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DESENVOLVIMENTO DE SOBREMESA LÁCTEA CREMOSA PREBIÓTICA SABOR CHOCOLATE COM SUBSTITUIÇÃO DA SACAROSE POR EDULCORANTES

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Faculdade de Engenharia de Alimentos

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Tese apresentada à Faculdade de Engenharia de Alimentos da Universidade Estadual de Campinas como parte dos requisitos exigidos para obtenção do título de Doutora em Alimentos e Nutrição, na Área de concentração Consumo e Qualidade de Alimentos.

Orientadora: Prof[a]. Dr[a]. Helena Maria André Bolini

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RESUMO GERAL

As sobremesas lácteas são produtos amplamente consumidos em todo o mundo e estão atualmente instituídas como parte integrante de diversas dietas modernas. A crescente procura dos consumidores por produtos alimentícios com valor agregado estimula o estudo da adição de prebióticos e edulcorantes. Na primeira parte deste trabalho, que avaliou os efeitos da adição de prebióticos (inulina:frutooligossacarídeos; 50:50) e gomas, nas propriedades sensoriais de sobremesas lácteas cremosas sabor chocolate, a adição de 7,5% (p/p) de prebióticos e 0,2% (p/p) de gomas (guar:xantana; 2:1) foi considerada ótima pelos consumidores, de acordo com modelo avaliado por metodologia de superfície de resposta. No segundo estudo, a análise ideal de doçura determinou a concentração ideal de sacarose como 8% (p/p). A análise relativa de doçura mostrou que o neotame apresentou o maior poder adoçante, na sobremesa láctea cremosa prebiótica sabor chocolate, seguido pela sucralose, aspartame e estévia. No terceiro estudo, os atributos de aparência, aroma, sabor, textura e impressão global foram avaliados por 120 consumidores usando escala hedônica de 9 pontos. Um mapa de preferência interno de três dimensões foi obtido por meio da análise de fator paralelo (PARAFAC). Análise de componentes principais (ACP) também foi realizada e comparada ao PARAFAC. A caracterização física das amostras de sobremesa láctea cremosa sabor chocolate foi determinada por meio da análise do perfil de textura e medidas de cor. A amostra integral foi caracterizada por firmeza e gomosidade e por cor mais clara que as amostras com adição de prebióticos e edulcorantes. O quarto estudo avaliou a qualidade das sobremesas lácteas cremosas sabor chocolate por meio das análises de tempo-intensidade (TI) múltiplo e dominância temporal das sensações (TDS). A análise tempo-intensidade mostrou que a amostra com neotame apresentou a maior intensidade de doçura; as amostras com neotame e estévia a maior intensidade de amargor; e as amostras com sacarose, sucralose, aspartame, e a integral, apresentaram a maior intensidade de sabor de chocolate. No TDS a substituição de sacarose pelos edulcorantes sucralose e aspartame apresentou um perfil temporal similar. No quinto estudo as seis sobremesas lácteas cremosas sabor chocolate foram avaliadas por 14 provadores treinados utilizando a metodologia da Análise Descritiva Quantitativa. Os assessores identificaram 20 termos descritores para aparência, aroma, sabor e textura. As amostras apresentaram diferença significativa entre si ($p \leq 0,05$) em 14 atributos avaliados. Análises de composição centesimal também foram realizadas com o intuito de avaliar as propriedades globais das sobremesas lácteas. As amostras com edulcorantes foram definidas como *diet*, por serem isentas de açúcar, e *light*, em calorias e lipídios. E, no sexto estudo, foi avaliada a influência da alegação de propriedade funcional e *diet/light* na aceitação das sobremesas lácteas cremosas sabor chocolate pelos consumidores. Os consumidores avaliaram as alegações de maneira diferente.

Palavras-chave: análise descritiva quantitativa; sobremesa láctea; aceitação; tempo-intensidade; dominância temporal das sensações; alegações funcionais.

ABSTRACT

Dairy desserts are widely consumed products worldwide and are now established as an integral part of many modern diets. The growing consumer demand for food products with added value encourage the study of prebiotics and sweeteners addition. In the first part of this study, which evaluated the effects of prebiotics and gums incorporation on chocolate dairy desserts, the addition of 7.5% (wt/wt) prebiotics (inulin:fructooligosaccharides, 1:1) and 0.2% (wt/wt) gums (guar:xantham, 2:1) was considered as optimal by consumers, according to a model provided by response surface methodology (RSM). In the second study, the ideal sweetness analysis revealed that 8.0% (wt/wt) was the ideal concentration of sucrose. The relative sweetness analysis showed that neotame presented the highest sweetening power with respect to the prebiotic chocolate dairy dessert containing 8.0% of sucrose, followed by sucralose, aspartame and stevia. In the third part, the attributes of appearance, aroma, flavor, texture and overall liking were evaluated by 120 consumers using a 9-point hedonic scale. A three-way internal preference map was obtained by parallel factor analysis (PARAFAC). A principal component analysis (PCA) was also discussed and compared to PARAFAC. A physical characterization of chocolate dairy dessert samples was determined by texture profile analysis and color measurements. The integral sample was characterized by firmness and gumminess and was lighter colored than the others with prebiotic and sweetener agents. The fourth study analyzed the quality of chocolate dairy desserts by the multiple time-intensity (TI) analysis and temporal dominance of sensations (TDS). TI analysis showed that the sample developed with neotame had a higher intensity of sweetness; the samples with neotame and stevia had a higher intensity of bitterness; and the samples with sucrose, sucralose, aspartame, and the integral one had a higher intensity of chocolate flavor. In TDS analysis the replacement of sucrose by the sweeteners sucralose and aspartame presented a temporal profile similar to the one. In the fifth study the six creamy chocolate dairy desserts were evaluated by 14 trained panelists using the methodology of Quantitative Descriptive Analysis. Assessors identified 20 descriptor terms for appearance, aroma, flavor and texture. Samples differed significantly ($p \leq 0.05$) in 14 attributes. Chemical composition analyses were also performed in order to evaluate the overall properties of dairy desserts. The samples with sweeteners were defined as diet, being no added sugar, and light in calories and fat content. And in the sixth study, the influence of the functional property and diet/light claims on acceptance of creamy dairy desserts of chocolate flavor was evaluated by consumers. Consumers rated the claims differently.

Keywords: sensory; quantitative descriptive analysis; gluten-free bread; acceptance; time-intensity; temporal dominance of sensations; functional claim.

SUMÁRIO

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INTRODUÇÃO GERAL

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Uma tendência que vem sendo apresentada no mercado é o desenvolvimento e consumo de alimentos funcionais, que são os alimentos definidos como aqueles que, “além de apresentarem funções nutricionais básicas, produzem efeitos metabólicos e/ou fisiológicos e/ou efeitos benéficos à saúde do consumidor, devendo ser seguro para consumo sem supervisão médica” (ANVISA, 1999; SLOAN, 2012). Uma propensão mundial que está tendo um grande impacto sobre as indústrias de produtos lácteos é a crescente conscientização dos consumidores sobre sua saúde e bem estar (BECHTOLD e ABDULAI, 2014). Os consumidores já relacionam seus hábitos alimentares e sua saúde, e estão à procura de novos produtos que lhes ofereçam benefícios adicionais equilibrados à uma alimentação prazerosa (SLOAN, 2012).

O uso de alimentos que promovem um estado de bem estar, melhoria na saúde e redução do risco de doenças tornou-se popular com os consumidores que se tornam mais conscientes em relação à saúde (BIGLIARDI e GALATI, 2013; MUSSATTO e MANCILHA, 2007). Alguns bons exemplos são os alimentos que contêm componentes ativos fisiologicamente, como probióticos e prebióticos. Prebióticos são “ingredientes seletivamente fermentados que permitem mudanças específicas, tanto da composição e/ou atividade na microbiota gastrointestinal, que conferem benefícios para o hospedeiro, como bem-estar e saúde” (GIBSON et al., 2004; ROBERFROID et al., 2010). A inulina, um tipo de frutano, tem sido amplamente investigada em relação ao seu efeito prebiótico, e apresenta evidência mais extensa e generalizada para suportar sua eficácia (GIBSON et al., 2004; ROBERFROID, 2005; ROBERFROID et al., 2010). Além dos seus benefícios nutricionais, a inulina é usada como um ingrediente na formulação de novos alimentos para substituição de gordura ou açúcar, como um agente espessante de baixa caloria e como agente de textura (AIDOO et al., 2014; RODRÍGUEZ-GARCÍA et al., 2014; TUNGLAND e MEYER, 2002).

Uma ampla gama de sobremesas lácteas, prontas para comer, está disponível para o consumidor, oferecendo uma grande variedade de texturas, sabores e aparências (VERBEKEN et al., 2006). As características nutricionais e sensoriais estimulam o seu consumo por vários grupos de consumidores, incluindo crianças e idosos (BRUZZONE et al., 2011; CARDARELLI et al, 2008). As variações nas características dessas sobremesas, e as interações com seus ingredientes produzem diferenças notáveis nas propriedades físicas e sensoriais dos produtos formulados. Estas diferenças podem influenciar a sua aceitabilidade pelos consumidores (FERNANDES et al., 2013; TÁRREGA e COSTELL, 2007).

O desenvolvimento de um produto funcional proporciona uma oportunidade de contribuir para a melhoria da qualidade dos alimentos assim como da saúde dos consumidores (AL-SHERAJI et al., 2013; ARCIA et al., 2010; HASLER, 1998; MILNER, 1999). Novos produtos funcionais são desenvolvidos modificando as fórmulas tradicionais de alimentos, eliminando ou substituindo alguns ingredientes, ou por meio da adição de compostos saudáveis. As sobremesas lácteas foram estudadas recentemente (ARCIA et al., 2010; ARES et al., 2009; ARES et al., 2012; GONZÁLEZ-TOMÁS et al., 2009) e a adição de ingredientes prebióticos em alimentos lácteos processados é uma realidade (CRUZ et al., 2013; ISIK et al., 2011; PIMENTEL et al., 2013;) e tem sido explorado pela indústria alimentar.

Produtos desenvolvidos com sacarose geralmente distinguem-se pela aparência e sabor. Além do sabor doce, a sacarose aumenta a viscosidade e confere textura e estabilidade adequadas (ALONSO e SETSER, 1994; NABORS, 2012). Pesquisas de alimentos com adição de edulcorantes para substituição da sacarose, ou adição de novos ingredientes, são muito relevantes e também apresentam uma importante contribuição científica para o conhecimento da ciência sensorial, pois a substituição ou adição de um novo ingrediente pode apresentar variações na performance sensorial em função da modificação na matriz alimentar (DI MONACO et al., 2013; HEIKEL et al., 2012; PALAZZO e BOLINI, 2014).

Diante da constante procura dos consumidores por alimentos mais saudáveis, capazes de agregar benefícios à saúde, e aliados ao prazer, o objetivo deste trabalho foi desenvolver sobremesas lácteas cremosas sabor chocolate com propriedades funcionais, devido aos efeitos benéficos dos prebióticos, e com substituição total do açúcar (*diet*) por edulcorantes; assim como avaliar este produto sensorialmente, estabelecendo o perfil sensorial e sua aceitação por consumidores, e por meio de análises físico-químicas e de composição centesimal.

O presente trabalho foi submetido e aceito pelo Comitê de Ética (FCM/UNICAMP) sob o nº 73256/2012, seguindo as normas da Resolução nº196 de 10/10/1996 e suas complementares, descritas pelo CONEP (Comissão Nacional de Ética em Pesquisa) e Conselho Nacional de Saúde (Brasília/DF).

Este trabalho será apresentado conforme descrito a seguir:

Revisão Bibliográfica. Apresenta uma revisão sobre a definição e mercado das sobremesas lácteas; características e legislação; descrições e características dos alimentos funcionais, dos prebióticos e em maior ênfase inulina e frutooligossacarídeos; descrição e importância dos edulcorantes, especialmente sucralose, aspartame, estévia e neotame;

uma abordagem sobre análise sensorial de alimentos e métodos de avaliação sensorial; e uma breve revisão sobre as metodologias de análise estatística.

Artigo 1. Development of Chocolate Dairy Dessert with Addition of Prebiotics and Replacement of Sucrose by Different High Intensity Sweeteners. *Artigo publicado na revista Journal of Dairy Science*. Neste artigo está apresentado o estudo da formulação das sobremesas lácteas cremosas sabor chocolate, para avaliar o efeito das variáveis (i) concentração de gomas e (ii) concentração de prebióticos, nas propriedades sensoriais (ideal de cremosidade e impressão global). Também apresenta a determinação da doçura ideal e os testes de estimativa de magnitude para determinar as concentrações dos edulcorantes que substituem a concentração ideal de sacarose.

Artigo 2. PARAFAC and PCA preference map provides similar configuration regarding prebiotic low sugar chocolate dairy desserts. *Artigo submetido para publicação na Journal of Dairy Science*. Neste estudo foi realizado um teste afetivo de aceitação com as seis formulações de sobremesa láctea cremosa sabor chocolate avaliadas por consumidores em relação à aparência, aroma, sabor, textura e impressão global. Os dados da aceitação foram avaliados por Análise de Componentes Principais (PCA) e PARAFAC; os métodos de avaliação foram comparados. Análises físicas de cor e textura também foram realizadas e avaliadas.

Artigo 3. Multiple Time-Intensity Analysis and Temporal Dominance of Sensations of Chocolate Dairy Dessert Using Prebiotic and Different High Intensity Sweeteners. *Artigo submetido para publicação na Journal of Sensory Studies*. Neste artigo a qualidade das sobremesas lácteas cremosas sabor chocolate foi analisada através da aplicação das metodologias de análise de tempo-intensidade (TI) e *temporal dominance of sensations* (TDS).

Artigo 4. Prebiotic and Diet/Light Chocolate Dairy Dessert: Chemical Composition, Sensory Profiling and Relationship with Consumer Expectation. *Artigo submetido para publicação na LWT – Food Science and Technology*. Neste estudo, os direcionadores de preferência das sobremesas lácteas cremosas sabor chocolate foram identificados. 120 consumidores avaliaram as amostras de sobremesa em relação à impressão global utilizando teste de aceitação. O perfil sensorial das sobremesas foi avaliado por 14 provadores selecionados e treinados utilizando a análise descritiva quantitativa (ADQ). Os dados da ADQ foram avaliados por Análise de Componentes Principais (ACP), e uma regressão por quadrados mínimos parciais (PLS) foi realizada para identificar os direcionadores de preferência das sobremesas, utilizando dados da ADQ e de impressão global do teste de aceitação.

Artigo 5. Influence of functional and diet/light claims on chocolate dairy dessert consumers' evaluations: bi- and multi-linear decomposition methods. *Artigo submetido para publicação na Journal of Sensory Studies*. Neste artigo, o efeito da alegação de propriedade funcional na aceitação de sobremesas lácteas cremosas sabor chocolate foi avaliado. 100 consumidores participaram do teste de aceitação em relação aos atributos de aparência, aroma, sabor, textura e impressão global. A técnica de mapa de preferência interno utilizando PARAFAC e a de análise de componentes principais (ACP) foram empregadas utilizando os dados do teste de aceitação. Os resultados obtidos foram comparados.

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REVISÃO BIBLIOGRÁFICA

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1. Sobremesas lácteas

As sobremesas lácteas se enquadram como "alimentos prontos para consumo". Do ponto de vista regulatório (BRASIL, 2005), alimentos semiprontos ou prontos para consumo "são os alimentos preparados ou pré-cozidos ou cozidos, que para o seu consumo não necessitam da adição de outro(s) ingrediente(s). Podem requerer aquecimento ou cozimento complementar".

Uma ampla variedade de sobremesas lácteas prontas para comer estão disponíveis no mercado, oferecendo uma grande variedade de texturas, sabores e aparências (DEPYPERE et al., 2009). Estas variações ocorrem devido à utilização de diferentes ingredientes, equipamentos e condições de processo (VERBEKEN et al., 2006), os quais influenciam as características nutricionais, físico-químicas e sensoriais, com impacto direto na aceitação pelos consumidores (ARCIA et al., 2011).

As sobremesas lácteas são produtos consumidos em todo o mundo, e suas diferentes características nutricionais e sensoriais estimulam e favorecem seu consumo por diversos grupos de consumidores, incluindo crianças e idosos (BRUZZONE et al., 2011; CARDARELLI et al., 2008; TÁRREGA e COSTELL, 2007).

1.1. Tendências de mercado

O mercado de sobremesas está crescendo rapidamente, com muitos novos produtos e conceitos. Produtos prontos para servir, porções individuais e fáceis de preparar são tendências. Uma nova tendência para sobremesas lácteas é a linha "leve" (*slim-line*). Elas atendem à demanda dos consumidores por produtos doces, considerados de luxo, com baixo teor de gordura e calorias. Servidas com frutas frescas ou da própria maneira que é oferecida, podem ser desfrutadas com pouca preocupação e ajuste perfeito para todas as ocasiões (ARCIA et al., 2010; ARES et al., 2010).

Estudos de mercado dos alimentos indicam que o aumento do consumo de sobremesas prontas para consumo está fortemente influenciado por preocupações com a saúde. O envelhecimento das populações e famílias com menor número de membros também estimulou o crescimento do mercado de alimentos de conveniência, tais como sobremesas geladas e prontas para consumo. Os hábitos dos consumidores estão se tornando mais diversificados e sofisticados, e os produtos de conveniência são garantia de sucesso (MAGALHÃES, 2008).

O mercado busca formas de incluir alimentos mais saudáveis e os consumidores estão cada vez mais exigentes, em busca de uma alimentação equilibrada e prazerosa. Este fato viabiliza o desenvolvimento de sobremesas com características funcionais (HENRIQUE et al., 2009). Os ingredientes inovadores e os sistemas tecnológicos aplicados nas fábricas de laticínios têm proporcionado novas alternativas às sobremesas lácteas contribuindo para a produção de sobremesas de maior digestibilidade e valor nutritivo (ARCIA et al., 2011; MERCER et al., 2008), podendo ser consideradas como excelente veículo para a incorporação de prebióticos (BAYARRI et al., 2010; CARDARELLI et al., 2008).

1.2. Tipos de sobremesas lácteas

De acordo com SAUNDERS (2011), em um nível básico, a maioria das sobremesas lácteas são produzidas com cinco ingredientes principais: água, leite, gordura (láctea e/ou vegetal), modificadores de textura, e sabor/cor. O tipo/combinação dos modificadores de textura, assim como os parâmetros de processamento, irão determinar a forma e funcionalidade da sobremesa final, que serão divididas em: sobremesas cremosas; pudins; sobremesas em pó (que devem ser batidas com leite); sobremesas aeradas (mousses) e outras sobremesas lácteas (regionais).

2. Hidrocolóides

Os agentes de textura são de grande importância para se obter a desejada consistência e textura de uma sobremesa láctea. O termo hidrocolóide (ou colóide hidrofílico) é utilizado para descrever uma variedade de espessantes e/ou gelificantes de sistemas aquosos. Tais substâncias são polímeros de alto peso molecular, solúveis/dispersas em água. A capacidade de formar gel ou espessamento da fase aquosa de cada hidrocolóide é dependente de vários fatores. O espessamento é, em grande parte, dependente da concentração, temperatura e pH, enquanto a capacidade de formar gel envolve, normalmente, uma interação com íons específicos (SAUNDERS, 2011).

Algumas características dos hidrocolóides (goma xantana e goma guar) utilizados na formulação das sobremesas lácteas cremosas sabor chocolate são abordados a seguir.

2.1. Goma xantana

A goma xantana é um aditivo alimentar identificado como INS 415 ou E-415, e como tal pode ser utilizado numa variedade de alimentos como espessante, estabilizante, emulsionante e espumante (FAO/WHO, 2013).

Foi descoberta em 1950, por pesquisadores do *Northern Regional Research Laboratory* (NRRL), do Departamento de Agricultura dos Estados Unidos (BORN, LANGENDORFF e BOULENGUER, 2002), em um estudo para identificação de microrganismos que produzem gomas de interesse comercial, solúveis em água. O polissacarídeo B-1459, ou goma xantana, produzido pela bactéria *Xanthomonas campestris* pv campestris NRRL B–1459 foi extensamente estudado por apresentar propriedades espessantes e estabilizantes.

A partir de 1960, pesquisas foram realizadas em alguns laboratórios industriais, culminando na produção semicomercial da goma Kelzan pela empresa Kelco (Estados Unidos) (GARCÍA-OCHOA et al., 2000) e, em 1964, a produção comercial do polímero para propósito industrial tornou-se viável, para a aplicação em produtos não alimentícios (HARDING, CLEARY e IELPI, 1994). Em 1969, a goma xantana foi aprovada pelo FDA (*Food and Drug Administration*) para uso como estabilizante, emulsificante e espessante em alimentos (ROCKS, 1971).

Sua utilização em alimentos tornou-se crescente com o passar dos anos. Diversos estudos têm sido realizados com a utilização da goma xantana em produtos alimentícios, como caramelo (KRYSTYJAN et al., 2012), pastas de amido de milho (HEYMAN et al., 2014), filmes comestíveis à base de gelatina (GUO et al., 2014) e suco de maçã (PAQUET et al., 2014).

2.2. Goma guar

A goma guar é um heteropolissacarídeo, extraída do endosperma (parte da semente) do vegetal de espécie *Cyamoposis psoraloides*, originária da Índia e do Paquistão. Possui alto peso molecular, é formada de cadeia linear de manose (β-1,4) com resíduos de galactose como cadeias laterais, na proporção de uma unidade de galactose para duas de manose. Quanto maior a relação molar galactose/manose, maior a solubilidade em água fria. Desde 1950, as sementes da planta de onde se extrai o guar têm sido usadas como aditivo alimentar, espessante ou como fibra alimentar (RODGE et al., 2011; SANDERSON, 1996).

É um aditivo amplamente usado pelas indústrias alimentícias e de outros segmentos também, pois em contato com a água forma uma solução altamente viscosa. Não forma gel, mas atua como espessante e estabilizante. A viscosidade de suas soluções aumenta exponencialmente com o aumento da concentração da goma em água fria, sendo influenciada por temperatura, pH, tempo, grau de agitação (cisalhamento), tamanho da partícula da goma e presença de sais e outros sólidos. É instável a pH muito baixo. À baixas concentrações confere cremosidade (DAMODARAN et al., 2010), o que é uma propriedade muito importante para a formulação da sobremesa láctea cremosa sabor chocolate.

A goma guar é compatível com outras gomas, amidos, hidrocolóides e agentes geleificantes, aos quais pode ser associada para enriquecer a sensação tátil bucal, textura e para modificar e controlar o comportamento da água em alimentos. É indicada para uso no preparo de sorvetes, cremes, produtos à base de queijo, molhos, sopas e produtos de panificação (RODGE et al., 2011; SANDERSON, 1996).

Estudos recentes têm sido realizados com a aplicação da goma guar em alimentos, tais como óleo de menta (SARKAR et al., 2012), soluções de sacarose (GALMARINI et al., 2011), espaguete de trigo (ARAVIND et al., 2012), farinha de castanha (TORRES et al., 2013) e iogurtes (TONIAZZO et al., 2014).

3. Alimentos Funcionais

O mercado de alimentos funcionais tem crescido em todo o mundo, oferecendo produtos que podem afetar positivamente o bem estar dos consumidores (GOETZKE et al., 2014). Novos produtos são lançados continuamente e a concorrência torna-se cada vez mais intensa (MENRAD, 2003; ARES et al., 2010) e um fator importante é a saúde, que é considerada como motivação importante para o consumo destes alimentos (CHEN, 2011; SZAKÁLY et al., 2012).

Um alimento pode ser considerado funcional se for demonstrado que o mesmo pode afetar beneficamente uma ou mais funções alvo no corpo, além de possuir os adequados efeitos nutricionais, de maneira que seja relevante tanto para o bem estar e a saúde quanto para a redução do risco de uma doença (ROBERFROID, 2002; ROBERFROID, 2005; ROBERFROID et al., 2010).

A conceituação e uso de alimentos funcionais ganhou impulso na década de 80, no Japão, com o programa FOSHU ("*Foods for Specified Health Use*") que visava a redução de custos com medicamentos, e por meio do qual os alimentos deveriam ser baseados em ingredientes naturais, ser consumidos como parte da dieta alimentar, e cumprir funções específicas no organismo, como a melhoria dos mecanismos de defesa biológica, ou prevenção de algum tipo de doença (ANJO, 2004; ROBERFROID et al., 2010).

De acordo com MORAES e COLLA (2006) os alimentos e ingredientes funcionais podem ser classificados de dois modos: quanto à fonte, de origem vegetal ou animal, ou quanto aos benefícios que oferecem, atuando em seis áreas do organismo: no sistema gastrointestinal; no sistema cardiovascular; no metabolismo de substratos; no crescimento; no desenvolvimento e diferenciação celular; e no comportamento das funções fisiológicas e como antioxidantes.

A Portaria nº398 de 30/04/99, da Secretaria de Vigilância Sanitária do Ministério da Saúde no Brasil fornece a definição legal de alimento funcional: "todo aquele alimento ou ingrediente que, além das funções nutricionais básicas, quando consumido como parte da dieta usual, produz efeitos metabólicos e/ou fisiológicos e/ou efeitos benéficos à saúde, devendo ser seguro para consumo sem supervisão médica” (BRASIL, 1999a).

A regulamentação dos alimentos funcionais é feita pela Agência Nacional de Vigilância Sanitária (ANVISA), que em 1999 publicou duas resoluções relacionadas aos alimentos funcionais:

- Resolução ANVISA/MS nº18, de 30/04/1999 (republicada em 03/12/1999): aprova o regulamento técnico que estabelece as diretrizes básicas para análise e comprovação de propriedades funcionais e/ou de saúde alegadas em rotulagem de alimentos (BRASIL, 1999b).
- Resolução ANVISA/MS nº19, de 30/04/1999 (republicada em 10/12/1999): aprova o regulamento técnico de procedimentos para registro de alimento com alegação de propriedades funcionais e/ou de saúde em sua rotulagem (BRASIL, 1999c).

As evidências científicas sobre a relação entre alimentação e saúde têm contribuído para o aparecimento deste novo segmento alimentar de rápida expansão nos últimos anos: o mercado dos alimentos funcionais (SZAKÁLY et al., 2012).

Há um interesse por parte da população em manter ou melhorar o estado de saúde por meio do consumo de alimentos tradicionais incorporados de ingredientes bioativos (CHEN, 2011; PALANCA et al., 2006). Dentre esses ingredientes encontram-se os probióticos e os prebióticos, vistos como promotores de saúde e que podem estar associados à redução do risco de doenças crônicas degenerativas e não transmissíveis.

Os prebióticos foram utilizados no presente trabalho devido às suas características já estudadas como substitutos de gordura (RODRÍGUEZ-GARCÍA et al., 2014) e açúcar

(AIDOO et al., 2014), e com o intuito de agregar valor às sobremesas lácteas cremosas, por proporcionar benefícios à saúde do consumidor (ROBERFROID et al., 2014).

3.1. Prebióticos

A atenção mundial que tem sido dada à saúde vem refletindo também nos hábitos alimentares de toda a população mundial. Produtos mais saudáveis e com alegações de propriedades funcionais e/ou de saúde ganham destaque nas pesquisas, no desenvolvimento de novos produtos e nos supermercados (GOETZKE et al., 2014).

O conceito de prebióticos foi introduzido em 1995 por Gibson e Roberfroid como uma abordagem alternativa para a modulação da microbiota intestinal (GIBSON e ROBERFROID, 1995). Uma definição mais recente do termo é "um ingrediente seletivamente fermentado que permite mudanças específicas, tanto na composição e/ou atividade da microbiota gastrointestinal, que confere benefícios de bem estar e saúde" (GIBSON et al., 2004).

De acordo com a legislação brasileira, prebióticos podem ser definidos como: "todo ingrediente alimentar não digerível que afeta de maneira benéfica o organismo por estimular seletivamente o crescimento e/ou atividade de um ou um número limitado de bactérias do cólon" (BRASIL, 1999c). É uma substância que modifica a composição da microbiota colônica, de tal forma que as bactérias com potencial de promoção de saúde tornam-se a maioria predominante (STEFE et al., 2008).

As características necessárias para uma substância ser considerada prebiótica são: resistência às enzimas salivares, pancreáticas e intestinais, bem como ao ácido estomacal; não deve sofrer hidrólise enzimática ou absorção no intestino delgado; quando atingir o cólon deve ser metabolizado seletivamente por número limitado de bactérias benéficas;

deve ser capaz de alterar a microbiota colônica para uma microbiota bacteriana saudável e ser capaz de induzir efeito fisiológico relevante para a saúde (STEFE et al., 2008).

Os prebióticos passam pelo intestino delgado para o intestino grosso e tornam-se acessíveis por bactérias probióticas sem serem utilizados por outras bactérias intestinais. Lactulose, galactooligossacarídeos, frutooligossacarídeos, inulina e os seus hidrolisados, maltooligossacarídeos, e amido resistente, são prebióticos normalmente utilizados na dieta humana. Os componentes finais essenciais para o metabolismo de hidratos de carbono são os ácidos graxos de cadeia curta, particularmente o ácido acético, ácido propiônico e ácido butírico, que são utilizados pelo organismo hospedeiro, como uma fonte de energia. Eles também podem ser encontrados em diferentes fontes, como chicória, cebola, alho, aspargo, alcachofra, alho-poró, bananas, tomates e muitas outras plantas (CAPRILES et al., 2006; SHERAJI et al., 2013).

Os prebióticos têm sido associados com uma variedade de benefícios para a saúde, incluindo um aumento na biodisponibilidade de minerais, especialmente o cálcio (ROBERFROID et al., 2010), a modulação do sistema imune (LOMAX e CALDER, 2009; SEIFER e WATZL, 2007), prevenção da incidência ou melhoria na gravidade e duração das infecções gastrointestinais, como diarreia do viajante, diarreia aguda e diarreia associada a antibióticos (LOMAX e CALDER, 2009), modificação de condições inflamatórias, como a síndrome do intestino irritável, colite ulcerativa e doença inflamatória intestinal (HEDIN et al., 2007; SPILLER, 2008; STEED et al., 2008), a regulação de distúrbios metabólicos relacionados com a obesidade (CANI et al., 2009; PARNELL e REIMER, 2009; PETERS et al., 2009), e a redução do risco de câncer (LIONG, 2008).

Além das propriedades benéficas à saúde, os prebióticos podem ser usados em formulações de sorvetes e sobremesas lácteas, em formulações para diabéticos, em produtos funcionais que promovam efeito nutricional adicional, iogurtes, biscoitos e demais produtos de panificação, substituindo carboidratos e gerando produtos de teor reduzido de açúcar (BORTOLOZO e QUADROS, 2007; CAPRILES et al., 2006; MANSO et al., 2008; PIMENTEL et al., 2005; ROBERT et al., 2008; RONKART et al., 2009).

A adição de ingredientes prebióticos é uma realidade para alimentos lácteos processados (CRUZ et al., 2013; PIMENTEL et al., 2013; ISIK et al., 2011) e tem sido explorado pela indústria alimentar.

3.1.1. Inulina e frutooligossacarídeos (FOS)

ROBERFROID et al. (2010) mostraram que os frutanos do tipo inulina, tais como inulina e frutooligossacarídeos (FOS), e galactooligossacarídeos (GOS) exibem efeitos prebióticos. Muitas espécies de plantas, tais como chicória (*Chicorium intybus*), cebola, alcachofra de Jerusalém (*Helianthus tuberosus*), e yacon, contém frutanos do tipo inulina como carboidratos de reserva (BHATIA e RANI, 2007; CARABIN e FLAMM, 1999).

Os frutanos são hidratos de carbono que consistem em uma ou mais unidades de frutose ligadas ou não a uma molécula de sacarose terminal, que pode ter uma estrutura linear ou ramificada com moléculas unidas por ligações frutosil-frutose, do tipo $\beta(2\rightarrow1)$ ou $\beta(2\rightarrow6)$. Os frutanos do tipo inulina são divididos de acordo com o seu grau de polimerização em inulina, com grau de polimerização de 10 a 60 unidades de monossacarídeos e compostos relacionados, e FOS, com um grau de polimerização inferior a 10 unidades (ROBERFROID e SLAVIN, 2001).

Para a incorporação de prebióticos em alimentos, estes não devem afetar negativamente as propriedades organolépticas do produto, e devem ser estáveis durante o processamento (CHARALAMPOPOULOS e RASTALL, 2012). Entre os prebióticos estabelecidos, a inulina é utilizada na indústria alimentícia como substituto de gordura ou modificador de textura. Possui solubilidade moderada em água, o que é conveniente para a sua incorporação em sistemas alimentares líquidos, apresenta sabor neutro e é ligeiramente doce (FRANCK, 2008).

Devido às suas propriedades, tem sido utilizada principalmente em produtos lácteos com baixo teor de gordura, incluindo leites fermentados, iogurtes, sobremesas lácteas, queijos e sorvetes (GONZÁLEZ-TOMÁS et al., 2009; KUSUMA et al., 2009; ARCÍA et al., 2010; BURITI et al., 2010; ARCIA et al., 2011; MEYER et al., 2011), como substituto de gordura, e em produtos de panificação como modificadores de textura, muitas vezes em combinação com fibras dietéticas (DUTCOSKY et al., 2006; ANGIOLONI e COLLAR, 2008; HAGER et al., 2011; RODRÍGUEZ-GARCÍA et al., 2014).

As propriedades físico-químicas da inulina dependem consideravelmente do seu grau de polimerização; quanto mais longas as cadeias (grau de polimerização maior que 10), mais forte o gel, o que leva a uma melhor sensação de corpo e preenchimento na boca (VORAGEN, 1998; ARYANA et al., 2007; FRANCK, 2008; TÁRREGA et al., 2011); isto é devido ao fato de que as cadeias mais longas possuem uma menor solubilidade e, portanto, irá cristalizar mais rapidamente (MEYER et al., 2011). A estrutura química da inulina está representada a seguir:

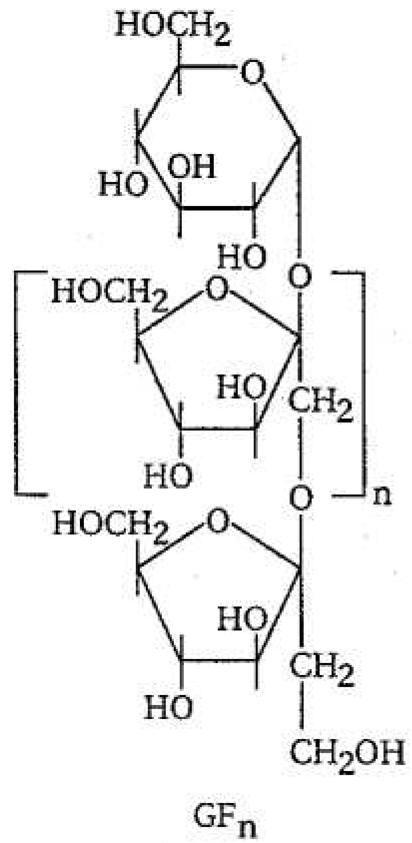

Figura 1. Estrutura química da inulina.

Fonte: ROBERFROID, 1993

Os frutooligossacarídeos (FOS) são muito mais solúveis do que a inulina. São mais doces (30-35% em comparação com a sacarose) e têm propriedades tecnológicas semelhantes à sacarose e xaropes de glicose; como resultado, eles são frequentemente utilizados como substitutos de açúcar (BOSSCHER, 2009). Os FOS já têm sido aplicados em uma variedade de produtos lácteos, pois são considerados ingredientes ideais para dar massa com menos calorias e aumentar o valor funcional, sem comprometer o sabor e a sensação na boca provocada pelo produto (FRANCK, 2008). Eles também têm sido utilizados em pães e produtos de panificação para substituir o açúcar e reter a umidade do produto (MUJOO e NG, 2005; RONDA et al., 2005).

Em relação aos galactooligossacarídeos (GOS), existem poucos exemplos comerciais de produtos alimentícios contendo GOS, e muito pouca informação sobre o impacto do GOS sobre as propriedades físico-químicas de alimentos (CHARALAMPOPOULOS e RASTALL, 2012). Eles são, no entanto, como outros oligossacarídeos, muito solúveis em água, levemente doces, e podem ser utilizados para melhorar as propriedades de textura de produtos lácteos, como iogurtes (SANGWAN et al., 2011). Eles também são ingredientes adequados para uso em pão e produtos de padaria, devido à sua elevada capacidade de retenção de umidade (TORRES et al., 2010), assim como na produção de sucos de frutas, devido à alta estabilidade ácida.

4. Alimentos para Fins Especiais

Os alimentos para fins especiais são aqueles especialmente formulados ou processados, nos quais se realizam modificações no conteúdo de nutriente a fim de atender às necessidades nutricionais de pessoas em condições metabólicas e fisiológicas específicas, como por exemplo, diabéticos e hipertensos (BRASIL, 1998).

Nos últimos anos, o aumento da mortalidade relacionada com a obesidade resultou em uma onda de produtos e dietas para perda de peso. É amplamente entendido que, de muitos fatores que contribuem, uma dieta rica em açúcar e alto teor de gordura é, parcialmente, culpa para a obesidade crescente e problemas de saúde relacionados, tais como diabetes mellitus tipo II, doença cardiovascular, hipertensão e certos tipos de câncer (MENDENDEZ et al., 2009; TANDEL, 2011).

Como resultado das diversas condições negativas de saúde, associadas com o consumo excessivo de açúcar, têm havido um aumento no consumo de edulcorantes como alternativa (ZYGLER et al., 2011). O consumo de alimentos que contenham edulcorantes aumentou entre as pessoas de todas as idades, com 28% de toda população relatando a ingestão (SYLVETSKY et al., 2012).

O aumento da incidência de obesidade e problemas de saúde relacionados, principalmente diabetes mellitus tipo II e doenças cardiovasculares, resultaram em um aumento da produção e consumo de alimentos com edulcorantes. O princípio fundamental baseia-se no fato de que os indivíduos podem desfrutar de alimentos e bebidas, sem o risco de consumir calorias adicionais. Os edulcorantes já podem ser encontrados na maioria dos produtos alimentícios, tais como bebidas, sorvetes, gomas de mascar, chocolates, geleias, iogurtes e molhos para saladas (SHANKAR et al., 2013).

De acordo com VENTURA (2010), atualmente, 80% dos jovens afirmam, em pesquisas, procurar alimentos mais saudáveis e naturais, sendo que 35% dos domicílios brasileiros consomem produtos *diet* e *light*. Esse fato pode ser constatado nas gôndolas dos supermercados, uma vez que é ofertada uma variedade cada vez maior de alimentos e bebidas classificados como *diet* e *light*. Os produtos vão desde leite, iogurtes, pães, geleias, refrigerantes, requeijão, chocolates, barras de cereais, até comidas pré-cozidas.

4.1. Edulcorantes

A preferência pelo sabor doce é inata, e adoçantes podem aumentar o prazer de comer. Adoçantes nutritivos contêm carboidratos e fornecem energia. Eles ocorrem naturalmente nos alimentos, ou podem ser acrescentados no processamento de alimentos, ou pelos consumidores antes do consumo. A maior ingestão de açúcares adicionados é associada com maior consumo de energia e menor qualidade da dieta, o que pode aumentar o risco de obesidade, pré-diabetes, diabetes tipo II e doenças cardiovascular (AND, 2012).

As substâncias edulcorantes são consideradas não calóricas pelo fato de não serem metabolizadas pelo organismo, ou por serem utilizadas em quantidades tão pequenas, que o aporte calórico torna-se insignificante. Devido a estas características são consideradas indispensáveis aos regimes dietéticos, caracterizado pelo diabetes, ou a dietas de perda ou manutenção do peso corporal (AND, 2012; CAVALLINI e BOLINI, 2005).

Uma grande variedade de edulcorantes estão disponíveis, e são diferenciados com base no fato de serem de alta intensidade, de baixas calorias, de elevada potência, e/ou não nutritivos (ZYGLER et al., 2011). Os edulcorantes são conhecidos por serem, pelo menos, 30 a 13.000 vezes mais doces, comparados com o açúcar (sacarose). Esta doçura intensa permite menores porções para obtenção da doçura em produtos alimentares, permitindo assim ao fabricante classificá-los como “sem açúcar” ou “não calórico” (ZYGLER et al., 2011).

De acordo com a Resolução RDC nº 3, da Anvisa, de 02/01/2001, os edulcorantes permitidos pela legislação brasileira (BRASIL, 2001) para adição em alimentos são divididos em dois grandes grupos: edulcorantes naturais, os quais compreendem o sorbitol, manitol, isomaltose, esteviosídeo, maltitol, lactitol e xilitol; e edulcorantes artificiais, sendo eles: acessulfame-k, ciclamato monossódico, sacarina sódica, aspartame e sucralose. Recentemente, foram liberados para uso no Brasil os edulcorantes neotame, taumatina e eritritol (BRASIL, 2008), segundo Resolução nº18, da Anvisa, de 24/03/2008.

A elaboração e aprovação de uma variedade de edulcorantes com baixas calorias proporciona à indústria a oportunidade de atender a demanda crescente do consumidor por produtos *light/diet*. A doçura percebida é dependente e pode ser modificada por alguns fatores. A composição química e física do meio em que o adoçante é dispersa influencia o sabor e intensidade. A concentração do edulcorante, a temperatura na qual o produto é consumido, o pH, os outros ingredientes do produto, e a sensibilidade do provador são todos fatores importantes (NABORS, 2012).

Estudos de produtos com adição de edulcorantes para substituição da sacarose são muito relevantes, e são uma importante contribuição científica para o conhecimento da ciência sensorial, pois a potência adoçante e respectiva performance sensorial pode apresentar variações, em função da matriz alimentar de diferentes produtos (HEIKEL et al., 2012; DI MONACO et al., 2013).

Diversos estudos têm sido realizados, em diferentes produtos alimentícios, com este intuito de substituir a sacarose por diferentes edulcorantes, tais como em chocolate (PALAZZO e BOLINI, 2014), geleia (DE SOUZA et al., 2013), queijos tipo Petit Suisse (SOUZA et al., 2011; ESMERINO et al., 2013), sorvete (CADENA et al., 2012), café (MORAES e BOLINI, 2010), gelatina (PALAZZO e BOLINI, 2009) e néctar de pêssego (CARDOSO e BOLINI, 2007).

4.1.1. Sacarose

As propriedades dos açúcares estão diretamente relacionadas com a estrutura química deles e, portanto, é com base nelas que é possível escolher qual açúcar ou carboidrato será utilizado para a fabricação de um determinado alimento (AND, 2012).

A sacarose é o dissacarídeo mais consumido, e ocorre naturalmente em frutas e legumes, sendo suas principais fontes a cana-de-açúcar e a beterraba. É composta por glicose e frutose em partes aproximadamente iguais (Figura 2) e é utilizada como adoçante nutritivo e para outras propriedades funcionais (MELO FILHO e VASCONCELOS, 2011).

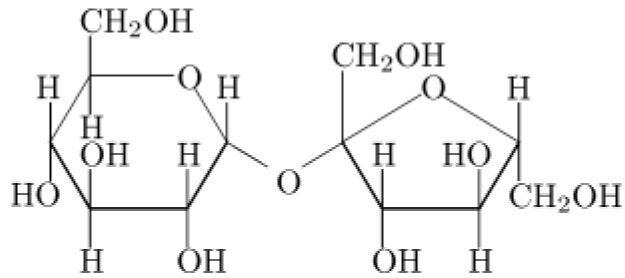

Figura 2. Estrutura química da sacarose.

Fonte: MELO FILHO e VASCONCELOS, 2011.

A sacarose faz-se importante também pela sua ampla aceitabilidade, palatabilidade, alta disponibilidade e baixo custo de produção (AND, 2012; MORI, 1992). Foi adotada como padrão de doçura relativa e perfil de sabor, pois sua doçura é rapidamente percebida (entre um e dois segundos), persistindo por aproximadamente trinta segundos, sem deixar gosto residual (AND, 2012; KETELSEN, KEAY e WIET, 1993).

4.1.2. Sucralose

A sucralose é um dissacarídeo obtido pela cloração da molécula da sacarose (Figura 3). Foi aprovada pela *Food and Drug Administration* (FDA) para utilização como edulcorante de mesa e de uma série de sobremesas e bebidas em 1998, e como edulcorante de utilização geral, em 1999 (AND, 2012; SHABERT et al., 2005). No Brasil, é permitida para alimentos e bebidas desde 1995 (GOLDSMITH e MERKEL, 2001).

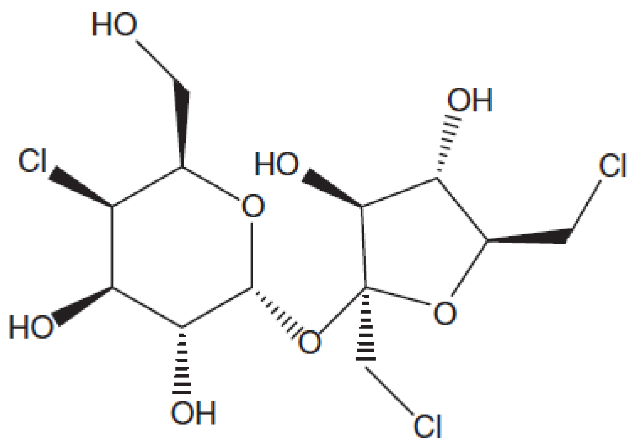

Figura 3. Estrutura química da sucralose.

Fonte: GROTZ et al., 2012.

É um edulcorante não calórico e apresenta características singulares como alto poder edulcorante, alta estabilidade e isenção de calorias (TASHIMA e CARDELLO, 2003; NACHTIGALL e ZAMBIAZI, 2006). A potência da sucralose é da ordem de 600 vezes em relação à sacarose; caracteriza-se pelo sabor semelhante ao da sacarose e ausência de gosto residual desagradável (GROTZ et al., 2012).

Devido às características apresentadas e excelentes aspectos físico-químicos e sensoriais, a sucralose pode ser utilizada em uma grande variedade de produtos, tais como produtos de panificação, pudins, gelatinas, cafés, chás, gomas de mascar, leites aromatizados e fermentados, entre outros (GROTZ et al., 2012).

4.1.3. Aspartame

Aspartame é uma molécula composta por dois aminoácidos (L-aspártico e L-fenilalanina), ligados por um éster de metila (Figura 4). Foi descoberto em 1965 e aprovado pela *Food and Drug Administration* (FDA), em 1981, para uso em alimentos específicos e, em 1983, para uso em refrigerantes. Em 1996, foi aprovado como edulcorante de uso geral

(AND, 2012). Atualmente, estima-se que o aspartame é utilizado em cerca de 6.000 produtos diferentes no mundo todo (ABEGAZ et al., 2012).

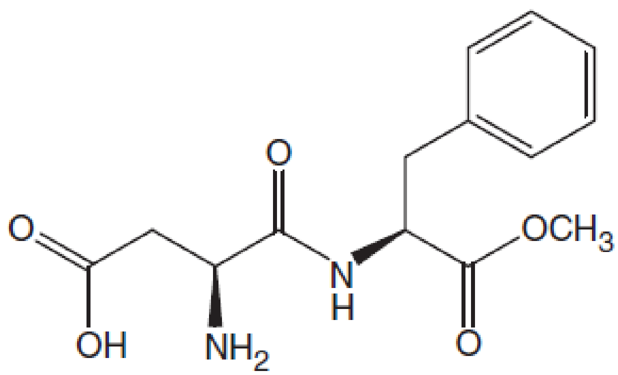

Figura 4. Estrutura química do aspartame.

Fonte: ABEGAZ et al., 2012.

A potência adoçante do aspartame é da ordem de 160 a 220 em relação à sacarose, podendo variar dependendo do sistema de sabor, do pH, e da quantidade de sacarose ou de outros açúcares a serem substituídas (BECK, 1978; ABEGAZ et al., 2012; AND, 2012).

Sua estabilidade é determinada pelo tempo, umidade, temperatura e pH. O aspartame pode suportar o processamento térmico utilizado para produtos lácteos e sucos, processamento asséptico, e outros processos onde são empregadas as condições de alta-temperatura em curto-tempo. No entanto, a capacidade do aspartame em hidrolisar ou ciclizar pode, sob algumas condições de calor excessivo, limitar algumas aplicações do mesmo (ABEGAZ et al., 2012).

4.1.4. Neotame

O neotame resultou de um programa de pesquisa de longo prazo, projetado para descobrir os adoçantes de alta potência com características otimizadas de desempenho.

Cientistas franceses inventaram o neotame a partir de uma simples N-alquilação do aspartame (Figura 5) (NOFRE e TINTI, 1991; GLASER et al., 1995; NOFRE e TINTI, 2000). Atualmente, está aprovado para utilização em 69 países em todo o mundo (MAYHEW et al., 2012).

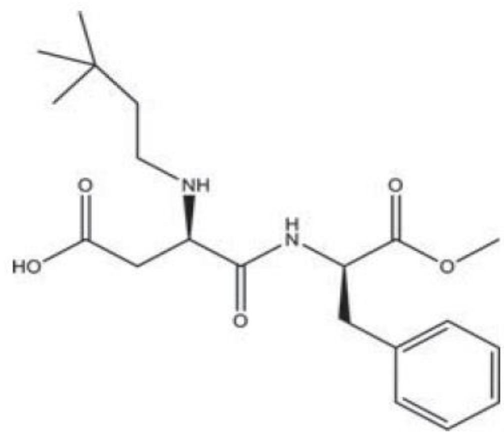

Figura 5. Estrutura química do neotame.

Fonte: MAYHEW et al., 2012.

É um adoçante de elevada potência, sendo de 7.000 a 13.000 vezes mais doce do que a sacarose, e intensificador de sabor. Fornece zero caloria; tem um sabor doce limpo, sem características de sabor indesejáveis, como residual amargo ou metálico; é funcional e estável em uma ampla variedade de bebidas e alimentos. Dada a sua elevada potência e baixo consumo requerido, resultado em aplicações alimentares e de bebidas, o neotame provou ser um dos adoçantes de maior custo-benefício no mercado (MAYHEW et al., 2012).

4.1.5. Extratos de folha de estévia

O esteviosídeo é um adoçante natural, não calórico, de alta pureza, obtido das folhas da *Stevia rebaudiana* (Bert.) Bertoni, uma planta da América do Sul. Quimicamente é um glicosídeo do esteviol (Figura 6), um diterpeno tetracíclico da classe dos cauranos (YODA et al., 2003; CARAKOSTAS et al., 2012).

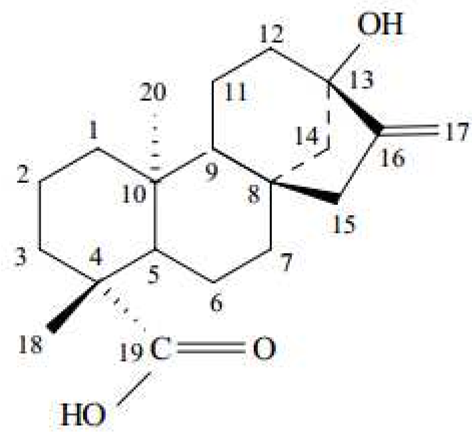

Figura 6. Estrutura química do esteviosídeo.

Fonte: CARAKOSTAS et al., 2012.

Por ser um produto de origem vegetal, ou natural, o extrato de folha de estévia é largamente apreciado pelos consumidores em geral, sendo de grande interesse para a indústria global de alimentos (CARAKOSTAS et al., 2012). Apresenta-se de 110 a 300 vezes mais doce que a sacarose, sendo o extrato composto pelo esteviosídeo e por seus anômeros, os rebaudiosídeos (KINGHORN, WU e SOEJARTO, 2001; CARAKOSTAS et al., 2012).

O esteviosídeo exibe mais amargor do que o rebaudiosídeo A, sendo responsável pelo gosto residual indesejado. Assim, a maioria dos novos produtos adoçantes utilizando a estévia, contêm altos níveis de rebaudiosídeo A, para tentar mascarar este gosto residual amargo característico do esteviosídeo (CARAKOSTAS et al., 2012). CADENA et al. (2013) estudaram o perfil sensorial de néctar de manga, adoçado com edulcorantes de alta intensidade, ao longo do tempo de armazenamento. Concluíram que a estévia com 97% de rebaudiosídeo não apresentou *off-flavor* e que sua aceitação e perfil sensorial foi semelhante ao controle adoçado com sacarose.

4.1.6. Resumo sobre os edulcorantes

Tabela 1. Principais informações sobre os edulcorantes sucralose, aspartame, neotame e estévia.

Edulcorante	Doçura em relação à sacarose	IDA* (mg/kg peso/dia)	Principais características
Sucralose	600	15	Estável em temperaturas elevadas. Uso geral. Perfil sensorial mais próximo ao da sacarose.
Aspartame	160 – 220	40	Instável a temperaturas elevadas. Realçador de sabor. Aprovado para uso geral. Consumo contraindicado em situação clínica de fenilcetonúria.
Neotame	7.000 – 13.000	2	Elevada potência. Intensificador de sabor. Estável em ampla variedade de alimentos e bebidas.
Estévia	110 – 300	Não especificada	Adoçante natural. Apresenta gosto residual amargo. Resistente a temperaturas elevadas.

*IDA; Ingestão Diária Aceitável (BRASIL, 2008).

No caso dos edulcorantes em que a IDA é "não especificada" significa que aquela substância não apresenta risco à saúde nas quantidades necessárias para que se obtenha o efeito tecnológico desejável.

5. Mecanismos da percepção do gosto doce

Gostar da doçura é inato, mas a percepção do gosto doce e o nível preferível de doçura variam entre os indivíduos. A percepção do gosto começa na língua e palato, onde os receptores gustativos interagem com alimentos ou bebidas. As células receptoras gustativas são organizadas em papilas gustativas, que são distribuídas ao longo da língua e em estruturas especializadas, chamadas papilas (REED et al., 2006; AND,2012).

O gosto doce é percebido através da interação com um receptor doce, identificado como um receptor dimérico acoplado à proteína-G composto de subunidades T1R2 e T1R3 com múltiplos locais ativos (MEYERS e BREWER, 2008).

A sinergia entre os edulcorantes é devido ao fato de que eles ligam em diferentes subunidades. A ligação em uma única subunidade ativa a resposta doce, enquanto uma segunda ligação em uma outra subunidade realça a resposta (TEMUSSI, 2006). Um mecanismo de transdução traduz a mensagem química doce através do sistema nervoso, para a percepção do gosto doce no cérebro. As características desta via de transdução ainda não estão bem definidas (MEYERS e BREWER, 2008).

A percepção do gosto e a preferência por alimentos são complexos e as diferenças na concentração de papilas, número e tipo de receptores gustativos, ou sequenciamento de genes de moléculas de transdução de sinal, contribuem para a variação individual (TEMUSSI, 2006; AND, 2012).

6. Análise Sensorial de Alimentos

A análise sensorial é considerada uma ciência multidisciplinar estruturada em princípios científicos relacionados às diferentes áreas do conhecimento, como ciência dos alimentos, psicologia, fisiologia humana, estatística, sociologia e conhecimento sobre as práticas de preparação do produto. O objetivo principal é obter respostas objetivas em relação aos alimentos e em relação à maneira pela qual estas respostas são percebidas pelos seres humanos (STONE et al., 2012).

De acordo com CRUZ et al. (2010) diferentes estudos têm sido reportados na literatura científica relatando a aplicação da análise sensorial, com diferentes objetivos, na busca de informações que possam contribuir efetivamente para gerar novos conhecimentos, e fornecer as bases para obtenção de melhores produtos alimentícios.

O objetivo final a que se propõe o desenvolvimento e inovação de um produto é a aceitação por parte do consumidor; todo o trabalho que se tem ao estudar um produto envolve o entendimento dos fatores que determinam as percepções do consumidor. Neste ponto, a análise sensorial mostra-se de extrema importância (MINIM et al., 2010).

A qualidade do alimento compreende três aspectos fundamentais: nutricional, sensorial e microbiológico. O aspecto de qualidade sensorial é o mais intimamente relacionado à escolha do produto alimentício. Desta maneira, as características de qualidade sensorial, tais como sabor, textura e aparência, precisam ser monitoradas desde o momento da percepção e escolha desta qualidade, por meio de estudos do consumidor, assim como em outras situações no processamento do alimento (DUTCOSKY, 2013).

Por meio da análise sensorial, as características ou propriedades de interesse relativas à qualidade sensorial do alimento são identificadas e adequadamente estudadas com base em metodologias sensoriais de coleta de dados e em métodos estatísticos de avaliação e interpretação dos resultados (DELLA LUCIA, MINIM e CARNEIRO, 2006; TUORILA e MONTELEONE, 2009).

Atualmente já se tem conhecimento da grande necessidade da prática sensorial no controle de qualidade global do produto; métodos sensoriais têm sido desenvolvidos e melhorados, e as especificações sensoriais para os produtos têm evoluído, de maneira que o pesquisador ou analista sensorial tem em mãos um grande número de opções de ferramentas sensoriais para a aplicação em seus estudos (MINIM et al., 2010).

6.1. Metodologias de avaliação sensorial

As metodologias de avaliação sensorial são classificadas em: métodos discriminativos, métodos afetivos ou subjetivos, e métodos descritivos.

6.1.1. Métodos discriminativos

Os testes discriminativos, como uma classe de testes, representa uma das duas ferramentas analíticas mais úteis disponíveis para o profissional sensorial. É com base na diferença percebida entre dois produtos que se pode justificar a procedência de um teste descritivo, a fim de identificar a base da diferença; ou o inverso, os produtos não são percebidos como diferentes, e são tomadas medidas adequadas (STONE, BLEIBAUM e THOMAS, 2012).

Dentro desta classe geral de métodos discriminativos está uma variedade de métodos específicos; alguns são bem conhecidos, tais como comparação pareada, teste triangular, duo-trio, e testes de diferença direcional, enquanto que outros são relativamente desconhecidos, tal como o teste de padrão duplo. Basicamente, os três tipos de testes discriminativos que são usados na maioria das vezes são: comparação pareada, duo-trio e triangular. Alguns outros tipos de teste foram desenvolvidos, mas são de limitada aplicação (STONE, BLEIBAUM e THOMAS, 2012).

6.1.2. Métodos afetivos ou subjetivos

Os testes afetivos são uma importante ferramenta, pois obtém diretamente a opinião (preferência ou aceitação) do consumidor em relação a ideias, características específicas ou globais de determinado produto, sendo, por isso, também denominados de teste de consumidor. Os métodos afetivos determinam qual o produto preferido e/ou mais aceito por determinado público-alvo, em função de suas características sensoriais (MINIM, 2013). De acordo com DUTCOSKY (2013) os testes afetivos também podem ser classificados em testes qualitativos e testes quantitativos.

Os testes qualitativos são aplicados quando se busca um posicionamento inicial do consumidor em relação ao conceito de um produto ou de um protótipo para entender a terminologia usada pelos consumidores para descrever os atributos sensoriais de um conceito, protótipo ou produto comercial ou para estudar os hábitos e atitude dos consumidores frente a uma determinada classe de produtos (DUTCOSKY, 2013). De acordo com MINIM (2013) estes testes podem ser classificados em: grupos de foco (*focus group*), equipes de foco (*focus panels*) e entrevistas individuais (*one-on-one interviews*).

Os testes quantitativos são aqueles que avaliam a resposta de um grande grupo de consumidores a uma série de perguntas que visam a determinar o grau de aceitabilidade global de um produto, identificar fatores sensoriais que determinam a preferência ou medir respostas específicas a atributos sensoriais específicos de um produto (DUTCOSKY, 2013). São apresentados em duas classes principais: a) testes de preferência (pareado; ordenação; pareado ou ordenação múltiplos) e b) testes de aceitação (aceitabilidade; avaliação hedônica; escala *just-about-right*; avaliação dos atributos; hedônica; intensidade) (DUTCOSKY, 2013; STONE, BLEIBAUM e THOMAS, 2012).

A análise de aceitação possibilita a obtenção de informações importantes, refletindo o grau que os consumidores gostam ou não de um determinado produto. É muito utilizado para comparar produtos concorrentes, no desenvolvimento de novos produtos e na melhoria da qualidade. Entre os métodos sensoriais existentes para medir a aceitação e preferência de um grupo de provadores, o que utiliza escala hedônica de nove centímetros é o mais aplicado, devido à sua simplicidade, confiabilidade e validade de seus resultados (STONE, BLEIBAUM e THOMAS, 2012).

PICKINA et al. (2011) avaliaram a aceitação de sobremesa láctea diet simbiótica de maracujá por idosos, por meio de teste afetivo com 60 idosos, utilizando escala de 10 pontos, em que mais de 50% dos provadores avaliaram as amostras pontuando entre 8,1 e 10, o que mostra uma boa aceitação dessa sobremesa.

6.1.3. Métodos descritivos

São métodos que descrevem qualitativamente e quantitativamente as amostras. Têm como objetivo caracterizar as propriedades sensoriais dos produtos alimentícios. Na análise descritiva, o julgador também avalia o grau de intensidade com que cada atributo está presente no alimento. Para tanto, os julgadores devem ser treinados a usarem escalas de forma consistente com relação à equipe sensorial, em relação às amostras e por meio de todo o período de avaliação (STONE, BLEIBAUM e THOMAS, 2012).

Os métodos descritivos classificam-se em: avaliação de atributos – testes de escalas; perfil de textura; perfil de sabor; análise descritiva quantitativa – ADQ; perfil livre; tempo-intensidade; teste da amostra única (LAWLESS e HEYMANN, 2010).

A análise descritiva é a mais sofisticada dos métodos disponíveis para o profissional de sensorial. Um teste descritivo fornece palavras descritoras de produtos, uma base para comparar as semelhanças e diferenças de produtos, e uma base para determinar os atributos sensoriais que geram impacto nas preferências. Os resultados permitem relacionar um ingrediente específico, ou variáveis do processo, com alterações específicas em alguns (ou todos) atributos sensoriais do produto (STONE, BLEIBAUM e THOMAS, 2012).

6.1.3.1. Análise descritiva quantitativa (ADQ)

A análise descritiva quantitativa (ADQ) apresenta-se como uma metodologia que proporciona a obtenção de uma descrição completa de todas as propriedades sensoriais de um produto, representando um dos métodos mais completos e sofisticados para a caracterização sensorial de atributos importantes (LAWLESS e HEYMANN, 2010). Possui inúmeras aplicações, como por exemplo, o acompanhamento de produtos concorrentes, testes de armazenamento de produtos, desenvolvimento de novos produtos, controle da qualidade de produtos industrializados e realização de testes sensoriais e instrumentais (STONE, BLEIBAUM e THOMAS, 2012).

A ADQ permite traçar o perfil sensorial dos produtos avaliados e, quando associada ao estudo afetivo do consumidor permite chegar a conclusões de extrema importância, tais como saber quais as características sensoriais e em que intensidade estas características estão presentes nos produtos, mais ou menos aceitos pelos consumidores, e ainda verificar em que produtos concorrentes diferem entre si. Desta forma, se desejável, é possível saber exatamente quais atributos sensoriais devem ser atenuados, intensificados, suprimidos ou colocados em um produto para que ele possa superar seu concorrente (STONE, BLEIBAUM e THOMAS, 2012).

Esta metodologia vem sendo utilizada para descrever diferentes produtos alimentícios tais como leite (CHAPMAN, LAWLESS e BOOR, 2001), tomates (KRUMBEIN, PETERS e BRUCKNER, 2004), cerveja (FRANÇOIS et al., 2006), cultivares de uva (VILANOVA, MASA e TARDAGUILA, 2009), bebidas quentes (MOUSSAOUI e VARELA, 2010), vinhos (CADOT et al., 2010) e pães (MORAIS et al., 2014).

6.1.3.2. Análise tempo-intensidade

Um teste sensorial que vem ganhando atenção especial ao longo do tempo é o denominado tempo-intensidade (TI). Isto tem ocorrido, principalmente, pois com o rápido desenvolvimento da informática nos últimos anos, a principal dificuldade deste teste, que era a coleta de dados, tem sido muito facilitada (BOLINI-CARDELLO et al., 2003; NUNES e PINHEIRO, 2013).

A análise tempo-intensidade é um complemento da análise sensorial clássica, pois mede a intensidade do estímulo percebido de acordo com o tempo percorrido (CLIFF e HEYMANN, 1993; LAWLESS e HEYMANN, 2010). Consiste na medida da velocidade, duração e intensidade, percebidas por um único estímulo, através da associação da percepção humana com recursos da informática (REIS, 2007). Esta técnica é importante na avaliação sensorial de um alimento, uma vez que a percepção do aroma, do sabor e da textura é um fenômeno dinâmico e não estático (MONTEIRO, 2002).

A técnica tempo-intensidade pode fornecer informações sobre determinado estímulo, no decorrer do tempo, mediante curva que registra variações na intensidade de um estímulo sensorial, percebido pelo provador com o passar do tempo. As variáveis ou parâmetros das curvas tempo-intensidade mais utilizados são: tempo para atingir a intensidade máxima, área sob a curva, tempo total de duração da intensidade máxima, e tempo em que a intensidade máxima começa a declinar. Outros parâmetros também podem ser utilizados (CARDELLO e DAMÁSIO, 1996; LAWLESS e HEYMANN, 2010).

Acredita-se que a aceitação de diferentes edulcorantes pelos consumidores está associada à semelhança do seu perfil temporal sensorial em relação ao da sacarose. Edulcorantes que apresentam gosto residual podem ser menos aceitos pelos consumidores. No entanto, uma goma de mascar com sabor duradouro, ou um vinho com um "final longo" podem ser desejáveis (LAWLESS e HEYMANN, 2010). Estes exemplos mostram como o estudo do perfil temporal de determinado atributo de um produto é de aspecto muito importante para a aceitação do mesmo.

A análise tempo-intensidade tem sido utilizada para determinar o perfil temporal de diversos alimentos tais como café (MONTEIRO et al., 2005), cerveja (FRANÇOIS et al., 2006), gelatina (PALAZZO e BOLINI, 2009), sorvete de baunilha (CADENA e BOLINI, 2011), chocolate (PALAZZO et al., 2011) e pães (MORAIS et al., 2013).

6.1.3.3. Dominância temporal de sensações

Um método para identificar alterações dependentes do tempo e definir o perfil relatado para um subconjunto de sensações-chave é chamado de Dominância Temporal de Sensações (*Temporal Dominance of Sensations* – TDS) (PINEAU et al., 2009). O TDS é uma metodologia relativamente recente no campo sensorial que dá a oportunidade de descrever a evolução das percepções sensoriais dominantes durante a degustação de um produto alimentar (PINEAU, CORDELLE e SCHLICH, 2003; PINEAU et al., 2009; PINEAU et al., 2012).

Consiste na apresentação aos provadores de uma lista completa de atributos, na tela de computador. Posteriormente, é solicitado aos provadores para provarem a amostra e avaliarem qual dos atributos é percebido como dominante (isto é, a percepção mais marcante em um determinado tempo). No decorrer da avaliação, se o provador considerar que o atributo dominante mudou, ele tem de marcar o novo atributo dominante, e assim por diante, até que a percepção acabe (PINEAU et al., 2009).

De acordo com ALBERT et al. (2012) esta técnica permite determinar o impacto que cada atributo da percepção apresenta para o consumidor ao longo do tempo de consumo, e os resultados obtidos podem ser relacionados à aceitação. Estudos com o TDS têm sido realizados para descrever os padrões sensoriais temporais de diferentes alimentos e bebidas, como laticínios (PINEAU et al., 2003), vinho (MEILLON, URBANO e SCHLICH, 2009), bebidas quentes (LE RÉVÉREND et al., 2008), géis com sabor (LABBE et al., 2009), cereais matinais (LENFANT et al., 2009) e manteiga (SOUZA et al., 2013).

7. Mapas de preferência

Durante o desenvolvimento ou melhoria de produtos alimentares é importante ouvir atentamente as preferências dos consumidores, a fim de garantir a boa aceitação do produto. Ao longo dos anos, muitas ferramentas e técnicas têm sido desenvolvidas para o uso no processo de desenvolvimento do produto (FELBERG et al., 2010; MAHANNA e LEE, 2010). Técnicas de mapa de preferência estão entre as ferramentas de pesquisa de marketing mais populares (DONADINI e FUMI, 2010). Além de sua aplicação em uma ampla gama de desafios de marketing, elas são frequentemente utilizadas em melhoria do produto (VAN KLEEF et al., 2006; LOVELY e MEULLENET, 2009).

O mapa de preferência é essencialmente uma representação gráfica (*Multidimensional Scaling* – MDS) das diferenças de aceitação entre as amostras, que permite a identificação de cada indivíduo e suas preferências em relação às amostras analisadas. O mapa de preferência pode ser dividido em duas categorias: o Mapa de Preferência Interno (MDPREF), quando se realiza a análise apenas sobre o conjunto de dados de aceitação/preferência gerados a partir de testes afetivos, e o Mapa de Preferência Externo (PREFMAP), no qual se incluem também a análise das medidas descritivas geradas por uma equipe de provadores treinados, relacionando-as com dados de aceitação/preferência dos produtos avaliados (VAN KLEEF et al., 2006; MINIM, 2013).

Apesar de serem essencialmente com base nos mesmos dados, analises de preferência interna e externa representam diferentes perspectivas sobre os dados e, portanto, eles extraem informações diferentes um do outro (VAN KLEEF et al., 2006). O mapa de preferência é um instrumento útil para a avaliação dos produtos, pois se baseia na análise do julgamento individual do consumidor. Permite a visualização gráfica das amostras que receberam as maiores pontuações hedônicas na análise de aceitação, e podem também ser utilizados para verificar as semelhanças ou diferenças entre as amostras, em função das pontuações hedônicas recebidas (NUNES, PINHEIRO e BASTOS, 2011).

As técnicas de mapa de preferência interno e externo foram utilizadas por GUINARD, UOTANI e SCHLICH (2001) para avaliar a aceitação dos consumidores e a relação com as marcas e preços de cervejas comerciais tipo lager. CADENA et al. (2012) utilizaram a técnica de mapa de preferência externo para avaliar os resultados do perfil sensorial de sorvetes de baunilha com teor reduzido de açúcar e gordura.

8. ***Parallel factor analysis*** **(PARAFAC)**

O PARAFAC (*Parallel factor analysis*) pode ser considerado uma generalização da Análise de Componentes Principais (ACP) para dados multidimensionais (BRO, 1997). O

ACP fornece uma análise exploratória das amostras em função das variáveis, enquanto o PARAFAC é capaz de proporcionar uma interpretação exploratória destas amostras e variáveis, tendo em conta as diferentes condições nas quais estes dados foram gerados.

Este método está ganhando cada vez mais interesse na quimiometria e áreas associadas por várias razões, tais como a maior consciência do método e suas possibilidades, o aumento da complexidade dos dados tratados na ciência e na indústria, e o aumento do poder computacional (SMILDE, 1992). O PARAFAC foi utilizado por NUNES, PINHEIRO e BASTOS (2011) para avaliar a aceitação de bolos e hambúrgueres de carne bovina. CRUZ et al. (2012) utilizaram este método para estudar a aceitação de consumidores em relação a iogurtes convencionais e probióticos.

9. Regressão por quadrados mínimos parciais

A análise sensorial geralmente enfrenta o problema de relacionar dados obtidos com base em diversas características que descrevem um produto. A identificação da relação entre as fontes, tais como informações sobre o produto, avaliação sensorial e atitude e preferência do consumidor é fundamental para o sucesso de uma análise. A Regressão por Mínimos Quadrados Parciais (*Partial Least Squares* (PLS) *Regression*) é uma técnica recente, útil na análise de preferência do consumidor, que generaliza e combina características da análise de componentes principais (ACP) e regressão múltipla (ABDI, 2004).

A regressão por mínimos quadrados parciais estende o conceito do modelo inverso (propriedade como função da resposta instrumental) trocando as variáveis originais por um subconjunto truncado das variáveis latentes dos dados originais. Foi desenvolvida na década de 70 por Herman Wold (COSTA FILHO, 1998; MESSERCHMIDT, 1999).

Esta técnica possui a finalidade de comparar preferências e relacioná-las com as características de qualidade do produto, auxiliando na segmentação do mercado em grupos definidos de consumidores, assim como determinar os atributos sensoriais que influenciam de forma positiva na apresentação do produto. Assim, o produto pode ser introduzido no segmento correto do mercado ou ser otimizado a partir das principais características de qualidade e da indicação de preferência do consumidor (MINIM, 2013).

MELO, BOLINI e EFRAIM (2009) utilizaram o PLS para determinar direcionadores de preferência de chocolates com reduzida caloria, e concluíram que os atributos aroma doce e doçura foram positivamente correlacionados com a aceitação global. MORAIS et al. (2014) também utilizaram esta metodologia para determinação de direcionadores de preferência em pães sem glúten. Os autores verificaram que os atributos maciez aparente, aroma de pão, doçura e cor do miolo foram considerados positivos na aceitação do pão.

10. Análise de Penalidades (*Penalty analysis*)

No contexto de encontrar "dicas", também chamados de direcionadores, para melhorar seus produtos, os fabricantes têm várias ferramentas. Entre elas, a análise de penalidades é conhecida. De acordo com MEULLENET et al. (2007), ROTHMAN e PARKER (2009) e SENSORY SOCIETY (2012), o princípio desta análise pode ser resumido em cinco pontos:

1) Um conjunto de consumidores é convidado a avaliar vários produtos utilizando uma série de variáveis chamadas de variáveis JAR (quase ideal). Além disso, eles são convidados a manifestar a sua impressão global em relação a cada produto.

2) Uma variável JAR é uma escala de atributo bipolar que mede os níveis de um atributo do produto em relação ao nível teoricamente considerado ideal pelos avaliadores. Essas escalas têm um ponto central ancorado de “ideal”.
3) Para um produto *P*, um primeiro indicador é a frequência de cada categoria não ideal. Por exemplo, a porcentagem de consumidores que avaliaram o produto *P* como muito doce.
4) Para avaliar a influência de uma categoria não ideal *m* na aceitação, a diferença entre a média para os consumidores que selecionar a categoria *m* e a média para os consumidores que selecionaram a categoria ideal correspondente é calculada. Esta diferença é chamada “mean drop” ou “penalty” (“penalidade”) (associada com *m*).
5) Estes resultados são resumidos traçando em um gráfico de dispersão cada categoria não ideal em relação à sua frequência (no eixo x) e a sua penalidade (no eixo y).

A análise de penalidades tem sido aplicada em diferentes estudos com produtos alimentícios. NARAYANAN et al. (2014) utilizaram esta análise para determinar as concentrações apropriadas do edulcorante estévia em iogurte de baunilha. ARES et al. (2014) identificaram direcionadores de preferência e direções para reformulação de produtos alimentícios utilizando a análise de penalidades.

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ARTIGO 1: Development of Chocolate Dairy Dessert with Addition of Prebiotics and Replacement of Sucrose by Different High-Intensity Sweeteners

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ABSTRACT

The aims of this study were (1) to optimize the formulation of a prebiotic chocolate dairy dessert and assess the extent to which sensory properties were affected by adding different concentrations of prebiotics (inulin and fructooligosaccharides) combined with different levels of xanthan and guar gums, and (2) to analyze the ideal and relative sweetness of prebiotic chocolate milk dessert sweetened with different artificial and natural sweeteners. Acceptability was evaluated by 100 consumers using a 9-cm hedonic scale, and the level of sample creaminess was evaluated using a 9-point just-about-right (JAR) scale. Data were subjected to a multivariate regression analysis and fitted to a model provided by response surface methodology. The optimal concentrations were 7.5 (wt/wt) prebiotic and 0.20 (wt/wt) gum (guar and xanthan, in a 2:1 ratio). The ideal sweetness analysis revealed that the ideal concentration of sucrose was 8.13%. The relative sweetness analysis showed that Neotame (NutraSweet Corp., Chicago, IL) had the highest sweetening power compared with the prebiotic chocolate dairy dessert containing 8% of sucrose, followed by sucralose, aspartame, and stevia. The study of sweetness in this product is important because consumers desire healthier functional products with no added sugar.

Keywords: just-about-right (JAR) scale, prebiotic, response surface modeling, magnitude estimation, equi-sweetness.

INTRODUCTION

Functional product development provides an opportunity to contribute to the improvement of food quality and consumer health and well-being (Siró et al., 2008). Prebiotic ingredients such as inulin and oligofructose are good example of this processed food category, being nondigestible fructans of interest in human nutrition because of their ability to stimulate growth or activity of colonic bacteria that benefit the host and to inhibit growth of pathogens and harmful microorganisms (Saad et al., 2013). Addition of prebiotic ingredients to processed dairy foods is a reality (Isik et al., 2011; Arango et al., 2013; Cruz et al., 2013; Pimentel et al., 2013) and has been explored by food industry.

The just-about-right (JAR) scale is an alternative method to acceptance tests that combines assessment of attribute intensity and hedonics by consumers, providing information on how consumers feel about a product and how much a sample deviates from an ideal point (Gagula et al., 2007). When applied together with response surface methodology (RSM; De Marchi et al., 2009; Cruz et al., 2010b; Mondragón-Bernal et al., 2010), the JAR scale can be a useful tool for optimizing the sensory quality of foods, as an optimal formulation derived from JAR responses maximizes consumer acceptance in the sense it is the best possible formulation given a fixed set of ingredients.

When replacing sucrose with sweeteners, it is essential to have a clear understanding of which sweetener and what concentration of sweetener best match the sweetness intensity and characteristics of the equivalent product sweetened with sucrose. To substitute sucrose successfully, it is necessary to know sweetener concentrations that would be used and their sweetness equivalency related to sucrose. One of the most utilized methodologies to obtain this information is magnitude estimation and graphical presentation of the normalized results using Steven´s power function (Cardoso and Bolini, 2007; Moraes and Bolini, 2010; Souza et al., 2011; De Souza et al., 2013; Esmerino et al., 2013).

Dairy desserts are appreciated by consumers and can be formulated with several ingredients as stabilizers. These ingredients interact, resulting in a wide variety of textures, flavors and appearances (Verbeken et al., 2006), which, in turn, influence the nutritional, physical, and sensory characteristics, with direct effects on consumer acceptability (Arcia et al., 2011) However, to date, these published studies only evaluated the effect on the physicochemical and structural characteristics of the products.

In this context, the main aim of this study was to optimize the formulation of a prebiotic chocolate dairy dessert formulated with different concentrations of prebiotics (inulin and fructooligosaccharides) and thickeners (xanthan and guar gum) using JAR responses and RSM, evaluating the extension to which the sensory properties are affected by adding these ingredients. A second aim of this work was to analyze the ideal and relative sweetness of the optimized prebiotic chocolate milk dessert sweetened with different artificial and natural sweeteners.

MATERIALS AND METHODS

Ingredients and Preparation of Chocolate Dairy Dessert

This study was developed in 2 stages. The first stage was to optimize formulation of the chocolate dairy dessert with the addition of prebiotics and gums. The next stage proceeded with the study of the replacement of sucrose by sweeteners.

The samples were produced with prebiotic Biofis Inufos (Siba Ingredientes, São Paulo, SP, Brazil), guar and xanthan gums (SweetMix, Sorocaba, Brazil), commercial skim milk powder (Molico®, Nestlé, Araraquara, SP, Brazil), commercial UHT skim milk (Molico®, Nestlé, Brazil), cocoa powder (Garoto®, Vila Velha, ES, Brazil), sucrose (União®, Tarumã, SP, Brazil), and light cream (Nestlé®, Araçatuba, SP, Brazil). Chocolate milk dessert samples were sweetened with different high-intensity sweeteners and sucrose. The sweeteners were Neotame (NutraSweet, Chicago, IL; obtained from SweetMix); sucralose (SweetMix); stevia with 95% of rebaudioside (SweetMix); and aspartame (SweetMix).

The solid ingredients were mixed in a dry pan. The UHT skim milk was heated to 40°C and added to the mixture of solid ingredients under constant agitation. Subsequently, the temperature was increased to 90 ± 2°C for 3 minutes for pasteurization. The temperature was then reduced to 40°C, cream was added, and the mixing continued for another 2 minutes. The samples were put into plastic cups (40mL), covered to avoid drying, and stored under refrigeration (4 ± 1°C) until sensory analysis.

Optimization of Chocolate Dairy Dessert Formulation

Nine chocolate milk desserts were formulated (Table 1) with different concentrations of prebiotic (5.0, 7.5, and 10.0% wt/wt) and gum (0.10, 0.20, and 0.30% wt/wt). The concentrations of sucrose (11.0% wt/wt), skim milk powder (10.0% wt/wt), cocoa powder (4.0% wt/wt), and cream (25.0% wt/wt) were kept constant. The UHT skim milk was added to 100% (wt/wt) of formulation. Previous studies determined the level of the ingredients used in this study.

Table 1. Experiment design composed by the variables in coded units and original.

Experiments	Codified levels of the variables		Levels of the original variables	
	X_1	X_2	G (%)	P (%)
1	+1	-1	0.30	5.00
2	0	-1	0.20	5.00
3	-1	-1	0.10	5.00
4	+1	0	0.30	7.50
5	0	0	0.20	7.50
6	-1	0	0.10	7.50
7	+1	+1	0.30	10.00
8	0	+1	0.20	10.00
9	-1	+1	0.10	10.00

Where: X1 = the codified level of the variable gum; X2 = codified level of the variable prebiotic, G = gum content (%) and P = prebiotic content (%).

Optimization Design. To determine the optimal concentration of guar and xanthan gums (in a 2:1 ratio) and prebiotics to be used in formulating the dairy dessert, an experiment was conducted using a completely randomized design, as shown in Table 2. The acceptance test was performed with 100 habitual consumers (32 male and 68 female) of dairy desserts, not trained and representative of the target public. An hedonic test was carried out using a continuous 9-cm unstructured line scale with the anchors “dislike extremely” and “like extremely” for the attributes of appearance, aroma, taste, texture, and overall impression. Sensitivity in defining consumer perception is greater with use of line scales than with the 9-point hedonic scale (Greene et al., 2006). In addition, a JAR scale (Desai et al., 2013) was applied to evaluate the ideal creaminess considered by the consumer panelists. Consumers were requested to evaluate creaminess by placing a mark on a continuous 9-cm unstructured line scale from “not nearly creamy enough” (-4.5) to “much too creamy” (+4.5), and “just right” in the middle (corresponding to zero; Cadena and Bolini, 2012a; Esmerino et al., 2013).

Table 2. Ingredients and respective quantities ($g.kg^{-1}$) employed for the production of the nine formulations of prebiotic chocolate dairy dessert.

Ingredients	Trials								
	F1	F2	F3	F4	F5	F6	F7	F8	F9
Prebiotic	50.0	50.0	50.0	75.0	75.0	75.0	100.0	100.0	100.0
Skimmed milk powder	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Cocoa powder	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
Sucrose	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Gum	3.0	2.0	1.0	3.0	2.0	1.0	3.0	2.0	1.0
Milk cream	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0
UHT skimmed milk	462.0	463.0	464.0	437.0	438.0	439.0	412.0	413.0	414.0

Samples coded with 3-digit numbers were presented monadically in a balanced block design to consumers in acrylic cups. Consumers received an evaluation form followed by the sample and were asked to evaluate the sample in relation to each attribute. Sessions were held at the Sensory Science and Consumer Study laboratory of the Faculty of Food Engineering/Department of Food and Nutrition (University of Campinas, Campinas, Brazil) in individual air-conditioned booths in a single session; taste-free water and biscuits were provided for palate cleansing. Each consumer´s decisions were based solely on the sensory characteristics of the desserts, because product information and formulation were not provided.

Statistical Analysis. The acceptability data were analyzed by mixed ANOVA considering sample and consumers as sources of variation (sample as fixed effect and consumer as random effect), and Tukey`s honestly significant difference (HSD) average test. Analyses were carried out using SAS software (version 9.1.2; SAS Institute, 2009) at a 5% significance level.

To relate the studied variables to concentration, data were subjected to a multivariate regression analysis and fitted to a second-order model equation provided in the design given by RSM (Equation [1]):

$$Y = B_0 + B_1X_1 + B_2X_2 + B_{11}X_1^2 + B_{22}X_2^2 + B_{12}X_{12} + \text{error}, \quad [1]$$

where Y is the studied variable; B_0 is the intercept (constant); B_1, B_2 are the linear effects; B_{11}, B_{22} are the quadratic effects; B_{12} is the interaction effects; X_1 is the gum content; and X_2 is the prebiotic content.

To analyze data obtained with the JAR scale, the percentage of consumers rating the creaminess of sample in each point of scale was first calculated. Second, the approach proposed by Gacula et al. (2007) was followed, estimating deviations below and above point 0 on the JAR scale. Individual scale scores -4.5, -2.25, 0, 2.25, 4.5 were transformed to -2, -1, 0, 1, 2, respectively. Two groups of data emerged from this calculation, one for consumers who felt that the sample lacked the attribute (bellow JAR) and another for those consumers who felt the product exceeded the attribute (above JAR). For each sample, the mean of values below JAR point 0 corresponded to the negative deviation value (too little of the attribute) and the mean of values above JAR point 0 corresponded to the positive deviation value (too much of the attribute). These analyses were carried out using the software R (R Development Core Team, 2012) and the rsm package. In addition, penalty analysis (Drake et al., 2011) was performed to reach conclusions related to the effects of creaminess on overall liking, identifying decreases in acceptability associated with this sensory attribute not at optimal levels in a product. This analysis was performed in XL-STAT 2013 (Addinsoft, Paris, France).

Ideal and Equivalent Sweetness of Chocolate Dairy Dessert

The optimized formulation in the previous step was tested using different levels of sucrose and sweeteners. The concentrations of sucrose and sweeteners varied, and UHT skim milk was added to 100% (wt/wt) of the formulation.

Sucrose Ideal Sweetness. To reach the equivalent sweetness for various sweeteners compared with sucrose, sensory evaluations were conducted at various stages. Determining the optimal concentration of sucrose (%) to be added to the processed chocolate dairy dessert was performed by means of an affective test, using the JAR scale (Esmerino et al., 2013). The samples were sweetened with 5 concentrations of sucrose: 6.0, 8.0, 10.0, 12.0, and 14.0% (wt/wt) to determine the ideal level of sucrose in chocolate milk dessert.

The samples were evaluated in individual booths in the Sensory Science and Consumer Study Laboratory, Department of Food and Nutrition (University of Campinas, Campinas, Brazil). Sample presentation was monadic in acrylic cups coded with 3-digit numbers, using a balanced complete block design (Walkeling and MacFie, 1995). The consumers were served 30 g of each dessert sample containing different sucrose concentrations and requested to evaluate the sweetness using the JAR scale anchored with "not nearly sweet enough" (-4) to "much too sweet" (+4), with "just right" in the middle (corresponding to zero). A total of 100 consumers of dairy dessert (63 women and 37 men with mean age of 33 yr recruited on the University of Campinas campus through posters and e-mail lists) evaluated the samples.

The sensory evaluation results were analyzed by histograms with the sensory response distribution (%) with respect to the sucrose concentration added to the dessert, and also by simple linear regression between hedonic values and sucrose concentration, as suggested by Vickers (1988).

Equivalent Sweetness of High-Intensity Sweeteners. Panelists were selected and trained to evaluate the equivalent sweetness of sweeteners. A series of triangular tests with 30 recruited tasters was held to select panelists, and the Wald sequential analysis was applied to check the discrimination ability of each individual. The assessors had to identify which of 3 samples served was different from the other two. Tasters were selected or rejected according to the number of correct tests analyzed in the triangular test. Fifteen assessors, 10 women and 5 men with mean age of 34 yr, were selected for the determination of the equi-sweet concentrations of the different sweeteners.

Panelists preselected by the Wald sequential analysis were trained to use magnitude scales with different sweetness potency standards. The training was based on an explanation of the methodology and the correct use of the magnitude scale.

Determination of Equivalent Sweetness and Sweetener Potency. The relative sweetness of high intensity sweeteners was measured using the magnitude estimation method, which allows a direct quantitative measurement of the subjective intensity of sweetness. The dessert samples were presented according to a balanced complete block design followed by a reference sample sweetened with sucrose in the ideal concentration, with which the sweetness equivalence was determined. The reference sample was designated to have an intensity of 100, followed by a random series of samples with greater and lesser intensities as compared with the reference intensity. The assessor had to estimate the sweetness intensity of the unknown samples relative to the reference. For example, if a sample was twice as sweet as the reference, it would receive an intensity of 200, whereas if it were half as sweet, the intensity would be 50, and so on. Assessors were instructed not to rate the sample intensity as 0.

To determine the equivalent sweetness of sweeteners relative to sucrose, the series of concentrations presented in Table 3 was used. For data analysis, the estimated sweetness magnitude values of sucrose and sweeteners were converted into geometric averages, and these values were set to a logarithmic scale. The logarithmic concentration (C) values used for each sweetener were plotted against the logarithmic values of the estimated magnitudes for the stimuli perceived as sensations (S), and a linear regression of points was obtained, such that a simple power function $S = a \cdot C^n$ described the data, where a and n are the parameters to be estimated.

Table 3. Concentrations of the sweeteners used for determining the equivalent sweetness in processed prebiotic chocolate dairy dessert to 8% of sucrose.

Sweetener	Concentration for the equivalent sweetness (%)				
Sucrose	6.0000	8.0000	10.0000	12.0000	14.0000
Sucralose	0.0063	0.0100	0.0160	0.0256	0.0410
Aspartame	0.0200	0.0340	0.0550	0.0880	0.1408
Stevia	0.0391	0.0625	0.1000	0.1600	0.2560
Neotame[1]	0.0070	0.0010	0.0017	0.0027	0.0041

[1]NutraSweet (Chicago, IL)

The equivalent concentration of each sweetener was calculated using the equation obtained for the prebiotic chocolate dairy dessert with sucrose; in place of C (sweetener concentration), the value of 8% (wt/wt) was assigned, which is the ideal sweetness of sucrose. Thus, the value of S (sucrose sweetness perceived) was mathematically estimated. The S values for sucrose were substituted into the other equations (for other sweeteners) and thus the optimal concentration of each sweetener was determined in reference to the equivalent prebiotic chocolate dairy dessert with 8% sucrose.

RESULTS AND DISCUSSION

Consumer Acceptability of Chocolate Dairy Desserts

The sensory attributes evaluated through the acceptance test are presented in Table 4. Significant differences between samples (α = 0.05; P ≤ 0.05) were detected for all attributes, indicating that enrichment with prebiotic and gum caused changes in the sensory characteristics of chocolate dairy desserts. Similar results were found in dairy desserts formulated with different levels of carrageenan, cacao, and polydextrose (Ares et al., 2010), suggesting the importance of formulating desserts with ingredients that influence the texture of the product.

Table 4. Means of the attributes evaluated by 100 consumers (9-cm unstructured line scale)

Samples	Attribute				
	Appearance	Aroma	Flavor	Texture	Overall Impression
F1	6.26 d	7.02 b	6.69 f	4.62 f	6.31 e
F2	8.03 c	7.02 b	7.30 d	6.93 c	7.46 b
F3	2.70 f	6.43 d	7.93 c	5.86 e	5.92 f
F4	8.28 b	6.83 c	7.16 e	6.46 d	7.35 c
F5	8.63 a	7.95 a	8.45 a	7.67 a	8.27 a
F6	3.71 e	7.01 b c	8.11 b	7.14 b	6.65 d
F7	3.60 e	5.01 e	5.55 g	3.89 g	3.39 f
F8	4.01 e	5.63 d e	5.91 g	4.51 f	4.01 f
F9	2.55 f	4.77 e	5.78 g	4.60 f	2.99 f

Values with different letters within a column are significantly different according to Tukey test ($P < 0.05$).

As shown in Table 4, addition of 7.5% prebiotic and 0.2% gum caused a significant increase in appearance, aroma, flavor, texture, and overall acceptability of chocolate dairy desserts, indicating that consumers perceived positively the changes in these attributes introduced by these levels of prebiotics and gum. For example, overall liking ranged from 6.65 to 8.27 ($P < 0.05$), whereas taste and texture had values ranging from 7.16 to 8.11 and 6.46 to 7.67, respectively.

Addition of 10.0% prebiotic, independent of the concentration of added gum, caused a significant reduction in appearance, aroma, flavor, texture, and overall acceptability of chocolate dairy desserts, indicating that consumers perceived negatively the changes in these attributes introduced by the higher levels of prebiotics. The overall acceptability of the dairy dessert with 7.5% prebiotic and 0.20% gum was 8.27, but it decreased to 4.01 when 10.0% prebiotic was added. Muñoz et al. (1992) considered an acceptability score of 6.0 in a 9-point hedonic scale (the first score in the liking category) as the lower limit of acceptability for a commercial product. Therefore, by this criterion, a chocolate dairy dessert containing 10.0% prebiotics would not be acceptable. These findings indicate that development of processed food with added prebiotic ingredients should be carefully evaluated by sensory methodologies (Cruz et al., 2010a)

As shown in Table 4, the addition of 0.10% (wt/wt) gum, independent of the concentration of added prebiotic, caused a significant reduction in appearance, aroma, flavor, texture, and overall acceptability of chocolate dairy desserts, indicating that consumers perceived negatively the changes in these attributes introduced by the lower levels of gums.

Creaminess Suitability Assessed by Consumers

Creaminess in dairy desserts is a sensory attribute extremely valued by consumers (Antmann et al., 2011a,b). The JAR scale was used to evaluate the creaminess of a chocolate dairy dessert to determine how much each sample varied from or approached the desirable level for this product. The percentage of consumers that considered creaminess to be JAR varied greatly among samples, from 3.75% for sample 9 (0.10% wt/wt gum, 10.0% wt/wt prebiotic) to 48.75% for sample 5 (0.20% wt/wt gum, 7.5% wt/wt prebiotic; Table 5). The model explaining the relationship between the percentage of consumers considering creaminess as JAR (% Consumer in JAR) and sample composition (where P = prebiotic and G = gum) was as follows (Equation [2]):

$$\% \text{ Consumer JAR} = -138.61 + 525.00G + 36.75P - 1.583.33G^2 - 2.83P^2 + 15GP \qquad [2]$$

Table 5. Percentage of consumers considering creaminess as just about right (JAR) and deviation (positive and negative values) for each dairy dessert sample.

Sample	Consumers considering creaminess as JAR (%)	Deviation[1]	
		Too little	Too much
F1	8.75	-0.660	0.796
F2	35.00	-0.379	0.570
F3	17.50	-0.834	0.717
F4	25.00	-0.796	0.767
F5	48.75	-0.316	0.706
F6	20.00	-0.388	0.397
F7	10.00	0.000	0.672
F8	6.25	0.000	1.079
F9	3.75	0.000	1.229

[1]Based on 9-cm JAR scale: “not nearly creamy enough” = -4.5, “much too creamy” = +4.5, and “just about right” in the middle (corresponding to zero).

Both prebiotic and gum concentrations significantly affected consumer assessment of creaminess, showing an inverted U-shaped relationship within the concentration ranges considered in this study (Figure 1). The most adequate creaminess corresponded to samples with intermediate levels of prebiotic and gum. For consumers who did not consider creaminess adequate but considered it as “too much” or “too little”, creaminess deviation from the JAR was calculated for each sample (Table 5). Deviation values depended on both gum and prebiotic contents. The addition of prebiotic at high concentrations (>7.5%) resulted in samples with too strong creaminess, independent of gum concentration (samples 7, 8 and 9) because the term associated with the interaction between the effects of both ingredients was not significant. Penalty analysis values ranged from -0.241 (sample 7) to 0.054 (sample 3); however penalty analysis values did not differ significantly (P > 0.05), suggesting that, at the levels studied, the overall acceptance of the prebiotic dairy desserts was not influenced by the creaminess level. It is interesting to note that no samples were considered "excellent" from a sensory standpoint.

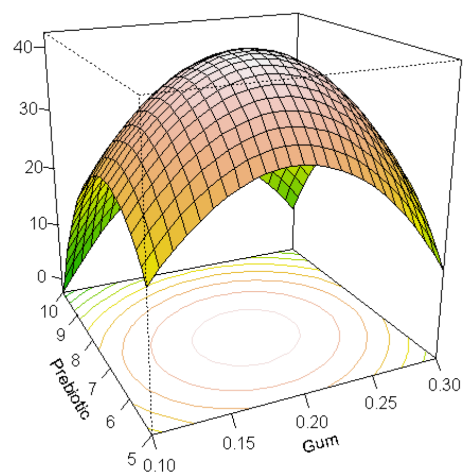

Figure 1. Relation between percentage of consumers considering creaminess of samples as a function of the just-about-right (JAR) scale, gum concentration (% wt/wt), and prebiotic concentration (% wt/wt).

Arcia et al. (2011) evaluated the thickness of prebiotic dairy desserts in relation to sucrose and inulin contents. They observed that the effect of inulin depended on sucrose concentration and vice versa. González-Tomás et al. (2009) studied an inulin-enriched dairy dessert and showed that adding 7.5% inulin (concentration close to that found to be optimal in this study) of different average chain lengths can give rise to products with different rheological behaviors and different sensory characteristics.

The concentration ranges of each ingredient for maximum acceptability in relation to the ideal creaminess were determined using contour plots of the obtained model. According to Figure 1, maximum acceptability values were obtained with concentrations of 7.21 and 0.19% for prebiotic and gum, respectively. These values are close to those obtained for overall impression in the acceptance test and confirm results of a previous study that compared JAR scales and attribute liking to evaluate appropriate sensory attributes of milk desserts (Ares et al., 2009). The gum and prebiotic concentrations for ideal creaminess and overall acceptability were 0.20% (wt/wt) and 7.5% (wt/wt), respectively; therefore, these concentrations were used in the subsequent tests.

Ideal Concentration of Sucrose

According to the consumer evaluation, a significant difference (at a 5% probability by an *F*-test) was observed between samples sweetened with different concentrations of sucrose. Therefore, a regression model was adjusted to relate ideal sweetness to sucrose concentrations of prebiotic chocolate dairy dessert samples. The linear model showed the best data fit (R^2 = 0.91; Figure 2). Through the regression equation, the amount of sucrose to be added to the prebiotic chocolate dairy dessert was calculated and found to be 8.13%. Therefore, in subsequent experiments, a concentration of 8.0% was chosen.

Indeed, the ideal concentration of sucrose varies with the type of product. Moraes and Bolini (2010) determined that 9.5% was the ideal concentration of sucrose in instant coffee beverages, 10% sucrose was determined as ideal by Cardoso and Bolini (2007) for peach nectar, 7.0% sucrose was ideal for mango nectar Cadena and Bolini (2012), whereas

Souza et al. (2011) found a greater value (17% sucrose) in Petit Suisse cheese, which has a semi-solid structure like our chocolate dairy dessert. In the case of the chocolate dairy dessert in the current study with the addition of the prebiotic fructooligosaccharides (FOS), the need to add sucrose decreases, because the prebiotic itself has sweetening power, although in lesser amounts than sucrose. According Villegas et al. (2010), fructooligosaccharides (FOS) products enhance flavor and sweetness and can be used to partly replace sucrose.

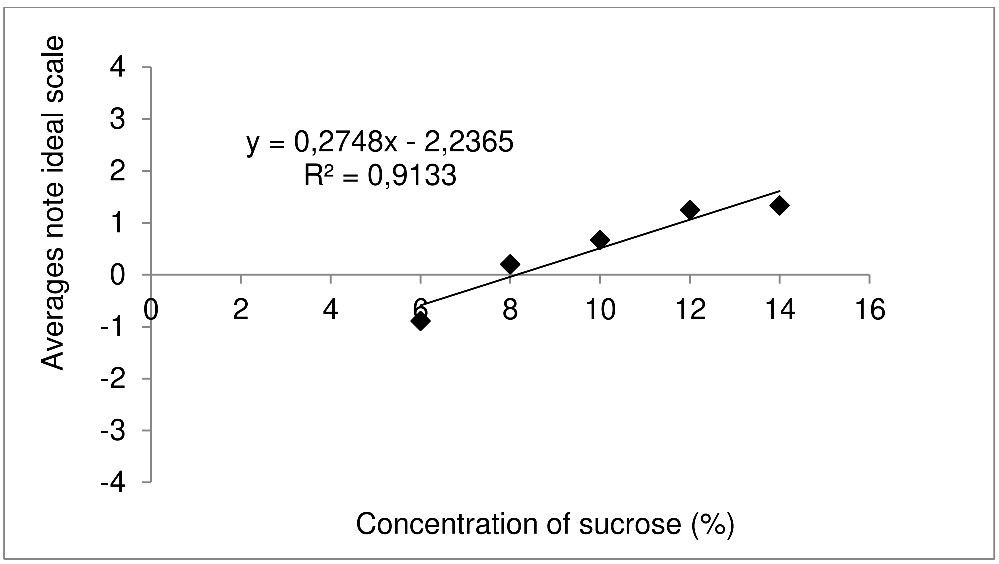

Figure 2. Graphic representation of the regression equation and the coefficient of determination of average notes ideal scale as a function of sucrose concentration in prebiotic chocolate dairy dessert.

Determination of Equivalent Sweetness

The logarithmic values of concentrations (C) for sucrose and for each sweetener were plotted against the logarithmic values of the estimated magnitudes (appropriately normalized) for stimuli perceived as sensations (S). A linear regression of points obtained for sucrose and the various sweeteners was then made, and a straight-line equation was obtained for each of the sweeteners (Figure 3). These results allowed us to determine the concentrations of each sweetener equivalent to the sucrose concentration (8.0% wt/wt) in the prebiotic chocolate dairy dessert.

Table 6 shows the results for the angular coefficient (A), intercept on the ordinate (n), linear coefficient of determination (R^2), and the power function of each sweetener; Figure 3 shows the relationship between sweetness intensities and concentrations on a logarithmic scale.

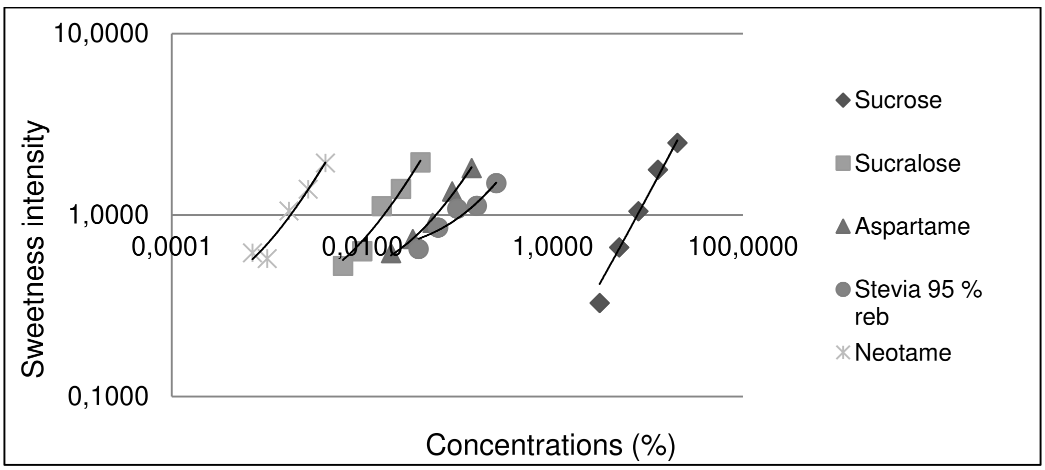

Figure 3. Results of the linearized power function for prebiotic chocolate dairy dessert sweetened with sucrose, sucralose, aspartame, Neotame (NutraSweet, Chicago, IL), and stevia with 95% rebaudioside. The x-axis shows the concentration of the sweeteners (%) and y-axis shows the values of the estimated magnitudes appropriately normalized.

Table 6. Angular coefficient (A), intercept on the ordinate (n), linear coefficient of determination (R^2) and power function of the results to determine the equivalent sweetness of each sweetener in relation to 8% sucrose concentration of prebiotic chocolate dairy dessert

Sweetener	A	n	R^2	Power function
Sucrose	1.0736	-0.9696	0.9859	$S = 0.1072.C^{1.0736}$
Sucralose	0.7308	1.3118	0.9764	$S = 20.5021.C^{0.7308}$
Aspartame	0.5678	0.7193	0.9702	$S = 5.2396.C^{0.5678}$
Stevia	0.4154	0.4154	0.9603	$S = 2.6025.C^{0.4154}$
Neotame	0.7059	1.9597	0.9483	$S=91.1381.C^{0.7059}$

Using the position of the curves observed in the graph shown in Figure 3, it is possible to identify the ratio of the sweetness of various sweeteners used. The positioning of the curves indicates the sweetening intensity of each sweetener. The sucrose curve is distant from the others, indicating that much higher concentrations of sucrose are needed to achieve the same sweetness sensation. Neotame is furthest from sucrose, indicating that a lower concentration of Neotame is required to express the same sweetness as sucrose.

Neotame [N-(*N*-(3,3-dimethylbutyl)-L-α-aspartyl)-L-phenylalanine 1-methyl ester] is a high-potency sweetener and flavor enhancer that is currently approved for use in 69 countries worldwide. This zero-calorie sweetener has a clean, sweet taste with no undesirable taste characteristics, and it is functional and stable in a wide array of beverages and foods. Given its high potency, Neotame has proven to be one of the most cost-effective sweeteners on the market (Mayhew et al., 2012). It is approved for use in processed foods in the United States and its principal utility is in reduced-calorie products, in which up to 25% calorie reduction can be achieved without significant decrement in taste quality. In the United States, Neotame has an acceptable daily intake (ADI) of 0.3 $mg.kg^{-1}$ of body weight (BW; DuBois and Prakash, 2012).

From the power function of each sweetener, we were able to calculate the concentration equivalent of each sweetener and its potency compared with sucrose. The concentrations of each sweetener were calculated in equivalence of the ideal sweetness of sucrose in prebiotic chocolate dairy dessert (8.0%) and the results are shown in Table 7. No data were found in the literature on the use of sweeteners in processed dairy dessert. However, comparing the concentration values of sweeteners in other products, it appears that our values were within the range of values reported previously (Cadena and Bolini, 2012; Esmerino et al., 2013).

From Table 7, it can be seen that Neotame required the lowest quantity to provide sweetness equivalent to 8.0% sucrose in prebiotic chocolate dairy dessert, followed by sucralose, aspartame, and stevia. Thus, Neotame had the highest sweetening power, being 5,000 times sweeter than sucrose. Thus to substitute sucrose by Neotame in a prebiotic chocolate dairy dessert with 8.0% of sucrose, 0.0016% of Neotame would be required. Nofre and Tinti (2000) reported that Neotame is 6,000 to 10,000 times sweeter than sucrose.

Table 7. Equivalent concentration and potency of the sweeteners, corresponding to the 8.0% sucrose concentration in prebiotic chocolate dairy dessert

Sweetener	Concentration equivalent to sucrose 8.0%	Sweetener potency at 8.0% sucrose
Sucralose	0.0160	500.00
Aspartame	0.0540	148.15
Stevia	0.1000	80.00
Neotame[1]	0.0016	5,000.00

[1]NutraSweet (Chicago, IL).

Sucralose presented a sweetness power of 500, a value slightly below to the values of 636 in instant coffee and 599 in ground roasted coffee by Moraes and Bolini (2010) and the value of 629 found by Cardoso and Bolini (2007) in peach nectar. Souza et al. (2011) found a value of 261 in strawberry-flavored Petit Suisse cheese. Stevia with 95% of rebaudioside was 80 times sweeter than sucrose, having lower values compared with instant coffee and mango nectar (100 and 134, respectively; Moraes and Bolini, 2010; Cadena and Bolini, 2012). Stevioside [19-Oβ-glucopyranosyl-13-Oβglucopyranosyl(1,2)-β-glucopyranosyl-steviol] is a mixture of active components of sweet taste. With high purity and zero calories, stevia is of great interest to the global food industry (Carakostas et al., 2012).

The differences between the concentration values of sweeteners found in our prebiotic chocolate dairy dessert and the values found in the literature can be explained by the difference in the types of product and in their optimal concentration of sucrose. The perception of the sweetness of a sweetener is influenced by several factors such as type and concentration of the sweetener, dispersion medium (aqueous, lipidic, or other food ingredients), synergy of other components present in the food matrix, temperature, pH, and other properties (Wiet and Beyts, 1992). It is also important to verify the difference in sweetening power when a product is more complex; that is, when other ingredients, such as fat, proteins, acids, or carbohydrates, are involved. When a sweetener (or a combination of sweeteners) is added to a food product, it is necessary to consider the various interactions among the sweeteners and the food ingredients that could alter the sweetener`s potency. The ideal sweetener should present a similar profile to sucrose, the ingredient most used to create sweet taste in processed foods. In addition, for economic reasons, only a small amount of sweeteners should be added during formulation. In this regard, sucralose and Neotame meet these requirements, as they presented the highest potency values (500.00 and 5,000.00, respectively), requiring addition of just 0.016 and 0.0016% (wt/wt) to achieve the same perception of the sweet taste as that obtained with sucrose. Therefore, these options are available to the dairy industry to produce prebiotic dairy desserts with reduced caloric value.

Overall, our findings present valuable for the functional dairy industry, because it was possible to determine and optimize the concentration of sweeteners from a sensory point of view. A food matrix with an added prebiotic ingredient also contributes to global sweetness because of the sweetening power of fructooligosaccharides. Future research should include sensory profiling by a trained painel (Cadena et al., 2012; Morais et al., 2014) as well as consumer profiling techniques (Santos et al., 2012; Cruz et al., 2013). Dynamic sensory methodologies, such as a time-intensity method, would also be useful (Cadena and Bolini, 2011; Morais et al., 2013). Sweeteners present different characteristics in different types of foods and beverages that influence the perception of sweetness and the product`s acceptance; these factors must be considered when replacing sucrose.

CONCLUSIONS

The addition of prebiotic and gum to chocolate dairy desserts affected acceptability. The effect depended not only on the concentration of added prebiotic but also on that of gum. We established a relationship between the acceptability of chocolate dairy dessert and its composition. Our models predicted acceptability and ideal creaminess in terms of the concentrations of prebiotic and gum. This information will be useful in designing new products with nutritional and sensory characteristics that meet consumer demand. The concentration of sucrose considered ideal in our prebiotic chocolate dairy dessert was 8.0%. The magnitude estimation method allowed us to determine the sweetness equivalence of sucralose, aspartame, stevia, and Neotame compared with 8.0% sucrose; the concentrations of each that should be added to processed dessert were 0.0160, 0.0540, 0.100, and 0.0016%, respectively. Neotame was found to be strongest sweetener and stevia the weakest. The development of dairy products with sugar substitutes must consider the acceptability of the product to consumers. Each sweetener presents a characteristic sensory profile and must be used according to its power of sweetness and consumer acceptability.

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ARTIGO 2: PARAFAC and PCA preference map provides similar configuration regarding prebiotic low sugar chocolate dairy desserts

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ABSTRACT

The addition of prebiotic and sweeteners in chocolate dairy desserts opens up new opportunities to develop dairy desserts that, besides having a lower calorie intake, still have functional properties. In this study, prebiotic low sugar dairy desserts were evaluated by 120 consumers using a 9-point hedonic scale, in relation to the attributes of appearance, aroma, flavor, texture, and overall liking. Internal Preference map using parallel factor analysis (PARAFAC) and Principal Component Analysis (PCA) was performed using the consumer data. In addition, physical (texture profile) and optical (instrumental color) analyses were also performed. PARAFAC allowed the extraction of more relevant information in relation to PCA, demonstrating that consumer acceptance analysis can be evaluated by simultaneously considering several attributes. Multiple factor Analysis (MFA) reported Rv value of 0.964, suggesting excellent concordance for both methods. Consumers similarly liked prebiotic dairy desserts added with sucrose and sucralose. The former was characterized by firmness and gumminess and was lighter colored than the others with prebiotic and sweetener agents. The use of PARAFAC to evaluate consumer data should be incentive.

Keywords: PARAFAC, principal component analysis, acceptance, prebiotic low sugar dairy dessert.

INTRODUCTION

Dairy desserts are widely consumed products worldwide. The nutritional (composition) and sensory characteristics stimulate their consumption by several groups of consumers, including children and elderly people (Cardarelli et al., 2008; Bruzzone et al., 2011). Variations in the characteristics of these desserts and the interactions with their ingredients produce noticeable differences in the physical and sensory properties of the formulated products (Tarrega and Costell, 2007) which could influence their acceptability by consumers. While consumers generally do not consider dessert a primary source of nutrients, dairy desserts do contain significant nutrients (Serrano-Rios, 1994; Muehlhoff et al., 2013). Researches continue to identify positive ways that milk impacts in health. In addition to building healthy bones, consuming milk and dairy products can boost immunity, lower blood pressure, reduce risk of diabetes, reduce risk of some cancers and help maintain weight. Milk is an excellent source of high-quality protein, which is important throughout life (Muehlhoff et al., 2013).

Functional product development provides an opportunity to contribute to the improvement of food quality and consumer health and well-being (Granato et al., 2010a,b). New functional products are developed by modifying traditional food formulas, eliminating or replacing certain ingredients or adding wholesome compounds, and the dairy desserts have been studied lately (Gonzalez-Tomas et al., 2009; Ares et al., 2009; Arcia et al., 2010; Ares et al., 2012). Prebiotic foods represents an important class of functional foods (Al-Sheraji et al., 2013), being used in several food matrices (Morais et al., 2014; Isik et al., 2013; Pimentel et al., 2013; Cruz et al., 2013; Orango et al., 2013).

There are two basic approaches to the analysis and understanding of consumers' preferences, which are generally referred to as internal and external preference mapping

(Cadena et al., 2012). Although they are essentially based on the same data, internal and external preference analyses represent different perspectives on this data, and hence they extract different information from it. External preference analysis requires both sensory and preference data, whereas internal preference analysis can, in principle, be conducted solely based on preference data (van Kleef et al., 2006).

Parallel factor analysis (PARAFAC) can be considered a generalization of PCA for multidimensional data (Bro, 1997), without requiring orthogonality in the computation of the factors to identify the model besides generating a unique solution (Marini, 2013). PCA provides an exploratory analysis of samples as a function of variables, while PARAFAC is able to provide an exploratory interpretation of these samples and variables, taking into account the different conditions in which these data were generated (Nunes et al., 2011). Recently, the potential use of PARAFAC as a tool to model consumer sensory acceptance data has been demonstrated; a suitable explanation towards the data variability of consumer preferences of beef burger and herb cake (Nunes et al., 2011), grape juice (Nunes at al., 2012) and probiotic and conventional yogurt (Cruz et al., 2012).

In this context, this research aimed to evaluate the acceptance of chocolate dairy desserts and the influence of prebiotic and sweeteners addition on acceptance, using the internal preference map through PARAFAC. For comparatives purposes, the data were submitted to principal component analysis (PCA). In addition, physical and optical analysis (texture profile and instrumental color) were also performed.

MATERIALS AND METHODS

Materials

Five dessert samples were produced with the addition of prebiotic Biofis Inufos (inulin and fructooligosaccharides – 50:50) (Siba Ingredients, Sao Paulo, SP, Brazil), guar and xanthan gum (SweetMix, Sorocaba, SP, Brazil), commercial skimmed-milk powder (Molico®, Nestle, Araraquara, SP, Brazil), commercial UHT skimmed-milk (Molico®, Nestle, Araraquara, SP, Brazil), cocoa powder (Garoto®, Vila Velha, ES, Brazil), sucrose (Uniao®, Taruma, SP, Brazil), and light milk cream (Nestle, Aracatuba, SP, Brazil). Chocolate dairy dessert samples were sweetened with different high intensity sweeteners and sucrose. The sweeteners were neotame (NutraSweet, Chicago, IL; obtained from SweetMix, Sorocaba, SP, Brazil); sucralose (SweetMix, Sorocaba, SP, Brazil); stevia with 95% of rebaudioside (SweetMix, Sorocaba, SP, Brazil); and aspartame (SweetMix, Sorocaba, SP, Brazil). One sample (the integral) was produced with guar and xanthan gum (SweetMix, Sorocaba, SP, Brazil), commercial milk powder (Ninho®, Nestle, Ituiutaba, MG, Brazil), commercial UHT milk (Ninho®, Nestle, Ituiutaba, MG, Brazil), cocoa powder (Garoto®, Vila Velha, ES, Brazil) sucrose (Uniao®, Taruma, SP, Brazil), and milk cream (Nestle, Aracatuba, SP, Brazil).

Chocolate dairy desserts processing

The concentrations of prebiotic, gum, milk powder, cocoa powder, and milk cream were kept constant. The concentrations of sucrose and sweeteners varied according to previously study on power sweetness, and the UHT milk was added until completing 100 wt.% of the formulation (Table 1).

The solids ingredients were mixed in a dry pan. The UHT milk was heated to 40ºC and added to the mixture of solid ingredients under constant agitation. Subsequently, the temperature was increased to 90 ± 2°C for 3 minutes for pasteurization. The temperature was then reduced to 40°C, cream was added, and the mixing continued for another 2 minutes. The samples were put in an acrylic cup (40 ml), covered to avoid drying, and stored under refrigeration (6 ± 2°C) until sensory and physicochemical analysis.

Table 1. Proportion of ingredients in chocolate dairy dessert formulations

Ingredients	Formulations (wt.%)					
	Sucrose	Sucralose	Aspartame	Neotame	Stevia	Integral
Sweetener	8.0	0.016	0.054	0.0016	0.1	10.0
Prebiotic	7.5	7.5	7.5	7.5	7.5	----
Skimmed-milk powder	10.0	10.0	10.0	10.0	10.0	----
Milk powder	---	----	----	----	----	12.0
Cocoa powder	4.5	4.5	4.5	4.5	4.5	4.5
Gum	0.2	0.2	0.2	0.2	0.2	0.2
Light milk cream	25.0	25.0	25.0	25.0	25.0	----
Milk cream	----	----	----	----	----	25.0
UHT skimmed-milk	44.8	52.7	52.7	52.7	52.7	----
UHT milk	----	----	----	----	----	48.3

Consumer test

Sensory analysis was carried out in individual air-conditioned (22°C) booths with white light. Water and crackers were provided for palate cleansing. Sessions were held at the Sensory Science and Consumer Study Lab, Department of Food and Nutrition of University of Campinas. Sample`s presentation was in in acrylic cups coded with three digit numbers, and tasters were served 30 g of each chocolate dairy dessert sample.

Overall liking was determined using a 9-cm linear hedonic scale (not structured) (Stone and Sidel, 2004), with anchors of “dislike extremely” on the left and “like extremely” on the right. Consumers evaluated appearance, aroma, flavor, texture, and overall liking. All the samples were presented monadically using a balanced complete block design

(Walkeling and MacFie, 1995). 120 consumers (71 females and 49 males, aged between 18 and 60) recruited through personal contact took part in the affective test. Each consumer conducted the assessment of the six chocolate dairy dessert samples in a single session. To prevent bias, no information about the samples was given to the consumers.

Principal Component Analysis (PCA)

The PCA is based on the idea of finding the most important directions of variability in the high dimensional space of all the measured variables and presenting the results in plots that can be used for simple interpretation. It can be looked upon as a purely descriptive mathematical method that simply extracts the main information in the data and presents the results graphically. In addition, it is used in an early phase of an investigation as an explorative technique in order to provide an overview, but the method can also be used to generate hypotheses (Naes et al., 2010; Cruz et al., 2013).

The consumer acceptance data sets were arranged in a matrix of *i* lines (samples) and *j* columns (consumers) for the attribute of overall liking; and in a matrix of *i* lines (samples) and *j* columns (attributes) by calculating the average of consumer assessments (Cruz et al., 2012). Data were auto scaled and the PCAs were carried out using SensoMaker software – version 1.7 (Pinheiro et al., 2013). Plots of scores and loadings were built from the first two principal components.

Paralell factor analysis (PARAFAC)

Consumer acceptance data sets were arranged in an array of *i* lines (samples), *j* columns (consumers), and *k* cubes (attributes). The three-way arrays underwent PARAFAC analysis. PARAFAC calculations were carried out using the SensoMaker software – version 1.7 (Pinheiro et al., 2013). The orthogonality constraint was used in the first mode. The other parameters were used in the default. The core consistence was used as the choice criterion of the number of factors (Cruz et al., 2012), as it estimates the appropriateness of the PARAFAC solution, indicating if the model is appropriate or not. The explained variance is the amount of variance explained for the assumed number of factors (Marini, 2013). Biplots were made for the first two factors for each loading mode.

Physical and optical analysis

Physical and optical analyses of the chocolate dairy dessert samples were performed at the Central Lab, Department of Food and Nutrition of University of Campinas. Samples were evaluated in four repetitions.

The texture profile of the chocolate dairy desserts was carried out using the universal TA-XT2R Texture Analyzer (Stable Micro Systems, Godalming, Surrey, UK) with a 0.05 N load cell. Compression measurements were conducted at 10ºC using a probe of 50 mm diameter to apply 20% constant strain to a sample of 50 mm diameter and 40 mm height (Pons and Fiszman, 1996). The test speed was 174 2 mm/s with two penetration cycles. The force exerted on the sample was automatically recorded, and the parameters of hardness (N), adhesiveness (N.s), elasticity ($N.s^{-1}$), and gumminess were automatically evaluated from the force (N) x time (s) curves generated during the test by the Texture Expert for Windows software version 1.19 (Stable Micro Systems).

The instrumental color of chocolate dairy dessert samples was measured in a Color Quest®II Sphere colorimeter (Hunter Associations Laboratory, Inc., Reston, Virginia, USA). A 3.5 cm thick layer of sample was contained in optical glass cells 3.8 cm high and 6 cm in diameter to measure diffused reflected light from the cell bottom using an 8 mm diaphragm aperture. Results were given using the CIELab System for illuminant D 65 and a 10º angle of vision. Registered parameters were L* (brightness), a* (red component), and b* (yellow component).

Statistical analysis

Data obtained from the consumer test and the results of the physical and optical analyses were evaluated by univariate statistical analysis (ANOVA), and the means were compared using Tukey test (at 5% significance). The calculations were performed using the statistical software Statistical Analysis System – SAS 9.1.2 (SAS Institute Inc., Cary, NC, 2008).

Multiple factor analysis was performed to compare the product position on the profiling maps produced by the PARAFAC and PCA. This analysis was performed on a table composed of six rows, corresponding to the six prebiotic low sugar desserts, and two groups of columns, corresponding positions of the products at the two first dimensions of PARAFAC and PCA preference mapping. The comparison of the methods was performed by Rv coefficient (0 to 1), a quantitative index of their correspondence, and represents a simple way of measuring the similarity between two sets of variables. They were performed using XLSTAT for Windows version 2012.5 (Adinsoft, Paris, France).

RESULTS AND DISCUSSION

Consumer test

The 120 consumers evaluated the chocolate dairy dessert samples for liking of appearance, aroma, flavor, texture, and overall liking. Results are presented in Table 2 and showed that the sucrose chocolate dessert received most of the high hedonic scores and that most consumers like this sample because of the appearance, but it not differed statistically (P > 0.05) from the low sugar samples with sucrose, sucralose, aspartame, and stevia. As the main function of the sucrose is proportionate the sweet taste, our findings confirm previous studies (Orjuela-Palacio et al., 2014; Villamor et al., 2013; Delgado et al., 2013; Alleger et al.,2010) indicating that the sweetness is highly related to overall linking of the processed product.

Table 2. Consumer mean of acceptance test with chocolate dairy desserts* (9-cm unstructured line scale)

Attributes	Samples						SD
	Sucrose	Sucralose	Aspartame	Neotame	Stevia	Integral	
Appearance	7.29a	7.13a	7.10a	6.74b	7.02a,b	7.30a	0.34
Aroma	6.70a	6.50a	6.59a	6.29a	6.48a	6.39a	0.44
Flavor	6.68a	6.67a	6.91a	4.97c	5.53b	6.69a	0.55
Texture	6.44a,b	6.62a	6.47a,b	6.15a,b	6.04b	6.15a,b	0.51
Overall liking	6.77a	6.82a	6.93a	5.52c	5.99b	6.75a	0.44

*Mean data from 120 consumers and based on a 9-point hedonic scale (1 = dislike extremely. 9 = like extremely). Different letters in the same line indicate statistical difference (P ≤ 0.05) among treatments (desserts).

In relation to aroma, the light sample with sucrose presented the highest mean but did not differ significantly (P > 0.05) from the other samples. Thus, it can be said that the addition of prebiotic and sweeteners did not change the aroma of chocolate dairy dessert.

In relation to the flavor, the sucrose sample did not differ significantly ($P > 0.05$) from the low sugar samples with sucrose, sucralose, and aspartame, and differed from the light samples with stevia and neotame, which obtained the lowest score for this attribute being the least accepted. According to Mayhew et al. (2012) neotame is a high potency sweetener and flavor enhancer which have potentiated the bitter taste of the cocoa. And stevia, due to the presence of stevioside in its composition, presents the bitter taste characteristic from this compound (Carakostas et al., 2012).

The results for texture indicated that the low sugar chocolate dairy dessert with sucralose presented the highest score of evaluation but this sample did not differ significantly ($P > 0.05$) from the integral one and from the light samples with sucrose, aspartame and neotame. The light sample with stevia presented the lowest score of evaluation in relation to the texture attribute. Indeed, products developed with sucrose generally distinguished by appearance and taste. In addition to the sweet taste, sucrose increases the viscosity conferring adequate texture and stability (Cadena et al., 2013). The use of sweetener may be suitable for flavor, but often do not provide the desired texture and appearance characteristics (Nabors, 2012).

The hedonic test showed that the chocolate dairy desserts had a good acceptability. Munoz, Civille, and Carr (1992) considered an acceptability score of 6.0 in a 9-point hedonic scale (the first score in the liking category) as commercial or quality limit. Considering this criterion, the samples of chocolate dairy dessert, both light and prebiotic as the traditional one, would be acceptable, since all notes in relation to overall liking were higher than 6.0. The overall liking of the traditional chocolate dairy dessert (added with sucrose) did not differ from the low sugar and prebiotic chocolate dairy desserts with sucrose, sucralose, and aspartame. This is a very good result, since according to Cruz et al. (2010) a prebiotic chocolate dairy dessert cannot be different from a conventional one in relation to their global sensory characteristics.

Dairy desserts supplemented with prebiotic ingredient also obtained good acceptance scores in some attributes, as flavor, aroma, and texture. Similar findings were reported in other dairy matrices supplemented with prebiotic ingredient, such as peach yogurt containing prebiotics (Gonzalez e al., 2011) and functional milk puddings (Ares et al., 2009) where the addition of prebiotic ingredients in the food formulation also improved the product`s sensory acceptance.

The sample added with sucralose presented the highest scores for all attributes, showing a higher acceptance in comparison to the other samples, followed by the low sugar samples with aspartame and sucrose and the integral one (which did not differ statistically from the light sample with sucralose) for the degree of liking of appearance, aroma, flavor, texture, and overall liking. It is able to report the feasibility to develop low sugar chocolate dairy dessert and supplemented with prebiotic ingredient that presents a good sensory acceptance. This product can represent an innovative functional food added of extra quality, due to benefits of prebiotic fibers for the human health.

Principal component analysis (PCA)

Principal component analysis (PCA) was applied using the matrix with dimensions of 6 samples x 120 consumers, for acceptance in relation to overall impression of the chocolate dairy desserts. Data were autoscaled and the result was presented using a biplot graph (Figure 1). PCA was then reapplied using the matrix with dimensions of 6 samples x 5 attributes obtained by calculating the average of consumer assessments for acceptance of chocolate dairy desserts. Data were autoscaled and the result was presented also using a biplot graph (Figure 2).

Analyzing the first two principal components of Figure 1, 56.19% of the variance in the data was explained by the model, allowing the evaluation of the samples that were best linked in relation to overall impression of chocolate dairy dessert samples. In the preference map it is evident that the light sample with aspartame, sucrose and sucralose were preferred, followed by the by the integral one. Light samples with neotame and stevia received were lowest preferred by the consumers. This can be confirmed by the results for overall liking (Table 2), where the light samples with aspartame, sucralose and sucrose, and the integral one showed higher average scores for acceptance.

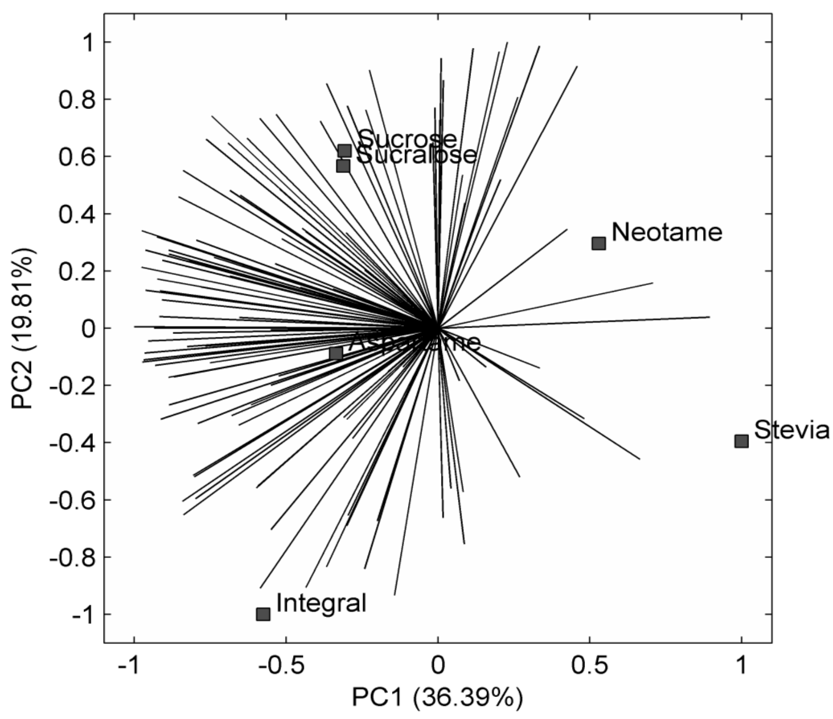

Figure 1. Biplot of principal component analysis (PCA) for overall impression for chocolate dairy desserts.

Figure 2 presents the PCA with the mean values of acceptance for the performance of the samples in the different parameters evaluated. In this figure the first two principal components explained 98.43% of the variance in the data. This explication allowed the evaluation of the samples that were best linked by the average consumers in relation to the attributes of appearance, aroma, flavor, texture, and overall impression. It can be seen that the sample with sucrose was the one with greater global acceptance. The difference between this PCA for PARAFAC is that the PCA was generated by with the average grade of acceptance, without regard to the individuality of the consumers. PARAFAC takes into account the individual score of each consumer.

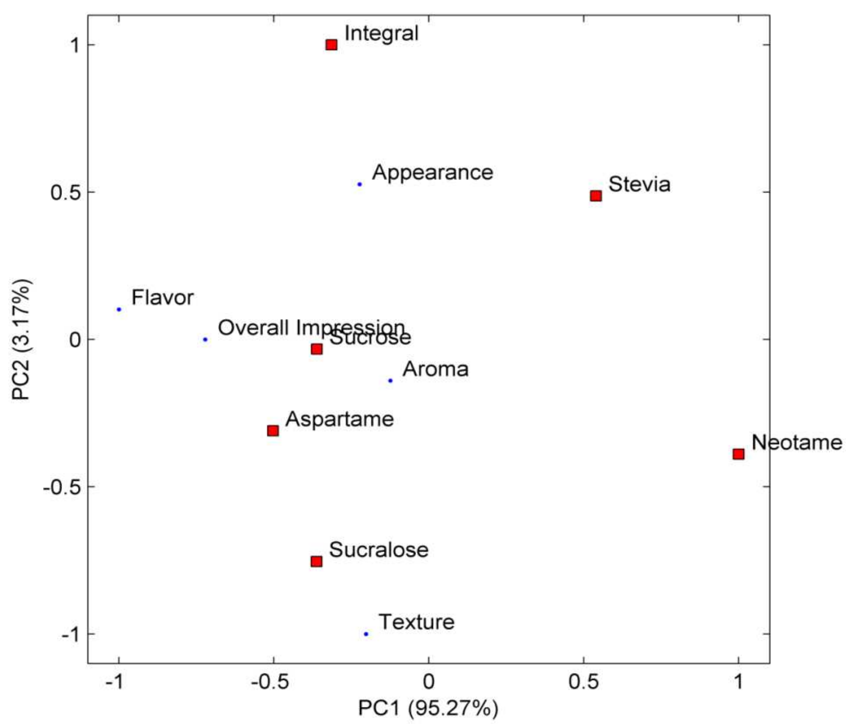

Figure 2. Biplot of principal component analysis (PCA) for chocolate dairy desserts.

Samples with sucrose and aspartame garnered the highest scores for aroma and overall impression. The light sample with sucralose presented the highest scores for texture, and the light sample with stevia and the integral one received the highest scores for appearance. The sample with stevia stood out from the others. PCA showed these results, however in an unclear way and did not take account the individuality of the consumers.

Three-way internal preference map – PARAFAC analysis

Data were organized in a three-way array with dimensions of 6 x 5 x 120 referring to samples x attributes x consumers. To build the three-way internal preference map, PARAFAC models using from 1 to 4 factors were fitted in order to choose the adequate number of factors. The results are presented in Table 3. The core consistence suggested that two factors are indicated, being observed explanation 29.72% of the variance and presented a core consistence value of 89.74%. Although it is reported a low amount of information in two dimensions, the core consistency value, which indicates the quality of the model presented elevated, emphasizing the potential of the PARAFAC method for consumer study.

Table 3. Parallel factor analysis models performance for chocolate dairy desserts acceptance data

Factors	Explained variance (%)	Core consistence (%)
1	19.39	100
2	29.72	89.74
3	39.03	55.85
4	47.23	27.19

Figure 3 shows the graph of the loadings in mode one (samples), loadings in mode two (sensory attributes), and loadings in mode three (consumers) plot, for the first two components. The light sample with neotame and the integral one showed highly distinct acceptance as compared to the other samples, with respect to the degree of liking of appearance, aroma, flavor, texture and overall impression. Light samples with sucrose and sucralose were similarly liked by consumers.

In relation to the first component, the overall impression and flavor were the most important attributes in explaining the disposition of the samples, whilst for the second component; also the overall impression and the texture presented the greatest loadings, confirming the importance of these attributes on the product's evaluation. In general, all attributes evaluated were perceived in a similar way by the consumers, since all of them were allocated in the same region of the graph. These results are in accordance to those described in the literature for chocolate (Palazzo and Bolini, 2009), carrot cupcakes (Villanueva et al., 2010), probiotic cheese (Gomes et al., 2011a), low sodium cheese (Gomes et al., 2011b), and probiotic and conventional yogurt (Cruz et al., 2012).

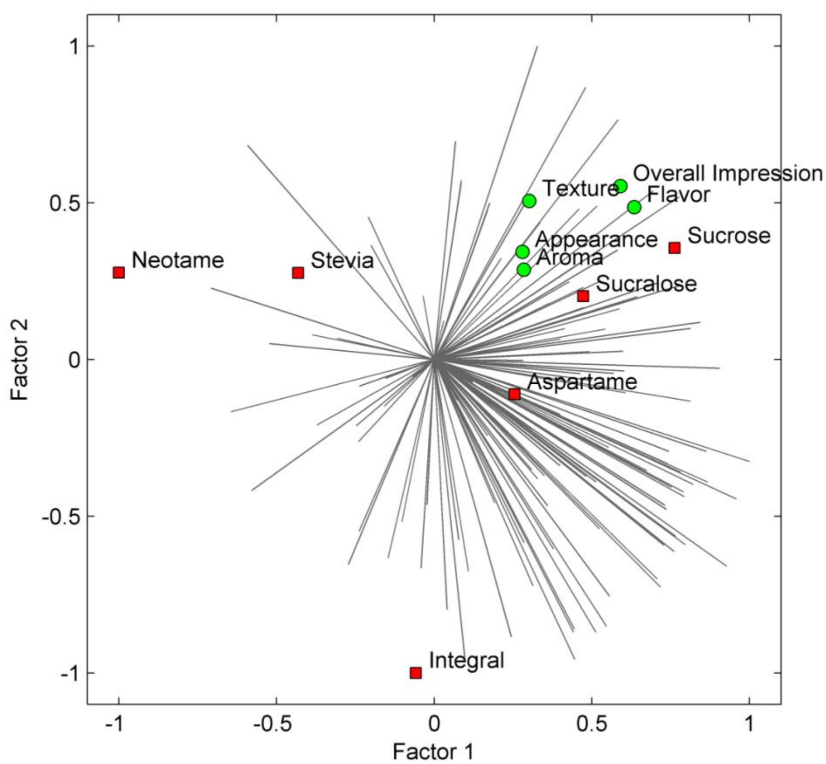

Figure 3. Three-way internal preference map for appearance, aroma, flavor, texture and overall liking for chocolate dairy desserts.

The three-way analysis enabled a comparison of the overall performance of the samples in the acceptance test, indicating that the light samples with sucrose, sucralose and aspartame presented similar behavior, as did the light with neotame and with stevia samples, whereas the integral one stood out from the others.

Regarding the consumer's information, one can infer that consumers were more homogeneous in evaluating the attributes of the first component, and heterogeneous in evaluating the second component. According to Cruz et al. (2012) this information is not new, as the divergences in the scores attributed by some consumers reflected the different modes of liking the products.

Comparing the results of acceptance test, the PCA for overall liking, the PCA for all attributes and the three-way internal preference map, it can be seen that they are in accordance. Indeed, the PCA for the overall liking showed that the light sample with aspartame is highest preferred by consumers followed by the ones with sucrose and sucralose, and the acceptance is in accordance with this since this sample presented the highest mean for this attribute and did not differ statistically ($p > 0.05$) from the light samples with sucrose and sucralose and the integral one. The PCA analyzed with the means of the attributes also showed that the light samples with sucrose, sucralose and aspartame are characterized by highest scores of overall liking, as the three-way internal preference map in which these three samples also presented the highest scores for this attribute (overall liking). So, considering the attribute overall liking, the methods of evaluation presented accordance in the results.

Comparison of the sensory maps

Comparing the three-way internal preference map and the PCA with the means of the attributes it can be seen that the PCA methodology presents as negative point no presentations of consumers in the graph, showing the advantage of the three-way method. So, the three-way showed that all attributes had importance in evaluating the chocolate dairy desserts, and that the samples which were most characterized by these attributes were the light ones with sucrose, sucralose, and aspartame. These are the samples preferred by consumers since they are located in the same region of samples in the graph (Figure 3). In PCA the attributes were allocated in different regions (Figure 2). The light samples with sucrose and aspartame were characterized by the attributes of overall liking and aroma, and the on with sucralose was characterized by the attribute of texture, but this methodology did not allowed to detect how was the sample preferred by consumers.

Multiple factor analysis (MFA) is dedicated to datasets where variables are structured into groups. Several sets of variables (continuous or categorical) are therefore simultaneously studied. The structure of the data allows balance the influence of each group of variables and study the links between the sets of variables (Pagès, 2004). MFA is extended to include types of variables in order to balance the influence of the different sets when a global distance between units is computed (Bécue-Bertaut and Pagès, 2008).

Figure 4 compares the distribution of prebiotic low sugar chocolate dairy desserts obtained by Multiple Factor Analysis (MFA), according to PARAFAC and PCA sensory map. Using just two dimensions, it was obtained 99.08 % of the total variation of the data. The similar positions show absence of difference among the samples, suggesting that both methods present similar information regarding the sensory attributes of the prebiotic low sugar chocolate desserts. The high Rv value obtained – Rv = 0.964 – confirms this hypotheses, suggesting the potential of PARAFAC of evaluating consumer data.

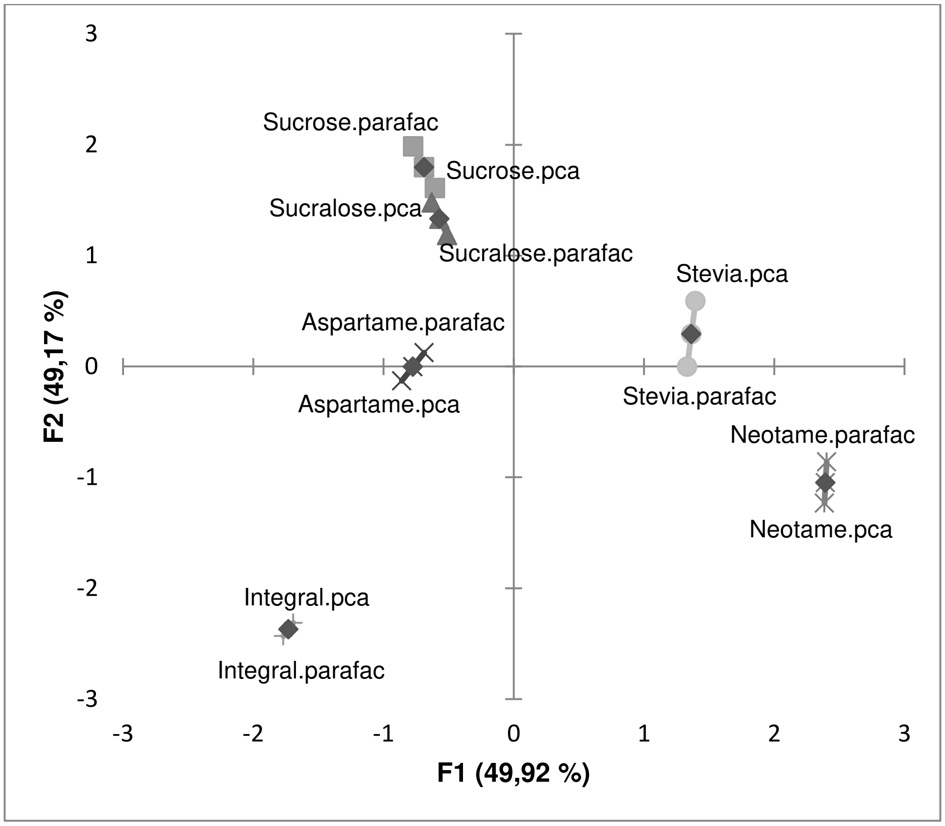

Figure 4. Comparative MFA on individual configurations of PCA and PARAFAC sensory map of prebiotic low sugar chocolate dairy desserts.

Physical and optical characterization

Tables 4 and 5 present the mean values for the physical characteristics of the chocolate dairy dessert samples. The chocolate dairy desserts were evaluated for firmness, adhesiveness, elasticity, and gumminess. Statistical significant differences (P ≤ 0.05) were obtained among samples in relation to all attributes evaluated.

Table 4. Instrumental texture parameters obtained for the chocolate dairy desserts*

Parameters	Samples						SD
	Sucrose	Sucralose	Aspartame	Neotame	Stevia	Integral	
Firmness (N)	230.31b	189.95cd	198.47c	172.68d	165.44d	298.90a	25.12
Adhesiveness (N.s)	-65.80c	-51.42ab	-55.97bc	-45.13ab	41.08a	-135.06d	13.48
Elasticity ($N.s^{-1}$)	0.096b	0.107ab	0.104ab	0.118ab	0.131a	0.061c	0.034
Gumminess (N)	130.62b	109.30cd	118.01c	105.32d	105.71d	176.25a	9.86

*Different letters in the same line indicate statistical difference (P ≤ 0.05) among treatments (desserts).

Table 5. Color parameters obtained for the chocolate dairy desserts*

Parameters	Samples						SD
	Sucrose	Sucralose	Aspartame	Neotame	Stevia	Integral	
L*	15.29 c	24.33 b	24.22 b	22.90 b	23.56 b	29.45 a	2.56
a*	25.84 a	20.75 b	21.27 b	21.13 b	21.05 b	18.60 c	1.47
b*	26.33 ab	29.38 ab	31.26 a	31.29 a	30.72 ab	25.34 b	5.72

*Different letters in the same line indicate statistical difference (P ≤ 0.05) among treatments (desserts).

Texture is directly related to the ingredients of the formulation, as well as its balance. Firmness is sensorial defined as the ´force required to compress a substance between tongue and palate` and physically defined as ´maximum force required to compress the sample` (Muller-Fisher and Windhab, 2005). Firmness was statistically different (P ≤ 0.05) among the formulations studied, and the sucrose chocolate dairy dessert presented the highest value, followed by the low sugar sample with sucrose. According to Nabors (2012) sucrose increases the viscosity, which was confirmed with the present result. Cardarelli et al. (2008) evaluated functional chocolate mousse and observed that symbiotic samples presented highest means of firmness in relation to control and probiotic samples.

Adhesiveness is sensorial defined as the ‘force required to remove the material that adheres to the mouth – generally the palate – during the normal eating process’ and physically defined as ‘the work required to pull the sample away from a surface’ (Rosenthal, 1999; Muller-Fisher and Windhab, 2005). The highest adhesiveness was found for the light chocolate dairy dessert with stevia, which did not differ ($P > 0.05$) from the light samples with neotame and sucralose. The sucrolase chocolate dairy dessert presented the lowest value of adhesiveness differing statistically ($P \leq 0.05$) from the others.

According to Shimada and Cheftel (1989) the parameter of elasticity is strongly related to the formation of intermolecular disulfide bonds. The light chocolate dairy dessert with stevia presented a highest mean of this parameter, and did not differ statistically ($P > 0.05$) from the light ones with sucralose, aspartame and neotame. The sucralose chocolate dairy dessert presented the lowest value of elasticity differing statistically ($P \leq 0.05$) from the others. Vidigal et al. (2012) reported that fat-free desserts supplemented with whey protein concentrate showed greater elasticity.

Gumminess is defined as the energy required to break down a semi-solid food ready for swallowing (Muller-Fisher and Windhab, 2005). In relation to this parameter, the integral chocolate dairy dessert presented the highest mean value, and differed statistically ($P \leq 0.05$) from the other desserts, followed by the light chocolate dairy dessert with sucrose. The low sugar sample with stevia presented the lowest mean value in relation to this parameter, and did not differ ($P > 0.05$) statistically from the light samples with neotame and sucralose.

The color of chocolate dairy desserts is a very important factor in their marketing and is directly influenced by the raw materials used in the formulation and also by the procedure conditions. Table 6 shows the mean values of the instrumental color parameters of brightness (L*), redness (a*), and yellowness (b*) for chocolate dairy dessert samples. The instrumental color analysis showed that the L* parameter values ranged from 15.29 to 29.45, characterizing the samples as dark colored. The integral chocolate dairy dessert presented the highest mean for this parameter, which differed significantly ($P \leq 0.05$) from the other chocolate dairy dessert samples. The light and prebiotic sample with sucrose was characterized as the darkness among the samples, presenting the lowest mean and differing significantly from the others. Gonzalez-Tomas et al. (2009) also reported a slight decrease in the reflectance in skim milk dairy desserts. They observed that milk type significantly affected all color parameters; in general, whole milk samples were the lighter colored ones and showed a stronger yellow-orange color.

For the a* coordinate, the light chocolate dairy dessert with sucrose presented higher mean and differed statistically ($P \leq 0.05$) from the others. The integral sample presented the lowest mean for the a* color coordinate, differing significantly ($P \leq 0.05$) from each other. The light samples with sucralose, aspartame, neotame and stevia presented intermediated mean values for this color coordinate, and did not differ significantly among them.

The light and prebiotic chocolate dairy dessert samples with aspartame and neotame were characterized by higher means for b* color coordinate, did not differing significantly ($P > 0.05$) from the light and prebiotic samples with sucrose, sucralose, and stevia. And the sucralose chocolate dairy dessert sample presented the lowest mean for the b* color coordinate with difference ($P \leq 0.05$) from the light and prebiotic samples with aspartame and neotame, but did not differ significantly ($P > 0.05$) from the light and prebiotic samples with sucrose, sucralose, and stevia.

Considering the acceptance test, in which the samples that presented highest scores in all attributes were the low sugar samples with sucrose, sucralose, and aspartame, the instrumental texture parameter related to these high scores of acceptance cover the high values of the former for low values for adhesiveness and elasticity, high values for firmness and intermediate values of the gumminess parameter. In relation to the color parameters obtained for the chocolate dairy desserts, the samples who presented greater acceptance varied in the color parameters (L*, a*, b*), without a clear tendency.

These results have not been reported previously and these findings can be useful for dairy processors who can choose ingredients able to emphasize the sensory sensations related to the instrumental parameters, which improve chance of commercialization with regular consumers.

CONCLUSIONS

There is an imminent need for developing prebiotic dairy desserts with sweeteners which presents high acceptance by consumers, so that their purchase is made periodically. The use of preference maps using PARAFAC may constitute a potential tool for obtaining results of hedonic test with consumers; providing similar information in relation to PCA with the advantage of using data from three-dimensional shape.

The addition of sweeteners and prebiotics simultaneously may be suitable to be used in a chocolate dairy dessert with low calorie and high acceptance by consumers who appreciate the firmness and adhesiveness of these products. These results are very useful for dairy processors who wish to participate for the competitive market of functional foods.

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ARTIGO 3: Multiple time-intensity analysis and temporal dominance of sensations of chocolate dairy desserts using prebiotic and different high intensity sweeteners

Artigo resubmetido para publicação na Journal of Sensory Studies após correções

ABSTRACT

This paper presents a novel concept for producing chocolate dairy desserts using prebiotic and sucrose substitutes. The quality of chocolate dairy desserts was analyzed by the multiple time-intensity analysis and temporal dominance of sensations. Time-intensity analysis showed that the sample developed with neotame had a higher intensity of sweetness; the samples with neotame and stevia had a higher intensity of bitterness; and the samples with sucrose, sucralose, aspartame, and the integral one had a higher intensity of chocolate flavor. Sucralose and aspartame provided a temporal profile with parameter curves closer to the one sweetened with sucrose, as well as the addition of prebiotics. The TDS analysis also showed a similar profile between the integral sample and the prebiotic light samples with sucralose and aspartame, in relation to the attributes of sweetness, bitterness, milk chocolate flavor, bittersweet chocolate flavor, milk powder, cream, and off-flavor. In this context, the addition of prebiotic and replacement of sucrose by sweeteners opens up new opportunities in product development, especially in chocolate formulation for dietetic and functional purposes.

Key words: dairy dessert, prebiotic, time-intensity analysis, temporal dominance.

PRACTICAL APPLICATIONS

Temporal dominance of sensations (TDS) has led to improve a better understanding of temporality behavior of dairy desserts` taste and flavor. In this study, the time-intensity (TI) analysis allowed the verification of changes in the perception of a product's attribute over time while TDS provided how the flavor behavior is for consumers during the dairy dessert ingestion and obtained the temporal profile of all attributes related to flavor. These methodologies are complementary and they are very useful for dairy dessert processors and people who works in the functional and sweetener industry.

INTRODUCTION

Alternative sweeteners to sucrose continue to be of great interest to the food industry, health professionals, consumers, and the media. They may assist the industry in reducing the calorie content of good-tasting foods and beverages, which is also of interest to health professionals (Nabors 2012). The consumption of low-calorie foods and no caloric sweeteners has been rapidly increasing. With increased consumer interest in reducing sugar intake, a great number of sweeteners during the last decade have triggered the development of new sugar-free products. Changes in eating habits and lifestyle are mainly due to incessant search for health (Pinheiro *et al.* 2005; Reis *et al.* 2011).

High intensity sweeteners are successful if they match perfectly the quality of sucrose (Portmann and Kilcast 1996). However, the replacement of sucrose by alternative sweeteners can be providing changes in the perception of bitter and sweet taste (Bolini-Cardello *et al.*, 1999; Cadena and Bolini 2011). Alternative sweeteners should have a quick onset and a minimum persistence to mimic sucrose (Portmann and Kilcast 1996). Therefore, the characteristics of interest related to the sensory quality of chocolate dairy dessert should be identified and properly studied by way of a sensory analysis.

Time-intensity analysis is used to obtain the temporal profile of an attribute in a product. This technique is different from the conventional descriptive analysis because it allows the verification of changes in the perception of a product′s attribute over time (Alves *et al.* 2008). Time-intensity analysis is an extension of the descriptive sensory analysis and provides temporal information in relation to perceived sensations in a food (Dijksterhuis and Piggott 2001). This sensory technique has been used to analyze many food matrices such as gluten-free breads (Morais *et al.* 2013), chocolates (Palazzo *et al.* 2011; Palazzo and Bolini 2014), ice creams (Cadena and Bolini 2011), coffee (Moraes and Bolini 2010), raspberry-flavored gelatin (Palazzo and Bolini 2009) and cooked bologna type sausage (Ventanas *et al*. 2010), demonstrating thus the importance of such technique in sensory evaluation of foods. The multiple time-intensity analysis (MTIA) is a way of graphically representing in a simultaneously way, the dynamic profiles of two or more sensory attributes of a single sample. This form enables to make visualization of the group of sensations selected for being important (Cadena and Bolini 2011; Palazzo and Bolini 2014).

Temporal dominance of sensations (TDS), proposed by Pineau *et al*. (2003), is a recent methodology that provides the sequence of sensory attributes perceived over time. Tasters assess which sensation is dominant over time until the sensation ends or another appears as dominant (Labbe *et al*. 2009; Pineau *et al*. 2009). This method has been used currently to assess the profile of products as butter (Souza *et al*. 2013), extra-virgin olive oil (Dinnella *et al*. 2012), candies (Saint-Eve *et al*. 2011), and white wine (Sokolowsky and Fischer 2012), also demonstrating thus the importance of such method in sensory evaluation of foods.

Sokolowsky and Fischer (2012) evaluated bitterness in white wine applying descriptive analysis, time-intensity analysis, and TDS analysis, and compared the information of all sensory parameters by multiple factor analysis and correlation. Each technique provided additional valuable information regarding the complex bitter perception in white wine. On the other hand, Pineau *et al*. (2009) studied the temporality of the sensory perception in five dairy products using TI analysis and TDS analysis in order to compare the two methodologies. Authors concluded that TDS and TI results exhibit close patterns of sensations but TDS is found to better enhance the sequence of sensations over time.

Dairy desserts are appreciated by consumers in several age groups (Granato *et al*. 2010). They are formulated with several ingredients as stabilizers, fruit pulps, which interact themselves resulting in a wide variety of textures, flavors and appearances (Verbeken *et al*. 2006), which influence the nutritional, physical and sensory characteristics, with direct impact at the acceptability by consumers (Tárrega and Costell 2007). Recently the use of prebiotic ingredients in dairy foods formulation has been incentive in dairy foods (Arcia *et al*. 2011; Ares *et al*. 2010; Ares *et al*. 2012; Granato *et al*. 2012), and dairy desserts following this tendency. However the available studies only evaluate the impact on the physic-chemical and structural characteristics of the products. In this sense, the formulation of prebiotic dairy desserts with high intensity sweeteners is not studied in a sensory point of view. In this context, the aim of this study was to analyze the time-intensity profile and temporal dominance of sensations in chocolate dairy dessert in the traditional version (with sucrose and traditional ingredients) and with prebiotic and light version (sweetened with different sweeteners and light ingredients).

MATERIALS AND METHODS

Ingredients

Five samples were produced with prebiotic Biofis Inufos (inulin and fructooligosaccharides – 50:50) (Siba Ingredientes, São Paulo, SP, Brazil), guar and xanthan gum (SweetMix, Sorocaba, SP, Brazil), commercial skim milk powder (Molico®, Nestlé, Araraquara, SP, Brazil), commercial UHT skim milk (Molico®, Nestlé, Brazil), cocoa powder (Garoto®, Vila Velha, ES, Brazil), sucrose (União®, Tarumã, SP, Brazil), and light cream (Nestlé®, Araçatuba, SP, Brazil). Chocolate dairy dessert samples were sweetened with different high intensity sweeteners and sucrose. The sweeteners were Neotame (NutraSweet, Chicago, IL; obtained from SweetMix); sucralose (SweetMix); stevia with 95% of rebaudioside (SweetMix); and aspartame (SweetMix). And one sample (the integral) was produced with guar and xanthan gum (SweetMix, Sorocaba, SP, Brazil), commercial milk powder (Ninho®, Nestlé, Araçatuba, SP, Brazil), commercial UHT milk (Ninho®, Nestlé, Brazil), cocoa powder (Garoto®, Brazil), sucrose (União®, Brazil), and cream (Nestlé®, Brazil).

Chocolate Dairy Desserts Preparation

The concentrations of prebiotic, gum, milk powder, cocoa powder, and cream were kept constant. The concentrations of sucrose and sweeteners varied, and the UHT milk was added to 100% (wt/wt) of the formulation (Table 1). All desserts were batching produced (1,000 g) in the Sensory Science and Consumer Research laboratory (UNICAMP/FEA/DEPAN – Campinas, Brazil). Previous study determined the level of the ingredients used in this study (Morais *et al*. 2014).

TABLE 1. PROPORTION OF INGREDIENTS IN CHOCOLATE DAIRY DESSERT FORMULATIONS

Ingredients	Formulations (wt. %)					
	Sucrose	Sucralose	Aspartame	Neotame	Stevia	Integral
Sweetener	8.0	0.016	0.054	0.0016	0.1	10.0
Prebiotic	7.5	7.5	7.5	7.5	7.5	---
Skimmed-milk powder	10.0	10.0	10.0	10.0	10.0	---
Milk powder	---	---	---	---	---	12.0
Cocoa powder	4.5	4.5	4.5	4.5	4.5	4.5
Gum	0.2	0.2	0.2	0.2	0.2	0.2
Light milk cream	25.0	25.0	25.0	25.0	25.0	---
Milk cream	---	---	---	---	---	25.0
UHT skimmed-milk	44.8	52.7	52.7	52.7	52.7	---
UHT milk	---	---	---	---	---	48.3

The solids ingredients were mixed in a dry pan. The UHT skim milk was heated to 40ºC and added to the mixture of solid ingredients under constant agitation. Subsequently, the temperature was increased to 90 ± 2ºC for 3 min for pasteurization. The temperature was then reduced to 40ºC, cream was added, and the mixing continued for another 2 min. The samples were put into acrylic cups (40mL), covered to avoid drying, and stored under refrigeration (6 ± 2ºC) until sensory analysis.

Sensory Analyses

Sensory analyses were performed in individual air-conditioned (22º C) booths in the Laboratory of Sensory Science and Consumer Research of the School of Food Engineering (Department of Food and Nutrition, UNICAMP, Campinas, Brazil), and evaluated under with white light, thus ensuring comfort and privacy for the panelists. Taste-free water and biscuits were provided for palate cleansing. Samples coded with 3-digit numbers were presented to tasters in acrylic cups with 20 g of each chocolate milk dessert sample. A complete balanced block design was used (MacFie *et al*. 1989; Stone *et al*. 2012), and the samples were presented sequentially in a monadic way.

Selection of Assessors

For the definition of samples that would be used in the triangular test and in Wald´s sequential analysis for subject selection, a paired comparison test was first performed. In this test we used two samples of commercial chocolate dairy dessert, and added 0.025% (wt/wt) of aspartame to one. This paired comparison test was carried out using 40 consumers, in which the two samples were presented and the difference at 1% significance were confirmed.

Subjects were recruited among University of Campinas undergraduates, graduates and employees, who presented themselves as consumers of chocolate dairy desserts and showed interest in becoming members of the sensory group to be trained. For the selection of assessors to comprise the team, a series of triangular tests with 30 recruited assessors was held, and the Wald´s sequential analysis was applied to check the discrimination ability of each individual (Meilgaard *et al*. 2004). The subjects had to identify which of three samples served was the different.

To determine the Wald´s sequential analysis, were used the following values: P = 0.30 (maximum incapability acceptable), P1 = 0.70 (minimum acceptable skill) and the risks α = 0.10 (probability of accepting a candidate without sensory acuity) and β = 0.10 (probability of rejecting an applicant with sensory acuity). Assessors were selected or rejected according to the number of correct tests analyzed in the triangular test. Fifteen subjects were prescreened for the determination of time-intensity stimuli and temporal dominance of sensations as potential panelists.

Training Session

References of the time-intensity stimuli were determined by a consensus of all the assessors and they were then further trained with respect to the product attributes using identified reference (Table 2). Training for the formation of sensory memory and equalization among the panelists was performed by direct contact of the individuals with the reference of maximum intensity for each stimulus (sweetness, bitter taste and chocolate flavor). The panel was trained in six 1h training sessions to perform the T-I trials.

TABLE 2. DEFINITIONS FOR STIMULI ANALYZED IN TIME-INTENSITY ANALYSIS AND RESPECTIVE REFERENCES USED IN TRAINING THE JUDGES

Stimuli	Definitions	References
Sweet taste	Characteristic taste of sucrose or sweeteners solution	None: taste-free water Strong: 90g of chocolate dairy dessert (Danette, Danone, Brazil) added with 0.060 g of aspartame (SweetMix, Brazil)
Bitter taste	Characteristic taste related to the presence of cocoa and other bitter compounds on dessert	None: taste-free water Strong: 90g of chocolate dairy dessert (Danette, Danone, Brazil) added with 5.0 g of cocoa powder (Garoto®, Brazil)
Milk chocolate flavor	Characteristic flavor of milk chocolate	None: taste-free water Strong: Milk chocolate bar (Classic, Nestlé®, Brazil)

Two preliminary sessions were held in the TDS analysis as described by Albert et al. (2012). In the first session, the panelists were introduced to the notion of the temporality of sensations (TDS) and were introduced to the data acquisition program SensoMaker (Pinheiro *et al*. 2013). In the second session, the panelists participated in a simulation of a TDS session with several samples of chocolate dairy dessert to answer any questions of the participants and so they could get used the computer program and methodology (Souza *et* *al*. 2013). This session also defined the total duration time of the experiment to be 90 s, and the attributes selected by the panel were sweetness, bitter taste, milk chocolate, bitter-sweet chocolate, milk powder, cream, off-flavor, and none (if perception finishes in time less than 90 seconds).

Time-intensity Parameters

The time-intensity parameters of interest were Imax (maximum intensity recorded by the assessor), Timax (time in which the maximum intensity was recorded), Area (area of the time × intensity curve) and Ttot (total duration time of the stimulus) (ASTM 1999; Palazzo and Bolini 2014).

The data collection for the time-intensity analysis was carried out on a computer using a dynamic sensory profile using TIAF, which was developed at the Laboratory of Sensory Science and Consumer Research of the School of Food Engineering (UNICAMP, Campinas, Brazil) (Bolini 2012).

The standardized conditions for analysis of the three attributes were as follows: (1) judge's wait time, 10 s; (2) time with sample in the mouth, 10 s; (3) time after swallowing, 60 s; and (4) intensity scales, 9. These conditions were determined by a consensus considering that the time of total duration of perception does not exceed the final time period.

Team Final Selection

The software time manager is pre-established for each food analyzed. In the present analysis, all conditions were standardized with the same time for the three stimuli. On hearing the first signal given by the computer (10 s) after pressing start, the panelist took the full amount of the sample in their mouth and indicated the intensity of the particular sensory attribute on the scale using the mouse. Upon hearing the second signal (10 s), the panelist swallowed the sample while a third signal (60 s) indicated the end of the test.

From assessors' selection to data collection, the samples were analyzed by all subjects for all three stimuli. Samples were presented sequentially in a monadic way with three repetitions (in three separate sessions). Panelists evaluated the sample using a computer mouse to record the intensity of the attribute on the scale according to the time. The software shows a continuous scale marked with 10 points with numbers (0 to 9) on the screen. The mouse cursor slides freely so that the trained assessor can continuously indicate the perceived intensity as a function of time. The continuous scale is horizontal and is labeled such that 0 corresponds to none (far left), 4.5 corresponds to moderate (middle) and 9 corresponds to strong (far right). Data are continuously collected by the software from the start until conclusion of the test. A plot and table with each tenth of a second of analysis and its corresponding intensity were generated (Palazzo and Bolini 2014).

In the selection of the judges for the TI assessment, analysis of variance (ANOVA) was applied for each panelist and each stimulus separately, and 13 assessors out of 15 were selected to participate according to their discriminating capability ($P < 0.30$) and repeatability ($P > 0.05$). An individual consensus was also considered (Damásio and Costell 1991) as verified in relation to each parameter curve separately for each stimulus.

Time-intensity Analysis Evaluation

The assessors evaluated three stimuli intensities during the time assessment. The stimuli of sweetness, bitterness and chocolate flavor were analyzed. The dessert samples were presented in a sequential monadic way with three repetitions (in three different sessions) by recording the intensity of the stimuli over time. Each one of the stimuli was analyzed separately and collected one at a time by the same group of selected and trained assessors.

All assessors presented discrimination power verified by pF_{sample} (< 0.03), reproducibility $pF_{repetition}$ (> 0.05) and consensus with other members of the panel. Based on these results, a representation of means for each curve for each stimulus was proposed, and the curves were then superimposed, modelling the multiple time-intensity according to ASTM (2013).

Temporal Dominance of Sensations (TDS)

The thirteen participants from the panel of the time-intensity analysis were also recruited to participate in TDS analysis. They evaluated the attributes of the samples with a sequential monadic presentation, using a balanced complete block design (Walkeling and MacFie 1995), and three repetitions (in three different sessions).

Participants were requested to select the dominant taste over the time. To avoid possible misunderstandings, it was clearly explained that the dominant taste is the taste that is perceived with greater clarity and intensity among others. Then, the panelists were requested to put the sample of chocolate dairy dessert (around 5 g) in the mouth and immediately start the evaluation.

The methodology of Pineau *et al*. (2009) was used in the software SensoMaker (version 1.7) to compute the TDS curves. In brief, two lines are drawn in the TDS graphical display, 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 this proportion should equal to be considered to be significantly (Pineau *et al*. 2009; Souza *et al*. 2013). It is calculated using the confidence interval of a binomial proportion based on a normal approximation, according Pineau *et al*. (2009).

Statistical Analyses

The parameters obtained from time-intensity curves and TDS curves were evaluated by univariate statistical analysis (ANOVA), and the means were compared using Tukey's test averages (at 5% significance). All statistical analyses were performed using the software Statistical Analysis System – SAS 9.1.2 (SAS Institute, Inc., Cary, NC, 2012).

RESULTS AND DISCUSSION

Foods are a complex system and the interaction of chemical compounds can modify the flavor sensation and sweeteners powder; this is why sweeteners and prebiotics are each time more studied (Aidoo *et al*., 2013; Aidoo *et al*., 2014; Bolini *et al*. 1999; Di Monaco *et al*. 2013; Heikel *et al.* 2012; Palazzo *et al*. 2011; Palazzo and Bolini 2014; Souza *et al*. 2011; Villegas *et al*. 2007).

This interaction has been a challenge for researches and industries alike, since high intensity sweeteners are being more used by consumers who search for products with reduced sucrose contents, either for their reduced energy content or due to the demands of diabetes mellitus sufferers (Cadena *et al*. 2013; Palazzo and Bolini, 2014). As the use of sweeteners, the functional properties of the prebiotics have encouraged the development of products and the addition of them in chocolate dairy desserts shown to be a promising market (Morais *et al.* 2014).

Time-intensity analysis of sweet taste stimulus

The sweet taste was the first attribute analyzed by the 13 selected assessors. Table 3 shows the mean values for this stimulus. The sweetness attribute is expected in all samples since all of them were sweetened with sugar or sweeteners. However, it was expected that samples sweetened with sweeteners would present a sweet residue, due to their use, which usually leave a sweetness sensation during consumption (Bolini-Cardello *et al*. 1999; Cadena and Bolini 2011).

According to Mayhew *et al*. (2012) the sweetness potency of neotame is at least orders of magnitude greater than most other high potency sweeteners; the sample with the substitution by neotame differed ($P \leq 0.05$) from the others due to the greater sweetness perceived as well as in relation to the parameters of total time and area. This result proves the high sweetening power of neotame as its residual sweetness which was expected since according to Nofre and Tinti (2000) neotame is a derivative of aspartame and is 6000-10 000 times sweeter than sucrose.

TABLE 3. TIME-INTENSITY ANALYSIS FOR SWEETNESS STIMULUS

Parameters	Samples						MDS
	Sucrose	Sucralose	Aspartame	Neotame	Stevia	Integral	
Imax	5.72^{bc}	6.21^{ab}	5.91^{bc}	6.54^{a}	5.84^{bc}	5.45^{c}	0.54
Timax	16.69^{a}	16.19^{a}	16.10^{a}	16.10^{a}	15.91^{a}	16.20^{a}	1.66
Ttot	38.21^{b}	40.66^{ab}	40.30^{ab}	44.30^{a}	39.62^{ab}	36.62^{b}	5.00
Area	126.70^{bc}	140.55^{bc}	142.13^{b}	170.59^{a}	140.53^{bc}	115.73^{c}	25.84

Means with a same superscript letter in the line are not significantly different at a 5% level.
Imax, maximum intensity recorded by the judge; Timax, time at which the maximum intensity was recorded; Ttot, total duration time of the stimulus; Area, area of time x intensity curve; MDS, minimum significant difference in Tukey's test ($P \leq 0.05$).

The perception of sweet taste can be influenced by viscosity, temperature, the chemical state of the saliva, and the presence of other tastings in the solution being tasted (Cadena and Bolini 2011). According to Wiet *et al.* (1993), in a study with pasteurized skimmed milk, the perception of sweet taste increases as decreases the lipid content. In the present study the integral sample presented the lesser intensity of sweetness perceived, but it not differed ($P > 0.05$) from samples with sucrose, aspartame and stevia, which are samples made with light ingredients. Guinard *et al.* (1997) and Cadena and Bolini (2011) studied ice cream and perceived that the perception of sweet taste stimulus increased with the increase of lipid content.

Sucralose, aspartame and stevia were ideal to replace sucrose in relation to sweetness, considering all the curve parameters evaluated during the analysis (Table 3). According to Grotz *et al.* (2012) sucralose is made from sucrose and the result is a sweetener that is remarkably different from sucrose in its intensity and stability, although it has a comparable taste quality. Abegaz *et al*. (2012) describe the taste of aspartame as clean and sweet like sugar but without the bitter chemical or metallic aftertaste often associated with some other high-intensity sweeteners. And Carakostas *et al.* (2012) show that as with most high-potency sweeteners, stevia, consisting of stevioside and rebaudioside A, exhibit clean sweetness at low stevioside levels, but have other negative taste attributes, as bitterness, at higher stevioside levels.

Time-intensity analysis of bitter taste stimulus

Table 4 shows the results of the analysis of variance (ANOVA) and Tukey´s mean test in relation to the bitter taste stimulus.

TABLE 4. TIME-INTENSITY ANALYSIS FOR BITTERNESS STIMULUS

Parameters	Samples						MDS
	Sucrose	Sucralose	Aspartame	Neotame	Stevia	Integral	
Imax	4.44^{b}	4.65^{b}	4.74^{b}	5.96^{a}	5.88^{a}	4.49^{b}	0.64
Timax	16.73^{a}	16.43^{a}	17.33^{a}	17.80^{a}	16.33^{a}	16.87^{a}	2.13
Ttot	37.26^{b}	39.09^{ab}	40.08^{ab}	42.86^{a}	41.36^{ab}	38.05^{b}	4.76
Area	97.59^{b}	109.27^{b}	109.37^{b}	151.62^{a}	142.36^{a}	94.27^{b}	25.80

Means with a same superscript letter in the line are not significantly different at a 5% level.
Imax, maximum intensity recorded by the judge; Timax, time at which the maximum intensity was recorded; Ttot, total duration time of the stimulus; Area, area of time x intensity curve; MDS, minimum significant difference in Tukey's test ($P \leq 0.05$).

According to Harwood et al. (2013) endogenous polyphemolic compounds in cocoa impart both bitter and astringent characteristics to chocolate based confections. Thus, the bitterness attribute was expected in all samples due to the use of cocoa powder, but with greater intensity in samples with sweeteners, which usually leave a bitterness sensation and a bitter residue during consumption (Bolini-Cardello *et al*. 1999).

Samples with neotame and stevia differed ($P \leq 0.05$) from the others due to the greater intensity of bitterness perceived as well as in relation to the parameter of area. It was expected that the sample with stevia would present the highest intensity of bitter taste, but sample with neotame did not differ from it one. According to Mayhew *et al.* (2012) neotame is a high potency sweetener and flavor enhancer which have potentiated the bitter taste of cocoa. And stevia, due to the presence of stevioside in its composition, presents the bitter taste characteristic from this compound (Carakostas *et al.*, 2012).

The integral sample did not differ ($P > 0.05$) from light samples with sucrose, sucralose and aspartame, in relation to the parameters of maximum intensity, total time and area. This behavior indicates that these samples showed a similar time-intensity profile for the bitterness attribute.

Sucralose and aspartame were ideal to replace sucrose in relation to bitterness, mainly with respect to the maximum intensity and total duration time during the analysis.

Time-intensity analysis of milk chocolate flavor stimulus

Table 5 shows the mean values for milk chocolate flavor stimulus. The integral sample did not differ ($P > 0.05$) from light samples with sucrose, sucralose, aspartame, and stevia in relation to the parameter of maximum intensity, differing only from the sample with neotame. However, in relation to the parameters of total duration time and area, the integral one did not differ from light samples with sucralose, aspartame, stevia, and neotame, differing only from the sample with sucrose.

Integral sample and samples with sucralose, aspartame and stevia did not differ in any of the evaluated parameters, indicating that these samples presented a similar temporal profile, and showing that the addition of prebiotics does not alter the temporal profile of the chocolate dairy dessert samples.

TABLE 5. TIME-INTENSITY ANALYSIS FOR CHOCOLATE FLAVOR STIMULUS

Parameters	Samples						MDS
	Sucrose	Sucralose	Aspartame	Neotame	Stevia	Integral	
Imax	6.73^{a}	6.21^{a}	6.32^{a}	5.58^{b}	6.16^{ab}	6.32^{a}	0.58
Timax	15.56^{a}	14.57^{a}	16.13a	15.26^{a}	14.21^{a}	15.44^{a}	1.95
Ttot	43.62^{a}	37.93^{b}	41.24^{ab}	37.25^{b}	38.22^{b}	38.06^{b}	4.54
Area	192.77^{a}	148.45^{b}	153.84^{b}	149.32^{b}	158.82^{ab}	152.31^{b}	35.30

Means with a same superscript letter in the line are not significantly different at a 5% level.
Imax, maximum intensity recorded by the judge; Timax, time at which the maximum intensity was recorded; Ttot, total duration time of the stimulus; Area, area of time x intensity curve; MDS, minimum significant difference in Tukey's test ($P \leq 0.05$).

Sucralose, aspartame and stevia were ideal to replace sucrose in relation to chocolate flavor, mainly with respect to maximum intensity perceived and time at the maximum intensity during the analysis.

Multiple time-intensity analysis

Multiple time-intensity analysis (MTIA) is a form used to analyze the data obtained from the time–intensity measurements, when more than two stimuli are analyzed under the same standardized conditions, and represented on the same graph (Palazzo and Bolini 2009; Cadena and Bolini 2011).

According to Palazzo *et al.* (2014) MTIA must be applied in studies on the replacement of ingredients in each type of product because MTIA clearly shows that the substitution of materials promotes the modification of the time-intensity profile during consumption differently for each attribute and food type analyzed, and this information is not supplied by a classic sensory descriptive analysis. Fig. 1 shows the sensory profile of each chocolate dairy dessert sample for the three attributes studied in the time-intensity analysis.

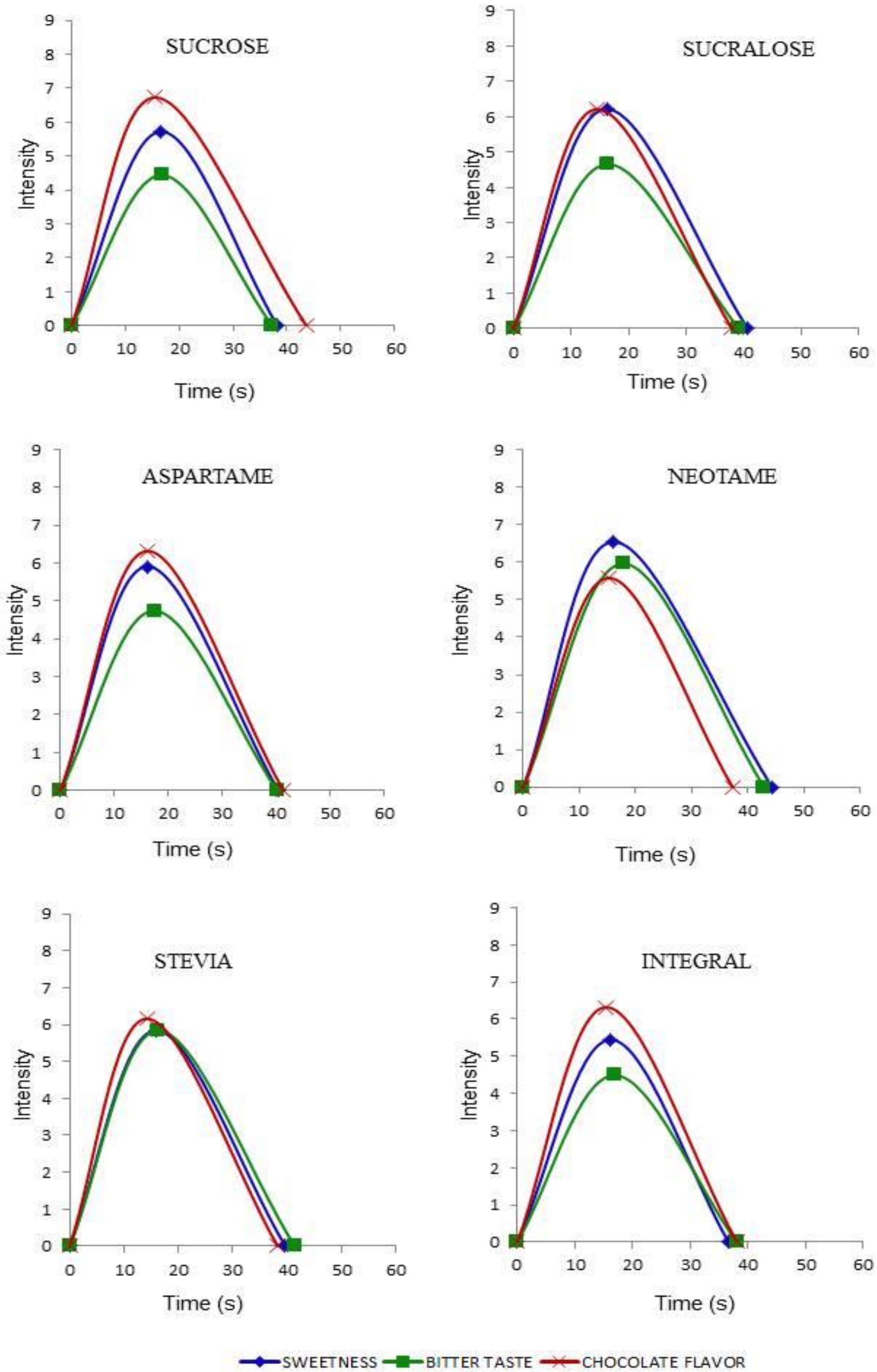

FIG. 1. MULTIPLE TIME-INTENSITY PROFILE OF CHOCOLATE DAIRY DESSERT SAMPLES FOR SWEETNESS, BITTERNESS AND CHOCOLATE FLAVOR

All samples presented a different time-intensity profile. However, the integral one presented a profile similar to prebiotic light samples with sucrose, sucralose and aspartame indicating that addition of prebiotics and sugar substitutes can provide a dessert with temporal profile similar to the traditional. This is a very interesting result since the competition for a new product on the market, being prebiotic or light, must present a profile the nearest possible from the traditional one.

MTIA shows aspartame and sucralose as ideal sucrose replacers of chocolate dairy dessert samples in relation to their temporal profile when evaluating sweetness, bitterness and chocolate flavor.

Temporal dominance of sensations (TDS)

Figs. 2-7 represent the TDS profiles for the six chocolate dairy desserts evaluated in the study. Each curve shows the evolution of the dominance rate of an attribute over time. The TDS analyzes show that in the light chocolate dairy dessert with sucrose (Fig. 2) the sweetness was the dominant taste in the initial time, followed by the bitter-sweet chocolate taste in the middle to the 55 s time.

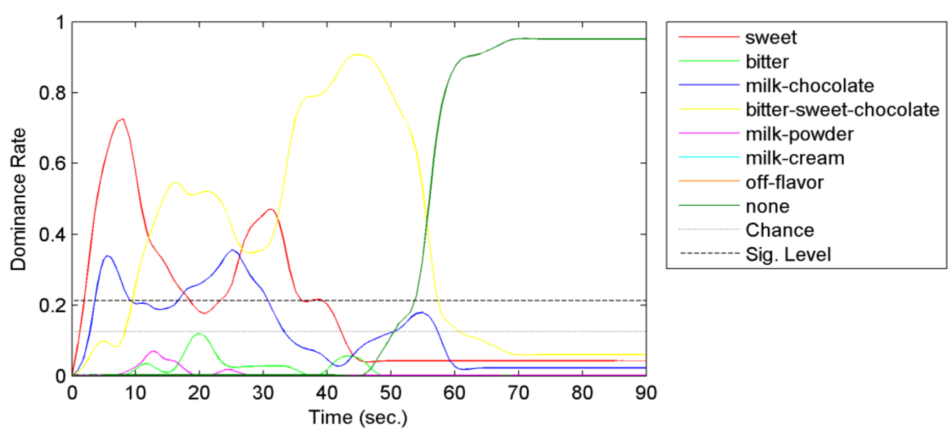

FIG. 2. A GRAPHICAL TDS REPRESENTATION FOR THE PREBIOTIC CHOCOLATE DAIRY DESSERT WITH SUCROSE.

The light chocolate dairy dessert with sucralose (Fig. 3) presented a TDS profile similar to the sample with sucrose. The sweetness was the dominant in the initial time as well as the milk chocolate taste, and also followed by the bitter-sweet chocolate taste in the middle to the end of the perceived time (57 s). Fig. 4 presents the TDS curves of the light chocolate dairy dessert with aspartame, which also was similar to the samples with sucrose and sucralose. In this sample the sweetness was perceived with greater dominance rate up to 15 s of evaluation. In this time of evaluation the milk chocolate taste was the dominant, and from 38 s up to 60 s of evaluation the bitter-sweet chocolate taste was the dominant.

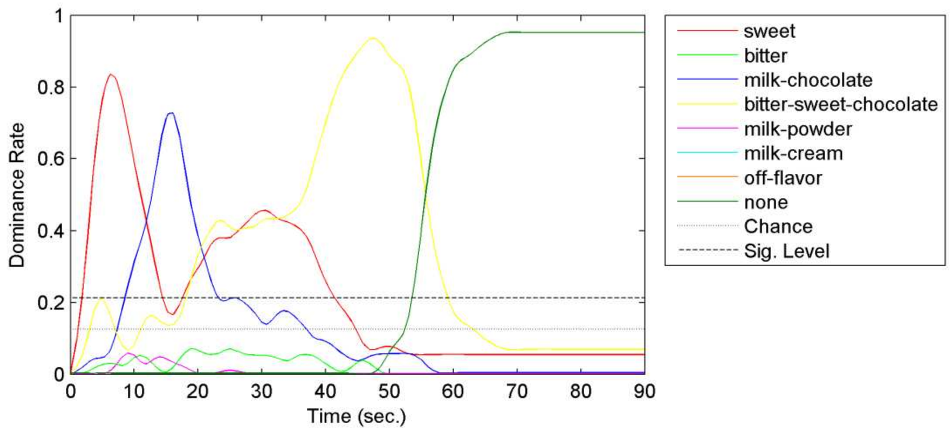

FIG. 3. A GRAPHICAL TDS REPRESENTATION FOR THE PREBIOTIC CHOCOLATE DAIRY DESSERT WITH SUCRALOSE.

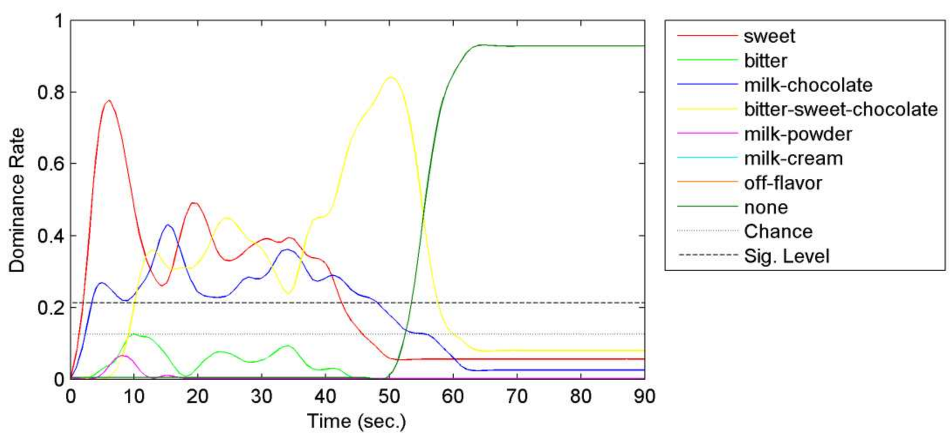

FIG. 4. A GRAPHICAL TDS REPRESENTATION FOR THE PREBIOTIC CHOCOLATE DAIRY DESSERT WITH ASPARTAME.

The light chocolate dairy dessert with neotame (Fig. 5) presented a TDS curves different from the other desserts. The sweetness perception was predominant in almost all the time, reinforcing the sweet aftertaste of neotame up to 75 s. The bitter taste was perceived with greater dominance from 12 s up to 31 s of evaluation and it was significantly perceived from 8 s up to 57 s. Neotame is a flavor enhancer (Mayhew *et al*. 2012), and so it may have favored the perception of bitter taste due to the presence of cocoa in the formulation.

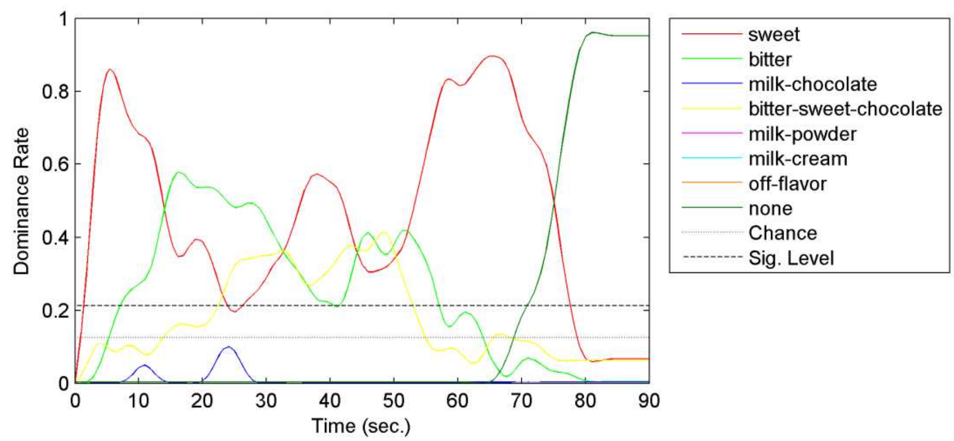

FIG. 5. A GRAPHICAL TDS REPRESENTATION FOR THE PREBIOTIC CHOCOLATE DAIRY DESSERT WITH NEOTAME.

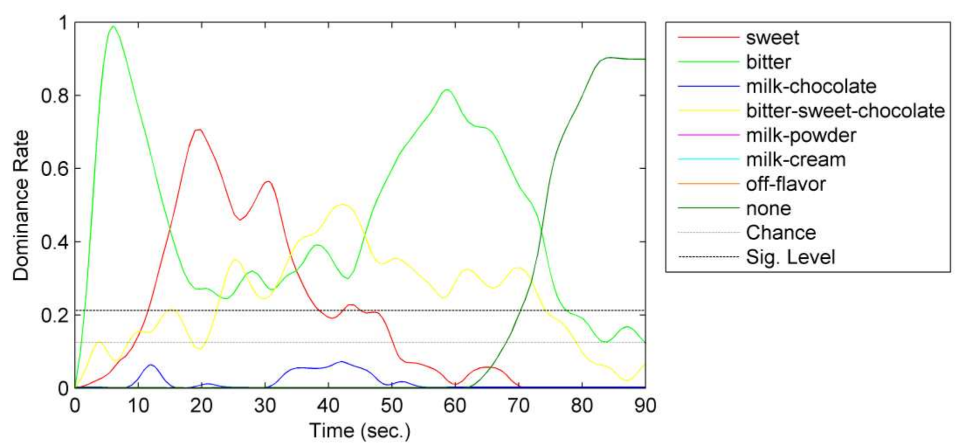

FIG. 6. A GRAPHICAL TDS REPRESENTATION FOR THE PREBIOTIC CHOCOLATE DAIRY DESSERT WITH STEVIA.

Fig. 6 presents the TDS curves of the light chocolate dairy dessert with stevia. The bitter taste was dominant from 02 s up to 14 s and from 46 s up to 74 s. This behavior confirms the residual bitter taste of stevia (Carakostas et al., 2012), as observed in TI analysis. The sweetness stimulus was dominant from 14 s up to 33 s, and the bitter-sweet chocolate flavor was dominant from 33 s up to 45 s.

The integral chocolate dairy dessert (Fig. 7) was characterized by the milk chocolate flavor. This stimulus was perceived significantly in almost all the time of evaluation. The sweetness taste was dominant only at the beginning of the evaluation. In comparison with the other samples, the perception of the stimuli in this one was perceived in less time as in the light sample with sucrose. Samples with sweeteners presented a longer perception of stimuli.

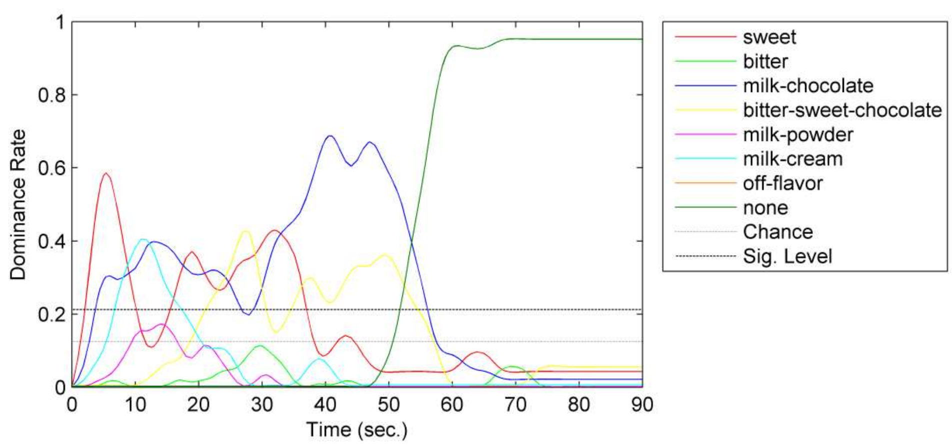

FIG. 7. A GRAPHICAL TDS REPRESENTATION FOR THE INTEGRAL CHOCOLATE DAIRY DESSERT.

According to the results of TDS analysis, the replacement of sucrose by sweeteners in chocolate dairy desserts is recommended especially if by the sweeteners sucralose and aspartame, which presented a temporal profile similar to the chocolate dairy dessert with sucrose.

Comparison of TI and TDS results

Sweeteners are increasingly being studied because foods are a complex system and the interactions of chemical compounds can modify the flavor sensation and sweetener effects (Bolini *et al*. 1999; Melo *et al*. 2010; Souza *et al*. 2011; Palazzo *et al*. 2014).

MTI analysis showed that the integral sample presented a similar profile to prebiotic light samples with sucrose, sucralose and aspartame in relations to the attributes of sweetness, bitterness and chocolate flavor. The TDS analysis also showed a similar profile between the integral sample and the prebiotic light samples with sucralose and aspartame, in relation to the attributes of sweetness, bitterness, milk chocolate flavor, bitter-sweet chocolate flavor, milk powder, cream, and off-flavor.

These results show that both TI and TDS analysis generated similar temporal profiles when comparing the prebiotic and light desserts with the traditional one. However, a more comprehensive evaluation was performed using the TDS enabling a simultaneous assessment of more attributes which describe the chocolate dairy desserts.

The high intensity sweeteners used in this study as replacers of sucrose presented a good stability in prebiotic chocolate dairy dessert samples and may be considered as a potential for palatable food in the formulation of diabetic/reduced calorie and light chocolate dairy desserts.

The replacement of sucrose in chocolate dairy desserts obtained desired results when the sweeteners used were sucralose and aspartame. In view of the temporal sensory profile, chocolate dairy desserts with addition of prebiotics in recommended to replace sucrose by sucralose or aspartame. Palazzo and Bolini (2014) studying chocolates also obtained a sucralose soy-based chocolate with multiple time-intensity results with parameter curves that were not significantly different ($P > 0.05$) from those of the sucrose control.

CONCLUSIONS

In chocolate dairy desserts, sucralose and aspartame provided a dynamic sensory profile with parameter curves closer to the one sweetened with sucrose. The prebiotic addition also provided a temporal profile curves closer to the traditional one (integral with no addition of prebiotics).

The results showed that the time-intensity (TI) analysis and the temporal dominance of sensations (TDS) are complementary methodologies which provide more precise information of the temporal behavior of flavor attributes present in a chocolate dairy dessert. The addition of prebiotic and sweetener opens up new opportunities to develop chocolate dairy desserts that may present similar temporal properties to the traditional one.

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ARTIGO 4: Prebiotic and diet/light chocolate dairy dessert: chemical composition, sensory profiling and relationship with consumer expectation

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Artigo submetido para publicação na LWT – Food Science and Technology

Abstract

The preference for healthier and convenience products has led to a growing demand for functional and ready-to-eat foods that present a suitable sensory acceptance. This study aimed to identify the drivers of liking of chocolate dairy desserts. A consumer test with 120 people was performed. The sensory profiling was carried out by 14 trained assessors using quantitative descriptive analysis (QDA). In addition, the principal component analysis (PCA) identified two significant principal components that accounted for 73.49% of the variance in the sensory attribute data, and partial least squares (PLS) regression was used to identify the drivers of liking of chocolate dairy desserts. The results show that the most desired sensory properties of such products are sweetness, milk chocolate flavor, sweet aroma, and mouth fill, whereas bitterness and bitter aftertaste were considered undesirable. In this context, these attributes can be considered drivers of liking and disliking of chocolate dairy desserts and they should be taken into consideration by dairy processors at the development of new dairy products.

Keywords

Dairy desserts; Prebiotics; Quantitative descriptive analysis; Principal component analysis; Partial least squares regression.

1. Introduction

The dessert market is growing rapidly with many new products and concepts. Ready-to-serve single portions and easy to prepare products are particularly trendy. One new trend is for sweet, slim-line products such as milk-based desserts. They meet consumer demand for sweet luxury products with a low fat content and calorie count. Many varieties also make dairy desserts so popular. Served with fresh fruits or as they are, dairy desserts can be enjoyed with little concern and fit perfect for all occasions (Arcia, Costell, & Tárrega, 2010; Ares, Barreiro, Deliza, Gimenez, & Gambaro, 2010).

The nutritional value and the possibility of improving some sensory properties of food formulations, enhancing taste to the products, makes the use of prebiotic ingredients advantageous (Wang, 2009). In order to achieve healthier and better sensory characteristics, the supplementation of food products with prebiotic ingredients has already been reported for some products, such as petit Suisse cheese (Cardarelli, Aragon-Alegro, Alegro, Castro, & Saad, 2008), fermented dairy beverages (Castro et al., 2009), yogurts (Aryana and McGrew, 2007; Cruz et al., 2013), soy-based desserts (Granato, Ribeiro, Castro, & Masson, 2010), sausage (Mendoza, García, Casas, & Selgas, 2001), gluten-free breads (Morais, Cruz, Faria, & Bolini, 2014), and mortadellas (Santos et al., 2013).

A high consumption of sugar has been associated with several diseases; therefore, low intake of this macronutrient is strongly recommended. The dairy industry must reduce the sugar content of processed foods, which is a major challenge as products have to be reformulated while maintaining their popularity and appealing character (Chollet, Gille, Schmid, Walther, & Piccinali, 2013). It is important that such alternatives do not cause significant changes in the sensory characteristics of the product (Bolini-Cardello, Silva, & Damásio, 1999; De Mello, Bolini, & Efraim, 2009; Palazzo & Bolini, 2014).

Descriptive techniques are frequently used in product development to measure how close a new introduction is to the target or to assess suitability of prototype products. They are the most sophisticated tools in the arsenal of the sensory scientist. These techniques allow the sensory scientist to obtain complete sensory descriptions of products, to identify underlying ingredient and process variables, and/or to determine which sensory attributes are important to acceptance (Lawless & Heymann, 2010).

Quantitative descriptive analysis (QDA) is presented as a methodology that provides obtaining a complete description of all the sensory properties of a product, representing one of the most complete and sophisticated methods for sensory characterization of important attributes. It has innumerous applications, such as monitoring of competing products, in the storage tests of products, new product development, quality control of manufactured products and conducting sensory and instrumental tests (Stone, Bleibaum, & Thomas, 2012).

In this context, the identification of the most relevant sensory and chemical properties of prebiotic and diet/light chocolate dairy desserts can facilitate the development and assessment of new dairy products that best interpret the hedonic dimension of this increasing market. The objective of the present study was to study the influence of prebiotics and sugar replacement in the sensory profile and chemical composition of chocolate dairy desserts. Light/diet and prebiotic chocolate dairy desserts were compared with traditional one using quantitative descriptive analysis (QDA), principal component analysis (PCA) and chemical composition analysis. Besides, partial least squares (PLS) regression was performed to assess the correlation of the consumer acceptability data with the results obtained by using QDA.

2. Material and methods

2.1. Ingredients

Five samples were produced with prebiotic Biofis Inufos (inulin and fructooligosaccharides – 50:50 (wt/wt)) (Siba Ingredientes, São Paulo, SP, Brazil), guar and xanthan gum (SweetMix, Sorocaba, SP, Brazil), commercial skim milk powder (Molico®, Nestlé, Araraquara, SP, Brazil), commercial UHT skim milk (Molico®, Nestlé, Araraquara, SP, Brazil), cocoa powder (Garoto®, Vila Velha, ES, Brazil), sucrose (União®, Tarumã, SP, Brazil), and light cream (Nestlé®, Araçatuba, SP, Brazil). Chocolate milk dessert samples were sweetened with different high intensity sweeteners and sucrose, which were neotame (NutraSweet, Chicago, IL; obtained from SweetMix, Sorocaba, SP, Brazil); sucralose (SweetMix, Sorocaba, SP, Brazil); stevia with 95% of rebaudioside (SweetMix, Sorocaba, SP, Brazil); and aspartame (SweetMix, Sorocaba, SP, Brazil). And one sample (the integral/traditional) was produced with guar and xanthan gum (SweetMix, Sorocaba, SP, Brazil), commercial milk powder (Ninho®, Nestlé, Araraquara, SP, Brazil), commercial UHT milk (Ninho®, Araraquara, Nestlé, Brazil), cocoa powder (Garoto®, Vila Velha, ES, Brazil), sucrose (União®, Tarumã, SP, Brazil), and cream (Nestlé®, Araçatuba, SP, Brazil).

2.2. Samples preparation

For chocolate dairy dessert samples preparation the concentrations of prebiotic, gum, milk powder, cocoa powder, and cream were kept constant. The concentrations of sucrose and sweeteners varied, and the UHT milk was added until completing 100% (wt/wt) of the formulation, as presented in Table 1. Previous study determined the level of ingredients used in the present study (Morais, Morais, Cruz, & Bolini, 2014).

Table 1

Proportion of ingredients in chocolate dairy dessert formulations.

Ingredients	Formulations (wt. %)					
	Sucrose	Sucralose	Aspartame	Neotame	Stevia	Integral
Sweetener	8.0	0.016	0.054	0.0016	0.1	10.0
Prebiotic	7.5	7.5	7.5	7.5	7.5	---
Skimmed-milk powder	10.0	10.0	10.0	10.0	10.0	---
Milk powder	---	---	---	---	---	12.0
Cocoa powder	4.5	4.5	4.5	4.5	4.5	4.5
Gum	0.2	0.2	0.2	0.2	0.2	0.2
Light milk cream	25.0	25.0	25.0	25.0	25.0	---
Milk cream	---	---	---	---	---	25.0
UHT skimmed-milk	44.8	52.7	52.7	52.7	52.7	---
UHT milk	---	---	---	---	---	48.3

The solids ingredients were mixed in a dry pan. The UHT milk was heated to 40°C and added to the mixture of solid ingredients under constant agitation. Subsequently, the temperature was increased to 90 ± 2°C for 3 minutes for pasteurization. The temperature was then reduced to 40°C, cream was added, and the mixing continued for another 2 minutes. The samples were put in an acrylic cup (40mL), covered to avoid drying, and stored under refrigeration (6 ± 2°C) until sensory analysis.

2.3. Sensory analyses

Sensory analyses were carried out in individual air-conditioned (22° C) booths and evaluated under white light, thus ensuring comfort and privacy for the judges. Sessions were held at the Sensory Science and Consumer Research Laboratory of the School of Food Engineering (Department of Food and Nutrition of University of Campinas). The tasters were served 30 g of each chocolate dairy dessert sample, and taste-free water and crackers were provided for palate cleansing. Sample´s presentation was sequentially in a monadic way in acrylic cups coded with 3-digit numbers, using a balanced complete block design (Walkeling & MacFie, 1995; Stone, Bleibaum, & Thomas, 2012).

2.3.1. Quantitative Descriptive Analysis

The sensory profiling of all the six chocolate dairy dessert samples was generated by the quantitative descriptive analysis (QDA) according to methodology proposed by Stone, Bleibaum, & Thomas (2012). This technique has been adopted to analyze several food products, and its principles and steps are well established (Volpini-Rapina, Sokei, & Conti-Silva, 2012; Gonzalez, Adhikari, & Sancho-Madriz, 2011; Adhikari, Dooley, Chambers IV, & Blumiratana, 2010; Granato, Bigaski, Castro, & Masson, 2010).

2.3.1.1. Selection of assessors

Subjects were recruited among University of Campinas undergraduates, graduates and employees, who presented themselves as consumers of dairy desserts, had available time, no restrictions as to the consumption of this product, and showed interest in becoming members of the sensory group to be trained. In the preselection, 30 subjects were submitted to Wald's sequential analysis using triangle tests (Amerine et al., 1965) to select people with high discrimination ability. In these tests, the subjects received three chocolate dairy dessert samples sweetened with a significant difference of 1%, predetermined by a paired-comparison test with 60 subjects. The subjects had to identify which one of three samples served was the different.

To determine the Wald's sequential analysis, the following variable values were used: P = 0.40 (maximum incapability acceptable), P1 = 0.70 (minimum acceptable skill) and the risks α = 0.10 (probability of accepting a candidate without sensory acuity) and β = 0.10 (probability of rejecting an applicant with sensory acuity). Subjects were selected or rejected according to the number of correct tests analyzed in the triangular test. Fifteen subjects, 10 women and 5 men with mean age of 34 years old, were prescreened as potential panelists.

2.3.1.2. Development of descriptive terminology

For the stage of development of descriptive terminology, Kelly's Repertory Grid Method (Moskowitz, 1983) was used. All samples were presented by pair, and the subjects described the same and different aspects for each pair evaluated in relation to appearance, aroma, flavor, and texture. A total of 27 descriptive terms were defined through panel discussion and redundant terms were excluded by consensus of all judges. Overall, 20 sensory attributes covering appearance, aroma, flavor and texture were generated.

2.3.1.3. Training session

References were determined by a consensus of all the subjects and they were then further trained with respect to the product attributes using them, as described in Table 2. Training for the formation of sensory memory and equalization among the panelists was performed by direct contact of the individuals with the reference of maximum and minimum intensity for each attribute. The panel was trained in six 1h training sessions to perform the QDA trials.

2.3.1.4. Selection of subjects for QDA

Each subject evaluated the six chocolate dairy dessert samples in three repetitions. Panelists were chosen for participation according to their discriminating capability ($P \leq 0.30$) and repeatability ($P > 0.05$), using the data collected during the training sessions; individual consensus was also considered (Damásio & Costell, 1991). Based on the selection criteria fourteen panelists (10 women and 4 men; mean age of 33) were selected for further evaluation of the sensory profile of the chocolate dairy desserts.

Table 2

Descriptors used for sensory profiling of chocolate dairy desserts.

Descriptors	Definition	Reference
Brown color (COL)	Brown color characteristic of chocolate dairy dessert	Weak: chocolate UHT dairy drink (Alpino, Nestlé, Brazil) diluted in UHT skimmed milk (Molico, Nestlé, Brazil) (1:1) / Strong: a bar of semisweet chocolate (Classic, Nestlé, Brazil)
Brightness (BRI)	Ability of the dairy dessert surface in reflect light	Weak: Chocolate cake (Bauducco, Brazil) / Strong: Chocolate flan (Danette, Danone, Brazil)
Apparent viscosity (VIS)	Feature density of the dessert perceived by rotating cup with dessert	Weak: Plum yogurt (Activia, Danone, Brazil) / Strong: Condensed milk (Moça, Nestlé, Brazil)
Creaminess (CRAP)	Feature density of the dessert perceived to punch the dessert with a spoon	Weak: Condensed milk (Moça, Nestlé, Brazil) / Strong: Nutella (Ferrero, Brazil)
Aeration (AERA)	Presence of air bubbles on the surface of dairy dessert	None: distilled water / Strong: Underside of the chocolate bar (Sufflair, Nestlé, Brazil)
Sweet aroma (SWAR)	Characteristic aroma related to the presence of sucrose and sweeteners on dessert, perceived on smelling	Weak: chocolate UHT dairy drink (Alpino, Nestlé, Brazil) diluted in UHT skimmed milk (Molico, Nestlé, Brazil) (1:2) / Strong: White chocolate bar (Classic, Nestlé, Brazil)
Semisweet chocolate aroma (CHOAO	Characteristic aroma of semisweet chocolate, perceived by smell	None: distilled water / Strong: Semisweet chocolate bar (Classic, Nestlé, Brazil)
Milk cream aroma (CREA)	Characteristic aroma of milk cream, perceived by smell	None: distilled water / Strong: milk cream (Nestlé, Brazil)
Sweet taste (SWE)	Characteristic taste of sucrose or sweeteners solution	None: distilled water / Strong: 90g of chocolate dairy dessert (Danette, Danone, Brazil) added with 0.060 g of aspartame (SweetMix, Brazil)
Residual sweet taste (RSWE)	Sweetener sweet taste that remains after ingestion of dairy dessert.	None: distilled water / Strong: 90g of chocolate dairy dessert (Danette, Danone, Brazil) added with 0.0020g of neotame (SweetMix, Brazil)
Bitter taste (BITTE)	Characteristic taste related to the presence of cocoa and other bitter compounds on dessert	None: distilled water / Strong: 90g of chocolate dairy dessert (Danette, Danone, Brazil) added with 5.0 g of cocoa powder (Garoto®, Brazil)

Residual bitter taste (RBITE)	Bitter taste that remains after ingestion of dairy dessert.	None: distilled water / Strong: 90g of chocolate dairy dessert (Danette, Danone, Brazil) added with 0.12g of stevia 95% (SweetMix, Brazil)
Milk chocolate flavor (MCHO)	Characteristic flavor of milk chocolate	None: distilled water / Strong: Milk chocolate bar (Classic, Nestlé®, Brazil)
Semisweet chocolate flavor (BITSWE)	Characteristic flavor of semisweet chocolate	None: distilled water / Strong: Semisweet chocolate bar (Classic, Nestlé®, Brazil)
Milk powder flavor (MPOW)	Characteristic flavor of milk powder	None: distilled water / Strong: 20g of milk poder (Ninho, Nestlé, Brazil) mixed in 20mL of mineral water.
Milk cream flavor (CREFL)	Characteristic flavor of milk cream	None: distilled water / Strong: Milk cream (Nestlé, Brazil)
Viscosity (VISC)	Property of flow resistance of the dairy dessert in the mouth	Weak: natural yogurt (Activia, Danone, Brazil) / Strong: aerated dessert of strawberry Creamcake (Danubio, Brazil)
Creaminess (CREAM)	Dairy dessert thick characteristic perceived by pressing the tongue on the palate	Weak: Plum yogurt (Activia, Danone) / Strong: Nutella (Ferrero, Brazil)
Melting (MELT)	Dairy dessert property in ridding in the mouth equally	Weak: bar of milk chocolate (Classic, Nestlé, Brazil) / Strong: chantilly cream spray (Fleischmann, Brazil)
Mouth fill (MFILL)	Sense of the oral cavity filling	Weak: chantilly cream spray (Fleischmann, Brazil) / Strong: condensed milk (Moça, Nestlé, Brazil)

2.3.1.5. Evaluation by quantitative descriptive analysis (QDA)

The fourteen selected assessors evaluated the six chocolate dairy dessert samples according to the previously determined references for all attributes. Panelists received 30 g of chocolate dairy dessert sample and were asked to rate the intensity of each attribute using a continuous 9-cm unstructured line scale with anchor “weak” or “none” on the left, and “strong” on the right. The samples were sequentially presented in a monadic way with four repetitions (each repetition was realized in a session) using a balanced block design (MacFie, Bratchell, Greenhoff, & Vallis, 1989).

2.3.2. Consumer test

Overall liking was determined using a 9-cm linear hedonic scale (not structured) (Stone & Sidel, 2004), with anchors of “dislike extremely” on the left and “like extremely” on the right. Consumers evaluated the attributes of appearance, aroma, taste, texture, and overall liking. All the samples were presented monadically using a balanced complete block design (Walkeling and MacFie, 1995). 120 consumers (71 females and 49 males, aged between 18 and 60) recruited through personal contact took part in the affective test. Each consumer conducted the assessment of the six chocolate dairy dessert samples in a single session. To prevent bias, no information about the samples was given to the consumers.

2.4. Chemical and compositional analyses

Chemical and compositional analyses were carried out at the Chemical Composition Laboratory of the School of Food Engineering (Department of Food and Nutrition of University of Campinas). After one day of storage 6 ± 2ºC, the chocolate dairy desserts were analyzed for moisture, total solids, ash, protein, and fat content. Determinations were made for each sample, in triplicate.

2.4.1. Moisture content determination

The moisture content was determined according to the gravimetric method described by the Instituto Adolfo Lutz (IAL, 1985), by oven drying at 105 ° C overnight in the presence of sand.

2.4.2. Total solids determination

The moisture content was determined according to the gravimetric method described by the Instituto Adolfo Lutz (IAL, 1985), by oven drying at 105 ° C overnight in the presence of sand.

2.4.3. Ash determination

Ash was determined gravimetrically by heating the sample of chocolate dairy dessert samples at 550°C for 4 hours (AOAC, 2011).

2.4.4. Protein content determination

Protein was estimated by measuring the nitrogen content using the Kjeldahl method and multiplying it by a conversion factor (6.38) (AOAC 930.33, 2011).

2.4.5. Fat content determination

Fat was determined through lipid extraction with ethyl ether, using the Soxhlet device. Carbohydrate content was calculated by difference to achieve total content of 100% (AOAC 952.06, 2011).

2.4.6. Calorie determination

The energy content (calories) of chocolate dairy dessert samples was determined by adding the content of carbohydrate multiplied by 4, plus the protein content also multiplied by 4, and plus the lipid content multiplied by 9.

2.5. Statistical analyses

QDA results were analyzed by ANOVA, using two factors (panelist and sample) and their interaction, followed by a Tukey's test averages ($P > 0.05$). These analyses were carried out using Statistical Analysis System – SAS 9.1.2 (SAS Institute, Inc., Cary, NC, 2008). Principal Component Analysis (PCA) was also performed and data sets were arranged in a matrix of *i* lines (samples) and *j* columns (attributes). Data were auto scaled and the PCA was carried out using SensoMaker software – version 1.7 (Pinheiro, Nunes, & Vietoris, 2013). Plots of scores and loadings were built from the first two principal components.

The acceptability results were analyzed by ANOVA, using two factors (consumer and sample), and Tukey's test averages ($P > 0.05$). Descriptive information obtained from the trained panel was related to the consumer preference data using partial least squares regression (PLS). All these statistical analyses were carried out using XLSTAT Software at a 5% significance level.

Chemical and compositional results were analyzed by ANOVA, using two factors (sample and repetition) and their interaction, followed by a Tukey's test averages ($P > 0.05$). These analyses were carried out using Statistical Analysis System – SAS 9.1.2 (SAS Institute, Inc., Cary, NC, 2008).

3. Results

3.1. Quantitative descriptive analysis

The list of 20 sensory attributes, with their relevant definition and reference standard is reported in Table 2. Of the 20 descriptor terms generated by QDA, five were in relation to appearance, three in relation to aroma, eight regarding flavor, and 4 of texture attributes.

The results for each sample are shown in Table 3. Samples presented statistical differences ($P \leq 0.05$) in most attributes at the descriptive test, suggesting that the assessors were able to detect differences among the samples. The attributes of brightness, apparent viscosity, sweet aroma, viscosity, creaminess, and melting did not present significantly difference ($P > 0.05$) among the chocolate dairy dessert samples. In relation to these attributes the additions of prebiotic, sweeteners, and light ingredients have no significant effect statistically.

In relation to the brown color appearance attribute the light sample with sucrose presented the highest mean and differed significantly ($P \leq 0.05$) from the other light samples and the integral one. The integral sample presented the lowest mean; however this sample did not differ from the light sample with sucralose. The appearance of the integral chocolate dairy dessert was similar to the appearance of light desserts which is important because appearance is one of the four main sensory characteristics that plays a role in sensory acceptability (Jones, 1996; De Melo, Bolini, & Efraim, 2009).

Table 3

Attribute means for each sample of chocolate dairy dessert in QDA (9-cm unstructured line scale).

Attributes	Samples						MDS
	Sucrose	Sucralose	Aspartame	Neotame	Stevia	Integral	
Brown color (col)	6.75 ^{a}	5.43 ^{cd}	5.97 ^{b}	5.99 ^{b}	5.70 ^{bc}	5.14 ^{d}	0.44
Brightness (bri)	6.76 ^{a}	6.65 ^{a}	6.72 ^{a}	6.77 ^{a}	6.68 ^{a}	6.50 ^{a}	0.33
Viscosity (vis)	4.43 ^{a}	4.56 ^{a}	4.77 ^{a}	4.70 ^{a}	4.78 ^{a}	4.11 ^{a}	0.71
Creaminess apparent (crap)	3.86 ^{a}	3.88 ^{a}	3.99 ^{a}	3.87 ^{a}	3.96 ^{a}	3.01 ^{b}	0.72
Aeration (aera)	1.68 ^{a}	1.56 ^{ab}	1.91 ^{a}	1.81 ^{a}	1.11 ^{bc}	0.99 ^{c}	0.54
Sweet aroma (swar)	4.72 ^{a}	4.25 ^{a}	4.56 ^{a}	4.39 ^{a}	4.33 ^{a}	4.68 ^{a}	0.59
Chocolate aroma (choa)	3.35 ^{a}	3.15 ^{ab}	3.11 ^{ab}	3.09 ^{ab}	2.86 ^{b}	2.94 ^{ab}	0.48
Milk cream aroma (crea)	1.26 ^{b}	1.23 ^{b}	1.25 ^{b}	1.36 ^{b}	1.23 ^{b}	2.18 ^{a}	0.45
Sweet taste (swe)	5.14 a	4.89 ^{a}	4.78 ^{a}	3.74 ^{c}	4.12 ^{b,c}	4.69 ^{a,b}	0.62
Sweet aftertaste (rswe	1.38 ^{a,b}	1.71 ^{a,b}	1.38 ^{a,b}	1.86 ^{a}	1.95 ^{a}	1.01 ^{b}	0.75
Bitter taste (bitte)	1.89 ^{b}	1.70 ^{b}	2.02 ^{b}	2.95 ^{a}	3.10 ^{a}	2.05 ^{b}	0.61
Bitter aftertaste (rbitte)	0.57 ^{c}	0.64 ^{b,c}	1.17 ^{b}	2.46 ^{a}	2.64 ^{a}	0.58 ^{b,c}	0.59
Milk chocolate flavor (mcho)	2.79 ^{a,b}	2.89 ^{a}	2.46 ^{b,c}	2.13 ^{c}	2.28 ^{c}	2.94 ^{a}	0.41
Bittersweet chocolate flavor (bitswe)	3.21 ^{a,b}	2.79 ^{b}	3.28 ^{a}	3.37 ^{a}	3.32 ^{a}	3.11 ^{a,b}	0.47
Milk powder flavor (mpow)	1.23 ^{b}	1.27 ^{a,b}	1.28 ^{a,b}	1.18 ^{b}	1.20 ^{b}	1.49 ^{a}	0.23
Milk cream flavor (crefl)	1.24 ^{b}	1.23 ^{b}	1.11 ^{b}	1.11 ^{b}	1.12 ^{b}	2.53 ^{a}	0.39
Viscosity (visc)	3.93 ^{a}	3.80 ^{a}	4.18 ^{a}	3.96 ^{a}	4.37 ^{a}	3.89 ^{a}	0.69
Creaminess (cream)	3.84 ^{a}	3.80 ^{a}	3.82 ^{a}	3.81 ^{a}	4.13 ^{a}	3.51 ^{a}	0.74
Melting (melt)	5.24 ^{a}	5.35 ^{a}	4.99 ^{a}	5.35 ^{a}	5.11 ^{a}	5.02 ^{a}	0.79
Mouth fill (mfill)	5.24 ^{a}	4.81 ^{b,c}	5.14 ^{a,b,c}	4.80 $_{c}$	5.16 ^{a,b}	4.99 ^{a,b,c}	0.36

Means with a same superscript in a line are not significantly different at a 5% level.

MDS, minimum significant difference in Tukey's test (P ≤ 0.05).

Compared to the integral chocolate dairy dessert, desserts made with the high intensity sweeteners sucralose, aspartame and stevia did not differ statistically ($P > 0.05$) in relation to the sweetness. The dessert with neotame presented the highest mean of this attribute but it was similar in magnitude for stevia, and differed statistically ($P \leq 0.05$) from the other desserts. The light desserts have an increase in sweet aftertaste, but this increase in sweet aftertaste was similar in magnitude for all the light samples. The integral dessert differed statistically ($P \leq 0.05$) from the light samples with neotame and stevia in relation to the sweet aftertaste, but did not differ statistically ($P > 0.05$) from the light samples with sucrose, sucralose and aspartame.

The bitterness attribute was expected in all samples due to the use of cocoa powder, but with greater intensity in samples with sweeteners, which usually leave a bitterness sensation and a bitter residue during consumption (Bolini-Cardello, Silva, & Damásio, 1999). The desserts produced with neotame and stevia were also found to have the highest bitterness and bitter aftertaste differing statistically ($P \leq 0.05$) from the other desserts. It was expected that the sample with stevia would present the highest intensity of bitter taste, but sample with neotame did not differ statistically from it one. According to Mayhew et al. (2012) neotame is a high potency sweetener and flavor enhancer which have potentiated the bitter taste of cocoa. And stevia, due to the presence of stevioside in its composition, presents the bitter taste characteristic from this compound (Carakostas, Prakash, Kinghorn, Wu, & Soerjato, 2012).

Other studies showed that some replacers/substitutes can affect food product attributes. Cardarelli, Aragon-Alegro, Alegro, Castro, & Saad (2008) have shown that the addition of prebiotic and probiotic can affect the attributes of chocolate mousses. Samples added with prebiotic and probiotic presented highest means of color, taste and texture compared with the control sample (with no addition of prebiotic and probiotic). De Melo, Bolini & Efraim (2009) studied the sensory profile of reduced calorie chocolate using the quantitative descriptive analysis (QDA). They observed no difference between conventional, diabetic and diabetic/reduced calorie milk chocolates for brightness, cocoa aroma, cocoa butter aroma, and cocoa flavor.

In relation to the mouth fill attribute, the light sample with sucrose presented the highest mean but did not differ significantly ($P > 0.05$) from the light samples with aspartame and stevia, and the integral one. The light sample with neotame presented the lowest mean of mouth fill, but did not differ significantly ($P > 0.05$) from the light samples with sucralose and aspartame, and the integral one. The other attributes of texture (viscosity, creaminess and melting) did not differ statistically among the chocolate dairy desserts. This is a very good result since the replacement of sucrose by sweeteners and the addition of prebiotic can provide a chocolate dairy dessert with low calorie and functional properties, and then presents similar characteristics to the traditional one (with sugar and without prebiotic), which is desirable for consumers.

Principal component analysis (PCA) was performed (Fig. 1) and the first and second principal components described 73.49% of the variance and confirmed QDA results. The integral chocolate dairy dessert is closer to the light and prebiotic sample with sucralose than the other samples, indicating that these samples are more similar. PCA suggested that chocolate dairy desserts produced with light ingredients and with neotame and stevia sweeteners were closer and characterized by the attributes of bitterness and bitter aftertaste which is negatively correlated with sweetness. It also suggested that light chocolate dairy desserts with prebiotic and sucrose, sucralose and aspartame are more similar.

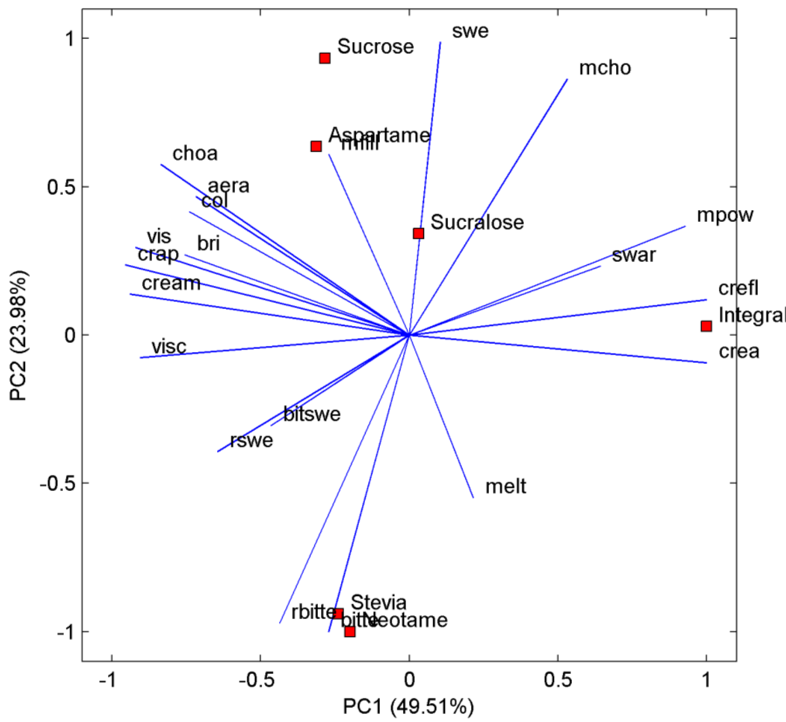

Fig. 1. Biplot of principal component analysis (PCA) for ADQ attributes for chocolate dairy desserts.

col, brown color; bri, brightness; vis, apparent viscosity; crap, apparent creaminess; aera, aeration; swar, sweet aroma; choa, chocolate aroma; crea, milk cream aroma; swe, sweet taste; rswe, sweet aftertaste; bitte, bitter taste; rbitte, bitter aftertaste; mcho, milk chocolate flavor; bitswe, bittersweet chocolate flavor; mpow, milk powder flavor; crefl, milk cream flavor; visc, viscosity; cream, creaminess; melt, melting; mfill, mouth fill.

3.2. Drivers of liking of chocolate dairy desserts

The relationship between sensory and hedonic data was investigated by means of PLS modeling. PLS is a multivariate method that establishes linear relationships between a set of predictors (X-block, sensory descriptor) and one response (Y-block, consumer acceptability). PLS was performed to determine the sensory attributes (resulting from descriptive test, QDA) and the overall liking of samples determined using the consumer test. The purpose of PLS was to establish which sensory attributes are mainly related to the preference of the chocolate dairy dessert samples and to evaluate whether individuals based their preference on the same sensory descriptors. In this case, one model was built relating to the sensory profile generated by the assessors to the preference of habitual consumers (Fig. 2).

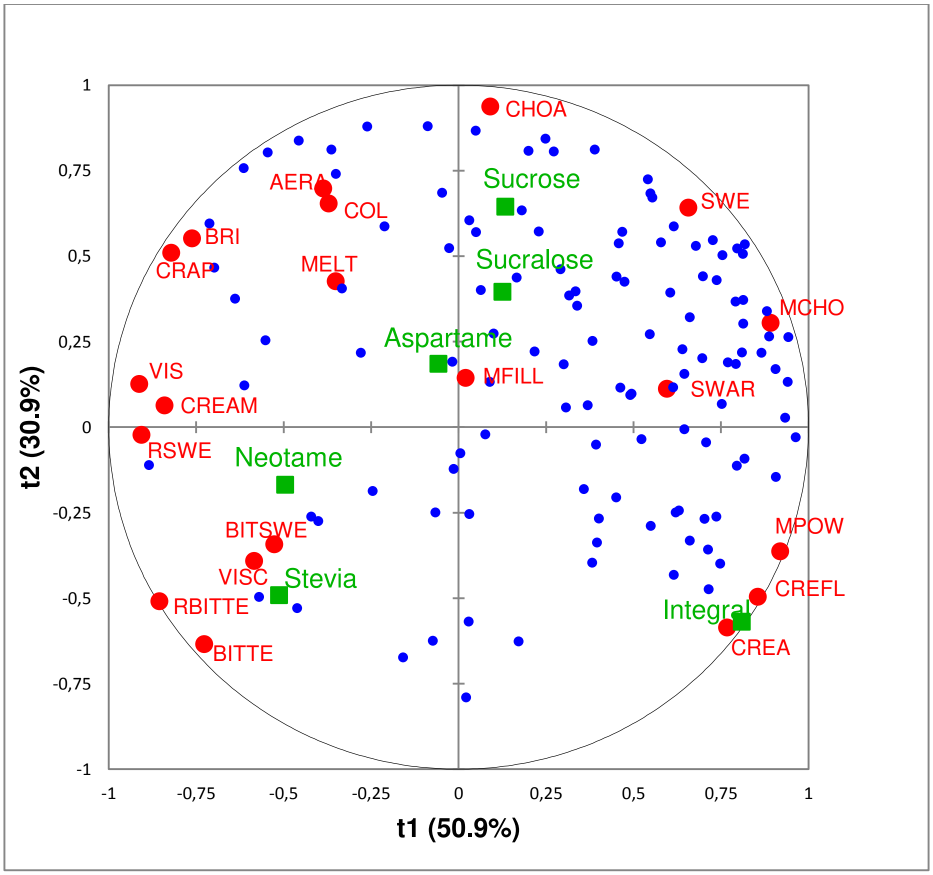

Fig. 2. Scores and Loadings Plot obtained by the PLS model for chocolate dairy dessert samples.

COL, brown color; BRI, brightness; VIS, apparent viscosity; CRAP, apparent creaminess; AERA, aeration; SWAR, sweet aroma; CHOA, chocolate aroma; CREA, milk cream aroma; SWE, sweet taste; RSWE, sweet aftertaste; BITTE, bitter taste; RBITTE, bitter aftertaste; MCHO, milk chocolate flavor; BITSWE, bittersweet chocolate flavor; MPOW, milk powder flavor; CREFL, milk cream flavor; VISC, viscosity; CREAM, creaminess; MELT, melting; MFILL, mouth fill.

The first factor explains up to 50.9% of the variation while the second factor accounts for 30.9%. Most of overall liking scores of consumers are located in the upper right quadrant.

Generally, variables located close to the upper right quadrant give a positive contribution to the X estimate, while variables located in the opposite part of the graph contribute negatively to the X estimate – sensory preference. In this case, as the first factor retains almost information, variables that present a positive coordinate on the first factor show a direct correlation with preference, while variables with a negative coordinate on factor 1 are negatively correlated to preference.

Considering the bi-dimensional plot (Fig. 2), it can be noted that, for the considered chocolate dairy dessert samples, the overall liking is positively correlated to sweetness, milk chocolate flavor, sweet aroma, and mouth fill, and negatively correlated to bitterness and bitter aftertaste and to a minor degree to the other variables located in the negative part of factor 1. These are the most important sensory descriptors driving the preference for the chocolate dairy desserts.

Creamy chocolate dairy desserts with stevia and neotame were perceived as the least preferred as compared to the other samples. Producers should address particular attention to the descriptors which negatively affect the chocolate dairy dessert hedonic dimension, because these are probably the most critical factors for consumer`s acceptability and consequently purchase intentions. Our findings suggest that bitter aftertaste make the products less pleasant for consumers. Indeed, creamy chocolate dairy desserts with sucrose, sucralose, aspartame and the integral one were perceived as the most preferred, garnering the highest mean score values for overall liking. These samples were characterized by sweetness, milk chocolate flavor and sweet aroma, which are attributes related positively with overall liking.

De Melo, Bolini & Efraim (2009) also used the PLS methodology to determine drivers of liking of diabetic/reduced calories chocolate, and obtained that sweet aroma, melting rate, and sweetness attributes were highly positively correlated with overall liking. The attributes of sweetness and sweet aroma were also perceived in the present study. In addition, acceptability was determined mainly by lack of bitterness, bitter aftertaste, adherence, and sandiness attributes, which were drivers of disliking. So, the attribute of bitter aftertaste was also perceived as a driver of disliking in the present study. Ares, Giménez, Barreiro, & Gámbaro (2010) identified drivers of liking of milk desserts by the use of an open-ended question. Samples described as delicious were associated with creaminess and thickness, suggesting that these characteristics were drivers of liking. On the other hand, milky flavor and lack of thickness were drivers of disliking. These attributes were not described in the current study.

3.3. Chemical and compositional analyses

Table 4 presents the mean values for the chemical composition of chocolate dairy dessert samples. Significant differences ($P \leq 0.05$) were obtained among samples in relation to all characteristics evaluated, indicating that the addition of light ingredients, prebiotics and sweetener agents affect the chemical and compositional properties of chocolate dairy desserts.

In relation to the moisture parameter all samples were statistically different ($P \leq 0.05$) among them. The samples with the addition of sucrose (the light sample with sucrose and the integral one) were characterized by lesser values. Sucrose is hygroscopic and are able to bind water through its hydroxyl groups, thus, being able to retain moisture, providing a lower moisture content value for the desserts with addition of this component.

Table 4

Means of chemical and compositional analysis for the chocolate dairy dessert samples.

Chemical composition (g/100g)	Samples						MDS
	Sucrose	Sucralose	Aspartame	Neotame	Stevia	Integral	
Moisture	58.26^{f}	68.16^{c}	66.97^{d}	70.24^{a}	69.39^{b}	60.11^{e}	0.30
Total solid	41.77^{a}	31.84^{d}	33.03^{c}	29.76^{f}	30.61^{e}	39.89^{b}	0.28
Ash	2.07^{ab}	1.91^{b}	2.12^{a}	1.71^{c}	1.99^{ab}	1.45^{d}	0.17
Protein	7.06^{a}	6.65^{c}	7.07^{a}	6.72^{bc}	6.83^{b}	6.67^{bc}	0.18
Lipid	5.03^{b}	5.05^{b}	5.08^{b}	5.08^{b}	5.05^{b}	11.78^{a}	0.13
Carbohydrate	27.58^{a}	18.23^{d}	18.76^{c}	16.25^{f}	16.74^{e}	20.06^{b}	0.47
Calorie (kcal)	183.83^{b}	144.96^{d}	149.07^{c}	137.60^{f}	139.70^{e}	212.29^{a}	0.72

Means with a same superscript in line do not differ statistically at a 5% level.

MDS, minimum significant difference in Tukey's test ($P \leq 0.05$).

In relation to the content of lipids the integral sample presented the highest mean for this parameter differing statistically ($P \leq 0.05$) from the others, which did not have statistical difference ($P > 0.05$) among them. This result was expected since the integral sample was prepared using conventional/integral ingredients, while in the preparation of the other samples light ingredients were used. According to the Brazilian legislation (BRASIL, 1998) the term "light" is used for any food that presents a minimum reduction of 25% in a given nutrient or calories, compared to conventional food. For lipid content a reduction of over 40% was obtained, confirming that the samples with addition of prebiotics and light ingredients can be considered "light" in relation to this parameter.

Regarding calories all samples presented significant ($P \leq 0.05$) differences. The integral samples presented the highest mean for this parameter. The sample with sucrose differed significantly from the integral one but, according to Brazilian legislation (Brasil, 1998) this sample cannot be considered "light" in relation to the conventional sample since this sample showed no minimum reduction of 25% compared to the calorie content. However, all samples with addition of sweeteners can be considered light in relation to calories compared to the integral one because they presented reduction greater than 29% in relation to this parameter. And, among these light samples the one with neotame presented the lowest mean for calories being the prebiotic chocolate dairy dessert with less caloric intake.

In addition to present light characteristics these samples with sweeteners can be considered diet samples in relation to the sucrose addition. According to the Brazilian legislation (BRASIL, 1998) “diet” is a term used most often as a synonym for removing a nutrient (sugars, sodium, fats, some amino acids...) without entailing, however, the reduction in calories of the food. The light samples of prebiotic creamy chocolate dairy desserts with the addition of sweeteners have no addition of sucrose and can be considered as diet samples.

The samples of creamy chocolate dairy desserts with sweeteners, in addition to be considered light with respect to the fat and calorie contents and diet since they have no sugar, being possible to be consumed by diabetics people, they present functional benefits due to the addition of prebiotics, such as contribute to the balance of intestinal flora (Roberfroid et al., 2010).

4. Discussion

Prebiotics have attracted the interest of researches and the food industry due to their nutritional and economic benefits (Bosscher, 2009; Scheid, Moreno, Maróstica-Júnior, & Pastore, 2013). The health-promoting effects of prebiotics include benefits to host nutrition, the growth inhibition of pathogens, and the promotion of beneficial microbiota (Choque-Delgado, Tamashiro, Maróstica-Júnior, Moreno, & Pastore, 2011). The functional properties of the prebiotics have encouraged the development of products and the addition of them in chocolate dairy desserts shown to be a promising market (Morais, Morais, Cruz, & Bolini, 2014).

For new dairy product development it is important to perform the quantitative characterization of the sensory attributes of the product, and this can be achieve using a trained panel and quantitative descriptive analysis principles (Cadena, Cruz, Faria, & Bolini, 2012; Santos et al., 2013). The addition of prebiotics in chocolate dairy desserts showed no statistically differences ($P > 0.05$) when compared with integral desserts without prebiotics; the samples were similar in relation to some attributes of appearance, aroma, flavor and texture. This indicates that the addition of prebiotics in chocolate dairy desserts provides a dessert with similar sensory profile of the traditional one, and, moreover, with added functional value.

In addition to the sweet taste, other sensory attributes may be modified when replacing the sucrose by another sweetening agent. This has been a challenge for researches and industry alike (Cadena et al., 2013), since high intensity sweeteners are being more used by consumers who search for products with reduced sucrose contents, either for their reduced energy content or due to the demands of *diabetes mellitus* sufferers (Cadena & Bolini, 2011; Palazzo & Bolini, 2014).

Sucralose is made from sucrose by the selective replacement of three hydroxyl groups with chlorine; the result is a sweetener that is remarkably different from sucrose in its intensity and stability, although it has a comparable taste quality (Grotz, Molinary, Peterson, Quinlan, & Reo, 2012). Some studies has been considered sucralose as the sweetener that best substitutes sucrose, since it provokes less sensory alterations in the product (Brito & Bolini, 2010; Cadena et al., 2013; Cardoso & Bolini, 2008; De Marchi, McDaniel, & Bolini, 2009). In the present study the sensory profile of dairy desserts with sucralose was similar than that one with sucrose; these samples, in QDA, differed statistically ($P \leq 0.05$) only in relation to the attribute of brown color. Considering the principal component analysis (PCA) the sucralose sample was mainly related to the attributes of sweetness and milk chocolate flavor, which are positively related with overall liking by consumers in partial least squares (PLS) regression.

The replacement of sucrose in prebiotic chocolate dairy desserts confirmed sucralose as the best substitute when compared with the high intensity sweeteners of aspartame, neotame, and stevia. However, the high intensity sweeteners used in this study presented a good stability in prebiotic chocolate dairy desserts and may be considered as a potential for palatable food in the formulation of diabetic/reduced calorie and light chocolate dairy desserts. The results obtained in the chemical composition showed that all samples with the replacement of sucrose by sweeteners were considered light in relation to lipid content and calories.

PCA showed that the addition of light ingredients and the sweeteners neotame and stevia was characterized by chocolate dairy dessert samples with bitterness and bitter aftertaste attributes and were evaluated in a negative way by the consumers.

Stevia is unlikely to be used as a sole sweetener in chocolate dairy desserts. However, this limitation is easily addressed by blending with any other of a number of sweeteners. A blend with sucrose where rebaudioside A contributes to 15%-50% of the sweetness exhibits flavor and temporal profiles very close to those of sugar with fewer calories (Carakostas, Prakash, Kinghorn, Wu, & Soerjato, 2012). Stevioside exhibits much more bitterness than rebaudioside A, so most new steviol glycoside sweetener products now contain high levels of rebaudioside A or are nearly pure rebaudioside (Carakostas, Prakash, Kinghorn, Wu, & Soerjato, 2012). Cadena et al. (2013) studied the sensory profile of mango nectar sweetened with high intensity sweeteners throughout storage time and concluded that the sweetener stevia with 97% rebaudioside did not show off-flavor and also presented similar acceptance and sensory profile in relation to control with sucrose.

Endogenous polyphenolic compounds in cacao impart both bitter and astringent characteristics to chocolate product confections (Harwood, Ziegler, & Hayes, 2013), showing that a food produced with cocoa powder presents a natural bitter taste. While an increase in these compounds may be desirable from a health perspective, since the consumption of cocoa is associated with a lower risk of CVD and improvements in endothelial function (West et al., 2014) they are generally incongruent with consumer expectations which associate the bitterness as a negative attribute. A study of a sensory-guided decomposition of roasted cocoa nibs revealed that, besides theobromine and caffeine, a series of bitter-tasting 2,5-diketopiperazines and flavan-3-ols were the key inducers of the bitter taste as well as the astringent mouthfeel imparted upon consumption of roasted cocoa (Stark, Bareuther, & Hofmann, 2006).

According to Mayhew et al. (2012) neotame is a high potency sweetener and flavor enhancer. As the basis for the chocolate flavor in the dairy desserts was the cocoa powder, neotame can be potentiated the bitter taste of the compounds presented in it. Palazzo & Bolini (2014) also perceived higher bitterness when studying the replacement of sucrose by neotame in soy-based chocolate. However, the addition of neotame in milk chocolate provided a sensory dynamic profile closer to the sweetened with sucrose.

To date, no study including comparison with different sweeteners and addition of prebiotic was reported in dairy desserts and this can be an interesting alternative to develop an added-value functional dessert that features sensory characteristics desired by consumers.

5. Conclusions

The descriptive test (QDA) revealed that the chocolate dairy dessert sensory characteristics were dependent on the variation of ingredients (sucrose, sweeteners and prebiotics) added in the formulations, as expected.

The findings of this current study indicate that the crucial attributes that determine consumer acceptability in chocolate dairy dessert samples are sweetness, milk chocolate flavor, sweet aroma, and mouth fill whereas bitterness and bitter aftertaste were drivers of disliking. In this context, these attributes can be considered drivers of liking and disliking of chocolate dairy desserts and they should be taken into consideration by dairy processors when dairy desserts are produced.

The present study indicated that the sucrose substitution by high-intensity sweeteners, sucralose, aspartame, neotame, and stevia have potential as a palatable food in the formulation of diabetic/reduced calorie and light chocolate dairy desserts. The findings could be applied by the dairy industry to develop and reformulate the recipes of diabetic and/or reduced calorie and light desserts to better meet consumer requirements.

The creamy chocolate dairy desserts in addition of being light in calories and fat, and diet in sugar content, present functional characteristics due to the addition of prebiotic and sensory characteristics desirable by consumers. It is a very strong tendency of dairy market because add value to the product and is available for all types of consumers, including diabetics.

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ARTIGO 5: Influence of functional and diet/light claims on chocolate dairy dessert consumers` evaluations: bi- and multi-linear decomposition methods

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ABSTRACT

This study evaluates the effect of functional and diet/light claims on acceptance of chocolate dairy desserts. One hundred consumers participated in the tests of sensory acceptability in relation to the attributes of appearance, aroma, flavor, texture and overall liking. Tests were conducted using the same composition of samples and varying only the claims. Internal Preference map using parallel factor analysis (PARAFAC) and Principal Component Analysis (PCA) was performed using the consumer data. Data showed that consumers evaluated the claims differently. The samples with the addition of prebiotic claim and declaring the functional property of prebiotics were preferred by them. As the samples with the addition of diet/light claims, which received highest scores. It was concluded that the addition of claims may be suitable to be used in a chocolate dairy dessert with high acceptance by consumers.

Keywords: prebiotic, functional claim, dairy dessert, sensory acceptability, parafac.

PRACTICAL APPLICATIONS

The role that food industry plays on people's everyday life is undeniable, as well as the importance of diet on the prevention of diseases and its association to health promotion. Food industry has amplified market by providing practical foods and goods for consumers' convenience. The effect of information addition on the label of these foods is a study of great importance for food industries, as contributing to a better targeting of information, as the claims, and thus greater acceptance by consumers.

INTRODUCTION

A very complex phenomenon is the consumer perception of food products where sensory characteristics are not the only determinants (Ares *et al*. 2010; Carrillo *et al*. 2012; Vidal *et al.* 2013). As the markets for functional foods increase, studying and understanding consumers' perception is essential to develop products that have a good consumer acceptance (Ares *et al.* 2008). A better understanding of consumers` perception for this type of food product and identify the determinants of consumers` acceptance for functional foods is one key aspect to assist the development of functional foods (van Kleef *et al.* 2002; Ares *et al*. 2011).

According to Ares *et al.* (2008) preferred health claims varies with gender and age. Women seem to be more concerned than men about gut health and osteoporosis. Regarding the influence of age, younger people tend to emphasize disease-preventing claims, while older people tend to give more importance to short-term effects on health. The influence of information both on consumer perception and expectations about various food products, using different methodologies, has been studied recently, and some studies have mainly focused on overall liking scores (Varela *et al*. 2010; Olsen *et al*. 2011; Torres-Moreno *et al.* 2012). Exploring the influence of information on consumer perception of sensory attributes would provide supplementary information (Deliza *et al*. 2003; Vidal *et al*. 2013).

Health claims can be attractive to different market segments, and therefore, consumer research is necessary to determine which health claims can be used according to which segment of the market the product is addressed to (Ares *et al.* 2008). Health concerns play an important role in people's consumption of food products and judgments of food taste. Previous studies on the effects of food labeling suggest that consumers' sensory evaluations are influenced by health concerns (Chiou *et al*. 2009). Findings from these studies demonstrate consumers' knowledge and insights of functional food and its health effects. These help food manufacturers understand the consumers who are latent in purchasing functional food products in the market and develop functional food products that will ensure their success in the market (Chung *et al*. 2011).

The same goes for diet/light foods. The diet and light terms are widely used on food labels, and may cause confusion when purchasing a product. According to Carrillo *et al*. (2014) most people do not know the difference of light and diet products. They related that consumers are not sufficiently informed about the meaning of these terms and feels unsafe to use such foods, or misappropriates due to lack of understanding of the labeling declarations. In this way, the study of diet/light claim will enable the understanding of how consumers evaluate the presence of these claims in reduced-calorie and -fat products.

There are two basic approaches to the analysis and understanding of consumer preferences. These are generally referred to as internal and external preference mapping (Cadena *et al.* 2012). Although they are essentially based on the same data, internal and external preference analyses represent different perspectives on this data, and hence they extract different information from it. External preference analysis requires both perceptual and preference data, whereas internal preference analysis can, in principle, be conducted solely based on preference data (van Kleef *et al*. 2006).

Principal component analysis (PCA) and Parallel factor analysis (PARAFAC) are bi-linear and multi-linear decomposition methods, respectively, which decompose the array into sets of scores and loadings that describe the data in a more condensed form than the original data array (Bro 1997; Marini and Bro 2013). PCA provides an exploratory analysis of samples as a function of variables, while PARAFAC is able to provide an exploratory interpretation of these samples and variables, taking into account the different conditions in which these data were generated (Nunes *et al*. 2011). Recently, the potential use of PARAFAC as a tool to model consumer sensory acceptance data has been demonstrated as in beef burger and herb cake (Nunes *et* al. 2011), grape juice (Nunes *et al*. 2012), Brazilian cerrado fruit jam (Souza *et al.* 2012), and probiotic and conventional yogurt (Cruz *et al.* 2012).

In this context, the aim of this study was to evaluate the influence of functional claims in acceptance of chocolate dairy desserts using the methods of principal component analysis (PCA) and Parallel factor analysis (PARAFAC) to better understand the consumers' perception and the influence of gender and age on this perception. In addition, a comparison of the utility of methods used was also evaluated.

MATERIALS AND METHODS

Materials

Chocolate dairy desserts were produced with prebiotic Biofis Inufos (inulin and fructooligosaccharides – 50:50 (wt/wt)) (Siba Ingredients, São Paulo, SP, Brazil), guar and xanthan gum (SweetMix, Sorocaba, SP, Brazil), commercial skim milk powder (Molico®, Nestlé, Araraquara, SP, Brazil), commercial UHT skim milk (Molico®, Nestlé, Brazil), cocoa powder (Garoto®, Vila Velha, ES, Brazil), sucrose (União®, Tarumã, SP, Brazil), and light cream (Nestlé®, Araçatuba, SP, Brazil).

Chocolate dairy desserts production

The concentrations of prebiotic, gum, sucrose, milk powder, cocoa powder, cream and UHT milk were: 7.5% (wt/wt), 0.2% (wt/wt), 8.0% (wt/wt), 10.0% (wt/wt), 4.5% (wt/wt), 25.0% (wt/wt), and 44.8% (wt/wt), respectively. The level of the ingredients used were determined in a previous study (Morais *et al.* 2014a).

The solids ingredients were mixed in a dry pan. The UHT skim milk was heated to 40ºC and added to the mixture of solid ingredients under constant agitation. Subsequently, the temperature was increased to 90 ± 2ºC for 3 minutes for pasteurization. The temperature was then reduced to 40ºC, cream was added, and the mixing continued for another 2 minutes. The samples were put in an acrylic cup (40mL), covered to avoid drying, and stored under refrigeration (6 ± 2ºC) until sensory analysis.

Functional property and diet/light claims

Figures containing claims were presented to consumers in the same way as each sample. Five different functional property claims were used, according to Table 1; as well as the five diet/light claims presented in Table 2.

TABLE 1. FIVE DIFFERENT FUNCTIONAL CLAIMS USED IN ACCEPTANCE TEST*

Code	Functional property claim
159	Chocolate Creamy Dairy Dessert
238	Chocolate Creamy Dairy Dessert – with the addition of prebiotics
352	Chocolate Creamy Dairy Dessert – with the addition of prebiotics. “Prebiotics contribute to the balance of intestinal flora. Consumption must be associated with a balanced diet and healthy lifestyle habits”
476	Chocolate Creamy Dairy Dessert – with the addition of inulin and fructooligosaccharides
521	Chocolate Creamy Dairy Dessert – with the addition of inulin and fructooligosaccharides. “Inulin and fructooligosaccharides contribute to the balance of intestinal flora. Consumption must be associated with a balanced diet and healthy lifestyle habits”

* Functional property claims approved by the Brazilian legislation (BRASIL, 2008).

Sensory analyses

Sensory analyses were performed in individual air-conditioned (22°C) booths and evaluated under white light; thus ensuring comfort and privacy for the tasters. Taste-free water and crackers were provided for palate cleansing. Sessions were held at the Laboratory of Sensory Science and Consumer Research of the School of Food Engineering (Department of Food and Nutrition, UNICAMP, Campinas, Brazil). Samples coded with 3-

digit numbers were presented to tasters in acrylic cups with 30 g of chocolate dairy dessert sample followed by the figure with the functional property claim coded with the same 3-digit numbers. A complete balanced block design was used (MacFie *et al*. 1989; Stone *et al*. 2012), and the samples with figures were presented sequentially in a monadic way.

TABLE 2. FIVE DIFFERENT DIET/LIGHT CLAIMS USED IN ACCEPTANCE TEST*

Code	Diet/light claim
159	Chocolate Creamy Dairy Dessert
238	Light Chocolate Creamy Dairy Dessert
352	Light Chocolate Creamy Dairy Dessert – reduction in calories and fat
476	Diet Chocolate Creamy Dairy Dessert
521	Diet Chocolate Creamy Dairy Dessert – no added sugar

* Diet/light claims approved by the Brazilian legislation (BRASIL, 1998).

Acceptance tests

Acceptance was determined using a 9-cm unstructured line hedonic scale (Stone and Sidel 2004; Stone *et al*. 2012), with anchors of “dislike extremely” on the left and “like extremely” on the right. Consumers evaluated the chocolate dairy dessert samples in relation to the attributes of appearance, aroma, flavor, texture, and overall liking. Consumers received an evaluation form followed by the sample and the figure and were asked to evaluate the sample in relation to each attribute, and to fill in the questionnaire.

A hundred consumers (58 females and 42 males, aged between 18 and 60) and also a hundred consumers (62 females and 38 males, aged between 17 and 68) recruited through personal contact took part in the affective tests evaluating the functional and diet/light claims, respectively. Each consumer conducted the assessment of the five chocolate creamy dairy dessert samples in a single session. To prevent bias, no information about the samples were provided to the consumers.

The data obtained from the acceptance tests were evaluated by univariate statistical analysis (ANOVA), and the means were compared using Tukey's test averages (at 5% significance). All statistical analyses were performed using the software Statistical Analysis System – SAS 9.1.2 (SAS Institute, Inc., Cary, NC, 2008).

Principal Component Analysis (PCA)

Principal component analysis (PCA) is used in an early phase of an investigation as an explorative technique in order to provide an overview, but the method can also be used to generate hypotheses (Naes *et al.* 2010). This technique is based on the idea of finding the most important directions of variability in the high dimensional space of all the measured variables and presenting the results in plots that can be used for simple interpretation. It can be looked upon as a purely descriptive mathematical method that simply extracts the main information in the data and presents the results graphically (Cruz *et al*. 2013).

The consumer acceptance data sets were arranged in a matrix (5 x 100) of *i* lines (samples) and *j* columns (consumers) for each attribute of appearance, aroma, flavor, texture and overall liking; and in a matrix (5 x 5) of *i* lines (samples) and *j* columns (attributes) by calculating the average of consumer assessments (Cruz *et al*. 2012). Data were auto scaled and the PCA was carried out using SensoMaker software – version 1.7 (Pinheiro *et al*. 2013). Plots of scores and loadings were built from the first two principal components.

Three-way internal preference mapping obtained by parallel factor analysis (PARAFAC)

The three-way arrays underwent PARAFAC analysis. PARAFAC calculations were carried out using the SensoMaker software – version 1.7 (Pinheiro *et al*. 2013) that is freely available. Consumer acceptance data sets were arranged in an array of *i* lines (samples), *j* columns (consumers), and *k* cubes (attributes).

The core consistence was used as the choice criterion of the number of factors (Cruz *et al*. 2012), as it estimates the appropriateness of the PARAFAC solution, indicating if the model is appropriate or not. The explained variance is the amount of variance explained for the assumed number of factors (Marini and Bro 2013). Biplots were made for the first two factors for each loading mode.

RESULTS AND DISCUSSION

Acceptance test of functional property claims

The 100 consumers evaluated the creamy chocolate dairy desserts for liking of appearance, aroma, flavor, texture, and overall liking. Results are presented in Table 3, and showed that the functional claim influenced in the acceptance of desserts.

TABLE 3. MEANS OF THE ATTRIBUTES OF ACCEPTANCE TEST WITH CHOCOLATE DAIRY DESSERT SAMPLES (9-CM UNSTRUCTURED LINE SCALE) (N=100)

Attributes	Samples					MDS
	1	2	3	4	5	
Appearance	7.30^{a}	7.57^{a}	7.43^{a}	6.59^{b}	6.53^{b}	0.64
Aroma	6.45^{a}	6.53^{a}	6.33^{a}	6.24^{a}	6.35^{a}	0.80
Flavor	6.95^{b}	7.09^{ab}	7.75^{a}	6.85^{b}	6.78^{b}	0.76
Texture	6.40^{a}	6.40^{a}	6.24^{a}	6.06^{a}	6.08^{a}	0.84
Overall liking	7.77^{a}	7.09^{a}	7.73^{a}	6.62^{b}	6.77^{b}	0.68

Means with a same superscript letter in the line are not significantly different at a 5% level.

1, chocolate creamy dairy dessert; 2, chocolate creamy dairy dessert – with the addition of prebiotics; 3, chocolate creamy dairy dessert - with the addition of prebiotics. "Prebiotics contribute to the balance of intestinal flora. Consumption must be associated with a balanced diet and healthy lifestyle habits"; 4, chocolate creamy dairy dessert – with the addition of inulin and fructooligosaccharides; 5, chocolate creamy dairy dessert – with the addition of inulin and fructooligosaccharides. "Inulin and fructooligosaccharides contribute to the balance of intestinal flora. Consumption must be associated with a balanced diet and healthy lifestyle habits"; MDS, minimum significant difference in Tukey's test ($P \leq 0.05$).

The affective test with dairy dessert consumers showed that in relation to the attributes of aroma and texture, consumers did not differ the samples ($P > 0.05$), showing that claims did not influence the consumers` acceptance regarding aroma and texture. Considering the attributes of appearance, flavor and overall liking, consumers differed significantly the samples ($P \leq 0.05$). The claims influenced consumers' acceptance in relation to these attributes.

Sample with no claim (sample 1) presented high means for the attributes of appearance, aroma, texture and overall liking. However, for the attribute of flavor the sample with the addition of prebiotic claim (sample 2) and the sample declaring the functional property of prebiotics (sample 3) presented high values and did not differed significantly ($P > 0.05$) from each other. Samples declaring the types of prebiotic added (sample 4) and its functional properties (sample 5) were not statistically different ($P > 0.05$) from the other samples in relation to the attributes of aroma and texture. However these samples presented lowest average of acceptance in relation to the attributes of appearance, flavor and overall liking.

These findings show that the change in the functional property claim influenced the acceptance by consumers of chocolate dairy desserts. In general, consumers preferred the sample with no functional claim and the samples with the addition of prebiotic claim and the one declaring the functional property of prebiotics.

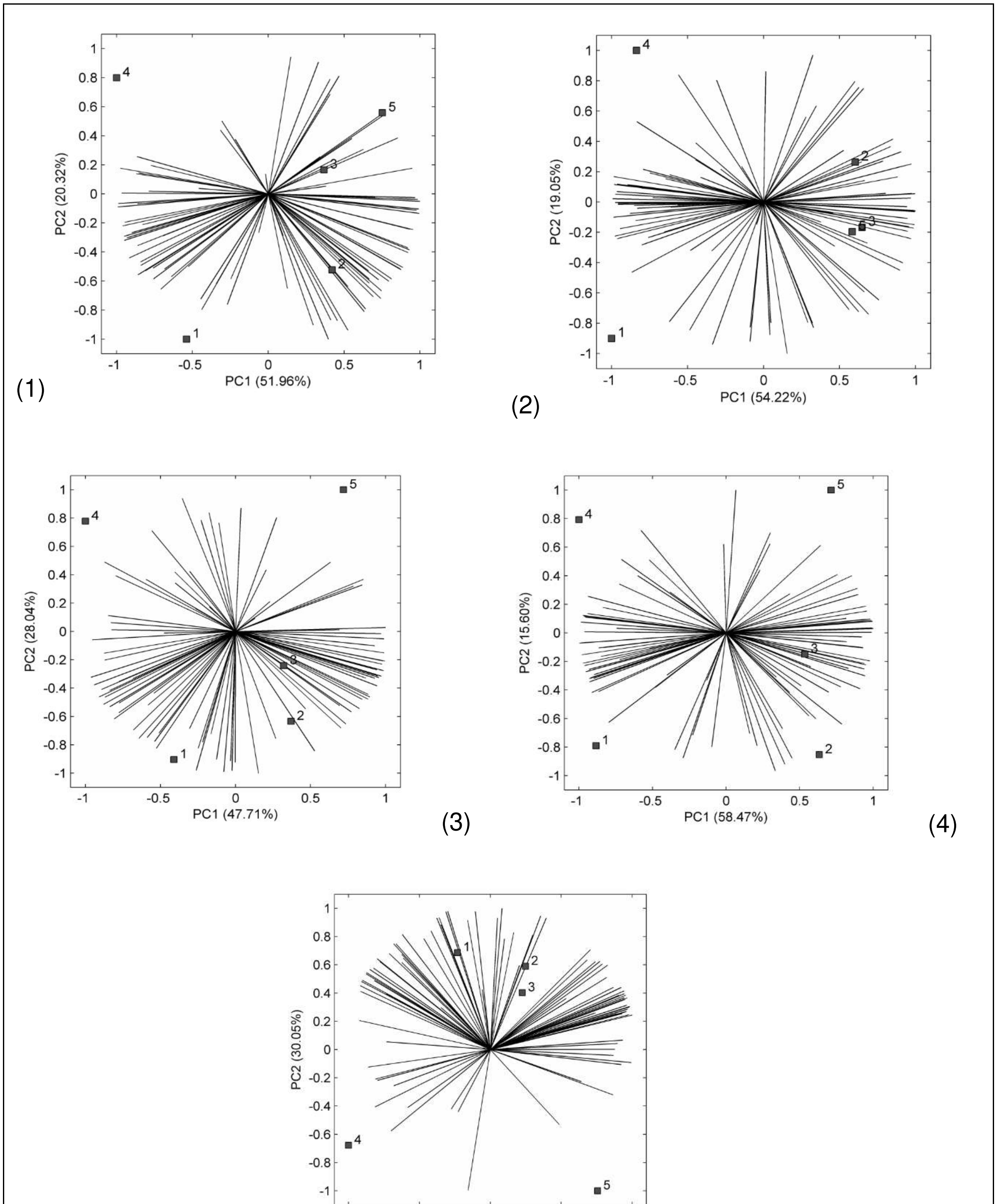
The consumer knowledge regarding the functional properties may interfere in acceptance. Consumers were asked about prebiotic and functional food products. 67% of consumers reported having knowledge about these products; and they have consumed at least a product with functional property claim. 78% of women reported liking of food products with functional property claim and 66% reported that if the prebiotic chocolate dairy desserts were available on the market, they would have a positive intention to purchase. However, 55% of men reported liking of food products with functional property claim and 65% of them reported that the claim does not influence in their acceptability of the product.

These results show that women are more involved and were more likely to accept products with functional properties, while men do not consider the claim as an attraction for consumption. According to Ares *et al.* (2008) preferred health claims varies with gender and age. They reported that women seem to be more concerned than men about gut health and osteoporosis. Regarding the influence of age, younger people tend to emphasize disease-preventing claims, while older people tend to give more importance to short-term effects on health.

According to Barrios *et al.* (2008), the influence of attitudes, beliefs and opinions on food choice and purchase is especially important in the acceptance of some types of foods, as functional, that are presented to the consumer as a possible alternative to the conventional foods. Overall, the results are valuable for the functional dairy industry, because it was possible to determine a better and more appropriate presentation of functional dairy products on the market, contributing to a greater acceptance.

Principal component analysis (PCA)

The results of acceptance test for each attribute were analyzed by conventional internal preference maps (Fig. 1-5). The preference map for the appearance (Fig. 1) indicated that the samples 2 and 3 received most of the high hedonic scores. The preference map for the aroma (Fig. 2) indicates that the 2, 3 and 5 samples were preferred. Fig. 3 presented the preference map for flavor, which indicated that the samples 3 and 2 were preferred, and that sample 1 was preferred secondarily. The PCA for the texture (Fig. 4) showed that the sample 3 received most of the high hedonic scores and that most consumers preferred this sample in relation to texture. In relation to the overall impression (Fig. 5) samples 1, 2, and 3 were preferred and received most of the high hedonic scores.



FIGS. 1-5. BIPLOT OF PRINCIPAL COMPONENT ANALYSIS (PCA) FOR APPEARANCE (1), AROMA (2), FLAVOR (3), TEXTURE (4) AND OVERALL LIKING (5) OF CHOCOLATE DAIRY DESSERT SAMPLES.

The PCA showed that consumers evaluated the samples differently, in which the claim influenced the preference of consumers in relation to the different attributes. According to Nunes *et al.* (2011) the regular internal preference map provides information regarding the preferred samples separately for each attribute. However, it was not able to clearly highlight the samples that were globally better accepted in the consumer acceptance test. On the other hand, a three-way approach can be useful to emphasize the globally preferred samples.

Three-way internal preference map – PARAFAC analysis

The results of acceptance test for all attributes were analyzed by a three-way preference map. Data were organized in a three-way array with dimensions of 5 x 4 x 100 referring to samples x attributes x consumers. To build the three-way internal preference map, PARAFAC models using from 1 to 4 factors were fitted in order to choose the adequate number of factors. The results are presented in Table 4. The core consistence suggested that two factors are indicated, being observed explanation 48.13% of the variance and presented a core consistence value of 65.94%. Although it is reported a low amount of variance in two dimensions, the elevated core consistency value indicates a good quality of the model (Nunes *et al.* 2011).

TABLE 4. PARALLEL FACTOR ANALYSIS MODEL PERFORMANCE FOR CHOCOLATE DAIRY DESSERTS ACCEPTANCE DATA

Factors	Explained variance (%)	Core consistence (%)
1	37.36	100
2	48.13	65.94
3	56.71	43.30
4	62.24	19.96

Fig. 6 shows the graph of the loadings in mode one (samples), loadings in mode two (sensory attributes), and loadings in mode three (consumers) plot, for the first two components. The sample with the addition of prebiotic claim (sample 2) and the sample declaring the functional property of prebiotics (sample 3) showed highly distinct acceptance as compared to the other samples, with respect to the degree of liking of appearance, aroma, flavor, texture and overall impression. Consumers similarly liked these two samples.

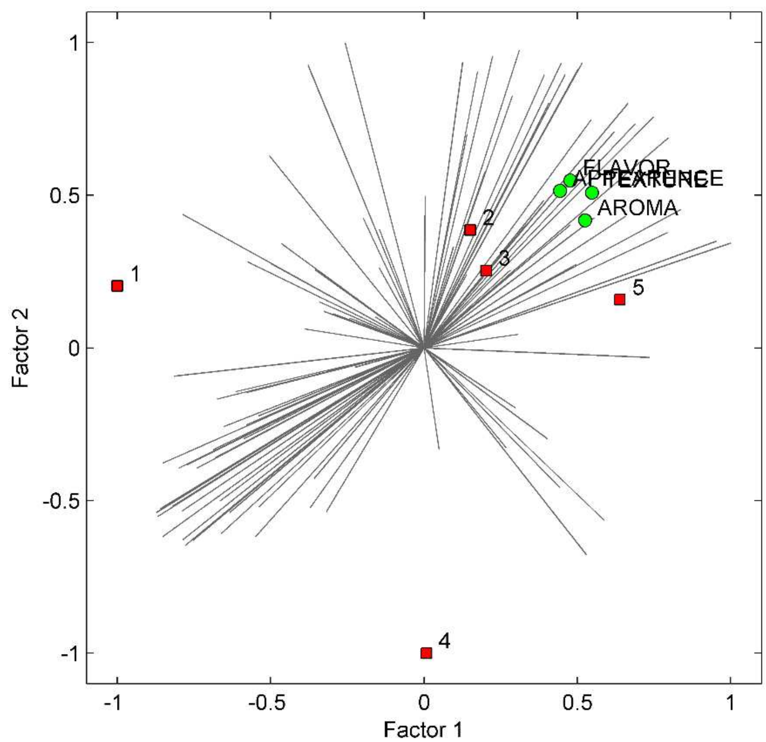


FIG. 6. THREE-WAY INTERNAL PREFERENCE MAP FOR APPEARANCE, AROMA, FLAVOR, AND TEXTURE FOR CHOCOLATE DAIRY DESSERTS.

The three-way analysis enabled a comparison of the overall performance of the samples in the acceptance test, indicating that the sample with the addition of prebiotic claim (sample 2) and the sample declaring the functional property of prebiotics (sample 3) presented similar behavior, whereas the sample with no claim stood out from the others, as did the samples declaring the types of prebiotic added (sample 4) and its functional properties (sample 5).

In general, all attributes evaluated were perceived in a similar way by the consumers, since all of them were allocated in the same region of the graph. These results are in accordance to those described in the literature for chocolate (Palazzo and Bolini 2009), carrot cupcakes (Villanueva *et al*. 2010), probiotic cheese (Gomes *et al.* 2011a), low sodium cheese (Gomes *et al.* 2011b), and probiotic and conventional yogurt (Cruz *et al*. 2012).

Comparison of the results of acceptance test, PCA and PARAFAC

Comparing the results of acceptance test, the PCA for overall liking and the other attributes and the three-way internal preference map, it can be seen that they are in accordance. Indeed, the PCA for the overall liking showed that the sample with no claim (sample 1) and the samples with the addition of prebiotic claim (sample 2) and declaring the functional property of prebiotics (sample 3) were highest preferred by consumers, and the acceptance test is in accordance with this since these samples presented the highest means for this attribute and did not differ significantly ($P > 0.05$) from each other. So, considering the attribute overall liking, the methods of evaluation presented accordance in the results.

Comparing the three-way internal preference map and the PCA it can be seen that the PCA methodology presents as negative point the representation of each attribute separately, showing the advantage of the three-way method. So, the three-way showed that all attributes had importance in evaluating the chocolate dairy desserts, and that the samples which were most characterized by these attributes were the samples with the addition of prebiotic claim (sample 2) and declaring the functional property of prebiotics (sample 3). These are the samples preferred by consumers since they are located in the same region of samples in the graph (Fig. 6). In PCA the samples were allocated in different regions (Figs. 1-5) according to the different attributes, being characterized differently for each attribute. Thus, this did not allow detecting how was the sample preferred by consumers in general, but only for each attribute separately.

In general, both methodologies of evaluation showed that consumers differed samples, in which claims influenced in acceptance of chocolate dairy desserts. According to results the samples with the addition of prebiotic claim (sample 2) and declaring the functional property of prebiotics (sample 3) were preferred by consumers. Vidigal *et al*. (2011) studied the effect of a health claim on consumer acceptance of exotic Brazilian fruit juices and concluded that the information of health benefits can positively influence sensory acceptance, provided there is sensory pleasure. This was confirmed in the present study, as the samples with claim of functional property of prebiotics, without citing types of prebiotics, were more preferred. Sabbe *et al*. (2009) also studied the effect of a health claim and personal characteristics on consumer acceptance of fruit juices with different concentrations of açaí (*Euterpe oleracea* Mart.) and concluded that older respondents and women were more likely to accept fruit juices claim that a particular health benefit.

Acceptance test of diet/light claims

Diet/light products have been widely studied (Melo *et al.* 2010; Leksrisompong *et al.* 2012; Esmerino *et al*. 2013; Palazzo and Bolini 2014). However, the study of the diet/light claims and the relationship to the acceptance by consumers has not been reported.

The 100 consumers evaluated the creamy chocolate dairy desserts for liking of appearance, aroma, flavor, texture, and overall liking. Results are presented in Table 5, and showed that the diet/light claims influenced in the acceptance of desserts.

The affective test with dairy dessert consumers showed that in relation to the attributes of appearance, aroma, and texture, consumers did not differ the samples ($P > 0.05$), showing that claims did not influence the consumers` acceptance regarding these attributes. Considering the attributes of flavor and overall liking, consumers differed significantly the samples ($P \leq 0.05$). Thus, the claims influenced consumers' acceptance in relation to flavor and overall liking. In the study of functional claim, consumers also differed samples regarding these two attributes.

TABLE 5. MEANS OF THE ATTRIBUTES OF ACCEPTANCE TEST WITH CHOCOLATE DAIRY DESSERT SAMPLES (9-CM UNSTRUCTURED LINE SCALE) (N=100)

Attributes	Samples					MDS
	1	2	3	4	5	
Appearance	7.31^{a}	7.79^{a}	7.62^{a}	7.51^{a}	7.58^{a}	0.59
Aroma	6.51^{a}	6.59^{a}	6.37^{a}	6.31^{a}	6.38^{a}	0.47
Flavor	6.97^{a}	8.01^{b}	7.80^{b}	7.64^{ab}	7.81^{b}	0.81
Texture	7.40^{a}	8.10^{a}	8.12^{a}	7.85^{a}	8.22^{a}	0.84
Overall liking	6.91^{a}	7.89^{b}	7.84^{b}	7.92^{b}	7.85^{b}	0.71

Means with a same superscript letter in the line are not significantly different at a 5% level.

1, creamy chocolate dairy dessert; 2, light creamy chocolate dairy dessert; 3, light creamy chocolate dairy dessert – reduction in calories and fat; 4, diet creamy chocolate dairy dessert; 5, diet creamy chocolate dairy dessert – no added sugar.

MDS, minimum significant difference in Tukey's test ($P \leq 0.05$).

Claims are designed to provide useful information to the consumer concerning the benefits of products and current legislation is designed to protect consumers from misleading and false information (Nocella and Kennedy 2012). Understanding what consumers know about the claims is very important because consumers' knowledge directly affects acceptance. 55% of consumers reported knowing the definition and difference between the terms diet and light, while 31% reported that they had consumed diet/light products but do not know the definition and difference between these terms.

Principal component analysis (PCA)

Different factors beyond sensorial characteristics have become influencing in consumer's food choice and their elucidation contributes to a better understanding of the dietary behavior and the search for a healthy status in food consumption (Saba *et al.* 2010; Carrillo *et al.* 2011).

The results of acceptance test were analyzed by principal component analysis (PCA). The preference map for overall liking (Fig. 7) indicated that the samples 3, 5, 2, and 4 received most of the high hedonic scores and that most consumers like these samples because of the overall liking. Fig. 7 also indicated that sample 1 was least preferred by consumers. These results show that consumers in relation to overall liking preferred chocolate dairy dessert samples with diet/light claims.

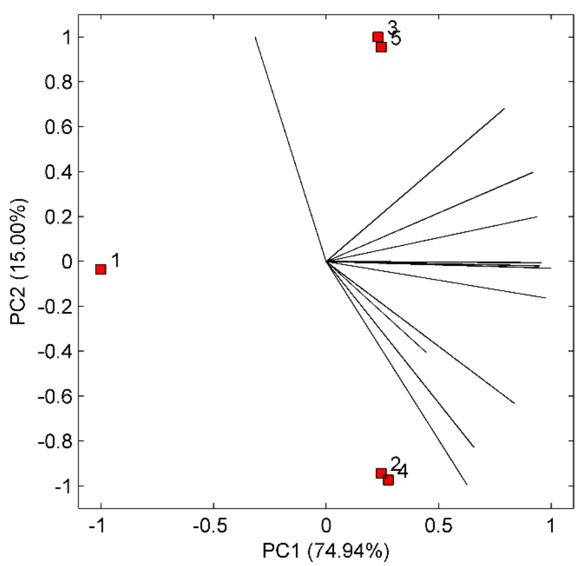


FIG. 7. BIPLOT OF PRINCIPAL COMPONENT ANALYSIS (PCA) FOR OVERALL LIKING OF CHOCOLATE DAIRY DESSERT SAMPLES.

The first contact between a consumer and a food product is the package, which is considered a tool to communicate messages about the product. In fact, packaging plays a major role in attracting consumer attention, as it is the most accessible marketing communication tool (Ares *et al.* 2010b; Carrillo *et al.* 2014). Fig. 8 confirms what was shown in Fig. 7. Sample 1 was the least preferred, indicating that consumers evaluated the other samples in a best way. Samples 2, 3, 4, and 5 received most of the high hedonic scores and most consumers preferred these samples in relation to appearance, aroma, and texture. These are very interesting results as marketing tool, since consumers best evaluated chocolate dairy dessert samples with diet/light claims.

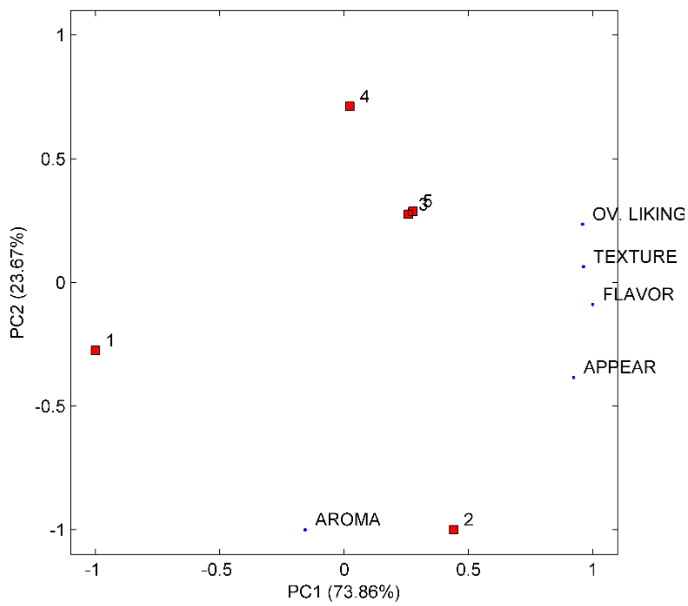


FIG. 8. BIPLOT OF PRINCIPAL COMPONENT ANALYSIS (PCA) FOR APPEARANCE, AROMA, FLAVOR, AND TEXTURE OF CHOCOLATE DAIRY DESSERT SAMPLES.

Three-way internal preference map – PARAFAC analysis

Data were organized as the PARAFAC realized by functional property claims, in a three-way array with dimensions of 5 x 4 x 100 referring to samples x attributes x consumers. To build the three-way internal preference map, PARAFAC models using from 1 to 4 factors were fitted in order to choose the adequate number of factors. The results are presented in

Table 6. The core consistence parameter indicates two factors to be used in accordance to this parameter (Nunes *et al.* 2011).

TABLE 6. PARALLEL FACTOR ANALYSIS MODEL PERFORMANCE FOR CHOCOLATE DAIRY DESSERTS ACCEPTANCE DATA

Factors	Explained variance (%)	Core consistence (%)
1	23.89	100
2	34.58	86.78
3	39.70	62.33
4	43.89	9.14

Fig. 9 shows the graph of the loadings in mode one (samples), loadings in mode two (sensory attributes), and loadings in mode three (consumers) plot, for the first two components.

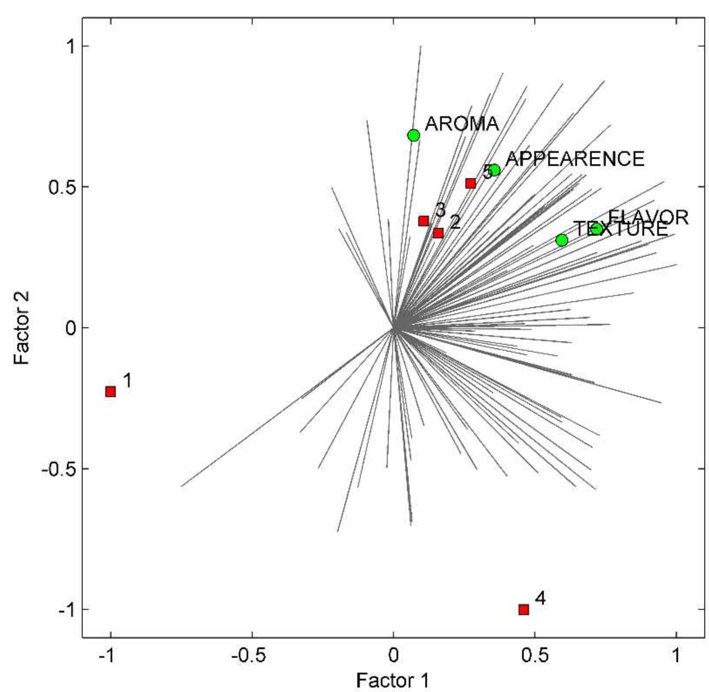


FIG. 9. THREE-WAY INTERNAL PREFERENCE MAP FOR APPEARANCE, AROMA, FLAVOR, AND TEXTURE FOR CHOCOLATE DAIRY DESSERTS.

The sample without the addition of diet/light claim (sample 1) show low acceptance by consumers receiving lower scores, and being less preferred in relation to the attributes of appearance, aroma, flavor, and texture. On the other hand, the samples 2, 3, and 5, which were with addition of diet/light claims and with the information of no added sugar, showed highly distinct acceptance as compared to the other samples, with respect to the degree of liking of appearance, aroma, flavor, and texture. Consumers similarly liked these three samples, which presented similar behavior, whereas the sample with no claim stood out from the others, as did the sample declaring the diet claim (sample 4). As observed in the analysis of functional property claims, all attributes evaluated were perceived in a similar way by the consumers, since all of them were allocated in the same region of the graph.

Occasionally, food legislation regarding labelling and allowed claims may differ depending on the country in which food products are commercialized and these regulatory standards must be rigorously obeyed for international trade purposes (Komatsu *et al.* 2013). For a final commercialization of a reduced-fat and -calorie dairy dessert, these new features can be explored, mainly regarding advantageous changes on consumers' perception of diet/light claims, besides the potential nutrition claims.

Trying to get the consumers to imagine how the product could be is a challenge (Carrillo *et al.* 2014). If their perception is favourable, the message could enhance their expectations and influence their initial choice (Ares *et al*. 2010b). In this way, the diet/light claims may contribute to a higher acceptance by consumers of chocolate dairy desserts.

CONCLUSIONS

The regular internal preference map provided information regarding the preferred samples separately for each attribute, indicating the influence of functional claim in each attribute. The three-way evaluation evidenced the globally acceptance of samples and enabled a comparison of the overall performance of the samples in the acceptance test, indicating that consumers evaluated claims differently. Samples with the addition of prebiotic claim and declaring the functional property of prebiotics were preferred. As the samples with the addition of diet/light claims, which received highest scores.

Future studies should compare data from consumer acceptability test with more demographic data to specify the market segment that will best meet. The addition of claims may be suitable to be used in a chocolate dairy dessert with high acceptance by consumers who appreciate this product. These results are very useful for dairy processors who wish to participate for the competitive market of functional and diet/light foods.

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CONCLUSÃO GERAL

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A adição de prebióticos e a substituição total de sacarose por edulcorantes, em sobremesa láctea cremosa sabor chocolate, propicia a obtenção de um produto com qualidade sensorial.

Por meio da avaliação físico-química, da composição centesimal e dos testes sensoriais, é possível concluir que a adição de prebióticos e edulcorantes, em sobremesas lácteas, é um segmento promissor para as indústrias lácteas, funcionais e dietéticas. Foram obtidas sobremesas lácteas cremosas sabor chocolate "diet" em relação ao açúcar e "light" em relação ao teor de lipídeos e calorias. A adição de prebióticos agrega características funcionais às sobremesas propiciando efeitos benéficos à saúde dos consumidores. A avaliação sensorial mostrou que estas sobremesas obtiveram boa aceitação em relação à aparência, aroma, sabor, textura e impressão global.

SUGESTÕES PARA TRABALHOS FUTUROS

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A determinação do potencial prebiótico das sobremesas pode mostrar a quantidade de prebiótico disponível no produto final, para avaliar se houve algum tipo de perda durante processamento.

O estudo da utilização de *blend*s de edulcorantes seria interessante, principalmente na utilização da estévia, que é um adoçante natural, no entanto apresentou gosto residual amargo.

Testes com dados sócio-demográficos mais abrangentes podem ser realizados para determinar o segmento de mercado consumidor de sobremesas lácteas prebióticas com substituição de açúcar por edulcorantes.

A determinação da vida de prateleira das sobremesas também seria de grande interesse, em função das mesmas serem consideradas como produtos de média vida de prateleira.

A utilização de prebióticos e edulcorantes em sobremesas lácteas apresentou resultados satisfatórios, sendo interessante suas aplicações em diferentes matrizes alimentares.