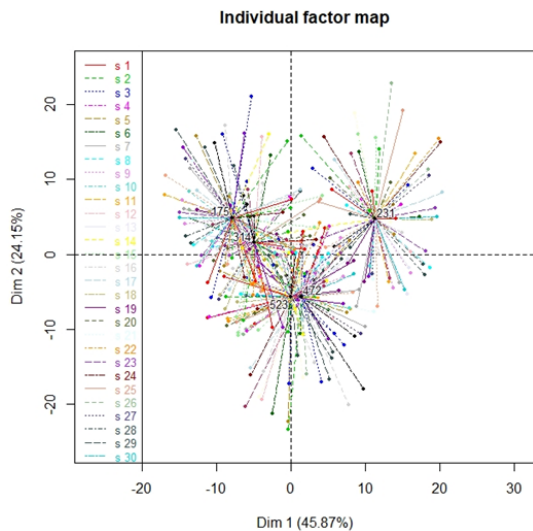

Fig. 4: Individual Factor Map of Chocolate Drink Based Fermented Cocoa Powder With F1 (0%), F2 (10%), F3 (20%), F4 (30%) unfermented cocoa beans and BM (Benchmark)

Fig.4 shows the sample divided into three clusters. The first group is samplesBM; the second group consisted of samples F1 and F2; the third group of samples F3 and F4. The samples were divided into four clusters in which the greater the area means the more heterogenous the samples are. BM has a greater area (heterogeneous) compared to other samples. This shows that the panelists gave more diverse values to this sample. BM is located in a different quadrant to the sample, thus Panelists agree that BM has very different attributes from other samples.(Fig.4). In the second group, the F1 and F2 samples have a smaller area compared to BM. The samples are in the same group because they are considered to have a high degree of similarity in the characteristics of the sensory attributes. Similarly, samples F3 and F4 are located in the same quadrant.

Fig.5 and 6 show the results of the sensory profile analysis found in quadrants one through four.

Samples and sensory attributes located in the same quadrant show the characteristics of the sample. BM has the characteristics of sweetness, smoke, fresh, soil, vanilla, chocolate, and sour. Samples F1 and F2 located in quadrants two and three have sensory characteristics namely milk, astringent, sour, bitter, peanut aroma, and have caramel, bitter, and creamy aftertaste. F3 and F4 which are located in quadrant four have the sensory characteristics of peanut, salty, roasted, creamy, roasted, and beans taste. The sensory profile contained in each sample is influenced by the processing, the composition of the materials used, and the interactions between the components of the product.[33]
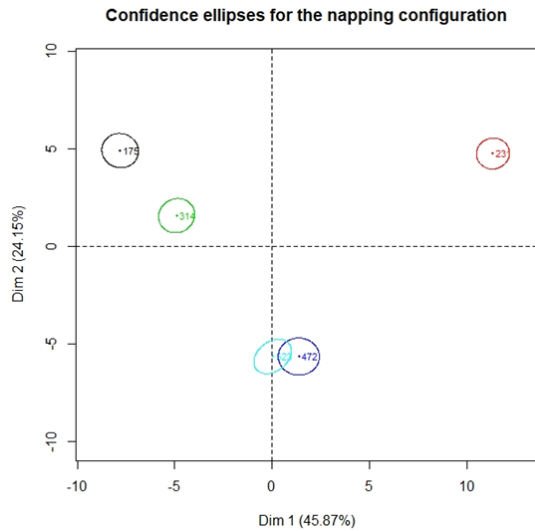

Fig. 5: Confidence Ellipses for the Napping Configuration of of Chocolate Drink Based Fermented Cocoa Powder with 472/ F1 (0%), 523/ F2 (10%), 314/ F3 (20%), 175/ F4 (30%) unfermented cocoa beans and 231/ BM (Benchmark)
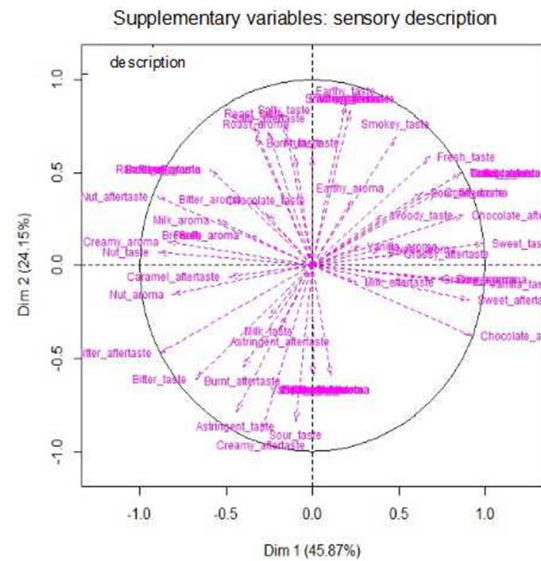

Fig. 6: Supplementary Variable Beverage Products of Chocolate Drink Based Fermented Cocoa Powder with F1 (0%), F2 (10%), F3 (20%), F4 (30%) unfermented cocoa beans and BM (Benchmark)

The aroma of chocolate, the bitter taste, and the bitter aftertaste formed are typical flavors of cocoa beans.[34] The distinctive flavors identified in the four samples were due to the composition of the ingredients derived from a mixture of fermented and unfermented cocoa powder. In fermented cocoa powder, a distinctive chocolate flavor is formed.[8] Whereas the unfermented cocoa powder has a more bitter taste than the fermented one. That is due to the cocoa powder there are polyphenol compounds that play a role in the formation of bitter and astringent flavors.[35] The taste is formed through the deposition mechanism of proteins that are rich in proline in saliva and contribute to the bitter taste of chocolate along with alkaloids, some amino acids and peptides, and pyrazines.[36] The higher the polyphenol content in chocolate the higher the bitter and astringent taste. High polyphenol content is found in unfermented cocoa.[37]

There are 12 characters commonly used to describe or assess the taste of cocoa. The characters are the aroma of cocoa (chocolate), nutty (nuts), fruity (fruits), tobacco, molasses, bright (fresh), caramel, grassy, bitter, winey (grapes), spicy (herbs), and floral (flowers). Generally, Indonesian cocoa has a weak chocolate flavor, fruit aroma, and sour aroma.[36]

Furthermore, the sample descriptions are analyzed in terms of similarities and differences between samples. The aroma attribute equation between samples BM and F3 is that there is chocolate, sweet, milk, bean, coffee, vanilla, bitter, cream, wheat, and candy. As for the difference, sample BM has the aroma of roast, coffee, grass, soil, and wood, and sample F1 has the scent of scorch. In the samples F2, F3 and F4 had the same aroma which had the aroma of chocolate, sweet, milk, beans, cream, roast, bitter, ground, and vanilla. The difference

between the three samples is that sample F2 has a scent of grass, fruit, and tasteless. Sample F3 has the aroma of brownies and salty and sample F4 has the aroma of wheat, leaves, and acid.

The aromas are formed due to the presence of volatile compound in the ingredient used. Apart from the ingredients used, the aromas can also be formed due to product processing. For example, fermentation processes involving microbial activity and Maillard reactions involving sugars and proteins.[38]

In the taste attributes, sample BM and F1 panelists describe the similarity between the two, namely sweet, bitter, chocolate, earth, milk, roasted, vanilla, fresh, salty, wood, acid, cream, wheat, peanuts, fruit, and astringent. While the difference is in sample BM there is a sense of smoke, grass, coffee, burnt, and tobacco while in sample F1 there is a sense of alcohol. Samples F2, F3 and F4 had similarities to the taste attributes, they were bitter, sweet, chocolate, baked, milk, sour, astringent, cream, wood, peanuts, salty, smoke, and soil. Whereas the difference is sample F2 has vanilla, spice, and savory flavors. Sample F3 had a fresh taste and F4 had a flower, wheat, fruit, and charred flavor.

The distinctive taste of chocolate that is formed is a combination of basic tastes of bitter, sour, and sweet composed of unique components in chocolate.[39] The detected sweetness is a taste derived from sweeteners used in making products. In this study, sweeteners used in sample BM were sugar cane type sweeteners, and for other samples using stevia type. Stevia sweetener has a higher level of sweetness compared to sugar cane sweetener but has lower calories.[4]

Group Representation
Group representation described the results of the assessment of the 75 panelists on samples of beverage products based on a mixture of fermented cocoa powder and unfermented. The results of the selected Group Representation value are based on the largest dimension diversity which is found in dimensions one and two (70.02%). The color in Group Representation correlates with the color of the sample ellipses in Fig.7.

In this result, it is known that the panelists assess the sample in a variety of ways that are known based on the position of the representation of the panelists (Fig.7) which corresponds to the sample representation in the Confidence Ellipses (Fig.5). Fig.7 shows that the panelist representation of a widespread sample is not close together or focused on one region.This indicates that the panelist's assessment of the sample can be trusted. Although the results of the data obtained varied, the panelists still grouped the samples according to their level of similarity.
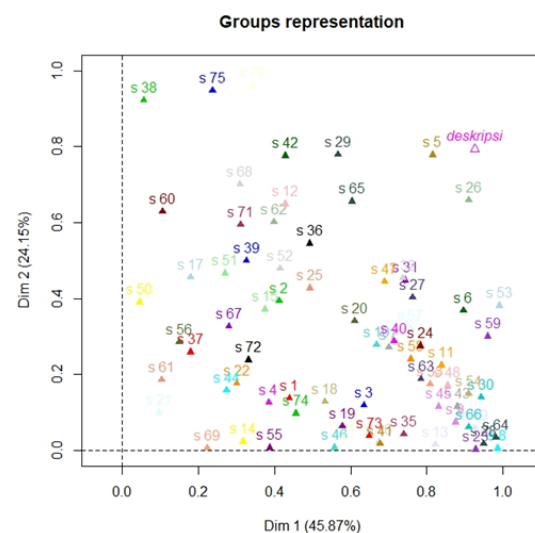

Fig. 7: Group Representation of Beverage Based Products of Chocolate Drink Based Fermented Cocoa Powder with F1 (0%), F2 (10%), F3 (20%), F4 (30%) unfermented cocoa beans and BM (Benchmark)

Points generated by the BM sample are in an adjacent area. It indicates that Panelists have similarities in analyzing the characteristics of sensory attributes of BM samples. Panelist agreed that sample BM is a differentiator from other samples. This is consistent with the fact that sample BM is the benchmark in this study. As for samples F1, F2, F3, and F4 panelist representations are more widespread than those in sample BM. It can be seen that panelist assessments of the four samples are more diverse but panelists still group them according to their similarities as can be seen in Fig.5.
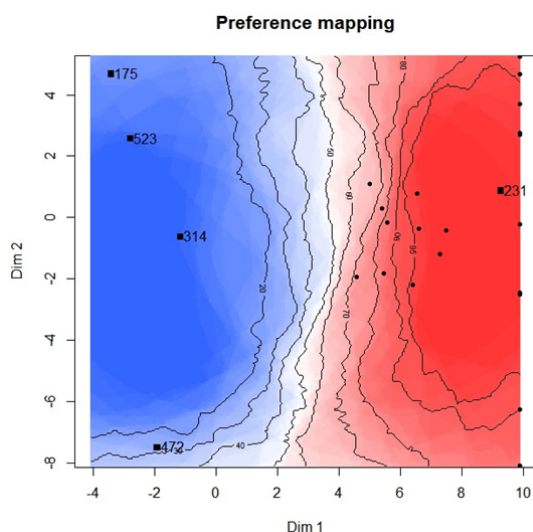
Preference mapping

Fig. 8: Preference Mapping of Drinking Products Made from Mixture of Fermentation and Non-Fermented Cocoa Powder

Preferences Mapping

The Preference Mapping Method is a method that connects hedonic data with descriptive data on the product being tested.[42] In Fig. 6, Preference Mapping divides the area into two parts. In addition, the elevation value of the panelist preference level for the sample was also obtained. The higher the elevation value of the sample, the higher the preference of the panelists for that sample.[43] The sample that has the highest elevation value is BM which is at 95° elevation. Thus, BM is the sample that is most widely accepted and chosen by the panelists. This is evidenced by its sensory attributes, namely the aroma of chocolate, chocolate taste, sweetness, and sweet aroma that consumers like (Table 3). These results follow the BM sample which is the benchmark in this study. The next highest elevation value is found in the F1 sample which is located at an elevation of 20°-30°. Sample F1 is a sample of chocolate drink product with 10% unfermented cocoa powder. Thus, it can be interpreted that the panelist preference level for this sample is higher than samples F2, F3 and F4. However, BM with F1 samples is located at a different pole. Therefore, when compared with the BM sample, this F1 sample was not acceptable to the panelists. Nevertheless, the sensory attributes of the F1 sample are considered better than the other samples. Samples F2, F3 and F4 are the samples that have the lowest elevation at 20° elevations.

Hence, Fig. 7 shows that panelists prefer samples with 100% fermented cocoa powder (BM). The fermentation process in cocoa beans can result in the formation of precursor compounds that play a role in forming a distinctive chocolate taste.[30] In terms of preference, chocolate products with good processing of cocoa beans will be preferred compared to those without good processing. Included in this study, fermentation plays an important role in the formation of flavor precursors and color attributes. Due to the fermentation process will increase the color preference of cocoa beans.[44]

Conclusion

The results of the sensory analysis of drinks made from a mixture of fermented and unfermented cocoa powder showed various descriptions in each sample. On the Individual Factor Map and Ellipses Confidence for the Napping, the sample results are divided into three groups according to the percentage of that beverage. The dominant sensory attributes obtained in samples F1, F2, F3 and F4 are the chocolate aroma, bitter taste, and bitter aftertaste. Whereas sample BM has the dominant attributes of chocolate aroma, sweet taste, and sweet aftertaste.It can be seen that the mixture between fermented and unfermented cocoa powder used was not detected by panelists. The description given by the panelists in each sample was not much different. In the preference mapping results obtained panelist preference level results on the sample. The sample that has the highest elevation value is sample BM (benchmark) is at elevation 95°. The next highest elevation value is in sample F1 which is located at an elevation of 20°-30°. Sample F1 is a sample of chocolate drink products with raw material for commercial fermented cocoa powder 100%. Samples F2, F3 and F4 are the samples that have the lowest elevation at elevation 200. Thus, the addition of cocoa powder from unfermented cocoa beans decreases the level of preference of panelists against chocolate drinks. Sensory attributes show that unfermented cocoa powder addition into the fermented cocoa have not been able to compete with the benchmark so there needs to be an improvement in the sample formulation. The addition of cocoa powder from unfermented cocoa beans has not been accepted by consumers due to its bitter taste and bitter aftertaste.

Conflict of Interest
All authors declare no conflict of interest.

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