Sensory Profiling Evaluation and Panel Performance Test of Chocolate Ice Cream Premix Products

Fransiska Utami[1*], Dede Robiatul Adawiyah[2,3], Dias Indrasti[2,3]

[1]Food Technology Masters Study Program, Postgraduate School, Bogor Agricultural University, Graduate School Building, Darmaga Highway, Campus of IPB Darmaga, Bogor, West Java, Indonesia
[2]Department of Food Science and Technology, Faculty of Agricultural Technology, Bogor Agricultural University, Fateta Building Floor 2, Darmaga Highway, Campus of IPB Darmaga, Bogor, West Java, Indonesia
[3]Southeast Asia Food and Agricultural Science and Technology (SEAFAST) Center, LPPM, Bogor Agricultural University, Ulin Street No. 1 Campus of IPB Darmaga, Bogor, West Java, Indonesia
[*]Corresponding author: Fransiska Utami, Email: utami.dh@gmail.com

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ABSTRACT

The growth of the food and beverage industry in Indonesia is creating new opportunities for the ice cream sector, which experienced a remarkable 51.9% growth between 2013 and 2018. Nowadays, crafting ice cream at home has become convenient through the use of premixes, often added with chocolate flavor. Therefore, this study aimed to conduct a sensory profiling evaluation and panel performance test on chocolate ice cream mix powder products. Sensory analysis was used to analyze product quality, differences, and similarities, with humans as measurement tools. This study also employed a group of trained and reliable panelists for product testing. The sensory profile and performance of several chocolate ice cream premixes on the market were assessed with the quantitative descriptive analysis (QDA) method. The premix products considered were those registered with BPOM, and the analysis encompassed physical characteristics (overrun and melting rate) and sensory evaluation. Meanwhile, the panelist selection was based on ISO 8586 Year 2012. Panelist performance evaluation was conducted to determine their proficiency in sensory analysis, and the results obtained were analyzed using *sensehub* and XLSTAT. The QDA test results showed that PT XYZ chocolate ice cream premix was superior in all sensory attributes. However, the weaknesses identified in this premix were related to low overrun value and higher melting rate. The panelist performance evaluation indicated that panelists P1 to P9 needed retraining in discrimination skills. This is because although the panelists had a relatively good consistency, their discrimination ability showed insignificant results.

Keywords: Chocolate ice cream mix powder; melting rate; overrun; panel performance; quantitative descriptive analysis method

INTRODUCTION

The food and beverage industry growth in 2018 was approximately 3.74%, contributing nearly 23.57% to the expansion of large and medium-scale manufacturing industries (BPS, 2020). The ice cream industry is one of the sectors with growth potential (Fitrahdini et al., 2010). In 2019, ice cream sales experienced an increase compared to 2018 (Statista, 2020). This popularity can be attributed to its status as a preferred snack by the Indonesian population due to the hot climate (Kusumastuti & Adriani, 2017).

Nowadays, consumers can easily make ice cream at home using ice cream premix. According to the food category in Regulation of BPOM Head no. 21 of 2016, ice cream premix is a product made from milk, dairy

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products, or their mixtures, processed with the addition of water or other ingredients. Chocolate products are frequently used to add flavor (Goff & Hartel, 2013). The Mintel Global New Product Database in 2020 showed that chocolate-flavored products remain highly popular in the market among others introduced in 2019. Ice cream has various sensory and physical attributes that affect overall quality and consumer acceptance. The important sensory attributes include color, hardness, and melting rate which influence the speed of ice cream melting (Goff & Hartel, 2013). Overrun is also an important parameter, as it indicates the increase in volume due to °air entrapment in the mixture during the mixing pro°ess. This parameter affects the texture and density, determining the ice cream quality (Harwood et al., 2013).

The ice cream premix market accommodates not only large players but also small and medium-scale enterprises. With the high abundance in the market, sensory analysis is necessary to compare products with similar features. In the food industry, this analysis is used not only to make marketing decisions but also to determine a product stand in comparison to other competitors (Iannario et al., 2012). Aroma, taste, aftertaste, and physical appearance are parameters for evaluating consumer acceptance of a food product. This underscores the necessity for food and beverage manufacturers to understand the sensory analysis concept (Purcell, 2019). Furthermore, selecting and training panelists are routine practices, which involve assessing employees suitable for various sensory evaluations and quality determinations (Rogers, 2018). Effective sensory analysis hinges on the performance of monitoring panelists individually and as a group (Kermit & Lengard, 2006).

Quantitative Descriptive Analysis (QDA) provides a comprehensive description of a product's sensory attributes (Stone & Sidel, 2004). This method can be applied to product development, optimization, market assessment, and competitor analysis (Kemp et al., 2009). It is also used to evaluate the sensory profile of the products and understand the characteristics of various chocolate ice cream premixes available in the market. This evaluation employs an interval scale of about 15 cm, with descriptive terms such as "weak" and "strong" positioned 1.25 cm from each end (Rogers, 2018). The QDA data is analyzed using univariate and multivariate statistical techniques. Multivariate analysis of variance and Principal Component Analysis can be derived from QDA test results (Lawless & Heymann, 2010). Although food companies have predominantly employed hedonic testing to assess consumer acceptance, the use of QDA for evaluating characteristics, sensory profiles, and mapping of chocolate ice cream premix remains unexplored in Indonesia. Common tests in the food industry include difference and consumer acceptance tests (Ackbarali & Maharaj, 2014). The QDA results can aid in assessing the performance of sensory analysis panelists. Therefore, this study aimed to evaluate the characteristics and sensory profiles of chocolate ice cream premix in the market. The results were expected to facilitate the industry in developing products with added value as well as enhance academic literacy for further studies or investigations on chocolate ice cream premix.

METHODS

Materials

The main materials for this study were three types of chocolate ice cream premixes with MD circulation permit numbers from BPOM. These premixes were obtained through a search on the BPOM product website (https://cekbpom.pom.go.id) in Figure 1 using keywords such as "*bubuk premix es krim* (ice cream premix powder)" and "*bubuk es krim* (ice cream powder,)". The used chocolate ice cream premixes are listed in Table 1. Other ingredients include sugar, salt, caffeine, milk powder (NZMP, New Zealand), cocoa powder (Bendico, Indonesia), peanut butter (Morin, Indonesia), and whipping cream (Haan whiptopp, Indonesia). These ingredients were employed as sensory attribute standards.

Table 1. Names of used chocolate ice cream premix products

Product name	Company name	Expiration date	Net weight (g)	Price (Rp)	Price/kg
Chocolate ice cream powder	PT XYZ	October 2022	90	12.500	Rp138.889
Chocolate ice cream flour	PT ABC	November 2022	75	9.310	Rp124.133
Chocolate ice cream powder	PT DEF	August 2022	250	22.730	Rp90.920

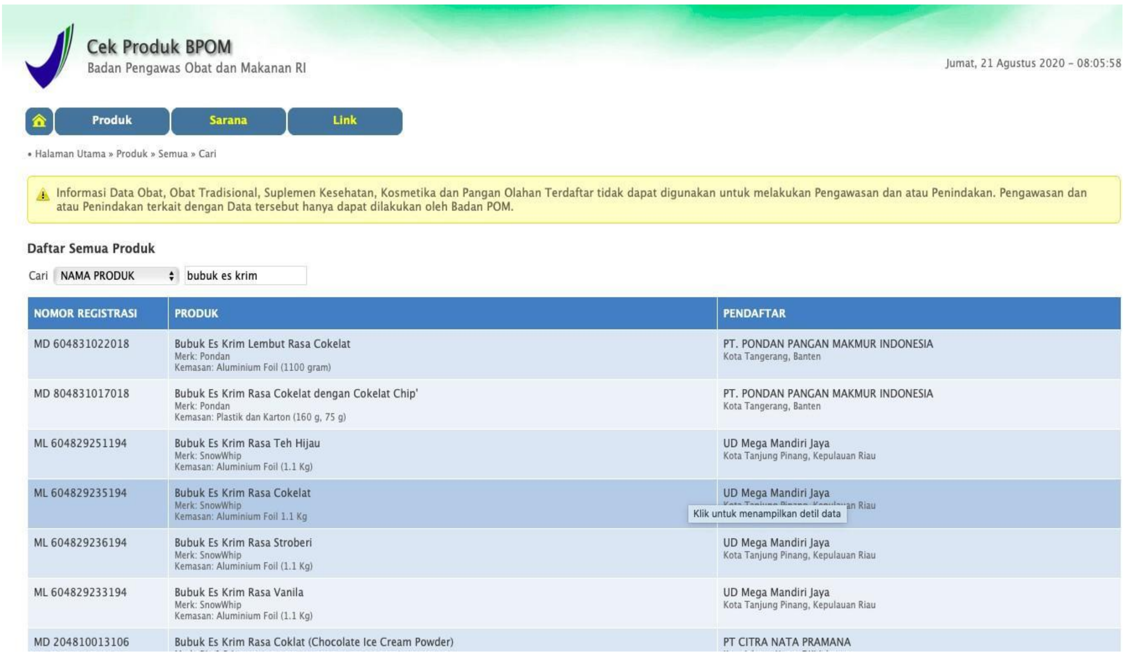


Figure 1. BPOM product check website with the keyword search for ice cream powder

The equipment used in this study included a hand mixer (Philips HR1559), plastic containers, technical scales (AND EK 6100i), as well as sensory analysis tools namely plastic cups (suapi brand, 35 mL capacity), plastic spoons, glass bottles, and others.

Panelist Selection and Training

In the Quantitative Descriptive Analysis (QDA) method, panelist selection as well as training are essential. A selection was made from 40 employees at PT XYZ, while only 17 underwent training and subsequently conducted QDA testing on chocolate ice cream premix products. The selection and training were in line with ISO 8586 of 2012 (ISO, 2012). The training phase spanned a duration of three days, involving three different samples. The process included discrimination testing (triangle test) and training on product description skills. Panelist selection involved basic taste (gustation) and aroma (olfaction) matching tests. Successful candidates were required to achieve a minimum of 80% in their responses. Subsequently, selected panelists underwent further training involving triangle and product description tests. Only those who could consistently demonstrate a minimum of 50% accuracy in conducting the QDA test for the chocolate ice cream premix were designated as the final 9 trained panelists. The blind test was conducted, wherein samples were coded with three distinct digits and placed in identical containers to reduce bias, while testing was repeated five times.

Observation on Characteristics of Chocolate Ice Cream Premix

In the observation of physical characteristics (overrun and melting rate), the measurement of overrun involved weighing the initial solution and the final ice cream weight in percentage (%) using the Equation 1 (Muse and Hartel, 2004).

$$\text{Overrun (\%)} = \frac{(\text{Initial ice cream's weight} - \text{final ice cream's weight})}{\text{final ice cream's weight}} \text{ x } 100 \quad (1)$$

The melting rate test was performed to determine the ability of the ice cream to resist melting when exposed to warm temperatures (Clarke, 2004). This test involved placing an ice cream sample in a container for 12 hours. The sample was then positioned on a sieve (6 holes/cm), underneath which a beaker glass was placed. The ice cream was kept in a temperature-controlled environment (room temperature) of 25 °C (RH = 50%). Observations were made every 10 minutes over 3 hours to monitor the dripping and melting (Muse & Hartel, 2004).

Panelist Performance Evaluation

Panelist performance evaluation aimed to assess the repeatability, distinctiveness, homogeneity, and consistency of sensory testing results. The evaluation

Table 2. References to flavor and texture sensory attributes

Parameter	Sensory score				Material
	2	5	10	15	
Sweet flavor	2%	5%	10%	16%	Sucrose
Bitter flavor	0,05%	0,08%	0,15%	0,20%	Caffeine
Chocolate flavor	0,25%	0,60%	1%	5%	Cocoa powder
Milky flavor	2%	6%	11%	17%	Milk powder
Smoothness	Peanut butter		Whipping cream		Peanut butter (Morin) Whipping cream: Haan Whiptopp powder

considered both individual and overall performance. After the trained panelists conducted the QDA sensory testing on chocolate ice cream premix products, the data were statistically analyzed using ANOVA. Panelist performance was assessed for each tested attribute. Repeatability and reproducibility among panelists were calculated based on standard deviation consistency across sessions and panels using the two-way ANOVA (ISO 8586 2012).

QDA (*Quantitative Descriptive Analysis*) Test

Sensory testing with the QDA method was conducted for sweet and bitter-flavored ice cream premixes using a universal reference scale. Meanwhile, the chocolate flavor was determined based on sensory references to cocoa powder (Leite et al., 2013; World Coffee Research, 2017). The parameter of smoothness was assessed in line with references from sensory testing of vanilla ice cream (Dooley et al., 2010). The sensory attribute references used in this study are shown in Table 2.

The QDA method utilized an interval scale with a length of approximately 15 cm, where labels such as "weak" and "strong" were placed at each end (Rogers, 2018). The test was repeated five times over five different days. The chocolate ice cream premix samples were assigned randomly generated three-digit codes.

RESULTS AND DISCUSSION

Panelist Performance Evaluation

The descriptive test data were subsequently processed using the SensesHub with the XLSTAT software, and the results are shown in Table 3.

In the sample column, the p-value indicates the discrimination ability of the panelists, while bold numbers in the table imply significance at a 95% confidence level. The attributes of smoothness, chocolate, and milky flavor were significantly distinguished by the panelist, as demonstrated by the bold p-value at a confidence level of 95%. Bitter and sweet flavors in the chocolate ice cream did not show significance, suggesting the panel could not discern significant differences between these two flavors. According to ISO 8586 of 2012, significant analysis results implied that the panel effectively differentiated between sample products. Panel agreement (consensus) can be observed in the sample:

Table 3. Summary p-values from the analysis of variance of panelist performance as a group

Attribute	Sample	Panelists	Session	Order	Sample: panelists	Sample: session	Panelist: session
Smoothness	**7.6e-05**	**4.1e-06**	**2.1e-02**	8.8e-01	1.7e-01	9.9e-01	5.3e-01
Chocolate Flavor	**7.4e-03**	**7.5e-12**	1.5e-01	**3.6e-02**	**9.0e-05**	8.1e-01	4.8e-01
Milky flavor	**1.0e-02**	**3.5e-12**	4.9e-01	9.6e-01	**7.9e-04**	7.5e-01	**2.7e-02**
Bitter flavor	1.5e-01	**1.0e-11**	6.1e-02	4.2e-01	1.2e-01	6.9e-01	5.9e-01
Sweet flavor	3.3e-01	**6.8e-04**	3.0e-01	6.4e-01	**4.4e-03**	9.2e-01	5.0e-01

Description: Bold numbers indicate significance at a 95% confidence level.

Table 4. Summary of p-values for panelist discrimination ability in chocolate ice cream premix

Panelist	Chocolate flavor	Smoothness	Milky flavor	Bitter flavor	Sweet flavor
P1	**1.8e-02**	1.7e-01	1.1e-01	8.1e-02	8.3e-01
P2	**5.5e-06**	6.0e-01	1.5e-01	1.8e-01	1.8e-01
P3	5.5e-02	6.0e-01	5.5e-01	2.5e-01	3.3e-01
P4	**5.5e-03**	**5.8e-03**	8.8e-02	3.3e-01	1.4e-01
P5	**1.0e-02**	5.1e-02	5.5e-02	2.1e-01	5.9e-01
P6	4.5e-01	5.4e-02	**2.1e-02**	2.7e-01	1.1e-01
P7	4.3e-01	**2.6e-02**	**1.6e-03**	1.0e+00	4.6e-01
P8	**1.1e-02**	**1.5e-03**	**5.2e-03**	2.9e-01	**5.1e-03**
P9	4.5e-01	1.2e-01	**2.8e-02**	6.0e-01	7.9e-01

Description: Bold numbers indicate significance at a 95% confidence level.

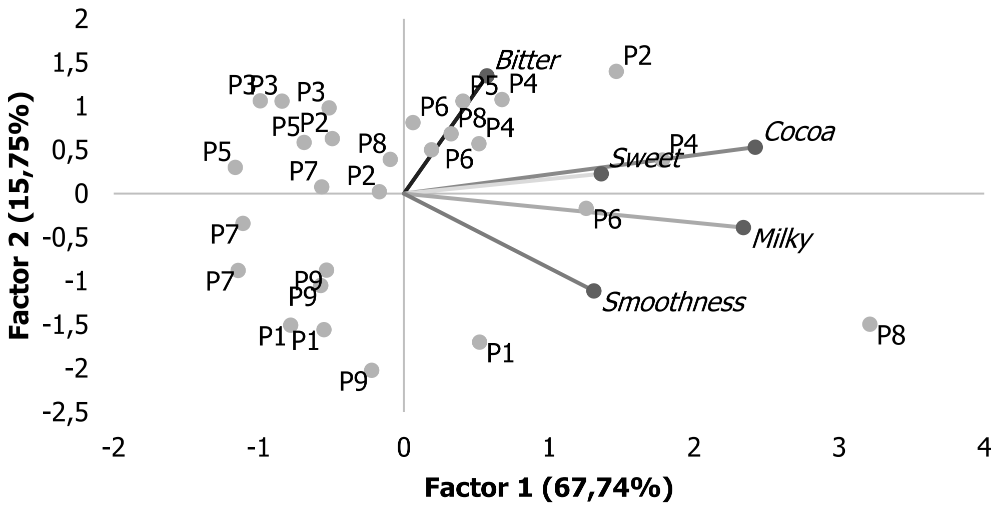
panelists column. For the attributes of chocolate, milk, and sweet flavors, the p-values showed significance at a 95% confidence level, indicating differences in perception ranking or scale for these attributes.

The reliability of panel performance was assessed in the sample: session column, where no p-value yielded a significant result at a 95% confidence level. Reliability refers to the ability to reproduce a response, either by individual panelists or as a panel unit. This can involve repeated testing, duplicate sample products, or the use of controls (Meilgaard et al., 2016). In this case, the results, presented as a whole panel unit did not demonstrate reliability. From the summarized p-value data of panelist discrimination ability at Table 4, panelist P8 was identified to effectively distinguish the attributes of chocolate flavor, smoothness, milky, and sweet flavor. This observation was supported by the significant p-values (95% confidence level) associated with these four attributes.

The primary method used for evaluating discrimination ability involved conducting ANOVA to assess individual panelists, with the p-value serving as an indicator of the test outcome (Meilgaard et al., 2016). Panelists P5, P4, P1, and P2 exhibited discrimination ability for chocolate flavor, P4 and P7 effectively distinguished smoothness, while P6, P7, and P9 had significant ability for milky flavor. However, none of the nine panelists showed discrimination ability for the bitter flavor of the presented products. This was because the bitter taste in the chocolate ice cream premix was either subtle or nearly absent. Table 5 shows the panelist consistency results for several attributes. Low standard deviation values indicate good consistency among the panelists (ISO 8586, 2012). Panelists with a standard

Table 5. Summary of the standard deviation of error or root mean squared error (RMSE) values for each panelist

Panelist	Bitter flavor	Chocolate flavor	Smoothness	Milky flavor	Sweet flavor
P1	**0.37**	**1.67**	**1.35**	2.68	2.94
P2	2.33	**0.77**	3.03	2.79	2.33
P3	**0.88**	**0.88**	**1.76**	2.00	**0.80**
P4	**0.80**	**1.30**	**1.30**	**1.35**	**1.78**
P5	2.98	2.36	2.03	**1.48**	3.04
P6	**0.55**	2.41	2.00	**1.76**	**1.33**
P7	**1.00**	2.71	**1.14**	**0.56**	**1.94**
P8	2.04	3.05	2.09	2.98	2.87
P9	**0.61**	**0.83**	**1.62**	**1.13**	**1.59**



Description: Bold numbers indicate significance at a 95% confidence level

Figure 2. Principal component analysis results of panelists with sensory attributes of chocolate ice cream premix using XLSTAT 2021

deviation of error values below 2 were considered to have good consistency.

Table 5 presents the results of data analysis using the SenseHub software, illustrating that panelists P4 and P9 exhibited good consistency across almost all sensory attributes. In the Biplot 1 graph, panelist P4 showed positive correlations with the bitter, sweet, and chocolate flavors. This consistency was evident both in the SenseHub and XLSTAT 2021 data analysis results (Figure 2). Similarly, panelist P6 demonstrated good consistency in perceiving the milky flavor attribute.

Sensory Profile of Chocolate Ice Cream Premix

The panelists who conducted the QDA testing for the chocolate ice cream premix underwent a performance evaluation. Among the 17 selected panelists, only 9 were qualified to participate in the test. The spider web diagram in Figure 3 showed that the chocolate ice cream premix from PT XYZ exhibited stronger attributes of smoothness, chocolate, bitterness, sweetness, and milk compared to other premixes. Based on the results, ice cream from PT DEF exhibited the weakest flavors of chocolate and milk.

The attribute of smoothness in ice cream is significantly influenced by the microstructure of the product. A key microstructural aspect involved is the size of both ice crystals and air bubbles present. The distribution of ice crystal size and the amount present affect the characteristics of smoothness in ice cream (Clarke, 2004).

One of the main ingredients in chocolate ice cream is cocoa powder, which contains theobromine and caffeine,

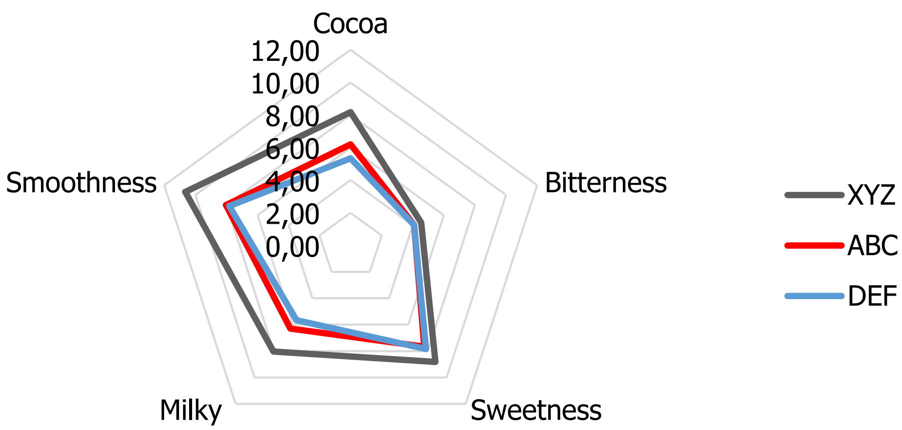


Figure 3. Spider web diagram of chocolate ice cream premix testing results

Table 6. Overrun values of the three samples used

	PT XYZ	PT ABC	PT DFE
Initial Product Weight (g)	84.73	87.5	87.04
Final Product Weight (g)	35.97	31.7	32.15
Overrun	135.5%	176%	170.5%

Description: XYZ (PT XYZ ice cream premix); ABC (PT ABC ice cream premix), DEF (PT DEF premix)

contributing to its bitter taste. Therefore, chocolate ice cream requires additional sweetening compared to other flavored types. Cocoa powder together with the added sweeteners influenced the solid content of chocolate ice cream (Prindiville et al., 1999). The texture and viscosity affect the intensity of aroma perception. Chocolate ice cream lacking milk fat reduces the aroma of cream, milk, and chocolate. This phenomenon highlights the role of milk fat in maintaining the stability of texture and flavor in ice cream during storage (Prindiville et al., 1999).

Overrun and Melting Rate Testing of Chocolate Ice Cream Premix

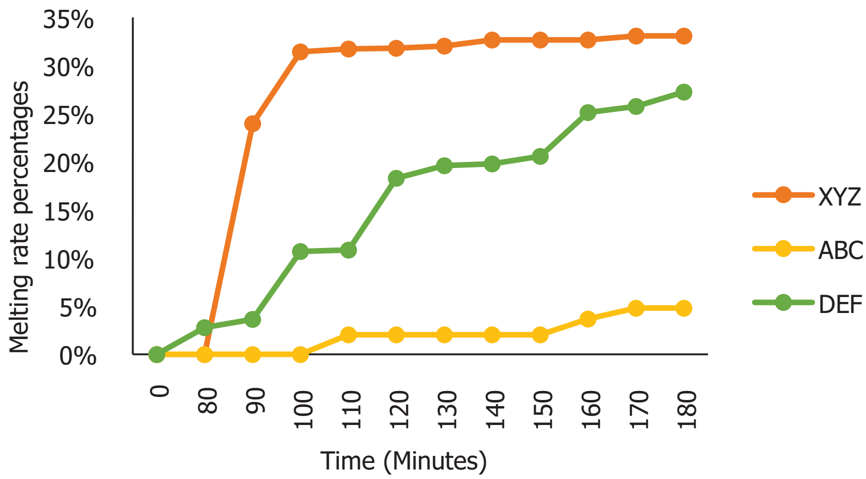
Overrun refers to the foaming ability and foam stability, which are linked to surface tension reduction in a system composed of air and water, caused by the absorption of protein molecules (Failisnur, 2013). It also indicates the amount of air trapped in the ice cream mix due to the freezing process (Goff & Hartel, 2013). Among the three samples, the premix from PT XYZ exhibited a low overrun compared to the other samples, as shown in Table 6. This low overrun value indicated that the amount of air incorporated into the ice cream mix was lower than in the other samples.

The physical composition of ice cream has a significant impact on the melting rate and hardness. The melting rate was found to be influenced by the amount of air within the product, the natural properties of ice crystals, and the network of globular fats formed during freezing (Muse & Hartel, 2004). Ice cream with a rough texture and low total solids content has low resistance to melting, causing it to melt quickly (Failisnur, 2013). Figure 3 illustrates the melting rate test results over a duration of 180 minutes at a room temperature of 24.6 °C and relative humidity of 56%.

The overrun value also influenced the melting rate of ice cream, with samples having low overrun melting faster compared to those with high overrun. This was because ice cream with high overrun had a reduced rate of heat transfer due to the large volume of air encompassed within. Furthermore, the fat network affected the melting rate of ice cream (Muse & Hartel, 2004). The XYZ sample had a low overrun value, resulting in a faster melting rate compared to the other two samples.

Mapping the Characteristics of Chocolate Ice Cream Premix Products

The principal component analysis (PCA) was used to map the characteristics of the chocolate ice cream premix products. This technique helps identify groups of variables that are highly correlated with each other or have no correlation with those from other groups (Meilgaard et al., 2016). It is also used to visualize the relationship



Description: XYZ (PT XYZ ice cream premix); ABC (PT ABC ice cream premix), DEF (PT DEF premix)

Figure 4. Melting rate graph of chocolate ice cream premix

Table 7. Correlation values between chocolate ice cream premix attributes (Pearson correlation matrix (n))

Variables	Chocolate	Bitter	Sweet	Milky	Smoothness	Overrun	Melting rate
Chocolate	**1**	0,957	0,794	**1,000**	0,975	**-0,997**	0,504
Bitter	0,957	**1**	0,585	0,951	0,870	-0,934	0,233
Sweet	0,794	0,585	**1**	0,807	0,909	-0,836	0,925
Milky	**1,000**	0,951	0,807	**1**	0,980	**-0,999**	0,522
Smoothness	0,975	0,870	0,909	0,980	**1**	-0,989	0,682
Overrun	**-0,997**	-0,934	-0,836	**-0,999**	-0,989	**1**	-0,564
Melting rate	0,504	0,233	0,925	0,522	0,682	-0,564	**1**

*Bold numbers are different from 0 and have a significance level of 0.05

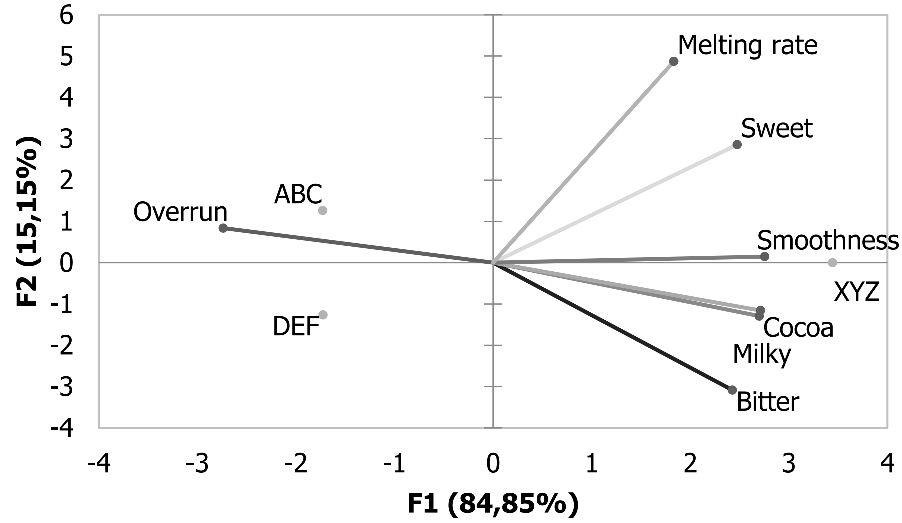


Figure 5. Results of mapping the characteristics of chocolate ice cream premix products using principal component analysis

between product samples and testing attributes. This can be applied to examine consumer preference data and generate internal preference maps (Lawless et al., 2010).

From the Biplot figure, sensory attributes correlated negatively or in the opposite direction to physical attributes (overrun). Product XYZ was positively correlated to texture attributes (smoothness), sweet flavor, and melting rate (Figure 4). Sweet flavor and melting rate were in the same quadrant and close to each other, indicating a positive correlation. Sweeteners in ice cream products affect the freezing point and increase the melting rate (Goff & Hartel, 2013).

Product ABC correlated positively with the physical attribute of overrun and had the highest value compared to other samples. This was attributed to the greater air entrapped in the premix of this product. Meanwhile, based on the results, product PT DEF was in a different quadrant and had distinct characteristics. Correlation values obtained by XLSTAT Table 7 processing implied attributes of chocolate and milky flavors, as well as smoothness. Bitter and sweet flavors showed a close correlation, but in Biplot Figure 5, these attributes had different positions. This was because the addition of more sweeteners reduced the bitter taste of the product.

CONCLUSION

In conclusion, the quantitative descriptive analysis showed that the chocolate ice cream premix from PT XYZ had better sensory attributes compared to PT ABC and PT DEF. However, in terms of physical parameters, the overrun value was lower, resulting in a higher melting rate. Sensory attributes alongside physical parameters such as overrun and melting rate are important factors in consumer product acceptance and should be considered. For the smoothness, chocolate, and milky flavor attributes, the panelists exhibited significant discrimination ability as indicated by the bolded p-values. There was a panel agreement (consensus) for the chocolate, milk, and sweet attributes, as illustrated by the significance at a 95% confidence level. Based on the summary of p-values for panelist discrimination ability, P8 effectively distinguished chocolate, smoothness, as well as milky and sweet flavor attributes. Panelists P5, P4, P1, and P2 had significant abilities for the chocolate flavor attribute, while P4 and P7 effectively distinguished the smoothness attribute. Additionally, P6, P7, and P9 had substantial discrimination abilities for the milky flavor attribute. The nine panelists did not have significant abilities to differentiate the bitter taste among the presented products. Panelist P4 exhibited good consistency in perceiving bitter, chocolate, and sweet attributes, while P6 demonstrated a similar result on the milky flavor, as shown in both SenseHub and XLSTAT 2021 analyses.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest with other parties.

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