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Sensory Profiling of Commercial Sweet Crackers Using Check-All-That-Apply and Just-About Right Methods

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ABSTRACT

This study employed a dual-sensory technique to assess six commercially available sweet cracker products. The just-about-right (JAR) method was used to measure ideal intensity, while the check-all-that-apply (CATA) method was employed to determine attribute presence. A focus group discussion generated a lexicon of eighteen descriptors, from which six essential attributes, coarseness, roughness, creaminess, milkiness, sweet aftertaste, and grittiness, were selected for the JAR evaluation. In a randomized home-use test (HUT), thirty-three Indonesian panelists evaluated these attributes. JAR data were analyzed for deviation percentages and penalty effects on overall liking, while CATA responses were subjected to Cochran's Q test with Bonferroni-adjusted McNemar comparisons. The findings indicate that adjusting attribute intensities to align with panelists' ideals significantly improves acceptability, particularly for sample 363. Recommen-dations are provided for improving the formulation.

Keywords: *check-all-that-apply (CATA), home-use test (HUT), ideal product, just-about-right (JAR), sweet crackers*

INTRODUCTION

Crackers are popular snack products consumed by both children and adults, with a wide variety of flavor options compared to earlier versions (Arief *et al.,* 2018). Among these consumers, younger individuals, particularly teenagers and young adults, demonstrate a strong preference for crackers. A study by Hendra *et al.* (2019) involving high school students from Bali, Indonesia; Palembang, Indonesia; Pontianak, Indonesia; and Yogyakarta, Indonesia, revealed that crackers were the most frequently mentioned snack (49.0%), followed by breads or cakes (38.9%) and noodles or pasta (34.9%). Similarly, Tehubijuluw and Sari (2017) found that out of 155 Roma Malkist cracker consumers, 33% favored the meat floss variant, 32% preferred chocolate, and 19% chose the original flavor. Most respondents (73%) were between the ages of twenty and thirty-five, reinforcing the relevance of this product category to younger markets.

Despite strong consumer interest, many manufacturers continue to rely on traditional hedonic tests to evaluate product acceptance. These tests, which assess parameters such as color, taste, texture, and crispness, provide an overall measure of liking but often fail to uncover the specific sensory attributes that drive consumer preference and repeat purchase (Kusumawardani *et al.*, 2018; Meilgaard *et al.*, 2016). To address this limitation, advanced sensory profiling tools such as check-all-that-apply (CATA) and just-about-right (JAR) have been increasingly adopted in sensory and consumer science, offering a deeper understanding of how product characteristics relate to consumer satisfaction and product optimization (Ares & Varela, 2018).

CATA enables consumers to describe food products by checking all relevant sensory attributes from a predetermined list (Hunaefi *et al.,* 2021). While effective for identifying perceived characteristics, CATA's binary format does not differentiate between products with similar profiles (Adawiyah *et al.,* 2019). Therefore, it is often paired with JAR analysis, which captures consumer perceptions of attribute intensity in relation to an ideal level (Luc *et al.,* 2022). The integration of these two methods not only helps identify which attributes matter, but also whether those attributes are present at optimal levels, which is essential for product reformulation (Hunaefi *et al.,* 2018). Lee *et al.* (2021) demonstrated improved

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discrimination among samples of Yakju (Korean rice wine) using this combined approach compared to CATA alone. Similarly, Varela and Ares (2012) highlighted that the CATA-JAR integration provides a holistic consumer-driven framework for new product development across categories including dairy, snacks, and beverages.

In Indonesia, the application of combined CATA-JAR analysis remains limited, especially in the context of sweet crackers. Most existing research on crackers in Indonesia has employed traditional hedonic methods. For example, Novidahlia *et al.* (2018) examined crackers made from purple sweet potato and taro pasta using hedonic scales, while Santoso and Pamungkaningtyas (2022) evaluated the impact of almond extract flour substitution on cracker quality using seven-point hedonic ratings. Although both studies explored formulation and acceptance, neither addressed ideal attribute intensity or specific sensory drivers of preference. Meanwhile, Chaerudin (2018) investigated sensory satisfaction using five commercial Roma Sweet Cracker variants, confirming the positive relationship between sensory attributes and consumer satisfaction. More recent reviews, such as by Lawless and Heymann (2010), support the growing trend toward incorporating diagnostic tools like CATA and JAR to bridge the gap between hedonic ratings and actionable sensory data.

Given these gaps, this study aimed to identify key sensory attributes in commercial sweet crackers that influence consumer preferences and to determine whether those attributes are present at ideal intensity levels. A consumer-centered sensory evaluation was conducted using a combination of CATA and JAR methods to provide actionable insights for product optimization.

MATERIALS AND METHOD

Sample selection and storage

Six brands of original-flavor sweet crackers from Indonesia were selected from various retail sources. Hatari Malkist (original flavor) and Gery Saluut Malkist were obtained from Nayla Grocery Store, located in Dramaga, Bogor, Indonesia. Roma Sweet Crackers were purchased from Indomaret Babakan Minimarket, also in Dramaga, Bogor, Indonesia. Meanwhile, Unibis Malkist (original flavor), Kokola Malkist Milk, and Khong Guan Sugar Puff were sourced through Shopee, an Indonesian online retail platform. All products were stored at room temperature (25±2 °C) and anonymized using three-digit codes prior to sensory evaluation.

Panelists selection

A focus group discussion (FGD) was conducted with nine students from IPB University (aged 20–35 years) to generate sensory descriptors, following the approach of Omoba *et al.* (2015). After consolidation, the attributes were finalized into five sensory categories: appearance, aroma, texture, flavor, and aftertaste. The number of panelists and their selection criteria were based on the Indonesian National Standard (SNI 01-2346-2006), which specifies a minimum of 30 non-trained (consumer) panelists. This study was conducted under human ethics approval No. 873/IT3.KEPMSM-IPB/SK/2023.

Home-use test (HUT)

Thirty-three panelists participated in a randomized home-use test (HUT), following the protocol of Lee and Lee (2021). They received coded samples and completed online CATA and JAR questionnaires from their homes. A 250 mL cup of water was provided for palate cleansing.

Attribute rating

The CATA questionnaire presented 18 binary attributes; JAR scales (7-point) targeted six key attributes selected based on CATA must-have drivers. Attributes for the JAR test were selected from the most influential and discriminating attributes identified via CATA. While based on the same sensory dimensions, the two tests serve different functions, CATA for presence and significance, and JAR for intensity and optimization.

Data processing

CATA frequencies were analyzed by Cochran's Q test to identify significant differences across samples, followed by McNemar's multiple pairwise comparison with Bonferroni correction (XLSTAT v.2019). JAR data were summarized as mean intensity scores; deviation percentages (responses ≠ 4) quantified under or over intensity. Penalty analysis calculated mean drop in overall liking when attribute ratings were non-ideal with significance at $p<0.05$.

RESULTS AND DISCUSSION

Sensory attributes identification

A focus group discussion (FGD) involving nine panelists (11.11% male, 88.89% female) generated an initial list of eighteen sensory descriptors. These attributes were then categorized into five primary attributes in sensory wheels: appearance, aroma, texture, flavor, and aftertaste (Figure 1). This approach aligns with standard sensory methodology, where qualitative exploratory tools such as FGDs are used to capture consumer-relevant language prior to formal evaluation (Ares & Jaeger, 2013; Varela & Ares, 2012).

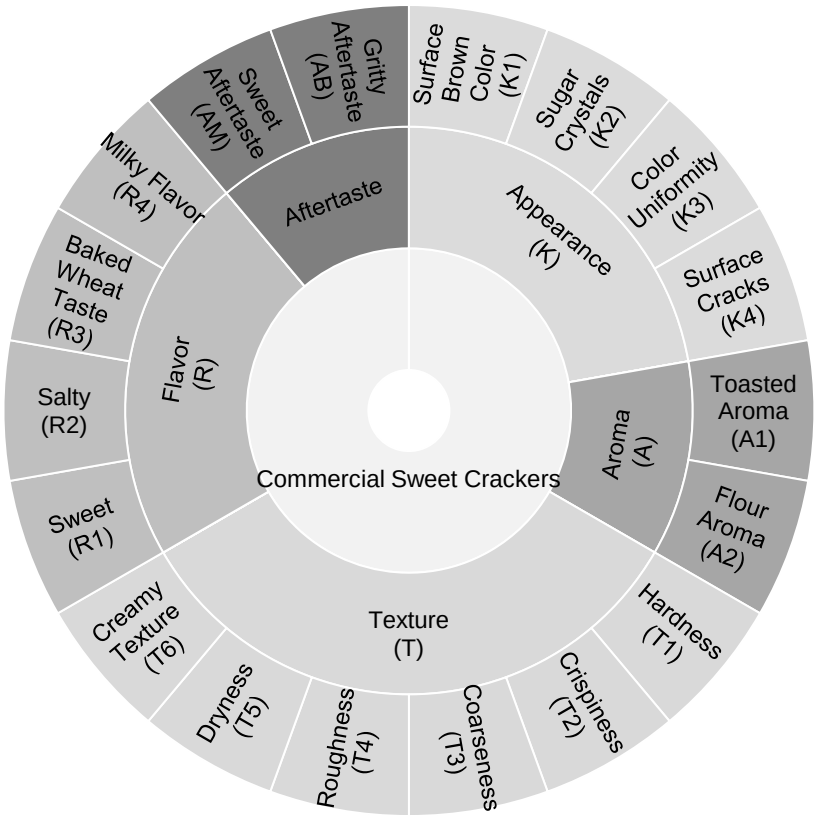


Figure 1. Sensory wheel of commercial sweet crackers

The lexicon developed from the FGD served as the foundation for constructing both the check-all-that-apply (CATA) and just-about-right (JAR) instruments. The use of consumer language in attribute development has been shown to enhance the validity of consumer-based sensory testing by improving familiarity and response reliability (Ares & Varela, 2018). The finalized set of attributes was used in subsequent testing, where thirty-three untrained panelists (aged 20–35 years) participated in a home-use test (HUT) to evaluate six commercial sweet cracker samples.

CATA outcomes

According to Cochran's Q test and the subsequent Bonferroni-adjusted McNemar pairwise comparisons, nine sensory attributes showed significant differences among the samples (p<0.05), while the remaining nine did not (Table 1). Attributes such as “color uniformity”, “roughness”, “creamy texture”, “salty”, “milky flavor”, and “sweet aftertaste” exhibited significant variation across products. In contrast, “surface cracks”, “sweet”, and “gritty aftertaste” did not show statistically significant differences among the samples.

Notably, some discrepancies were observed between the overall Q test and individual pairwise comparisons, which may reflect the limitations of consumer-based sensory profiling in detecting subtle sensory distinctions—an issue previously highlighted by Hunaefi *et al.* (2022). A biplot (Figure 2) provided a visual representation of perceived differences among the samples, indicating that samples 363 and 642 were positioned closest to the ideal sensory space, particularly for the attributes “milky flavor” and “creamy texture”, respectively.

Although these attributes were not strictly categorized as “must-have” drivers in Table 2, results from the principal coordinate analysis (PCoA) (Figure 3) revealed that other sensory factors such as “baked wheat taste”, “flour aroma”, and “surface brown color” also played substantial roles in shaping consumer preferences. These attributes should be given high priority during product development and reformulation, as they may strongly influence overall liking and purchase intent.

Table 2 classifies sensory attributes into three categories: “does not influence” (e.g., “color uniformity” and “salty”), “does not harm” (e.g., “surface cracks”), and “must-have” attributes (e.g., “coarseness”, “roughness”, “creamy texture”, “milky flavor”, “sweet aftertaste”, and “gritty aftertaste”). The “must-have” attributes were shown to have a strong influence on consumer preference; failure to optimize these attributes in product development could reduce overall product acceptability (Ares *et al.*, 2010; Varela & Ares, 2012).

Table 1. Results of Cochran's Q test and multiple pairwise commercial sweet crackers

Attributes	*p-value*	Sample					
		103	363	642	710	726	851
Surface brown color	0.180	1.000^{a}	0.939^{a}	0.970^{a}	0.970^{a}	1.000^{a}	0.909^{a}
Sugar crystals	0.199	0.939^{a}	0.970^{a}	0.970^{a}	0.879^{a}	0.970^{a}	1.000^{a}
Color uniformity	0.000	0.424^{a}	0.727^{ab}	0.848^{b}	0.727^{ab}	0.394^{a}	0.455^{ab}
Surface cracks	0.014	0.364^{a}	0.303^{a}	0.333^{a}	0.576^{a}	0.485^{a}	0.515^{a}
Toasted aroma	0.306	0.909^{a}	0.909^{a}	0.848^{a}	0.970^{a}	0.848^{a}	0.970^{a}
Flour aroma	0.094	0.879^{a}	0.939^{a}	0.697^{a}	0.848^{a}	0.848^{a}	0.848^{a}
Hardness	0.757	0.970^{a}	0.939^{a}	0.939^{a}	0.939^{a}	1.000^{a}	0.970^{a}
Crispiness	0.549	0.970^{a}	1.000^{a}	1.000^{a}	1.000^{a}	1.000^{a}	0.970^{a}
Coarseness	0.365	0.667^{a}	0.818^{a}	0.667^{a}	0.727^{a}	0.667^{a}	0.788^{a}
Roughness	0.003	0.576^{ab}	0.667^{ab}	0.455^{ab}	0.758^{b}	0.394^{a}	0.667^{ab}
Dryness	0.820	0.758^{a}	0.848^{a}	0.788^{a}	0.848^{a}	0.818^{a}	0.818^{a}
Creamy texture	0.000	0.697^{ab}	0.939^{b}	0.970^{b}	0.576^{a}	0.576^{a}	0.727^{ab}
Sweet	0.000	0.970^{a}	0.970^{a}	1.000^{a}	0.758^{a}	0.970^{a}	1.000^{a}
Salty	0.000	0.485^{ab}	0.758^{b}	0.364^{a}	0.758^{b}	0.606^{ab}	0.515^{a}
Baked wheat taste	0.661	0.848^{a}	0.939^{a}	0.909^{a}	0.939^{a}	0.939^{a}	0.909^{a}
Milky flavor	0.000	0.727^{ab}	0.909^{b}	0.939^{b}	0.545^{a}	0.667^{ab}	0.818^{ab}
Sweet aftertaste	0.000	0.818^{b}	0.909^{b}	0.909^{b}	0.394^{a}	0.818^{b}	0.848^{b}
Gritty aftertaste	0.009	0.515^{a}	0.606^{a}	0.485^{a}	0.727^{a}	0.394^{a}	0.697^{a}

Note: The different letters within each attribute indicates significant difference (p<0.05)

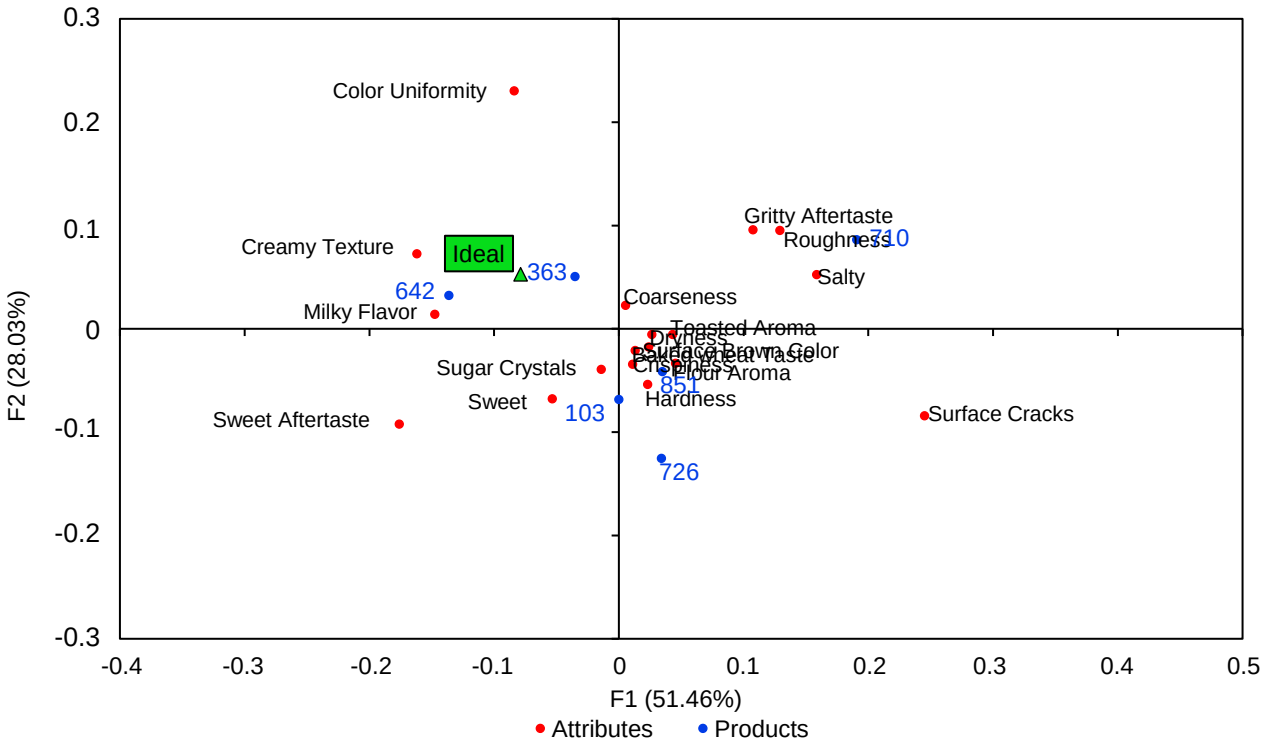


Figure 2. Biplot of commercial sweet crackers

Table 2. Classification of attributes based on consumer panelists preference

Must Have	Nice to Have	Does Not Influence	Does Not Harm	Must Not Have
Coarseness		Color uniformity	Surface cracks	
Roughness		Salty		
Creamy texture				
Milky flavor				
Sweet aftertaste				
Gritty aftertaste				

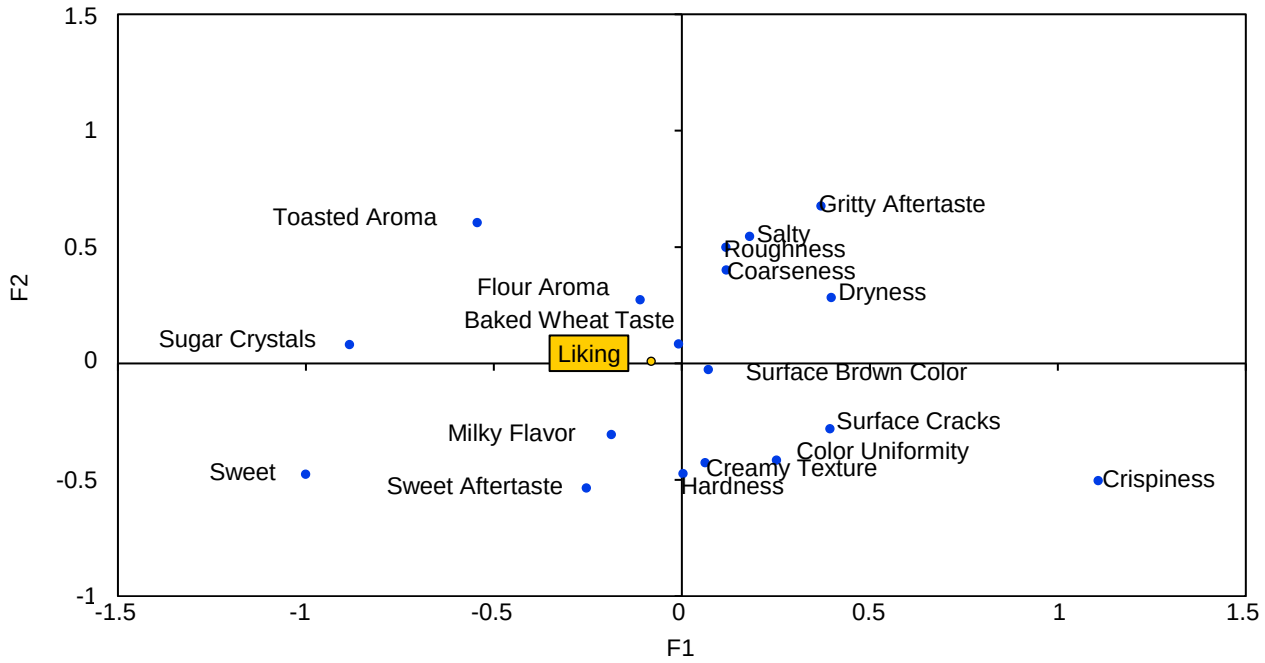


Figure 3. PCoA of commercial sweet crackers sensory attributes

Attributes in the “does not influence” category were found to have no significant effect on consumer liking or purchase intent. In contrast, “does not harm” attributes—although not preferred—were tolerated by consumers and did not significantly decrease overall liking (Adawiyah *et al.*, 2019; Hunaefi *et al.*, 2022). These categorizations are consistent with previous penalty analysis models where intensity deviations from ideal are assessed in terms of their impact on liking (Lee *et al.*, 2021; Moskowitz & Krieger, 1995). For the just-about-right (JAR) analysis, only attributes classified as “must-have” were selected, as they provide the most actionable insights for guiding product reformulation and consumer-oriented improvements.

JAR intensities and penalty analysis

The JAR results (Figure 4) indicated that sample 363 exhibited the best alignment with ideal intensity levels, particularly for “sweet aftertaste” and “roughness”, both rated as “just-about-right” by 42.42% of the panelists. However, more than half of the panelists perceived “sweet aftertaste” (54.55%), “creamy texture” (51.52%), and “gritty aftertaste” (72.73%) in this sample as “too little”, suggesting room for sensory optimization. Sample 851 also showed moderate alignment with the ideal for “creamy texture” and “gritty aftertaste” (both at 33.33%), yet was frequently rated as lacking in “milky flavor” (63.64%), “gritty aftertaste” (51.52%), and “roughness” (57.58%).

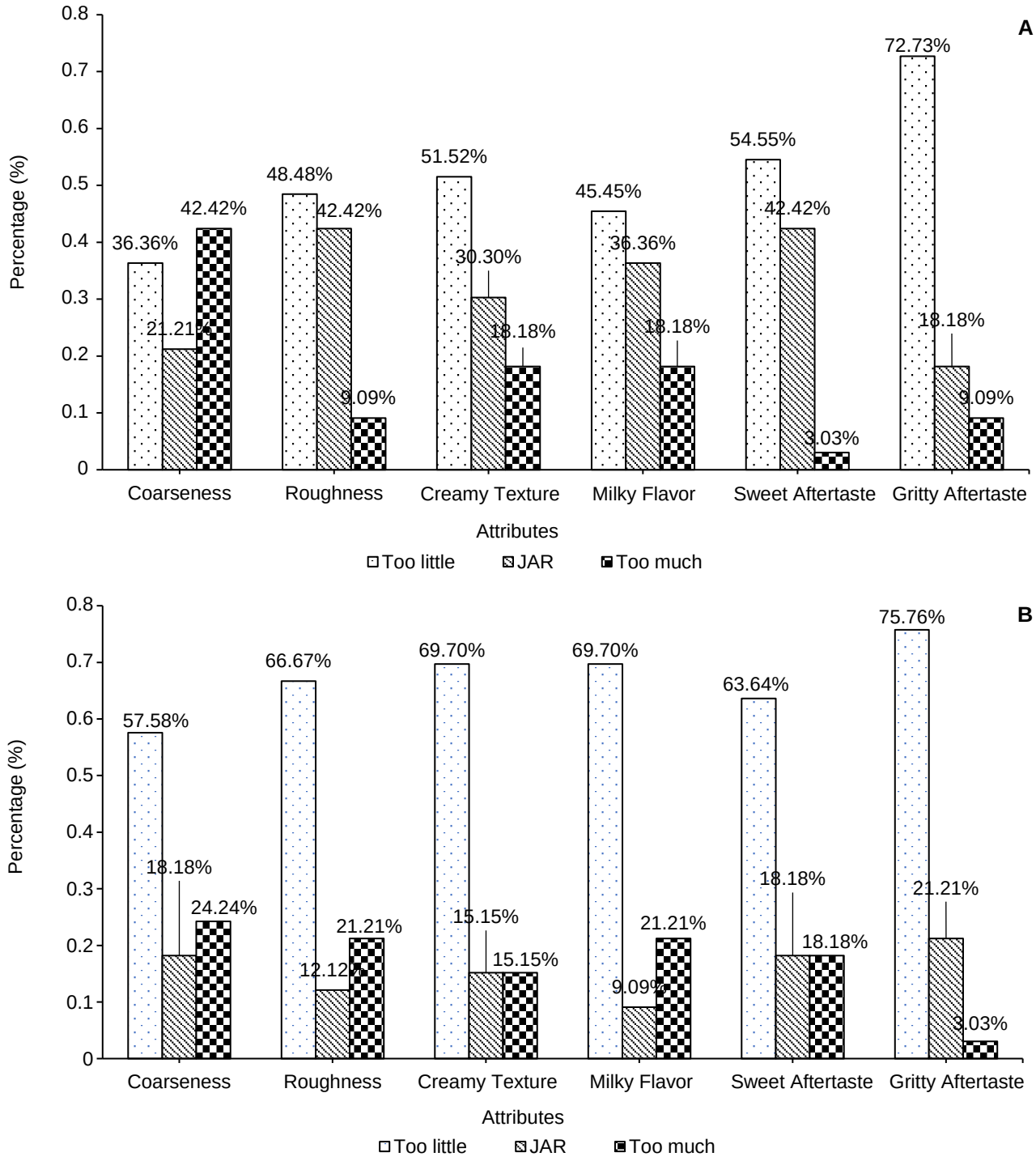
A similar pattern was observed in samples 103 and 726, where over 50% of panelists rated all six attributes as “too little”, reflecting significant negative variation. For example, “coarseness” was rated “too little” in 48.48% of responses for sample 103 and 42.42% for sample 851, while “sweet aftertaste” was perceived as insufficient by 39.39% of panelists in sample 851. Among all products, sample 710 showed the poorest alignment, with “sweet aftertaste” (96.97%), “creamy texture” (81.82%), and “milky flavor” (87.88%) most often rated as too weak. In contrast, sample 642 was over-perceived for several attributes, with “creamy texture”, “milky flavor”, and “sweet aftertaste” rated as “too much” by 81.82%, 81.82%, and 63.64% of panelists, respectively.

These results suggest that balanced intensities of “creamy texture” and “milky flavor” contribute positively to product acceptability, whereas excessive “coarseness”, “gritty aftertaste”, and “roughness” reduce liking. This is consistent with prior research indicating that overly intense textural attributes can evoke negative consumer responses (Ares *et al.*, 2010; Moskowitz & Krieger, 1995).

To identify key reformulation targets, a 20% deviation threshold was applied, as recommended by Wheeler *et al.* (2015). Attributes with more than 20% deviation from the ideal and a corresponding drop in overall liking were considered critical. Penalty analysis (Figure 5) showed that sample 363 was penalized for excessive “coarseness” and low intensity across all attributes except “creamy texture”. Samples 103, 726, and 851 shared similar penalty patterns for insufficient attribute intensity, while sample 851 also received penalties for excessive “roughness”, and sample 103 for excessive “milky flavor”. Sample 710 was heavily penalized for both under- and over-perceived attributes including

"coarseness", "roughness", "gritty aftertaste", and "milky flavor".

Interestingly, sample 642 was only mildly penalized, despite having some over-perceived attributes, suggesting that consumers may tolerate certain excesses—particularly in sweet products—if core attributes are sufficiently pleasant. Additionally, "roughness" was frequently penalized when rated as "too little", but the impact on liking was moderate (e.g., –0.6 drop in sample 851), suggesting that panelists may be less sensitive to the absence of rough textures. This aligns with the understanding that consumer tolerance for texture varies based on product type and context (Lawless & Heymann, 2010; Varela & Ares, 2012).



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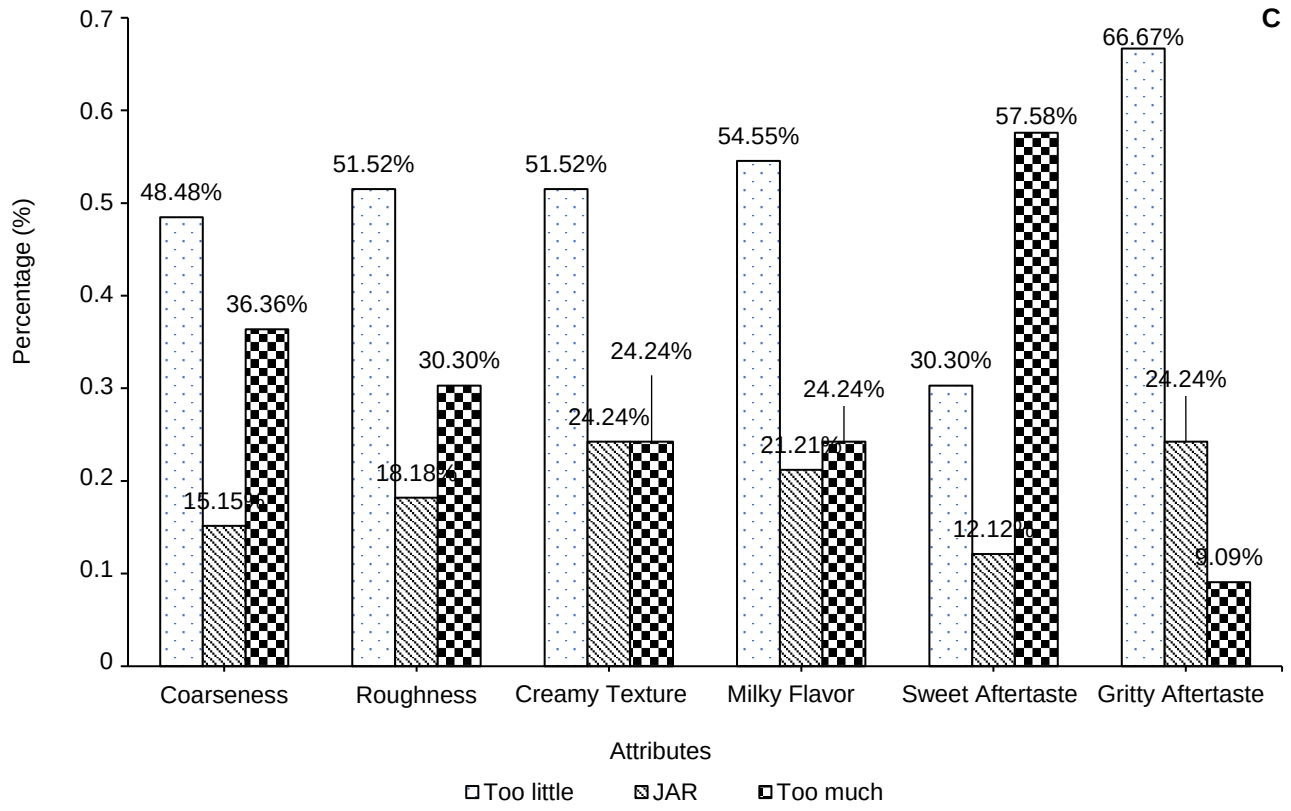

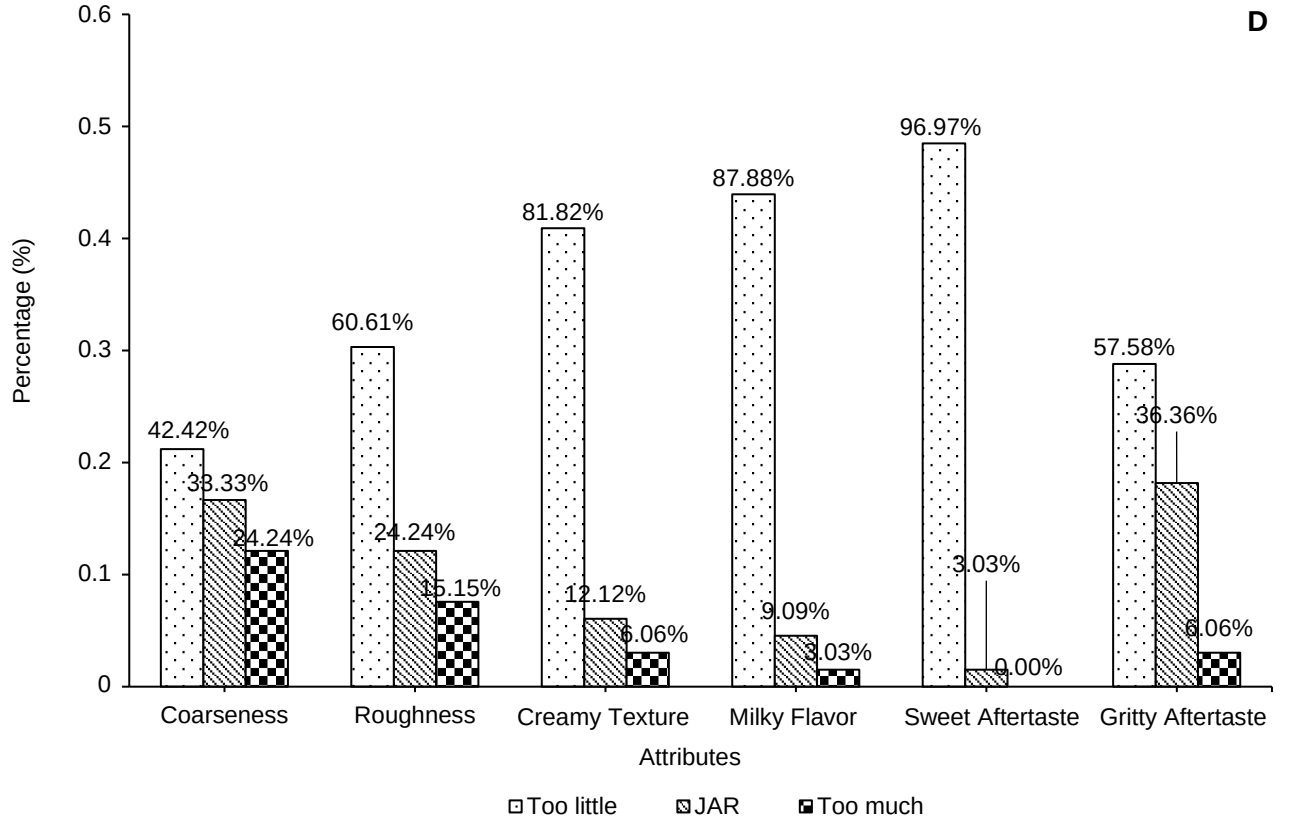

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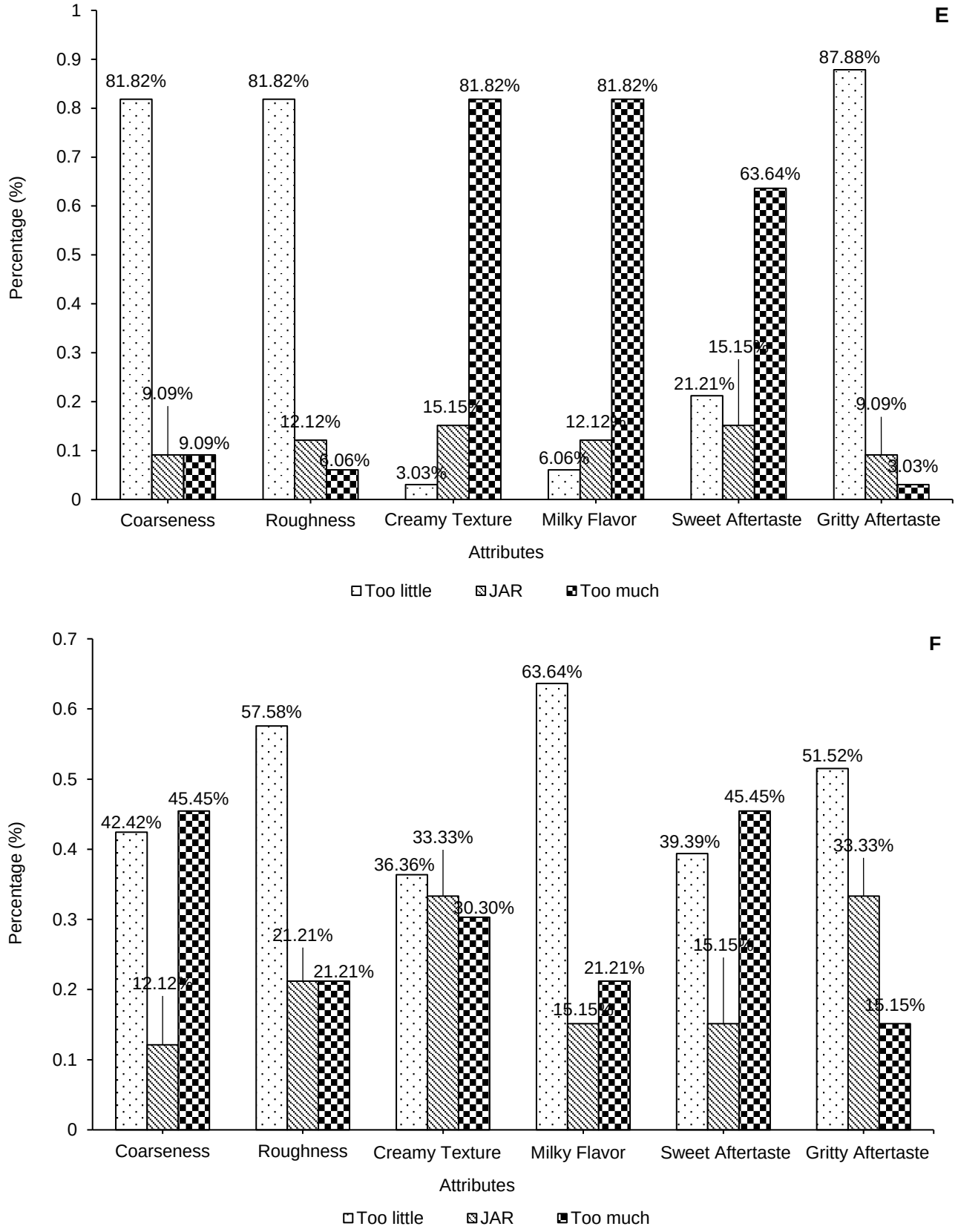
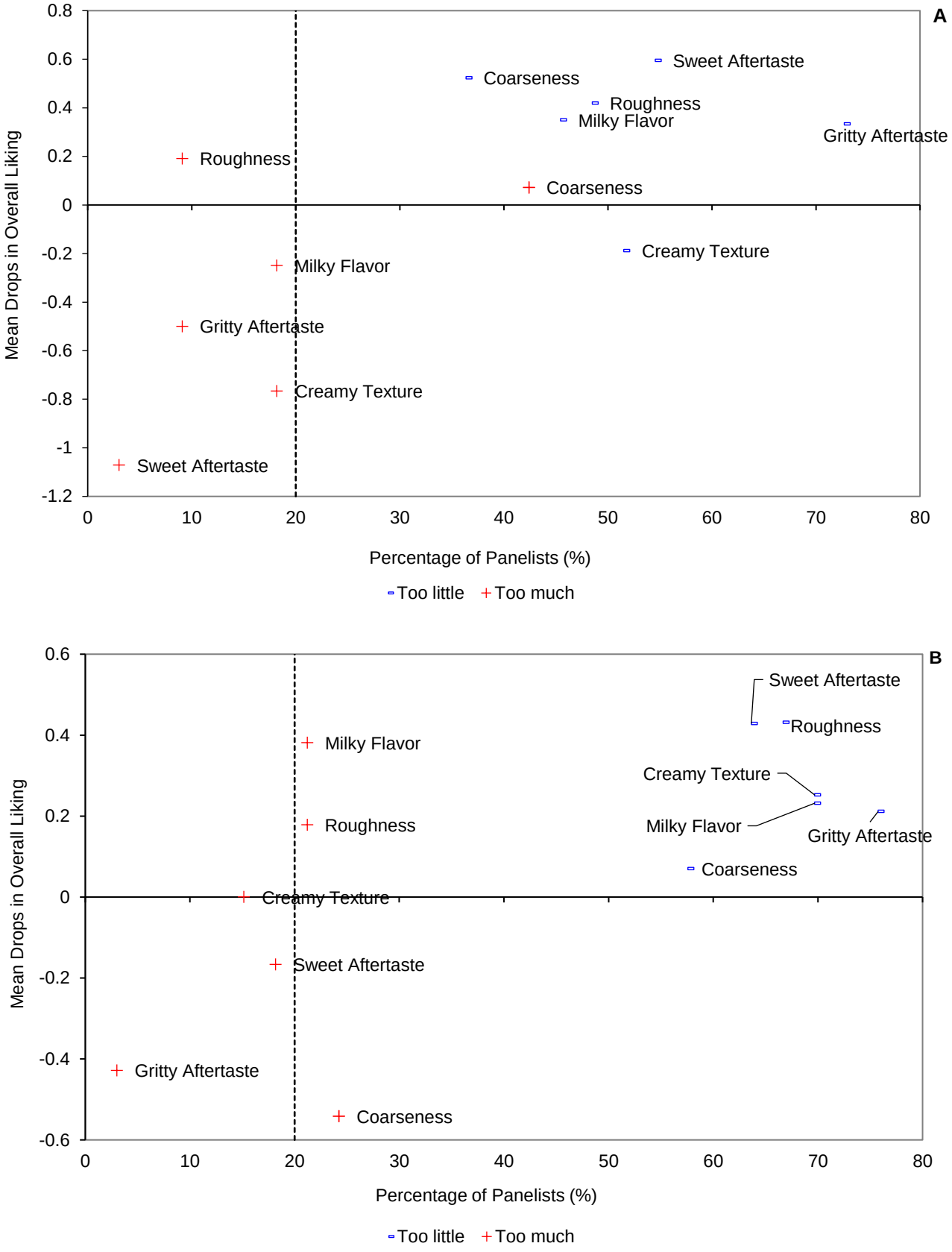


Figure 4. Just-about-right (JAR) frequencies of commercial sweet cracker attributes of sample 363 (A), 726 (B), 103 (C), 710 (D), 642 (E), 851 (F)



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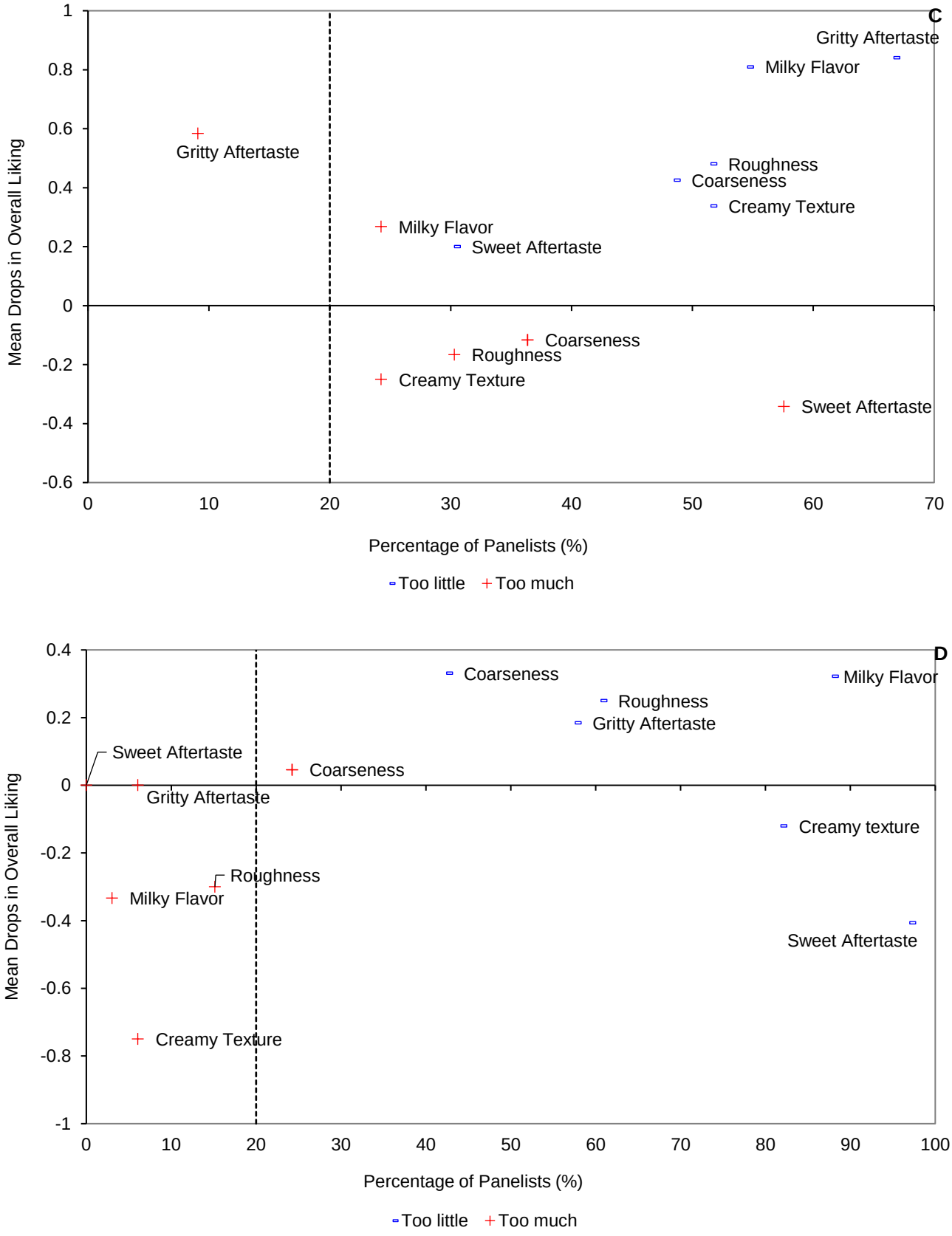

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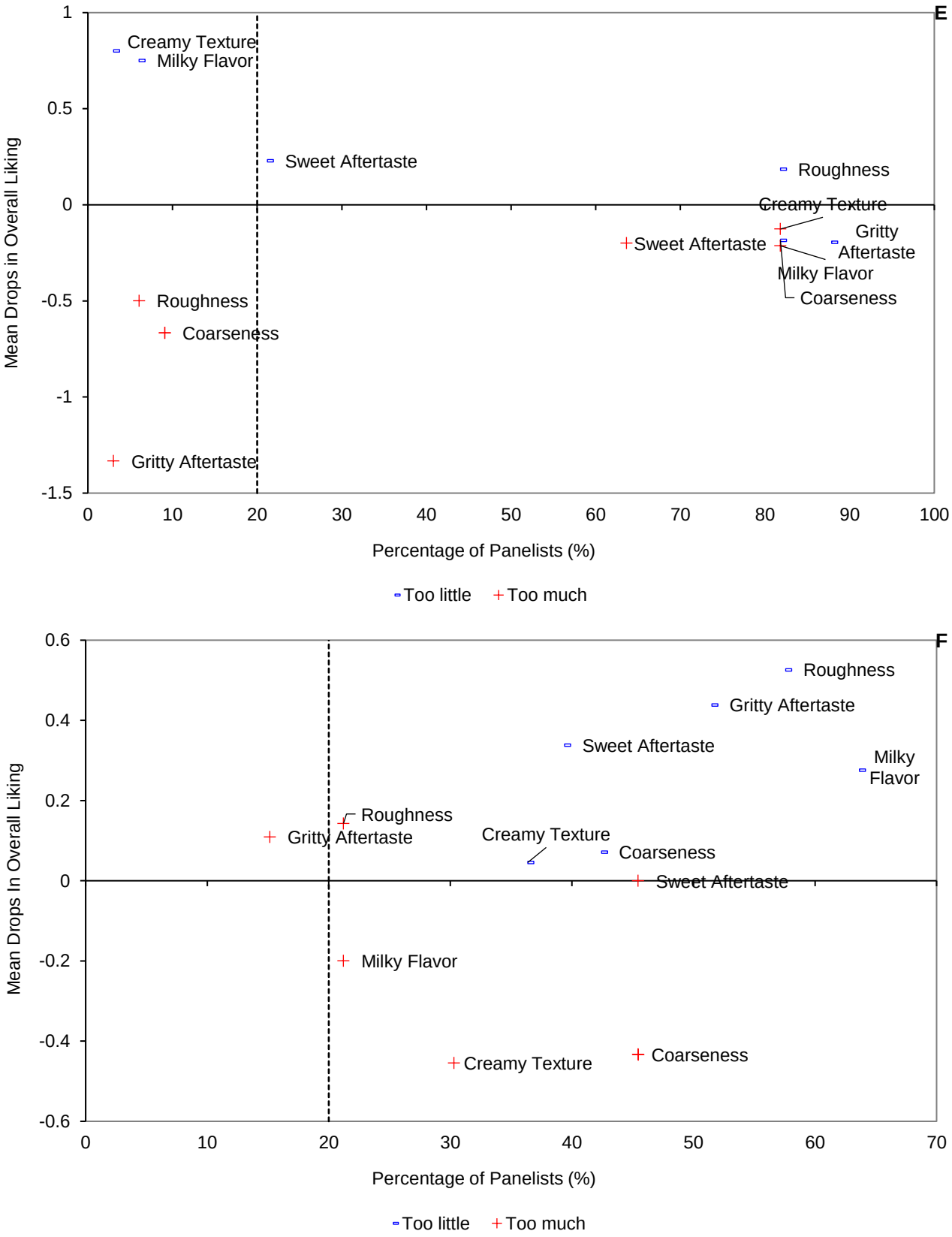

Figure 5. Plot of mean drops vs % response not JAR commercial sweet crackers of sample 363 (A), 726 (B), 103 (C), 710 (D), 642 (E), 851 (F), the dotted line shows the absolute threshold for the percentage of non-JAR scale panelist responses (threshold 20%)

The combination of CATA and JAR methods enhanced the ability to discriminate between sweet cracker samples and clearly identified the sensory attributes influencing panelist approval. As noted by Lee *et al.* (2021), this combined approach reduces potential hedonic bias and provides more robust diagnostic support for product reformulation. The integration of CATA's attribute identification and JAR's intensity assessment has been widely recognized for its ability to reveal not only what matters to consumers, but also how closely products align with their expectations (Ares & Varela, 2018).

The symmetrical plot (Figure 2) highlighted "milky flavor" as a "must-have" attribute with optimal intensity, confirming its role as a key driver of liking. In contrast, attributes such as "surface cracks" were categorized as "does not harm" (Table 2), suggesting that while perceptible, their influence on overall liking was negligible (Moskowitz & Krieger, 1995).

However, the JAR penalty plot (Figure 5) revealed that attributes such as "coarseness", "crispness", and "hardness"—particularly when perceived as overly intense—were positioned far from the ideal range and associated with significant reductions in consumer liking. These results underscore the importance of moderating negative texture perceptions, which have been shown in previous studies to significantly influence product rejection when not properly balanced (Ares *et al.,* 2010).

Variability in surface browning and color consistency was evident across samples during visual inspection (Figure 6). For example, samples 642 and 363 exhibited a more uniform, golden-brown appearance, while sample 851 showed uneven browning—likely reflecting differences in manufacturer standards. As noted by Santoso *et al.* (2021), the Maillard reaction and sugar content during baking play a crucial role in determining the degree of browning and overall aesthetic appeal. Inconsistent browning may result from localized sugar accumulation due to insufficient mixing during dough preparation.

While this study offers useful insights into the sensory characteristics of commercial sweet crackers, several limitations should be acknowledged. First, increasing the number of panelists would improve statistical robustness and help minimize sampling bias. Second, applying stricter health criteria—such as recent blood glucose screening—would enhance consistency in consumer responses, particularly when testing sweet products. Expanding the panel size and refining participant selection would ultimately increase the reliability and generalizability of the findings.

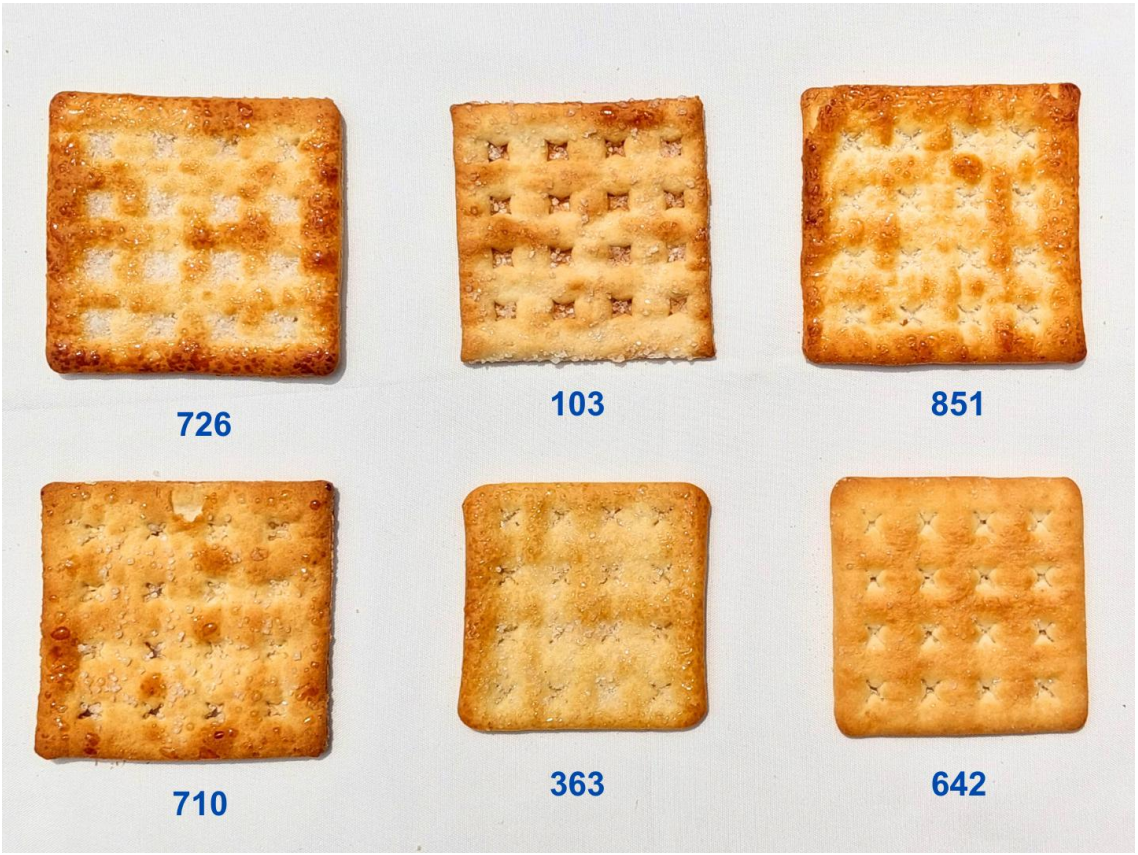

Figure 6. Commercial sweet crackers samples

CONCLUSION

This study employed a consumer-centered approach by combining Focus Group Discussion (FGD), Just-About-Right (JAR), and Check-All-That-Apply (CATA) methods to identify the key sensory attributes influencing acceptance of commercial sweet crackers. The FGD successfully generated a lexicon of relevant sensory descriptors, which formed the basis for the subsequent JAR and CATA instruments. These tools enabled a comprehensive evaluation of how specific attributes shaped consumer preferences. Positive drivers of liking included “milky flavor”, “creamy texture”, and “sweet aftertaste”, while negative attributes such as “roughness”, “gritty aftertaste”, and “coarseness” were associated with lower approval. CATA revealed that “surface cracks” and “sweetness” varied across samples, whereas “color uniformity” and “creamy texture” remained relatively consistent. Among the six samples evaluated, sample 363 exhibited the best alignment with ideal sensory characteristics. In contrast, sample 642 was perceived as overly creamy, and sample 710 lacked several important attributes. Interestingly, moderate levels of “roughness” were generally tolerated, suggesting that not all textural irregularities are detrimental to consumer liking. These findings offer actionable recommendations for manufacturers. Enhancing “milky flavor” and “creamy texture”, adjusting sweetness levels, and refining baking processes to improve consistency, particularly in browning and surface appearance, can support product optimization. Furthermore, future research should expand consumer representation and incorporate health-screened participants to improve the generalizability and reliability of sensory data.

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