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APRIMORAMENTO DE TÉCNICAS SENSORIAIS DESCRITIVAS: APLICAÇÃO DE MÉTODOS RÁPIDOS E TEMPORAIS NA AVALIAÇÃO DE PRODUTOS ALIMENTÍCIOS

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Tese apresentada à Universidade Federal de Lavras, como parte das exigências do Programa de Pós-Graduação em Ciência dos Alimentos, para a obtenção do título de Doutor.

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IMPROVEMENT OF DESCRIPTIVE SENSORY TECHNIQUES: APPLICATION OF QUICK AND TIMELY METHODS IN THE EVALUATION OF FOOD PRODUCTS

Tese apresentada à Universidade Federal de Lavras, como parte das exigências do Programa de Pós-Graduação em Ciência dos Alimentos, para a obtenção do título de Doutor.

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RESUMO GERAL

A análise descritiva sensorial consiste em uma ferramenta muito útil na indústria de alimentos e bebidas, amplamente utilizada para controle de qualidade e desenvolvimento de produtos. Nos últimos anos, metodologias mais rápidas, que não exijam um painel sensorial treinado, têm sido cada vez mais implementadas com o objetivo de economizar tempo e recursos. À medida que essas metodologias ganham popularidade, mais intensa é a necessidade de se entender como os diferentes provadores utilizam estas técnicas. Este estudo teve como objetivo aprimorar técnicas sensoriais descritivas rápidas e temporais, como o *Preference Sorting (PS)* e o *Temporal Dominance of Sensations* (TDS), otimizando as condições para a realização desses testes com consumidores. Para isso, foram realizados dois estudos: o primeiro avaliou a aplicabilidade do PS e o comparou com o *Check-all-that-apply* (CATA) na identificação de atributos sensoriais que impulsionam a aceitação dos consumidores. O segundo estudo investigou como diferentes definições de "dominância" influenciam as percepções sensoriais ao longo do tempo de ingestão, utilizando o TDS. No primeiro estudo, cem consumidores avaliaram dez amostras de doce de leite utilizando PS e o CATA. No método PS, os consumidores agruparam as amostras com base em níveis de aceitação semelhantes, atribuíram uma pontuação de aceitação para cada grupo e descreveram os atributos que mais influenciaram essa aceitação. No método CATA, os participantes identificaram individualmente os atributos sensoriais associados a cada produto e indicaram sua aceitação. Os resultados demostraram que PS e CATA identificaram de forma semelhante os direcionadores sensoriais de aceitação do doce de leite. Embora o CATA tenha sido considerado mais fácil de usar, o PS provou ser uma alternativa eficaz para a triagem rápida de grandes quantidades de amostras, oferecendo resultados comparáveis aos do CATA. No segundo estudo, duas abordagens do conceito de "dominância" foram exploradas: TDS-I (sensação que mais atrai atenção) e TDS-II (sensação mais intensa). Essas abordagens foram aplicadas na análise de queijos Minas artesanais da Canastra e chocolates com diferentes teores de cacau, avaliando como os consumidores interpretam e respondem aos estímulos sensoriais ao longo do tempo. Curvas de TDS foram construídas e análises como a Análise de Componentes Principais (PCA), curvas de diferença, Análise de Múltiplos Fatores (MFA) e o coeficiente de vetor de regressão (RV) foram utilizadas para comparar as duas abordagens. Os resultados indicaram que ambas as abordagens geram dados consistentes, e que a escolha da terminologia ("dominante" vs. "intenso") não influenciou significativamente os resultados do teste. Consequentemente, pode-se adotar maior liberdade e flexibilidade na terminologia utilizada para instruir os participantes durante o teste TDS. Por fim, este estudo contribuiu para o avanço das metodologias sensoriais descritivas, demonstrando que o PS e o TDS são eficazes em diversos contextos, oferecendo insights valiosos sobre a aceitação do consumidor e as percepções sensoriais dinâmicas. Os resultados reforçam a importância de ampliar o uso dessas técnicas para diferentes produtos e perfis de consumidores, fortalecendo a tomada de decisões na formulação e desenvolvimento de produtos.

Palavras-chave: CATA; Consumidor; Dominância Temporal das Sensações; *Preference Sorting.*

GENERAL ABSTRACT

Sensory descriptive analysis is a highly useful tool in the food and beverage industry, widely used for quality control and product development. In recent years, faster methodologies that do not require a trained sensory panel have been increasingly implemented to save time and resources. As these methodologies gain popularity, it becomes increasingly important to understand how different assessors use these techniques. This study aimed to improve rapid and temporal sensory descriptive techniques, such as Preference Sorting (PS) and Temporal Dominance of Sensations (TDS), optimizing the conditions for conducting these tests with consumers. To this end, two studies were conducted: the first evaluated the applicability of PS and compared it with Check-all-that-apply (CATA) in identifying sensory attributes that drive consumer acceptance. The second study investigated how different definitions of "dominance" influence sensory perceptions over the course of ingestion, using TDS. In the first study, one hundred consumers evaluated ten samples of dulce de leche using PS and CATA. In the PS method, consumers grouped samples based on similar acceptance levels, assigned an acceptance score to each group, and described the attributes that most influenced their acceptance. In the CATA method, participants individually identified the sensory attributes associated with each product and indicated their acceptance. The results showed that PS and CATA similarly identified the sensory drivers of acceptance for dulce de leche. While CATA was considered easier to use, PS proved to be an effective alternative for rapid screening of large quantities of samples, offering results comparable to CATA. In the second study, two approaches to the concept of "dominance" were explored: TDS-I (sensation that most attracts attention) and TDS-II (most intense sensation). These approaches were applied in the analysis of artisanal Minas cheeses from the Serra da Canastra region and chocolates with different cocoa contents, evaluating how consumers interpret and respond to sensory stimuli over time. TDS curves were constructed, and analyses such as Principal Component Analysis (PCA), difference curves, Multiple Factor Analysis (MFA), and the regression vector coefficient (RV coefficient) were used to compare the two approaches. The results indicated that both approaches generated consistent data, and the choice of terminology ("dominant" vs. "intense") did not significantly influence the test results. Consequently, greater freedom and flexibility can be adopted in the terminology used to instruct participants during the TDS test. Finally, this study contributed to the advancement of descriptive sensory methodologies, demonstrating that PS and TDS are effective in various contexts, offering valuable insights into consumer acceptance and dynamic sensory perceptions. The results highlight the importance of expanding the use of these techniques for different products and consumer profiles, strengthening decision-making in product formulation and development.

Keywords: CATA; Consumer; Temporal Dominance of Sensations; Preference Sorting.

INDICADORES DE IMPACTO

Este estudo contribuiu significativamente para o avanço das metodologias sensoriais descritivas na ciência dos alimentos, enfatizando os impactos sociais, tecnológicos e acadêmicos. Os resultados têm potencial para aplicação na indústria alimentícia, fornecendo ferramentas mais rápidas e acessíveis para a caracterização sensorial de produtos, beneficiando tanto as empresas quanto os consumidores. Socialmente, as metodologias desenvolvidas e aplicadas nesta pesquisa promovem maior envolvimento do consumidor em testes sensoriais, permitindo a criação de produtos mais alinhados às suas preferências, influenciando positivamente a aceitação dos alimentos e fomentando o consumo responsável. Tecnologicamente, o uso de Preference Sorting (PS) e Temporal Dominance of Sensations (TDS) introduziu uma abordagem inovadora para identificar atributos sensoriais que impulsionam a aceitação e mapear percepções dinâmicas durante o consumo. Esses resultados têm o potencial de otimizar os processos de pesquisa e desenvolvimento na indústria alimentícia, atendendo às demandas dos consumidores com maior eficiência. Além disso, este trabalho integra atividades de extensão ao envolver populações externas, como consumidores e produtores, em estudos aplicados, fomentando a troca de conhecimento e a inclusão social. Ao incorporar o queijo Minas artesanal da região da Canastra, reconhecido como patrimônio cultural, a pesquisa ressalta a importância da preservação e valorização dos bens culturais. Desenvolvido em ambiente acadêmico, o estudo também fortalece os impactos educacionais ao promover a formação acadêmica e técnica de profissionais qualificados, envolvendo alunos, técnicos e professores em ações colaborativas. Isso se alinha ao compromisso da UFLA com a pesquisa de impacto, abordando quatro áreas temáticas da Política Nacional de Extensão: comunicação, por meio de artigos divulgados; cultura, pela valorização dos alimentos tradicionais; educação, por meio da capacitação profissional; e tecnologia e produção, ao disponibilizar metodologias com aplicações industriais.

IMPACT INDICATORS

This study significantly contributed to the advancement of descriptive sensory methodologies in food science, emphasizing social, technological, and academic impacts. The findings hold potential for application in the food industry, providing faster and more accessible tools for sensory characterization of products, benefiting both companies and consumers. Socially, the methodologies developed and applied in this research promote greater consumer involvement in sensory tests, allowing for the creation of products better aligned with their preferences, positively influencing food acceptance and fostering responsible consumption. Technologically, the use of Preference Sorting (PS) and Temporal Dominance of Sensations (TDS) introduced an innovative approach to identifying sensory attributes that drive acceptance and mapping dynamic perceptions during consumption. These results have the potential to optimize research and development processes in the food industry, meeting consumer demands with greater efficiency. Furthermore, this work integrates extension activities by involving external populations, such as consumers and producers, in applied studies, fostering knowledge exchange and social inclusion. By incorporating artisanal Minas cheese from the Canastra region, recognized as cultural heritage, the research highlights the importance of preserving and valuing cultural assets. Developed within an academic environment, the study also strengthens educational impacts by promoting the academic and technical training of qualified professionals, involving students, technicians, and professors in collaborative actions. This aligns with UFLA's commitment to impactful research, addressing four thematic areas of the National Extension Policy: communication, through disseminated articles; culture, by valuing traditional foods; education, through professional training; and technology and production, by providing methodologies with industrial applications.

SUMÁRIO

PRIMEIRA PARTE

1 INTRODUÇÃO

A análise sensorial é uma área fundamental na ciência dos alimentos, sendo amplamente utilizada para avaliar a qualidade de produtos alimentícios por meio da percepção humana. Tradicionalmente, a caracterização de produtos é obtida por meio de análises descritivas, cujo objetivo é fornecer uma descrição completa das características sensoriais dos produtos (Varela; Ares, 2012), incluindo aspectos como aparência, aroma, sabor e textura (Loures *et al*., 2010). Essas técnicas são amplamente reconhecidas como ferramentas essenciais na análise sensorial (Alcantara; Freitas-Sá, 2018).

Embora as metodologias descritivas tradicionais ofereçam uma descrição detalhada dos produtos, elas exigem avaliadores treinados, o que torna o processo demorado e oneroso, devido à necessidade de várias sessões de treinamento para minimizar erros no uso de escalas (Alcantara; Freitas-Sá, 2018). Como resposta a essas limitações, nas últimas décadas houve um avanço significativo no desenvolvimento de métodos sensoriais alternativos, que visam fornecer uma caracterização sensorial com maior simplicidade em um menor intervalo de tempo, quando comparados às metodologias tradicionais (Ruiz-Capillas *et al.,* 2021).

Entre essas novas metodologias, destacam-se as técnicas rápidas, como o *Check-all-that-apply* (CATA), amplamente utilizado para caracterizações sensoriais derivadas de consumidores (Jaeger; Ares, 2023). No CATA, os consumidores recebem uma lista pré-definida de atributos e são solicitados a marcar todas as alternativas que consideram apropriadas para descrever uma amostra apresentada, podendo selecionar quantas alternativas forem necessárias (Ares *et al*., 2015). A frequência de seleção desses atributos é então utilizada para criar perfis sensoriais (Jaeger *et al*., 2023). O CATA também é frequentemente associado a testes de aceitação, uma combinação que permite compreender as preferências dos consumidores e identificar os atributos que impulsionam essa aceitação pelos produtos (Ares; Jaeger, 2015; Rodrigues *et al*., 2021).

Outra técnica amplamente utilizada é o *Sorting*, que consiste na categorização de produtos em grupos, de acordo com suas semelhanças ou diferenças (Chollet *et al.*, 2014). Cada participante avalia as amostras de acordo com seu critério pessoal, agrupando amostras semelhantes e separando as diferentes em grupos distintos (Alcantara; Freitas-Sá, 2018). Em alguns casos, os provadores também fornecem descrições das características dos grupos, enriquecendo as respostas (Delarue *et al*., 2022; Ares; Varela, 2018; Rodrigues *et al*., 2020). O *Sorting* e suas variações têm sido aplicados a uma grande variedade de produtos com diferentes complexidades sensoriais (Cartier *et al*., 2006; Chollet *et al.*, 2014; Ribeiro *et al.*, 2024). Dentre

essas variações, destaca-se o *Preference Sorting*, que foca na identificação dos atributos que impulsionam a aceitação dos consumidores. Nesse método, os provadores agrupam as amostras com base na sua aceitação, ou seja, amostras aceitas de forma semelhante são colocadas no mesmo grupo (Rodrigues *et al*., 2021). Embora os resultados obtidos por Rodrigues *et al*. (2021) sejam promissores, o *Preference Sorting* ainda é pouco explorado e necessita de mais estudos para validar sua aplicação em diferentes contextos.

Tanto o CATA quanto o *Preference Sorting* abordam a percepção sensorial como um fenômeno estático, capturando-a de maneira pontual, sendo amplamente utilizadas para traçar perfis sensoriais. Por outro lado, a percepção sensorial é um fenômeno dinâmico, no qual as sensações mudam ao longo do tempo durante o consumo de um produto (Thomas *et al*., 2015). Para captar essa natureza dinâmica, foram desenvolvidas metodologias temporais, como o *Temporal Dominance of Sensations* (TDS), que proporciona uma visão contínua da experiência sensorial (Pineau *et al.,* 2009).

O TDS é considerado um método descritivo de múltiplos atributos, rápido e eficaz, quando comparado a outros métodos convencionais, permitindo descrever a evolução temporal das sensações dominantes durante o consumo de alimentos. O método utiliza uma lista pré-determinada de atributos, apresentados por meio de uma interface computacional (Pineau *et al*., 2009; Pineau; Schlich, 2023), e as percepções são representadas por curvas que mostram a frequência com que cada sensação foi considerada dominante durante a avaliação (Pineau *et al*., 2009).

O conceito de "dominância" é central ao TDS (Keefer *et al.*, 2023; Pineau; Schlich, 2023), no entanto, não há uma definição universalmente aceita (Varela *et al*., 2018; Pineau; Schlich, 2023). Na literatura, várias definições foram dadas. Foi definida como a sensação que "surgir" (Pineau *et al*., 2009; Rodrigues *et al*., 2016), ou a sensação que "atrai mais sua atenção" (Lenfant *et al*., 2009; Pineau; Schlich, 2023; Di Monaco *et al*., 2014) ou "a sensação mais intensa" (Labbe *et al*., 2009; Albert *et al*., 2012). Essas diferentes interpretações do que constitui uma sensação dominante podem gerar heterogeneidade nas respostas, comprometendo potencialmente a precisão dos dados do TDS (Ares *et al*., 2015; Varela *et al*., 2018). Portanto, há uma necessidade de estudos adicionais para compreender melhor como as distintas interpretações de dominância influenciam os resultados sensoriais.

À medida que essas técnicas se tornam cada vez mais populares, cresce a necessidade de pesquisas adicionais sobre suas aplicabilidades, confiabilidade e reprodutibilidade. O entendimento de como diferentes provadores aplicam essas técnicas é essencial para preencher as lacunas existentes. Neste contexto, o presente estudo teve como objetivo aprimorar as

técnicas sensoriais descritivas rápidas e temporais, como o *Preference Sorting* e o *Temporal Dominance of Sensations*, otimizando as condições para a realização desses testes com consumidores. Assim, dois estudos foram conduzidos: o primeiro avaliou a aplicabilidade do *Preference Sorting* e o comparou com o CATA na identificação de atributos sensoriais que impulsionam a aceitação dos consumidores; o segundo estudo explorou como diferentes definições de "dominância" influenciam as percepções sensoriais ao longo do tempo de ingestão, utilizando o TDS.

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SEGUNDA PARTE – ARTIGOS

ARTIGO 1: PREFERENCE SORTING VERSUS CHECK-ALL-THAT-APPLY ON SENSORY DRIVERS OF LIKING DETERMINATION: A COMPLEMENTARY STUDY ASSESSING DULCE DE LECHE

Preference sorting x CATA on sensory drivers of liking

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Abstract

Product sensory description is a fundamental action in sensory science, traditionally achieved through descriptive sensory tests. Rapid methods (Sorting and check all that apply [CATA]) that do not require trained sensory panels have been increasingly implemented to save time and costs. Considering the traditionality of the CATA method, this study is an extension of previous research on sensory drivers of liking of dulce de leche, comprising an investigation of Preference Sorting (PS) versus CATA to compare the results and information obtained from both techniques. PS and CATA tests showed similar results in determining dulce de leche sensory drivers of liking. However, some differences on sensory description were noted. Consumers considered the PS test more difficult than CATA. PS proved to be an alternative in determining the product sensory drivers of liking for a screening of a large number of samples, providing similar results to the traditional test - the CATA test.

Practical Applications

The findings of this study show practical utility for consumer-based methodologies, focusing on sorting tasks and sensory drivers of liking determination, complementing the preference sorting studies in a comparative perspective with a traditional sensory method to understand the technique and its applicability better. In addition, they are useful for Brazilian dulce de leche producers as they enable an understanding of consumer preferences to plan production, marketing, and commercialization strategies.

Keywords: CATA; Preference Sorting; Sensory drivers of liking.

INTRODUCTION

Sensory description of products is a key tool in sensory science used by the food industry in the development of new products, changes in ingredients and/or formulations, and quality control (Alcantara & Freitas-Sá, 2018; Lawless & Heymann, 2010; Varela & Ares, 2012).

Descriptive characterization is traditionally achieved through descriptive sensory tests (Stone & Sidel, 2004), and when used in conjunction with consumer testing, it provides valuable information for the introduction and strategic positioning of products in the market (Horita et al., 2017; Torrico et al., 2018), allowing the identification of the sensory drivers of liking of products (Alcantara & Freitas-Sá, 2018).

Sensory drivers of liking are the attributes with the most relevant positive effects on general taste, aroma, appearance, and texture (Kuesten & Bi, 2018; Lee et al., 2021). Like this, the sensory drivers of liking are the sensory attributes that drive product acceptance (Moskowitz, 2002; Rocha et al., 2020).

In practice, the combination of descriptive and affective sensory approaches has been used to obtain data on how perceptible differences in the sensory attributes of the product affect the hedonic responses of consumers (Horita et al., 2017; Stone, 2015; Torricoet al., 2018). Traditional descriptive sensory approaches use trained evaluators and unstructured scales to evaluate products, which is an expensive, labor-intensive, and time-consuming process mainly due to the exhaustive panel training sessions (Alcantara & Freitas-Sá, 2018). To reduce the analysis time and costs inherent to descriptive tests, other rapid methods have been gaining relevance as an alternative to achieve faster and less costly responses without compromising data reliability (Aguiar et al., 2019; Nguyen & Varela, 2021; Rodrigues et al., 2021a; Rodrigues et al., 2021b).

Rapid techniques focus on sensory perceptions and relate them to consumer expectations to obtain the sensory drivers of liking of products (Nguyen & Varela, 2021). Understanding the sensory drivers of liking is essential to achieve a better market share (Viana et al., 2016). Their identification is also important for launching and reformulating products according to consumer expectations (Lee et al., 2021; Rodrigues et al., 2018).

From these rapid descriptive methods, we can stand out the Preference Sorting (PS) proposed by Rodrigues et al. (2021a). These authors showed that sorting criteria and the sensory description task influenced sensory results, and focusing on sensory drivers of liking determination, grouping criteria based on preference (name as Preference Sorting), following the description of their characteristics that most contribute to product acceptance, seems to be interesting. However, there are still few studies regarding the use of this technique and comparison with other rapid descriptive methodologies.

Check all that apply (CATA) has been widely used in the sensory field as a descriptive technique for reducing panel time, requirements, and training (Godoy et al., 2019; Silva et al., 2020). It is also a technique that can be performed with consumers to obtain a product description simply and quickly (Godoy et al., 2019). Its association with an acceptance assessment is common to understand consumer preferences and product liking drivers (Ares & Jaeger, 2015; Jaeger et al., 2013; Rodrigues et al., 2021b).

Considering the traditionality of the CATA method, this study is an extension of previous research on dulce de leche sensory drivers of liking (Rodrigues et al., 2021a). The authors demonstrated that the sorting criterion influenced the results and suggested the PS test to determine sensory drivers of liking and screening of products. However, PS is still little explored. Thus, to better understand the technique and its applicability, this study comprises an investigation of PS and CATA to compare the results and information obtained from both techniques on sensory drivers of liking determination.

METHODS

The study was performed in a standardized sensory environment (International Organization for Standardization, 2007; ISO 8589) and following good sensory practices (Lawless & Heymann, 2010) at the Sensory Analysis Laboratory of the Food Science Department of the Federal University of Lavras (UFLA), Brazil.

Samples

Ten commercial brands of dulce de leche (Product obtained by concentrating and heating milk or reconstituted milk under normal or reduced pressure, added with sucrose), comprising two market leaders (samples 1 and 5), were evaluated. The brands of dulce de leche had variable sensory features (appearance, texture, color, and flavor) and contained the following basic ingredients: milk, sugar, and sodium bicarbonate; some samples also included cornstarch and/or potassium sorbate in their formulation. All packages of a given product were from the same batch and had the same expiration date.

5 g of each sample at room temperature (27°C) were served in disposable cups coded with three-digit numbers in each test.

Experiment overview

One hundred consumers of dulce de leche (34 male and 66 female, aged from 20 to 50 years old) performed the tests. They were recruited by online questionnaires, in which they should indicate their frequency of consumption of dulce de leche, if they had experience with sensory tests and if they had good health. Individuals with a consumption frequency at least once a week, who have already participated in consumer sensory tests, who are non-smokers, and who are in good health were included in the survey. They agreed to participate in the study by filling out a term approved by a research ethics board (CAAE: 55719316.3.0000.5148). They attested to their agreement and interest in participating in all research sessions.

To compare the results obtained by PS (Rodrigues et al., 2021a) and CATA test (followed by an acceptance test), all consumers performed both tests. Each test was performed in 1 day, totaling 2 days of testing. The order of tests was randomized among consumers in order to minimize learning effects. Thus, some individuals performed the PS on the first day and then the CATA test on the second day; and other tasters did the opposite (CATA test first and PS on the second day). Both tests were performed based on the same attribute list previously generated by a Focus Group (Esmerino et al., 2017; Speight et al., 2019).

All products were presented simultaneously in a random and balanced order during the PS; and during two sessions (five samples per session) in a sequential monadic way, with the serving order balanced across respondents during the CATA test (Wakeling; Macfie, 1995; Gutiérrez-Salomón et al. 2014; Rodrigues et al. 2021).

The degree of difficulty of the two tests was assessed immediately after completion of each test by the consumers, using a 9-point scale ranging from "extremely easy " to "extremely difficult ".

Attribute list

The attribute list was generated by a Focus Group according to Esmerino et al. (2017) and Speight et al. (2019). The focus group was carried out with 10 consumers (eight female and two male), aged between 20 and 40 years, and with a minimum frequency of consumption of dulce de leche of once a week to identify the particular product characteristics (Rodrigues et al., 2020).

Attribute list comprised multiple sensory modalities (appearance, flavor/taste, texture, and off-tastes) and the following terms: yellow; brown; bright; soft; milk_aroma; vanilla_flavor; caramel_aroma; canned_milk_aroma; sweet_flavor; flavorless; creamy; uniform; sticky; sandy; milk_taste; canned_milk_flavor; caramel_flavor; excessive_sweetness;

balanced_sweetness; butter_taste; burned_taste; unpleasant_taste. The order of presentation of the terms was randomized and balanced (Ares et al., 2014); and the "other" option, in which the taster could include some attribute not belonging to the list, was included. However, no new term was cited.

Preference sorting

PS was conducted according to Rodrigues et al. (2021a). Consumers were instructed to taste all products and then sort the samples (n = 10) according to their acceptance, that is, similar accepted samples (with similar acceptance grades) would be grouped in the same group. The assessors were free to make as many groups as they considered necessary with as many products as they wanted in each group (Chollet et al., 2013). An acceptance score for each group using a 9-point hedonic scale ranging from "extremely dislike" to "extremely like" (Peryam & Pilgrim, 1957) was also indicated. After the sorting task based on preference, they were instructed to cite the characteristics (from the attribute list) that most contributed to the acceptance of each group (sensory drivers of liking) (Rodrigues et al., 2021a).

CATA and Acceptance test

During the CATA test, samples were served one at a time, with the serving order balanced across respondents, accompanied by the respective answer sheet. Consumers were instructed to verify all the CATA terms (from attribute list) that they considered adequate to describe each sample (Ares et al., 2014). After they indicated their sensory acceptance regarding the overall impression of the sample, using a 9-point scale ranging from "extremely disliked" to "extremely liked" (Stone & Sidel, 2004).

Data Analysis

Acceptance results obtained from PS and CATA tests were represented by histograms. As in the study Rodrigues et al. (2021a), the PS data were arranged in a co-occurrence matrix for each assessor in each approach. In a co-occurrence matrix, the rows and columns represent the samples and a value of 1 between a row and column indicates that the assessor grouped the samples together, whereas a value of 0 indicates that the samples were not grouped together. The co-occurrence matrices were transformed into distance matrices by subtracting the co-occurrence matrices from a conformable matrix filled with 1 s. The distance matrices were then transformed into cross-product matrices that are aggregated to create a compromise cross-product matrix, which represents the consensus of the assessors (Abdi et al., 2007). For the CATA question, the citation frequencies of each descriptor for a sample were calculated by counting the number of consumers who indicated the descriptor to describe the product and were organized in a contingency table (Jaeger et al., 2013). To study the association between PS and CATA, the Chi square test for independence at 5% significance was applied for each sample. These data are presented in supplementary material (Table S1).

PLS regression was also conducted using PS and CATA results, attributes (matrix X: independent variable), and hedonic mean (matrix Y: dependent variable) (Lee et al., 2021) to filter the most significant attributes to predict the sensory drivers of liking.

Data obtained from bidimensional maps for each approach (PS and CATA), after filtering the attributes, were evaluated by multiple factor analysis (MFA) (Varela & Salvador, 2014; Worch, 2013). A matrix data set composed of 10 rows (products) and 14 columns covering two groups (Group 1 with 13 columns covering the frequency of the sensory descriptors used to describe the groups of samples in each approach. Group 2 composed a column that corresponds to the mean overall liking of each sample).

A second MFA was conducted to obtain a comparison among the tasks (PS and CATA), assessing the positioning of the products in a single sensory map. This involved the construction of a 10-row matrix (products) with two groups of columns that corresponded to the data used to describe the samples in each task.

The RV coefficient was calculated to compare the results obtained by PS and CATA tests. It was calculated using the CA contingency tables of the two tasks. The RV coefficient is a multivariate statistic ranging from 0 (uncorrelated, orthogonal configurations) to 1 (perfect agreement, homothetic configurations; Robert & Escoufier, 1976). Its significance was tested using the standardized RV coefficient according to Josse et al. (2008).

The degree of difficulty in performing each test was evaluated by means and t-test. All statistical analyses were performed using XLStat 2022 (Addinsoft, Paris, France).

RESULTS

Figure 1 shows the acceptance score obtained for dulce de leche's samples from both approaches (PS and CATA + acceptance test). Sample V was the preferred sample with grades varying between 7 - I liked it moderately and 8 - I liked it a lot, followed by samples I and II in PS test; and followed by I, II, and VI in CATA test, with grades between 6 - I liked it slightly and 7 - I liked it moderately. Samples I and V are considered market leaders (Rodrigues et al. 2021a). Samples VIII, III, X e IX were less preferred from PS, while the samples VIII, X, and IX stand out as least preferred by CATA, which indicates a ranking of acceptance between samples similar between approaches.

Table S1a (supplementary material) shows the PS cross table and PS contingency, CATA contingency (Table S1b), and the Chi square test between (Table S1c) the same samples for both methods (PS and CATA). The RV coefficient was calculated to quantify the general

similarity between the resulting sensory configurations. The RV was 0.88 (p = .0001), indicating similarity between the tasks.

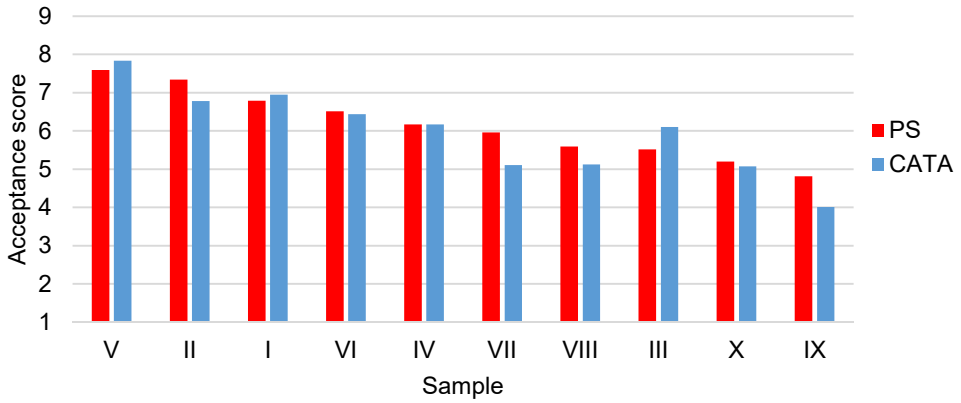


FIGURE 1. Histogram of acceptance scores for PS and CATA tests for dulce de leche. CATA, check all that apply; PS, preference sorting.

Regarding the descriptive description obtained from both methods, Table S1c (supplementary material) presents a comparison between the citation frequency of the attributes between the same samples for both methods.

It is noted that the attributes regarding to sample's appearance ("yellow" and "uniform") were the ones that varied the most between the approaches, being significative for six (I, II, III, IV, V, and X) and five (I, IV, V, IX, and X) samples, respectively; followed by "sand" attribute that was significative in four samples (I, II, VIII, and X; $p \leq .005$).

Figure 2 displays correlation loadings plot of the PLS models and value of the variable importance for the projection (VIP) for each explanatory variable, for an increasing number of components. PLS is a multivariate method capable of establishing linear relationships between a set of predictors (sensory descriptors) and a response (Liking) (Morais et al., 2014). The objective of PLS was to establish which sensory attributes are related to the sensory drivers of liking.

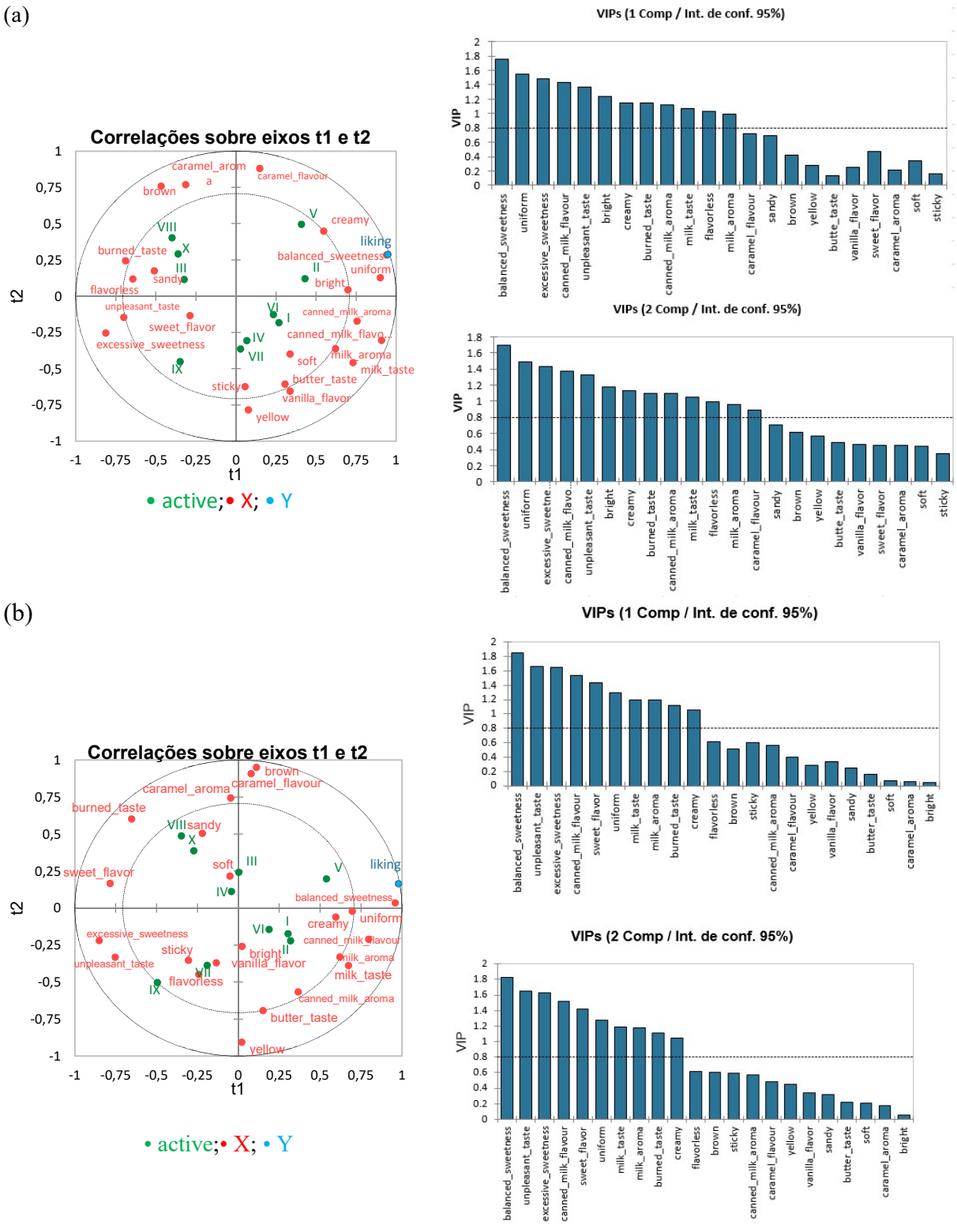


FIGURE 2. Correlation loadings plot of the PLS models and value of VIP'S by Preference sorting and CATA tests. (a) Preference sorting; (b) CATA; Ellipses represent r 2 = 50% and 100% explained variance. CATA, check all that apply; VIP, variable importance for the projection.

Variables are visualized on a graphical display, “the correlation circle” (Figure 2) used their correlations with the PLS components. In general, it is observed that the sensory drivers of liking and not liking of dulce de leche were similar in both tasks.

Figure 2 allows to quickly identify which are the explanatory variables that most contribute to the models, predicting the sensory drivers of liking of the product attributes of both tests (PS and CATA). All predictive variables (attributes) were weighted, and the relative importance of attributes for sensory drivers of liking was investigated. The attributes that present values of high VIP (VIP index ≥0.8 - horizontal dotted line on the graph) can be classified as key attributes for the sensory drivers of liking, that is, the variable with VIP ≥0.8 was statistically significant (Rossini et al., 2012).

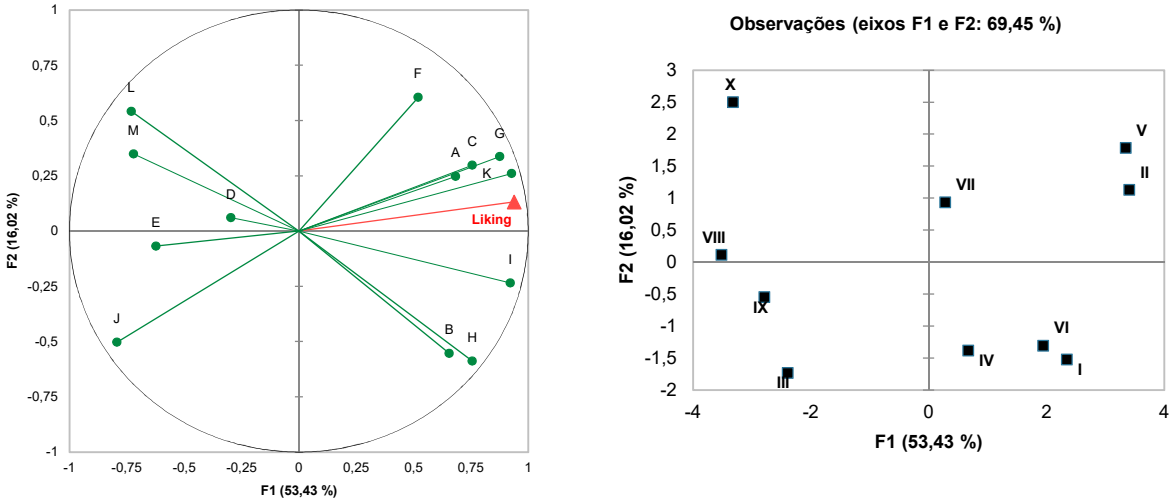
Overall, the sensory drivers of liking and disliking for dulce de leche, obtained from both tasks, were similar. It is possible to note that the attributes brown, creamy, uniform, milk taste and aroma, canned milk flavor, canned milk aroma, and balanced sweetness were positive factors for the sensory drivers of liking, showing that consumers preferred dulce de leches with these attributes (Figure 2). The least important attributes, in both tasks, were yellow, brown, sticky, soft, caramel_aroma, sweet flavor, vanilla flavor, butter_taste, sandy, caramel flavor, and milk_aroma, which have VIP indices smaller than 0.8. That is, considering the confidence intervals, they were not significantly larger than 0.8.

According to Rossini et al. (2012), these attributes, not significantly, could be discarded thus saving time and fatigue to assessors, because according to the authors attributes with low VIP values does not compromise the characterization of products. PLS takes account of the within and between product variations while minimizing the impact of multicollinearity (Rossini et al., 2012).

Therefore, we have discarded these attributes and performed a MFA on the remaining variables, for both tasks. A MFA analysis was conducted on each approach to evaluate the PS

data versus the CATA data (Figure 3), both for the descriptive and acceptance data. Differences on samples' and descriptions' displays were noted among the approaches. However, the liking vector was very similar displayed for both tests.

(a)



(b)

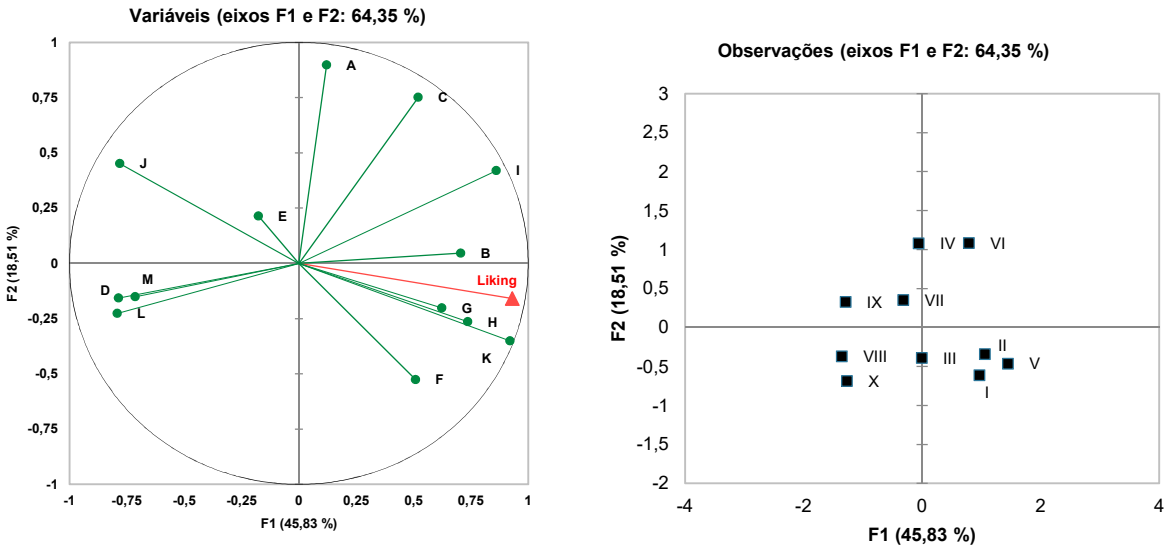


FIGURE 3. MFA of PS and CATA tests evaluations, considering the significative attributes. (a) Preference sorting; (b) CATA; •-attribute; ■-product; ▲-Liking; Attributes (A-M): A-bright; B-milk_aroma; C-canned_milk_aroma; D-sweet_flavor; E-flavorless; F-creamy; G-uniform; H-milk_taste; I-canned_milk_flavor; J-excessive_sweetness; K-balanced_sweetness;

L-burned_taste; M-unpleasant_taste. CATA, check all that apply; MFA, multiple factor analysis; PS, preference sorting

Despite the different sensory configurations obtained through MFA (Figure 3), overall, the sensory drivers of liking and disliking for dulce de leche, obtained from both tasks, were similar. Considering the first-dimension analysis, attributes bright, milk_aroma, canned_milk_aroma, creamy, uniform, milk_taste, canned_milk_flavor, and balanced_sweetness were directed for the liking vector in both approaches, while sweet_flavor, flavorless, excessive_sweetness, burned_taste, and unpleasant_taste were considered as negative attributes. Samples II an V were considered as preferred in PS, and I, II, and V in the CATA test.

Another MFA was applied to all data significant from PS and CATA tasks to compare the distribution of 10 products according to the different approaches, being each product represented by different colors (Figure 4).

79.33% and 84.69% of the variance was explained in the data set, for liking and attributes and products, respectively. The different positions of the products at the MFA bidimensional map show clear differences, suggesting the consumers were able to distinguish the products. RV coefficients were calculated to quantify the overall similarity between the resulting sensory configurations. RV values for attributes and liking were 0.800 ($p = .00015$); and for products, RV were 0.813 ($p = .001$), indicating similarity between PS and CATA results

(a) (b)

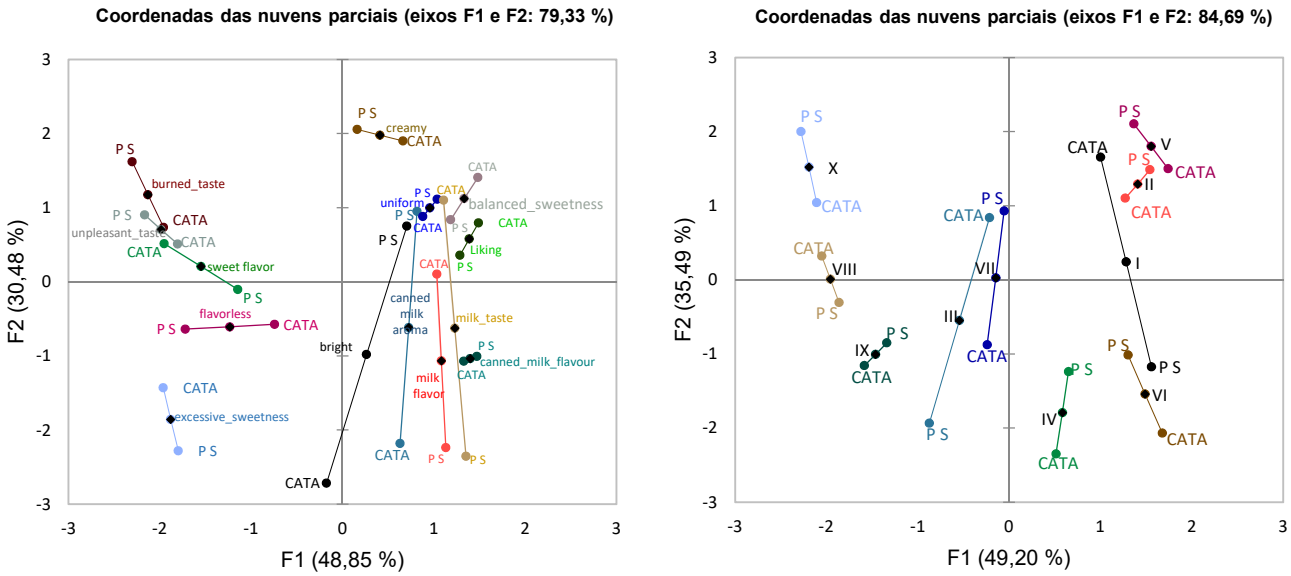


FIGURE 4. Comparative MFA obtained through the different tasks (PS and CATA). (a) Liking and attributes; (b) samples. CATA, check all that apply; MFA, multiple factor analysis; PS, preference sorting.

There was a significant difference ($p \leq .05$; $p = 3.04^{-15}$) between the degree of difficulty indicated by the consumers when conducting the two methods. PS was found to be more difficult (average difficult degree = 5.0) when compared to the CATA method (average difficult degree = 2.24), based on the scale used (9-point scale ranging from "extremely easy" to "extremely difficult").

DISCUSSION

Comparing the acceptance means from both tests (Figure 1), the results suggested that through the CATA it was possible to discriminate more the acceptance of the samples, despite they were classified within the same range of the hedonic scale. Probably, it is due to the task of grouping in the PS. However, the same samples (II and V) were pointed as preferred samples

from both approaches. Moreover, it is noteworthy that both results would be interesting in different situations. For example, when screening a large number of samples, grouping can be interesting.

As acceptance is attributed differently in the two tasks, the distributions obtained in the two approaches are justified. However, when evaluating the sensory drivers of liking, the relationship between acceptance scores and sample descriptors is considered. Despite the differences observed for descriptive descriptions obtained from both methods (Figures 1 and 3), PS and CATA tests showed similar results on determining the sensory drivers of liking for dulce de leche (Figures 2 and 3). Varela and Ares (2012) and Ares et al. (2011) also reported that sorting and CATA questions were equivalent and could provide similar information. CATA is one of the most popular approaches to obtaining sensory information based on consumer characterizations, considered easy and intuitive (Ares et al., 2017). According to Varela and Ares (2012), sorting also does not require lengthy training and generates little fatigue and boredom, which is suitable for trained evaluators and consumers. Moreover, this methodology has recognized practicability for screening many complex samples (Lahne et al., 2018). The PS technique also allows the free description of the samples, which can help in the survey of attributes that were really perceived by consumers and relevant to the acceptance of the product (Rodrigues et al., 2020; Varela & Ares, 2012).

During the CATA test, evaluators focus on specific characteristics of products. On the other hand, during PS, the evaluators focus their attention on the global perception of the products, which makes it possible to verify their most relevant sensory characteristics. When more specific or detailed product information is needed, focusing on attributes is helpful. However, the judgment would be more artificial than holistic approaches (Varela & Ares, 2012), such as PS.

According to Prabhu (1987), sorting tasks can become challenging, especially when dealing with abstract concepts, being difficult for the individuals to perform the task correctly. Nevertheless, based on the group criteria on preference/acceptance—as proposed by Rodrigues et al. (2021a), named as Preference Sorting - similar sensory drivers of liking results of the CATA technique were observed.

However, as the sorting task focuses before on clustering and then on describing the samples, the clustering criterion can affect the results (Chollet et al., 2011; Rodrigues et al., 2021a). This may explain the differences observed for descriptions based on PS and CATA. During the PS, after the grouping criteria based on acceptance (i.e., samples with similar acceptance grades were grouped together (Rodrigues et al., 2021a), the characteristics that most contributed to the acceptance of the group were pointed out. As samples with different characteristics may have been grouped in the same group with the same degree of liking (acceptance grade), that is, even presenting different sensory characteristics, the degree of liking of the samples were similar, only similar characteristics between them were pointed out during the description of the group. In CATA, as the description was made individually for each sample, this reflected directly on the results. These small differences are justified by the classification process and attribution of a note to the group of samples with similar acceptance.

According to Rodrigues et al. (2017), saturation can be a problem in the analysis of a large number of dulce de leche samples. Considering this aspect, the sorting and description process in PS seems interesting with a focus on determining the sensory drivers of liking from a large number of samples, as this point is highlighted during the instruction of the task to the taster; and sorting is based on categorization which is a natural cognitive process routinely used in everyday life. However, consumers considered the PS more difficult to perform, which can be explained by the difficulty in describing the characteristics that contributed to the acceptance of the group since different samples with different characteristics can obtain the same result,

the same degree of acceptance (Rodrigues et al., 2021a). Considering this aspect, it is very important that guidance from the tasters is adequate and clear. According to Fleming et al. (2015), special care must be taken to ensure that participants can understand and complete the sorting task correctly, once some untrained assessors may find the task difficult, especially when asked to complete the task without the guidance of the experimenter (Fleming et al., 2015).

Varela and Ares (2012), Ares et al. (2011), and Scott et al. (2017) showed that, despite consumers being able to understand sorting and projective mapping, they still find it more difficult than CATA questions, requiring more information to perform the tasks correctly. Thus, the importance of adequate guidance during the test application is reinforced. According to (Lahne et al., 2018), presenting a previous list of attributes generated from a focus group (as done in this study) can also help execute the task. This simplifies the task, and the synonymization and lemmatization could be avoided (Lahne et al., 2018). Another assumption is that the PS method is relatively new, while providers are already more used to performing the CATA test. Despite the greater difficulty of PS, this method can be interesting when working with a screening of a large number of samples (based on their acceptance), with time savings, conducting the task in a single session.

Sorting studies are already becoming a popular alternative to more time- and cost-intensive descriptive studies (Lahne et al., 2018) and are among the emerging fast descriptive tests. The results of this study show the application of PS in determining sensory drivers of liking of products, especially for the optimization and screening of a large number of samples. However, focusing on a rich descriptive description, CATA seems to provide a greater wealth of results.

Moreover, other studies should be conducted with a larger number of samples and attributes and with other product categories to better investigate the PS strengths and weaknesses.

CONCLUSIONS

Preference Sorting and CATA tests showed similar results in determining the sensory drivers of liking for dulce de leche. However, some differences on sensory description were noted. It is hypothesized that such differences are due to the task of grouping and describing the attributes that most contributed to the acceptance of the group in the PS. Consumers considered the PS test more difficult than CATA. PS can be an alternative in determining the product sensory drivers of liking for a screening of a large number of samples, providing similar results to the traditional test - the CATA test.

This study focused on dulce de leche evaluations. However, other studies assessing the implications and limitations of the method with a larger number and other sample categories, and compared to other rapid descriptive methods are recommended.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Research data are not shared.

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Supplementary material

Table 1 - Preference Sorting cross table and contingency table (A), CATA contingency table (B) and Chi square test between the same samples for both methods (PS and CATA) (C).

a

Sample	I	II	III	IV	V	VI	VII	VIII	IX	X	Yellow	Brown	Bright	Soft	Milk aroma	Vanilla flavor	Caramel aroma	Canned Milk aroma	Sweet flavor	Flavorless	Creamy	Uniform	Sticky	Sandy	Milk taste	Canned Milk flavour	Caramel flavour	Excessive sweetness	Balanced sweetness	Butter taste	Burned taste	Unpleasant taste
I	100	34	16	11	18	11	22	8	21	8	34	19	7	4	27	8	10	7	8	5	39	5	10	5	17	12	15	13	20	9	0	0
II	34	100	11	19	31	21	28	9	11	12	1	2	17	11	17	7	17	11	7	7	41	10	1	3	14	15	15	4	27	7	1	4
III	16	11	100	12	9	6	7	16	16	16	20	35	5	3	15	3	12	5	6	12	18	1	7	38	8	6	19	27	7	5	1	2
IV	11	19	12	100	15	49	18	15	10	7	20	23	17	29	19	4	10	10	14	6	13	5	22	5	14	14	13	25	11	8	5	0
V	18	31	9	15	100	22	20	23	7	23	16	47	17	1	19	1	24	14	8	7	50	8	6	2	9	13	27	6	30	7	2	0
VI	11	21	6	49	22	100	26	10	9	3	31	14	16	30	17	3	15	10	5	7	19	8	18	2	15	15	21	23	16	6	0	0
VII	22	28	7	18	20	26	100	10	19	11	34	10	18	3	15	7	16	11	10	8	30	6	14	2	8	11	8	17	12	11	5	8
VIII	8	9	16	15	23	10	10	100	17	45	3	55	10	2	13	1	31	1	12	8	26	2	10	10	5	4	23	31	5	3	10	10
IX	21	11	16	10	7	9	19	17	100	17	37	11	3	5	17	5	12	8	9	9	25	1	11	6	9	7	7	28	4	8	6	19
X	8	12	16	7	23	3	11	45	17	100	5	60	7	1	7	3	33	7	9	8	30	4	1	7	2	2	19	19	7	8	15	13

b

Sample	Yellow	Brown	Bright	Soft	Milk aroma	Vanilla flavor	Caramel aroma	Canned Milk aroma	Sweet flavor	Flavorless	Ccream y	Sticky	Uniform	Sandy	Milk taste	Canned Milk flavour	Caramel flavour	Excessive sweetness	Balanced sweetness	Butter taste	Burned taste	Unpleasant taste
I	27	40	10	8	35	13	14	12	14	22	79	5	34	0	38	23	16	14	37	13	0	2
II	56	22	18	16	38	14	21	14	8	10	67	2	30	0	29	28	17	13	36	11	0	9
III	15	66	4	0	33	8	23	12	19	11	15	14	8	56	24	18	25	11	30	4	1	9
IV	18	50	53	52	31	11	20	16	12	16	23	39	23	2	9	29	25	34	15	16	7	1
V	5	91	24	2	36	4	27	16	9	11	83	3	45	0	23	27	30	5	47	10	2	2
VI	52	19	47	49	25	8	12	28	10	18	31	37	28	0	18	35	28	15	25	15	2	0
VII	46	6	38	0	30	21	15	16	16	11	20	35	20	0	22	10	12	27	19	22	2	16
VIII	3	89	15	41	25	13	25	6	23	9	12	10	11	33	12	4	36	27	11	6	21	9
IX	53	0	21	6	25	7	6	16	20	25	38	22	16	2	12	9	2	38	3	11	8	26
X	1	94	16	6	6	6	52	4	14	18	68	6	33	1	1	4	44	24	12	2	23	16

c

Sample	Yellow	Brown	Bright	Soft	Milk aroma	Vanilla flavor	Caramel flavor	Canned Milk aroma	Sweet flavor	Flavorless	Ccreamy	Sticky	Uniform	Sandy	Milk taste	Canned Milk flavour	Caramel flavour	Excessive sweetness	Balanced sweetness	Butter taste	Burned taste	Unpleasant taste
I	+									+		+	+	+								
II	+	+												+								
III	+																	+	+			
IV	+		+										+		+							
V	+												+									
VI							+											+				
VII											+											
VIII				+		+	+				+			+				+				
IX		+	+				+						+				+					
X	+												+	+						+		

*significant difference according to the chi-square test, with $p \leqslant 0.05$

ARTIGO 2: TEMPORAL DOMINANCE OF SENSATIONS: DO DIFFERENT CONCEPTS OF "DOMINANCE" AFFECT THE RESULTS?

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HIGHLIGHTS

- "Dominant" vs. "Intense": A Consumer Perspective.
- Similar interpretations of "dominant" and "intense".
- Terminology flexibility in TDS instructions confirmed.

ABSTRACT

The purpose of this study was to understand the role of "dominance" definitions in the results of TDS applied to consumers. This study compared two temporal dominance of sensations (TDS) approaches − TDS-I − that attracts the most attention and TDS-II − most intense/strongest sensation − in the context of evaluating artisanal Minas cheeses from the Serra da Canastra and chocolate with different cocoa concentrations samples. TDS curves were constructed and a trajectory-based principal component analysis (PCA) was performed dominance rates at ten equally spaced time points. Additionally, difference curves, multiple factor analysis (MFA) and regression vector coefficient (RV coefficient) were performed to compare the two approaches. The findings showed that the two approaches produced similar results, suggesting that consumers interpret the terms dominant and intense in a similar way during TDS evaluations, the results were even closer at the chocolate study than at the cheese study. However, in both approaches were observed low dominance rates and differences between the sensation perception time, mainly in the evaluation of cheese flavor. This variability may be attributed to the complexity of the cheese's flavor and the varied interpretations of dominance among evaluators. Despite these differences, the approaches showed similar characterizations across the same samples, demonstrating high reproducibility and a strong ability to differentiate between samples. This study demonstrates that the choice between the terms dominant (which captures more attention) or intense (stronger) to guide consumers in performing the sensory test does not significantly influence the results. Consequently, it is possible to adopt greater freedom and flexibility in the terminology used to instruct participants in conducting the test.

Keywords: Consumer behavior; Dominance; Intensity; Sensory evaluation; Temporal Dominance Sensation

1. INTRODUCTION

Temporal Dominance of Sensation (TDS) has been widely used as a powerful tool in sensory analysis (Peltier et al., 2023). TDS is a sensory methodology that aims to record the evolution of the dominant sensory perceptions of a product, using a predetermined list of various attributes along the tasting period, using a computer interface (Pineau et al., 2009, Pineau and Schlich, 2023). In the food sector, it has been applied to some products of different complexity, from dairy products and drinks to chocolates and cheeses, demonstrating its versatility (Bruzzone et al., 2013; Bemfeito et al., 2016, Rodrigues et al., 2014; Rodrigues et al., 2016a, Rodrigues et al., 2016b; Hutchings et al., 2022).

The term "dominant" is a key part of this approach (Keefer et al., 2023). However, there is no universal definition of dominance (Varela et al., 2018, Pineau and Schlich, 2023). Similarly, there is no consensus on the concept of "dominant" among evaluators. These differences in interpretation can lead to heterogeneity in responses and potentially compromise the accuracy of TDS data (Varela et al., 2018).

The ISO standard (2016) describes dominant in TDS as "the sensation that attracts attention at a given time, which does not necessarily mean that this sensation is the most intense in the product". However, other different definitions can also be found in the literature (Pineau and Schlich, 2023, Di Monaco et al., 2014, Varela et al., 2018). From "the most intense sensation" (Labbe et al., 2009, Albert et al., 2012), to "a new sensation popping up at a given time, not necessarily the most intense" (Rodrigues et al., 2016a).

The concept of dominance in TDS has generated considerable debate in the literature. Hutchings et al. (2022) have underscored the pivotal importance of comprehending how participants, whether trained panelists or consumers, perceive and conceptualize dominance. Echoing similar concerns, other scholars, including Pierguidi et al. (2021) and Schlich (2017), have highlighted the lack of consensus among sensory scientists regarding its definition. Consequently, a persistent challenge in TDS application lies in the heterogeneous interpretation of dominance among evaluators.

This variance in interpretation can lead to disparate criteria being employed by evaluators to designate the dominant sensation, thereby yielding divergent TDS outcomes (Ares et al., 2015, Varela et al., 2018). Given the existing divergences regarding dominance in the TDS methodology, this study aims to deepen the application and understanding of the Temporal Dominance of Sensations in different contexts. In this context, we aim to understand the role of the definitions of "dominance" in the results of TDS applied to consumers, in order to

improve the understanding and application of this methodology. By incorporating both artisanal Minas cheese and chocolate, our study provides a comparative analysis across distinct sensory contexts, offering insights into the generalizability and applicability of dominance definitions in diverse food product categories.

Additionally, our methodology includes qualitative analysis through open-ended questions, enabling a deeper exploration of consumers' conceptualizations of dominance and its impact on sensory perception. Through these innovative approaches, our study contributes to advancing the understanding and application of TDS methodology in consumer research, addressing existing divergences and enhancing the reliability and validity of sensory evaluations in real-world consumption scenarios.

2. MATERIAL AND METHODS

2.1 Study overview

The study was approved by the Ethics Committee of the Federal University of Lavras (CAAE: 60320922.8.0000.5148). Consumers were recruited at the Federal University of Lavras and provided informed consent. Analyses were conducted on artisanal Minas cheeses from the Serra da Canastra and chocolates with different cocoa concentrations, maintaining methodological similarities for both products with a shared objective.

The selection of artisanal Minas cheese and chocolate extends beyond their sensory appeal and widespread consumption. This study evaluates the generalizability and applicability of dominance definitions across different food contexts, focusing on the distinction between the salty taste of cheese and the sweet taste of chocolate. Such diversity in sensory characteristics not only enriches the investigation of the perception of dominance and intensity, but also builds on the accumulated experience of previous studies that specifically applied the TDS methodology to these products (Rodrigues et al., 2016a, Rodrigues et al., 2016b Bemfeito et al., 2016).

Three samples of each food were evaluated, with one sample in duplicate to verify the reproducibility of the sensory results (Kim, Heo & Kwak, 2023). The evaluation included the TDS method and qualitative analysis through open-ended questions to explore their conceptualization of dominance. For both cheese and chocolate evaluations, participants were prompted with the following inquiries, to which they responded on a five-point Likert scale ranging from 'strongly agree' to 'strongly disagree':

1- I was able to conduct the tests differently in terms of perceiving a dominant and intense attribute.

2- My perceptions were different during the evaluation of the samples in terms of dominant and intense attributes.

It is important to note that the cheese and chocolate products were tested in different weeks with different groups of consumers. Initially, the analysis was conducted on the cheese samples. After analyzing the preliminary results from the cheese study, supplementary open-ended questions were added to the chocolate study to gather more detailed insights into the diverse factors that inform the consumer's conceptualization of dominance:

1- Why did the attributes you selected caught your attention during the test run?

2- What was it that caused you to change your choice of attributes during the tests?

These questions were designed to delve deeper into the evaluative process, providing insight into why certain attributes emerged as significant and the reasoning behind any changes in attribute selection throughout the testing phase.

The attributes used in the TDS tests for both products were defined using Kelly's repertory grid method (Moskowitz, 1983), where the assessors analyzed the samples in pairs and described their similarities and differences between them. Before the TDS testing, the listed terms were discussed with a group of 30 consumers, eliminating less-cited terms to retain those most suitable for describing the products and familiar to the consumers. This discussion also served to determine the ideal duration of the TDS test to allow consumers to fully experience and report the perceived sensations of the cheese and chocolate without causing fatigue or loss of concentration. Additionally, a delay time of 2 s was established, corresponding to the time it takes the consumer to bring the sample to the mouth.

Beyond the terms defined through discussion, the terms “No Flavor” and “No Perception” were included in the list of attributes to indicate when no sensation was perceived (Rodrigues et al., 2018a; Rodrigues et al., 2022). These terms were included to capture periods of absence of sensation, providing a more comprehensive view of the sensory experience over time. Furthermore, it reduces pressure on evaluators, preventing them from selecting an attribute when none is perceived, which could lead to inaccurate or unreliable data.

It's crucial to mention that the panelists in the initial selection process differed from those in the TDS testing. Evaluations took place in a standardized sensory environment (ISO, 2007). The samples were served monadically, in disposable cups coded with three digits in a balanced order (Wakeling & Macfie, 1995). In addition, during TDS testing participants were instructed to place the entire samples in their mouths and chew each sample slowly and

thoroughly, ensuring that all parts of the sample were equally exposed to their taste receptors before swallowing. This protocol aimed to standardize the mastication process across all participants and ensure consistent sensory evaluations.

2.2 Study I: Artisanal Minas cheeses

Canastra cheese, produced exclusively in the Serra da Canastra region of Minas Gerais, Brazil, is known for its distinct flavor derived from the unique terroir of the area, which includes soil, pasture, climate, altitude, and water (Rotolo, 2019). Made from raw cow's milk and using "pingo" - a fermented whey from the previous day's cheese—each farm produces cheese with specific lactic cultures (Resende et al., 2011). Factors such as terroir and altitude influence the lactic acid bacteria (LAB) populations, while the use of raw milk preserves natural microbiota, contributing to the cheese's complex and unique sensory attributes (Guimarães et al., 2011). These factors combined create a product with rich and varied sensory characteristics.

67 cheese consumers, of both genders, aged 18 to 50 years that consume at least once a week, took part in the test. Three samples of artisanal Minas cheese from the Serra da Canastra, matured for 14 days, were purchased from different producers registered with the Instituto Mineiro de Agropecuária (IMA). Samples A and A2 from the Mantíbio farm (to verify the reproducibility of the sensory results), sample B from Jequitibá and sample C from Medeiros. All of the farms are located in the Serra da Canastra, but the altitudes and municipalities vary.

During the sessions, approximately 5 g of cheese at room temperature (25 °C), was presented for evaluation. The total duration of the TDS analysis was 50 s with a "delay time" of 2 s. The samples were evaluated for texture and flavor separately during the sessions according to Rodrigues et al. (2018a). Evaluating texture and flavor separately aims to clearly understand whether dominance plays a distinct role in the consumer's reaction to varied sensory stimuli, thus providing a deeper understanding of the sensory evaluation process by identifying the influence of dominance on texture and flavor independently.

Consumers first evaluated flavor using the following attributes: salty, bitter, acid, butter flavor, fruity flavor, musty flavor, and no flavor. Second, the texture was evaluated using the following attributes: soft, firm, crumbly, rubbery, and no perception.

2.3 Study II: Chocolate

57 chocolate consumers, of both genders, aged 18 to 40 years and consuming at least once a week, took part in the test. The TDS test was performed using three chocolate samples

from Cacau Show® with different cocoa concentrations: 28 %, 65 %, and 85 %. The 28 % cocoa chocolate was also evaluated in duplicate (28 %*). The chocolates from different categories (milk, semisweet and dark) were selected as the object of this study because chocolate can present different sensations during ingestion (Rodrigues et al., 2016a), being also a food product globally consumed.

During the sessions, approximately 3 g of chocolate, at room temperature (25 °C), was presented for evaluation. The total duration of the TDS analysis was 40 s with a "delay time" of 2 s. As in Study 1, the samples were evaluated for texture and flavor at different times during the sessions. Consumers first evaluated flavor using the following attributes: sweet, bitter, butter flavor, milk, caramel, cocoa, acid, and no flavor. Second, the texture was evaluated using the following attributes: creamy, astringent (dries the mouth), melts in the mouth, firm, soft, sandy, crumbly and no perception.

2.4 Experiment Overview

Two TDS approaches were evaluated. To compare the results obtained by the two approaches, all consumers performed both approaches. Each test was performed in one day, totaling two days of testing. The order of approaches was randomized among consumers in order to minimize learning effects (Rodrigues et al., 2023). Thus, some individuals performed the TDS-I on the first day and then the TDS-II test on the second day; and other participants did the opposite (approach TDS-II first and approach TDS-I on the second day). Both tests were performed based on the same attribute list previously generated. The only difference between the two approaches was the instruction given to the consumer:

- TDS-I - Click Start, place the entire sample in your mouth and begin chewing. Select the DOMINANT SENSATION as soon as you can, i.e. the one that ATTRACTS THE MOST ATTENTION during the time of ingestion. Sensations may change during the period of ingestion, change your selection if the dominant sensation changes (you can also select the same term more than once). Click No Flavor/No Perception if you no longer perceive any flavor or texture.
- TDS-II - Click Start, place the entire sample in your mouth and begin chewing. Select the MOST INTENSE SENSATION as soon as you can, i.e. the STRONGEST FEELING during the time of ingestion. Sensations may change during the period of ingestion, change your selection if the most intense sensation changes (you can also

select the same term more than once). Click No Flavor/No Perception if you no longer perceive any flavor or texture.

They were asked to review the position of the attributes on the computer screen before the task to make it easier to find the attributes during the TDS assessment. To avoid bias in list order, all attributes were listed in random order, but this order was always the same for a given person to help them locate the relevant attribute. Consumers were instructed to click No Flavor/No Perception when they could no longer perceive any flavor or texture. The degree of difficulty of the two approaches was assessed immediately after the completion of each test by the consumers, using a 5-point scale ranging from “very easy ” to “very difficult ” (Hutchings et al., 2014).

2.5Data Analysis

First, the TDS curves of samples (cheeses and chocolate) evaluated were plotted according to the methodology proposed by Pineau et al. (2009). In the graphical representation of the TDS, two lines were drawn: the "chance level" and the "significance level". The "chance level" is the dominance rate that an attribute can obtain by chance and the "significance level" is the minimum value of this ratio considered significant (Pineau et al., 2009). For this calculation, we used the confidence interval for a normal proportion based on the normal approximation according to Pineau et al. 2009 (1).

$$Ps = P0 + 1.645\sqrt{\frac{\sqrt{P0(1-p0)}}{n}}$$

Where “Ps” is the lowest significant proportion value (α = 0.05) at any point in time for a TDS curve, “n” is the number of subjects * replication, and “Po” is equal to 1/p, “p” is the number of attributes.

Additionally, a covariance-based Principal Component Analysis (PCA) was conducted on dominance rates at ten equally spaced time points (representing 10 %, 20 %, …, 100 % of the chewing period), as described by Lenfant et al. (2009) and Schlich (2017). This PCA was applied to illustrate sensory trajectories in the sensory space throughout the mastication process. The variables included are the sensory attributes that proved significant for each food matrix (Artisanal Minas cheeses and chocolate), with the samples (four for each product) acting as individuals in the PCA. The sensory trajectories were visualized on the map by linking the ten time points corresponding to each product, indicating the evolution of sensory perception from the beginning to the final point before swallowing.

From the TDS curves, six parameters were calculated for each significant sensation of each sample across all evaluations: Dr_max (maximum dominance rate), T_max (time at which the Dr_max occurred), D_90 (duration at 90 % of Dr_max), D_sig (duration of significant dominance), T_first (time of first significant dominance), and T_last (time of last significant dominance) (Pineau & Schilch, 2015). Moreover, to simultaneously take into account the duration and dominance of each attribute, the area under the curve above signicance (AAS) was calculated (Bruzzone et al., 2013; Pineau and Schilch, 2015, Pu et al., 2022). These parameters are detailed in the supplementary material.

Difference curves were constructed to compare the approaches. These curves are constructed by subtracting the dominance rate of each pair of samples at each moment. Differences in dominance rates are considered significant when significantly different from zero according to a classic test of comparison of normal proportions (Pineau et al., 2009). All curves were generated using Sensomaker software (Nunes & Pinheiro, 2012).

After filtering the significant attributes, multiple factor analysis (MFA) was conducted using parameters extracted from the TDS curves (Dr_max, T_max, D_sig, T_first, T_last and AAS), to compare the product positioning on the profiling maps generated between the approaches (Bruzzone et al., 2013; Rodrigues et al., 2023). To compare the general configurations of the samples, the regression vector coefficient (RV) was used (Robert & Escoufier, 1976). This coefficient indicates the degree of relationship between the two individual spaces generated by the MFA, ranging from 0 (total disagreement) to 1 (perfect agreement), as discussed by Fonseca et al. (2016). The degree of difficulty in performing each approach was evaluated by means and *t*-test. All statistical analyses were performed using XLStat 2022 (Addinsoft, Paris, France).

In relation to the open-ended questions presented in both approaches, the data were qualitatively analyzed through the creation of word clouds. Word clouds are graphical representations of key concepts, highlighting popular ideas associated with the concept using different font sizes, and are a powerful way to summarize large amounts of data (Cidell, 2010). The font sizes in the word clouds indicate the relative frequency of each term, with larger fonts representing terms that were mentioned more frequently.

3. RESULTS

The results are presented by product type. It is beyond the scope of this paper to present or discuss the TDS curves for all products evaluated. These curves are included only to interpret

the qualitative information provided by the approaches. For more details on the curve parameters, see supplementary material.

3.1 Artisanal Minas cheeses

Fig. 1, Fig. 2 show the TDS curves for all the Serra da Canastra Minas Artesanal cheese samples evaluated, plotted for the two approaches (TDS-I − that attracts the most attention and TDS-II − most intense/strongest sensation), for flavor and texture, respectively. Each curve shows the evolution of the dominance rate of all the attributes from the start of chewing (t = 0) to the finish of perception (near 50 s). The chance level was 0.14 and 0.2 for flavor and texture, respectively. If the TDS curve for an attribute is above the significance level, the attribute is considered dominant at the panel level. The significance level was 0.21 and 0.28, corresponding to a dominance rate of 21 % and 28 % for flavor and texture, respectively.

Note from the TDS curves that when considering Sample A in the TDS-I approach, the consumers initially perceived the bitter taste as dominant. The maximum rate of dominance (Dr_max) recorded was 0.22, reached in 24.5 s (T_max). In contrast to the TDS-II approach for the same sample, the Dr_max was slightly higher at 0.27, but the time to reach this dominance was faster (T_max = 15 s). For sample A2 in the TDS-I approach, the initial dominance was again attributed to the bitter taste (Dr_max = 0.24, T_max = 20.8 s) as the dominant taste, but for the TDS-II approach, the first perceived attribute was acid (Dr_max = 0.28, T_max = 15.3 s) followed by bitter (Dr_max = 0.24, T_max = 27.5 s). Despite these nuances between the approaches, it is important to note that the acid attribute was perceived by consumers in samples A and A2, approaching the significance line. Thus, there appears to be a competition between these flavors. This corroborates the study by Rodrigues et al. (2016a), where various sensation curves were observed between the chance level and the significance level. This phenomenon can be attributed to the complexity of the cheese (i.e., the expression of different flavors), making it challenging for the panel to detect the dominant sensation. For texture, in both approaches, the soft attribute was perceived as dominant for samples A and A2, but with different Dr_max and T_max. Additionally, the areas under the curve (AAS) for each approach were relatively close, with values measuring 4.92 and 5.74 for TDS-I and II respectively for sample A, and 4.39 and 5.20 for TDS-I and II respectively for sample A2.

For Canastra cheese B, salty and firm were perceived as dominant in both approaches. It should also be noted that the attributes butter flavor and bitter were also perceived in sample B. For the TDS-II approach, there appears to be closer competition between these flavor attributes. For Canastra cheese C, for flavor, acid was perceived as well as salty, but both

differed in perception time and Dr_max. In TDS-I the salty flavor was predominantly dominant, while in TDS-II the salty flavor is also initially dominant, but there is a transition to acidic that becomes more dominant over time.

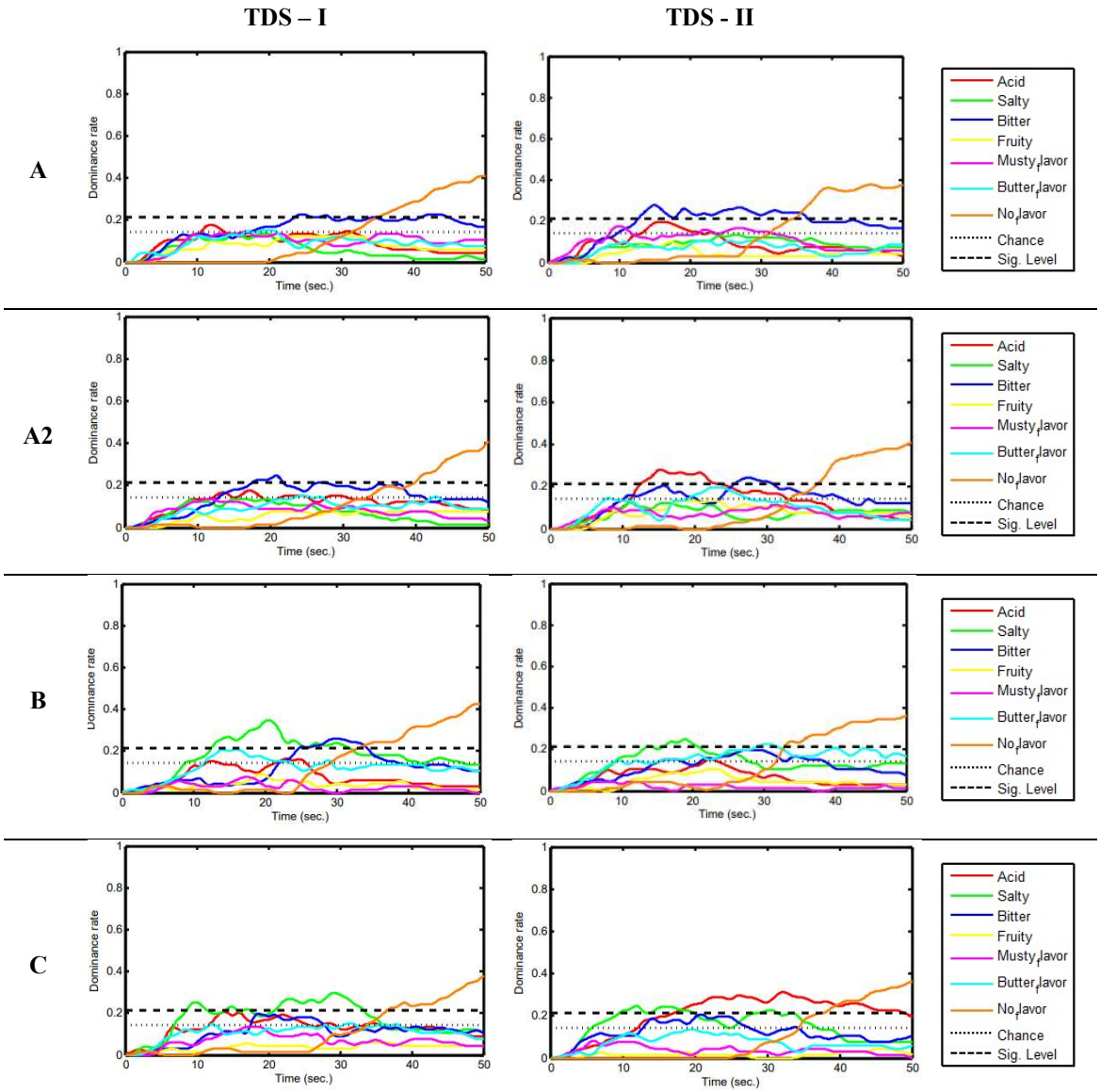


Fig. 1. TDS curves related to the flavor of artisanal Minas cheeses from Serra da Canastra.

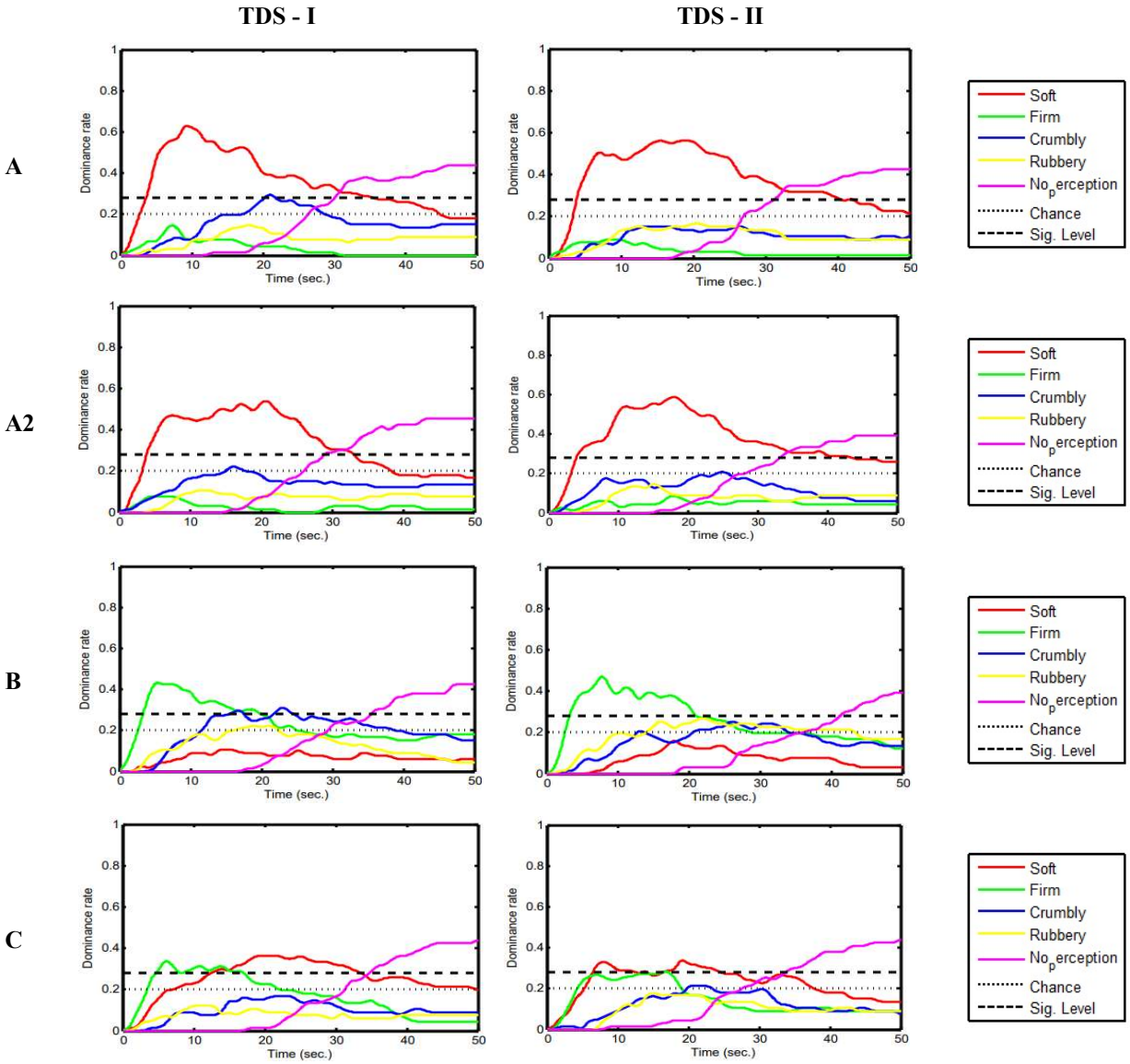


Fig. 2. TDS curves related to the texture of artisanal Minas cheeses from Serra da Canastra.

Figure 3 shows the PCA for the distribution of dominance rate trajectories for both flavor and texture of Artisanal Minas cheeses. The first and second dimensions of the PCA accounted for 65.29% and 69.78% of the variance in the data for flavor and texture respectively, for both approaches evaluated, indicating that consumers were able to discriminate well between samples.

Each trajectory connects ten temporal points, corresponding to a complete sensory evaluation cycle. These points span from the initial 5 s (t10) to the last 5 s before swallowing (t100), evenly spaced throughout the 50-second tasting period. The plots for both flavor and texture display similar trajectory patterns for the two TDS approaches (I and II), indicating a consistent temporal perception dynamic between the methods. However, for flavor, despite this overall consistency, small variations in dominance rates for certain attributes at specific times

are noted. The lack of significant variation in flavor among the cheese samples can be attributed to the inherent complexity of the product. Additionally, the cheeses do not exhibit markedly distinct characteristics due to being from the same region and having identical maturation times. However, there is consistency observed in the samples evaluated repeatedly in both approaches (TDS-I and TDS-II), as samples A and A2 exhibited similar perceptions of soft texture, confirming the reproducibility of the data. Sample B is distinguished by its perception of firm and crumbly textures, while Sample C was primarily noted for its crumbly texture.

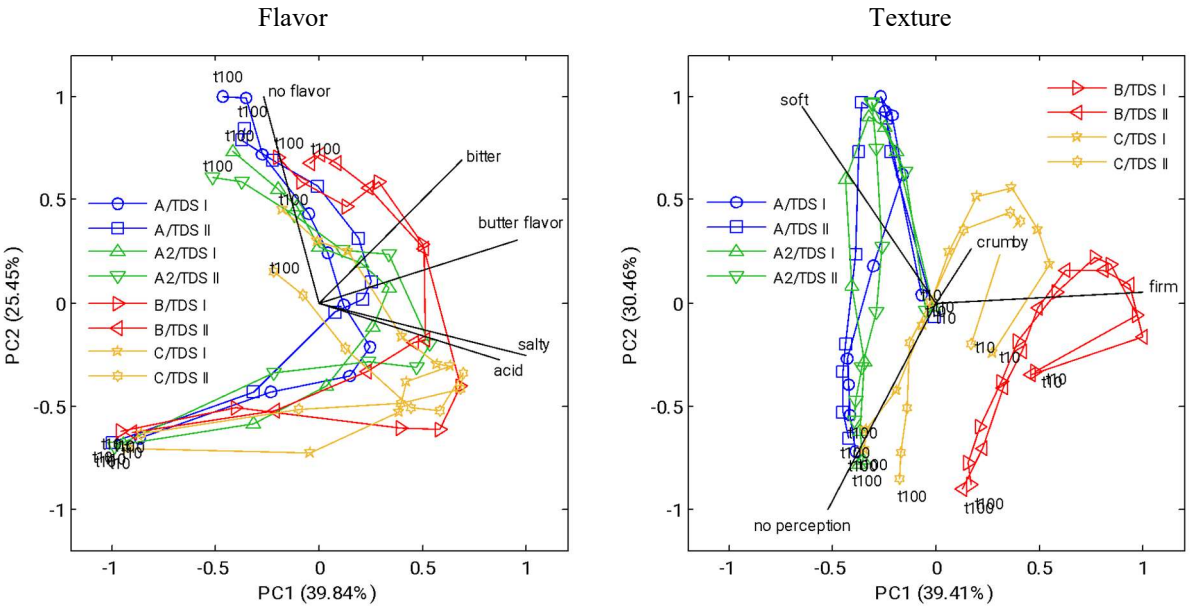


Fig. 3. Principal Component Analysis: Biplot representing the distribution of dominance rate trajectories for flavor and texture for the artisanal Minas cheeses.

3.2 Chocolate

Figures 4 and 5 show the TDS curves for flavor and texture of the chocolate samples with different cocoa contents, for both approaches (TDS-I and TDS-II). Each curve shows the evolution of the dominance rate of all the attributes from the start of chewing (t = 0) to the finish of perception (near 40s), with a dominance rate of 19% for flavor and texture.

Note that both 28 % cocoa chocolates of the samples have similar profiles, ensuring the reproducibility of the data (Kim et al., 2023). For the flavor of the attribute sweet was the first significant dominant attribute detected during the 40 s evaluation in the 28 % cocoa chocolate, followed by milk. The cocoa and bitter attributes were dominant in the 65 % and 85 % cocoa chocolates. Specifically, in the 65 % cocoa chocolate, the cocoa attribute showed a Dr_max of 0.38 at a T_max of 17.8 s and a Dr_max of 0.39 at a T_max of 27.7 s, and the bitter attribute

showed a Dr_max of 0.30 at a T_max of 25.3 s and a Dr_max of 0.30 at a T_max of 21.3 for TDS-I and TDS-II, respectively. Conversely, in the 85 % cocoa chocolate, the cocoa attribute was recorded with a Dr_max of 0.28 and a T_max of 11.7 s, and a Dr_max of 0.25 at a T_max of 35 s, and the bitter attribute was recorded with a Dr_max of 0.61 and a T_max of 24.7 s, and a Dr_max of 0.51 at a T_max of 20.2 s, for TDS-I and TDS-II, respectively. The cocoa attribute dominated in the 65 % sample, whereas bitter dominated more quickly in the 85 % sample.

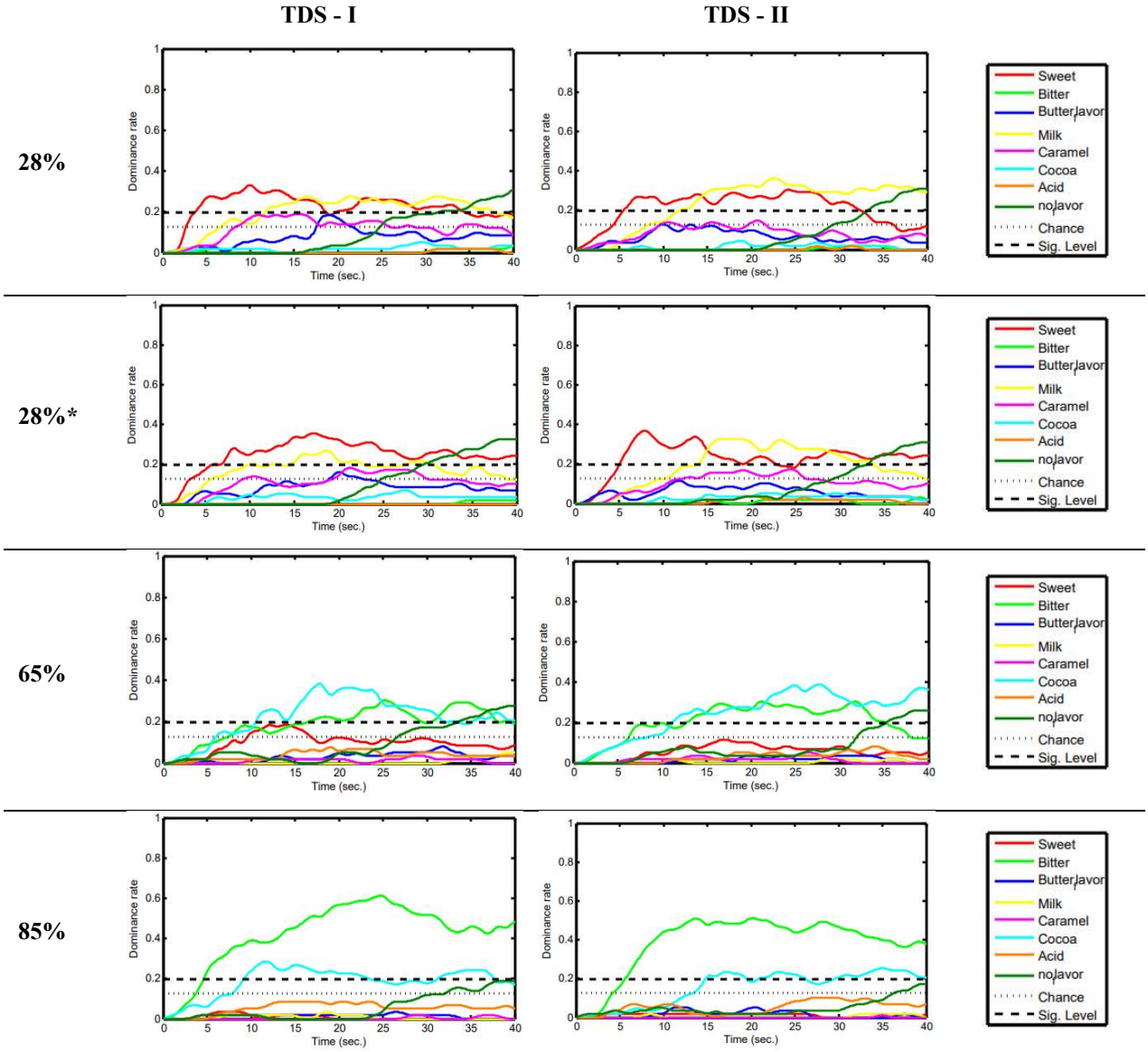


Fig. 4. TDS curves related to the chocolate flavor.

TDS – I TDS - II

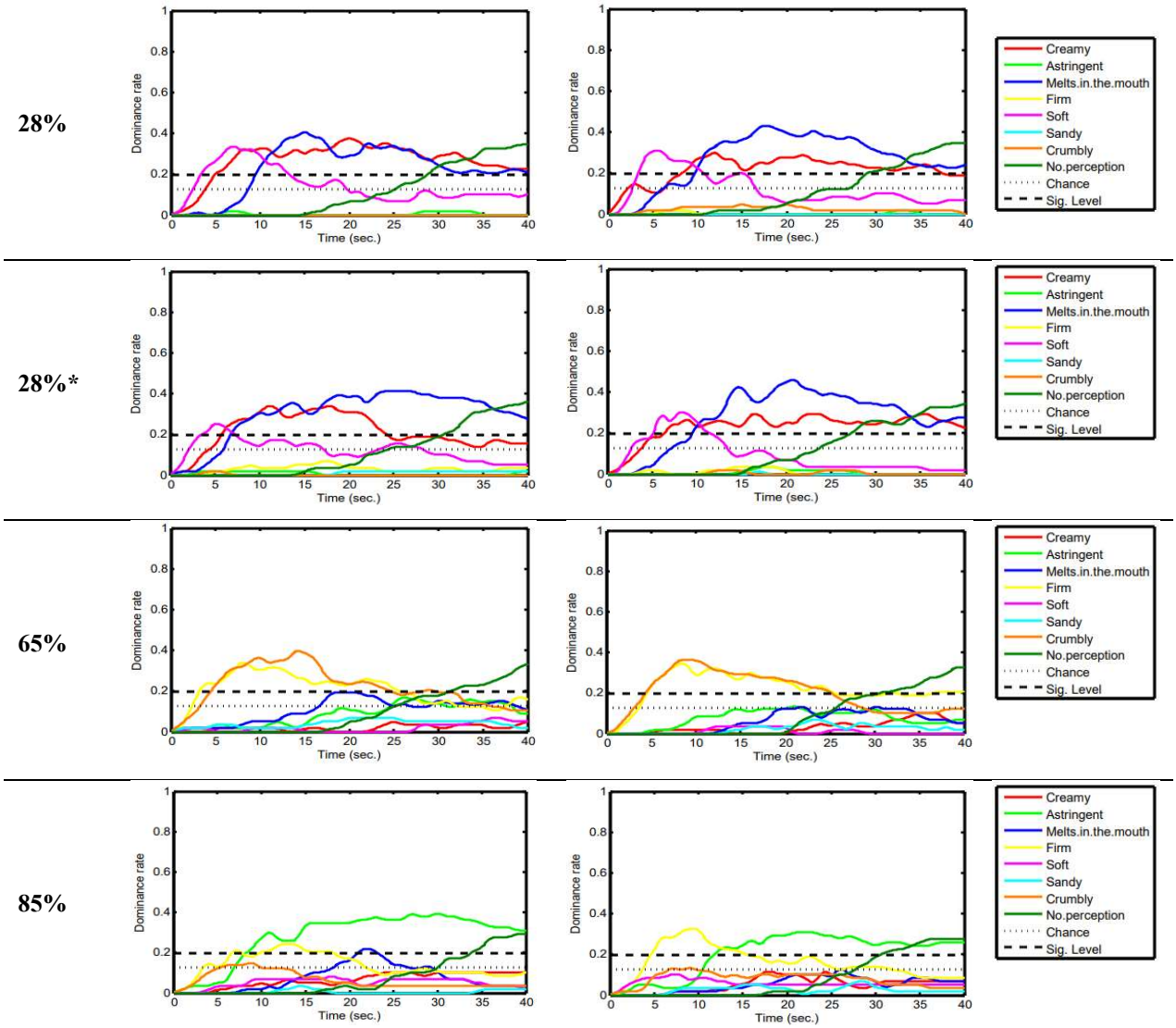


Fig. 5. TDS curves related to the texture of chocolate.

In terms of texture, soft was the first significant dominant attribute found in the 28 % cocoa chocolate ratings, followed by creamy and melts in the mouth. The firm and crumbly attributes were dominant in the 65 % cocoa chocolate, and the firm and attribute was dominant in the 85 % cocoa chocolate. These TDS profiles were expected because chocolates with lower cocoa content are sweeter and have more cocoa butter, while those with higher cocoa content are bitter and have more cocoa flavor as presented by Rodrigues et al. (2016b).

It can be seen that the chocolates with the highest cocoa content (65 % and 85 %) are similar in terms of the marked attributes and that these products have a complex signature, with overlapping attributes that diffuse into each other at different times.

In general, for both the taste and texture graphs, there seems to be consistency between TDS-I and TDS-II in the perception of attributes over time. As in the cheese study, a similar

evolution of the attribute trends between the approaches can be observed for chocolate; however, there are some differences in terms of dominance rates and sensation perception time (Table 2 supplementary material).

Fig. 6 shows the PCA for the distribution of dominance rate trajectories for both flavor and texture of chocolates with different cocoa concentrations. Each trajectory connects ten evenly spaced temporal points from the initial 4 s (t10) to the last 4 s before swallowing (t100) across a 40-second sensory evaluation cycle. As shown, the first and second dimensions of the PCA accounted for 82.25 % and 72.26 % of the variance in the data, for the flavor and texture respectively, of both approaches evaluated. Like the cheese results, the chocolate graphs show parallel trajectory patterns for flavor and texture across both TDS approaches, indicating a consistent temporal perception dynamic between the methods. There is a distinct influence of cocoa content on both flavor and texture perceptions. Lower cocoa concentrations (28 %) are closely associated with sweet and milk attributes for flavor, and creamy and melts in the mouth for texture. In contrast, higher cocoa concentrations (65 % and 85 %) align with bitter and cocoa for flavor, and firm and astringent for texture, illustrating the shift in both flavor and texture as the cocoa content increases.

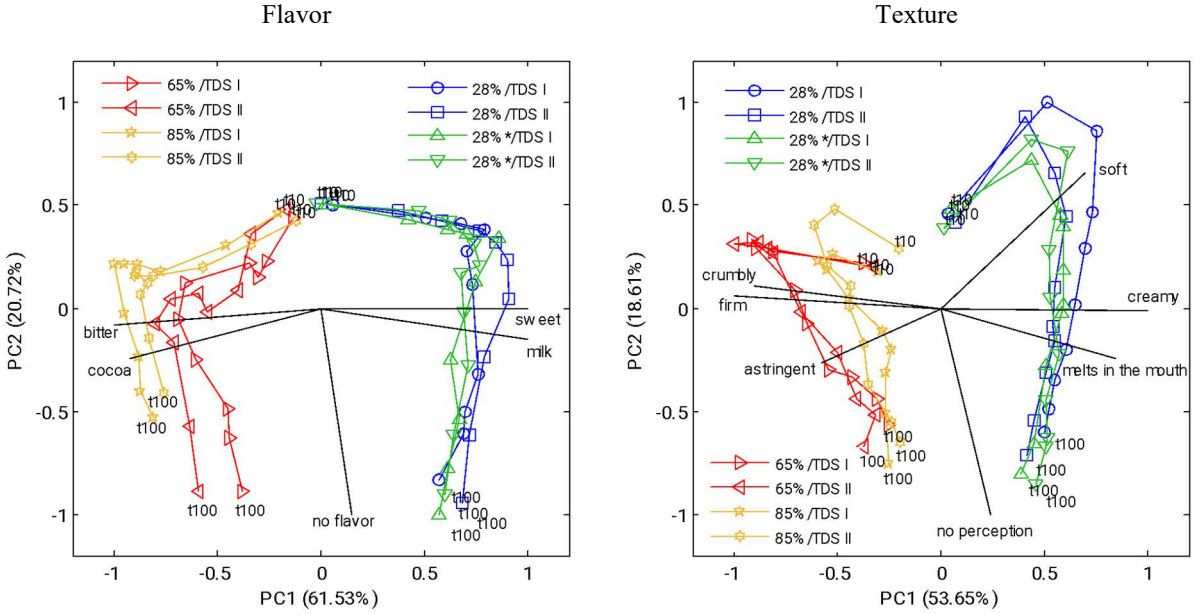


Fig. 6. Principal Component Analysis: Biplot representing the distribution of dominance rate trajectories for flavor and texture for the chocolate.

3.3 Comparison approaches

The TDS difference curves, shown in Fig. 7, Fig. 8, were generated to highlight variations in dominance rates between the approaches (Pineau et al., 2009). These curves are essential for pinpointing moments and attributes where perceptions diverge significantly between approaches, visually illustrating the magnitude and timing of these differences.

For both products, the difference curves generally remain close to zero, suggesting minimal or null perceptual variance between the two approaches. This indicates that regardless of whether an attribute is perceived as dominant or intense, the overall sensory profile recognized by consumers remains consistent. However, occasional peaks in the difference curves, such as those observed for the flavor of cheese sample C and the 85 % cocoa chocolate, indicate brief moments where perceptions diverge between the approaches.

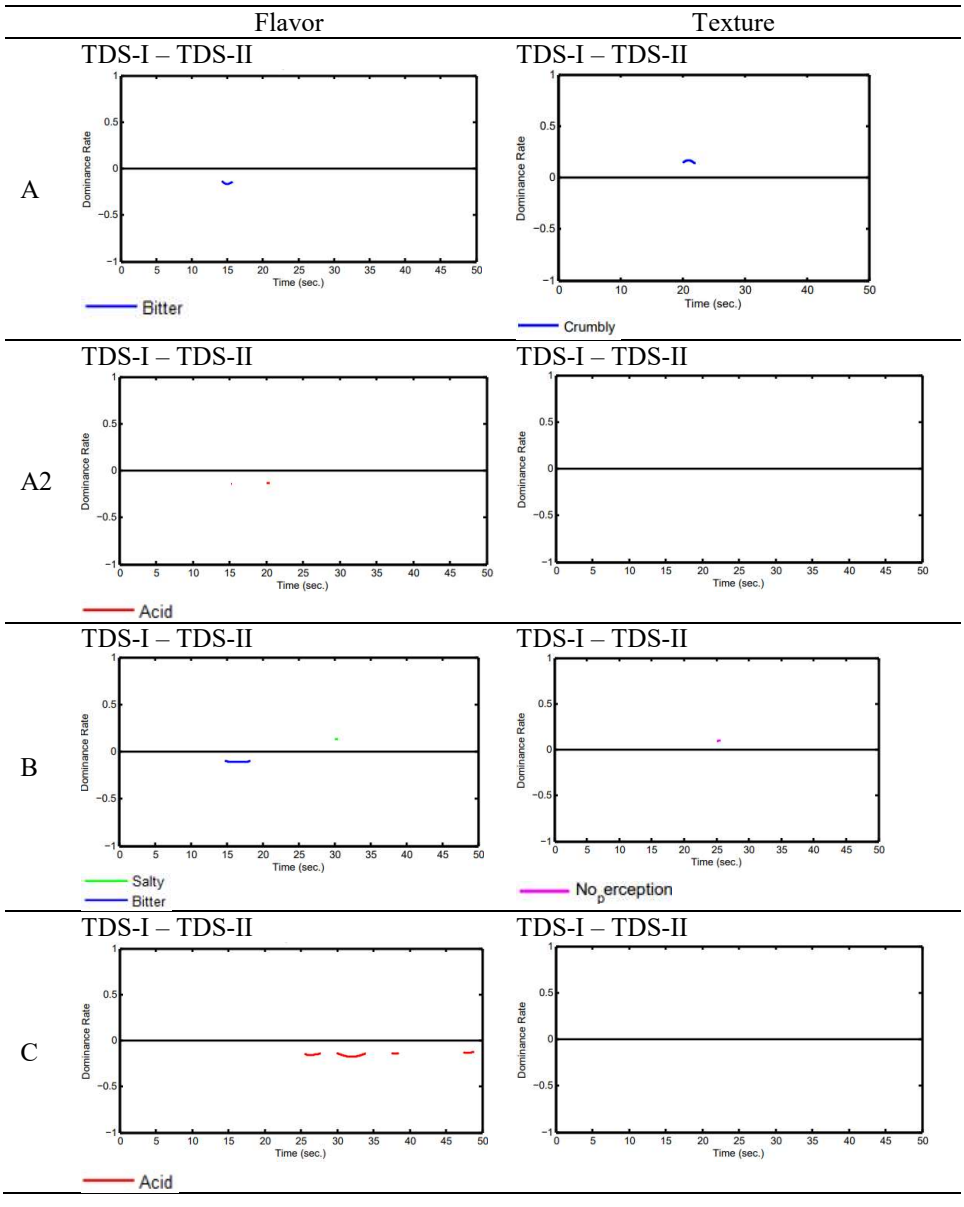


Fig. 7. Difference curves for flavor and texture attributes between the two approaches for artisanal Minas cheeses.

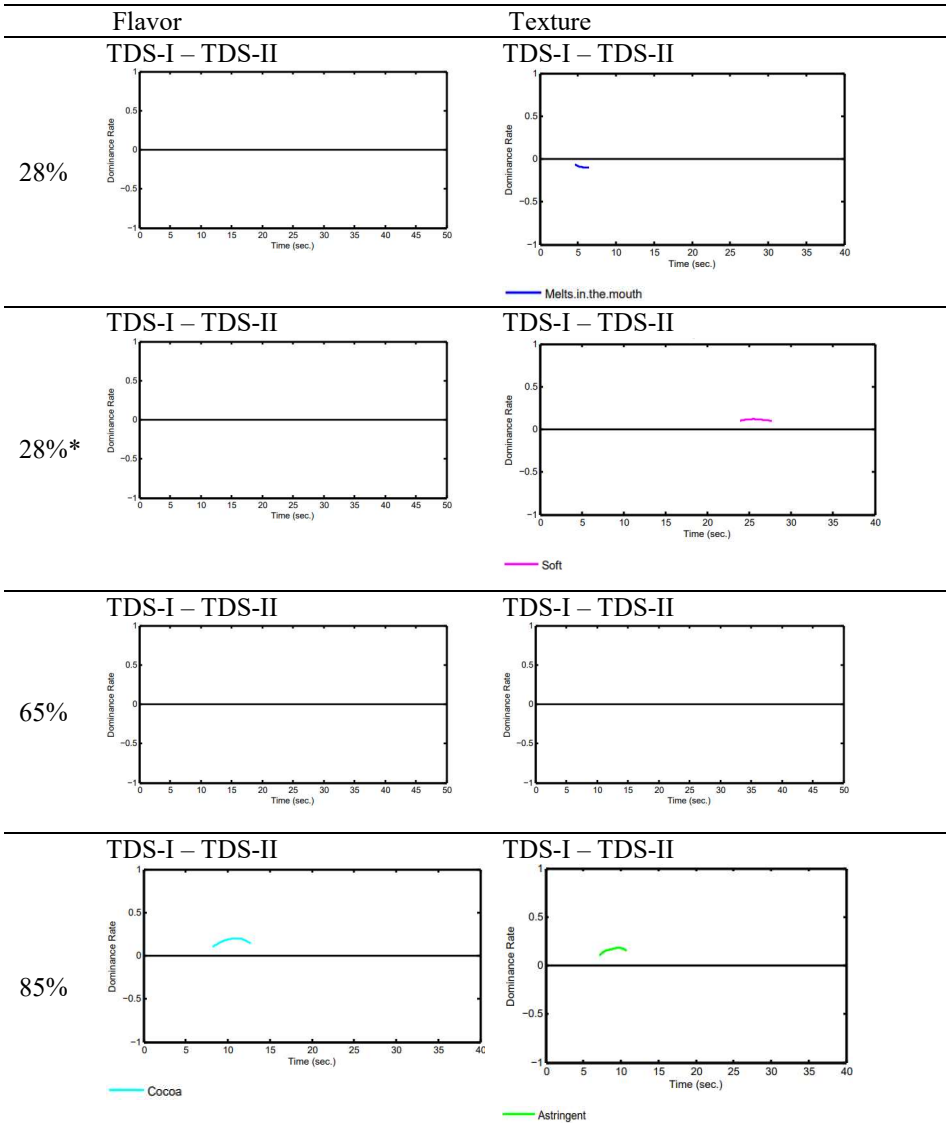
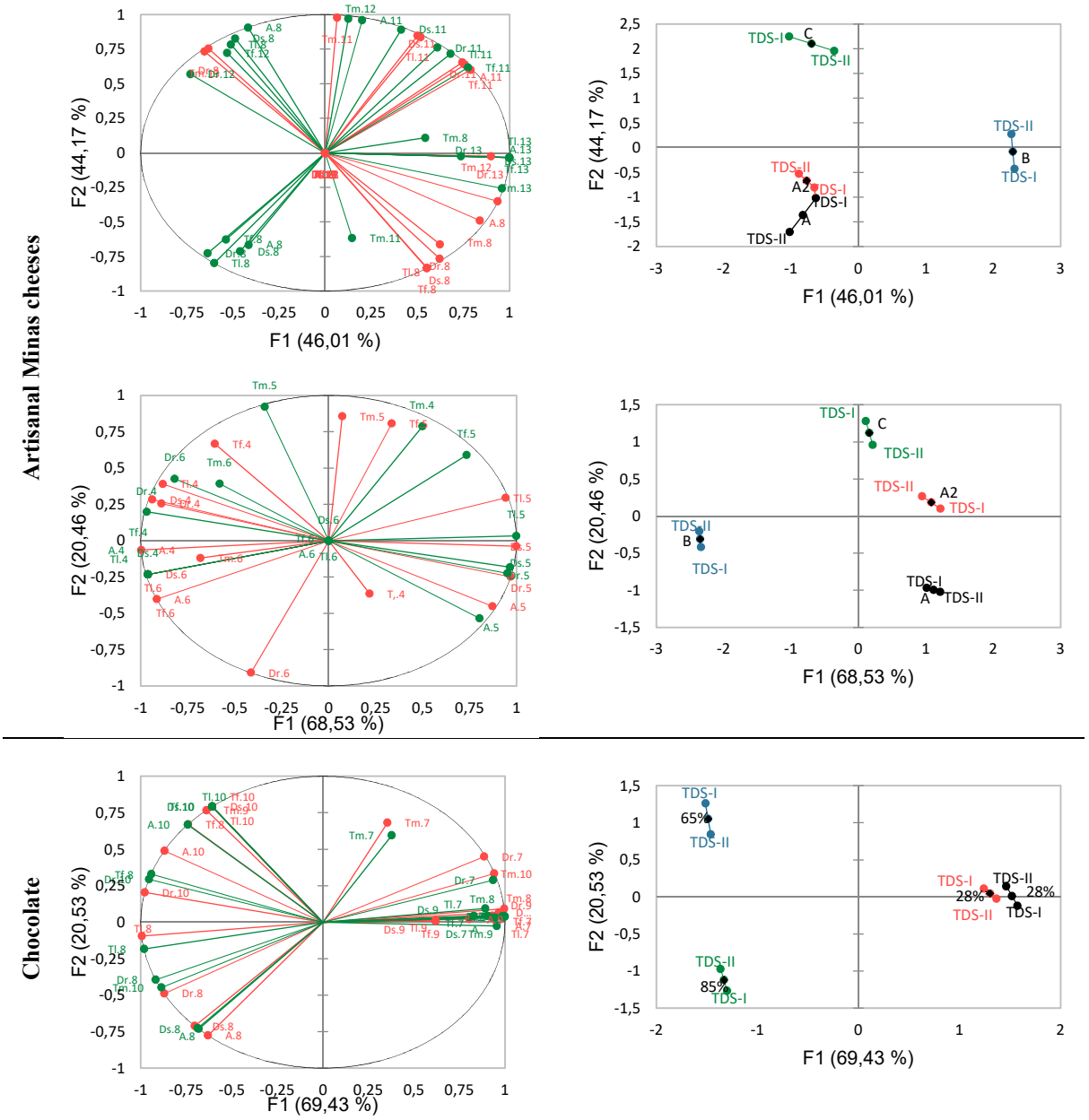


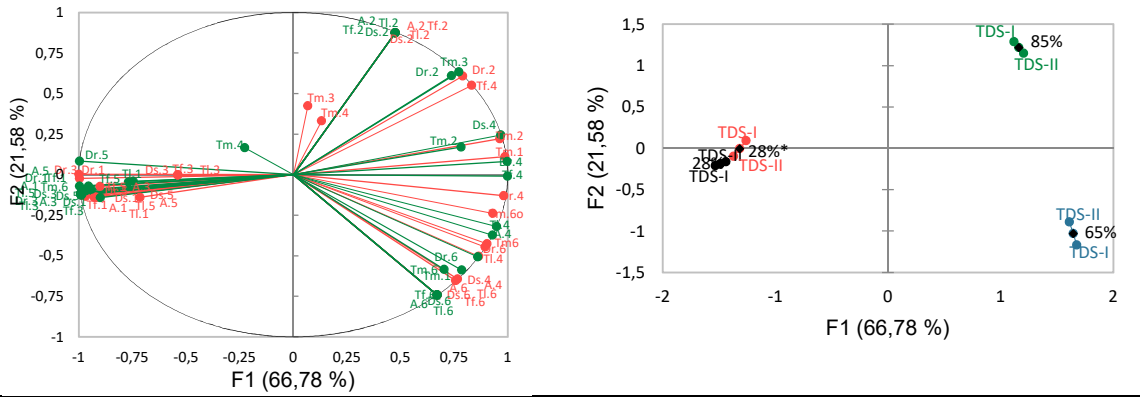
Fig. 8. Difference curves for flavor and texture attributes between the two approaches for chocolate.

Fig. 9 shows the results of the MFA analysis, comparing the product positioning on the profiling maps generated between the two approaches in terms of flavor and texture for the evaluated products. Based on the results of the TDS curves and PCA for the distribution of dominance rate trajectories, the similarities between the two approaches indicate that the type of dominance definition (TDS-I and TDS-II) in the TDS method did not have a significant impact on the temporal results. This observation is further supported by the MFA of the samples in the first two dimensions (Fig. 9). As shown, the two approaches have a high degree of

similarity (RV=0.976 cheese flavor; RV=0.909 cheese texture; RV=0.996 chocolate flavor; RV=0.997 chocolate texture).

These values suggest that both dominant and intense attributes are perceived similarly by consumers, with the proximity of perceptions for chocolate being more pronounced than for cheese. This results aligns with the recommendations of Louw et al. (2014), who suggested an RV value of 0.70 as a cut-off point for good similarity.





• TDS I; •TDS II; A: AAS; Dr: Dr_max; Tm: T_max; Ds: D_sig; Tf: T_first; Tl: T_last; 1: Creamy; 2: Astringent; 3: Melts in the mouth; 4: Firm; 5: Soft;6: Crumbly; 7: Sweet; 8: Bitter; 9: Milk; 10: Cocoa; 11: Salty; 12: Acid; 13: Butter flavor

Fig. 9. Representation of the attributes and partial representation of the samples evaluated in the first and second dimensions of the multifactorial analysis performed on the data from the two TDS approaches.

3.4 Panelists Comments

Fig. 10 highlights consumer feedback in relation to the TDS tasks. Although consumers agree that perceptions are different (Fig. 10A), the TDS curves and consumer feedback indicate otherwise (Fig. 10B – word cloud). Fig. 10A shows that the majority of consumers agree that they performed the tests differently, in other words, the majority of consumers felt that the perceptions were different between the tests and that the perceptions were consistent with the definitions given in the tests (TDS-I and TDS-II). Fig. 10B illustrates consumer feedback on the concepts of dominant and intense for the two products tested (artisanal Minas cheeses and chocolate). The responses show variation, but certain trends and differences between the concepts are evident. The black terms in the word clouds represent similarities between the two studies. There are consumers who see dominant and intense as similar concepts during the execution of the test. In contrast, other consumers identify a clear distinction between the terms. Specifically, intense is often associated with peaks of flavor during tasting or something stronger, while dominant refers to something that predominates for longer.

In relation to the degree of difficulty, the average for artisanal Minas cheese was 2.24 and 2.14 and for chocolate 2.07 and 2.16 for TDS-I and TDS-II, respectively. There was no significant difference ($p > 0.05$) between the degree of difficulty reported by the tasters in performing the two approaches, and the two approaches were considered easy to perform.

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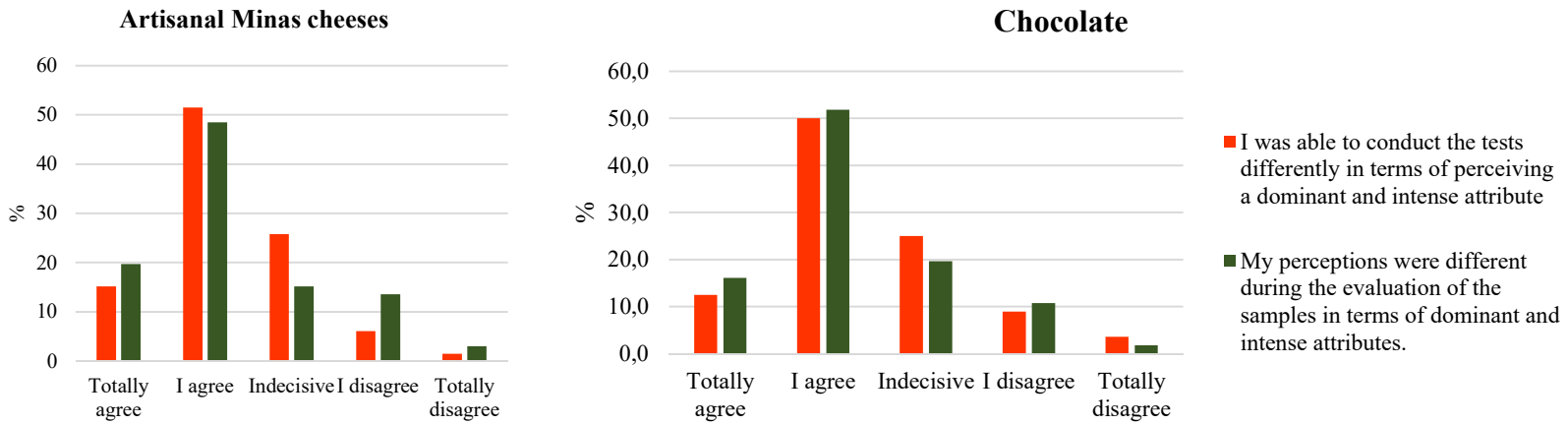
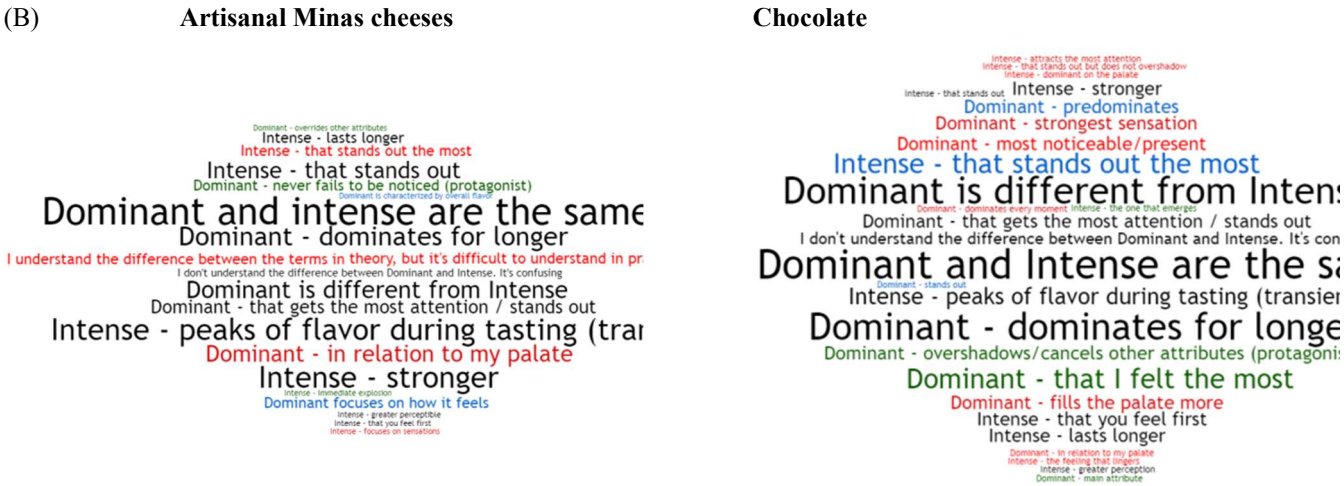
(A)



(B)



(A) Agreement scale; (B) Word cloud

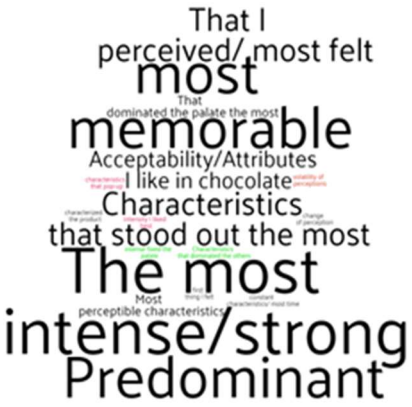
Fig. 10. Shows the tasters' feedback on how the TDS tasks were performed.

For chocolate, additional questions were proposed to provide further evidence of the diversity of factors underlying the conceptualization of what dominance means to the consumer. Fig. 11 illustrates the motivators for attribute selection and exchange during the execution of the TDS approaches. Fig. 11A illustrates consumers' feedback on the motivators behind attribute selection, and Fig. 11B illustrates the reasons that led them to change attribute selection during the execution of two TDSs. In both TDS approaches, the terms and phrases highlighted in black represent similarities that reveal recurring motivators and shared sensory experiences between the two methodologies. The complexity of these responses highlights the multifaceted nature of sensory perception and the importance of considering product-specific context when interpreting consumer feedback in TDS studies

(A) why did the attributes you selected caught your attention during the test run?

TDS I

TDSII



(B) What was it that caused you to change your choice of attributes during the tests?

TDS I

TDSII

Fig. 11. Motivators for attribute selection and exchange during execution of TDS approaches.

4. DISCUSSION

Artisanal Minas cheese is renowned for its unique sensory characteristics, such as texture and flavor, which are influenced by the origin of the starter cultures, the raw materials used, and the maturing conditions (Costa et al., 2022, Nogueira et al., 2021). Menis-Henrique (2020) and Bemfeito et al. (2016) studies found lower dominance rates for flavor than for texture, suggesting a divergence in evaluator consensus, potentially due to flavor's complex nature as a blend of taste, aroma, and oral sensations.

In addition, lower dominance rates can be attributed to the variability in consumer preferences and sensory expectations. Ares et al. (2017) highlight that consumers tend to select attributes they either like or dislike, as well as those that deviate from their expectations. Hutchings et al. (2022) also argue that sensory and hedonic expectations, along with individual preference patterns, play a significant role in influencing dominance.

The application of TDS proved effective in distinguishing sensory nuances, corroborating previous studies that highlight the methodology's ability to differentiate food products (Hutchings et al., 2014, Labbe et al., 2009). However, it is important to emphasize that these results do not necessarily imply that the samples differ in the level of the attributes, but rather that the attributes are dominant (or not) at different times in the samples, in other words, the temporal predominance of such attributes in the samples (Rodrigues et al., 2016b).

Moreover, the findings indicated that both approaches yielded similar outcomes, with a comparable number of attributes selected across the methodologies. While the curves of the chocolate samples appeared quite similar between the approaches, for cheese samples both approaches had disparities in dominance rates and attribute perception durations between the two approaches (TDS-I and TDS-II). Notably, certain attributes may achieve dominance more swiftly in one approach while persisting as dominant for a prolonged period in the other. This divergence in temporal dynamics underscores the nuanced sensory complexity inherent to cheese products (Rodrigues et al., 2016a). While exhibiting greater variability in curves, particularly in perception time, this variability appears intricately linked to product sensory complexity rather than the specific approach. This assertion finds support in the PCA graphs (Fig. 3, Fig. 6), which display parallel and similar trajectory patterns for both TDS approaches (I and II), indicating a consistent temporal perception dynamic across the methods. Additionally, the minimal variance observed in the difference curves (Fig. 7, Fig. 8) and the close alignment in the MFA (Fig. 9) results further corroborate this observation, demonstrating that the methodological differences between TDS-I and TDS-II have a limited impact on the perceived dominance of sensory attributes.

This implies that both the traditional approach (TDS-I − emphasizing the most attention-grabbing aspects) and the TDS-II approach (highlighting the most intense or strongest sensations) provided similar results as perceived by consumers. This similarity indicates that regardless of the approach, consumers perceived and spontaneously selected attributes directly related to their sensory experiences during tasting.

This observation aligns with Hutchings et al. (2022), who observed that TDS outcomes are only partially influenced by dominance definitions. The authors examined the influence of different definitions of dominance on consumer groups when tasting chocolate with different cocoa concentrations. Our study extends their findings, suggesting an instinctive reaction by consumers to perceived sensations. Overcoming the limitations of the study by Hutchings et al. (2022), we applied flavor and texture evaluations at separate times from the TDS test, and the same evaluator carried out the tests with both approaches (TDS-I and TDS-II). To mitigate the carry-over effect, session orders were balanced among assessors. Furthermore, we employed sample duplicates to assess assessor reproducibility, and the inclusion of different product samples from various food matrices allowed for a more robust and in-depth comparison of consumers' perception of dominance, enriching our understanding of the applicability and interpretation of the TDS method.

The findings of this study suggests that consumers may not clearly differentiate between dominant and intense. Pineau et al. (2009) and Meyners (2010) highlight the distinction between dominance and intensity, indicating that the dominant attribute may not always be the most intense. Hutchings et al. (2022) found that dominance, as defined in TDS, is more linked to attribute change/appearance than intensity, particularly among consumers.

The lack of consensus on this topic suggests a fundamental gap in understanding dominance, with reasons for attention varying among individuals and product types (Schlich, 2017). In line with this, Varela et al. (2018) reported consumers' motivations for choosing the dominant attribute, with 34 % selecting based on intensity, 20 % on striking sensation, and 19 % on the sensation that “popped up”.

In this complex context, low dominance rates as observed in artisanal Minas cheese flavor ratings may stem from consumers' diverse interpretations of dominance (Schlich, 2017) and the heterogeneity in its conceptualization by evaluators (Varela et al., 2018), leading to data variance and difficulty in identifying significant differences between samples. These considerations underscore the importance of understanding factors influencing dominance perception and enhancing TDS application in consumer sensory evaluations.

Delving deeper into approaches, temporal sensations' performance is noteworthy, revealing variations in detection time, duration, and sequence. Although similarities exist in descriptions obtained from both approaches, the temporal aspect significantly enhances sensory characterization via TDS, facilitating a more robust analysis of sensory perceptions during chewing (Rodrigues et al., 2018b).

Temporal variations can have wide-ranging implications, from consumer experience to marketing strategies. The sequence and duration of sensations can directly influence satisfaction and overall perception of a product. For example, if a desired flavor in a food is perceived too late or for too short a time, it may result in a less satisfying experience for the consumer. This understanding is also critical in product development, allowing professionals to adjust sensory characteristics when manipulating ingredients or processes. From a marketing perspective, this understanding of sensory perception can be translated into effective advertising strategies, such as highlighting a flavor that is easily recognizable and long-lasting.

Consequently, elucidating the precise focus of the test, whether centered on dominance or intensity, emerges as imperative in sensory science research. Ensuring a shared comprehension of these terms among evaluators and consumers stands as a pivotal prerequisite for the accurate interpretation of TDS outcomes and the broader integration of sensory evaluation within the realms of food science and industry.

Although consumer responses may vary due to several factors (e.g., acceptability, individual's flavor perception threshold, the complexity of the tested product, and others), they were able to reproduce consistent TDS results across different sessions and instructions, suggesting a robustness in the methodology. This finding indicates that greater freedom and flexibility can be adopted in the use of dominant or intense terminologies used to instruct participants while conducting the TDS test.

5. CONCLUSION

This study compared two TDS approaches (TDS-I − that attracts the most attention and TDS-II − most intense/strongest sensation) when evaluating Artesanal Minas cheese and chocolate samples. The results showed that both approaches produced consistent and similar results in terms of attribute selection and differentiation of samples, suggesting that the concepts of dominance and intensity are interpreted in a nearly equivalent manner by consumers in the context of TDS, for the products evaluated here (Artisanal Minas cheeses and chocolate). This highlights the flexibility of the TDS method to capture sensory nuances even when different terminologies are used in the test instructions provided to the tasters.

Furthermore, it was possible to clearly distinguish the characteristics of the cheese and chocolate samples, underscoring the effectiveness of TDS in highlighting sensory differences between foods. The results also confirm that the choice between the descriptors dominant and intense does not significantly influence test outcomes, permitting greater flexibility in the terminology used to guide participants during sensory evaluations.

Acknowledging the study's focus on artisanal Minas cheese and chocolate, it's important to recognize the limited range of products as a potential constraint on the generalizability of the findings. Including a more diverse array of food items in future research could offer a broader perspective on how the observed trends in dominance and intensity interpretation extend across varied sensory contexts.

6 ACKNOWLEDGEMENTS

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Supplementary material

Table 1 - Parameters of the TDS curves of the significant flavor and texture attributes for the samples of artisanal Minas cheese from Serra da Canastra.

Attributes		TDS-I- DOMINANT							TDS-II - INTENSE						
	Samples	DR_max	T_max	D_90	D_sig	T_first	T_last	AAS	DR_max	T_max	D_90	D_sig	T_first	T_last	AAS
Acid	**A**	0.177686	12	2.2	0	0	0	0	0.19697	15.5	3.9	0	0	0	0
	A2	0.176309	17.2	3.5	0	0	0	0	0.28168	15.3	7.2	10.5	12.55	23.05	0.427
	B	0.162534	23	5.4	0	0	0	0	0.151515	22.5	2.4	0	0	0	0
	C	0.206612	13.8	5.3	0	0	0	0	0.312672	32.2	10.5	2.5	18.5	39.55	1.568
Salty	**A**	0.136364	15.5	5.4	0	0	0	0	0.136364	26.5	4.5	0	0	0	0
	A2	0.136364	15.5	7.8	0	0	0	0	0.126446	11.1	4.4	0	0	0	0
	B	0.348485	20.5	2.6	15.4	12.55	27.95	0.900	0.249311	19	3.8	5.8	13.55	20.85	0.096
	C	0.297521	29.2	3.8	17.8	8.55	33.25	0.662	0.247658	11.9	9.1	8	9.55	18.05	0.194
Bitter	**A**	0.227273	24.5	14.6	4	23.55	28.45	0.062	0.279614	15	7.8	22.9	12.75	35.65	0.721
	A2	0.246556	20.8	3.6	4.2	17.55	21.75	0.065	0.242424	27.5	4.8	5.3	25.55	30.85	0.088
	B	0.257576	29.5	5.6	6	27.95	33.95	0.216	0.19697	27.5	5.5	0	0	0	0
	C	0.19697	18.5	6.2	0	0	0	0	0.206612	20.8	5.9	0	0	0	0
Butter flavor	**A**	0.151515	19.5	4.8	0	0	0	0	0.106061	21.5	9.9	0	0	0	0
	A2	0.151515	24.5	6.3	0	0	0	0	0.19697	22.5	3.9	0	0	0	0
	B	0.207989	16	4.2	0	0	0	0	0.227273	30.5	5.60	2.7	29.15	31.85	0.020
	C	0.151515	31.5	8.5	0	0	0	0	0.136364	19.5	3.1	0	0	0	0
Soft	**A**	0.629477	9.4	3.8	27.3	3.55	30.85	4.922	0.560606	15.5	9.9	28.7	3.85	32.55	5.744
	A2	0.539256	20.7	8.7	27.6	3.95	31.55	4.393	0.586777	18	9.8	30.4	4.05	34.45	5.207
	B	0.106061	14.5	4.2	0	0	0	0	0.158402	18	1.6	0	0	0	0
	C	0.363636	19.5	12.1	18.5	14.95	33.45	1.031	0.337466	19.2	6.6	14.3	6.55	24.45	0.327
Firm	**A**	0.145317	7.3	1.4	0	0	0	0	0.090909	8.5	3.2	0	0	0	0
	A2	0.075758	4.5	4.6	0	0	0	0	0.086777	18	.6	0	0	0	0
	B	0.432507	5.4	5.5	5.8	3.35	19.75	1.180	0.469284	7.9	2.2	17.7	3.25	20.95	1.786
	C	0.337466	6.2	4.9	9.6	4.75	14.95	0.24	0.282369	16.8	9.6	0	0	0	0.0002
Crumbly	**A**	0.294766	21	3.3	0	0	0	0	0.151515	13.5	9.8	0	0	0	0
	A2	0.221763	16.2	2.9	0	0	0	0	0.207989	25	4.3	0	0	0	0
	B	0.309917	23	5	3.3	16.5	24.45	0.058	0.252066	26.2	7.2	0	0	0	0
	C	0.166667	21.5	8.1	0	0	0	0	0.212121	20.5	5.5	0	0	0	0

DR_max: maximum dominance rate; T_max: the time when the maximum dominance rate occurred; D_90: duration at 0.9 x D_max; D_sig: duration of significant dominance; T_first: time first significant dominance; T_last: time last significant dominance; AAS area above significance

Table 2 - Parameters of the TDS curves of the significant flavor and texture attributes for the samples of chocolate.

		TDS-I - DOMINANT							TDS-II - INTENSE						
Attributes	Samples	DR_max	T_max	D_90	D_sig	T_first	T_last	AAS	DR_max	T_max	D_90	D_sig	T_first	T_last	AAS
Sweet	**28%**	0.330721	10	3.8	16.9	3.65	28.35	1.751	0.303292	24.3	7.7	8.9	5.45	14.35	1.686
	28%*	0.355799	17.2	5.6	27.5	5.75	33.25	2.537	0.368025	7.9	2.8	16	5.05	35.45	1.949
	65%	0.184953	14	4	0	0	0	0	0.115987	17	2.1	0	0	0	0
	85%	0.034483	6.5	3.3	0	0	0	0	0.017241	3.5	23.95	0	0	0	0
Bitter	**28%**	0.034483	40	0.15	0	0	0	0	0.017241	30.5	4.9	0	0	0	0
	28%*	0.017241	34.5	5.95	0	0	0	0	0.029781	39	0.9	0	0	0	0
	65%	0.303292	25.3	5.4	7.29	24.85	36.95	1.060	0.303292	21.3	10.4	6.09	9.85	32.55	1.537
	85%	0.613636	24.7	8.3	35.45	4.55	40	9.538	0.510972	20.2	16.1	34.45	5.55	40	8.344
Milk	**28%**	0.275862	16.5	14	14.7	15.55	35.25	1.307	0.362069	22.5	6.1	24.3	14.35	38.65	3.012
	28%*	0.268339	18.7	3.7	0	0	0	0.346	0.327586	16.5	7	13.7	14.95	28.65	1.583
	65%	0.051724	40	12.5	0	0	0	0	0.017241	7.5	10.7	0	0	0	0
	85%	0.034483	18.5	1.1	0	0	0	0	0.017241	8.5	7.8	0	0	0	0
Cocoa	**28%**	0.051724	29.5	1.5	0	0	0	0	0.045455	18.8	0.9	0	0	0	0
	28%*	0.068966	27.5	1.5	0	0	0	0	0.051724	21.5	4	0	0	0	0
	65%	0.383072	17.8	6.4	19.2	10.45	31.35	2.206	0.389498	27.7	7.45	23.05	11.15	40	3.059
	85%	0.28605	11.7	3.9	0	0	0	0.869	0.253918	35	7.3	0	0	0	0.565
Creamy	**28%**	0.374608	20	5	14.3	7.95	33.15	3.408	0.29906	11.9	6.8	1.3	9.35	10.65	1.477
	28%*	0.338558	17.8	9.2	7.5	6.25	16.65	1.815	0.293103	16.5	10.1	0.6	33.95	34.55	1.907
	65%	0.052632	40	0.65	0	0	0	0	0.103448	35.5	2.8	0	0	0	0
	85%	0.103448	40	14.95	0	0	0	0	0.115987	18	3	0	0	0	0
Adistringent	**28%**	0.017241	6.5	7.8	0	0	0	0	0.017241	6.5	4.8	0	0	0	0
	28%*	0.017241	3.5	13.85	0	0	0	0	0.034483	17.5	2.3	0	0	0	0
	65%	0.169059	26.2	4.7	0	0	0	0	0.133229	21	5.7	0	0	0	0
	85%	0.39185	30	14.1	31.75	8.25	40	4.381	0.310345	21.5	10	21.3	12.75	34.05	1.970
melts in the mouth	**28%**	0.404389	15	4.4	0	0	0	2.729	0.431034	17.5	601	22.7	10.65	33.35	3.974
	28%*	0.413793	24.5	14.4	22.4	12.15	36.15	4.985	0.458464	20.7	5	23.7	10.25	33.95	4.351
	65%	0.192982	18.5	5.1	0	0	0	0	0.131661	21.8	8.6	0	0	0	0
	85%	0.219436	22	2.4	0	0	0	0.031	0.126646	26.1	1.2	0	0	0	0
Firm	**28%**	0	0	0	0	0	0	0	0.017241	6.5	2.9	0	0	0	0
	28%*	0.068966	17.5	1.7	0	0	0	0	0.034483	14.5	5.3	0	0	0	0
	65%	0.339394	8.1	4.7	8.6	3.15	25.85	1.490	0.344828	8.5	4.5	6.8	5.45	25.65	1.664
	85%	0.241379	12.5	3.5	1.2	3.5	6.65	0.188	0.327586	9.5	2.9	8.2	4.55	12.75	0.737
Soft	**28%**	0.335423	7	3.9	5.4	3.35	9.25	0.806	0.310345	5.5	2.4	6	3.35	9.35	0.498

	28%*	0.251567	5.3	2.1	2.8	3.45	6.25	0.119	0.302821	8.3	2.8	5.2	5.05	10.25	0.411
	65%	0.070175	36.5	1.7	0	0	0	0	0.034483	12.5	8.1	0	0	0	0
	85%	0.081505	18	1.5	0	0	0	0	0.103448	7.5	1.9	0	0	0	0
Crumbly	**28%**	0	0	0	0	0	0	0	0.047022	15	2.5	0	0	0	0
	28%*	0.017241	4.5	1.9	0	0	0	0	0.017241	12.5	6.8	0	0	0	0
	65%	0.396332	14.3	4	15.8	5.15	29.85	2.047	0.362069	8.5	4.3	14.5	4.35	23.05	1.803
	85%	0.148903	8.8	3.8	0	0	0	0	0.133229	9	4.3	0	0	0	0

DR_max: maximum dominance rate; T_max: the time when the maximum dominance rate occurred; D_90: duration at 0.9 x D_max; D_sig: duration of significant dominance; T_first: time first significant dominance; T_last: time last significant dominance; AAS area above significance

TERCEIRA PARTE

CONSIDERAÇÕES FINAIS

Este estudo teve como objetivo aprimorar técnicas sensoriais descritivas, aplicando métodos rápidos e temporais, como *Preference Sorting* e *Temporal Dominance of Sensations* (TDS), na avaliação de produtos alimentícios com consumidores. Os resultados demonstraram que essas metodologias fornecem insights valiosos sobre a aceitação dos consumidores e a dinâmica das percepções sensoriais ao longo do tempo.

O *Preference Sorting* se mostrou promissor na identificação de atributos que influenciam a aceitação sensorial dos consumidores, especialmente em situações com um grande número de amostras. Ele complementa as informações obtidas por metodologias mais tradicionais, como o *CATA*. No entanto, o estudo destacou que o *Preference Sorting* ainda necessita de validações adicionais em diferentes contextos e com uma maior diversidade de produtos, uma vez que esta técnica é relativamente nova e pouco explorada na literatura. Essa lacuna oferece oportunidades para futuras pesquisas, que podem investigar sua aplicação em outras categorias alimentares, avaliar sua eficácia com diferentes perfis de consumidores e explorar sua viabilidade em variados contextos de pesquisa.

No que se refere ao *Temporal Dominance of Sensations* (TDS), a técnica mostrou-se eficaz na identificação de sensações dominantes ao longo do tempo de consumo. As abordagens TDS-I e TDS-II produziram resultados semelhantes, com algumas variações, especialmente em produtos de perfis sensoriais mais complexos. Os resultados sugerem que os consumidores tendem a associar a "sensação dominante" à "sensação mais intensa", embora essas definições, teoricamente, possam ser distintas. Apesar dos resultados encorajadores, o estudo reconhece que a variedade limitada de produtos testados restringe a generalização dessas descobertas. Pesquisas futuras, envolvendo uma gama mais diversificada de itens alimentares, podem ampliar a compreensão de como as tendências observadas na interpretação de dominância se aplicam a diferentes contextos sensoriais.

Por fim, o presente trabalho contribuiu para a consolidação das metodologias rápidas e temporais no campo da análise sensorial, destacando a importância de otimizar essas ferramentas para contextos mais aplicáveis aos consumidores. O uso dessas metodologias se torna cada vez mais valiosa para a indústria alimentícia, pois permite tomadas de decisão mais ágeis e assertivas na formulação e modificação de produtos. Com uma implementação mais ampla dessas técnicas, as empresas podem responder melhor às demandas do mercado, desenvolvendo produtos que atendam às expectativas dos consumidores.