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A multi-method sensory approach to characterize pasteurized ready-to-eat sausages in the indonesian market: from attribute screening to temporal dynamics

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Abstract

Ready-to-eat (RTE) sausages have become increasingly popular in the Indonesian market due to changing consumer preferences and growing demand for convenient, high-quality protein sources and innovative food products. However, comprehensive sensory studies evaluating these products in the local context remain limited. This study aimed to characterize the sensory attributes and temporal flavor dynamics of five commercial pasteurized RTE sausage brands using a multi-method sensory approach. A total of 144 untrained consumers participated in a Check-All-That-Apply (CATA) and 24 trained panelists conducted Temporal Dominance of Sensations (TDS) evaluations. CATA results revealed distinct sensory profiles among products, with Product 4 showing the strongest alignment with the ideal profile, and Product 2 receiving the highest overall liking score. TDS results further complemented these findings, where Product 2 showed a more prolonged and intense meaty flavor. Product 4 displayed more dynamic sensory transitions during mastication, whereas the lower-liked Product 5 exhibited less intense and less clearly defined dominance patterns. Penalty analysis identified fishy aroma, starchy flavor, and bitter aftertaste as key drivers of disliking. The integration of CATA and TDS sensory data highlights not only which attributes are important, but also how and when they are perceived. These findings may support future food product reformulation and sensory-driven innovation to improve consumer acceptance of innovative RTE protein products.

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RTE Food, Pasteurized Sausage, CATA, TDS, Sensory Characterization.

1. Introduction

Sausage is one of the most widely consumed processed meat products in Indonesia due to its practical form, extended shelf life, and favorable sensory characteristics. According to the United States Department of Agriculture (1), sausage is defined as a coarse or finely

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comminuted meat or poultry product prepared from one or more types of meat or meat byproducts, combined with varying amounts of water, and typically seasoned with condimental ingredients. In recent years, sausage consumption in Indonesia has shown an average annual growth of 4.46%, driven by changing consumer preferences from fresh meat toward more convenient options such as ready-to-cook or ready-to-eat (RTE) meat products (2). The increasing demand for convenience foods, the rise of meat-based snacks, and the trend toward premium and gourmet sausages have further contributed to the market's expansion.

RTE sausages have been available in the Indonesian market for some time, however, earlier versions were primarily designed to maximize shelf stability rather than sensory quality. These products were typically manufactured using sterilization processes and formulated to remain stable at room temperature. In recent years, major food manufacturers have introduced a new generation of RTE sausages with improved sensory quality through the use of higher-quality ingredients, refined formulations, advanced packaging technologies, and pasteurization processes combined with chilled storage. It correspond to the category of pasteurized meat sausages, defined by Indonesian Food and Drug Supervisory Agency (BPOM) as processed meat products made from finely comminuted meat, with or without the addition of other food ingredients, stuffed into sausage casings, cooked, hermetically packaged, subjected to pasteurization, and stored under chilled conditions below 5°C (3). These pasteurized RTE sausages offer enhanced textural and flavor properties, resulting in increased consumer interest. Despite this growing presence, there is still a lack of published sensory studies on these products, particularly those evaluating both sensory characteristics and consumer perception in the Indonesian context.

The sensory analysis of foods provides essential information regarding both the organoleptic profile of a product and consumer preferences (4). Among emerging sensory methods, Check-All-That-Apply (CATA) has been introduced as a technique that reflects the "consumer voice" from a sensory perspective, with the added advantage of being simple and easy to implement (5). In addition, the analysis of the CATA profile of the 'Ideal product', the product that maximizes consumer liking, combined with overall liking scores improves the interpretability of the results obtained through this method (6). CATA responses are directly linked to consumer perception of product characteristics and, when considered together with hedonic scores and the ideal product profile, can serve as complementary data to aid in the interpretation of consumer-driven sensory evaluations (7).

In parallel, it is well established that sensory perception during food consumption is a dynamic phenomenon, as multiple sensory inputs evolve and interact over time. Methods such as Temporal Dominance of Sensations (TDS) have been developed to capture this dynamic dimension, allowing researchers to identify which attribute is perceived as dominant at each moment of mastication (8). This method is particularly useful in the evaluation of meat products, where changes in flavor perception can significantly influence overall acceptance. While studies combining CATA and TDS have been conducted on dry-cured meats (9) and TDS alone has been applied to evaluate dynamic perception in sausage samples (10,11), these studies have focused mainly on dry or cured sausages, which differ from pasteurized RTE sausages in both processing and sensory profile.

A comprehensive understanding of sensory perception is essential for improving product quality and consumer acceptance. Different sensory methods provide complementary insights into how consumers perceive food products. The combination of rapid and temporal method allows the identification of key sensory attributes and how dominant taste and flavor perceptions evolve dynamically during consumption. When combined with liking data, these approaches provide a more holistic understanding of the relationship between sensory perception and consumer preference. Such information is particularly valuable for food manufacturers seeking to optimize product formulation and improve sensory quality.

Therefore, the present study focuses on the sensory characterization of commercial pasteurized RTE sausage products available in the Indonesian market by combining CATA, overall liking, and TDS. This integrated approach aims to explore the dominant sensory attributes perceived during consumption and identify drivers of liking, as well as the sensory profile of the ideal product according to consumer perception. The findings are expected to provide valuable insights for product developers, especially to consider reformulation strategies which influence not only the sensory attributes but also their temporal dynamics, which ultimately shape consumer acceptance.

2. Materials and Methods

2.1. Time and Location

This study was conducted from February to April 2025 at the Sensory Evaluation Laboratory, Department of Food Science and Technology, IPB University, Bogor, Indonesia.

2.2. Samples

The samples used in this study were pasteurized RTE sausages from five different commercial brands, selected based on top-selling rankings from four major Indonesian e-commerce platforms: Shopee, Tokopedia, Blibli, and Lazada. The selected samples represented the main pasteurized RTE sausage products available in the market at the time of the study (2024). All sausage products were purchased from Hari-Hari supermarket in Dramaga, Bogor, Indonesia, one day prior to the sensory evaluation. The sausages were stored under refrigeration approximately 4°C and brought to room temperature (approximately 26°C) for 2 hours prior to serving. Each sausage was sliced into approximately 4 cm segments, placed individually in plastic containers labeled with random three-digit codes, and served with a toothpick. Drinking water was provided as a palate cleanser between samples.

2.3. Panelist Screening and Attribute Generation

A preliminary screening questionnaire was distributed to potential participants to gather information on their frequency of consuming pasteurized RTE sausages. The recruitment process was conducted internally within the university and followed the guidelines of ISO 8586:2023 (12). Participants who indicated willingness and met the selection criteria were invited to join the sensory evaluation sessions. A separate group consisting of 24 trained panelists was recruited to perform the Temporal Dominance of Sensations (TDS) evaluation. These panelists were students enrolled in a sensory science course and had prior experience in multiple sensory evaluation sessions, including sausage products. These panelists had previously participated in several sensory evaluation training (≥7 sessions) and were familiar with dynamic sensory methods. Prior to the TDS test, a short review session was conducted to refresh their understanding of the TDS procedure and the use of sensory software.

To generate relevant sensory descriptors, a preliminary Focus Group Discussion (FGD) was conducted with eight panelists, following the approach used in descriptor development for CATA tests (13). Through group consensus, 15 attributes were identified, encompassing textural, aroma, taste, and flavor dimensions. The selected descriptors were further refined to ensure linguistic clarity and cultural relevance for Indonesian consumers. From these, six key attributes (sweet, salty, umami, meaty, garlicky, and peppery) were selected for use in the Temporal Dominance of Sensations (TDS) test to specifically explore the dynamic perception of taste and flavor during the chewing process. Selected attributes and definitions are shown in Table 1.

Table 1. Attributes and descriptions used on CATA and TDS sessions.

Sensory Method	Attribute	Description
CATA	Chewy texture	The degree of chewiness when repeatedly chewed
	Juiciness texture	Perception of moisture or release of juice when first bitten
	Tender texture	How easily the food breaks down when chewed
	Beef aroma	Characteristic aroma of cooked fresh beef
	Chicken aroma	Characteristic aroma of cooked fresh chicken
	Smoky aroma	Smoky aroma associated with wood smoking or grilling
	Fishy aroma	Pungent aroma associated with fish or seafood products
	Starchy flavor	Starchy flavor resembling uncooked or partially cooked flour/starch
	Bitter aftertaste	Lingering bitter taste in the mouth after 15 seconds
CATA & TDS	Sweet taste	Basic sweet taste as found in sugar
	Salty taste	Basic salty taste as found in salt
	Umami taste	Basic savory (umami) taste as found in MSG or broth
	Meaty flavor	Combination of taste and aroma of cooked or processed meat
	Garlicky flavor	Distinct taste and aroma of garlic
	Peppery flavor	Spicy and pungent taste and aroma of black pepper

2.4. Sensory Methods

2.4.1 CATA Considering Ideal Product and Liking

Five pasteurized RTE sausage samples were evaluated using the Check-All-That-Apply (CATA) methodology. A total of 144 participants who met the inclusion criteria voluntarily agreed to participate in the study. Prior to tasting, participants were instructed to access the questionnaire and complete the "ideal product" section by imagining their ideal version of product. Following this, participants proceeded with the actual sensory evaluation and each sample was assessed using a list of 15 sensory attributes that had been previously identified through FGD. Participants selected all attributes they perceived to be present, then rated the intensity of each selected attribute on a 6-point scale (1 = very weak, 6 = very strong) and their overall liking of each sample using a 6-point hedonic scale (1 = dislike extremely, 6 = like extremely). Samples were presented monadically in a randomized order, coded with three-digit numbers, and served in individual cups.

2.4.2 TDS

TDS was employed to assess the dynamic perception of six key attributes: sweet, salty, umami, meaty, garlicky, and peppery. This test involved 24 trained panelists and was conducted using RedJade sensory software. Each panelist received a personalized code along with written instructions on how to navigate the digital interface. During the session, panelists entered their unique code and followed a system-generated sequence of sample presentation. Upon placing the sample in their mouth, they clicked "start" and were instructed to chew naturally while continuously selecting the most dominant sensation displayed on-screen. The evaluation ended when panelists no longer perceived any dominant sensation and clicked "stop" manually. Between samples, participants were required to rinse their mouth with water to cleanse the palate before proceeding to the next evaluation.

2.5. Data Analysis

2.5.1 CATA Considering Ideal Product and Liking

CATA data analysis was conducted using XLSTAT 2024.4.1.1425 (Addinsoft, Paris, France). The Check-All-That-Apply (CATA) data were first organized into a contingency table summarizing the frequency of mention for each attribute across the five commercial RTE sausage samples and the ideal product. To determine whether there were significant differences in the selection frequency of attributes among samples, Cochran's Q test was applied and for attributes showing significant results ($p < 0.05$), multiple pairwise comparisons were carried out using the McNemar test with Bonferroni adjustment. The relationships between sensory attributes, products, and the ideal profile were further explored using Correspondence Analysis (CA) and visualized into a biplot diagram to see the similarities and differences among samples, as well as the sensory attributes contributing to each product's sensory profile (14). Additionally, Principal Coordinate Analysis (PCoA) was performed to investigate the association between sensory attributes and overall liking scores. A Penalty Analysis (PA) was conducted to identify sensory attributes that significantly influenced consumer liking by comparing actual product descriptions with the ideal product (15). This analysis was conducted using the Pareto principle with a 20% frequency threshold, meaning that only attributes selected by at least 20% of participants were considered (16). Furthermore, overall liking scores were analyzed using one-way ANOVA, followed by Tukey's Honestly Significant Difference (HSD) test to detect differences in acceptance between samples at a significance level of $p < 0.05$.

2.5.2 TDS

TDS data analysis was carried out using XLSTAT 2024.4.1.1425 (Addinsoft, Paris, France). Dominance rates, which defined as the proportion of panelists citing an attribute as dominant at each time point, were calculated, smoothed, and plotted over standardized time (left-right). Each panelist's evaluation was normalized from $X = 0.00$ (initial selection of a dominant attribute) to $X = 1.00$ (end of evaluation) to account for differences in mastication duration (17). TDS curves were generated for each product to illustrate the temporal evolution of sensory perceptions across all evaluated attributes, along with the associated chance and significance levels. The chance level represents the dominance rate an attribute could attain purely by chance, given the total number of evaluated attributes. The significance level denotes the minimum dominance rate required for an attribute to be considered significantly higher than chance. Attributes with dominance rates below the chance level are regarded as negligible, while those with curves exceeding the significance level can be considered consistently dominant across panelists (8). To identify which attributes were significantly dominant over time, band plots per attribute were constructed. Bands by attribute highlight the specific time windows during which each attribute showed statistically significant dominance ($p < 0.05$). The x-axis represents normalized time during consumption, while the y-axis displays the sensory descriptors. The height of each band is proportional to the mean dominance rate and is calculated by dividing the mean dominance rate of the attribute during that segment by the maximum dominance rate observed for the product, allowing a detailed and interpretable representation of the dynamic sensory characteristics of each product (18).

3. Results and Discussion

3.1. Sensory Characterization of RTE Sausage from 5 Commercial Brands by Cata Analysis

A total of 144 responses were collected, of which 124 valid responses were retained after data validation and included in the CATA and liking analyses. Table 2 presents the frequency of mention (%) for each sensory attribute across five RTE sausage brands and the Ideal product. Based on Cochran's Q test ($p \leq 0.05$), 18 out of 19 attributes showed significant differences among samples, except for chicken aroma. Chewy texture and juiciness were consistently cited across samples, with McNemar tests indicating Product 4 as the most distinct in pairwise comparisons for both attributes. Although attributes such as beef aroma, umami taste, and meaty flavor were cited by over 90% of participants, they did not differ significantly across samples, suggesting a shared sensory base. In contrast, fishy aroma, sweet taste, salty taste, peppery flavor, and starchy flavor were highly significant ($p \leq 0.001$), highlighting their strong discriminative power. McNemar analysis revealed that Product 3 was notably distinct in sweet and salty taste. Garlicky flavor and bitter aftertaste, while less frequently cited, still contributed to product differentiation with moderate significance ($0.01 < p \leq 0.05$). All frequency data, including responses for the Ideal product, were included in multivariate analyses such as Correspondence Analysis (CA), Principal Coordinate Analysis (PCoA), and Penalty Analysis (PA) to further explore sensory positioning and consumer-product gaps.

Table 2. Frequency of mention (%) of each attribute by consumers using CATA questionnaires for the five commercial brands of pasteurized RTE sausage and ideal product.

Attribute	1	2	3	4	5	Ideal
Chewy texture***	94 (ab)	94 (ab)	98 (ab)	100 (b)	87 (a)	91
Juiciness texture**	95 (ab)	98 (ab)	97 (ab)	100 (b)	92 (a)	98
Tender texture*	96 (ab)	93 (ab)	100 (b)	98 (b)	87 (a)	94
Beef aroma*	84 (a)	91 (a)	89 (a)	94 (a)	94 (a)	92
Chicken aroma^{ns}	75	78	76	78	74	86
Smoky aroma**	76 (b)	60 (a)	60 (a)	63 (ab)	61 (a)	55
Fishy aroma***	40 (a)	56 (b)	60 (b)	40 (a)	56 (b)	16
Sweet taste***	57 (a)	64 (a)	91(b)	64 (a)	70 (a)	41
Salty taste***	90 (b)	93 (b)	76 (a)	93 (b)	94 (b)	83
Umami taste*	97 (a)	99 (a)	93 (a)	99 (a)	97 (a)	99
Meaty flavor*	95 (a)	97 (a)	89 (a)	98 (a)	95 (a)	98
Garlicky flavor*	60 (ab)	76 (c)	50 (a)	60 (ab)	65 (bc)	44
Peppery flavor***	52 (c)	66 (c)	29 (a)	36 (ab)	50 (bc)	72
Starchy flavor***	43 (a)	45 (ab)	69 (c)	54 (ab)	60 (bc)	23
Bitter aftertaste*	41 (ab)	31 (a)	39 (ab)	37 (ab)	47 (b)	8

*Attributes which frequencies differ between samples at *** ($p \leq 0.001$), ** ($0.001 < p \leq 0.01$), * ($0.01 < p \leq 0.05$), ^{ns} no significant ($p > 0.05$). Values within rows with different lowercase superscripts are significantly different according to Mcnemar paired comparisons test (at $p < 0.05$).*

The CA map (Figure 1) illustrates the sensory differences among the five RTE sausage products and the Ideal product, with the first two dimensions explaining 87.54% of the total variance (72.98% for Dimension 1, and 14.56% for Dimension 2). The products were positioned in distinct quadrants, reflecting their unique sensory profiles. The Ideal product was located close to attributes such as chewy texture, juiciness, tender texture, beef aroma, umami, and meaty flavor, key characteristics that reflect core consumer expectations. Product 4 was closely aligned with these attributes, indicating strong sensory similarity with the Ideal. Products 1 and 2 appeared in the same quadrant yet were associated with different sensory drivers. Product 1 was more closely related to salty taste and smoky aroma, while Product 2 showed a weaker association with peppery and salty flavors. Product 3 was primarily associated with starchy flavor and dominant sweet taste, which is consistent with the findings of the McNemar test. In contrast, Product 5 demonstrated no clear sensory association, suggesting a more heterogeneous consumer perception and a lack of a distinct defining attribute. However, it still showed associations with fishy aroma and bitter aftertaste.

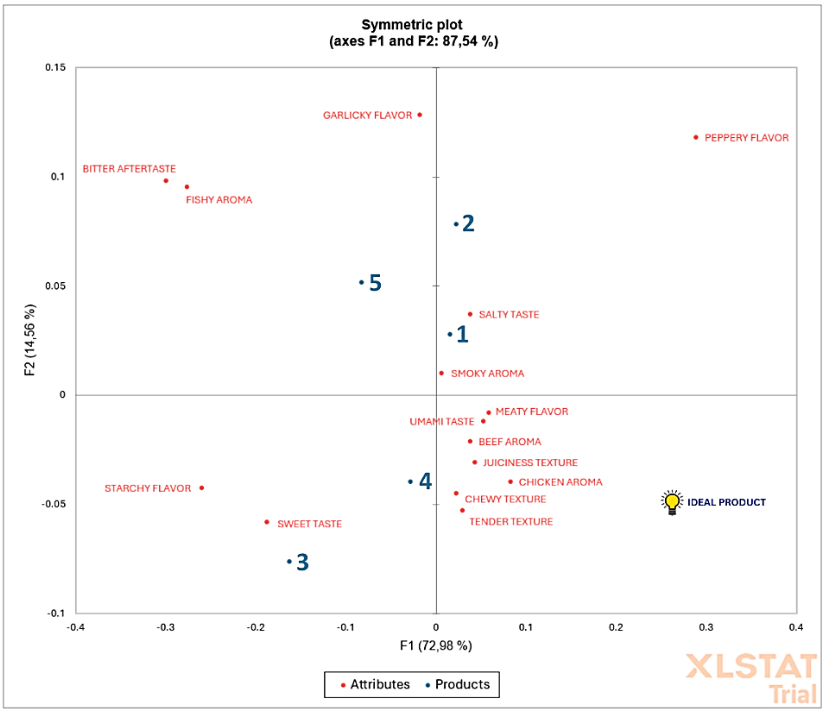

Figure 1. Correspondence Analysis (CA) of CATA term frequencies and ideal.

Product 2 obtained the highest overall liking value (4.19 ± 1.41), followed by Product 4 (3.98 ± 1.16), Product 1 (3.85 ± 1.32), Product 5 (3.31 ± 1.22), and Product 3 (3.04 ± 1.25). The sensory representation associated with overall liking is shown in the PCoA plot (Figure 2), where liking was located close to meaty flavor, beef aroma, tender texture, and juiciness—attributes that were also closely associated with the Ideal product. Notably, these sensory cues were aligned with Product 4, which appeared to best match consumer expectations in CA. However, the pairwise comparison using Tukey HSD ($p < 0.05$) indicated that Product 4 was not significantly more liked than the others in Group A (Product 2 and Product 1), with Product 2 ultimately receiving the highest mean liking score. This is particularly interesting considering that, in the CA space, Product 2 exhibited weaker associations, primarily related to salty and peppery flavors.

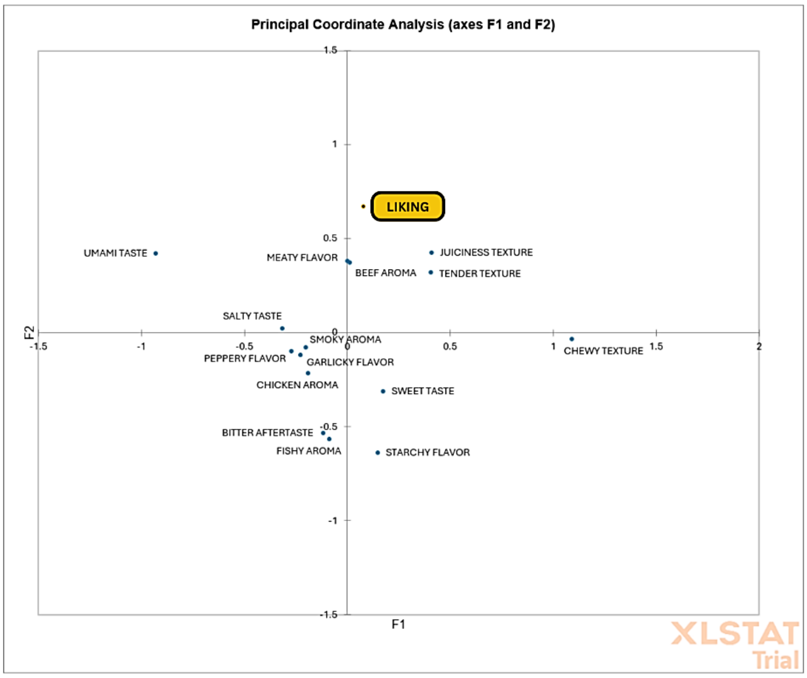

Figure 2. Principal Coordinate Analysis (PCoA) plot of CATA and overall liking scores.

Conversely, Products 3 and 5 formed a distinct group with significantly lower liking scores, supporting their categorization as less preferred samples. In the CA plot, Product 3 was closely related to sweet taste and starchy flavor, while Product 5 displayed no strong sensory association, indicating a more heterogeneous perception among consumers. However, Product 5 still presented ties to negative sensory cues, such as fishy aroma and bitter aftertaste. Starchy flavor, fishy aroma, and bitter aftertaste were confirmed as drivers of disliking in the Mean Impact plot shown in Figure 3, with negative coefficients contributing most strongly to the reduction in overall liking.

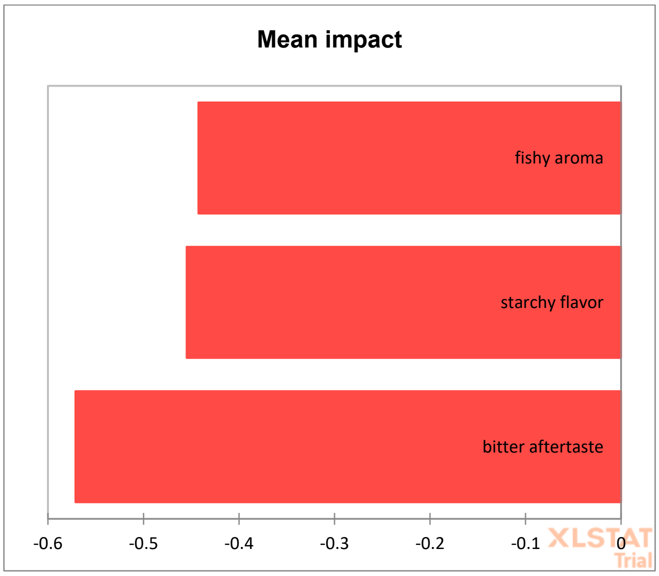

Figure 3. Liking mean impact plot of CATA displaying drivers of disliking attributes.

These findings suggest that consumer liking was enhanced by the presence of juicy, meaty, and tender sensory characteristics, and penalized by off-flavors or undesirable textural properties. This aligns with previous studies emphasizing the importance of meatiness and juiciness as key drivers of consumer preference in sausage (19).

3.2. Penalty Analysis Based on CATA Questionnaire Considering Ideal Product

For PA analysis, the instructions described by (20) were followed, considering the data of CATA of the five studied samples and the Ideal product. These instructions are based on the proportion of selection between real and Ideal products and how this proportion impacts the liking (congruence, incongruence). According to (21), attributes categorized as "must have" are sensory attributes with an X-coordinate value (%P (No) I (Yes)) greater than 20% and a positive Y-coordinate value (mean drops). Attributes potentially classified as "nice to have" or "must not have" are those with an X-coordinate value (%P (Yes) I (No)) greater than 20%, where positive mean drops indicate "nice to have" and negative mean drops indicate "must not have." However, attributes are only assigned these classifications if the differences are statistically significant (p-value < 0.05). If the impact is not significant, attributes are instead classified as "does not influence" (when %P (No) I (Yes) > 20%) or "does not harm" (when %P (No) I (Yes) < 20%), regardless of the sign of the mean drops.

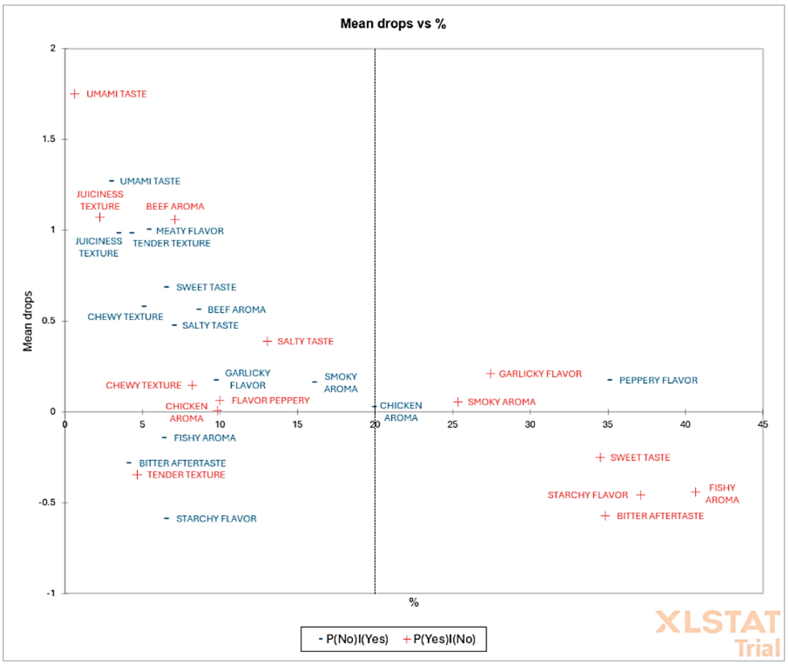

Figure 4. Penalty Analysis (PA) from CATA with ideal data.

Figure 4 shows the graphical representation of the PA analysis from the CATA data with Ideal product reference, while the detailed classification of each attribute is presented in Table 3. The "must have" attribute group consists of attributes that are necessary to obtain a higher preference score and an ideal product. Attributes included in the "nice to have" group were attributes that were needed to be liked but were not necessary in an ideal product. Attributes included in the "does not influence" group were attributes that do not affect preference and were not necessary to have. Attributes included in "does not harm" were attributes that did not affect likability and were not necessary in an ideal product. Attributes included in "must not have" were attributes that lower the likability score and were not necessary in an ideal product. The results revealed that *peppery* was categorized as "does not influence," while *sweet* and *garlicky* were identified as "does not harm." In contrast, *fishy*, *starchy*, and *bitter* were categorized as "must not have" attributes. These findings align with the mean impact results, which identified these three attributes as drivers of disliking. Attributes such as *fishy*, *starchy*, and *bitter* were found to significantly decrease liking when present, justifying their classification as "must not have." Conversely, positively perceived attributes such as *juiciness*, *tenderness*, or *beef aroma* did not significantly impact liking when absent. This suggests that, in the context of ready-to-eat sausage products, the presence of negative attributes exerts a stronger impact on consumer disliking than the absence of positive ones. This interpretation is further supported by the low liking scores observed in products 3 and 5, which were associated with a higher presence of *must not have* attributes.

Table 3. Summary of penalty analysis.

Must have	Nice to have	Does not influence	Does not harm	Must not have
-	-	Peppery flavor	Sweet taste Garlicky flavor	Fishy aroma Starchy flavor

3.3. Dynamic Sensory Characterization of RTE Sausage from Five Commercial Brands: TDS Approach

Temporal Dominance of Sensations (TDS) was employed to dynamically characterize taste and flavor perceptions during mastication of five commercial pasteurized RTE sausage products. For each product evaluated and each point in time, the dominance rates by attribute were calculated. These rates were obtained by dividing the number of citations of an attribute (all replications) by the number of panellists and the number of replications. Since a panellist can only have one dominant attribute at a time, the sum of the dominance rates of all the attributes at each point in time for that panellist is (22). The higher the dominance rate for the attribute, the better the agreement among panellists.

The definition of dominance is a critical aspect of the TDS methodology. It has been described as the sensation that "pops up" during mastication (22), or the one that "triggers the most your attention," thus extending beyond simple intensity (23,24). Further refinement of the concept emphasizes that dominance should also account for sensory contrast and temporal salience, making these broader definitions more suitable for dynamic sensory evaluation (25) As TDS methodology requires subjects to continuously select the most dominant sensation in real time from a fixed list, the chosen attributes must be comprehensive enough to include all potentially dominant sensations, yet concise enough to allow smooth cognitive processing. The list of attributes used in the TDS evaluation was developed not only through focus group discussions with trained panelists, but also by considering findings from previous studies on sausages (10,11). While these earlier studies incorporated texture, taste, and flavor attributes in a single TDS assessment, the present study focused specifically on the dynamic perception of taste and flavor attributes during mastication.

A review of 21 TDS studies reported that excessively long lists (>12 terms) reduced panel efficiency, as less salient attributes were often unused (26). Similarly, previous study showed that omitting key dominant attributes may lead to biased temporal sequences, as panelists tend to select less appropriate alternatives, while including a few non-essential terms had minimal impact, as they were seldom chosen (25). Informed by these findings, six attributes were selected for the current study: sweet, salty, umami, meaty, garlicky, and peppery—each judged to be perceptually salient and suitable for real-time dominance tracking. Bitter aftertaste were excluded because they typically emerge after swallowing and do not reflect in-mouth dynamics during mastication. Starchy flavor was also omitted due to its low perceptual salience; based on panel discussions and initial screening, it was found to be subtle, diffuse, and difficult to recognize as a dominant sensation within the rapid decision-making context of TDS.

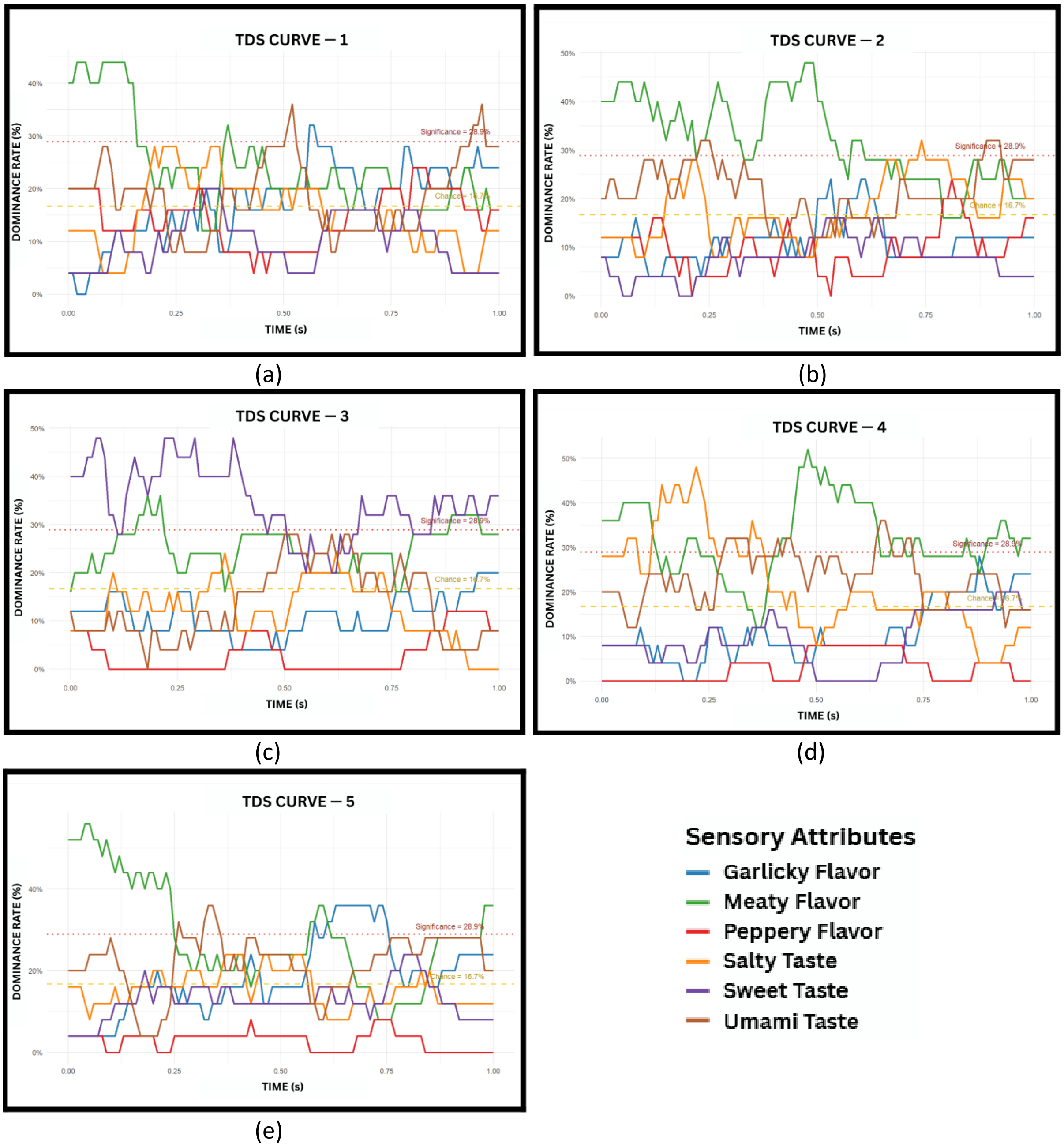

Figure 5. TDS curves of five commercial brands of RTE sausage. (a) TDS curves for Product 1; (b) TDS curves for Product 2; (c) TDS curves for Product 3; (d) TDS curves for Product 4; (e) TDS curves for Product 5.

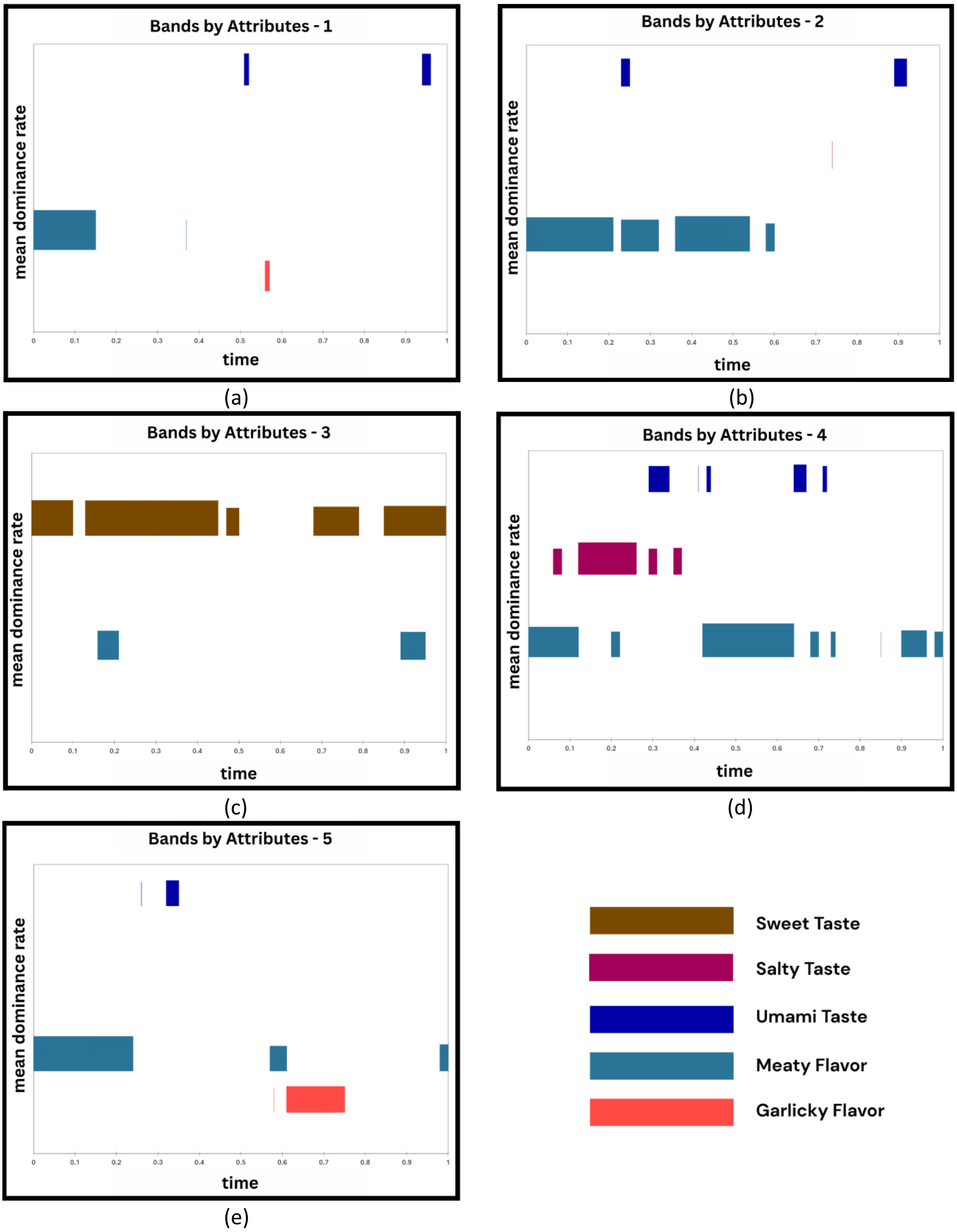

Figure 6. Bands by attributes of commercial pasteurized RTE sausage products during mastication. (a) Bands by attributes for Product 1; (b) Bands by attributes for Product 2; (c) Bands by attributes for Product 3; (d) Bands by attributes for Product 4; (e) Bands by attributes for Product 5.

Figures 5 and 6 display the TDS curves and band plots for the five evaluated pasteurized RTE sausage products, illustrating the temporal evolution of dominant flavor and taste attributes throughout the mastication period. Products 1 and 2 shared a similar overall sensory sequence, both beginning with a clear dominance of meaty flavor. In Product 1 (Figure 5a), meaty flavor emerged immediately upon consumption (~0–20%) and reappeared briefly around 40% of the normalized mastication time. Umami flavor then became dominant between 40% and 60%, followed by a return of meaty flavor in the final phase (~90–100%). While the TDS curve did not visually show significant dominance of garlicky flavor, the band plot statistically confirmed its presence around 60% of the chewing sequence. This phenomenon also observed in previous studies, such as those involving Syrah wine, where attribute sequencing was more precisely captured in band plots than in TDS curves alone (27). Figure 5b shows that among all attributes in Product 1, meaty flavor displayed the widest and tallest band, indicating not only prolonged dominance but also high panelist consensus. Umami flavor, though narrower in duration, exhibited a comparable band height, suggesting similarly strong perception when dominant. Garlicky flavor was represented by a narrow yet tall band, reflecting a short-lived but distinct sensory moment.

Product 2 (Figure 5b) followed a comparable initial trajectory but exhibited a more sustained dominance of meaty flavor, which remained significant from the onset until ~40% of the consumption period, and reappeared alongside salty taste between ~60–80%. In the final phase (~90–100%), umami flavor became dominant, with a brief overlap of meaty and umami also noted around 20–30%. Band plots (Figure 6b) reinforced these results, with meaty, salty, and umami identified as significantly dominant attributes. Meaty flavor exhibited both the widest and tallest band in this product, spanning nearly 60% of the mastication time and reflecting strong temporal stability and inter-panelist agreement. Salty taste showed a narrow but tall band between 70% and 80%, indicating a sharp but consistent sensory impression. Umami flavor displayed a moderate band, longer than salty but narrower than meaty, suggesting a notable yet slightly less consensual dominance. The longer meaty dominance observed in Product 2 compared to Product 1 may be attributed to its more complex meat composition (34.41% chicken meat, 14.78% beef, and 20.66% chicken skin), whereas Product 1 only contained chicken meat. A previous study supports the role of chicken skin in enhancing sausage flavor and color, particularly when used up to 20% in formulation (28). Additionally, Product 2 was the only sample formulated with skim milk powder, an ingredient commonly added to improve sausage texture and enhance flavor expression (29). These sensory advantages are consistent with the higher liking scores observed for Product 2.

Figure 5c and 6c present the TDS curve and band plot for Product 3. Sweet taste emerged as the consistently dominant sensation from the beginning and remained so until approximately 60% of the normalized mastication time. Meaty flavor appeared briefly around 20% and again at approximately 90% until the end. The band plot confirmed the prolonged and stable dominance of sweet taste, as indicated by a wide and tall band extending across nearly the entire mastication period. This suggests that sweet taste was not only consistently perceived but also highly intense among panelists. These results align with the CA, which associated Product 3 closely with sweet taste. In contrast, meaty flavor displayed narrow and low bands, indicating transient and less intense dominance episodes. Although the formulation of Product 3 was similar to that of Product 5, the origin of its distinct sweet taste remains unclear. It is likely related to the spice blend or the presence of specific formulation components. Notably, Product 3 contained the highest proportion of beef among all samples (40%), and beef naturally contains sugars, amino acids, and organic acids that contribute to sweet taste perception (30). A study suggested that alanine may contribute to sweet taste perception in beef (31), referencing earlier work by Schlichtherle-Cerny and Grosch, who identified alanine as a taste-active compound in stewed beef juice (32).

Figure 5d depict the TDS dynamics for Product 4, characterized by a more varied sequence of dominant sensations. Meaty flavor was initially dominant (~0–15%), followed by salty taste (~15–30%) and umami flavor (~30–40%). From 40% onwards, meaty flavor re-emerged and remained dominant until the end, with brief reappearances of umami flavor at ~65% and ~85%. Band plots (Figure 6d) confirmed three significantly dominant attributes: meaty, salty, and umami flavors. Meaty flavor exhibited two major dominance episodes, with the second phase being longer and more intense, as reflected by a wide and tall band. Salty taste showed a medium-width band early in the sequence, with height comparable to meaty, suggesting strong perception over a shorter period. Umami flavor had the shortest significant duration, represented by a narrow but moderately tall band, indicating brief yet distinct dominance. Product 4 also emerged as the closest to the Ideal product in the CA map. It demonstrated the longest salty taste dominance among all samples, likely due to its higher salt content. Salt plays a crucial role in processed meat by enhancing flavor and modulating texture. Previous studies have shown that salt can suppress both bitterness and sweetness (33) and enhance water-binding capacity by solubilizing myofibrillar proteins, which improves juiciness and contributes to greater sensory acceptance (34). These findings are consistent with CA results, where Product 4 was strongly associated with juiciness and meaty attributes, and not with bitter aftertaste or sweet taste.

Figure 5e shows the temporal dominance profile of Product 5. Meaty flavor was dominant during the initial phase (~0–30%), followed by umami flavor (~30–40%). No attribute reached statistical dominance between 40% and 60%. Around 60%, garlicky and meaty flavors co-dominated, followed by salty taste (~80%) and a final reappearance of meaty flavor (~90–100%). Band plots (Figure 6e) confirmed significant dominance of meaty, garlicky, and umami flavors. Meaty flavor exhibited a wide and tall band in the early stage, indicating sustained and intense perception. Umami flavor displayed the narrowest band but with moderate height, suggesting short-lived yet clearly perceptible dominance. The presence of umami flavor is plausible given the high chicken meat content (55.17%) in the product. Glutamic acid, a known taste-active compound in chicken breast meat, contributes significantly to umami taste perception and is considered a major contributor to chicken's characteristic flavor (35). Garlicky flavor appeared at ~60%, showing a wider band than umami with similar height, indicating a longer duration of moderate-intensity dominance—likely due to the use of garlic powder in the formulation. Interestingly, despite the strong perception of meaty flavor in the early and final phases, CA results showed that Product 5 was not strongly associated with any specific sensory attributes. This may be explained by the high proportion of soy protein isolate in the formulation. Soy protein isolate has been reported to suppress aroma and flavor intensity, often resulting in a blander overall sensory profile (36). This masking effect may have reduced the clarity of dominant sensations for this sample.

4. Conclusions

This study demonstrated the effectiveness of integrating CATA and TDS methods to evaluate the sensory characteristics of commercial pasteurized RTE sausages in Indonesia. Product 2 emerged as the most liked sample, despite being only moderately aligned with the ideal product profile; however, its prolonged dominance of meaty flavor in the TDS curves—longer than that of Product 1 and Product 4—may have contributed to its high consumer acceptance. Product 4, although not receiving the highest liking score, displayed the closest sensory resemblance to the ideal product, indicating strong alignment with consumer expectations, with a more dynamic transition in the TDS profile. In contrast, Products 3 and 5 were less preferred, with the presence of attributes such as sweet taste, starchy flavor, and fishy aroma contributing to their lower acceptance. Product 3 showed a dominance of sweet taste, which may explain its lower liking due to the unexpected sweetness. Meanwhile, Product 5 exhibited unclear dominant sensations, with weak and short-lived meaty and umami flavors. These TDS trajectories not only supported the findings from the CATA and liking tests but also highlighted how the timing and sequence of dominant sensations contribute to overall sensory experience. Future studies may integrate instrumental measurements such as Texture Profile Analysis or physicochemical analyses to further explain the mechanisms underlying the observed sensory attributes.

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Author Contributions

S.G.N., D.H., F.S.B., R.A.A., D.S., A.E.F., M.L.T., R.D.H. designed and performed the experiments. S.G.N., R.A.A., D.H. analysed the data. S.G.N. wrote the paper based on the analyzed data under the supervision of D.H., F.S.B., P.L.F., and I.S.

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Data Availability Statement

Available data are presented in the manuscript.

Conflicts of Interest

Authors may declare no conflict of interest

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