JÉSSICA FERREIRA RODRIGUES

INVESTIGAÇÕES SOBRE TÉCNICAS SENSORIAIS: UM ESTUDO SOBRE A METODOLOGIA DE DOMINÂNCIA TEMPORAL DAS SENSAÇÕES (TDS)

LAVRAS – MG
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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.

Orientadora
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LAVRAS-MG
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RESEARCH ON SENSORY TECHNIQUES: A STUDY OF THE TEMPORAL DOMINANCE OF SENSATIONS (TDS) METHODOLOGY

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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LAVRAS-MG
2017

Aos meus heróis, Antônio Augusto e Giani, por todo incentivo, apoio, amor e dedicação

DEDICO

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RESUMO GERAL

O teste de dominância temporal das sensações (TDS) objetiva descrever a evolução temporal de sensações durante o consumo de um produto. Ele tem sido extensivamente utilizado, uma vez que é considerado mais efetivo e rápido em comparação a outros métodos tradicionais. Entretanto, ainda existem algumas questões em aberto sobre os procedimentos adequados para realização do teste. Dentre essas questões destacam-se o painel sensorial e lista de eatributos mais adequados. Diante disso, foram realizados dois estudos: o primeiro obejetivou avaliar o comportamento de diferentes painéis durante a análise de TDS de chocolates, verificando qual o melhor painel sensorial para aquisição de dados de TDS mais confiáveis; o segundo estudo objetivou avaliar as implicações de analisar sensações de textura e sabor simultaneamente durante as descrições de TDS de queijo Prato. No primeiro experimento, chocolates com diferentes concentrações de cacau foram avaliados por meio de testes de TDS por diferentes painéis sensoriais: I: consumidores; II: painel selecionado; e III: painel selecionado e familiarizado. Os dados das curvas de TDS foram analisados via análise de variância multivariada (MANOVA), análise de componentes principais (ACP) e por indicadores de desempenho sensorial. Já no segundo estudo, queijos Prato de diferentes marcas comerciais foram avaliados por testes de TDS realizados de duas maneiras: I: os participantes realizaram os testes de TDS, avaliando uma lista de atributos com sensações de sabor e textura em uma mesma sessão; II: Foram realizados testes de TDS para cada tipo de atributo separadamente. Os resultados foram avaliados pelas curvas de TDS, por análise múltipla de fatores (MFA) e por ACP. Os diferentes painéis avaliados no estudo I forneceram descrições diferentes para amostras de chocolate com 35% e 53% de cacau e descrições semelhantes para a amostra com 63% de cacau. Além disso, maiores taxas de dominância foram observadas nos resultados dos consumidores. Através da MANOVA e ACP foi possível verificar que o painel I foi capaz de discriminar os três chocolates, enquanto que o painel selecionado e o painel selecionado e familiarizado apenas discriminaram o chocolate com 35% de cacau dos demais. Observou-se ainda que o grupo de consumidores gastou menos tempo para eleger a primeira sensação e usou mais atributos para descrever o chocolate com 35% de cacau. Portanto, os protocolos de seleção e familiarização utilizados no estudo não foram suficientes para melhorar as respostas de TDS em relação à avaliação dos consumidores. No estudo II observou-se que uma das principais implicações da análise simultânea de diferentes atributos nos resultados de TDS foi a diferença quanto à temporalidade. Além disso, apesar da avaliação simultânea ter proporcionado uma descrição de sabor semelhante à da avaliação separada, foram observadas diferenças no perfil de textura entre as abordagens. Embora a análise simultânea foi considerada mais difícil e menos confiável pelos provadores, ambos os resultados de TDS forneceram uma caracterização similar das amostras em relação à análise instrumental, sendo que sensações antagônicas foram positivamente correlacionadas na avaliação separada.

Palavras-chave: Lista de atributos. Painel sensorial. Protocolo de teste. TDS.

GENERAL ABSTRACT

The Temporal Dominance of Sensations (TDS) test aims to describe the sensations temporal evolution during the product consumption. It has been extensively used and it has been considered to be more effective and quick compared to other traditional methods. However, there are some questions about the proper procedures for conducting the test to be investigated. Among this questions are the most appropriate sensory panel and attribute list to be used during the analysis. Therefore, two studies were carried out: the first one aimed to evaluate the behavior of different panels during the TDS analysis of chocolates, verifying the best sensory panel for a more reliable TDS data acquisition; The second study aimed to evaluate the implications of analyzing texture and flavor sensations simultaneously during the TDS descriptions of Prato cheese. In the first experiment, chocolates with different cocoa contents were evaluated through TDS tests by different sensorial panels: I: consumers; II: selected panel; and III: selected and familiarized panel. TDS curves data were analyzed using multivariate analysis of variance (MANOVA), principal component analysis (PCA) and sensorial performance indicators. In the second study, Prato cheeses from different brands were evaluated by TDS tests performed in two ways: I- the panelists performed TDS tests of Prato cheeses, evaluating an attribute list with the taste and texture sensations in a same session; II- TDS evaluations were performed for each type of attribute separately. The results were evaluated by the TDS curves, by multiple factor analysis (MFA) and by PCA.The different panels provided different descriptions for chocolate samples with 35% and 53% cocoa and similar descriptions for the sample with 63% cocoa. Moreover, higher dominance rates were observed in the consumer results. Through MANOVA and PCA it was possible to verify that Panel I was able to discriminate the three chocolates, while the selected panel and the selected and familiarized panel only discriminated chocolate with 35% cocoa from the others. Furthermore, we found that the consumer's group spent less time to elect the first sensation and used more attributes to describe the chocolate with 35% cocoa.Thus, the selection and familiarization protocols used in this study associated with only two sessions to introduce the panelists to TDS were not sufficient to improve the TDS response regarding the consumer evaluation. In the study II, it was noted that one of the main implications of the simultaneous analysis on TDS results was the difference regarding the temporality. Moreover, the simultaneous evaluation provided a similar taste description of the separate evaluation, but differences on the texture profile were noted. Although the simultaneous analysis implied in greater difficulty in performing the tests and less reliable results according to the panelist's opinions, both TDS results seemed to provide similar sample's characterization regarding the instrumental analysis, being antagonistic sensations ('hard' x 'soft') correlated positively in the separate evaluation.

Keywords: Attribute list. Sensory panel. Test protocol. TDS.

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PRIMEIRA PARTE

1 INTRODUÇÃO

A análise descritiva sensorial é uma das ferramentas mais sofisticadas e amplamente utilizadas no campo sensorial, uma vez que fornece uma descrição completa das características sensoriais dos produtos (VARELA; ARES, 2012). Consiste em uma metodologia que permite medir a reação sensorial aos estímulos resultantes do consumo de um produto, proporcionando uma descrição dos aspectos qualitativos e quantitativos da percepção humana (LAWLESS; HEYMANN, 2010; MURRAY; DELAHUNTY; BAXTER, 2001; STONE; SIDEL, 2004).

Descrever as características sensoriais de um produto é uma prática comum na indústria de alimentos e bebidas, para a tomada de decisões de negócios, guiando o desenvolvimento de produtos que satisfaçam os anseios do consumidor; para verificar o efeito de determinados ingredientes e processos, para fins de controle de qualidade; para monitorar as alterações de produtos ao longo do tempo, e para correlacionar com as medições instrumentais (VARELA; ARES, 2012). No meio acadêmico também tem sido um recurso valioso que permite o estabelecimento de correlações com medições analíticas, auxiliando na explicação de como mudanças na textura, sabor, aroma ou características estruturais e microestruturas afetam as diferentes características sensoriais do produto, bem como, fornece uma melhor compreensão dos mecanismos subjacentes da percepção sensorial (GACULA, 1997; MOUSSAOUI; STONE; SIDEL, 2004).

O teste de Dominância Temporal das Sensações (TDS) consiste em uma metodologia relativamente nova no campo sensorial que descreve a evolução temporal das diferentes sensações desenvolvidas durante o consumo de alimentos (LABBE et al., 2009; PINEAU; CORDELLE; SCHILCH, 2003; PINEAU et al., 2009). Durante a análise, os provadores são convidados a indicar a sensação (de uma lista pré-determinada de vários atributos) dominante durante o tempo de análise. Suas percepções são representadas por curvas que mostram quantas vezes cada sensação foi considerada dominante durante o período de avaliação (PINEAU et al., 2009). É considerado um método descritivo multi-atributo rápido e eficaz quando comparado com outros métodos descritivos convencionais utilizados para avaliar um conjunto de sensações induzidas por um determinado alimento (PINEAU et al., 2009).

Estudos comparativos de produtos complexos com sensações de longa duração demonstraram que o TDS pode fornecer mais informações do que os métodos de perfis

convencionais (LABBE et al., 2009). De maneira análoga, TDS foi demonstrado ser útil para a avaliação de produtos com pequenas diferenças sensoriais (MEILLON et al., 2010). Além disso, a análise de TDS foi utilizada para fornecer uma melhor compreensão da textura, o aroma e o sabor dos produtos em comparação com outros testes de perfil estáticos e dinâmicos (DÉLÉRIS et al., 2011; DINNELLA et al., 2012; LENFANT et al., 2009; SAINT-EVE et al., 2011) epara o desenvolvimento de produtos com reduzido teor de sódio (RODRIGUES et al., 2014a; RODRIGUES et al., 2014b; RODRIGUES et al., 2016; SOUZA et al., 2013). Blake (2004) e Meillonet al. (2010) também demonstraram que os aspectos dinâmicos e multi-sensoriais de percepção de alimentos, desempenham um papel importante no processo utilizado pelos consumidores para avaliar a aceitabilidade e propriedades sensoriais de produtos alimentares.

No entanto, o procedimento de TDS é bastante diferente das metodologias sensoriais convencionais, uma vez que inclui uma dimensão temporal. Esta abordagem ainda é considerada exigente para o painel, visto que o provador deve concentrar-se continuamente na sensação dominante durante todo o tempo de degustação do produto (PINEAU et al., 2012). Embora este método tenha sido extensivamente utilizado para descrever vários produtos, ainda existe uma falta de conhecimento sobre o painel adequado para aquisição de dados.

Desde que a metodologia foi proposta, uma grande variação nos procedimentos de seleção e treinamento do painel para realização da análise é observada, sendo vários estudos realizados com consumidores que passam desde nenhum até um árduo treinamento (CHARLES et al., 2015; DIAZ et al., 2015; DINELLA et al., 2012; GALMARINI; VISALLIE; SCHLICH, 2016; HUTCHINGS et al., 2014; MA et al., 2016; MEILLON et al., 2009; RODRIGUES et al., 2014a; RODRIGUES et al., 2014b; ROSENTHAL; SHARE, 2014; THOMAS; CORDELLE; SCHLICH, 2015); outros trabalham com provadores selecionados segundo a ISO 8586 (2012) ou com experiência prévia em outros métodos descritivos como a análise descritiva quantitativa ou análise de tempo-intensidade, também com grande variação no treinamento aplicado após a seleção (ARES; JAEGER, 2015; PAULSEN et al., 2014; DEVEZEAUX DE LAVERGNE et al., 2015; PINEAU et al., 2009; RODRIGUES et al., 2016; SILVA et al., 2013; SOKOLOWSKYE; FISHER, 2012; SOUZA et al., 2013; VIDAL et al., 2016; ZORN et al., 2014). Além disso, enquanto alguns autores sugerem que o painel deve passar por várias sessões de formação, durante as quais eles são geralmente introduzidos pela primeira vez à noção de temporalidade das sensações e que o desempenho do painel deve ser avaliado segundo os critérios de discriminação

e consenso (PINEAU et al., 2012; LEPAGE et al., 2014), outros sugerem que os provadores não devem ser arduamente treinados, a fim de evitar a tendência dos sujeitos de citar descritores na mesma ordem para todos os produtos (MEILLON et al., 2009; ALBERT et al., 2010). Meyners (2010) sugere ainda que em TDS é útil usar provadores que desconhecem métodos descritivos clássicos, uma vez que podem confundir os conceitos de dominância e de intensidade.

A lista de atributos também consiste de outro ponto a ser investigado. Pineau et al. (2012) já elucidou alguns aspectos sobre como os provadores usam a lista de atributos durante um experimento de TDS, e como o número, tipo e localização dos atributos na lista impactam a resposta sensorial. Tradicionalmente, os testes de TDS são realizados avaliando apenas um tipo de atributo (textura ou sabor, por exemplo), mas alguns estudos sugerem que diferentes atributos (sabor, textura, aroma, etc.) podem ser avaliados em uma mesma avaliação (PINEAU et al., 2012; PESSINA et al., 2005), economizando tempo e dinheiro. No entanto, a influência exata de listar diferentes propriedades sensoriais na mesma lista ainda é desconhecida (DI MONACO et al., 2014) e não há estudos comparando os resultados obtidos a partir da avaliação simultânea e separada de diferentes atributos. Assim, é necessário investigar precisamente as implicações do uso de diferentes tipos de atributos em uma mesma sessão de TDS a fim de entender as vantagens e limitações desta abordagem (PINEAU et al., 2012).

Portanto, estudos comparativos, com diferentes painéis, listas de atributos, entre outros parâmetros de condução do teste e análise dos resultados são necessários para estabelecer o protocolo de teste adequado. Por esta razão, o objetivo do trabalho foi investigar e comparar o comportamento de diferentes painéis sensoriais, bem como avaliar as implicações da análise de diferentes atributos simultaneammente durante aanálise de Dominância Temporal das Sensações (TDS), a fim de estabelecer recomendações para condução do teste que garantam a aquisação de dados com qualidade e confiabilidade.

2 REFERENCIAL TEÓRICO

2.1 Análise Sensorial

O campo da análise sensorial cresceu rapidamente na segunda metade do século XX, juntamente com a expansão dos alimentos processados e indústrias de produtos de consumo (LAWLESS; HEYMANN, 2010). A avaliação sensorial compreende um conjunto de técnicas para a medição precisa das respostas humanas aos alimentos e produtos não-alimentares, minimiza potencialmente os efeitos da marca e outras influências da informação sobre a percepção do consumidor. Como tal, ela tenta isolar as propriedades sensoriais dos próprios alimentos e fornece informações importantes e úteis para os desenvolvedores de produtos, cientistas de alimentos e gerentes sobre as características sensoriais de seus produtos (LAWLESS; HEYMANN, 2010).

A análise sensorial pode ser definida como uma disciplina científica usada para evocar, medir, analisar e interpretar reações das propriedades sensoriais dos alimentos e materiais que são percebidas pelos órgãos dos sentidos da visão, olfato, gosto, tato e audição (ABNT, 1993a; STONE; SIDEL, 2004).

Em um mercado cada vez mais exigente, a qualidade sensorial do alimento e a manutenção da mesma auxiliam na fidelidade do consumidor a um produto específico (TEIXEIRA, 2009). Portanto, as técnicas sensoriais constituem-se de ferramentas muito importantes para a indústria alimentícia, farmacêutica, cosmética, entre outras, por avaliar a aceitabilidade mercadológica e qualidade do produto, sendo inseparável ao plano de controle de qualidade da indústria. Trata-se de um conjunto de técnicas que auxiliam na seleção de matérias primas e processos; na avaliação da percepção e da reação do consumidor diante dos atributos do produto; na comparação se um produto avaliado tem qualidade superior aos produtos concorrentes; na otimização de novas formulações; no desenvolvimento de novos produtos; na avaliação da embalagem; no estudo de vida de pratelira; etc (GULARTE, 2002).

A avaliação sensorial compreende um conjunto de métodos com diretrizes e técnicas estabelecidas para a apresentação do produto, tarefas de resposta bem definidas, análises estatísticas e interpretação dos resultados (LAWLESS; HEYMANN, 2010). Conforme o produto, o atributo sensorial e a finalidade do estudo, diferentes métodos sensoriais podem ser aplicados.

Segundo a NBR 12994, os métodos sensoriais podem ser classificados em discriminativos, descritivos e afetivos (ABNT, 1993b).

Os métodos discriminativos estabelecem diferenciação qualitativa e/ou quantitativa entre as amostras e incluem os testes de diferença e os testes de sensibilidade (ABNT, 1993b). São testes em que não se requer conhecer a sensação subjetiva que produz um alimento a uma pessoa, mas apenas se deseja estabelecer se existe diferença ou não entre duas ou mais amostras e, em alguns casos, a magnitude ou importância dessa diferença (ANZALDÚA-MORALES, 1994). São testes muito usados para seleção e monitoramento de equipe de julgadores, para determinar se existe diferença devido à substituição de matéria-prima, alterações de processo devido à embalagem ou ao tempo de armazenamento (FERREIRA et al., 2000).

Os métodos descritivos objetivam a descrição do perfil sensorial do produto (LAWLESS; HEYMANN, 2010). Atualmente, existe uma infinidade de métodos a serem explorados, dos quais podemos destacar o perfil de sabor, perfil de textura, a análise descritiva quantitativa – ADQ, os testes descritivos temporais (Tempo-intensidade e Dominância Temporal das Sensações – TDS) e os métodos descritivos rápidos (*Check all that apply – CATA, Sorting, Naping*, etc.) (ABNT, 1993b; ARES; JAEGER, 2015; CHOLLET et al., 2011; DEHLHOLM et al., 2012; VARELA; ARES, 2012). Nos testes descritivos procura-se definir as propriedades do alimento e medi-las de maneira mais objetiva possível. Neste caso, não são importantes as preferências ou aversões dos julgadores, e sim qual é a magnitude ou intensidade dos atributos do alimento (ANZALDÚA-MORALES, 1994).

Já os testes afetivos são usados para avaliar a preferência e/ou aceitação de produtos. Geralmente um grande número de julgadores é requerido para essas avaliações. Os julgadores não são treinados, mas são selecionados para representar uma população alvo (IFT, 1981). Os testes afetivos são uma importante ferramenta, pois acessam diretamente a opinião do consumidor já estabelecido ou potencial de um produto, sobre características específicas do produto ou idéias sobre o mesmo, por isso são também chamados de testes com consumidor (FERREIRA et al., 2000). As principais aplicações dos testes afetivos são a manutenção da qualidade do produto, otimização de produtos e/ou processos e desenvolvimento de novos produtos (LAWLESS; HEYMANN, 2010).

2.2 Métodos Sensoriais descritivos

A análise descritiva sensorial é uma das ferramentas mais sofisticadas e amplamente utilizadas no campo sensorial, uma vez que fornece uma descrição completa das características sensoriais dos produtos (VARELA; ARES, 2012). Consiste de uma metodologia que permite medir a reação sensorial aos estímulos resultantes do consumo de um produto, proporcionando uma descrição dos aspectos qualitativos e quantitativos da percepção humana (LAWLESS; HEYMANN, 2010; MOUSSAOUI; VARELA, 2010; MURRAY; DELAHUNTY; BAXTER, 2001; STONE; SIDEL, 2004).

Descrever as características sensoriais de um produto é uma prática comum na indústria de alimentos e bebidas, para tomada de decisões de negócios, guiando o desenvolvimento de produtos que satisfaçam aos anseios do consumidor, para verificar o efeito de determinados ingredientes e processos, para fins de controle de qualidade, para monitorar as alterações de produtos ao longo do tempo e para correlacionar com as medições instrumentais (VARELA; ARES, 2012). No meio acadêmico também tem sido um recurso valioso, que permite o estabelecimento de correlações com medições analíticas, auxiliando na explicação de como mudanças na textura, sabor, aroma ou características estruturais e microestruturais afetam as diferentes características sensoriais do produto, bem como, fornece uma melhor compreensão dos mecanismos subjacentes da percepção sensorial (GACULA, 1997; MOUSSAOUI; VARELA, 2010; STONE; SIDEL, 2004).

O primeiro método descritivo aplicado com um painel de juízes treinados foi o perfil de sabor®. Esse método foi desenvolvido no Arthur D. Little no final da década de 1940 (CAIRNCROSS; SJOSTROM, 1950). O método consistia de uma ferramenta abrangente e flexível para a análise detalhada do perfil de sabor para resolver problemas envolvendo sabores desagradáveis em cápsulas nutricionais e perguntas sobre o impacto sensorial da utilização de glutamato monossódico em vários alimentos processados (LAWLESS; HEYMANN, 2010). Juntamente com o método surgiu a concepção de realizar testes descritivos com um painel sensorial selecionado e treinado, tendo em vista que a resposta proveniente do consenso da equipe seria mais confiável que a resposta isolada de um único indivíduo (LAWLESS; HEYMANN, 2010).

Muitas variações e refinamento da técnica surgiram em seguida. No início dos anos 60, um grupo do *General Foods Technical Center* desenvolveu uma variação do método (Perfil de

textura®) para avaliação do perfil de textura do alimento. O método usava um conjunto de atributos relacionados à força necessária para romper o alimento, de forma a caracterizar as propriedades reológicas e táteis dos alimentos e como essas mudavam ao longo do tempo de mastigação (BRANDT et al., 1963; SZCZESNIAK et al., 1975).

Outras abordagens foram desenvolvidas para solucionar os problemas da análise descritiva. No início da década de 1970, no *Stanford Research Institute*, um grupo propôs um método para análise descritiva que solucionava algumas das deficiências aparentes do perfil de sabor® e que era aplicável a todas as propriedades sensoriais de um alimento, e não apenas ao sabor e à textura. Este método foi designado como Análise Descritiva Quantitativa® - ADQ (STONE et al., 1974). Outras variações nos procedimentos descritivos também foram estudadas e alcançaram certa popularidade, como o Método *Spectrum* (MEILGAARD et al., 2006), que incluiu um alto grau de calibração de provadores para o uso de escalas de intensidade, muito parecido com o Perfil de Textura.

Além das técnicas descritivas convencionais, tais como a Análise Descritiva Quantitativa (ADQ) e o método de Espectro (CIVILLE; LYON, 1996; STONE et al., 1974), uma série de novas metodologias têm sido estudadas e muito utilizadas atualmente, tendo em vista os aspectos temporais, econômicos, de consumo e tempo, de forma a fornecer uma informação descritiva mais rica do produto. Dentre essas metodologias destacam-se os testes descritivos rápidos como os testes *check all that apply - CATA, Napping e Sorting* (ARES; JAEGER, 2015; CHOLLET et al., 2011; DEHLHOLM et al., 2012; VARELA; ARES, 2012), e os testes descritivos temporais como o teste de Tempo-intensidade e Dominância Temporal das Sensações (TDS) (PINEAU et al., 2009).

Contudo, a análise descritiva provou ser a ferramenta de avaliação sensorial mais abrangente e informativa. É aplicável à caracterização de uma grande variedade de mudanças de produtos e questões de pesquisa no desenvolvimento de produtos alimentícios. A informação descritiva pode ainda ser relacionada com a informação afetiva (aceitação do consumidor) e com medidas instrumentais por meio de técnicas estatísticas (LAWLESS; HEYMANN, 2010).

2.2.1 Métodos sensoriais descritivos temporais

Piggott (2000) apontou que os processos envolvidos no consumo de alimentos, incluindo mastigação, salivação, movimento da língua, deglutição e assim por diante, modificam a percepção tanto da intensidade como da qualidade do aroma, sabor e textura de um produto de um momento para outro. Além disso, o efeito do tempo na liberação das características sensoriais (do gosto, aroma, textura e mesmo as sensações térmicas) em determinados produtos alimentícios, têm impacto significativo na preferência do consumidor (DI MONOCO et al., 2014). Assim, os métodos sensoriais estáticos convencionais que exigem uma única avaliação pontual dos provadores, podem perder alguma informação significativa do produto. Para superar essa desvantagem e entender verdadeiramente como os produtos são percebidos pelos consumidores durante o seu consumo e, consequentemente, como sua reação hedônica é afetada, diferentes métodos sensoriais dinâmicos devem ser adotados (DI MONOCO et al., 2014; LAWLESS; HEYMANN, 2010; PIGGOTT, 2000).

Diante disso, diferentes metodologias temporais têm sido desenvolvidas nas últimas décadas. Algumas delas têm sido largamente aplicadas na literatura, como o teste de Tempo-intensidade (TI) (LEE; PANGBORN, 1986) e mais recentemente a metodologia de Dominância Temporal das Sensações (TDS) (PINEAU et al., 2009), enquanto outras têm sido menos utilizadas, como o teste *Progressive Profile* (JACK; PIGGOTT; PATERSON, 1994) e *Sequencial Profiling* (METHVEN et al., 2010).

Dentre os métodos temporais mais utilizados, o teste de Tempo-intensidade consiste em registrar a evolução da intensidade de um dado atributo sensorial ao longo do tempo (LEE; PANGBORN, 1986).Este método tem sido utilizado numa grande variedade de produtos tais como:soluções modelo (BONNANS; NOBLE, 1995); cerveja (KING; DUINEVELD, 1999); vinho (ISHIKAWA; NOBLE, 1995); com alimentos sólidos, onde as propriedades de textura também foram avaliadas, como na carne (DUIZER; GULLETT; FINDLAY, 1993), ou queijo (WENDIN; JANESTAD; HALL, 2003); no estudo de edulcorantes (LABBE et al., 2009; SOUZA et al., 2011); e no desenvolvimento de produtos com reduzido teor de sódio (SOUZA et al., 2013; RODRIGUES et al., 2014a; RODRIGUES et al., 2014b). Em todos esses estudos, a metodologia de TI é realizada apenas em um pequeno número de atributos ou com um número limitado de produtos, pois apenas um atributo é avaliado de cada vez. No entanto, estudos sobre um grande número de produtos e com vários atributos também foram realizados (CHAYA et al., 2004), mas eles levam muito tempo porque exigem um grande número de testes.

A fim de reduzir a duração do experimento, a metodologia de dominância temporal das sensações foi proposta. O TDS consiste de um teste sensorial que descreve a evolução temporal das diferentes sensações desenvolvidas durante o consumo de alimentos (LABBE et al., 2009; PINEAU; CORDELLE; SCHILCH, 2003; PINEAU et al., 2009). Durante a análise, os provadores são convidados a indicar a sensação (de uma lista pré-determinada de vários atributos) dominante durante o tempo de análise. Suas percepções são representadas por curvas que mostram quantas vezes cada sensação foi considerada dominante durante o período de avaliação. É considerado um método descritivo multi-atributo rápido e eficaz quando comparado com outros métodos descritivos convencionais utilizados para avaliar um conjunto de sensações induzidas por um determinado alimento (PINEAU et al., 2009).

2.3 Análise de Dominância Temporal das Sensações

A metodologia de TDS foi desenvolvida no *Centre Européen des Sciences du Goût*, no laboratório LIRIS em 1999 e foi apresentada pela primeira vez no *Pangborn Symposium* por Pineau, Cordelle e Schlich (2003). O TDS estuda a sequência de sensações dominantes de um produto durante um determinado período de tempo (PINEAU et al., 2009). Mais precisamente, o teste consiste em identificar as sensações percebidas como dominantes até que a percepção termine. Assim os provadores têm que selecionar um novo atributo dominante sempre que percebem uma mudança nas sensações dominantes. Sendo que "Dominante" foi definido como a sensação que capta a atenção, a percepção mais marcante, ou a nova sensação que surge em um dado momento, mas não necessariamente a sensação mais intensa (LABBE et al., 2009; PINEAU et al., 2009).

TDS tem sido largamente aplicado na área de alimentos. Estudos comparativos de produtos complexos com sensações de longa duração demonstraram que o TDS pode fornecer mais informações do que os métodos de perfis convencionais (LABBE et al., 2009). De maneira análoga, TDS foi demonstrado ser útil para a avaliação de produtos com pequenas diferenças sensoriais (MEILLON et al., 2010). Além disso, a análise de TDS foi utilizada para fornecer uma melhor compreensão da textura, aroma e sabor dos produtos, em comparação com outros testes de perfil estáticos e dinâmicos (DINNELLA et al., 2012; LENFANT et al., 2009; DÉLÉRIS et al., 2011; SAINT-EVE et al., 2011) e para o desenvolvimento de produtos com reduzido teor de

sódio (SOUZA et al., 2013; RODRIGUES et al., 2014a; RODRIGUES et al., 2014b; RODRIGUES et al., 2016). Blake (2004) e Meillon et al. (2010) também demonstraram que os aspectos dinâmicos e multi-sensoriais de percepção de alimentos desempenham um papel importante no processo utilizado pelos consumidores para avaliar a aceitabilidade e propriedades sensoriais de produtos alimentares. Essa técnica permite ainda identificar o impacto que cada aspecto da percepção tem sobre o consumidor e os resultados são ligados à aceitação do produto (ALBERT et al., 2012).

2.3.1 Procedimento do teste

Desde que a metodologia foi proposta, uma grande variação nos procedimentos de seleção e treinamento do painel para realização da análise é observada, sendo vários estudos realizados com consumidores que passam desde nenhum treinamento, até um árduo treinamento (CHARLES et al., 2015; DIAZ et al., 2015; DINELLA et al., 2012; GALMARINI; VISALLI; SCHLICH, 2016; HUTCHINGS et al., 2014; MA et al., 2016; MEILLON et al., 2009; RODRIGUES et al., 2014a; RODRIGUES et al., 2014b; ROSENTHAL; SHARE, 2014; THOMAS; CORDELLE; SCHLICH, 2015); outros trabalham com provadores selecionados segundo a ISO 8586 (2012) ou com experiência prévia em outros métodos descritivos como a análise descritiva quantitativa ou análise de tempo-intensidade, também com grande variação no treinamento aplicado após a seleção (ARES; JAEGER, 2015; DEVEZEAUX DE LAVERGNE et al., 2015; PAULSEN et al., 2014; PINEAU et al., 2009; RODRIGUES et al., 2016; SILVA et al., 2013; SOUZA et al., 2013; VIDAL et al., 2016; ZORN et al., 2014).

Além disso, enquanto alguns autores sugerem que o painel deve passar por várias sessões de formação, durante as quais eles são geralmente introduzidos pela primeira vez à noção de temporalidade das sensações e que o desempenho do painel deve ser avaliado segundo os critérios de discriminação e consenso (PINEAU et al., 2012; LEPAGE et al., 2014),outros sugerem que os provadores não devem ser arduamente treinados, a fim de evitar a tendência dos sujeitos de citar descritores na mesma ordem para todos os produtos (MEILLON et al., 2009; ALBERT et al., 2010). Meyners (2010) sugere ainda que em TDS é útil usar provadores que desconhecem métodos descritivos clássicos, uma vez que podem confundir os conceitos de dominância e de intensidade. Já Meillon et al. (2009) afirma que uma vez que o painel tenha sido

treinado em avaliação sensorial de produtos, não são necessárias mais de três sessões para se familiarizarem com o procedimento de TDS.

O número ideal de provadores para execução do teste ainda não foi estudado ou verificado até a presente data. No entanto, Pineau et al. (2012) sugeriu que uma boa prática poderia ser a utilização deum painel maior que o utilizado nos métodos descritivos convencionais, ou seja, no mínimo trinta provadores.

Vale ressaltar que os juízes precisam estar altamente motivados e dedicados à medição de TDS, uma vez que são obrigados a fazer continuamente uma escolha entre vários atributos para determinar a sequência de sensações dominantes e, em alguns casos, suas intensidades também (NG et al., 2012; PINEAU et al., 2012). No entanto, verificou-se que a classificação de intensidade não é realmente necessária (PINEAU et al., 2012) e evidências mostram que as taxas de dominância sozinhas podem fornecer informações temporais importantes (DINNELLA et al., 2013; PAULSEN et al., 2013). Além disso, é importante que o protocolo de degustação seja padronizado pelos provadores, particularmente quando o modo de degustação, tal como a mastigação, pode provocar percepções sensoriais diferentes.

Uma lista de atributos que descrevem os produtos examinados normalmente é gerada durante o treinamento (PINEAU et al., 2012). Diferentes métodos foram adotados por diferentes pesquisadores para a seleção dos atributos. A maneira mais comum de construir uma lista de atributos é, em primeiro lugar, fornecer as amostras com diferentes propriedades percebidas aos provadores, pedindo-lhes para provar as amostras e anotar todas as sensações percebidas; em segundo lugar as respostas dos avaliadores são recolhidas e comparadas em uma discussão de grupo sob a orientação de um líder de painel, durante a qual termos hedônicos, quantitativos e irrelevantes são eliminados, e sinônimos são combinados. Por fim, apenas os atributos mais citados são selecionados e mantidos para a análise de TDS (ALBERT et al., 2012; MEILLON et al., 2009; PAULSEN et al., 2013). Além disso, as listas de atributos podem ser desenvolvidas com base em perfis sensoriais iniciais (BRUZZONE; ARES; GIMÉENEZ, 2013; LABBE et al., 2009; NG et al., 2012; TEILLET et al., 2010), que permite descrições significativas dos produtos obtidas a partir de dados de TDS.

Goupil de Bouille et al. (2010) analisaram 15 estudos de TDS e verificaram que os provadores se comportam de maneira diferente em relação ao número de atributos que eles usam para descrever uma determinada amostra, quando a lista de atributos contém mais de seis

atributos. Os mesmos pesquisadores também descobriram que os provadores usam em média cerca de 4 atributos para descrever uma única amostra e que a ordem de apresentação dos atributos não afeta o atributo escolhido. Já Pineau et al. (2012), com base nos resultados de 21 estudos de TDS,sugerem a utilização de cerca de 8 a 10 atributos por avaliação, e que para limitar o uso preferencial dos atributos listados, primeiramente os descritores devem ser apresentados de forma aleatória através do painel, mas permanecem os mesmos para um determinado provador durante toda a avaliação, facilitando sua aprendizagem dos termos e intensidades de pontuação durante uma avaliação (MEILLON et al., 2009, PINEAU et al., 2012).

Tradicionalmente, os testes de TDS são realizados avaliando apenas um tipo de atributo (textura ou sabor, por exemplo), mas alguns estudos sugerem que diferentes atributos (sabor, textura, aroma, etc.) podem ser avaliados em uma mesma avaliação (PINEAU et al., 2012; PESSINA et al., 2005), economizando tempo e dinheiro. No entanto, a influência exata de listar diferentes propriedades sensoriais na mesma lista ainda é desconhecida (DI MONACO et al., 2014) e não há estudos comparando os resultados obtidos a partir da avaliação separada e conjunta de diferentes atributos. Assim, é necessário investigar precisamente as implicações do uso de diferentes tipos de atributos em uma mesma sessão de TDS a fim de entender as vantagens e limitações desta abordagem (PINEAU et al., 2012).

Os provadores iniciam a avaliação quando colocam a amostra em suas bocas. Uma vez que o cronômetro dispara, eles identificam as sensações percebidas como dominantes e, às vezes, avaliam suas intensidades, se necessário, durante a realização do protocolo de degustação. A avaliação termina quando os provadores não conseguem perceber mais sensações e param o cronômetro (MEILLON et al., 2009). Caso contrário, a aquisição de dados termina automaticamente após certo período de tempo dependendo dos produtos e dos protocolos de teste. A aquisição de dados pode ser realizada em diferentes softwares, como o Fizz - que também permite a valiação da intensidade do atributo, EyeQuestion, Compusense, TimeSens e Sensomaker (NUNES; PINHEIRO, 2012).

Deve-se ressaltar que um atributo escolhido é registrado como dominante até que outro atributo seja escolhido. Durante o teste, os provadores são livres para escolher o mesmo atributo por várias vezes, enquanto eles considerem o atributo como dominante. No entanto, apenas um atributo pode ser selecionado a cada momento. Inversamente, eles também podem não usar todos os atributos fornecidos (PINEAU et al., 2009).

2.3.2 Análise e interpretação dos resultados

Geralmente os dados coletados durante TDS são: nome do atributo dominante, momento em que um atributo é selecionado como dominante, a duração da dominância e a intensidade atribuída para cada atributo dominante quando se trabalha com protocolos com escalas de intensidade (LABBE et al., 2009).

Os resultados são representados pelas curvas de TDS (PINEAU et al., 2009). As curvas TDS mostram as taxas de dominância dos atributos versus o tempo para cada amostra (BRUZZONE et al., 2013; MEILLON et al., 2010). Se as curvas TDS são normalizadas ou não, o eixo Y sempre representa a taxa de dominância, que é a porcentagem de seleções de um atributo como dominante em um ponto específico de tempo (NG et al., 2012). É calculada dividindo-se o número de citações de um atributo (todas as repetições) pelo número de execuções (provadores x repetições). Essas taxas de dominância podem ser vistas como um reflexo do consenso entre os provadores e, portanto, uma medida do desempenho do painel (PINEAU et al., 2009). Mais precisamente, uma vez que apenas um atributo pode ser selecionado como dominante em qualquer momento por qualquer provador, a soma das taxas de dominância de todos os atributos em cada ponto de tempo para esse juiz é 1. Quanto maior a taxa de dominância do atributo, maior é a concordância entre os provadores (ALBERT et al., 2012). É importante ter em mente que as curvas TDS dependem unicamente da seleção de um atributo como dominante ou não, não são mostrados dados referentes à intensidade do atributo.

Na figura 1 é apresentado um exemplo de uma curva de TDS obtida para um chocolate com 34% de cacau (RODRIGUES et al., 2016). Para auxiliar na interpretação dos resultados, duas linhas são desenhadas no gráfico de TDS: o "nível do acaso" e o "nível de significância". O "nível do acaso" é a taxa de dominância que um atributo pode obter ao acaso e o "nível de significância" é o valor mínimo dessa proporção para ser considerado significativo (PINEAU et al., 2009). Para esse cálculo, é usado o intervalo de confiança de uma proporção binomial, com base em uma aproximação normal, de acordo com Pineau et al. (2009) (1), dado por:

$$\mathrm{Ps} = \mathrm{Po} + 1.645\sqrt{\frac{Po(1-Po)}{n}} \qquad (1)$$

Em que Ps é o menor valor de proporção significativa (a = 0,05) em qualquer ponto no tempo para uma curva de TDS, n é o número de indivíduos * replicação. Po é igual a 1/p, sendo p o número de atributos.

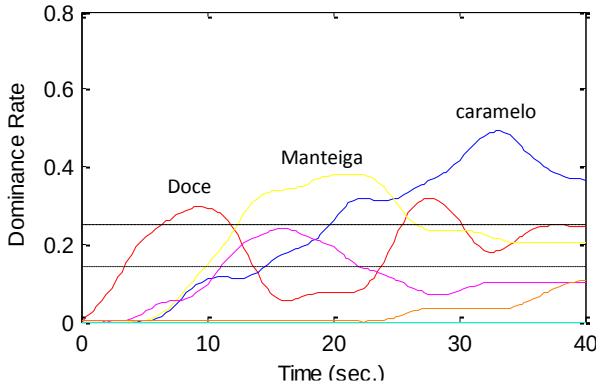

Figura 1 Exemplo de uma curva de TDS obtida para um chocolate com 34% de cacau (RODRIGUES et al., 2016).

Diferentes estudos têm diferentes critérios de definição de nível de painel. Por exemplo, Albert et al. (2012) consideram que as curvas TDS são consistentes ao nível do painel quando elas estão entre os níveis de acaso e de significância ou acima do último, enquanto outros autores sustentam que as curvas TDS são consistentes quando estão acima do nível de significância (LABBE et al., 2009; PINEAU et al., 2009; TEILLET et al., 2010).

Em alguns casos, por exemplo, quando a investigação está focada no que acontece imediatamente antes da deglutição, as curvas TDS são preferencialmente padronizadas. Isso leva a uma melhor exibição da evolução da percepção e um maior consenso em todo o painel (LENFANT et al., 2009).

A duração da mastigação - a partir do momento em que a amostra é colocada na boca dos provadores, até o momento em que a amostra está pronta para ser engolida pode ser medida antes de cada sessão formal usando um cronômetro. No entanto, em outras situações, como quando o tempo de duração da boca é importante, os dados não padronizados são preferíveis (MEYNERS, 2010). Portanto, a escolha entre padronização e não padronização depende do objetivo do estudo

Além das curvas de TDS, as curvas de diferença de TDS são geralmente plotadas para comparações de amostras (ALBERT et al., 2012; BRUZZONE et al., 2013; MEILLON et al., 2009; PINEAU et al., 2009). As curvas são desenhadas subtraindo as taxas de dominância de

duas amostras para cada atributo em cada ponto do tempo. A diferença na taxa de dominância é apenas traçada quando considerada significativamente diferente de 0, de acordo com um teste clássico de comparação de proporções binomiais (PINEAU et al., 2009).

Para avaliar o desempenho do painel e do avaliador, Lepage et al. (2012) propuseram o uso de valores agregados de frequência de dominância de atributos em um dado número de períodos de tempo, em vez de em todos os pontos de tempo coletados. Embora envolva a aplicação de um modelo de ANOVA simples aos dados de TDS, tornando-o fácil de implementar e rápido de executar, esta abordagem não tem sido utilizada em qualquer outra investigação publicada até à data, devido à falta de validade (DINNELLA et al., 2013).

Várias ferramentas e técnicas também foram desenvolvidas para comparar os resultados de TDS entre as amostras.Como exemplo, trajetórias de Análise de Componentes Principais (ACP) para mapear os produtos (LENFANT et al., 2009; RODRIGUES et al., 2016), análise de variância canônica (MEILLON et al., 2009; ALBERT et al., 2012), análise multivariada - MANOVA (THOMAS; CORDELLE; SCHLICH, 2015) e análise paralela de fatores (PARAFAC) (RODRIGUES et al., 2016).

2.3.3 Comparação com outros métodos sensoriais

Os testes dinâmicos de TI e TDS foram comparados em vários estudos e constatou-se que o TDS produziu informações semelhantes em termos das diferenças entre os produtos, atributos e evolução ao longo do tempo, além de ser mais rápido na obtenção de informações. No entanto, o TI foi considerado mais adequado para a determinação da cinética de um atributo específico, enquanto o TDS poderia ser usado para ilustrar a percepção do produto em função do tempo. Além disso, a informação adicional sobre a seqüência de sensações e multidimensionalidade, onde a interação entre atributos é necessária, pode ser fornecida pelo TDS (LE RÉEVÉEREND et al., 2008; PINEAU et al., 2009; VAZQUEZ-ARAUJO et al., 2013).

Apesar dos diferentes mecanismos psicológicos envolvidos na avaliação das sensações globais (focada em uma única classificação) ou temporal (escolha de um atributo a partir de uma lista ao longo do tempo), notou-se um bom acordo entre os dados de perfil descritivo convencional e as curvas TDS em estudos com produtos com diferentes propriedades de textura: vinhos brancos (SOKOLOWSKY; FISCHER, 2012), peixe (ALBERT et al., 2012),

especialmente em produtos semi-sólidos, incluindo géis (LABBE et al., 2011) e iogurte (BRUZZONE et al., 2013).

No entanto, as informações qualitativas e quantitativas fornecidas pelas técnicas estáticas e dinâmicas não são sempre as mesmas. Estudando nove diferentes géis, usando o perfil sensorial e o TDS, Labbe et al. (2009) descobriram que a percepção dinâmica difere da percepção imediata de produtos com percepção multi-sensorial de longa duração. Da mesma forma, ao analisar o impacto de dois óleos extravirgem italianos nos perfis sensoriais percebidos de feijão e tomate puros, Dinnella et al. (2012) descobriram que a importância de uma sensação durante o consumo alimentar não é necessariamente a mesma que a indicada pelas classificações de intensidade dos perfis sensoriais estáticos.

Em comparação com as técnicas sensoriais estáticas, o TDS apresenta vantagens graças à omponente temporal. No estudo de vinhos tintos parcialmente desalcoolizados (MEILLON et al., 2009), o TDS gerou o dobro do número de atributos que discriminam as amostras testadas e permitiu o reconhecimento das diferenças temporais entre os vinhos. Do mesmo modo, estudos sobre géis aromatizados (LABBE et al., 2009) e amoras (NG et al., 2012) confirmaram a capacidade do TDS para estimar alterações qualitativas de atributos dominantes durante e após o consumo dos alimentos, o que não pode ser obtido a partir dos métodos sensoriais convencionais. Além disso, o TDS ajuda a entender melhor a dinâmica dos fenômenos envolvidos nas interações textura-sabor (SAINT-EVE et al., 2011) e nas interações dos componentes alimentares (DINNELLA et al., 2012). Portanto, é mais adequado para a interpretação de respostas sobre o consumo e percepções de sensações complexas (DI MONOCO et al., 2014). Ademais, o método de TDS é mais rápido e o fato de que os atributos não são avaliados independentemente também constitui uma vantagem (SAINT-EVE et al., 2011; TEILLET et al., 2010). A informação dinâmica do TDS pode ainda contribuir para a compreensão dos atributos que direcionam a aceitação de um determinado produto (VARELA; PINTOR; FISZMAN, 2014).

Apesar de todos os méritos que o TDS possui, ele só permite a avaliação de sensações dominantes (NG et al., 2012; SAINT-EVE et al., 2011) e não pode, portanto, substituir o perfil sensorial convencional no contexto do desenvolvimento de produtos. No entanto, o TDS pode complementar os dados da análise descritiva estática, uma vez que este último só fornece informações a respeito de um ponto único sobre uma percepção, que realmente muda constantemente durante o consumo de alimentos devido a interações complexas entre os

componentes dos alimentos, estilo de mastigação, estrutura alimentar inicial, etc. (DINNELLA et al., 2012; NG et al., 2012; SOKOLOWSKY; FISCHER, 2012).

2.3.4 Questões a respeito da metodologia a serem discutidas

Segundo Di Monaco et al. (2014), como o teste de TDS trata-se de uma metodologia temporal recentemente desenvolvida, ainda há algumas lacunas no conhecimento sobre a realização dos testes e desenvolver pesquisas investigando os seguintes aspectos:

Como a "dominância" é definida e interpretada pelos provadores pode ter um impacto nos resultados do TDS. De acordo com Meyners (2010) mais pesquisas são necessárias para entender como a “dominância” é conceituada pelos provadores e pelos consumidores.

Considerando que o procedimento de TDS é bastante diferente das metodologias sensoriais convencionais, uma vez que inclui uma dimensão temporal, a abordagem ainda é considerada exigente para o painel, visto que o provador deve concentrar-se continuamente na sensação dominante durante todo o tempo de degustação do produto (PINEAU et al., 2012). Embora este método tenha sido extensivamente utilizado para descrever vários produtos, ainda existe uma falta de conhecimento sobre o painel adequado para aquisição de dados. Os números ótimos de provadores e de repetições para análise de TDS são outros pontos a serem investigados. A prática comum utiliza um número um pouco maior que o utilizado em métodos convencionais e os testes são normalmente executados em três repetições, a fim de não ter menos de 30 avaliações por produto (PINEAU et al., 2012).

Outro ponto a ser mais investigado trata-se da lista de atributos que compõe a análise. Como indicado por alguns estudos, os provadores podem usar diferentes tipos de atributos (sabor, textura e aroma) em uma única avaliação. No entanto, a influência exata de listar diferentes propriedades sensoriais na mesma lista ainda é desconhecida.

Portanto, estudos comparativos, com diferentes painéis e listas de atributos são necessários para entender o comportamento de diferentes provadores na análise Dominância Temporal das Sensações – TDS e para estabelecer o perfil do painel sensorial recomendado e composição da lista de atributos para realização da análise de TDS, de modo a obter dados com qualidade e confiabilidade.

3 CONSIDERAÇÕES GERAIS

Observou-se no estudo I que os diferentes painéis avaliados forneceram descrições diferentes para amostras de chocolate com 35% e 53% de cacau e descrições semelhantes para a amostra com 63% de cacau. Além disso, maiores taxas de dominância foram observadas nos resultados dos consumidores. Através da MANOVA e PCA foi possível verificar que o Painel I foi capaz de discriminar os três chocolates, enquanto os painéis II e III apenas discriminaram o chocolate com 35% de cacau dos demais. Além disso, observou-se que o grupo de consumidores gastou menos tempo para eleger a primeira sensação e usou mais atributos para descrever o chocolate com 35% de cacau. Isso indicou que o protocolo de seleção associado a apenas duas sessões para introduzir os provadores aos procedimentos de TDS e à noção de temporalidade, e o protocolo de familiarização com as sensações de TDS utilizado no estudo seguido por três testes de TDS preliminares não foram suficientes para melhorar a resposta de TDS em relação à avaliação dos consumidores. No estudo II observou-se que uma das principais implicações da análise simultânea de diferentes atributos nos resultados de TDS foi a diferença quanto à temporalidade. Além disso, apesar da avaliação simultânea ter proporcionado uma descrição de sabor semelhante à da avaliação separada, foram observadas diferenças no perfil de textura entre as abordagens. Embora a análise simultânea foi considerada mais difícil e menos confiável pelos provadores, ambos os resultados de TDS forneceram uma caracterização similar das amostras em relação à análise instrumental, sendo que sensações antagônicas foram positivamente correlacionadas na avaliação separada. Entretanto, observou-se que a intensidade dos parâmetros físicos e químicos (amplitude) não está fortemente relacionada à taxa de dominância máxima da sensação correspondente.

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SEGUNDA PARTE - ARTIGOS

ARTIGO 1: TEMPORAL DOMINANCE OF SENSATIONS (TDS) PANEL BEHAVIOR: A PRELIMINARY STUDY WITH CHOCOLATE

TDS panel behavior: A preliminary study with chocolate

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ABSTRACT: This study aimed to evaluate the behavior of different panels with three different profiles: consumers, panel selected based on their good sensory ability, and selected and "familiarized" panel(introduced to the attributes involved in the analysis and conducting three preliminary tests before the final test), for TDS analysis of chocolates with different cocoa contents. TDS curves were analyzed by multivariate ANOVA (MANOVA), followed by the interaction deployment and by PCA. The different panels provided different descriptions for chocolate samples with 35% and 53% cocoa and similar descriptions for the sample with 63% cocoa. Moreover, higher dominance rates were observed in the consumer results. Through MANOVA and PCA it was possible to verify that Panel I was able to discriminate the three chocolates, while the selected panel and the selected and familiarized panel only discriminated chocolate with 35% cocoa from the others. Furthermore, we found that the consumers group spent less time to elect the first sensation and used more attributes to describe the chocolate with 35% cocoa.This indicated that the selection protocol associated with only two sessions to introduce the panelists to TDS procedures and temporality notion, and the familiarization with the TDS sensations protocol used in this study followed by three preliminary TDS tests were not sufficient to improve the TDS response regarding the consumer evaluation.

Keywords: chocolate, consumers, familiarization stage, panel behavior, selection stage, TDS

1. INTRODUCTION

Temporal Dominance of Sensation (TDS) is a relatively new methodology in the sensory field for describing the temporal evolution of different sensations developed during food consumption (Labbe et al, 2009; Pineau, Cordelle, & Schilch, 2003; Pineau et al. 2009). During the test, the panelists are asked to indicate the dominant sensation (from a predetermined list of various attributes) during the evaluation period. Their perceptions are represented by curves that show how often each sensation was considered dominant during the evaluation period. It is a fast and effective multi-attribute descriptive method when compared to other dynamic sensory tests used to evaluate the set of sensations induced by a particular food (Pineau et al., 2009).

In comparative studies of complex products with long-lasting sensations, TDS has shown to provide more information than regular profile methods (Labbe et al., 2009). Likewise, TDS has proven to be useful for the evaluation of products with few sensory differences (Meillon et al., 2010). Furthermore, TDS analysis has been used to provide a better understanding of the texture (Lenfant et al., 2009), aroma and flavor of products compared to other static and dynamic profile tests (Dinnella, Masi, Zoboli & Monteleone, 2012; Déléris et al., 2011). Blake (2004) and Meillon et al. (2010) also showed that dynamic and multi-sensorial aspects of the perception of food play an important role in the process used by consumers to evaluate the acceptability and sensory properties of food products.

However, the TDS procedure is quite different from the standard sensory methodologies, as it includes a temporal dimension. This approach is still perceived as very demanding for the taste panel, as the taster must continually concentrate on the dominant sensation throughout the tasting perception time (for example, from intake to swallowing a piece of chocolate) (Pineau et al., 2012). Thus, even though this method has long been used to describe various products, there is still a lack of knowledge about the appropriate panel for data acquisition.

Since TDS methodology was first presented at the Pangborn Symposium by Pineau, Cordelle and Schlich (2003), several papers have used TDS with a great variability regarding the selection and training procedures of the sensory panel. Several studies use consumers for performing TDS, using from 1 to 4 sessions for recognizing the TDS procedure, temporality notion, the software used and/or introducing the attributes involved in the analysis (Meillon et al. 2009; Dinnella et al. (2012); Hutchings et al. (2014); Rodrigues et al. 2014a; Rodrigues et al. 2014b; Rosenthal & Share, 2014; Diaz et al. 2015; Thomas et al. 2015; Galmarini, Visalli and

Schlich (2016); Ma et al. 2016). About 2 months of training has even been utilized by Charles et al. (2015).

In other studies, the researchers have worked with a selected panel, mostly based on ISO 8586 (2012) and different tests, such as the Sequential Wald analysis, triangular test, taste recognition and odor identification (Pineau et al. 2009; Silva et al. 2013; Paulsen et al. 2014; Rodrigues et al. 2016a; Souza et al. 2013; Rodrigues et al. 2016b; Vidal et al. 2016). Sokolowsky and Fisher (2012), Zorn et al. (2014), Ares et al (2015) and Devezeaux de Lavergne et al. (2015), beyond the selection based on good sensory ability, also used tasters with previous experience in descriptive analysis (like quantitative descriptive analysis-QDA and time-intensity-TI). After panel selection, there was also a wide variability in the number of sections used for training the panel, varying from 1 up to 21 sections. Moreover, different protocols to introduce the panel to the notion of temporality was used, such as Ng et al. (2012), Slokolowsky and Fisher (2012) and Paulsen et al. (2014) that introduced the panelists to the notion of temporality and dominance of sensations using the analogy of an orchestra playing music.

Therefore, this study aimed to evaluate the behavior of different panels with three different profiles: consumers, a selected panel based on their good sensory ability, and a selected and "familiarized" panel (introduced to the attributes involved in the analysis and conducting three preliminary tests before the final test), for TDS analysis of chocolates. In this preliminary study the idea was to work with panels that were not over-trained, as suggested by Meillon et al. (2009), who affirms that panelists should not be over-trained, in order to avoid individual typed-responses, which is a tendency for subjects to quote descriptors in the same order for all products, and following the idea that TDS can assess the descriptive product information, thus reducing experiment duration (Ng et al. 2012). Moreover, Meyners (2010) suggests that in TDS it is useful to use individuals who are unaware of classical descriptive methods, since they can confuse the dominance and intensity concepts. Albert, Salvador, Schlich, &Fiszman, (2012) and Di Monaco et al. (2012) also infer that TDS requires almost no training, provided the attributes are simple enough to be understood by naive consumers and provided that no intensity is asked.

2. MATERIAL AND METHODS

2.1 Samples

The TDS test was performed using three chocolate samples from Harald Melken Unique Brasil® with different cocoa concentrations: 35%, 53% and 63%.

The chocolates from different categories (milk, semisweet and bitter) were selected as the object of this study because chocolate is a complex food that can present different sensations during ingestion.

2.2 Subjects

Pineau et al. (2012) suggested that 30 evaluations per product are required to perform TDS. Thus, the TDS sensory analysis was conducted with three different panels each composed of 10 subjects (5 males and 5 females, between 20-30 years of age) in triplicate:

Panel I - Consumers: 10 consumers that consume chocolate at least once a week and had good oral and general health were recruited through questionnaires. Consumers participated in one session (one hour) used to explain the TDS concept and another (one hour) to introduce them to the Sensomaker program. The consumers were informed that a dominant attribute was defined as the attribute associated to the sensation catching their attention at a given time. It should be understood mostly as a new sensation popping up at a given time. Therefore, the dominant attribute is not necessarily that with the highest intensity (Pineua et al. 2009).

Panel II – Selected Panel: 10 individuals that consume chocolate at least once a week and had good oral and general health passed through ten selection sessions based on ISO 8586 (2012). They performed the basic taste and odor recognition test during five sessions (one hour per session) and passed through the Wald sequential analysis as proposed by Amerine et al. (1965) using the following parameters: $p = 0.30$, $p1 = 0.70$, $\alpha = 0.10$ and $\beta = 0.10$. In the selection stage, eight triangular tests were applied during four days (one hour per day), using chocolates with 53% and 63% cocoa. Thus, individuals were selected with good discriminative power (Meilgaard et al., 1999). After the selection, the panelists participated in one session (one hour) to introduce them to the TDS procedures, in which the concept of dominant attribute was explained in the same way explained to Panel I, and another session (one hour) to introduce them to the Sensomaker software.

Panel III – Selected and Familiarized Panel: 10 individuals that consume chocolate at least once a week and had good oral and general health were selected through basic taste recognition test, the odor recognition test (ISO 8586, 2012) and the Wald sequential analysis

(Amerine, 1965) in the same way as Panel II, based on their good sensory ability, during nine sessions (one hour per session). After the selection, one session (one hour) was carried out to introduce the panelists to the TDS procedures and the concept of dominant attribute was explained in the same way explained to Painels I and II. One more session (one hour) was used tointroduce the Sensomaker program. Moreover, the subjects went through a familiarization stage to introduce them to the sensations involved in the analysis. In this stage, during three sessions (one hour per session), each panelist was familiarized with the sensations involved in the TDS analysis, providing a reference relative to each sensation according to Table 1 and then they performed TDS tests in triplicate (Meillon et al. 2009) in Sensomaker software (Nunes & Pinheiro, 2012).

Table 1. References to familiarize the selected tasters (Panel III) in relation to the sensations involved in the TDS test of chocolates

Sensations	**References**
Buttertaste	White Chocolate Harald Melken® -29% cocoa (5g)
Bittertaste	bitter chocolate with 70% cocoa LINDT® (5g)
Sweettaste	Sucrosesolution 0.8% (5ml)
Cocoataste	Cocoapowder Mãe Terra® (3g)
Milktaste	Milk chocolate Nestlé Classic® (5g)
Carameltaste	Caramels sweet Traditional Kraft®

2.3 Temporal Dominance of Sensations (TDS)

TDS analysis was conducted according to Pineau et al (2009), in triplicate for each individual of each panel, totaling 30 evaluations per panel, using the data acquisition program Sensomaker (Nunes & Pinheiro, 2012) under the same conditions: total duration of analysis of 40 s with a "delay time" of 2 s. These conditions were determined by TDS pretests considering the time spent for each panelist to evaluate the chocolate samples. Moreover, the “no taste” option was included in the attributes list to allow the taster to indicate that no more sensation was

perceived. The attributes used on TDS tests were defined by the Kelly grid method ("Kelly's repertory grid method") (Moskowitz, 1983). After the attributed definition, the attribute list was checked by performing TDS tests according to Pineal et al. (2012), in which the maximum frequency of citation was checked for each attribute to select only the main attributes for the final list. Thus, it was defined that the main attributes were: butter, bitter, sweet, cocoa, milk and caramel. The number of attributes per evaluation (maximum 10 attributes) and the randomized presentation of program attributes on the display were conducted as proposed by Pineau et al. (2012).

The samples (approximately 5 g) were balanced and coded with 3-digit numbers drawn from a table of random numbers and presented in monadic order (Macfie et al. 1989). The test was conducted in individual booths under white light with adequate ventilation. The panelists were instructed to taste and evaluate each sample and to rinse their mouths with water between samples.

2.4 Statistical analysis

To evaluate the panel behavior and investigate the impact of the selection and familiarization with the attributes procedures on the responses obtained, first the TDS curves of chocolate samples (35% cocoa, 53% cocoa and 63% cocoa) evaluated by each panel (I: consumers; II: selected panel; III: selected and familiarized panel) were plotted according to the methodology proposed by Pineau et al. (2009), using the Sensomaker software (Nunes & Pinheiro, 2012). One curve was plotted for each panel and each chocolate from thirty evaluations (ten panelists in three repetitions). Briefly, two lines were drawn on the TDS graphics: 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 binomial proportion based on the normal approximation according to Pineau et al. 2009 (1).

$$Ps = Po + 1.645\sqrt{\frac{Po(1-Po)}{n}} \quad (1)$$

where Ps is the significant proportion of lower value (= 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 being the number of attributes.

Three parameters for each sensation were also computed forthe curves of each repetition from ten evaluations for each panel and each chocolate: the maximum dominance rate (DRsensation), the time that the maximum dominance rate occurred (Tsensation) and the time interval (length of period) where the dominance rate is at least 90% of the maximum dominance rate (Psensation).

According to Galmarini, Visalli and Schlich (2016), with complex products which might have several dominant attributes at a time, the visual inspection of curves and product comparison can become a cumbersome task. In this case, MANOVA is a good alternative to assess TDS data, since multidimensional differences can be summarized over attributes by a multivariate ANOVA (MANOVA).

In this study, this approach considered that the variables of interest are parameters of each sensation. Thus, the data matrix was built with the three parameters (DRsensation, Tsensation and Psensation) obtained for each sensation (butter, sweet, bitter, cocoa, milk and caramel) in each repetition (3 repetitions - 10 evaluations per repetition,) for each panel (Panel I: consumers, Panel II: selected panel and Panel III: selected and familiarized panel) and each chocolate sample (35%, 53% and 63% cocoa), and then it was submitted to a multivariate ANOVA (MANOVA), where the sources of variation were chocolate, panel, and the interaction between chocolate and panel. If there was interaction between the factors, the chocolates were compared for each panel and vice versa. MANOVA was also used in order to evaluate the discrimination ability of the products by each panel, in a way similar to that in Delarue and Sieffermann (2004) and Veinand et al. (2011). The Wilks' Lambda of the MANOVA is associated with the Fisher's F, and its p-value provides some information about the product overall discrimination: the smaller the Lambda, the more the products are differentiated (Veinand et al., 2011). The data analyses were performed using the R software (R Core Team, 2016).

Principal component analysis was also applied to the TDS parameters. In this case, TDS curve parameters were generated for each panel and sample from all evaluations (30 evaluations) and they were arranged in a matrix of i lines (samples) and j columns (parameters) for each attribute evaluated according Rodrigues et al. (2015). The data were converted to a correlation

matrix, and PCA was performed using the Chemoface software (Nunes, 2012). Scores and loadings were plotted from the two first components to assess the samples organization in order to verify the differences and/or similarities among the descriptions of the different panels for the three chocolate samples.

Moreover, to evaluate the panel behavior, two indicators - "*Time for the first attribute"* and *"Average of number of attributes",* were analyzed according Lepage et al. (2014). The first indicator (*Time for the first attribute*) was assessed by ANOVA and the Tukey test in Sensomaker software (Nunes & Pinheiro, 2012) and the second (*Average of number of attributes*) was represented by the range of cited attributes for each panel (I: consumers; II: selected panel; III: selected and familiarized panel) and each chocolate (35%, 53% and 63% cocoa),

3. RESULTS

Description differences and the quality of product discrimination was investigated through applying a multivariate ANOVA (MANOVA) to the TDS parameters (the maximum dominance rate (DRsensation), the time that the maximum dominance rate occurred (Tsensation) and the time interval(length of period) where the dominance rate is at least 90% of the maximum dominance rate (Psensation)

Through MANOVA it was observed that the main panel effect was not significant ($p>0.05$), while the main chocolate effect and the chocolate and panel interaction were significant ($p<0.05$) (Table 2), indicating that there were differences in sensations perceived in chocolate samples by different panels.

Table 2. Multivariate ANOVA (MANOVA) results

SV	**Wilks' Lambda**	**F value**	**Pr>F**
Chocolate	0.000001	66.49	**0.015**
Panel	0.0000184	12.90	*0.074*
Chocolate*panel	0.000000	13.06	**0.001**

Bold values are significant at 5% probability and italic values are significant at 10% probability.

Thus, interaction deployment was carried out to assess the chocolate samples descriptions per panel. First the sample descriptions were evaluated by each panel (Table 3) and after thatthe different panel's descriptions for each chocolate were assessed (Table 4). Thus, orthogonal contrasts with practical interest with regard tocomposition were performed: comparison between the milk chocolate (A-35% cocoa) and bitter chocolates (B-53% cocoa and C-63% cocoa), and comparing the bitter chocolates (B-53% cocoa and C-63% cocoa) with each other (Table 3); comparison between the consumers (Panel I) and the selected and selected and familiarized panel (Panel II and III), and comparing the selected (Panel II) and selected and familiarized panel (Panel III).

Table 3. Interaction deployment: chocolate descriptions by each panel and respective contrasts.

	Wilks Lambda	**F value**	**Pr>F**
Samples descriptions evaluated by Panel I	0.000000	266.32	**0.004**
milk chocolate (A) x bitter chocolate (B and C)	0.000046	1211.79	**0.023**
bitter chocolate: B x C	0.000065	849.84	**0.027**
Samples descriptions evaluated by Panel II	0.0000001	210.22	**0.005**
milk chocolate (A) x bitter chocolate (B and C)	0.0001683	329.99	**0.043**
bitter chocolates: B x C	0.0002507	221.53	*0.060*
Samples descriptions evaluated by Panel III	0.0000004	85.89	**0.012**
milk chocolate (A) x bitter chocolate (B and C)	0.0001614	344.12	**0.042**
bitter chocolate: B x C	0.00231230	23.97	0.160

The F-value is computed according to Rao's approximation. (A: chocolate with 35% cocoa; B: chocolate with 53% cocoa; C: chocolate with 63% cocoa; Panel I: Consumers; Panel II: Selected panel; Panel III: Selected and familiarized panel); bold values are significant at 5% probability and italic values are significant at 10% probability.

Regarding Panel I (consumers), there was a significant difference among the chocolate samples ($p \leq 0.05$). Based on the defined contrast, there was significant discrimination between the milk chocolate with 35% cocoa (A) and bitter chocolates with 53% and 63% cocoa (B and C) and between Samples B and C, i.e., the panel was able to discriminate samples grouped as bitter chocolate. On the other hand, Panels II (selected panel) and III (selected and familiarized panel) were only able to significantly differentiate the sample with 35% cocoa from the others, i.e. there was no significant difference ($p>0.05$) between the TDS descriptions of the samples with 53% and 63% cocoa. Furthermore, we observed that the product discrimination varied among the panels. According to Veinand et al. (2011), the smaller the Lambda, the more the products are different. Examination of the Wilks' Lambda from the MANOVA (Table 3) confirms that the samples were more discriminated by Panel I (consumers), as a smaller Lambda was observed compared to the values obtained for Panel II (selected panel) and III (selected and familiarized panel) descriptions, which corroborates the results obtained by the F test.

Table 4. Interaction deployment: panel descriptions for each chocolate and respective contrasts.

	Wilks Lambda	F value	Pr>F
Panels descriptions for milk chocolate with 35% cocoa (A)	0.0000049	25.17	**0.039**
Panel I x Panel II and III	0.0003806	145.92	**0.050**
Panel II and Panel III	0.0006428	86.37	*0.084*
Panels descriptions for chocoalte with 53% cocoa (B)	0.0000038	28.49	**0.034**
Panel I x Panel II and III	0.0003069	180.97	**0.050**
Panel II and Panel III	0.0003597	154.40	*0.063*
Panels descriptions for chocolate with 63% cocoa (C)	0.000018	13.22	*0.073*

The F-value is computed according to Rao's approximation (A: chocolate with 35% cocoa; B: chocolate with 53% cocoa; C: chocolate with 63% cocoa; Panel I: untrained consumers; Panel II: selected panel; Panel III: selected and familiarized panel); bold values are significant at 5% probability and italic values are significant at 10% probability.

Evaluating the TDS descriptions by different panels for each sample separately, we noted that there was a significant difference for the description of the samples with 35% cocoa (A) and 53% cocoa (B) by different panels. On the other hand, for the bitter sample with 63% cocoa (C) there was no significant difference among the different panel descriptions (Table 5).

This can be observed in Figure 1, that shows the temporal dominance of sensations profile (TDS) obtained by each panel (Panel I: consumers; Panel II: selected panel; Panel III: selected and familiarized panel) for each chocolate sample (35% cocoa, 53% cocoa, 63% cocoa).

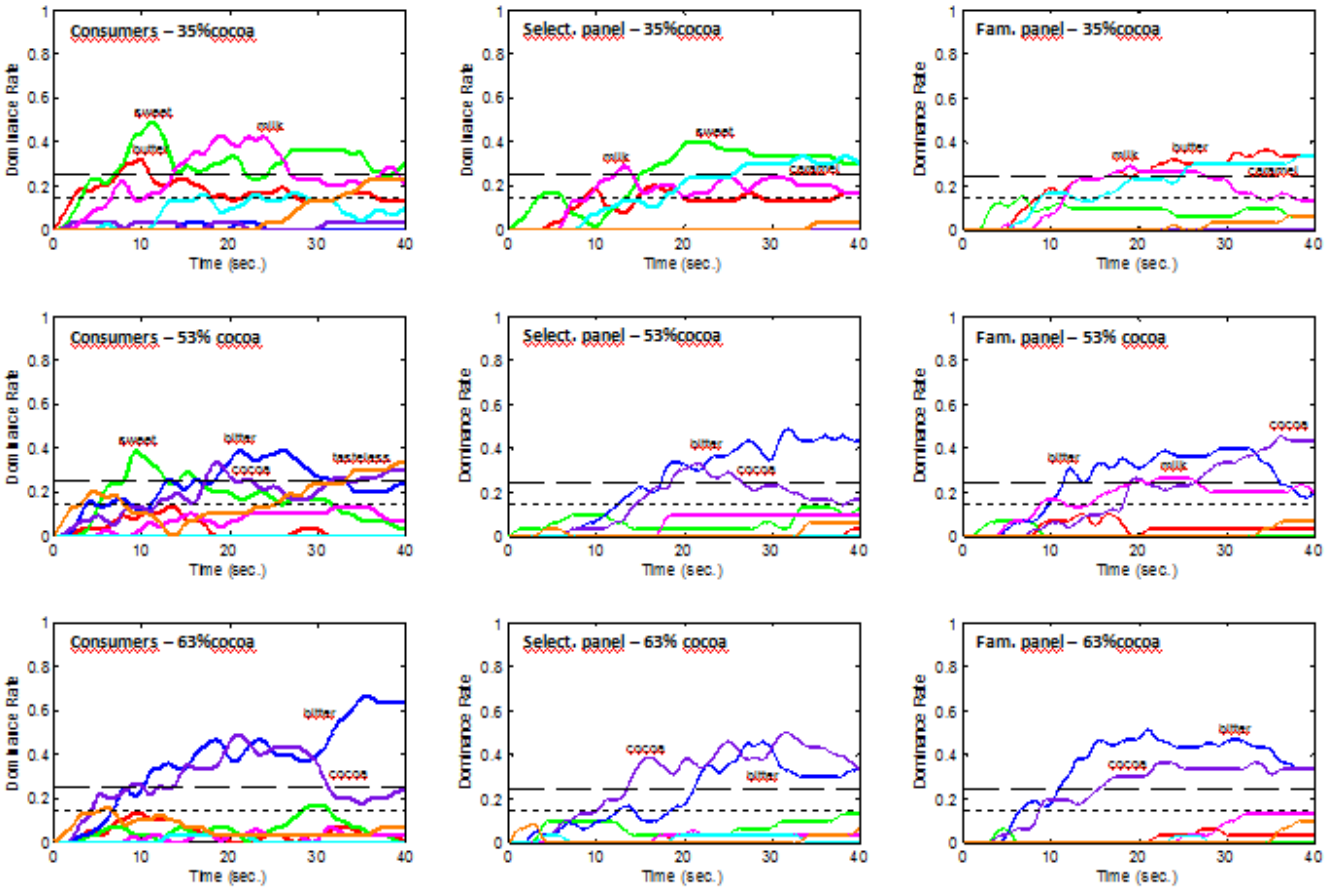

Figure 1. Temporal dominance of sensations profile (TDS) obtained by each panel (Panel I: consumers; Panel II: selected panel; Panel III: selected and familiarized panel) for each chocolate sample (35% cocoa, 53% cocoa, 63% cocoa).

The TDS curves of chocolate with 35% cocoa (Fig. 1) were the most differentiated among the panels, Panel I (consumers) significantly perceiving the sweet (DRmax=0.48, t=10.8 s), butter (DRmax=0.29, t=9.2 s) and milk (DRmax=0.42, t=22.8 s) sensations; Panel II (selected panel), the milk (DRmax=0.26, t=12.8 s), sweet (DRmax=0.40, t=21.6 s) and caramel (DRmax=0.34, t=38.4 s) sensations ; and Panel III (selected and familiarized panel), the butter (DRmax=0.36, t=34.4 s), milk (DRmax=0.28, t=9.2 s) and caramel (DRmax=0.34, t=40 s) sensations. From the values of maximum dominance rates of sensations, i.e., the percentage of panelists who chose the same sensation as dominant at a determined point in time, it can be inferred that the consumer group (Panel I) has more consistency in identifying the sensation in a given time, especially in relation to butter and milk sensations for the chocolate with 35% cocoa.

For the sample with 53% cocoa (Fig. 1), Panel I (consumers) detected the sweet (DRmax=12.36, t=10 s), cocoa (DRmax=0.31, t=12.40 s) and bitter (DRmax=0.39, t=25.6s) sensations as significant, while Panel II (selected panel) detected only cocoa (DRmax=0.32, t=21.2 s) and bitterness (DRmax=0.46, t=32.24 s) as dominant. In addition to cocoa (DRmax=0.44, t=37 s) and bitter (DRmax=0.41, t=31 s) sensations, the milk taste (DRmax=0.27, t=24 s) was detected as significant by Panel III (selected and familiarized panel). Considering that the sample with 53% is a sample with intermediate cocoa content among the samples evaluated in the present study, Panel I (consumers) and III (selected and familiarized panel) descriptions seem to be more consistent. Sensations normally found in milk chocolate were significantly perceived (i.e. sweet and milk respectively), as well as detection of bitter and cocoa sensations. However, Panel II (selected panel) reached higher maximum dominance rates, indicating a similar description by 41-44% of the panel members.

The sample with 63% cocoa had more similar description by all the sensory panels. All groups selected cocoa and bitter sensations as significantly dominant (Fig. 1). However, some variations were noted in the maximum dominance rates achieved by each panel. Panel I (consumers) found the cocoa flavor as dominant at 21.2 s with DRmax=0.48 and bitterness at 36 s with DRmax=0.66, while Panels II (selected panel) and III (selected and familiarized panel) detected these same sensations with DRmax of 0.48 (t = 32 s) and 0.36 (t=23.2 s) (cocoa) and

0.45 (t=28.4 s) and 0.50 (t= 21 s) (bitter), respectively. Thus, Panel I (consumers) showed a higher dominance rate for when compared to Panels II (selected panel) and III (selected and familiarized panel) and greater dominance rate for cocoa compared to Panel III (selected panel).Moreover, panels II and III have a different order of perception of the cocoa and bitterness compared to panel I.

For a better view of all descriptions obtained by the different panels, a principal component analysis - PCA was carried out from the parameters obtained in the TDS analysis for the different evaluated chocolate samples (Fig. 2). Scores and loadings were plotted from the two principal components to assess the samples organization in order to verify the differences and/or similarities among the descriptions of the different panels for the three chocolate samples.

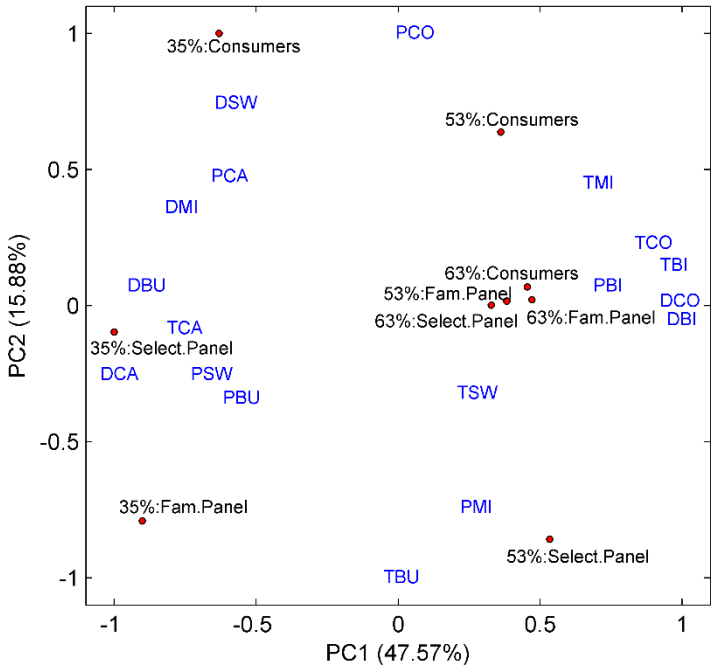

Figure 2. PCA of the TDS parameters of chocolate samples described by different panels (Chocolates with 35% cocoa; 53% cocoa and 63% cocoa; Panel I: Consumers; Panel II: Selected Panel; Panel III: Selected and familiarized Panel; D: maximum dominance rate; T: time that the

maximum dominance rate occurred; P: time interval where the dominance rate is at least 90% of the maximum dominance rate; SW: sweet; BU: butter; MI: milk, CA: caramel; BI: bitter; CO: cocoa).

Through the exploratory analysis of Figure 2, we observed that Sample A (35% cocoa) had more distinct descriptions by the panels, while the dominant sensations perceived in Sample C (63% cocoa) were very similar among all groups. Furthermore, through the samples arrangement in the graph, we can suggest a smaller sample differentiation by Panel III, since Samples B (53% cocoa) and C (63% cocoa) were very close. The results observed in the PCA reaffirm what was verified by MANOVA and the TDS curves, but it is important to highlight that Panel I (consumers) presented lower Wilk's lambda values, showing higher discrimination ability. Thus, the use of selected individuals with good sensory ability (Painel II) and the familiarization stages with the attributes (Painel III) probably does not contribute to a better product discrimination by Panels II and III.

To evaluate the panel behaviors, two indicators - "*Time for the first attribute"* and *"Agerage of number of elected attributes"* (Lepage et al. 2014) for each panel (I: consumers; II: selected panel; III: selected and familiarized panel) during each chocolate sample evaluation (35%, 53% and 63% cocoa) were computed. The ANOVA indicates that there was a significant effect on the time to elect the first attribute for all chocolates samples, and the average number of attributes elected for each panel are shown in Table 5.

Table 5. Panel behavior indicators: "*Time for the first attribute"* and *"Average of number of attributes"* for each panel during each chocolate sample evaluation.

	Chocolate with 35% cocoa	
	Time for the first attribute (s)	*Average of number of Attributes*
Consumers	5.53 a	3.4
Sel. Panel	11.60 b	2
Sel. and Fam. Panel	12.80 b	1.8
	Chocolate with 53% cocoa	
	Time for the first attribute (s)	*Average of number of Attributes*
Consumers	6.53 a	2.8
Sel. Panel	17.63 b	1.9
Sel. and Fam. Panel	13.33 b	2.3
	Chocolate with 63% cocoa	
	Time for the first attribute(s)	*Average of number of Attributes*
Consumers	6.93 a	2.9
Sel. Panel	14.67 b	2.2
Sel. and Fam. Panel	14.47 b	1.8

Means followed by the same letter did not significant differ at 5% probability by Tukey test

From Table 5 it is possible to note that consumers spent less time to elect the first sensation (between 5 and 6 s in chocolate with 35% cocoa and 6 and 7 s for chocolates with 53% and 63% cocoa) compared to the selected (11-12 s for sample with 35% cocoa; 16-18 s for chocolate with 53% cooa; 14-15 s for chocolate with 63% cocoa) and selected and familiarized (12-13 s for sample with 35% cocoa; 13-14 s for chocolate with 53% cocoa; 14-15 s for chocolate with 63% cocoa) panels that did not differ significantly. In relation to the number of attributes used to describe the chocolate samples, the consumers elected a higher number of attributes in relation to the other panels (on average 3 - 4 attributes and 1-2 respectively) to describe the sample with 35% cocoa, which suggests a good descriptive ability by consumers. For the samples with 53% and 63% cocoa, consumers used 2-3 attributes for both attributes, while the selected panel and selected and familiarized panel used, respectively, 1-2 and 2-3 attributes for chocolate with 53% cocoa and 2-3 and 1-2 for chocolate with 63% cocoa.

4. DISCUSSION

Based on the results of the multivariate ANOVA (MANOVA), TDS curves and panel indicators ("*Time for the first attribute"* and *"Average of number of attributes"*), it can be inferred that Panels II and III (selected panel and selected and familiarized panel) did not show better results than Panel I (consumers), since it showed a better discrimination of the samples (Table 2), presents the highest rate dominance for the bitter and cocoa attributes, indicating similar descriptions among the panelists (Figure 1), and uses a larger number of sensations to describe the chocolate samples.

Goupilet al. (2010), analyzing 15 TDS studies and Pineau et al. (2012) analyzing 21 TDS works, found that panelists behave differently with respect to how many and which attributes they use, when the attributes list contains six or more attributes. The same researchers also found that individuals commonly use an average of about 4 attributes to describe a single sample and that attribute order did not affect the attribute chosen. In this present study, the consumers showed similar results for the chocolate with 35% cocoa (Table 5), while the selected and familiarized panels had a poorer description, using a small number of attributes. So the selection

and familiarization protocols provided in this study do not give all results compliant with the expected level. Subjectively, it seems that the familiarization with the attributes and performing only three preliminary sessions had an opposite effect, i.e. it does not provide clarity about the TDS exercise and the notion of temporality, but results in more confusion. On the other hand, the fewer sensations perceived in bitter chocolates could be justified because they are less complex samples, with fewer dominant attributes.

The selection of panelists, by the basic taste and odors recognition test, triangular tests and sequential method of Wald, based on the principle of select tasters with good sensory ability anddiscriminative power (ISO 8586, 2012; Meilgaard et al., 1999) is a common procedure for performing descriptive analysis.However, in the case of this study, associated with only one session (one hour) to introduce them to the TDS procedures, in which the concept of the dominant attribute was explained and another session to introduce them to the software used in the analysis, did not provide an improvement in Panel II (selected panel) response compared to Panel I (consumers). This is an indicate that only selecting and performing two sessions was not sufficient for TDS understanding and description improvement, because the "selected" panel would be at the very beginning of a change between a true "consumer" mindset and an "analytical" one, e.g. from a kind of "naïve" mindset to something which starts to be a bit more analytical, but not as much as the one of a "professional" panel with a high level of training. However, this must be left for future investigation.

We also noted a counterintuitive result in Panel III, which was selected, introduced to TDS and the notion of temporality during two sessions, and was familiarized with the attributes proving references and performing three preliminary tests. One hypothesis for this is that the selection and familiarization stages probably increased the options and the panelist responsibility for detecting a greater number of sensations, promoting a psychological effect, spending more time to elect the dominant sensation, as observed in Table 6. Moreover, they used fewer attributes to describe the samples, which may also have affected the samples discrimination by these panels (Table 3).

On the other hand, another hypothesis is that the "familiarized" panel is maybe just one step further along on this "analytical" path, but still far from the end of a proper training, and thus provided poorer responses, spending more time to elect the first dominant attribute, showing lower dominance rates and consequently having a lower product discrimination.

Note that the results obtained in this study are valid for chocolate and the definition of the attribute list and the ability to identify them by each panel is an important point worthy of attention (Pineau et al. 2012). Thus, studies with other training protocols, with more samples and attributes and with other product categories are necessary to elucidate the appropriate panel to perform TDS tests.

5. CONCLUSIONS

We observed that the different panels (consumers, selected panel, and selected and familiarized panel) provide different descriptions regarding the temporal dominance of sensations of chocolates with 35% and 53% cocoa and similar descriptions for the sample with 63% cocoa. It was verified that Panel I was able to discriminate the three chocolates, while the selected panel and the selected and familiarized panel only discriminated chocolate with 35% cocoa from the others. Furthermore, it was found that the group of consumers had higher dominance rates, spent less time to elect the first sensation and used a greater number of attributes to describe the chocolate with 35% cocoa. This indicated that the selection protocol associated with only two sessions to introduce the panelists to TDS procedures and the temporality notion, and the familiarization with the TDS sensations of chocolates protocol used in this study followed by three preliminary TDS tests were not sufficient to improve the TDS response relative to the consumer evaluation. Therefore, studies with different and harder training protocols compared to consumer responses,with a larger number of samples and attributes and with other product categories must be carried out to elucidate the behavior of different panels during the TDS tests.

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ARTIGO 2: TDS OF CHEESE: IMPLICATIONS OF ANALYZING TEXTURE AND TASTE SIMULTANEOUSLY

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ABSTRACT: This study aimed to evaluate the implications of analyzing texture and taste simultaneously on TDS descriptions of cheese. Thus, the TDS tests were performed in two ways following a balanced order: I- the panelists performed TDS tests of Prato cheeses, evaluating an attribute list with the taste and texture sensations in a same session; II- TDS evaluations were performed for each type of attribute, i.e., one session was performed with a attribute list composed by taste sensations and other session was performed with texture sensations. After each test the difficulty and reliability on performing the tests were assessed by each panelist using an unstructured scale; and some physical and chemical parameters were determined to compare the sensory and instrumental results. It was noted that one of the main implications of the simultaneous analysis on TDS results was the difference regarding the temporality. Moreover, the simultaneous evaluation provided a similar taste description of the separate evaluation, but differences on the texture profile were noted between the approaches. Although the simultaneous analysis implied in greater difficulty in performing the tests and less reliable results according to the panelist's opinions, both TDS results seemed to provide similar sample's characterization regarding the instrumental analysis, being antagonistic sensations ('hard' x 'soft') correlated positively in the separate evaluation. However, it was noted that the physical and chemical parameter intensity (amplitude) are not strongly linked to the maximum dominance rate.

Keywords: attribute list, taste, texture, TDS, test protocol

1. INTRODUCTION

The complex process of food and beverages ingestion undergo a series of physical and chemical reactions and salivation, resulting in several perceived aroma, taste, flavor and texture sensations that changes over the time. In this context, the use of dynamic sensory methods such as the Temporal Dominance of Sensations (TDS) method, has proved to be useful to study the temporal dimension of different sensations during the food ingestion (Rodrigues et al. 2016a; Hutchings et al. 2014; Rodrigues et al. 2014; Rosenthal & Share, 2014; Souza et al. 2013; Dinnella et al. 2012; Déléris et al., 2011; Lenfant et al., 2009).

TDS consists of presenting to the panel a complete list of attributes on a computer screen and asking them to identify sensations perceived as dominant until perception ends (Pineau et al. 2009). Therefore, TDS enables several attributes to be evaluated simultaneously at different time points during the product tasting and shows the sequence of the dominant sensations (Ng et al. 2012). However, even though this method has proved effective to describe several products, there is still some questions about the methodology procedures (Rodrigues et al. 2016b; Monaco et al. 2014). It occurs due to the complexity of the analysis, in which the panelists are required to continuously make a choice among several attributes to determine the sequence of the dominant sensations (Ng et al., 2012; Pineau et al., 2012).

The attribute list used during the test is among these questions. Pineau et al. (2012) already elucidated some aspects regarding how the panelists use the attribute list during a TDS experiment, and how the attribute list characteristics (number, type and position) impact the panelist response. Traditionally, TDS tests are performed assessing only one attribute type (texture or taste per example), but some studies suggested that the panelists are able to use different attribute types (taste, texture and aroma) in a single evaluation (Pineau et al. 2012; Pessina, 2006; Pessina et al., 2005), saving time and money. Nevertheless, the exact influence of listing different sensory properties in the same list remains unknown (Monaco et al. 2014) and there are not studies comparing the results obtained from a single attribute type evaluation versus a set of attributes types in a same session. Moreover, though food perception analysis is a complex process per se, some kinds of food have complex structures that make this process even more arduous (Albert et al. 2012); and raises the question of using different types of attributes simultaneously to perform TDS analysis. Thus, it is need to investigate more precisely the implications of using different attributes types in a same session in order to understand the advantages and limitations of this approach (Pineau et al. 2012).

In this context, this study aimed to evaluate the implications of analyzing texture and taste simultaneously on TDS descriptions of Prato cheese. Moreover, we compared the TDS descriptions obtained through both evaluations (TDS with different attributes types - taste and texture - evaluated in a same list and TDS with the attributes types evaluated separately) with the

instrumental physical and chemical characterization. This comparison was made to help to determine which of two conditions is describing/distinguishing at best the sample.

2 MATERIAL AND METHODS

2.1 Samples

Five commercial Prato cheeses were acquired in the trade of Lavras – MG, Brazil. Products and brands were selected in order to assess cheeses with sensory variable features. The cheeses were from the same batch and within the validity period.

For sensory evaluation, the samples were prepared by cutting the cheeses to obtain a similar size (2 cm x 2 cm x 2 cm). The samples were stored at 10^{o} C and served in disposable cups coded with three digits in a balanced order (Walkeling & MacFie, 1995).

2.2 Physical and chemical characterization

Some physical and chemical parameters (NaCl and fat contents, acidity and texture parameters) were determined in order to compare the instrumental characterization with the sensory results in order to evaluate the descriptions robustness. The physical and chemical analyses were performed in triplicate, following the methodology described by Brazil (2006).

The instrumental texture of the cheeses was determined using a texturometer TA-XT plus model - Stable Micro Systems® with a 4500 g load cell. The cheeses were cut into cylinders of 20 mm diameter and 25 mm in height, placed in sealed plastic bags (to avoid dehydration) and stored at 10^{o} C for 1 h. Samples were taken from the middle of the cheese block to avoid surface effects. The speed of 1 mm/min was used at 40% compression test, using an acrylic cylindrical probe of 25.4 mm diameter and 35 mm height (Nepomuceno, Junior & Costa, 2016). The analyzed parameters were: hardness and chewiness (Amamcharla & Metzger, 2015).

2.3 Experiment overview

The study evaluated the implications of analyzing texture and taste simultaneously on TDS descriptions. Thus, the TDS tests were performed in two ways: I- the panelists performed

TDS tests of Prato cheeses, evaluating an attribute list with the taste and texture sensations in a same session; II -TDS evaluations were performed for each type of attribute, i.e., in one session the attribute list was composed by taste sensations and in other session the tests were performed with texture sensations. The test order was balanced in a way that each panelist did a different TDS test mode firstly, i.e., the TDS test with different attributes in a same session and after testing the attributes separately and vice-versa.

All evaluations were performed on the same products and within the same period of time (35 s). Evaluations took place in a standardized sensory environment (ISO 8589, 2007) and followed the good sensory practices (Lawless & Heymann, 2010).

2.4 Panel and selection of terms

According to Pineau et al. (2009), when a confidence interval of a proportion based on the normal approximation is calculated, it is recommended that $np(1-p)>5$, n being the number of trials and p the probability of success. As eight attributes will be evaluated in the TDS analysis, in this study $p=0.125$, so the minimum number of evaluations should be $n=5/[0.125 \times (1-0.125)]=46$. Thus, twenty-six panelists (14 females and 12 males, aged between 20 and 30 years) with previous experience in TDS analysis were selected based on the ISO 8586:2012. All of them consume Prato cheese at least once a week and they had good oral and general health. They performed the TDS tests in duplicate, totaling 52 evaluations.

Two preliminary sessions were conducted. In the first session the panelists were introduced to the TDS module of the Sensomaker software (Nunes & Pinheiro, 2012) and they were instructed that the dominant perception is the one perceived to have the greatest clarity and predominance; i.e., the most striking perception at a given time (Pineau et al., 2009). The second session was used to select the sensations involved in the TDS analysis. During this session they described all the in-mouth sensations regarding the taste and texture that they felt while tasting all the samples (5 cheeses). Thus, the most-cited sensations for the taste (salt, sour and bitter) and for the texture (hard, creamy, soft and rubbery) attributes were selected for the TDS tests. The ‘no perception’ option was also included in the attribute list to indicate when no sensation was

perceived. The number of attributes evaluated in this study was established according to Pineau et al. (2012), which proposed to keep the number of attributes around 8 to 10 based on the results of several studies.

2.5 TDS evaluation

TDS analyses were performed according to Pineau et al. (2009), in duplicate for each individual and under the same conditions: total duration of analysis of 35 s with a 'delay time' of 2 s.

The attributes involved in the module I of TDS tests (in which it was evaluated different attribute types - taste and texture in the same session) were: salt, sour, bitter, hard, creamy, soft, rubbery and 'no perception'. In the second module, they evaluated the samples according to the taste sensations (salt, sour and bitter) and according to the texture sensations (hard, creamy, soft and rubbery), in different sessions. The option 'no perception' was also included in the separate evaluations (both taste and texture evaluation). Thus, the three different evaluations (combined list, taste only and texture only) were performed in separate sensory sessions (hence 3 data collection sessions in total). The test order was balanced in a way that each panelist did a different TDS test module firstly. The module II conditions were also randomized, i.e. half of people assessed taste first and then texture and the second half conversely.

After the instructions, the panelists were instructed to put the sample in their mouth and start to chew the sample and start the TDS evaluation within two seconds. The run then lasted during 35 seconds. All tests included the option 'no perception'. Thus, the taster could indicate the perception absence and, consequently, the analysis end.

After each TDS tests, each panelist indicated the reliability degree (i.e. the degree to which panelists felt confident about their evaluations of the samples) and the difficulty degree in performing each test using unstructured scales of nine points varying up "unreliable" to "very reliable"; and varying up "very easy" to "very difficult" (Hutchings et al. 2014) respectively. These opinions were evaluated after each data collection session.

2.6 Statistical Analysis

The TDS curves were computed according to the methodology described by Pineau et al. (2009) using the Sensomaker software (Nunes & Pinheiro, 2012). First, The TDS curves were plotted from all evaluations (n=52) for each cheese evaluated in the different conditions (TDS with different attributes - taste and texture - evaluated in a same list and TDS with the attributes evaluated separately). Briefly, two lines were drawn on the TDS graphics: 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 to be considered significant (Pineau et al., 2009). For this calculation, we used the confidence interval for a binomial proportion based on the normal approximation according to Pineau et al. 2009 (1), given by:

$$Ps = Po + 1.645\sqrt{\frac{Po(1-Po)}{n}} \quad (1)$$

where Ps is the lowest significant proportion value ($\alpha = 0.05$) at any point in time for a TDS curve, n is the number of subjects * replication, and Pois equal to 1/p, being p the number of attributes.

It was also summarized in Table 1 the number of significantly perceived sensations (taste and texture attributes) in each evaluation (Module I - taste and texture evaluated simultaneously; Module II - taste and texture evaluated separately). In this data was applied a t-test (two-tailed) to verify, across samples, were those numbers significantly ($p \leq 0.05$) higher/lower.

Three parameters for each sensation were also computed from the curves for each sample from all evaluations: the maximum dominance rate (DRsensation), the time that the maximum dominance rate occurred (Tsensation) and the time interval (length of period) where the dominance rate was at least 90% of the maximum dominance rate (Psensation).

To compare the results obtained from both TDS evaluations, it was plotted two PCA's using these TDS parameters. The first PCA were arranged in a matrix of i lines (samples) and j columns (three TDS parameters) for each sensation evaluated in order to evaluate the temporal description of the samples. The other one was plotted only using the maximum dominance rate

parameter, considering that differences in the temporality were already expected due to the approaches format (differences in the number and type of attributes in each evaluation). Thus, multiple factor analyses (MFA) (Escofier & Pagès, 1994; Cruz et al. 2013) were applied to PCA's data to check the similarity of the TDS data obtained, considering each approach – taste and texture attributes evaluated simultaneously or separately. MFA is a multivariate analysis for multiple block data, with an advantage of working with different nature data simultaneously (quantitative, qualitative or frequency) (Worch, 2013). It involved a matrix establishment where the rows were the cheeses and the columns were the position of the samples in the first and second dimension of PCA in each evaluation.

Comparisons of overall sample configurations were made using the regression vector coefficient (RV) (Robert & Escoufier, 1976) to see how closely related they were according to use of different MFA model dimensions. The RV value served a numerical indicator between the two individual generated spaces, ranging from 0 (totally disagree) to 1 (perfect agreement) (Fonseca et al. 2016) and its significance was tested using the standardized RV coefficient according to Josse, Pagès and Husson (2008). The routines were performed on R software (R Core Team, 2016).

In a second step, the TDS results were compared with the instrumental physical and chemical characterization. This comparison was made to help to determine which of the approaches is describing/distinguishing at best the sample and to evaluate the accuracy of the sensory data collected based on expectations. Thus, the maximum dominance rates obtained from these TDS curves plotted from all evaluations (n=52) for each sensation (salt, sour and bitter, hard, creamy, soft and rubbery) and for each evaluation (TDS with different attributes – taste and texture - evaluated in a same list and TDS with the attributes evaluated separately) were analyzed by principal component analysis (PCA), using the mean instrumental results as supplementary variables (Abdi & Williams, 2010). The data was preprocessed (self-scaling) and the routines were performed on R software (R Core Team, 2016).

Finally, the reliability and difficulty degree results were assessed by ANOVA (sources of variation: ‘evaluation type’ and ‘observations’; both considering fixed effects) followed by the Tukey test, using the Sensomaker software (Nunes& Pinheiro, 2012).

3. RESULTS

To assess the TDS descriptions obtained through the both evaluations (TDS with different attributes – taste and texture - evaluated in a same list and TDS with the attributes evaluated separately), the TDS curves of the evaluated chesses are represented in Figure 1. Table 1 summarized the number of significantly perceived sensations (taste and texture attributes) in each evaluation (Module I - taste and texture evaluated simultaneously; Module II - taste and texture evaluated separately).

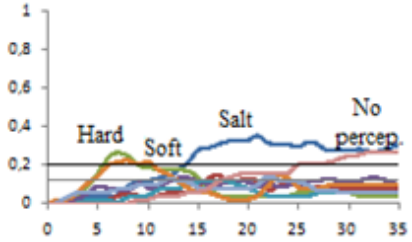
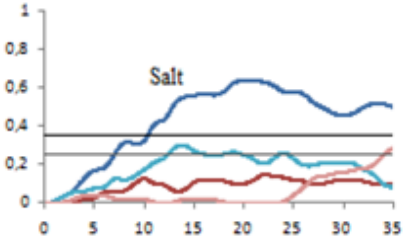
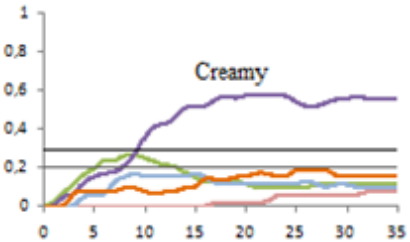
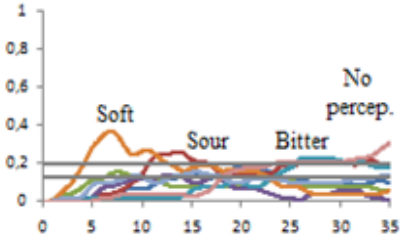
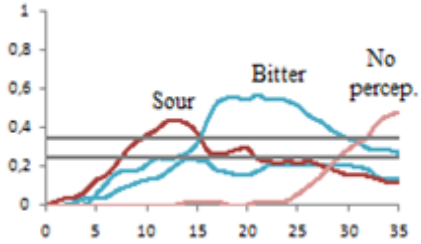
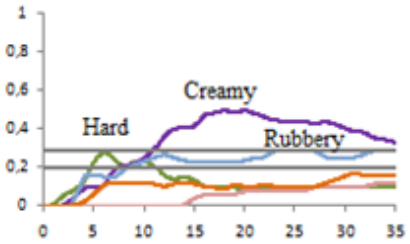
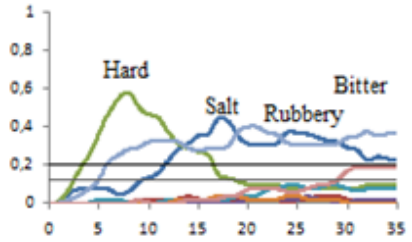
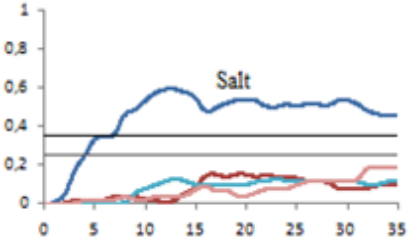
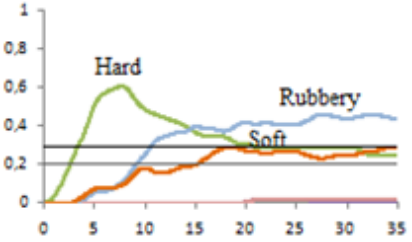
Samples	Module I	Module II	
	Taste and Texture evaluated simultaneously	*Taste and Texture evaluated separetely*	
		Taste evaluation	**Texture evaluation**
A			
B			
C			
			

Figure 1. TDS curves obtained for the cheeses trough both TDS evaluations (TDS with different attributes – taste and texture - evaluated in a same list and TDS with the attributes evaluated separately) (Continua)

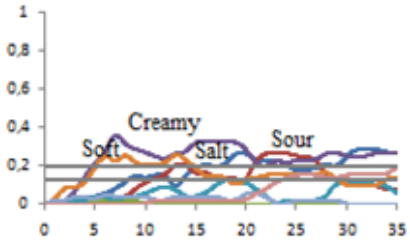
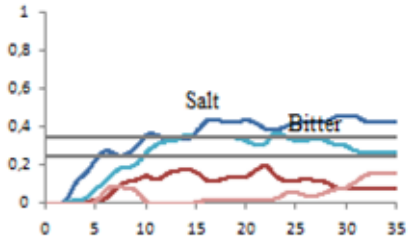
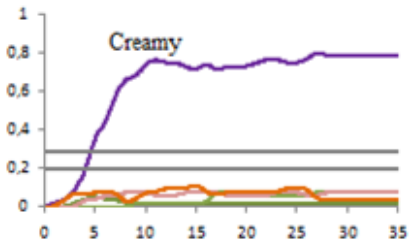
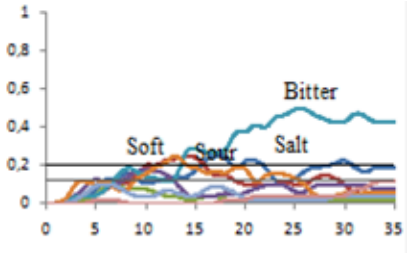
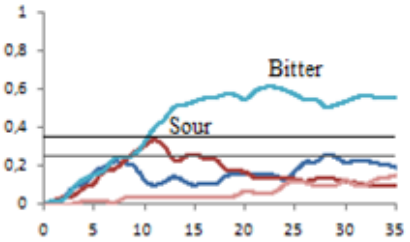
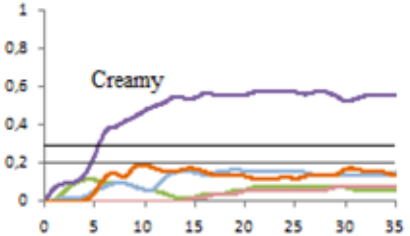
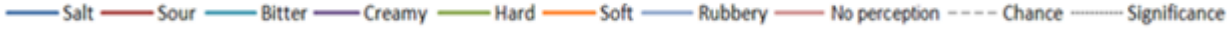
Samples	Module I	Module II	
	Taste and Texture evaluated simultaneously	*Taste and Texture evaluated separetely*	
		Taste evaluation	**Texture evaluation**
D			
E			
			

Figure 1. TDS curves obtained for the cheeses trough both TDS evaluations (TDS with different attributes – taste and texture - evaluated in a same list and TDS with the attributes evaluated separately) (Conclusão)

Table 1. Significant sensations perceived in each evaluation (Module I - Taste and Texture evaluated simultaneously; Module II - Taste and Texture evaluated separetely).

	Taste				**Texture**			
	Module I		**Module II**		**Module I**		**Module II**	
	Taste and Texture evaluated ***simultaneously***		*Taste and Texture evaluated* ***separately***		*Taste and Texture evaluated* ***simultaneously***		*Taste and Texture evaluated* ***separately***	
Samples	**Number of significative Taste perceptions**	**Taste perceptions**	**Number of significative Taste perceptions**	**Taste perceptions**	**Number of significative Texture perceptions**	**Texture perceptions**	**Number of significative Texture perceptions**	**Texture perceptions**
A	1	Salty	1	Salty	**2**	Hard - Soft	*1*	Creamy
B	2	Sour-Bitter	2	Sour-Bitter	1	Soft	1	Creamy
C	1	Salty	1	Salty	2	Hard-Rubbery	2	Hard-Rubbery
D	2	Salty-Sour	2	Salty - Bitter	**2**	Creamy-Soft	*1*	Creamy
E	**3**	Sour-Salty-Bitter	*1*	Bitter	1	Soft	1	Creamy

* When significant differences occurred between the approaches, highest values appear in bold and lowest values appear in italics. (Module I - Taste and Texture evaluated simultaneously; Module II - Taste and Texture evaluated separately).

From figure 1 it was noted that a larger number of sensations (including taste and texture attributes) were detected as dominant in the simultaneous evaluation, but with smaller dominance rates. It was observed in Table 1 that a larger number of taste sensations were detect as significantly dominant in sample E and a larger number of significantly textures sensations were also noted in samples A and D. In general, the taste sensations detected as dominant were the same in both evaluations. However, Table 1 shows that, for 3 of the 5 samples evaluated (samples A, B and E), the texture attributes that reached a significant dominance rate differed across evaluation methods. Sample C was the only sample in which texture attributes reaching significant dominance rate were identical across evaluation methods. The main difference detected was the change of the soft sensation detection (detected in the simultaneous evaluation) by the creamy predominance in the separate texture evaluation.

Regarding the temporality, Figure 1 shows that, within samples, there are noticeable differences in the time when sensations reaching significance across both evaluation methods become significant and in the duration of their significant dominance. For instance, for Sample B, bitter become significantly dominant later in Module I than in Module II, at about 25 and 15 s, respectively, and the duration of its significant dominance was shorter (about 5 s in Module I v. about 15 s in Module II). Moreover, for Sample C, bitter was a significantly dominant sensation from 5 s onwards in Module II, but only from about 12 s onwards in Module I. For this same sample, rubbery reached significant dominance earlier in Module I than in Module II, becoming significant at about 6 and 12 s respectively. As a result, for sample C, the sequence of sensations reaching significance in Module I (taste and texture attributes evaluated simultaneously) is hard, then rubbery, then bitter, whereas it was hard, then bitter, then rubbery in Module II (taste and texture attributes evaluated separately). What those specific examples highlight is that the temporality of the sensations perceived differed across evaluation approaches.

Regarding the sensation sequence, we noted that in most of the samples the first significantly sensation detected was a texture sensation in the simultaneous evaluation (Module I). Moreover, in both evaluations these sensations were related to chewing and initial food rupture, such as ‘soft’ and ‘hard’ sensations, followed by the ‘creamy’ and ‘rubbery’ sensations

that took longer chewing periods to be noticed. After, it was significantly detected the taste sensations, which prevailed until the end of the analysis in most of the samples. In the Module II (separate evaluation) it was noted that the first taste sensation perceived around 10 s in most of the chesses (A, B, D and E), while the texture sensation was significantly detected around 5 s for three (C, D and E) of the five samples.

To better evaluate the similarity degree in the sample configuration obtained using the two protocols, the data was analyzed using Multiple Factor Analysis in two ways (Figure 2 and 3). In the first way, the analysis considered all TDS parameters (the maximum dominance rate – Drsensation; the time that the maximum dominance rate occurred – Tsensation; and the time interval (length of period) where the dominance rate is at least 90% of the maximum dominance rate - Psensation) to asses all the TDS description (considering the temporality). In the other one, only the maximum dominance rate parameter was consider, to assess the samples configuration considering the main attributes that characterized the samples.

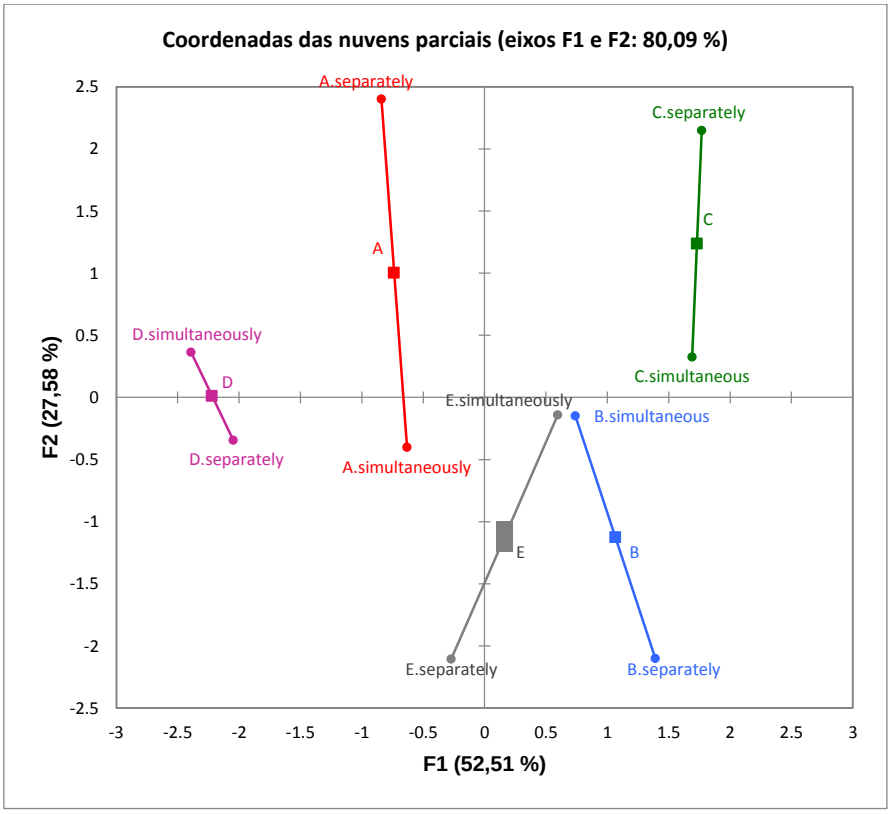


Figure 2. Comparative MFA on samples configurations obtained through both TDS evaluations (TDS with different attributes – taste and texture - evaluated in a same list and TDS with the attributes evaluated separately) for all TDS parameters.

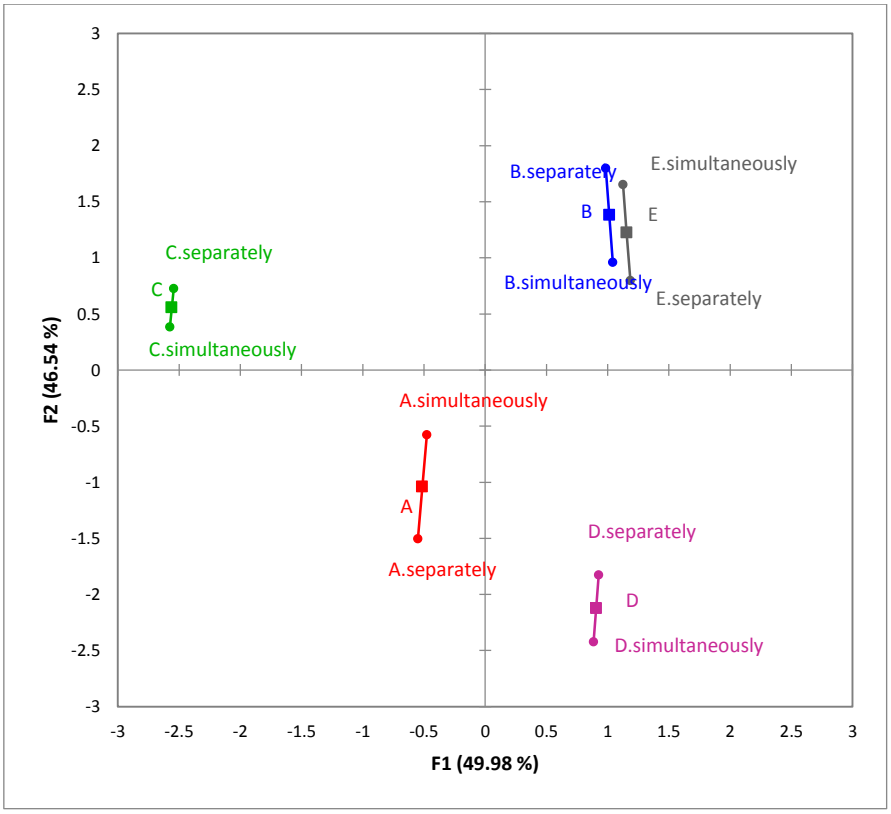


Figure 3. Comparative MFA on samples configurations obtained through both TDS evaluations (TDS with different attributes – taste and texture - evaluated in a same list and TDS with the attributes evaluated separately) for the maximum dominance rate.

MFA bidimensional map assessing all TDS parameters (Figure 2) explained 80.09% the variance, being 52.51% and 27.58% at the first and second dimensions, respectively. The RV coefficient value was not significant (p=0.71), indicating the difference in the sample configurations regarding the TDS evaluations (considering the temporality).

Evaluating the samples configuration regarding only the main attributes that most characterized the samples, Figure 3 shows that the two first dimensions of the MFA explained 96.52% the variance, being 49.58% and 46.53% at the first and second dimensions, respectively. The RV coefficient value of 0.87 (p=0.025) obtained suggests a great similarity between the

results obtained in each TDS evaluation, considering that the RV=0.70 have been suggested as a cut-off point for good similarity (Louw et al. 2014).

To compare the TDS results with the instrumental physical and chemical characterization, the maximum dominance rates obtained from the TDS curves plotted from all evaluations for each sensation and for each evaluation were analyzed by principal component analysis (PCA) (Figure 4). Figure 4 – I and II represents the results obtained from the simultaneous and separate evaluations, respectively. In Table 2 is showed the values obtained through the physical and chemical characterization.

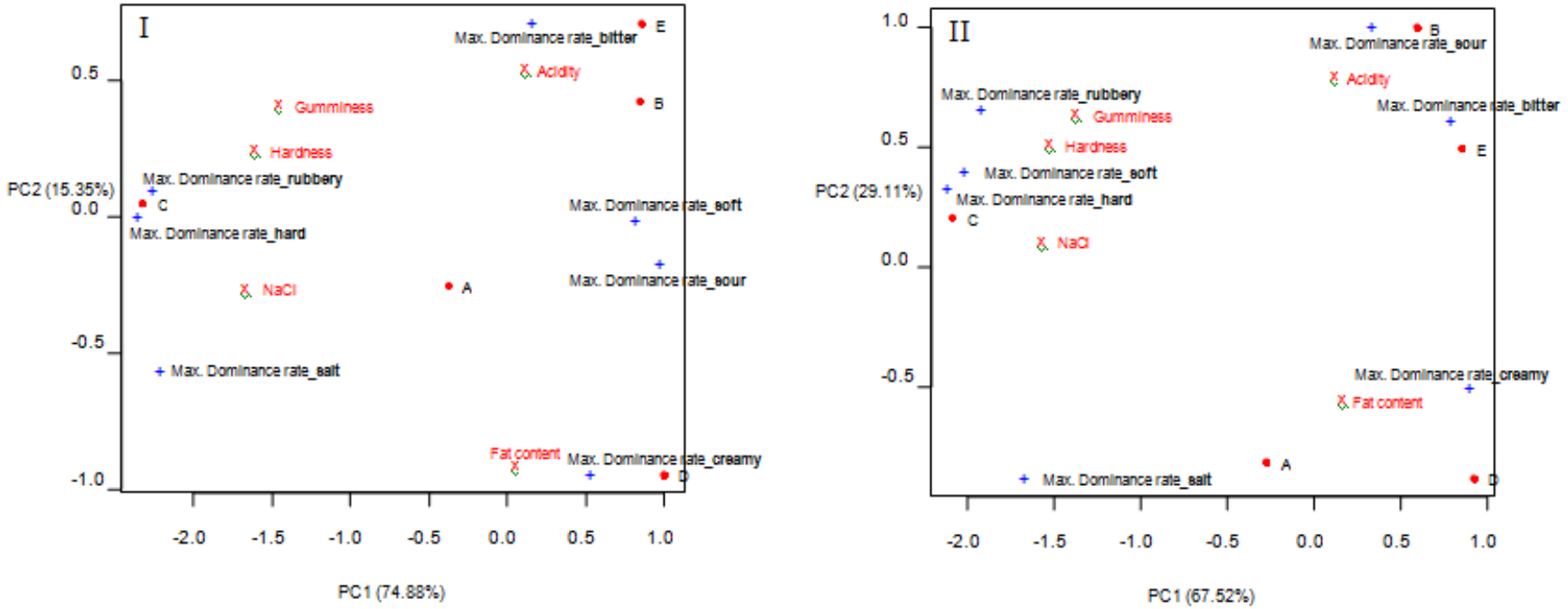


Figure 4. PCA for cheeses evaluated by TDS with different types of attributes (taste and texture) simultaneously (I) and separately (II) and the physical and chemical characterization as supplementary variables.

Table 2. Means obtained for the physical and chemical characterization of the evaluated cheeses

Sample	NaCl (%)	Fat content (%)	Acidity (%)	Hardness (N)	Gumminess
A	1.19±0.00 c	53.33±0.12 b	1.40±0.07 b	24.15±0.20 c	5.61±0.30 c
B	1.3±0.00 b	53.33±0.15 b	1.55±0.02 a	29.44±0.12 b	7.88±0.24 b
C	1.83±0.00 a	50.00±0.11 c	1.41±0.05 b	38.91±0.21 a	10.49±0.21 a
D	1.33±0.00 b	66.67±0.09 a	1.39±0.03 b	19.37±0.14 d	3.52±0.22 d
E	1.17±0.00 c	50.00±0.14 c	1.53±0.04 a	26.56±0.30 c	7.66±0.31 b

Means followed by the same letter in the column did not differ significantly ($p \leq 0.05$) by the Tukey test.

The two first principal components explained together 90.23% and 96.63% in Figure 4-I and 4-II, respectively. We noted a similar sample configuration in both PCAs, but in the separate TDS evaluation (II) the sample C was characterized by antagonistic sensations, i.e. it has higher dominance rates for hard and soft sensations, while in the simultaneous TDS analysis it did not occurred.

Regarding the dominant sensations and the chemical parameters, we noted that the samples with higher acidity (B and E) and fat content (A and D) were characterized by sour and creamy sensations, respectively, in the separate evaluation. In the simultaneous evaluation, the acidity and sour sensation vectors is not so close, but it is possible to note that the sample with higher NaCl content (C) had higher dominance rates for the salt sensation. Moreover, analyzing the texture parameters, the sample with higher hardness and chewiness values (C) had higher dominance rates for hard and rubbery sensations in both tests. In general this is an indicative of the description coherence obtained through both evaluations. However, in the separate evaluation, this sample was also described as a soft sample as mentioned before.

Assessing the test reliability and difficulty degrees, the ANOVA indicated that there were significant differences ($p \leq 0.05$) between the two evaluations (Table 3).

Table 3. Grades obtained for the reliability and difficulty degrees of both evaluations

TDS test		Means of reliability	Means of difficulty
Taste and texture evaluated simultaneously		5.67 a	2.53 a
Taste and texture evaluated separately	*Taste evaluation*	8.89 b	0.24 b
	Texture evaluation	8.67 b	1.02c

Reliability degree (i.e. the degree to which panelists felt confident about their evaluations of the samples) varied up" unreliable" to "very reliable"; and Difficulty degree varied up "very easy" to "very difficult" in unstructured nine-point scales.

* Means followed by the same letter in the column did not differ significantly by the Tukey test.

Trough Table 3 it was noted that the panel considered the separate evaluation easier and more reliable than the simultaneous evaluation. Moreover, regarding the separate evaluation, the panel considered the texture evaluation more difficult than the taste evaluation.

4. DISCUSSION

Figure 1 of Module I evaluation (taste and texture evaluated simultaneously) provided a higher number of attributes reaching the significance level than Module II evaluation for 3 of the 5 samples. This tends to suggest a superiority of the simultaneous evaluation of taste and texture attributes over their separate evaluations in the temporal sensory characterization obtained. This idea is further backed up by the fact that maximum dominance rates for the antagonistic 'hard' and 'soft' texture sensations are shown to be positively correlated positively in the PCA of Module II data whereas, as expected, they are negatively correlated negatively in the PCA of Module I data. Although in figure 1 it was noted that this antagonistic sensations ('hard' x 'soft') was also significantly detected for sample A in the simultaneous evaluation. A hypothesis for this is a possible difference in the pattern of cheese consumption by the tasters, which would lead to differences between them on the concepts of hard and soft. For example, a panelist who

frequently consumes softer cheese, such as a Minas Frescal cheese, probably considered the Prato cheese harder than a panelist that frequently consumes harder cheeses such as a Parmesan cheese.

Despite of the larger number of significant sensations detected in the simultaneous evaluation, it showed smaller dominance rates. This can be justified by the larger number of options (sensations) involved in the analysis (almost double), which may hamper the TDS task for the panelist, resulting in lower dominance rates. This can be corroborated by the greater degree of difficulty in performing the simultaneous analysis indicated by the panel (Table 3).

It is important to highlight that this study looks at taste and texture attributes only. And only the most important taste and texture sensations (determined by preliminary TDS tests) were evaluated. Therefore, other attribute lists with a larger number and other sensations types must be investigated. Moreover, some studies indicated that the panelists behave differently with respect to how many and which attributes they use, when the attributes list contains six or more attributes (Goupilet al. 2010; Pineau et al. 2012). The same authors also noted that individuals commonly use an average of about 4 attributes to describe a single sample, which could provide a less of information description in a simultaneous evaluation with a large number of attributes. However, it must be further investigated.

According to Lenfant et al. (2009) and Bouteille et al. (2013), the first detected dominant attributes normally are texture sensations. Albert et al. (2012) and Amamcharla and Metzger (2015) also suggested that the initial dominant perception correlates with the fracture properties of the product and it is related to the breaking strength of the food. This was noted in the simultaneous evaluation (Module I) for all samples, being the hard/soft sensation the first sensation detected significantly. Overlapping the taste and texture curves of the separate evaluation (Module II) it occurred for three (C, D and E) of the five evaluated samples. Moreover, from 15 s it was noted the prevalence of taste sensations until the analysis end in Module I, while both taste and texture profiles were significantly provided in Module II.

It was also noted that in most of the TDS curves of both evaluations the first significant sensation took a period of 5 to reach the significance line. This probably occurred due to the differences in the perception physiology (the chewing speed per example) among the individuals.

Thus, a longer period than the predetermined delay (2 s) was necessary to reach the description consensus, i.e., to reach the significance level. In the texture description evaluated separately the samples took a larger period to achieve the significance level, which may also have occurred due to the greater difficulty pointed out by the panel in describing the texture profile (Table 3).

It was noted that one of the main implications of the simultaneous analysis on TDS results was the difference regarding the temporality, as noted in both TDS curves and MFA (Figure 2). This probably occurred due to the approaches format, i.e., the number and types of attributes involved in each module. Per example: when the texture and taste were evaluated separately, the panelist was "obliged" to score only taste/texture sensations throughout the analysis time (35 s), while in the simultaneous analysis it did not occurred. This may have had a great influence on the time in which the maximum dominance rate of each sensation occurred and in the dominance duration. In addition, with more options, as in the case of the simultaneous evaluation in which they evaluated taste and texture sensations, the panelists tend to mark a greater number of attributes. This also affects the maximum dominance rates and the length of time for each attribute is likely to be shorter, promoting significant differences in the temporal description of the samples.

Considering the ‘static’ sample characterization, we noted that both approaches provided similar results (figure 3). In this sense, it is possible to infer that both methods summarized the static cheese characterization regarding their characteristics (sensory attributes), as suggested by some authors (Pessina et al., 2005; Pessina, 2006; Goupil et al. 2010; Pineau et al. 2012; Monaco et al. 2014). Pessina (2005) and Pessina et al. (2006) suggested that a TDS study with two attribute types (taste and aroma) can be a good summary of the two TDS studies performed separately. Furthermore, Pineau et al. (2012) also noted in a TDS study with ice cream involving both texture and taste attributes, that the TDS results recorded by the panelists were in agreement with prior knowledge about the products. However, it is important to highlight that the temporal component is of great importance in the characterization via TDS, and this is one of its differentials in relation to other static methods such as the Quantitative Descriptive Analysis (QDA) and the Check All That Apply (CATA) test.

Regarding the TDS descriptions obtained in each evaluation and their comparison with the physical and chemical characterization, we noted trough the PCA (Figure 4) that both TDS results seems to provide similar sample characterization regarding the instrumental analysis. However, in the separate evaluation, antagonistic sensations (‘hard’ x ‘soft’) were correlated positively.

However, analyzing the maximum dominance rates obtained through the TDS curves and the physical chemical results, it was noted that them are not strongly linked. For the salt and sour perceptions, it was not possible to establish a relationship between the physical chemical parameter and the maximum dominance rate. For the sample with the highest fat content (sample D) it was noted that it had the highest dominance rate for the creamy sensation (Module I - 0.36 and Module II - 0.80), but for the samples with the lowest fat contents (C and E), only the sample C had low dominance rates in both approaches (Module I- 0.03 and Module II – 0.02). Regarding the texture sensations (chewiness and hardness), the extremes (the highest (sample C) and lowest (sample D) values) instrumental values agreed with the extremes dominance rates (Sample C: Module I- 0.58 for hard and 0.46 for rubbery and Module II- 0.61 for hard and 0.60 for rubbery; Sample D: Module I- 0.02 for hard and 0..08 for rubbery and Module II- 0.0.05 for hard and 0.06 for rubbery) obtained among the samples, but it is not so clear among the intermediary samples (A, B and E) by both evaluations. According to Pineau (2009) and Meyners (2010), dominance and intensity are two different but complementary concepts. Therefore, the dominant attribute is not necessarily the one with the highest intensity, thus, a less intense sensation can rise during the tasting, which probably justified the results obtained by the comparison of the physical chemical parameter intensity and the dominance rates in this study.

According to MacFie (2008), the sensory protocols must be done as easier as possible for the panelist to ensure the data reability. Although the panel considered the separate evaluation easier and more reliable regarding the simultaneous evaluation, it did not compromise the TDS results obtained.

Given the results of this study, the choice for the protocol should mainly be driven by the questions to be addressed. E.g., if the question is about the characterization of the real

consumption of the product (involving several attributes in the same time) or about the global perception of the sample, the types of sensations (e.g. texture and flavor) cannot be dissociated since the question is actually about the interaction between the two types of sensations, which cannot be assessed if types of sensations are not in the same session. Moreover, considering the budget constraints should be adopted by the analyst, the simultaneous protocol seems to be a good alternative. However, it is important to highlight that the simultaneous and separate evaluation provided different TDS descriptions regarding the temporality, mainly in relation to the texture profile. In this sense, other studies focusing on the temporality differences when evaluating different types of attributes in a same or separate list must be investigated.

Moreover, studies with a larger number of samples and attributes and with other product categories are necessary to better elucidate the implications and limitations of different types of attributes on TDS descriptions.

5. CONCLUSIONS

Simultaneous evaluations of taste and texture sensations during TDS tests provided a similar taste description of the separate evaluation. However, differences on the texture profile were noted between the approaches. Moreover, the simultaneous evaluation provided a higher number of significant attributes, but at lower dominance rates.

It was noted that one of the main implications of the simultaneous analysis on TDS results was the differenceregarding the temporality (such as the sensation duration and sensations sequence). Regarding only the main attributes that most characterized the samples, we noted that both approaches provided a similar static sample configuration. However, it is important to highlight that the temporal component is of great importance in the characterization via TDS.

Both TDS results seem to provide similar sample characterization regarding the instrumental analysis, but in the separate evaluation, antagonistic sensations (‘hard’ x ‘soft’) were correlated positively. However, it was noted that the physical chemical parameter intensity are not strongly linked to the maximum dominance rate.

The simultaneous analysis implied in greater difficulty in performing the tests and less reliable results according to the panelist's opinions, but it did not compromise the TDS results.

Other studies with a larger number of samples and attributes and with other product categories must be done to better investigate the implications of different types of attributes on TDS description, mainly related to the temporality description.

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