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LEVELS OF SOURNESS, BITTERNESS AND SWEETNESS OF CHOCOLATE PRODUCTS ON CONSUMER ACCEPTANCE (CASE STUDY IN THE SPECIAL REGION OF YOGYAKARTA, INDONESIA)

TINGKAT ASAM, PAHIT DAN MANIS PRODUK COKELAT TERHADAP PENERIMAAN KONSUMEN (STUDI KASUS DI DAERAH ISTIMEWA YOGYAKARTA, INDONESIA)

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ABSTRAK

Identitas produk cokelat di Indonesia umumnya diasosiasikan dengan rasa manis yang tinggi, sehingga menimbulkan persepsi keliru terhadap cokelat couverture yang idealnya memiliki keseimbangan antara rasa asam, pahit, dan manis. Penelitian ini bertujuan untuk mengevaluasi tingkat penerimaan konsumen terhadap enam formulasi cokelat couverture di Provinsi Daerah Istimewa Yogyakarta (DIY) serta menentukan formulasi paling disukai berdasarkan profil sensori yang seimbang. Sebanyak 500 panelis tidak terlatih berusia 15–60 tahun dipilih menggunakan metode convenience sampling dari lima kabupaten di wilayah DIY. Panelis menilai atribut rasa manis, pahit, asam, aroma, tekstur, dan kesukaan keseluruhan melalui uji hedonik dan uji pemeringkatan. Parameter fisikokimia yang dianalisis meliputi pH, viskositas, dan kekerasan untuk mendukung hasil uji sensori. Hasil menunjukkan bahwa formulasi F1 dan F2 memperoleh skor kesukaan keseluruhan tertinggi karena memiliki tingkat kepahitan dan keasaman sedang, rasa manis yang disukai, serta tekstur yang lebih lembut. Uji pemeringkatan mengonfirmasi hasil tersebut dengan nilai peringkat terendah pada F1 dan F2. Analisis fisikokimia menunjukkan pH lebih tinggi (6,68 dan 6,63), viskositas sedang (6.580 dan 5.140 cP), dan kekerasan lebih rendah (46,83 dan 50,52 N). Faktor usia berpengaruh signifikan terhadap preferensi, di mana konsumen muda lebih menyukai cokelat yang manis dan lembut.

Kata kunci: cokelat; evaluasi sensori penerimaan konsumen; preferensi konsumen

ABSTRACT

In Indonesia, chocolate products are often associated with high sweetness, leading to distorted consumer perceptions of couverture chocolate, which ideally balances acidity, bitterness, and sweetness. This study aimed to evaluate consumer acceptance of six chocolate couverture formulations in the Special Region of Yogyakarta (DIY) and identify the most preferred formulation based on a balanced sensory profile. Using convenience sampling, 500 untrained panelists aged 15–60 years were selected across five districts in DIY Province. Participants evaluated sweetness, bitterness, acidity, aroma, texture, and overall acceptability through hedonic and ranking tests. Physicochemical parameters (pH, viscosity, and hardness) were also measured to support sensory findings. Results showed that formulations F1 and F2 achieved the highest overall acceptability scores due to moderate bitterness and acidity, preferred sweetness, and smoother texture. The ranking test confirmed these results, with F1 and F2 recording the lowest mean ranks. Physicochemical analysis supported these findings, showing higher pH (6.68 and 6.63), moderate viscosity (6,580 and 5,140cP), and lower hardness (46.83 and 50.52 N). Consumer age significantly influenced preference, with younger respondents favoring sweeter and softer chocolate. These findings emphasize the importance of optimizing sensory and textural attributes to meet diverse consumer expectations.

Keywords: consumer acceptance; consumer preference; chocolate; sensory evaluation

INTRODUCTION

Chocolate, derived from cocoa (*Theobroma cacao* L.), holds a significant place in global food consumption due to its rich flavour, texture, and versatility. Cocoa, a major agricultural commodity, forms the backbone of chocolate production and is vital to the economies of many producing countries. In Indonesia, chocolate is cherished as a confectionery item and has a substantial market, yet consumer perceptions about its flavour and identity remain inconsistent. Most consumers associate chocolate with sweetness, a perception largely driven by the dominance of compound chocolate in the market. Compound chocolate, which contains additional vegetable oils, is affordable, resistant to

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melting, and milder in taste, making it the preferred choice for many (Tarigan *et al.*, 2016; Fasha *et al.*, 2022). Despite the prevalence of compound chocolate, couverture chocolate—crafted from pure cocoa butter and cocoa solids—offers a superior flavour profile. Couverture chocolate retains the original bitterness and acidic notes of cocoa, making it distinctively richer than compound chocolate. These differences underscore the need to explore consumer perceptions and preferences for high-quality chocolate products, especially in regions with strong cocoa production potential, such as the Special Region of Yogyakarta (DIY Province) in Indonesia.

In recent years, the Indonesian chocolate market has experienced a gradual transformation toward more premium and artisanal consumption patterns. Young urban consumers are becoming increasingly interested in high-quality chocolate products that emphasize origin, authenticity, and craftsmanship. This shift reflects a broader lifestyle trend where food is perceived not only as nourishment but also as an expression of identity and sophistication. Aprilia and Hartatri (2022) identified that young, digitally literate consumers (particularly women) are the dominant segment of the local chocolate market, valuing product quality, design, and experiential aspects over affordability. Similarly, Suyanto and Soebiantoro (2023) observed that Generation Z consumers in Surabaya exhibit purchasing behaviour driven by brand image and packaging aesthetics when selecting premium chocolate products. These findings suggest that Indonesia's emerging consumer base increasingly associates chocolate with exclusivity and emotional value, creating opportunities for local producers to innovate through small-batch, couverture, and single-origin artisan chocolates tailored to evolving urban tastes.

This study aimed to examine consumer preferences for six couverture chocolate formulations in DIY Province by assessing key sensory attributes such as flavour (bitterness, acidity, and sweetness levels), aroma, and texture. The primary goal was to identify the most preferred sensory profile and provide actionable data for developing high-quality chocolate products that align with local consumer desires. Additionally, this research contributes to sustainable development in the cocoa industry, aligning with the United Nations' Sustainable Development Goals (SDGs), particularly in fostering innovation and industrial growth.

Chocolate's sensory appeal arises from its complex composition. According to Afoakwa et al. (2009), chocolate is broadly classified into dark, milk, and white variants. Dark chocolate features a higher cocoa content, with at least 50% cocoa solids, while milk chocolate combines cocoa with milk solids, creating a creamier taste and texture. Sensory studies in Europe have shown that consumer preferences vary by region. In Austria and Germany, the primary attributes driving dark chocolate acceptance are bitterness, sweetness, acidity, and the characteristic chocolate taste (Thamke *et al.*, 2009). Similarly, Italian consumers exhibit a preference for dark, extra-dark, and milk chocolates, with gender and geographical factors influencing choices (Merlino *et al.*, 2021).

In Indonesia, research by Fortunata et al. (2021) revealed that chocolate consumers prioritize attributes like flavour, price, type, size, and shape. However, these studies have largely focused on compound chocolate, leaving a gap in understanding preferences for couverture chocolate. Furthermore, sensory evaluation studies often highlight the importance of texture, viscosity, and aroma, which are influenced by chocolate's physicochemical properties, such as particle size, fat content, and tempering conditions (Tan and Balasubramanian, 2017).

Indonesia's cocoa industry is one of the largest globally, yet its potential remains underutilized, particularly in the production of premium chocolate products. DIY Province, with its fertile soil and favourable climate, is a hub for high-quality cocoa production. Despite this, consumer preferences for couverture chocolate in this region had not been thoroughly explored. The novelty of this study lies in its focus on evaluating consumer acceptance of couverture chocolate formulations in DIY Province, a market with untapped potential. By incorporating sensory evaluation methods—such as hedonic and ranking tests—and physicochemical analyses, this research bridges the gap between consumer preferences and product development. The results aim to guide local producers in crafting chocolate products that meet both quality standards and market demands, fostering sustainable growth in the cocoa sector.

This study offers valuable insights into how consumer preferences shape product development in the food industry. It highlights the significance of sensory attributes, such as bitterness, sweetness, aroma, and texture, in determining the acceptability of chocolate. Moreover, it underscores the role of physicochemical properties, such as pH, viscosity, hardness, and particle size, in creating the desired sensory experience. This research is particularly relevant in the context of global sustainability initiatives. The findings contribute to the development of high-quality chocolate products that leverage local resources, reduce dependency on imports, and create opportunities for small-scale producers. By aligning consumer preferences with product innovation, the study supports the sustainable development of Indonesia's cocoa industry while promoting the cultural and economic potential of DIY Province. In summary, this study addresses critical gaps in the understanding of consumer preferences for couverture chocolate in Indonesia. By evaluating sensory and physicochemical attributes, it provides

actionable insights for the development of chocolate products that cater to local tastes. The findings have broader implications for the global chocolate industry, emphasizing the importance of balancing sensory appeal with sustainable practices.

MATERIAL AND METHODS

Sample Preparation

Sample preparation was conducted in two locations: the roasting process took place at the Fabrication Laboratory, Field Research Center, Universitas Gadjah Mada (UGM), and the chocolate processing was carried out at the Cocoa Processing Laboratory, Department of Biotechnology and Veterinary Technology, Vocational College, UGM.

The chocolate-making process began with roasting cocoa beans and peeling the bean shells using a Cylindrical Roaster and Cocoa Winnower at the Field Research Center, UGM, with a capacity of 10 kg per batch. The cocoa nibs were then processed at the Cocoa Processing Room, Department of Biotechnology and Veterinary Technology, UGM, through the refining, conching, tempering, and moulding stages.

The final chocolate product was produced at a laboratory scale to conserve energy and time, as there were six formula variations (Table 1). Ingredient mixing for each formula was performed during the refining process using a ball mill. The mixture consisted of cocoa nibs, cocoa butter, milk, sugar, lecithin, and vanilla. The maximum capacity for a single refining process required 3.5 kg of cocoa beans.

Following refining, the conching process was conducted for 16 hours at a temperature of 60°C (Rasuluntari *et al.*, 2016). The next step was tempering, which was done using a stainless-steel table, knife, and scraper until the mixture reached a stable temperature of 30°C. Moulding was then performed using mini moulds.

The molded chocolates were packaged as samples and stored in a refrigerator for further analysis. The target output after molding was 500 pieces for each variant.

Sensory Panel

Sensory testing was conducted through a hedonic test using an organoleptic approach. A total of 500 panelists participated, distributed proportionally across the City of Yogyakarta, Sleman Regency, Bantul Regency, Kulon Progo Regency, and Gunung Kidul Regency in the Special Region of Yogyakarta, ensuring an equitable geographical representation. The panelists were selected using a convenience sampling method, with a focus on general consumers. The criteria for inclusion as an untrained consumer panelist were: (1) aged between 15 and 60 years old; (2) resided in one of the five districts of the DIY Province; and (3) was a regular chocolate consumer (defined as consuming any type of chocolate product at least once in the past month). This approach ensures that the panel represents the target market segment for chocolate products in the region. According to Djekic *et al.* (2021), trained panellists typically consist of 8–15 individuals with a good level of sensitivity toward the products being tested, while untrained panelists range from 25–100 individuals Bos *et al*. (2013). In this study, 3% of the panelists were experts, and 97% were untrained panelists. Expert panelists included researchers, academics, and business owners involved in the chocolate industry. This approach ensured that panellists represented the target market segment for chocolate products in Yogyakarta Province.

The sensory evaluation was conducted using both ranking tests and hedonic tests in accordance with ISO 8587:2006 and ISO 11136:2014 standards, respectively, with adjustments based on Rasuluntari *et al.* (2016). The attributes evaluated included acidity, bitterness, sweetness, texture, and aroma. Six coded samples were presented in individual containers, and mineral water was provided to neutralize the palate between samples. Panelists were instructed to assess all attributes based on their level of preference using a six-point rating scale: 1) Dislike; 2) Neutral; 3) Slightly like; 4) Like; 5) Strongly like; 6) Extremely like. All chocolate samples were removed from refrigeration 24 hours prior to testing, standardized in size, and maintained at room temperature (22 °C) throughout the evaluation process (Cantini *et al*., 2018). The overall testing procedure was aligned with the general principles of sensory analysis described in SNI 2346:2015

Table 1. Formula variations of sample

Formula	F1	F2	F3	F4	F5	F6
Nib (%)	27.3	31.8	36.4	50	60	70
Butter (%)	18.2	15.6	13.0	20	20	20
Milk (%)	22.7	22.7	22.7	0	0	0
Sugar (%)	31.3	29.3	27.4	29.4	19.4	9.4
Others (%)	0.6	0.6	0.6	0.6	0.6	0.6

Note: F1-F3 is milk chocolate, F4-F6 is dark chocolate

Physicochemical Analysis

The physicochemical analysis was conducted at the Quality Laboratory, Department of Biotechnology and Veterinary Technology, Vocational School, Universitas Gadjah Mada. This stage involved quantitative testing of the prepared chocolate samples, focusing on sensory analyses, including acidity level (pH), texture, viscosity, and particle size. Acidity was measured using a pH meter. According to Moser (2015), pH significantly influences the taste and color of chocolate products. Higher pH levels are associated with darker colors in the final chocolate product. Texture analysis was conducted to determine consumer preferences regarding the smoothness of the chocolate when consumed. The testing employed an IMADA Texture Analyzer FRTS-50N-I, with the chocolate samples in a round shape and a diameter of approximately 20 mm, analyzed at room temperature. The output parameters included hardness, stickiness, and chewiness. The testing was performed at a speed of 5 mm/s, with a recovery time of 0 seconds and a hold time of 0 seconds (Fibrianto *et al.*, 2021). Viscosity was analyzed using a Brookfield Viscometer DVEELVTJ0. Prior to testing, the chocolate samples were melted in an incubator at 38°C for one hour and analyzed at 20 rpm (He, 2024).

Statistical Analysis

The data analysis began with the collection of primary data obtained from the hedonic test, processed using Microsoft Excel 2010. The primary data were then analyzed using descriptive and statistical approaches. Descriptive analysis included presenting bar charts showing the proportion of ratings for each scale. Additionally, numerical scale data were visualized using spider web analysis to illustrate consumer preference patterns. The statistical analysis of hedonic test results employed multiple methods to determine differences in consumer acceptance across the chocolate variants provided. The tests included Kruskal-Wallis Test, Friedman Test, and ANOVA (Analysis of Variance). If significant differences were identified, further analysis was conducted using Duncan's Multiple Range Test (DMRT) with a 5% error rate to pinpoint specific variations. To fulfill the need for detailed market segmentation insight, further analysis will be conducted using the Mann-Whitney U test or Kruskal-Wallis test (for non-parametric data) and ANOVA (for parametric data) to assess the influence of demographic factors (Gender, Age Group, and Last Education) on the overall acceptance scores.

RESULTS AND DISCUSSIONS

Consumer Profile and Demographic Influence

The consumer participants (Table 2) consisted of 500 untrained panellists aged 15–60 years, proportionally selected from five districts in Yogyakarta Province. Most participants were female (58%) and aged 21–35 years (43%), representing the dominant age group of active chocolate consumers in the region. More than 60% had completed at least secondary education, and 64% reported consuming chocolate at least once a week, indicating high product familiarity and representativeness of the target market segment in Yogyakarta. The inclusion of regular chocolate consumers as untrained panellists ensured that the sensory responses reflected realistic preferences rather than expert evaluations. Similar sampling strategies were employed in local consumer studies by Fortunata *et al*. (2021), which demonstrated that familiarity and consumption frequency influence hedonic consistency and purchase intention among Yogyakarta consumers.

A Kruskal–Wallis test was performed to examine the influence of demographic variables (gender, age, and education level) on overall liking scores. The results showed that all demographic variables (age group, gender, education level) exhibited statistically significant differences on liking ($p < 0.05$). Younger participants (15–25 years) expressed higher preference for formulations with stronger sweetness and smoother texture (notably F1 and F2), while older participants tended to appreciate samples with more balanced cocoa bitterness.

Table 2. Demographic of consumer participants

Demographic Factor		Mean Rank	Kruskal-Wallis H	p-value
Gender	Male	1365.60	-	0.000
	Female	1561.11		
Age Group	15 – 25	1897.35	958.296	0.000
	26 – 36	1002.89		
	37 – 47	739.49		
	48 - 60	859.96		
Education	Elementary	1467.90	357.149	0.000
	Junior High School	1750.08		
	Senior High School	1671.05		
	Diploma	846.14		
	Bachelor	1075.52		
	Master	982.56		
	PhD	964.72		

This finding aligns with the observations of Hasanah *et al*. (2014), who reported that age and cultural exposure influence taste thresholds and preference for sweet and bitter flavours in Indonesian consumers. It also supports the results of Lebiedowska *et al*. (2025), which indicated that exposure to confectionery products in early adulthood leads to stronger liking for sweeter products. Moreover, educational level did not significantly affect hedonic perception, although respondents with tertiary education exhibited slightly more differentiated evaluations, likely reflecting greater product awareness and familiarity with quality cues. In summary, the results suggest that age-based segmentation remains a critical factor in chocolate product development. Younger consumers in Yogyakarta preferred sweeter and smoother chocolate, while older consumers valued the authenticity of cocoa bitterness and balanced flavour complexity. This differentiation supports a dual product and marketing strategy, combining indulgent, sweet-style products targeting the youth market and more intense, dark-type products aimed at mature consumers—consistent with recommendations from Fortunata *et al.* (2021) regarding local chocolate market segmentation in Yogyakarta.

Sensory Characteristics of Couverture Chocolate

The hedonic test results (Table 3) revealed significant differences among the six chocolate formulations across all sensory attributes ($p < 0.05$). Mean overall liking scores ranged from 2.63 ± 0.891 (F6) to 3.25 ± 1.342 (F2), indicating moderate overall acceptance. Sweetness and texture emerged as the most influential attributes affecting overall liking. Formulations F1 (4.26 ± 1.349) and F2 (4.33 ± 1.266) obtained the highest sweetness ratings, whereas F6 (1.20 ± 0.656) was the least liked. The preference for F1 and F2 suggests that higher sugar content or better balance between cocoa solids and fat improved perceived palatability. Similar trends have been reported by Cantini et al. (2018), where sweetness and volatile aroma components are key determinants of chocolate acceptance. Bitterness showed an inverse relationship with preference. The lowest bitterness scores were observed for F5 (1.71 ± 1.233) and F6 (1.40 ± 1.027), while F1 (3.55 ± 1.387) and F2 (3.60 ± 1.362) exhibited more moderate values that maintained cocoa character without overpowering taste. Afoakwa (2010) and Gunaratne et al. (2019) similarly noted that a balance between bitterness and sweetness contributes to desirable flavour complexity in dark chocolate. Regarding texture, F1 (3.87 ± 1.479) and F2 (4.01 ± 1.391) received the highest ratings, while F5 (2.75 ± 1.393) and F6 (2.87 ± 1.316) were less preferred. These differences likely reflect variations in viscosity and hardness, as perceived smoothness and meltability are influenced by fat content and particle size (Afoakwa, 2014; Beckett, 2015).

The findings of this study align with previous research highlighting the critical role of sensory attributes in shaping consumer preferences for chocolate products. Purba et al. (2018) emphasized that taste, texture, and aroma were the most influential sensory dimensions driving satisfaction among Indonesian chocolate consumers, while packaging and product variety supported the overall perception of quality. Their importance–performance analysis (IPA) revealed that improvements in taste balance and textural smoothness were essential for increasing product competitiveness in the domestic market. Similarly, Kusumaningrum et al. (2014) underlined the necessity of incorporating the voice of consumers into the new product development (NPD) process to ensure that the final product formulation reflects actual market expectations. Applying this perspective to couverture chocolate implies that sensory optimization—particularly in sweetness, bitterness, and mouthfeel—should be guided not only by technical formulation targets but also by consumer-derived insights. Therefore, the present findings reinforce the idea that a consumer-centred approach in developing couverture chocolate can enhance both acceptance and market relevance. By aligning sensory quality attributes with consumer preference patterns, local chocolate producers can strengthen product differentiation and foster innovation within Indonesia's cocoa-based food industry.

Table 3. Hedonic rating test result

	F1	F2	F3	F4	F5	F6
Odour	3.64±1.336^{a}	3.67±1.371^{a}	3.40±1.278^{b}	3.29±1.243^{bc}	3.13±1.459^{c}	3.41±1.379^{b}
Texture	3.87±1.479^{a}	4.01±1.391^{a}	3.50±1.405^{b}	3.24±1.283^{c}	2.75±1.393^{d}	2.87±1.316^{d}
Sweetness	4.26±1.349^{a}	4.33±1.266^{a}	3.78±1.342^{b}	2.74±1.316^{c}	1.66±1.106^{d}	1.20±0.656^{e}
Bitterness	3.55±1.387^{a}	3.60±1.362^{a}	3.29±1.335^{b}	2.43±1.336^{c}	1.71±1.233^{d}	1.40±1.027^{e}
Acidity	3.29±1.356^{a}	3.33±1.342^{a}	3.02±1.260^{b}	2.41±1.153^{c}	1.91±1.034^{d}	1.73±0.891^{e}
Overall	3.22±1.356^{a}	3.25±1.342^{a}	2.97±1.260^{b}	3.03±1.153^{b}	2.95±1.034^{b}	2.63±0.891^{c}

Note: Scores in one row with a different superscript are significantly different at $P < 0.05$ (one-way ANOVA and post-hoc Duncan's Multiple Range Test)

Different formulations have different sensory profiles, as seen in the radar graph (Figure 1). F1 and F2 were the most well-rounded in terms of aroma, texture, and sweetness, while F6 was at the bottom in almost every category. All things considered, the hedonic evaluation showed that formulas with a balance of mild chocolate bitterness, sufficient sweetness, and silky texture were the most popular with consumers (Muktiningrum *et al.,* 2022).

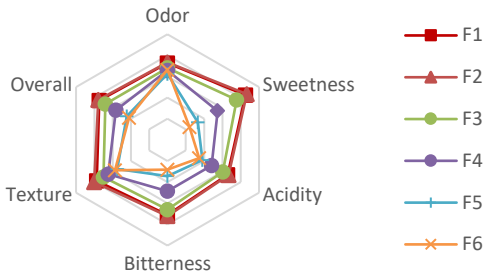

Figure 1. Radar graph of sensory analysis for chocolate couverture with different formulations

From the demographic characteristics that affected hedonic reactions, age was shown to have a significant effect on overall liking ($p < 0.05$), while neither gender nor educational level had any significant impact ($p > 0.05$). Younger panellists (those under the age of 25) preferred the smoother, sweeter F1 and F2 varieties, while older panellists (those over the age of 35) preferred the bittersweet, dark chocolate kind. This finding is in line with previous research by Hasanah *et al.* (2014), which reported that age affects sweet-bitter taste thresholds among Indonesian consumers, Demographic characteristics affected the sensory acceptability of cocoa-based drinks, as seen in a similar manner Fortunata *et al*. (2021), who observed that younger Yogyakarta consumers favour sweeter chocolate products, while mature consumers value authentic cocoa intensity. Kusumaningrum *et al*. (2021), found a comparable trend in their study on the impact of demographics on the sensory acceptability of cocoa-based drinks. Based on these results, chocolate manufacturers may target different age groups with different products: those seeking premium cocoa characteristics with darker, more intense chocolate items and those seeking a sweeter couverture variety.

The ranking test results confirmed the hedonic findings (Table 4). All qualities, including smell ($\chi^2 = 91.774$), sweetness ($\chi^2 = 1463.063$), acidity ($\chi^2 = 594.781$), bitterness ($\chi^2 = 475.592$), and texture ($\chi^2 = 268.331$), were shown to have significant differences across samples in the Friedman test, with a p-value of 0.000. A greater preference is shown by lower scores on the ranking exam. F1 and F2 seemed to dominate in terms of consumer choice, as they recorded the lowest mean ratings for sweetness (2.09 ± 1.26) and 2.19 ± 1.18, respectively. In contrast to the hedonic test pattern, F6 had the highest ranking score (least preferred) of 5.616 ± 0.85. Intermediate places were held by F3 (2.69 ± 1.11) and F4 (3.796 ± 1.05) across characteristics, indicating moderate acceptance. According to McClure *et al.*, (2022) the samples showed balanced This suggests that a more balanced flavour perception contributes to the samples' wider consumer appeal. The sensory results are more trustworthy since hedonic and rating data are consistent. Harmony between preference ranking and hedonic score shows that samples consistently discriminate based on sensory input, as shown by Meilgaard *et al.* (2016). The two most popular formulas, F1 and F2, were noted for their mild bitterness, improved texture, and increased sweetness.

Physicochemical Characteristic of Couverture Chocolate

All six chocolate recipes' physicochemical properties are shown in Table 5. All criteria, such as pH, viscosity, and hardness, demonstrated significant variations across the formulations ($p < 0.05$). The pH values ranged from 6.22 ± 0.00 (F6) to 6.68 ± 0.01 (F1). From F1 to F6, the hedonic acidity ratings declined with decreasing pH (Table 3), which indicates that either a higher cocoa content or less conching resulted in increased acidity.

Table 4. Ranking test result based on ranking scores

Parameter	Odour	Sweetness	Acidity	Bitterness	Texture
Chi-Square	91.774	1463.063	594.781	475.592	268.331
df	5	5	5	5	5
p-value	0.000	0.000	0.000	0.000	0.000
F1	3.06±1.64	2.09±1.26	2.58±1.49	2.77±1.59	2.85±1.69
F2	3.15±1.75	2.19±1.18	2.71±1.59	2.80±1.61	2.79±1.61
F3	3.47±1.50	2.69±1.11	3.00±1.39	3.03±1.33	3.39±1.57
F4	3.60±1.48	3.796±1.05	3.63±1.38	3.52±1.24	3.63±1.44
F5	4.02±1.61	4.658±1.10	4.27±1.49	4.11±1.53	4.20±1.64
F6	3.69±2.00	5.616±0.85	4.85±1.59	4.80±1.83	4.16±1.70

Table 5. Physicochemical characteristic

Formula	pH	Viscosity (cP)	Hardness (N)
F1	6.68 ± 0.01^{f}	$6,580 \pm 105.83^{f}$	46.83 ± 0.204^{a}
F2	6.63 ± 0.02^{e}	$5,140 \pm 52.91^{e}$	50.52 ± 0.60^{b}
F3	6.58 ± 0.00^{d}	$2,940 \pm 10.00^{d}$	50.61 ± 0.017^{b}
F4	6.31 ± 0.02^{c}	$1,790 \pm 10.00^{c}$	50.61 ± 0.02^{b}
F5	6.26 ± 0.01^{b}	$1,180 \pm 17.32^{b}$	50.81 ± 0.17^{c}
F6	6.22 ± 0.00^{a}	110 ± 2.00^{a}	51.20 ± 0.086^{d}
Sig.	0.00	0.00	0.00

Note: Scores in one row with a different superscript are significantly different at $P < 0.05$ (one-way ANOVA and post-hoc Duncan's Multiple Range Test)

Evidence from this association suggests that even little variations in pH levels in chocolate are perceived by humans as having a high acidity level (Beckett, 2015). The most noticeable change was in viscosity, which dropped from 6,580 ± 105.83cP (F1) to 110 ± 2.00cP (F6). A decrease in viscosity improves a liquid's flow and smoothness and may influence the release of flavour as well. It is suggested that a moderate viscosity is excellent for a nice mouthfeel, since the sensory results indicated that F2 had an intermediate viscosity level of 5,140 ± 52.91cP and F3 had 2,940 ± 10.00cP (Afoakwa, 2014; Sari *et al.*, 2022). Hardness increased progressively from 46.83 ± 0.204 N (F1) to 51.20 ± 0.086 N (F6). The significant differences ($p = 0.00$) suggest that higher fat crystallization and lower moisture contributed to firmer textures. The negative association between hardness and texture liking observed here agrees with Subroto *et al*. (2022) who reported that excessive hardness reduces the perceived melt-in-mouth quality of dark chocolate.

Formulations F1 and F2, which had a little higher pH, moderate viscosity, and lower hardness, were shown to have a greater level of sensory acceptability when the physicochemical and sensory results are taken into account. The least liked was F6, which had low viscosity and high hardness. Consumer perception and product quality are both positively impacted by physicochemical optimisation, as these links demonstrate.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

A combination of sensory and physicochemical variables significantly influenced the likeability of six distinct chocolate recipes, according to this study. Based on their high sweetness scores (4.26 ± 1.349 and 4.33 ± 1.266) and good texture ratings (3.87 ± 1.479 and 4.01 ± 1.391), F1 and F2 were consistently named as the most desired options in the hedonic and ranking tests. In contrast, F6 was not very popular due to its lack of sweetness (1.20 ± 0.656) and excessive hardness (51.20 ± 0.086 N). Moderate pH (6.63–6.68), viscosity (5,140–6,580cP), and hardness below 50 N were found to be related to higher sensory acceptability in physicochemical tests. These results are in line with what we already know about the sensory and rheological properties of chocolate: smoother textures and balanced flavour intensities make people like it more (Afoakwa, 2010; Cantini *et al.,* 2018; Muktiningrum *et al.,* 2022). In general, the results show that product optimisation should focus on finding the right balance between sweetness and bitterness while also controlling viscosity and hardness to get the right consumer perception. The study also shows that using both sensory evaluation and instrumental measurements is a strong way to create chocolate recipes that will sell well.

Recommendations

This study's results led to a number of suggestions for helping chocolate couverture products grow in the market and develop new products. Future formulation endeavours must prioritise the attainment of a balanced sensory profile through the optimisation of sweetness, bitterness, acidity, aroma, and texture, as evidenced by the efficacy of formulations F1 and F2. It is critical to maintain high pH levels and moderate viscosity for improved mouthfeel and increased customer appeal. It is essential to regulate the fat content and particle size distribution throughout processing. Because most Indonesians think of chocolate as sweet, there has to be an effort to change people's perceptions by highlighting the rich bitter and acidic notes that are actually present in couverture chocolate. Additionally, via the use of focused marketing tactics, items with more complex flavour profiles, such as F5 and F6, which are acidic and bitter, might be offered to specific consumers. To improve the prediction of preference shifts, future study should include consumer behaviour analysis and include a broader range of demographic groupings. Improving product quality could also be possible by looking at different kinds of ingredients, including different milk solids or sugars. Sustainability initiatives, local economies, and the SDGs pertaining to industry, innovation, and infrastructure might all benefit from a greater emphasis on sourcing and marketing cocoa from Yogyakarta.

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