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Sensory Profiling and Consumer Preference of Local Ginger Chocolate Bars Using Rate-All-That-Apply

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ABSTRACT

Commercial ginger chocolate bars combine cocoa flavour with pungent, warming ginger notes, yet differences in cocoa ingredients, fat systems, milk components, ginger form, and processing can yield markedly different consumer responses. This study compared five purposively selected Indonesian commercial ginger chocolate bars, anonymized as KR, NM, MG, CU, and MJ, and integrated consumer-based Rate-All-That-Apply (RATA), preference mapping, and product-level total sugar measurement. A focus group of 10 selected participants generated a final lexicon of 19 attributes covering aroma, appearance, taste, texture/mouthfeel, and aftertaste. Eighty untrained panelists aged 20-40 years evaluated five coded samples; 0 indicated that an attribute was not perceived, whereas 1-5 represented increasing intensity, and overall liking was rated on a six-point hedonic scale. RATA data were analysed using Kruskal-Wallis and Dunn tests, principal component analysis (PCA), and preference mapping. Total sugar was determined by the anthrone method against a glucose standard coefficients across five products were treated strictly as exploratory. Eighteen attributes differed significantly, while milky aroma did not ($p=0.085$). PCA explained 83.39% of sensory variation. KR occupied the 80-100% overall acceptance region and was associated with sweet taste, sweet aftertaste, brown colour, and milky aroma; MJ occupied the 60-80% region and was associated with softness and melting. Among the descriptive age-group maps, panelists aged 26-35 years showed the strongest acceptance pattern, with KR and MJ both located in the 80-100% region; this subgroup was therefore highlighted in the manuscript. MG had the highest total sugar (13.02%) but was not the most preferred, illustrating that anthrone-derived sugar concentration is not equivalent to perceived sweetness or liking. The findings support product development that balances ginger identity with familiar cocoa flavour, controlled pungency, and a soft-melting texture.

Contribution to Sustainable Development Goals (SDGs):

SDG 9: Industry, Innovation and Infrastructure

SDG 12: Responsible Consumption and Production

1. INTRODUCTION

Chocolate-bar quality emerges from interactions among cocoa solids, cocoa butter or alternative fats, sugar, milk ingredients, flavouring materials, particle structure, and processing conditions. These factors determine cocoa aroma, sweetness-bitterness

balance, surface gloss, hardness, oral lubrication, and melting behaviour [1-3,10]. Ginger (*Zingiber officinale*) is scientifically relevant because its aromatic compounds and pungent gingerols and shogaols add olfactory and trigeminal sensations to a fat-based cocoa matrix. This combination can diversify functional or spice-enriched chocolate, but excessive pungency or persistence may



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compete with familiar cocoa and sweet sensations, reducing acceptance [4].

Consumer-oriented sensory profiling is useful for comparing commercial products whose formulations and manufacturing histories cannot be experimentally controlled. Quantitative Descriptive Analysis (QDA) offers detailed intensity measurement through a selected and trained panel but requires substantial training and reflects expert consensus. Check-All-That-Apply (CATA) is faster and consumer-friendly but records attribute presence rather than intensity. RATA retains consumer-oriented terminology while adding graded intensity for applicable terms, providing more quantitative discrimination than CATA without the full training burden of QDA [5-7]. When combined with hedonic ratings, PCA, and preference mapping, RATA can identify combinations of attributes associated with liking, rather than treating acceptance as a response to a single attribute [7-9].

Previous studies examined formulated ginger chocolate, spice-containing chocolate, or sensory differentiation among chocolate products, but they mainly focused on controlled formulations, general hedonic responses, or products from a single producer [4,9,11]. Direct cross-brand evidence for Indonesian commercial ginger chocolate remains limited, even though retail products differ in cocoa sources, fat systems, milk ingredients, and ginger forms. Recent studies also emphasize that chocolate texture, sweetness-fat interaction, and consumer sensory response operate as interacting phenomena rather than isolated attributes [8,17,18].

The present study addresses this gap by integrating a consumer-generated ginger-chocolate lexicon, RATA profiling, PCA, preference mapping, descriptive age-group maps, and anthrone-derived total sugar values across five commercial products. This combination distinguishes chemical sugar concentration from perceived sweet taste and sweet aftertaste and provides formulation-oriented insight into how cocoa, ginger pungency, appearance, and oral texture jointly relate to acceptance.

The analysis is exploratory because the commercial sample was purposive and product-level sugar correlations were based on only five products.

1.1. Research Objective

This study aimed to: (1) identify and compare the sensory profiles of five local ginger chocolate bars using RATA; (2) determine the combinations of sensory attributes associated with consumer acceptance; (3) identify descriptively the age group showing the strongest acceptance pattern and characterize its preference map without making inferential age-effect claims; and (4) explore product-level relationships among anthrone-derived total sugar, perceived sweet taste, sweet aftertaste, and hedonic response.

2. MATERIALS AND METHODS

2.1. Commercial Samples

Five branded ginger chocolate bars produced by Indonesian manufacturers and available through e-commerce were selected purposively to capture contrasting commercial formulations. Products were eligible when they had intact retail packaging, declared ginger in the ingredient list, and showed label-level variation in cocoa ingredient, fat system, milk component, or ginger form. To preserve commercial anonymity in the manuscript, the five products were designated KR, NM, MG, CU, and MJ. These products represented cocoa beans, cocoa mass, or cocoa powder; cocoa butter or vegetable fat; milk or milk powder components; and ginger supplied as unspecified ginger, extract, candied ginger, or powder. The study was designed to compare these selected products rather than to estimate market share or represent the entire Indonesian ginger-chocolate market. Label-listed formulation contrasts are summarized in Table 1.

Table 1. Label-listed composition and formulation contrasts of the ginger chocolate samples.

Sample	Label-listed composition	Location
KR	Cocoa beans, sugar, cocoa butter, milk powder, ginger, sunflower lecithin, vanilla	Lampung, Indonesia
NM	Cocoa powder, vegetable fat, sugar, soy lecithin, milk, ginger extract	Yogyakarta, Indonesia
MG	Cocoa content (cocoa mass and cocoa butter), sugar, 9.5% candied ginger, soy lecithin, vanilla	Yogyakarta, Indonesia
CU	Cocoa butter, milk-cream powder, sugar, cocoa mass, ginger, soy lecithin	Bali, Indonesia
MJ	Cocoa mass, cocoa butter, sugar, milk powder, ginger powder	Jawa Timur, Indonesia

2.2. Sensory Lexicon and Consumer Evaluation

A focus group discussion was conducted in two sessions with 10 selected participants: five Food Technology students familiar with sensory terminology and five participants experienced with chocolate. Eligibility required good general health, no reported impairment of taste or smell, and no reported chocolate allergy. Participants first evaluated the five products and then discussed and agreed on terms and definitions that could be understood by untrained consumers. The final lexicon comprised 19 attributes: bitter, sweet, milky, and gingery aromas; glossy and brown appearance; sweet, bitter, spicy, and gingery tastes; hardness, softness, melting, and graininess as texture/mouthfeel attributes; and mouth-drying, spicy, sweet, bitter, and balsamic aftertastes. Attribute definitions were printed in the RATA questionnaire.

The consumer test involved 80 untrained panelists aged 20-40 years. Panelists did not receive formal descriptive-panel training; they evaluated the products using the questionnaire terms and definitions developed during the focus group. Eligibility included no reported cocoa allergy and no current impairment of taste or smell. Each panelist evaluated all five samples. Products were served in coded cups using random numeric codes, and presentation order was randomized. Water was provided as a palate cleanser between samples. For every RATA term, panelists first indicated applicability: 0 meant that the attribute was not perceived, whereas 1-5 represented low to high perceived intensity. The procedure therefore combined a non-applicability code with a five-category intensity component suitable for untrained consumers [5]. Overall liking was rated from 1 (dislike extremely) to 6 (like extremely), deliberately omitting a neutral category. Age was grouped descriptively as 20-25, 26-35, and 36-40 years.

2.3. Total Sugar Analysis

Total sugar was measured in duplicate using the anthrone-sulfuric acid colorimetric method. One millilitre of filtered sample extract was reacted with 0.1% anthrone reagent, heated in a 100 deg C water bath for 12 min, cooled, and measured at 630 nm. Concentrations were calculated against a glucose standard curve [14,15]. The anthrone response reflects acid-dehydrated carbohydrate-derived colour and was used here as a comparative chemical index of total sugar against glucose; it does not directly measure sensory sweetness, which also depends on tastant release, bitterness, aroma, fat phase, texture, and oral processing.

2.4. Statistical Analysis

Data were analysed using XLSTAT Statistical Software 2026. RATA intensities were summarized by product, and differences among the five samples were evaluated using the Kruskal-Wallis test at $\alpha=0.05$, followed by Dunn's multiple-comparison test when significant. PCA was applied to product-level mean RATA intensities to visualize relationships among products and attributes; F1 and F2 were retained for interpretation. Preference maps were generated in XLSTAT by overlaying hedonic responses on the sensory space using five acceptance regions: 80-100%, 60-80%,

40-60%, 20-40%, and 0-20% of panelists with liking above their individual mean. Age-group preference maps for 20-25, 26-35, and 36-40 years were examined descriptively; the 26-35-year group showed the strongest acceptance pattern and is therefore presented as the age-group map in the Results. No inferential product-by-age interaction test was conducted.

3. RESULT AND DISCUSSION

3.1. Focus Group Discussion (FGD) Results

The FGD was conducted in two sessions with 10 selected participants. During the first session, participants evaluated the five ginger chocolate products and reviewed candidate sensory terms; the second session was used to consolidate the terms and operational definitions for use by untrained consumers. The sour taste and sour aftertaste were not retained because they were not consistently detected during the FGD. The final lexicon contained 19 attributes across five domains: aroma, appearance, taste, texture/mouthfeel, and aftertaste. Graininess was classified as a texture/mouthfeel attribute, and uniform colour was not retained in the final lexicon (Table 2).

Table 2. Final sensory lexicon established by Focus Group Discussion (FGD).

Parameter	Attribute	Operational description
Aroma	Bitter aroma	Aroma with a distinct bitter-like note.
Aroma	Sweet aroma	Aroma associated with sugar, caramel-like sweetness, or vanilla.
Aroma	Milky aroma	Soft aroma characteristic of milk or dairy ingredients.
Aroma	Gingery aroma	Characteristic ginger or spice aroma.
Appearance	Glossiness	Shiny or glossy appearance of the chocolate surface.
Appearance	Brown colour	Perceived brown colour of the chocolate sample.
Taste	Sweet taste	Sweet taste associated with sugar or other sweetening ingredients.
Taste	Bitter taste	Bitter or sharp taste sensation perceived on the tongue.
Taste	Spicy taste	Hot or pungent sensation perceived on the tongue.
Taste	Gingery taste	Characteristic taste associated with ginger.
Texture/Mouthfeel	Hardness	Degree of hardness perceived when the chocolate is bitten.
Texture/Mouthfeel	Softness	Soft sensation perceived in the mouth.
Texture/Mouthfeel	Melting	Sensation of the chocolate melting in the mouth.
Texture/Mouthfeel	Grainy texture	Sandy or flour-like particulate sensation perceived in the mouth.
Aftertaste	Mouth-drying aftertaste	Drying sensation remaining in the mouth after tasting.
Aftertaste	Spicy aftertaste	Spicy and warming sensation that persists after swallowing.
Aftertaste	Sweet aftertaste	Sweet sensation remaining in the mouth after swallowing.
Aftertaste	Bitter aftertaste	Bitter sensation remaining in the mouth after swallowing.
Aftertaste	Balsamic aftertaste	Warm, slightly sharp sensation persisting from the base of the tongue toward the throat.

3.2. Sensory Differentiation of Ginger Chocolate Bars

Using the 19-attribute lexicon established through FGD, RATA differentiated 18 of 19 sensory attributes among the five anonymized products; milky aroma was the only non-significant attribute ($p=0.085$). This broad discrimination is consistent with the contrasts in label-listed cocoa ingredients, fat systems, milk components, and ginger forms. Because the products were

commercial samples rather than experimentally controlled formulations, ingredient-based explanations are interpreted as plausible sensory mechanisms rather than direct causal tests.

Values in the same row followed by different superscript letters were reported as significantly different in Dunn's test ($p \leq 0.05$). Intensity scale: 0=not perceived, 1=low, 2=slightly low, 3=moderate, 4=slightly high, and 5=high.

Table 3. Mean RATA intensities and Kruskal-Wallis p-values for five ginger chocolate bars.

Attribute	KR	NM	MG	CU	MJ	p-value
Bitter aroma	2.55 ^b	2.01 ^{ab}	2.40 ^{ab}	1.88 ^a	1.96 ^{ab}	0.007
Sweet aroma	2.96 ^{ab}	2.95 ^{ab}	2.85 ^{ab}	2.46 ^a	3.15 ^b	0.004
Milky aroma	2.93 ^a	2.98 ^a	2.85 ^a	2.50 ^a	2.97 ^a	0.085
Gingery aroma	1.30 ^a	1.72 ^a	2.58 ^{bc}	2.98 ^c	1.97 ^{ab}	<0.0001
Glossiness	2.37 ^b	2.72 ^b	1.65 ^a	2.91 ^b	2.33 ^b	<0.0001
Brown color	4.35 ^c	3.47 ^{ab}	3.65 ^b	2.92 ^a	4.27 ^c	<0.0001
Sweet taste	3.76 ^b	3.13 ^a	2.87 ^a	3.10 ^a	3.31 ^{ab}	<0.0001
Bitter taste	2.36 ^{bc}	1.81 ^{ab}	2.52 ^c	1.38 ^a	1.70 ^{ab}	<0.0001
Spicy taste	1.41 ^a	2.27 ^{bc}	2.96 ^c	2.15 ^b	1.62 ^{ab}	<0.0001
Gingery taste	1.70 ^a	3.17 ^b	3.55 ^b	3.32 ^b	2.87 ^b	<0.0001
Hardness texture	2.42 ^b	2.36 ^b	2.91 ^b	2.41 ^b	1.68 ^a	<0.0001
Soft texture	3.08 ^a	3.01 ^a	2.58 ^a	3.03 ^a	3.68 ^b	<0.0001
Melting texture	2.97 ^b	2.90 ^b	2.23 ^a	2.87 ^b	3.45 ^b	<0.0001
Grainy texture	1.53 ^c	0.67 ^{ab}	1.27 ^{bc}	0.81 ^{ac}	0.57 ^a	<0.0001
Mouth drying aftertaste	1.12 ^{ab}	1.38 ^b	1.61 ^b	1.27 ^{ab}	0.86 ^a	0.003
Spicy aftertaste	1.27 ^a	2.32 ^b	2.78 ^b	2.25 ^b	1.46 ^a	<0.0001
Sweet aftertaste	3.05 ^b	2.47 ^{ab}	2.35 ^a	2.65 ^{ab}	2.83 ^{ab}	0.004
Bitter aftertaste	1.96 ^{bc}	1.71 ^{ab}	2.43 ^c	1.38 ^a	1.78 ^{ab}	<0.0001
Balsamic aftertaste	1.42 ^a	2.65 ^b	2.91 ^b	2.65 ^b	1.58 ^b	<0.0001

Notes: Values are mean RATA intensity scores from 80 untrained panelists. Different superscript letters within the same row indicate significant differences among samples according to Dunn's multiple-comparison test ($p \leq 0.05$). RATA intensity scale: 0 = not perceived, 1 = low, 2 = slightly low, 3 = moderate, 4 = slightly high, and 5 = high. KR, NM, MG, CU, and MJ represent anonymized commercial ginger chocolate samples

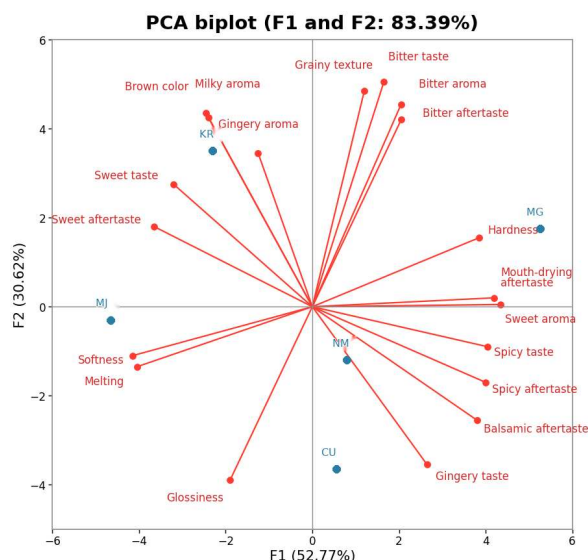


Fig. 1. PCA biplot of 19 sensory attributes and five anonymized ginger chocolate samples. F1 and F2 explain 83.39% of the variation; confidence ellipses were not calculated.

KR had the highest brown colour (4.35), sweet taste (3.76), sweet aftertaste (3.05), and grainy texture (1.53). Its label listed cocoa beans, sugar, milk powder, and vanilla. The combination of a clear cocoa-brown appearance, sweet taste, vanilla-associated aroma, and a persistent sweet finish may create cross-modal congruence: visual and olfactory cues conventionally associated with sweet chocolate can reinforce expectations of sweetness and product familiarity. Sweetness perception can be reinforced or suppressed by aroma, bitterness, texture, and other intrinsic sensory cues; therefore, the favourable position of KR should be understood as a combined sensory pattern within this panel rather than a universal response [18]. The relatively high graininess indicates that sweetness did not eliminate all textural limitations.

MJ showed the highest softness (3.68) and melting (3.45), together with the lowest hardness (1.68), mouth-drying aftertaste (0.86), and grainy texture (0.57). These attributes are sensory expressions of the continuous fat phase, particle dispersion, crystal structure, and oral breakdown of chocolate. Stable cocoa-butter crystallization contributes to gloss, snap, and melting, while fat-related oral processing can modify sweetness perception and flavour release [10,17,18]. Accordingly, a soft-melting product may be perceived as sweeter or more pleasant even without the highest chemical sugar concentration. Because refining, conching, tempering, and particle-size data were unavailable, the label-listed cocoa mass, cocoa butter, milk powder, and ginger powder can only be considered consistent with, rather than proven causes of, the observed mouthfeel.

MG exhibited the highest bitter taste (2.52), spicy taste (2.96), gingery taste (3.55), hardness (2.91), spicy aftertaste (2.78), bitter aftertaste (2.43), and balsamic aftertaste (2.91). Its label specified 9.5% candied ginger. A solid candied inclusion can increase mechanical heterogeneity during biting, while ginger-derived pungency activates trigeminal sensations that can remain after swallowing. Previous ginger-chocolate studies indicate that increasing ginger intensity can strengthen pungency and reduce liking when the spicy sensation becomes dominant [4]. Cocoa mass can simultaneously contribute bitter and persistent cocoa notes. CU showed the strongest gingery aroma (2.98) and glossiness (2.91), whereas NM contained ginger extract and vegetable fat but ranked lower in preference. These findings suggest that ginger form, cocoa bitterness, fat behaviour, and residual pungency interact rather than act as isolated drivers.

3.3. Principal Component and Preference Mapping

PCA component F1 explained 52.77% of the variation and F2 explained 30.62%, giving a cumulative representation of 83.39%. The map primarily separated a familiar sweet-soft chocolate direction (brown colour, sweet taste, sweet aftertaste, milky aroma,

softness, and melting) from a more bitter-pungent and persistent direction (bitterness, hardness, mouth drying, spicy and gingery sensations, and balsamic aftertaste). KR and MJ occupied different favourable sensory routes: KR was more strongly aligned with sweet-chocolate cues, whereas MJ was more strongly aligned with soft-melting texture. MG was aligned with bitterness, hardness, and persistent ginger sensations. PCA indicates associations and contrasts in the product space; it does not demonstrate that any single ingredient caused the loading pattern.

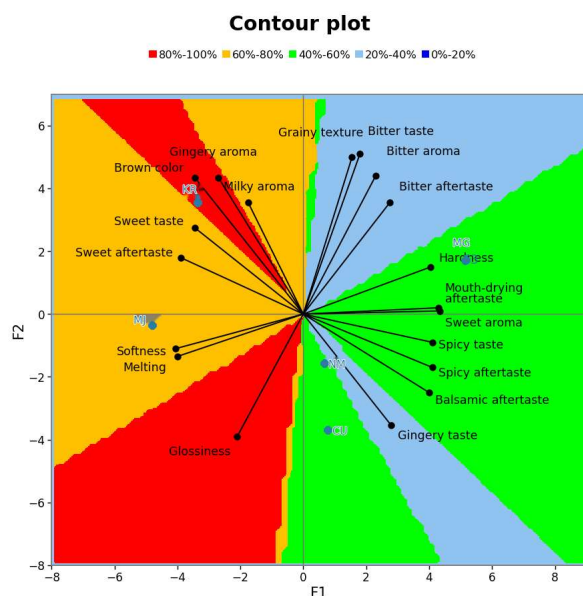


Fig. 2. Overall preference map of the five anonymized ginger chocolate samples and sensory attributes. Coloured fields indicate the proportion of panelists with liking above their individual mean and are not confidence regions.

The overall preference map placed KR in the 80-100% region and MJ in the 60-80% region; MG and CU were in the 40-60% region, and NM was in the 20-40% region. Higher acceptance was associated with a combination of sweet taste, sweet aftertaste, brown colour, milky aroma, glossiness, softness, and melting, whereas stronger bitter, spicy, hard, mouth-drying, and balsamic sensations were associated with medium- to low-acceptance regions. Mechanistically, the favourable combination joins expected chocolate cues with efficient oral breakdown and flavour release. Consumer acceptance therefore appears to depend on sensory balance: ginger can remain recognizable, but its pungency and persistence should not dominate the familiar cocoa-sweet and soft-melting experience. The map is descriptive and does not quantify causal contributions of individual attributes.

3.4. Preference Mapping of the Highest-Acceptance Age Group

Preference maps were examined descriptively for panelists aged 20-25, 26-35, and 36-40 years. The 26-35-year group showed the strongest acceptance pattern, with two products located in the 80-100% region, whereas the other age-group maps showed fewer products in the highest-acceptance region. Therefore, the 26-35-year preference map is presented as the age-group result. This selection is descriptive and does not establish a statistically significant age effect.

3.4.1. Panelists Aged 26-35 Years

In the 26-35-year subgroup map, KR and MJ were both located in the 80-100% region. KR was associated with brown colour, sweet taste, milky aroma, and sweet aftertaste, whereas MJ was associated with softness, melting, and glossiness. Descriptively, this subgroup combined flavour and appearance cues with oral texture, indicating two favourable sensory routes within the participating consumers.

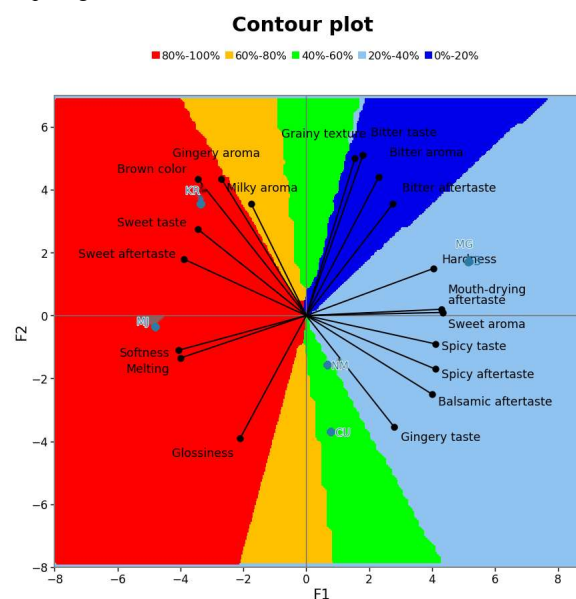


Fig. 3. Preference map for panelists aged 26-35 years, the age group showing the strongest descriptive acceptance pattern. Coloured fields indicate the proportion of panelists with liking above their individual mean and are not confidence regions.

CU occupied a moderate-acceptance region near gingery and spicy sensations, while NM and MG were located in lower-acceptance areas. MG combined cocoa bitterness, candied-ginger pungency, hardness, and persistent aftertaste. These positions are consistent with the overall finding that intense and prolonged ginger-cocoa sensations require balancing by sweetness and soft melting. Because no inferential product-by-age interaction test was conducted, this subgroup pattern should be interpreted descriptively.

3.5. Total Sugar and Sensory Acceptance

Total sugar ranged from 9.90% in NM to 13.02% in MG. MG had the highest measured total sugar but did not fall within the highest-acceptance region. This finding indicates that a higher analytical total sugar concentration was not necessarily accompanied by higher consumer acceptance.

The chemical and sensory variables represent different constructs. The anthrone assay quantifies a carbohydrate-derived colour response against glucose after strong-acid treatment; it does not directly measure perceived sweetness. In chocolate, sweetness perception is influenced not only by analytical sugar concentration but also by interactions with fat-related oral sensations, aroma, bitterness, texture, and other intrinsic sensory cues [14,15,17,18]. Bitter cocoa compounds and persistent ginger pungency may also compete with or mask sweet sensations.

Table 4. Total sugar concentrations and preference-map regions.

Sample	Total sugar (%)	Preference-map region
KR	11.33	80-100%
NM	9.90	20-40%
MG	13.02	40-60%
CU	10.70	40-60%
MJ	10.77	60-80%

Notes: Total sugar values were obtained using the anthrone method and are expressed as percentage (%). Analyses were performed in duplicate for each sample. Preference-map regions indicate the proportion of panelists whose liking scores were above their individual mean: 80–100%, 60–80%, 40–60%, 20–40%, and 0–20%. KR, NM, MG, CU, and MJ represent anonymized commercial ginger chocolate samples.

Consequently, MG could have the highest anthrone-derived total sugar value while KR and MJ were positioned in higher acceptance regions through different combinations of sensory characteristics. KR was associated with sweet taste, sweet aftertaste, brown colour, and milky aroma, whereas MJ was characterized by greater softness and melting. These findings suggest that consumer acceptance of ginger chocolate is shaped by the overall balance of sensory attributes rather than analytical total sugar concentration alone.

3.6. Practical Implications and Limitations

For product development, the findings support maintaining a recognizable ginger identity while controlling excessive pungency, bitterness, hardness, mouth drying, and balsamic persistence. A clear brown appearance, moderate perceived sweetness, sweet aftertaste, glossiness, and soft-melting texture were associated with higher acceptance in this panel. The study was limited to five purposively selected commercial products, a consumer panel aged 20–40 years, and descriptive age-group preference maps without an inferential product-by-age interaction test. Among the descriptive age groups, the 26–35-year group showed the strongest acceptance pattern and was therefore highlighted; however, this finding should not be generalized as evidence of a statistically significant age effect. In addition, the formulations and manufacturing conditions of the commercial products could not be experimentally controlled.

4. CONCLUSION

Among five purposively selected and anonymized Indonesian commercial ginger chocolate bars, RATA differentiated 18 of 19 sensory attributes, with milky aroma as the only non-significant attribute. KR occupied the highest overall preference-map region and was associated mainly with sweet taste, sweet aftertaste, brown colour, and milky aroma, whereas MJ was associated with softness and melting. Products positioned closer to strong bitterness, ginger pungency, hardness, mouth-drying, and balsamic persistence occupied lower-preference regions. Among the descriptive age-group maps, panelists aged 26–35 years showed the strongest acceptance pattern, with KR and MJ both located in the 80–100% preference region. However, this finding remains descriptive and should not be interpreted as evidence of a statistically significant age effect. MG had the highest measured total sugar concentration but was not the most preferred product. This result indicates that analytical total sugar concentration alone did not directly correspond to consumer acceptance. Overall, preference for ginger chocolate was associated with a balanced sensory configuration involving sweetness, sweet aftertaste, cocoa-brown appearance, milky aroma, glossiness, softness, and melting characteristics. Product development should therefore preserve a recognizable

ginger identity while controlling excessive pungency and supporting familiar cocoa-sweet, glossy, soft, and melting characteristics.

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