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TESE

Estratégias para redução de açúcar de alimentos industrializados destinados ao público infantil

Mayara Freitas Lima

2019

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PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIA E TECNOLOGIA DE ALIMENTOS

ESTRATÉGIAS PARA REDUÇÃO DE AÇÚCAR DE ALIMENTOS INDUSTRIALIZADOS DESTINADOS AO PÚBLICO INFANTIL

MAYARA FREITAS LIMA

Sob a orientação de **Rosires Deliza**

e co-orientação de **Gastón Ares**

Tese submetida como requisito parcial para obtenção do grau de **Doutora em Ciência e Tecnologia de Alimentos**, no Programa de Pós-Graduação em Ciência e Tecnologia de Alimentos, Área de Concentração Ciência de Alimentos.

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TESE APROVADA EM 19/03/2019

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‘‘Por vezes sentimos que aquilo que fazemos não é senão uma gota na água do mar. Mas o mar seria menor se lhe faltasse uma gota.’’

Madre Teresa de Calcutá

BIOGRAFIA

Mayara Freitas Lima, filha de Luzia Valentim Freitas Lima e Fernando de Oliveira Lima, nascida no dia 04 de março de 1990 na cidade do Rio de Janeiro/ RJ. No ano de 2013 graduou-se Bacharel em Nutrição pela Universidade Federal do Estado do Rio de Janeiro – UNIRIO. Durante a graduação foi monitora da disciplina de bromatologia, bolsista de Iniciação Científica pelas instituições FAPERJ e CNPq, onde desenvolveu atividades nos laboratórios de Análise Sensorial e Instrumental - Embrapa Agroindústria de Alimentos e Bioquímica de Alimentos - UNIRIO. Em 2015 concluiu o curso de Mestrado em Ciência e Tecnologia de Alimentos no Programa de Pós-Graduação em Ciência e Tecnologia de Alimentos pela Universidade Federal Rural do Rio de Janeiro – UFRRJ. No mesmo ano ingressou no curso de Doutorado em Ciência e Tecnologia de Alimentos na mesma instituição, desenvolvendo a parte experimental na Embrapa Agroindústria de Alimentos, e em escolas públicas e privadas do Rio de Janeiro/RJ e Rio Pomba/MG. No ano de 2017 foi aprovada no concurso para professor substituto na área de Ciência de Alimentos da faculdade de Nutrição da Universidade Federal Fluminense, onde trabalha atualmente.

RESUMO

LIMA, Mayara Freitas. **Estratégias para redução de açúcar de alimentos industrializados destinados ao público infantil.** 2019. 141p. Tese (Doutorado em Ciência e Tecnologia de Alimentos). Instituto de Tecnologia. Departamento de Tecnologia dos Alimentos, Universidade Federal Rural do Rio de Janeiro, Seropédica, Rio de Janeiro, RJ, 2019.

A obesidade é um dos maiores problemas de saúde pública atual e tem afetado as crianças de maneira expressiva. A obesidade infantil acarreta consequências como o aumento do risco de desenvolvimento de doenças crônicas durante a adolescência e vida adulta. Um dos fatores fortemente associados ao ganho de peso em crianças é o consumo excessivo de açúcar decorrente da elevada ingestão de produtos com apelo infantil, os quais apresentam alto teor energético e baixo valor nutricional. As bebidas açúcaradas (bebidas de fruta, refrigerantes) são apontadas como a principal fonte de açúcar consumida pelas crianças. Nesse sentido, diversas políticas públicas tem sido propostas para a redução do consumo de açúcar. O objetivo da tese foi avaliar o efeito da inclusão da rotulagem nutricional frontal (FOP) e da reformulação de alimentos como estratégias para a redução do consumo de açúcar pelo público infantil. Para tal, cinco estudos foram realizados no período entre outubro/2016 e abril/2018 com crianças na faixa etária de 6-12 anos, sendo que em três destes estudos houve a participação de adultos. Todos os estudos foram aprovados pelo comitê de ética em pesquisa (*Plataforma Brasil - CAAE 55023416.0.0000.5285*). Os dois primeiros estudos avaliaram a inclusão de modelos FOP (modelo não diretivo: valor diário (VD%), semi-diretivo: semáforo nutricional (SN) e diretivo: alertas nutricionais) como estratégia para reduzir a percepção de saudabilidade e modificar a resposta emocional em relação aos alimentos não saudáveis. Os estudos 3 e 4 avaliaram a reformulação de alimentos (redução de açúcar) como estratégia para reduzir o consumo de açúcar pelo público infantil, a partir da determinação do limiar de redução e da comparação da resposta hedônica e sensorial de crianças em relação às bebidas reduzidas em açúcar por diferentes métodos (redução gradual e sequencial). O último estudo, avaliou o efeito combinado da inclusão de modelos FOP e da redução do teor de açúcar na escolha de alimentos sob diferentes condições experimentais. Os resultados mostraram que para os pais, os alimentos contendo alertas nutricionais foram classificados como menos saudáveis ($p<0.05$). Já entre as crianças, os diferentes modelos FOP apresentaram efeito limitado na percepção de saudabilidade e da resposta emocional. No entanto, os modelos diretivo e semi-diretivo apresentaram efeito superior ao não diretivo (VD%) em ambos os estudos. Os resultados da determinação do limiar de redução de açúcar revelaram que as crianças tiveram menor sensibilidade às modificações nas concentrações de açúcar do que os adultos. A redução gradual foi a estratégia de reformulação mais adequada, pois causou menor modificação na percepção hedônica e sensorial das crianças, sugerindo que esta é uma política viável para a redução do consumo de açúcar. Em relação à avaliação do efeito combinado da redução de açúcar e da inclusão de modelos FOP, os resultados indicaram que os alertas nutricionais apresentaram maior efeito na expectativa de adultos e crianças em relação à seleção dos produtos; porém, durante o consumo, o sabor teve papel determinante na escolha dos participantes do estudo. A baixa escolha dos produtos com maiores níveis de redução de açúcar sugere que a combinação da redução gradual de açúcar e a inclusão dos alertas nutricionais pode ser a estratégia adequada, uma vez que são ações complementares. A inclusão de modelos FOP diretivos facilitaria a identificação de alimentos não saudáveis por crianças e adultos e a redução gradual de açúcar diminuiria o teor de açúcar dos produtos

disponíveis no mercado, contribuindo para a redução do consumo e modificação dos hábitos alimentares da população a longo prazo**.**

Palavras-chave: crianças; redução de açúcar, rotulagem nutricional frontal; reformulação de alimentos

ABSTRACT

LIMA, Mayara Freitas. **Sugar reduction strategies for food targeted at children.** 2019. 141p. Thesis (PhD in Food Science and Technology). Technology Institute. Department of Food Technology, Federal Rural University of Rio de Janeiro, Seropédica, Rio de Janeiro, 2019.

Obesity is one of the biggest public health problems nowadays and has expressively affected children. Childhood obesity has several consequences, including an increased risk of chronic diseases development during adolescence and adulthood. One of the factors strongly associated with weight gain in children is the excessive sugar ingestion due to the high consumption of products target at children, which present high energy content and low nutritional value. Sugary drinks (fruit drinks, soft drinks) are pointed out as the main source of sugar consumed by children. In this sense, several public policies have been proposed to reduce sugar consumption. The aim of this thesis was to evaluate the effect of the front of pack (FOP) labeling schemes and the food reformulation as strategies for reducing the consumption of sugar by children. For that, five studies were carried out between October/2016 and April/2018, with 6-12 years old children, and in three of them adults were also involved. All the studies were approved by the Brazilian Committee of Ethics in Research (*Plataforma Brasil - CAAE 55023416.0.0000.5285*). The first two studies evaluated the inclusion of FOP schemes (non-directive scheme: guideline daily amounts (GDA), semi-directive: traffic light system (TLS) and directive: nutritional warnings) as a strategy to reduce the healthfulness perception and modify positive emotional response related to unhealthy foods. The studies 3 and 4 evaluated the food reformulation (sugar reduction) as a strategy to reduce children sugar consumption, by determining the sugar reduction threshold and comparing children hedonic and sensory perception on sugar reduced drinks using different methods (gradual and sequential reduction). The last study evaluated the combined effect of FOP schemes and sugar reduction on children and adults' food choice under different experimental conditions. The results revealed that for parents, food products containing nutritional warnings were significantly classified as less healthy. On the other hand, FOP schemes had a limited effect on the children healthfulness perception and the emotional response. However, the directive and semi-directive FOP schemes had higher effect compared to the non-directive (GDA) in both studies. The results of the sugar reduction threshold determination showed that children were less sensitive to changes in sugar concentrations than adults. The gradual reduction was the most appropriate reformulation strategy because it caused less changes in children' hedonic and sensory perception, suggesting that this is a viable policy for reducing sugar consumption. Taking into account the combined effect of sugar reduction and FOP schemes, the results indicated that nutritional warnings had a higher effect on children and adults' expectation; however, after tasting the product, the flavor was determinant for the product choice. The low choice of products with higher levels of sugar reduction suggests the combination of gradual sugar reduction and the nutritional warnings as appropriate strategy, because they are complementary actions. The inclusion of directive FOP schemes would facilitate the identification of unhealthy foods by children and adults, and the gradual reduction of sugar would reduce the sugar content of products available in the market, contributing to the reduction of consumption, and modification of the population food habits in long-term.

Keywords: children; sugar reduction; front of pack nutritional schemes; food reformulation

SUMÁRIO

INTRODUÇÃO

A obesidade é um dos maiores problemas de saúde pública atual. Há duas décadas, a taxa de obesidade tem sido maior e mais rápida entre as crianças comparada à população adulta (LOBSTEIN, BAUR, & UAUY, 2004; ALLMAN-FARINELLI, 2008; HEBDEN, 2012). Estima-se que até o ano de 2025 o número de crianças com excesso de peso em todo o mundo aumentará para 70 milhões, caso medidas preventivas e de controle não sejam tomadas (WHO, 2015). No Brasil, dados da última pesquisa de orçamentos familiares indicou um aumento de cerca de 600% na incidência de obesidade em crianças entre o período de 1974 até 2009 (IBGE, 2009a). A obesidade infantil acarreta consequências como o risco aumentado no desenvolvimento de diversas doenças crônicas a na adolescência e vida adulta (WHO, 2016).

Apesar de sua origem multifatorial, os hábitos alimentares, cujo desenvolvimento envolve complexa interação de fatores genéticos, familiares e ambientais, têm sido apontados como fator determinante para o ganho de peso (NIELSEN, SIEGA-RIZ & POPKIN, 2010) sendo as preferências alimentares um dos principais fatores (PRENTICE & JEBB, 2004; SWINBURN et al., 1999). Nesse contexto, a introdução precoce de alimentos altamente calóricos e pobres em nutrientes e a exposição pelo marketing estão fortemente associados com a preferência por produtos não saudáveis (CAIRNS et al., 2013; MAZZONETO & FIATES, 2014). Os alimentos destinados ao público infantil são atrativos, uma vez que apresentam diversos apelos nas embalagens que estimulam o consumo. No entanto, a maioria deles possui baixa qualidade nutricional, pois apresentam excesso de açúcar, sódio e/ou gordura (ELIOTT, 2007; FERREIRA et al., 2015; GIMÉNEZ et al., 2017; HARYANTO, MOUTINHO & COELHO, 2016).

O consumo excessivo de açúcar tem sido identificado como a principal causa para o aumento na incidência de doenças crônicas como a diabetes, e pelo aumento da ingestão calórica, que é o principal fator dietético associado à obesidade em crianças (AMBROSINI et al, 2016; MALHOTRA, 2013). Tal fato é preocupante, uma vez que os alimentos ricos em açúcar apresentam grande aceitação pelos consumidores infantis. No entanto, ao avaliar o consumo de açúcar, deve-se levar em consideração que a ingestão em sua maioria está vinculada aos alimentos que contém açúcares adicionados, ou seja, produtos cuja adição é realizada durante as etapas de processamento ou preparação (JOHNSON et al., 2009; REEDY & KREBS-SMITH, 2010). Dados da Organização Mundial de Saúde revelam que o consumo de açúcar adicionado não deve ultrapassar 10% do total da ingestão calórica diária. Porém, essa ingestão é facilmente superada por adultos e crianças (WHO, 2015). As bebidas açucaradas representam uma das principais fontes de açúcar da dieta infantil (MALIK et al., 2013) e, devido à alta correlação com o ganho de peso e obesidade em crianças, tornou-se alvo de políticas públicas e interesse científico (OKUBO et al., 2016).

Com o objetivo de incentivar a redução do consumo de açúcar pela população, várias políticas públicas tem sido propostas como os regulamentos de mercado, restrições de publicidade e marketing, incentivos econômicos positivos e negativos (diferenciações tributárias) de acordo com a qualidade nutricional dos produtos comercializados, a reformulação de alimentos e medidas para incentivar as pessoas a fazerem escolhas alimentares mais conscientes, como a inclusão de informações simplificadas nos rótulos dos produtos (CAPACCI et al., 2012; SCRINIS & PARKER,2016). A presente tese enfoca duas destas políticas: a reformulação de alimentos (redução no teor de açúcar) e a inclusão de rotulagem nutricional frontal.

A redução do teor de açúcares adicionados tem sido apontada como uma das estratégias de melhor custo-benefício para a rápida redução do consumo de açúcar pela população (MacGREGOR & HASHEM, 2014). No entanto, o principal desafio para reduzir o açúcar em produtos processados está relacionado às mudanças no sabor e textura dos produtos, os quais são determinantes para a aceitação (VAN RAAIJ, HENDRIKSEN, &

VERHAGEN, 2009). Este aspecto é ainda mais importante quando o público alvo são as crianças, uma vez que apresentam maior preferência pelo gosto doce (VENTURA & MENELLA, 2011). Reduções graduais de açúcar geralmente não são percebidas pelos consumidores e podem modificar o consumo deste nutriente, sem que mudanças nas escolhas alimentares sejam realizadas (VAN RAAIJ, HENDRIKSEN, & VERHAGEN 2009; MacGREGOR &HASHEM, 2014).

A veiculação de informações sobre o conteúdo dos nutrientes é outra estratégia que, se adequadamente implementada, pode incentivar os consumidores a ingerir produtos com menor teor de açúcar (CAPACCI et al., 2012). A inclusão de informação nutricional nos rótulos de alimentos tem sido considerada uma das políticas públicas mais importantes para as escolhas alimentares saudáveis (GRUNERT & WILLS,2007). Diversos modelos de rotulagem nutricional frontal (FOP) tem sido propostos, os quais apresentam diferenças em relação ao grau em que direcionam os consumidores a avaliar as características nutricionais dos alimentos (HODGKINS et al., 2012). Os modelos diretivos, apresentam informações simplificadas, que facilitam a avaliação da saudabilidade dos produtos, podendo ser baseados em nutrientes específicos ou no produto como um todo (VAN KLEEF & DAGEVOS,2015) tendo sido considerados mais eficientes para encorajar escolhas mais saudáveis do que os modelos não diretivos e semi- diretivos, como o tradicional valor diário (VD%) e semáforo nutricional (SN), respectivamente (ARRÚA et al., 2017a; ARRÚA, et al., 2017b; DUCROT et al., 2016; JULIA et al., 2016; MHURCHU et al., 2017). Apesar de amplamente investigados, ainda não há um consenso sobre qual dos modelos FOP é o mais adequado para a população brasileira, e estudos avaliando o seu efeito junto ao público infantil ainda são limitados.

A presente Tese teve como objetivo geral investigar o efeito de duas estratégias para a redução do consumo de açúcar pelo público infantil: a rotulagem nutricional frontal e a reformulação de alimentos. Os objetivos específicos foram:

- Avaliar a influência do valor diário (VD%), semáforo nutricional (SN) e dos alertas nutricionais sobre a percepção de crianças e seus responsáveis em relação à qualidade nutricional dos alimentos;
- Avaliar o potencial do VD%, SN e dos alertas nutricionais em modificar a resposta emocional positiva de crianças em relação aos alimentos não saudáveis;
- Determinar o limiar de redução (%) de açúcar de crianças e adultos.
- Comparar estratégias de redução gradual e sequencial de açúcar em relação à aceitação e percepção sensorial em néctar de fruta;
- Avaliar o efeito combinado da inclusão de um modelo de rotulagem nutricional frontal e da reformulação de alimentos (redução de açúcar) na escolha de bebidas por adultos e crianças.

APRESENTAÇÃO DA TESE

O preocupante aumento da obesidade entre crianças, influenciado pelo consumo excessivo de açúcar gerou a necessidade de buscar alternativas para reduzir a ingestão de açúcar pelo público infantil. Em função disto, cinco estudos foram desenvolvidos para investigar o efeito de duas estratégias visando a redução do consumo de açúcar pelo público infantil, a saber: a inclusão de modelos de rotulagem nutricional frontal em produtos destinados às crianças e a reformulação de alimentos. Além da parte experimental, a revisão bibliográfica compôs a tese e foi fundamental para discutir aspectos importantes relacionados ao tema. A descrição do trabalho desenvolvido e das publicações geradas é apresentada a seguir.

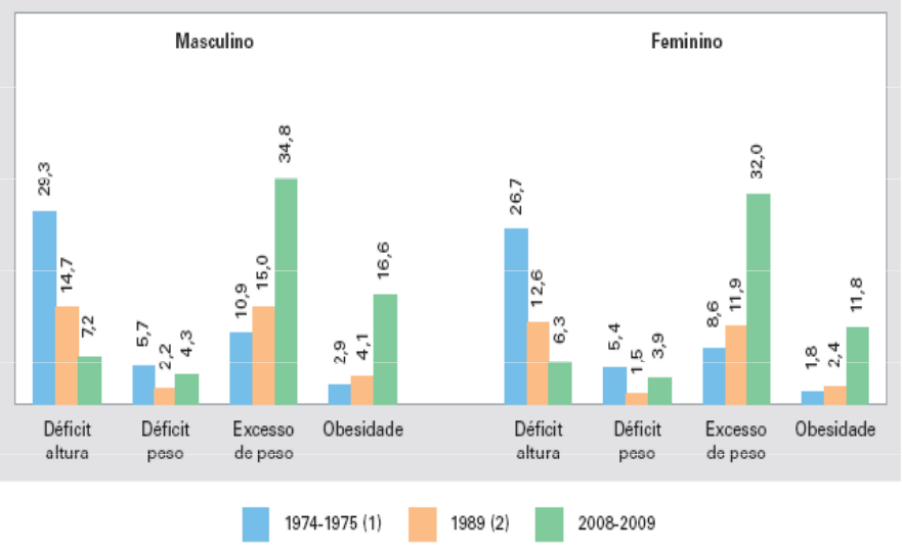
Capítulo	Tema	Periódico	Situação
-	**Revisão Bibliográfica** Contempla uma revisão sobre obesidade infantil, hábitos alimentares infantis, consumo de açúcar e políticas públicas voltadas para a redução de açúcar. Também aborda as duas estratégias a serem avaliadas na tese: A reformulação de alimentos e a rotulagem nutricional frontal.	-	-
I	**Como diferentes tipos de rotulagem nutricional frontal afetam a percepção de saudabilidade de alimentos destinados ao público infantil? Estudo com crianças e pais brasileiros.** *How do front of pack nutrition labels affect healthfulness perception of foods targeted at children? Insights from Brazilian children and parents.* Estudo realizado para avaliar como três tipos de rotulagem nutricional frontal (VD%, SN e alertas) afetam a percepção de saudabilidade por pais e crianças em relação aos alimentos destinados ao público infantil, os quais em sua maioria apresentam teor excessivo de açúcar, sódio e/ou gorduras.	*Food Quality and Preference*	Publicado
II	**Modelos de rotulagem nutricional frontal podem modificar as associações emocionais de crianças em relação a produtos alimentícios não saudáveis? Um experimento com *emoji*.** *Can front-of-pack nutrition labelling modify children's emotional associations with unhealthy food products? Na experiment using emoji.* Utilizando os mesmos modelos de rotulagem nutricional frontal (VD%, SN e alertas) e alguns dos produtos avaliados no Capítulo I, foi realizado um estudo para avaliar o efeito destas rotulagens na resposta emocional de crianças. *Emoji*s foram utilizados como ferramentas para investigar as associações emocionais.	*Food Research International*	Publicado
III	**Percepção hedônica e sensorial de adultos e crianças sobre redução de açúcar adicionado em néctar de uva.** *Children and adults' sensory and hedonic perception of added sugar reduction in grape nectar* Estudo realizado para determinar o limiar de redução de açúcar de adultos e crianças em néctar de uva. A partir dos resultados deste estudo, foi possível propor as estratégias de redução de açúcar	*Journal of Sensory Studies*	Publicado

	avaliadas no Capítulo IV.		
IV	**Comparação de duas estratégias de redução de açúcar com crianças: Estudo de caso com néctar de uva.** *Comparison of two sugar reduction strategies with children: Case study with grape nectars* Estudo realizado para avaliar o efeito da estratégia de redução de açúcar (gradual vs. sequencial) na aceitação e percepção sensorial de néctar de uva por crianças.	*Food Quality and Preference*	Publicado
V	**Não é somente informação! A experiência sensorial sobrepõe o impacto da informação nutricional na escolha de bebidas com redução de açúcar pelos consumidores.** *It is not all about information! Sensory experience overrides the impact of nutrition information on consumers' choice of sugar-reduced drinks* Este estudo avaliou o efeito combinado da inclusão de rotulagem nutricional frontal (SN e alertas) e da redução de açúcar na escolha de bebidas sob diferentes condições experimentais. Os tipos de rotulagem e as concentrações de açúcar utilizadas no estudo foram selecionadas a partir dos resultados encontrados nos Capítulos anteriores.	*Food Quality and Preference*	Publicado

REVISÃO BIBLIOGRÁFICA

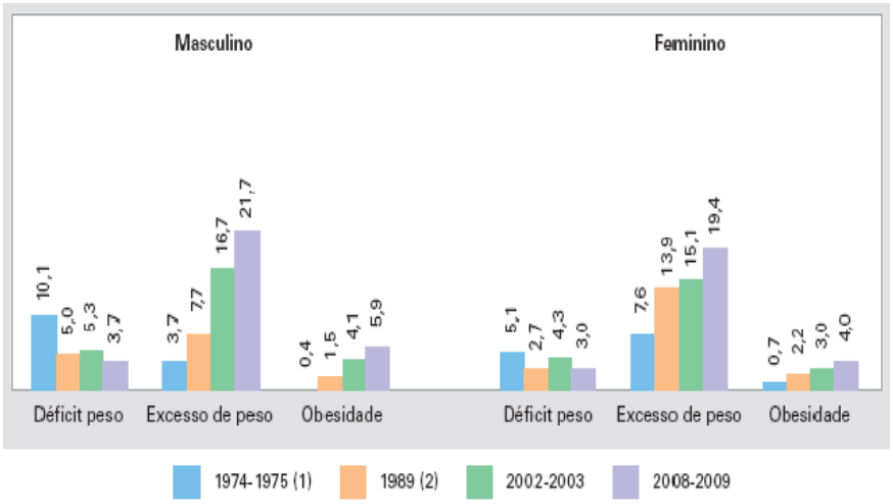
1. OBESIDADE INFANTIL

A obesidade é considerada um dos maiores problemas de saúde pública atual. O número de crianças e adolescentes (5-19 anos) obesos em todo o mundo aumentou dez vezes nas últimas quatro décadas, atingindo atualmente cerca de 124 milhões de crianças e adolescentes. Se as tendências atuais continuarem, em 2022 haverá mais crianças e adolescentes com obesidade do que com desnutrição moderada e grave (NCD RISK FACTOR COLLABORATION, 2017). A prevalência de obesidade é drasticamente superior na população de países desenvolvidos, mas têm crescido significativamente nos países subdesenvolvidos (LOBSTEIN, BAUR, & UAUY, 2004; POPKIN, ADAIR & NG, 2012). O Brasil tem apresentado comportamento semelhante. A obesidade infantil aumentou 600% nos últimos 40 anos e os estudos indicam que aproximadamente 30% das crianças estão acima do peso ou obesas (FRADKIN & YUNES, 2014). Dados da última Pesquisa de Orçamentos Familiares (POF) realizada no Brasil indicaram que entre 1974 até 2009 houve um aumento de cerca de 600% e 650% para meninos e meninas obesos entre 5-9 anos de idade, respectivamente (Figura 1). Na faixa etária de 10- 19 anos esse aumento foi menor, mas ainda sim expressivo (IBGE, 2009) (Figura 2). Estima-se que se os padrões atuais se mantiverem, no ano de 2025 o Brasil terá aproximadamente 11,3 milhões de crianças obesas (NCD RISK FACTOR COLLABORATION, 2017).



Fonte: Pesquisa de Orçamentos Familiares – IBGE (2009).

Figura 1. Evolução dos indicadores antropométricos na população de 5- 9 anos de idade, por gênero – Brasil – Períodos 1974-1975, 1989 e 2008-2009.



Fonte: Pesquisa de Orçamentos Familiares –IBGE(2009).

Figura 2. Evolução dos indicadores antropométricos na população de 10- 19 anos de idade, por gênero – Brasil – Períodos 1974-1975, 1989, 2002-2003 e 2008-2009.

A obesidade infantil aumenta significativamente a incidência de diversas doenças na adolescência e vida adulta (WHO, 2016). Crianças obesas estão mais propensas ao desenvolvimento de distúrbios cardiovasculares (colesterol elevado, hipertensão arterial sistêmica, infarto, acidente vascular encefálico), endócrinos (hiperinsulinemia, diabetes tipo II) e câncer durante a infância e no futuro (FREEDMAN et al., 2007). As doenças crônicas têm repercussão na economia da maioria dos países, sendo a principal fonte de custo da saúde pública (WHO, 2013). Estima-se durante o período de 2011- 2025, os sistemas de saúde dos países de baixa e média renda terão custos de cerca de 7 trilhões de dólares com doenças crônicas (ABEGUNDE et al., 2007). No Brasil, estima-se que esses gastos totalizam 69% da verba destinada ao sistema único de saúde (MINISTÉRIO DA SAÚDE, 2005).

Além do comprometimento físico, a obesidade tem demonstrado afetar negativamente a qualidade de vida e o desempenho escolar (NEUMARK-SZTAINER, 1997; WILLIAMS et al., 2005), aumentando o risco de depressão (SJOBERG, NILSSON & LEPPERT, 2005) e baixa autoestima (STRAUSS, 2000). Dessa forma, ações de prevenção e reversão do excesso de peso infantil são essenciais para a melhoria da qualidade de vida da população.

De acordo com a Organização Mundial da Saúde, a obesidade pode ser definida como o acúmulo excessivo de gordura a qual representa um risco a saúde (WHO, 2012). Embora a obesidade seja determinada pela interação complexa de genética, fatores socioeconômicos, comportamentais, ambientais e culturais, os hábitos alimentares são identificados como um dos principais contribuintes para o crescimento global na prevalência de obesidade (PRENTICE & JEBB, 2004; SWINBURN et al., 2011).

2. HÁBITOS ALIMENTARES INFANTIS

Hábitos alimentares inadequados representam uma das maiores causas da epidemia de obesidade e aumento das doenças crônicas (WORLD CANCER RESEARCH FUNDATION, 2014). O comportamento alimentar adquirido na infância, na maioria das vezes persiste durante a vida adulta (HUIZINGA & KRUSE, 2016; BIRCH & DOUB, 2014; COOKE,

2007).

No Brasil, os dados comparativos das POFs dos anos de 2002/03 e 2008/09 sobre a disponibilidade domiciliar de alimentos indicaram mudanças nos hábitos alimentares, os quais estão associados ao ganho de peso e o desenvolvimento de doenças em todas as faixas de renda, inclusive entre os mais pobres. O padrão de consumo de alimentos brasileiros combina uma dieta tradicional, baseada no arroz e feijão, com alimentos pobres em nutrientes e de alto teor calórico, aliados ao aumento do consumo de refrescos, refrigerantes e a um baixo consumo de frutas, verduras e legumes. Como resultado, existe uma elevada prevalência de consumo excessivo de açúcares e gordura saturada (61% e 82%, respectivamente) (IBGE, 2009).

Entre as crianças, esse consumo apresenta um comportamento semelhante. Hinnig & Bergamaschi (2012) avaliaram o consumo alimentar de escolares entre 7 e 10 anos e verificaram que os alimentos como arroz e feijão contribuíram de forma importante para o consumo de carboidratos, e que o leite foi uma das principais fontes de proteínas e gorduras, contribuindo significativamente para o consumo energético deste grupo. No entanto, a participação de alimentos não saudáveis como refrigerantes, refrescos, sucos industrializados e sobremesas foi muito elevada, representando cerca de 17% do total de carboidratos consumidos diariamente. Cadamuro et al. (2017) relataram que 66% das crianças brasileiras de baixo nível socioeconômico consumiram alimentos não saudáveis com frequência superior a três vezes por semana, contra 22% das crianças de alto nível socioeconômico, sugerindo que as mais pobres apresentam maior risco para o ganho de peso e obesidade. Nesse sentido, avaliar os fatores que influenciam os hábitos alimentares pode contribuir para o desenvolvimento de ações efetivas para a melhoria da alimentação infantil.

2.1. FATORES QUE INFLUENCIAM AS ESCOLHAS ALIMENTARES INFANTIS

A formação dos hábitos de alimentares infantis é um processo complexo, influenciado por fatores intrínsecos e extrínsecos (BIRCH & FISHER, 1997). Entre os pré-escolares, as preferências alimentares possuem papel fundamental no consumo de alimentos e qualidade da dieta (RAMOS & STEIN, 2000), uma vez que a seleção de alimentos nesta fase é basicamente guiada pelas propriedades do alimento, no qual destacam-se a densidade energética e atributos sensoriais (GIBSON & WARDLE, 2003; ROSE et al., 2004). No entanto, apesar de alguns aspectos das preferências alimentares serem inatos, como a preferência pelo gosto doce (VENTURA & MENNELLA, 2011), a introdução precoce de alimentos altamente energéticos e pobres em nutrientes também contribui para sua incorporação na alimentação diária (MAZZONETO; FIATES, 2014). O sabor, em particular é um item determinante para a seleção de alimentos. Crianças gostam do que é intensamente doce e rejeitam os amargos, com isso preferem consumir alimentos mais açucarados que, em geral, excedem a quantidade de açúcar recomendada (ANLIKER et al., 1991; NGUYEN, GIRGIS & ROBINSON, 2015).

As preferências alimentares, apesar de inatas, podem ser modificadas e aprendidas ao longo do tempo (HAWKES et al., 2015). Entretanto, na infância o contexto familiar torna-se a principal influência na alimentação, uma vez que os hábitos alimentares dos pais e familiares afetam diretamente o fornecimento e a disponibilidade de alimentos na residência. Desta forma, suas práticas podem propiciar ou impedir o desenvolvimento de hábitos alimentares saudáveis (KRAL & FAITH, 2009; SAVAGE, FISHER & BIRCH, 2007). Estudos sugerem que a abordagem e nível de controle que os pais impõem na alimentação das crianças

interferem diretamente no peso e na qualidade da alimentação na vida adulta. Este comportamento também pode ser afetado de maneiras distintas entre famílias de acordo com sua raça/ etnia, estado nutricional e status socioeconômico (DAVISON & BIRCH, 2002; KASEMSUP &REICKS, 2006; POWERS et al., 2006; SPRUIJT-METZ et al., 2006).

Um estudo comparativo entre as décadas de 1990 e 2000 verificou que após um aumento progressivo da obesidade entre crianças e adolescentes de famílias com elevado nível socioeconômico, a prevalência de obesidade diminuiu. O comportamento oposto foi observado entre as famílias de baixo nível socioeconômico, o que em parte pode estar relacionado com o aumento do acesso aos alimentos industrializados de baixo valor nutricional. O estudo também relatou que o aumento da escolaridade dos pais reduziu a prevalência de obesidade, aumentou a prática de atividades físicas e cuidados com a alimentação (FREDERICK et al., 2014). O preço dos alimentos também tem grande impacto na seleção e consumo de alimentos dos pais e, consequentemente, das crianças podendo dificultar o acesso à alimentação saudável (MOORE *et al*., 2009). Resultados de grupos focais com mães de baixo nível socioeconômico relatados por Machín et al. (2016) revelaram que as escolhas de alimentos para seus filhos foram influenciadas primeiramente pelo preço, seguido pelo nível de saciedade dos alimentos e preferências infantis. Nesse contexto, a presença de ambientes obesogênicos em comunidades, cidades, escolas e áreas de lazer também facilitam o consumo excessivo de alimentos energéticos e pobres em nutrientes, tornando difícil o acesso aos alimentos saudáveis (KELLY et al., 2019).

A publicidade e o *marketing* também afetam as escolhas e hábitos alimentares de crianças, pois despertam o interesse em consumir alimentos não saudáveis decorrentes da criação de associações emocionais familiares e positivas (CAIRNS et al., 2013; MCGINNIS et al., 2006). A televisão é um dos principais meios de exposição da publicidade de alimentos para o público infantil, e a alta frequência de comerciais exerce efeito direto nas preferências alimentares e no comportamento de compra deste grupo (FIATES, AMBONI & TEIXEIRA, 2008). Crianças que habitualmente assistem mais televisão demonstraram maior preferência por alimentos após a exposição na publicidade (BOYLAND & HALFORD, 2007), preferindo o sabor dos alimentos e de bebidas de marcas conhecidas aos produtos mais simples, e essas preferências em geral persistem durante a vida adulta (LETONA et al., 2014; ROBINSON et al., 2007) A internet e as mídias sociais são um fenômeno relativamente recente; no entanto, rapidamente tornaram-se um dos maiores alvos do marketing de alimentos, principalmente no que se refere à população infantil. Além da influência da televisão e dos demais meios de comunicação, as embalagens de alimentos tem relevante papel nas escolhas alimentares infantis (PIEDRAS, 2013), aumentando o interesse da indústria em desenvolver produtos específicos para esse público. Com o objetivo de controlar a publicidade de alimentos não saudáveis, foi aprovada a RDC nº 24/2010, que determinou o uso de linguagem direta para evidenciar o caráter promocional da publicidade; a indicação da presença de nutrientes que, em grande quantidade, aumentam os riscos de obesidade e de doenças do coração; e a necessidade de contextualizar o alerta de riscos à saúde na propaganda. No entanto, esta resolução foi suspensa desde setembro do mesmo ano por liminar da Justiça Federal de Brasília, a pedido da Associação Brasileira das Indústrias da Alimentação (ABIA), que questionou a competência da Anvisa para regulamentar a questão. Diversas entidades realizam movimentos com o objetivo de aprovar leis que controlem a publicidade voltada para o público infantil.

O ambiente escolar é apontado como uma importante influência na alimentação infantil (FAO, 2016; WESCHILER et al., 2000). Nesse sentido, estudos mostram que as escolas públicas brasileiras podem contribuir positivamente para a melhoria dos hábitos alimentares infantis, uma vez que os alunos têm acesso às refeições gratuitas durante o período escolar (TAROSSI et al., 2018). Tal oferta é viabilizada pelo Programa Nacional de

Alimentação Escolar (PNAE), que teve início em na década de 1950, e tem como objetivo promover hábitos alimentares saudáveis entre os alunos, além de melhorar o desenvolvimento e desempenho escolar (BRASIL, 2009). O PNAE oferece pelo menos uma refeição diária por aluno durante o período de aulas. O efeito positivo está associado às diretrizes do PNAE, que valorizam as refeições preparadas com alimentos naturais ou minimamente processados e evitam produtos, como bebidas açucaradas, salsichas e carne processada (SOUSA *et al*, 2015). Dessa forma, ações complementares àquelas já realizadas pelo PNAE podem contribuir para o potencializar o efeito na formação de hábitos alimentares mais saudáveis.

2.2. ALIMENTOS DESTINADOS AO PÚBLICO INFANTIL

Crianças são um grande potencial de mercado pois, embora não realizem suas próprias compras, tem grande influência na seleção dos alimentos da família, tornando-se assim grandes alvos da indústria de alimentos (YUSUF, 2007). Nesse contexto, é crescente a gama de produtos desenvolvidos para este público, sendo o marketing infantil o principal recurso utilizado para aumentar as preferências por estes alimentos, estimulando o seu consumo (CAIRNS et al., 2013).

Estudos que avaliaram a qualidade nutricional dos produtos destinados ao público infantil disponíveis no mercado revelaram que a maioria destes alimentos apresentam níveis excessivos de açúcar, sódio e gorduras, apresentando qualidade nutricional inferior aos produtos convencionais (ELIOTT, 2007; FERREIRA et al. 2015; GIMÉNEZ et al., 2015; HARYANTO, MOUTINHO & COELHO, 2016).

O uso de imagens (de personagens licenciados ou próprios), embalagens coloridas e apelos de diversão são apontados como os principais recursos de *marketing* utilizados tornando os produtos extremamente atrativos para as crianças. Segundo o relatório do Instituto de Medicina, apesar da utilização de personagens licenciados ser recomendada somente para alimentos que promovam a nutrição adequada de crianças e jovens, tais recursos têm sido aplicados de maneira indiscriminada em alimentos destinados ao público infantil (IOM, 2006). No Brasil, Rodrigues et al. (2016) revelaram que 10% de todos os produtos disponíveis no supermercado utilizam no mínimo uma estratégia de marketing direcionada para o público infantil. As categorias em que estes recursos são utilizados com maior frequência contemplam os produtos ricos em açúcar como as bebidas de fruta, bebidas achocolatadas e produtos de confeitaria em geral. De todos os alimentos disponíveis para esse público, somente 3% pertencem ao grupo dos vegetais e frutas.

Observando o aumento da disponibilidade de produtos ricos em açúcar desenvolvidos para crianças, Walker e Goran (2015) analisaram a composição de açúcares adicionados em diversos alimentos destinados a este público como suplementos alimentares, bebidas, cereais matinais, produtos lácteos e de panificação. Das 100 amostras avaliadas, 74% continham 20% ou mais do total de calorias/ porção oriundas de açúcares adicionados. A sacarose foi o tipo de açúcar mais adicionado em todas as categorias de alimentos estudados, inclusive nas fórmulas de suplementação infantil.

A utilização das estratégias acima citadas cria vínculos emocionais positivos nas crianças, despertando sua preferência e aumentando a frequência de consumo destes alimentos (KIM et al., 2015). Nesse sentido, desenvolver estratégias que reduzam as associações emocionais positivas das crianças é essencial para a reduzir o consumo destes produtos

3. CONSUMO DE AÇÚCAR E SAÚDE

O elevado consumo de açúcar é apontado como um dos principais problemas relacionados aos hábitos alimentares da população causando não somente o aumento de peso e diabetes, mas também sendo altamente associado ao aumento do colesterol e gordura no fígado, desenvolvimento de doenças cardíacas e síndrome metabólica (KEARNS, SCHMIDT & GLANTZ, 2016). O excesso de açúcar é mais preocupante para a saúde de crianças e adolescentes comparado aos adultos, uma vez que evidências sugerem que a exposição excessiva ao açúcar durante a fase de desenvolvimento pode afetar as escolhas e preferências alimentares ao longo de toda a vida (MENNELLA et al., 2014). Ao avaliar o consumo de açúcar, deve-se levar em consideração que a maioria dos açúcares consumidos pela população pertence à categoria dos adicionados, os quais são quimicamente indistinguíveis dos naturais (como a frutose presente nas frutas ou a lactose do leite e derivados), tornando-se preocupantes do ponto de vista da saúde pública, pois aumentam o conteúdo energético dos alimentos sem agregar valor nutritivo (JOHNSON et al., 2009; REEDY & KREBS-SMITH, 2010). Segundo a Organização Mundial da saúde, o consumo de açúcar adicionado não deve ultrapassar 10% do total de calorias consumidas; no entanto, sabe-se que adultos e crianças facilmente extrapolam este valor (WHO, 2012).

Estudos realizados em países desenvolvidos apontam o aumento de cerca de 500% do consumo *per capita* de bebidas açucaradas nos últimos 50 anos, sendo os refrigerantes e bebidas à base de frutas, bebidas e sobremesas lácteas as principais fontes de açúcares adicionados consumidos diariamente por crianças (PUTNAM & ALLSHOUSE, 1999; MORTON & GUTHRIE, 1998; REEDY & KREBS-SMITH, 2010; TORRE et al., 2016). No Brasil, dados da Pesquisa Nacional de Saúde do Escolar do ano de 2012 revelaram a mesma tendência. O consumo de guloseimas (doces, balas, chocolates, chicletes, bombons ou pirulitos) em cinco dias ou mais na semana foi referido por 41,3% dos escolares, juntamente com o consumo de biscoitos (35,1%) e de refrigerantes (33,2%), os quais foram apontados como os marcadores de alimentação não saudável mais referidos (IBGE, 2013). Em 2016 o Sistema de Vigilância Alimentar e Nutricional revelou que aproximadamente 67% das crianças na faixa etária de 5 a 9 anos apresentaram consumo frequente de bebidas açucaradas (BRASIL, 2016), confirmando a alta inadequação do consumo alimentar dos estudantes brasileiros, principalmente em relação ao açúcar.

Diversas revisões sistemáticas concluíram que o consumo de bebidas açucaradas tem relação direta com o aumento de peso em crianças e adultos (CLABAUGH & NEUBERGER, 2011; HU, 2013; MALIK et al., 2013). Ludwig, Peterson & Gortmaker (2001) estimaram que para cada porção de bebidas açucaradas consumidas em excesso, há um aumento nos valores do índice de massa corpórea - IMC (média 0,24kg/m2) e frequência de obesidade em crianças. Alguns estudos revelam que fatores familiares e socioeconômicos também influenciam os hábitos alimentares, os quais, estão diretamente associados com a ingestão de açúcares adicionados, onde as bebidas açucaradas são uma das principais fontes (GRIMM, HARNACK &STORY, 2004; RANJIT et al., 2010; PARK et al., 2012a; PARK et al., 2012b). Nesse contexto, o desenvolvimento de políticas com foco na relação de consumo destes alimentos pode contribuir positivamente para a redução do consumo de açúcar do público infantil.

4. POLÍTICAS PÚBLICAS PARA A REDUÇÃO DO CONSUMO DE AÇÚCAR

Do ponto de vista da saúde pública, o desenvolvimento de políticas que visam a redução do consumo de açúcar é necessário para melhorar a qualidade de vida da população. De acordo com Hawkes et al. (2015), a interação entre o ambiente alimentar das pessoas e a preferência é fundamental na identificação de mecanismos para que as políticas públicas sejam de fato efetivas. Nesta mesma revisão, são apontados quatro principais mecanismos pelos quais estas políticas devem atuar:

1) *Fornecer ambientes propícios para a aprendizagem das preferências alimentares saudáveis:* Baseia-se na evidência de que embora alguns aspectos das preferências alimentares sejam intatos eles, em sua maioria, são aprendidos. Ressalta-se a disponibilidade e comportamento alimentar de pais como modelos às crianças, assim como culturas e normas sociais relacionadas ao ambiente no qual se vive. No entanto, estas preferências podem ser modificadas em resposta às novas informações e ao marketing, mas também diante da exposição repetida. Nesse sentido, as políticas devem proporcionar um ambiente de aprendizagem de preferências alimentares positivas.

2) *Superar barreiras para o desenvolvimento de preferências alimentares saudáveis*: Este mecanismo leva em consideração que a capacidade de ter uma alimentação saudável é afetada por diversas barreiras, mesmo muitas vezes o indivíduo tendo interesse em manter boas práticas alimentares. São exemplos o baixo nível socioeconômico (o qual está relacionado ao custo de aquisição de alimentos mais saudáveis), baixa disponibilidade de alimentos nutritivos na área de residência, falta de tempo, recursos físicos, informações, habilidades, entre outros. Um papel importante para a política é o levantamento destas barreiras, para permitir o desenvolvimento de preferências alimentares saudáveis.

3) *Encorajar a modificação de preferências não saudáveis:* Este mecanismo baseia-se no fato de que as pessoas que já desenvolveram preferências alimentares não saudáveis resistem em realizar escolhas saudáveis. No entanto, estas escolhas podem ser modificadas a partir de mudanças na maneira com que os alimentos são apresentados e pelo preço em que são vendidos. Desta forma, um dos papeis importantes da política relacionada aos alimentos é influenciar preços, disponibilidade e apresentação de opções mais saudáveis para incentivar os consumidores a reavaliarem suas escolhas alimentares.

4) *Estimular uma resposta positiva dos modelos alimentares:* Baseia-se na evidência de que políticas relacionadas aos alimentos destinadas a influenciar as escolhas alimentares dos consumidores também estimulam ações em outros setores. Ações de governos para melhorar acesso e disponibilidade de alimentos saudáveis também pode afetar o ambiente alimentar e incentivar a melhoria da qualidade nutricional dos alimentos pela indústria. Logo, a política deve induzir a uma resposta que afete os demais setores do modelo alimentar.

Um desafio a ser enfrentado pelas políticas públicas voltadas para alimentos é criar ambientes favoráveis para a realização de escolhas saudáveis. Intervenções ambientais

baseadas em modelos (*frameworks*) podem reverter o baixo impacto dos programas individuais e de educação pública (CHEADLE et al., 1997). Nesse sentido, uma gama de políticas públicas tem sido propostas para alcançar este objetivo. Dentre elas podem ser citadas as regulamentações de mercado, restrições de publicidade e marketing, incentivos econômicos positivos e negativos (diferenciações tributárias) para as empresas e/ou consumidores de acordo com a qualidade nutricional dos produtos comercializados, a reformulação de alimentos e medidas para incentivar as pessoas a fazerem escolhas alimentares mais conscientes, como a inclusão de informações simplificadas nos rótulos dos produtos (CAPACCI et al., 2012; SCRINIS & PARKER, 2016). A presente tese é centrada em duas destas políticas: a reformulação de alimentos e a inclusão da informação nutricional frontal.

Um exemplo bem-sucedido e viável de reformulação de alimentos é o programa de redução voluntária de sal do Reino Unido, o qual incentivou a indústria a reduzir gradualmente o teor de sal adicionado dos produtos (HE et al., 2014). No ano de 2007, o Ministério da Saúde brasileiro e o setor de alimentos assinaram o Acordo de Cooperação para promover estilo de vida saudável, o que inclui uma dieta nutricionalmente adequada (BRASIL, 2007). Neste acordo, o Ministério da saúde ficou responsável por estabelecer uma estratégia gradual para a melhoria do perfil nutricional dos alimentos industrializados, concentrando-se na redução dos níveis de açúcar, sódio, gorduras saturadas e *trans* em alimentos processados. Resultados após as três primeiras rodadas de monitoramento indicaram que entre 90% e 100% dos produtos das categorias de alimentos alvo atingiram as primeiras metas sugeridas para o período de 2011–2013, pois as reduções médias nos teores de sódio dos produtos passaram de 5% para 21% nos dois primeiros anos (NILSON et al., 2017). Tais dados sugerem que com monitoramento e supervisão governamental, metas voluntárias para a redução podem ter impacto significativo em curtos períodos de tempo. Tais acordos seguem as tendências de políticas públicas para reduzir o consumo de açúcar no mundo, como os praticados no Reino Unido (MARKEY, LOVEGROVE, & METHVEN, 2015). Apesar do sucesso alcançado no processo de redução de sódio, poucas mudanças foram observadas nos teores de açúcar dos produtos disponíveis no mercado brasileiro até o momento (FERREIRA et al., 2015). Recentemente, o governo brasileiro assinou um novo acordo com a indústria para reduzir o consumo de 144 mil toneladas de açúcar até 2022. A redução voluntária será feita em 23 categorias de alimentos e bebidas compreendidas em cinco grupos: bebidas adoçadas, biscoitos, bolos prontos e misturas para bolo, achocolatados em pó e produtos lácteos. O acordo com o Ministério da Saúde foi assinado pela ABIA (Associação Brasileira das Indústrias da Alimentação); ABIMAPI (Associação Brasileira da Indústria de Biscoitos, Massas Alimentícias e Pães & Bolos Industrializados), ABIR (Associação Brasileira das Indústrias de Refrigerantes e Bebidas Não Alcoólicas) e VIVA LÁCTEOS (Associação da Indústria de Lácteos). Ao todo, fazem parte do acordo 68 indústrias, que representam 87% do mercado de alimentos e bebidas do País (MINISTÉRIO DA SAÚDE, 2018).

A política de inclusão da rotulagem nutricional frontal tem sido implementada em diversos países, diferindo em relação ao tipo de informação exposta, representação gráfica e perfil de nutrientes para expressar a saudabilidade (EUFIC, 2017). O Reino Unido foi o pioneiro na implementação do Semáforo Nutricional na rotulagem de seus produtos (FSA, 2007). A França aprovou o Nutri-Score, rotulagem nutricional frontal que classifica os produtos em cinco níveis de qualidade nutricional, associando com diferentes cores e letras (MINISTÈRE DE L'AGRICULTURE ET DE L'ALIMENTATION, 2017). A Austrália implementou o *Health-star rating*, que classifica os produtos entre 10 níveis de qualidade nutricional, usando somente estrelas, que variam de 0.5 a 5 (COMMONWEALTH OF AUSTRALIA, 2016). O modelo de alertas nutricionais foi implementado pelo governo

chileno e recentemente aprovado no Uruguai (MINISTERIO DE SALUD, 2015; MINISTERIO DE SALUD, 2018). Devido aos bons resultados com a população chilena, (CORREA *et al*, 2019; ARAYA *et al*, 2018), sua implementação tem sido considerada em vários países da América Latina, incluindo o Brasil, pois este modelo parece ter grande potencial para modificar os hábitos alimentares a longo prazo. No entanto, para serem eficientes, as políticas de rotulagem nutricional devem estimular a resposta da indústria de alimentos, incentivar a reformulação de produtos e influenciar a escolha alimentar do consumidor em diferentes contextos. Para tal, os rótulos devem ser visíveis, compreensíveis e não enganosos (HAWKES et al., 2015). Considerando que o Brasil tem como objetivo reduzir o teor de açúcar dos alimentos industrializados e está avaliando a implementação de um modelo de rotulagem nutricional frontal no rótulo dos seus produtos, investigar estas políticas é essencial para avaliar o potencial entre os brasileiros.

5. REFORMULAÇÃO DE ALIMENTOS

A reformulação é uma estratégia cujo objetivo principal é melhorar o perfil nutricional de alimentos e bebidas industrializadas, reduzindo o teor de açúcar, sal e/ou gordura (MARKEY, LOVEGROVE & METHVENA, 2015). A indústria possui dois principais métodos: a redução no conteúdo de açúcares adicionados sem modificações adicionais na formulação do produto ou, a substituição parcial/total do nutriente por outros ingredientes como os edulcorantes (WEBSTER, 2009).

A reformulação utilizando a substituição tem como vantagem compensar parte das mudanças sensoriais causadas pela redução e/ou retirada de açúcar na percepção do gosto doce. No entanto, apresenta desvantagens como a geração de características sensoriais negativas e incomuns aos produtos (DUBOIS & PRAKASH, 2012; PHELPS et al., 2006) e, no caso específico dos edulcorantes, a existência de dúvidas quanto aos malefícios à saúde em relação ao consumo a longo prazo (BISSACOTTI, ANGST & SACCOL, 2015; REIS et al.., 2017). Considerando que os consumidores não estão dispostos a aceitar alternativas alimentares mais saudáveis se estas não atenderem às expectativas hedônicas e sensoriais (CIVILLE & OFTEDAL, 2012), a redução gradual tem sido apontada como uma alternativa para a reformulação de alimentos, uma vez promove reduções lentas e progressivas no teor de açúcar. Dessa forma, os consumidores percebem menos as diferenças e se acostumam gradualmente aos produtos com menor teor de açúcar, o que a longo prazo contribui para aumentar a preferência por produtos menos doces (MacGREGOR & HASHEM, 2014).

A estimativa de limiares de diferença para redução de açúcar é definida como a menor alteração na concentração de açúcar capaz de modificar a percepção do consumidor (LAWLESS & HEYMANN, 2010), e tem sido empregada a fim de estabelecer recomendações para a redução de nutrientes em alimentos industrializados. De acordo com a lei de Weber, os limiares de diferença são uma proporção constante da intensidade do estímulo (LAWLESS & HEYMANN, 2010).

A determinação dos limiares pode ser realizada a partir de comparações pareadas entre a amostra controle e as reduzidas em açúcar e os consumidores devem indicar qual amostra é a mais doce. Para a determinação são realizados geralmente 5 ou 6 estudos, onde no primeiro, a concentração inicial de açúcar adicionada é semelhante aos produtos comerciais disponíveis no mercado, e as reduções são determinadas estatisticamente ou por meio de estudos piloto. No segundo estudo, o limiar de redução é iniciado a partir do resultado encontrado no estudo anterior. Esse padrão se repete até que os cinco ou seis limiares de diferença sejam estimados.

Devido às diferenças mínimas de concentração de açúcar avaliadas pelos

consumidores ao longo das comparações pareadas, não é possível determinar a exata concentração de açúcar a partir da qual cada indivíduo começa a perceber as amostras reduzidas em açúcar como menos doces que o controle. Dessa forma os limiares de diferença são estimados como o intervalo entre a concentração inferior a qual o consumidor percebe a amostra reduzida em açúcar como menos doce que a referência pela primeira vez, e a primeira concentração em que ele começa a identificar corretamente qual é a amostra doce de forma consistente (OLIVEIRA et al., 2016). O limiar de redução é determinado quando no mínimo 50% dos indivíduos percebem a diferença (BORING, 1942), e pode ser estimado a partir da análise de sobrevivência (HOUGH et al., 2003). Esta metodologia tem sido utilizada para determinar a sequência de reduções que pode ser aplicada a um determinado produto sem comprometer a aceitação dos consumidores. Oliveira et al. (2016) aplicaram o limiar de diferença para determinar as recomendações para a redução de açúcar em bebida achocolatada e reportaram que reduções na faixa de 6,7% no teor de açúcar adicionado na bebida achocolatada não foi percebida pelos consumidores.

Estudo visando a redução do conteúdo de sal em suco de tomate foi realizado por Boboski, Rendahl & Vickers (2015), no qual foram avaliadas duas formas: a redução gradual vs. a brusca. Os autores concluíram que a gradual foi mais eficaz, pois não afetou a aceitação a partir da primeira grande redução, mantendo-se estável durante todo o experimento. Entretanto, consumidores motivados a reduzir o consumo de sal tiveram respostas semelhantes em ambos os grupos (gradual e brusca), o que demonstra que diferenças individuais podem limitar a eficácia da redução de sal, devendo utilizar diferentes estratégias para grupos específicos de consumidores. Considerando o elevado consumo de açúcar por crianças e a baixa qualidade nutricional de muitos produtos disponíveis no mercado destinados ao público infantil, estratégias de reformulação de alimentos como a redução gradual de açúcar podem ser de grande utilidade para a melhoria dos hábitos alimentares e prevenção de doenças neste público. Entretanto, para a redução gradual ser efetiva, metas incrementais devem ser definidas para cada categoria de alimento, assim como um prazo específico para cada redução. Uma ação coordenada entre as indústrias pode contribuir para a redução global no consumo de determinados nutrientes, sem afetar as vendas dos produtos. Dessa maneira, a determinação dos limiares de diferença é essencial para o sucesso do processo de reformulação (CIVILLE & OFTEDAL, 2012).

6. ROTULAGEM NUTRICIONAL FRONTAL (FOP)

A inclusão de informação nutricional no rótulo de alimentos é uma das abordagens que tem sido implementadas para estimular os consumidores a realizar escolhas conscientes e mais saudáveis (COWBURN & STOCKLEY 2005). De acordo com o CODEX Alimentarius, a rotulagem nutricional é a lista de nutrientes em um rótulo alimentício acompanhada de alguma forma de quantificação, onde as informações têm como objetivo fornecer aos consumidores um perfil dos nutrientes de importância nutricional presentes nos alimentos (FAO/WHO, 1989). Apesar do Brasil ser um dos primeiros países da América do Sul a adotar a rotulagem nutricional obrigatória, estudos relatam que a informação nutricional atual é de difícil localização e compreensão até mesmo para os consumidores motivados a ter uma alimentação saudável (GRAHAM et al. 2012; SHARF et al. 2012). Além disso, a maioria das pessoas relatam não utilizar essas informações durante a seleção e compra de alimentos (GRUNERT & WILLS 2007). Estudos realizados com a população brasileira também confirmam esta tendência (FERRAZ, 2001; MANDON, 2003; MARTINS, 2004). Segundo a

pesquisa do Instituto de Defesa do Consumidor (IDEC) realizada com 807 mulheres de todas as faixas de renda, com idades entre 20 e 65 anos, 61% das participantes afirmaram não entender a informação nutricional o suficiente para ser capaz de utiliza-las na seleção e compra de alimentos (IDEC, 2014). Nesse sentido, a suplementação da informação nutricional localizada no verso das embalagens com a rotulagem nutricional frontal (FOP) é apontada como uma alternativa para encorajar os consumidores a selecionar alimentos mais saudáveis (GEIGER et al., 1991; SCOTT& WORSLEY, 1994; IOM, 2011). Devido ao seu destaque na embalagem dos produtos, os modelos FOP podem servir como um facilitador para estimular os consumidores a considerarem informações nutricionais dos alimentos no momento da compra (REISCH & SUNSTEIN, 2016). Além disso, os modelos FOP podem incentivar as indústrias de alimentos a reformular seus produtos, para que possam ter rotulagem mais favorável, evitando a rejeição pelos consumidores (ROODENBURG, POPKIN& SEIDELL, 2011).

Em geral, os modelos FOP apresentam informações relacionadas aos nutrientes que impactam no ganho de peso e desenvolvimento de doenças crônicas, podendo ou não indicar de maneira geral a qualidade nutricional do produto. Atualmente, diversos modelos FOP têm sido utilizados em diversos países, os quais variam em relação ao formato e tipo de informação (DRAPER et al., 2011). De acordo com o levantamento bibliográfico realizado pela Agência Nacional de Vigilância Sanitária (ANVISA) mais de 40 países já possuem algum modelo de rotulagem frontal implementado (BRASIL, 2018). Apesar de amplamente investigados, ainda não há um consenso sobre qual é o melhor modelo FOP, pois existem características específicas dependendo do país a ser implementado (ROBERTO et al., 2012).

Portanto, os países têm adotado voluntariamente o tipo de FOP que consideram mais adequado para inserir em seus rótulos (HAWLEY et al., 2013; HERSEY et al., 2013).

Os modelos FOP podem ser classificados em três categorias de acordo com o grau em que direciona os consumidores para a escolha de alimentos mais saudáveis, a saber: não diretivos, semi-diretivos e diretivos (HODGKINS et al., 2012).

O valor diário (VD%) é um exemplo de modelo FOP não diretivo, uma vez que apresenta informações sobre o conteúdo nutricional através do uso de números e porcentagens, indicando a proporção que cada um dos nutrientes representa do total recomendado a ser consumido em um dia por um adulto (Figura 3). Este modelo somente apresenta informações quantitativas sobre o conteúdo de nutrientes dos alimentos e requer maior atenção, conhecimento e tempo para processar a informação (HAMLIN, McNEILL, & MOORE, 2014; NEWMAN, HOWLETT, & BURTON, 2014).

Os modelos FOP semi-diretivos por sua vez (Figura 4), apesar de fornecerem elementos interpretativos que contribuem para a identificação dos nutrientes presentes no alimento, não apresentam informações diretas sobre a qualidade nutricional do produto. O semáforo nutricional (SN) é um exemplo de modelo semi-diretivo, o qual indica o nível dos nutrientes por meio das cores verde, amarela e vermelha (Figura 4A). Nesta categoria ainda se encontram os modelos híbridos como o SN com informação sobre o VD% (Figura 4B).

Os modelos diretivos (Figura 5) identificam verbalmente ou classificam de maneira geral a qualidade nutricional dos produtos por meio de logotipos, sem a utilização de informação numérica. Podem ser citados como exemplo o modelo de alertas nutricionais (*Nutritional Warnings*), com logos negros para indicar os nutrientes em excesso nos alimentos (Figura 5A), os logos de saúde (*Healthy Logos*), os quais são incluídos somente em alimentos adequados nutricionalmente (Figura 5B) e o modelo de ranqueamento (*Nutri- Score*), que indica o nível de saudabilidade do alimento por meio de letras e cores (Figura 5C).

Figura 3. Exemplo de modelo FOP não diretivo: Valor diário (VD%).

(A) (B)

Figura 4. Exemplos de modelos FOP semi-diretivos: (A) Semáforo Nutricional (SN) e (B)

Modelo híbrido: Semáforo Nutricional + VD%.

(A)

(B) (C)

Figura 5. Exemplos de modelos FOP diretivos: (A) Alertas nutricionais (*Nutritional Warnings*), (B) Logos de Saúde (*Healthy Logos)* e (C) Modelo de Ranqueamento (*Nutri-Score).*

Evidências experimentais sugerem que os modelos FOP diretivos e semi-diretivos possuem melhor performance que os modelos não diretivos, pois melhoram a capacidade dos consumidores para identificar corretamente os produtos saudáveis (ANTÚNEZ et al. 2015; ARRÚA et al., 2017b; BORGMEIER & WESTENHOEFER, 2009; FEUNEKES et al., 2008; KELLY et al., 2009; MAUBACH, HOEK & MATHER, 2014). Estas diferenças na eficiência dos modelos FOP podem estar associadas à dificuldade em processar informações numéricas em um curto período de tempo (VAN HERPEN & VAN TRIJP, 2011).

No Brasil, a busca por um modelo de rotulagem nutricional frontal é recente. Em 2014 a ANVISA decidiu criar um grupo de trabalho para diagnosticar os problemas existentes na veiculação de informações nutricionais pelos rótulos de alimentos, investigar diferentes modelos FOP e propor modelos que sejam efetivos para melhorar a compreensão dos rótulos de alimentos pela população brasileira. Em 2017 foi realizado o primeiro painel técnico sobre

rotulagem nutricional frontal, cujo objetivo foi discutir e avaliar propostas de modelos FOP sugeridas por representantes de diferentes segmentos da sociedade brasileira à ANVISA. Os modelos diretivos e semi-diretivos foram as principais opções sugeridas a serem investigadas. São exemplos de modelos investigados: o SN (Figura 4A), o modelo híbrido, contendo semáforo nutricional e valor diário (VD%) proposto pelo setor produtivo de alimentos (Figura 4B), os alertas nutricionais (Figura 5A) , além da versão dos alertas em formato triangular, proposto pelo IDEC e a Universidade Federal do Paraná (UFPR) e alguns modelos de alertas que estão sendo estudados pelo governo do Canadá (BRASIL, 2018). Apesar de existirem evidências que mostram a eficácia dos modelos FOP como uma política efetiva para rotulagem de alimentos (KHANDPUR et al.,2019; KHANDPUR et al.,2018; IDEC, 2016), não há clareza sobre qual é o modelo mais adequado para a população brasileira, e se os modelos FOP apresentam potencial para informar e direcionar crianças para escolhas alimentares mais saudáveis.

A descrição detalhada dos modelos FOP investigados são apresentadas a seguir.

6.1. VALOR DIÁRIO (VD%)

O VD% é conhecido internacionalmente como *Guideline Daily Amounts (GDA)* e foi desenvolvido em 1998, por meio de uma iniciativa do *Institute of Grocery Distribution* em parceria com o governo, organizações de consumidores e fabricantes de alimentos. Após alguns anos, o GDA passou a ser declarado no painel principal dos rótulos e foi difundido para outros países com algumas adaptações e modificações quanto ao nome. Atualmente é o modelo de rotulagem nutricional mais difundido globalmente (FDF, 2014).

O VD% é um modelo não diretivo adotado voluntariamente por diversas empresas internacionais, que utiliza ícones em formato de barril para informar as quantidades absolutas e relativas, na forma de valor diário (%) de determinados nutrientes. Dessa forma, o VD% emprega os mesmos elementos e linguagem da informação nutricional presente no verso das embalagens, e tem como principal foco o conteúdo energético dos alimentos. Em alguns produtos nutrientes como açúcares, gorduras totais, gorduras saturadas e sódio presentes na porção do alimento também são apresentados. Como este modelo não realiza qualquer classificação nutricional dos valores declarados, não é necessário incluir o perfil nutricional, o que simplifica a sua adoção. Este modelo é utilizado nos produtos brasileiros. Segundo informações da Associação Brasileira das Indústrias de Alimentos (ABIA), nove empresas associadas utilizam o VD% na rotulagem frontal de seus alimentos, onde a maioria é baseada nas diretrizes da associação, enquanto algumas adotam diretrizes globais (BRASIL, 2018).

Alguns países como Filipinas, México e Tailândia implementaram o VD% de forma obrigatória; porém, cada país criou suas próprias versões (MÉXICO, 2014; PHILIPPINES, 2012; THAILAND, 2016). Apesar de o VD% estar presente em vários países, este modelo é reportado em diversos estudos como de difícil compreensão e utilização, dificultando a correta identificação da qualidade nutricional dos alimentos pelos consumidores (DUCROT et al., 2016; IDEC, 2014; MACHÍN et al., 2016; PETTIGREW et al., 2017). Desta forma, os governos têm buscado investir em modelos FOP de mais fácil compreensão e que utilizem diferentes recursos visuais para auxiliar os consumidores a identificar as características nutricionais dos alimentos de forma rápida e simples, sem a necessidade de realizar cálculos (BRASIL, 2018).

6.2. SEMÁFORO NUTRICIONAL

Tendo em vista que para muitos consumidores as informações contidas nos rótulos de gêneros alimentícios são excessivamente técnicas e pouco claras, em 2004 foi criada no Reino Unido a Agência de Normas Alimentares (*Food Standards Agency* - FSA), autoridade independente com o objetivo de auxiliar os consumidores a efetuarem escolhas alimentares mais saudáveis (FSA, 2007). O FSA propôs modelo simples a fim de orientar o consumidor na escolha de produtos industrializados mais saudáveis. Esta ferramenta, que já se expandiu para outros países da Europa é chamada de Semáforo Nutricional (SN) ou *Traffic Light Labeling* (TLS) (Figura 2A), a qual fornece informações diretas e práticas sobre a composição nutricional do alimento, tornando a compreensão mais acessível aos leigos e às crianças, direcionando-os para dietas mais equilibradas (BALCOMBE; FRASER; DI FALCO, 2010).

Este modelo é baseado nas cores do semáforo. A cor vermelha indica o teor muito elevado de um nutriente, a amarela médio e a verde a quantidade adequada. A seleção da cor é realizada a partir da composição do alimento em 100g de produto, que posteriormente pode ser convertido em porção (Quadro 1) facilitando, assim, a comparação de produtos de uma mesma categoria (FSA, 2007). O SN é um dos modelos FOP mais investigados atualmente (HAWLEY et al. 2013). Na América do Sul, o Equador foi o primeiro país a aderir este modelo FOP, que pode ser incluído na frente e adicionalmente no verso da embalagem (IDEC, 2014).

Quadro 1. Pontos de corte em 100g de alimentos sólidos adaptados ao semáforo nutricional de acordo com as normas da FSA[§] (2007).

Nutriente	Verde	Amarelo	Vermelho
Gordura Total	≤ 3g	>3g ≤ 20g	>20g
Gordura Saturada	≤ 1,5g	>1,5g ≤5g	>5g
Sal (mg)	≤ 300 mg	>300mg ≤1500mg	>1500mg
Açúcares(g)	≤ 5 g	>5g ≤15g	>15g

Diversos estudos têm demonstrado que o SN é um modelo FOP que facilita a compreensão dos consumidores sobre as características nutricionais quando comparado ao VD% ou controle (sem FOP) (CAMPOS, DOXEY& HAMMOND, 2011; HAWLEY et al., 2013). Esse efeito foi descrito como superior em diferentes aspectos, tais como: na determinação da intenção de compra (DRICHOUTIS, NAYGA & LAZARIDIS, 2009; MACHÍN et al., 2018a), na identificação da saudabilidade dos alimentos por consumidores saudáveis e portadores de doenças crônicas (ME´JEAN et al., 2014; TALATI et al., 2017;), no aumento da visibilidade das informações nutricionais (ANTÚNEZ et al., 2013) e da escolha de alimentos mais saudáveis pelos consumidores (OLSTAD et al., 2015). No entanto, Pettigrew et al. (2017) revelaram que embora os consumidores prefiram o SN ao VD% para realizar escolhas alimentares, o sistema diretivo (*health star rating*.) foi apontado como o mais útil para a identificação da saudabilidade dos alimentos por adultos e crianças.

Estudos que avaliaram o potencial do SN pelo público infantil relataram que sua presença no rótulo dos alimentos reduziu a escolha de alimentos não saudáveis por crianças e reduziu a percepção de saudabilidade em alimentos com elevado teor de açúcar (WHITT et al. 2018; YOO et al. 2017), além disso facilitou a identificação correta sobre a qualidade nutricional dos alimentos comercializados em um restaurante fast-food por crianças e seus

pais (DOODS et al., 2014). No entanto, Ares et al. (2016) revelaram que a informação nutricional teve menor impacto que outras variáveis, como a presença de imagens infantis e apelos nutricionais, na escolha de alimentos por este público.

Apesar dos benefícios apontados pelos estudos que investigaram o SN, este modelo apresenta algumas limitações, entre elas a exigência que consumidores cheguem ao seu próprio julgamento sobre a saudabilidade, baseado na avaliação simultânea do conteúdo de vários nutrientes, o que pode ser uma tarefa desafiadora (BLACK & RAYNER, 1992). Além disso, pesquisas sugerem que as luzes verdes, que são utilizadas para expressar o baixo teor de um determinado nutriente, podem aumentar a percepção de saudabilidade de produtos com alto teor de outros nutrientes (MACHÍN et al., 2018a; McCANN et al., 2013), diminuindo a eficácia em estimular escolhas alimentares mais saudáveis.

6.3. ALERTAS NUTRICIONAIS

O uso de logos de saúde e a utilização de rotulagem nutricional mais detalhada na frente de embalagem tem recebido crescente atenção devido ao potencial para fornecer informações rápidas, capacitando os consumidores a identificar alimentos saudáveis mais facilmente (HAWLEY et al., 2013; SCRINIS & PARKER, 2016). No entanto, uma das desvantagens de tais logos é que podem incentivar a indústria de alimentos a melhorar a composição nutricional apenas dos produtos que desejam destacar como os saudáveis dentro de uma categoria, ao invés de encorajar a melhoria dos produtos como um todo (ARES et al., 2018b). Dessa forma, a utilização de modelos FOP que revelem os aspectos negativos dos alimentos pode incentivar a indústria a reformular seus produtos, além de facilitar a identificação daqueles não saudáveis pelos consumidores (MAGNUSSON, 2010). Os alertas nutricionais são um dos mais recentes modelos FOP propostos para orientar o consumidor, desencorajando-o a comprar alimentos não saudáveis (CORVALÁN et al., 2013).

O Chile foi o primeiro país a implementar este modelo nos rótulos de alimentos, que inclui logos octogonais pretos com a expressão “Alto em” (Figura 6) se o conteúdo calórico, de açúcares, gordura saturada e sódio excederem os limites estabelecidos (Tabela 1) (MINISTERIO DE SALUD, 2015).

Tabela 1. Limites do conteúdo de energia, sódio, açúcares e gorduras saturadas em alimentos de acordo com o modelo chileno.

	Energia (Kcal)/100g	**Sódio Mg/100g**	**Açúcares g/100g**	**Gorduras Saturadas g/100g**
Limites em alimentos sólidos. Valores maiores que:	275	400	10	4
	Energia (Kcal)/100ml	**Sódio Mg/100ml**	**Açúcares g/100ml**	**Gorduras Saturadas g/100ml**
Limites em alimentos líquidos. Valores maiores que:	70	100	5	3

Figura 6. Modelo de Alertas nutricionais chileno, o qual deve ser inserido nos rótulos dos alimentos industrializados quando estes apresentarem excessos (A) Energia (Kcal), (B) Sódio, (C) Açúcares, (D) Gorduras Saturadas.

Este modelo mostra-se particularmente relevante, considerando que o ambiente alimentar tem sido caracterizado pela ampla disponibilidade de produtos industrializados de composição nutricional desfavorável, como é o caso da América Latina (MONTEIRO et al., 2012; ORGANIZAÇÃO PAN-AMERICANA DA SAÚDE, 2016). Grupos focais conduzidos após o período de implementação dos alertas nutricionais no Chile revelaram que as mães participantes, de diferentes níveis sócio econômicos e idades de crianças, compreenderam esta intervenção como uma política para combater a obesidade infantil e demonstraram estar familiarizadas com o sistema. Ademais, tal iniciativa contribuiu para o aumento do interesse em consumir alimentos saudáveis, o que pode levar à mudança nos padrões alimentares a médio/longo prazo (CORREA et al., 2019). Devido ao grande potencial e resultados positivos na população chilena, este modelo recentemente foi introduzido no Peru e Uruguai (MINISTERIO DE LA SALUD PERU, 2017; MINISTERIO DE LA SALUD URUGUAY, 2018).

A presença dos alertas negros tem sido relatada como uma estratégia que facilita a identificação de produtos não saudáveis, desestimulando o seu consumo, além de apresentar efeito superior aos modelos FOP não diretivos e semi-diretivos como o VD% e SN, para direcionar a atenção para a informação nutricional e capacidade de diminuir percepção de saudabilidade de alimentos inadequados nutricionalmente (ARES et al., 2018a; ARRÚA et al., 2017a; ARRÚA et al.,2017b; KHANDPUR et al., 2019; KHANDPUR et al., 2018). Entre crianças, estudos revelaram que os alertas nutricionais desencorajaram o consumo de produtos infantis com alto conteúdo de açúcar (ARRÚA et al., 2017a); porém, devido à recente implementação, estudos avaliando o impacto no público infantil ainda são limitados.

Recentemente, um grupo de pesquisadores brasileiros, juntamente com a equipe de design gráfico apresentaram uma versão alternativa de sistema de alertas nutricionais, a qual foi apresentada a Agência Nacional de Vigilância sanitária como uma opção para a população brasileira (ANVISA, 2018). Este novo modelo de alerta é representado por um triângulo negro, símbolo universalmente reconhecido por indicar alertas, com letras brancas, sobreposto a um fundo quadrado de cor branca, garantindo maior contraste em relação às cores presentes nas embalagens dos produtos serão inseridas. Além de indicar excesso de sódio, açúcar e gorduras saturadas, este sistema alternativo também apresenta informações sobre excesso de gorduras totais e *trans* e a presença de edulcorantes artificiais. Estudos online indicaram que semelhante ao sistema de alertas nutricionais chileno, a proposta brasileira apresenta potencial superior ao SN em capturar a atenção dos consumidores, melhorar a compreensão sobre a qualidade nutricional dos produtos, reduzir a percepção de saudabilidade de produtos inadequados nutricionalmente e, consequentemente, reduzir a intenção de compra pelos consumidores brasileiros (KHANDPUR et al., 2018).

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CAPÍTULO I

Como diferentes tipos de rotulagem nutricional frontal afetam a percepção de saudabilidade de alimentos destinados ao público infantil? Estudo com crianças e pais brasileiros[1]

[1] Artigo publicado no periódico **Food Quality and Preference,** n. 64, p. 111-119, 2018. (Apêndice I)

RESUMO

O objetivo deste estudo foi avaliar o efeito de diferentes modelos de rotulagem nutricional frontal (FOP) na percepção de saudabilidade de crianças e pais. Para tal, 318 crianças com idades entre 6-12 anos e 278 pais de diferentes níveis sócio econômicos participaram de um estudo online onde classificaram a saudabilidade percebida em relação a oito alimentos destinados ao público infantil: bebida achocolatada, biscoito recheado, bolinho recheado, cereal matinal, gelatina, iogurte, refresco de fruta e salgadinho de milho, utilizando escalas de 7 pontos (1= não saudável e 7= muito saudável). Participantes foram aletoriamente incluídos em um dos três grupos experimentais, avaliando embalagem no visor de um computador contendo um dos três modelos de FOP: Valor diário (VD%), semáforo nutricional (TLS) e modelo de alertas nutricionais. A análise de variância (ANOVA) foi utilizada para verificar diferenças de saudabilidade entre os produtos avaliados, grupos experimentais, idade e níveis socioeconômicos. Para os pais, os produtos contendo o modelo de alertas foram significativamente classificados como menos saudáveis do que os que foram avaliados com o modelo VD%. O TLS não diferiu significativamente dos demais modelos. Idade e nível socioeconômico influenciaram o efeito dos modelos FOP na percepção de saudabilidade pelas crianças. Somente crianças na faixa de 9-12 anos de idade, de nível socioeconômico médio e alto foram influenciadas pelos modelos FOP: Os modelos de alerta e o TLS reduziram a percepção de saudabilidade destas crianças em relação ao cereal matinal quando comparadas com o modelo VD%. Apesar de sutil, os resultados mostram que modelos diretivos e semi-diretivos como as alertas nutricionais e o TLS possuem potencial para modificar a percepção de produtos destinados ao público infantil e reforçam a necessidade de maiores estudos que avaliem o efeito de variáveis individuais tais como idade e nível socioeconômico na percepção de modelos FOP.

CAPÍTULO II

Modelos de rotulagem nutricional frontal podem modificar as associações emocionais de crianças em relação a produtos alimentícios não saudáveis? Um experimento com *emoji*[1]

[1]Artigo publicado no periódico **Food Research International**, n.120, p.217–225, 2019. (Apêndice II)

RESUMO

O objetivo do presente estudo foi comparar as associações emocionais relacionadas aos alimentos contendo diferentes modelos de rotulagem nutricional frontal (FOP). Um total de 492 crianças com idades entre 6-12 anos foram recrutadas em escolas públicas e privadas nas cidades do Rio de Janeiro/RJ e Rio pomba/MG, as quais foram aleatoriamente divididas em três grupos experimentais: Valor diário (VD), semáforo nutricional (TLS) e modelo de alertas nutricionais. Para cada um dos seis alimentos rotulados (*bebida achocolatada, biscoito recheado, cereal matinal, gelatina, iogurte e salgadinho de milho*) e três alimentos não rotulados (*banana, brócolis e sorvete*), as crianças foram instruídas a selecionar dentre os 16 *emoji*s da lista, todos os que descrevessem como elas se sentiam ao imaginar que iria consumir o produto da imagem. Os dados foram analisados utilizando modelos lineares generalizados (GLM). No caso dos produtos embalados, tipo de alimento, modelo FOP, idade e tipo de escola frequentada e suas interações foram consideradas variáveis independentes. As crianças foram capazes de utilizar os *emoji*s para descrever suas emoções em relação aos alimentos, pois os três produtos não rotulados apresentaram diferenças significativas no uso dos *emoji*. Os modelos FOP afetaram significativamente a frequência de uso de 5 dos 16 *emoji*s. Em geral, a presença dos modelos diretivos e semi-diretivos, tais como o modelo de alertas nutricionais e o TLS causaram uma redução no uso de *emoji*s associados com emoções positivas. O efeito dos modelos FOP na resposta emocional foi modulado pela idade e tipo de escola frequentada. O efeito dos modelos FOP diretivos e semi-diretivos, em especial o modelo de alertas nutricionais tende a ser maior entre crianças mais jovens (6-10 anos) e entre crianças que frequentam escolas públicas. Esses resultados sugerem que os modelos FOP podem contribuir para desencorajar o consumo de produtos com excesso de nutrientes relacionados a doenças crônicas não transmissíveis por crianças.

CAPÍTULO III

Percepção hedônica e sensorial de adultos e crianças sobre redução de açúcar adicionado em néctar de uva[1]

[1] Artigo publicado no periódico **Journal of Sensory Studies,** v.33, e12317, 2018. (Apêndice III)

RESUMO

O objetivo deste estudo foi avaliar a percepção hedônica e sensorial de crianças e adultos em relação a redução de açúcar adicionado em néctar de uva. Para tal, dois estudos foram conduzidos. No primeiro, cinco limiares para a redução de açúcar foram determinados de forma sequencial utilizando comparações pareadas, os quais foram determinados separadamente para crianças e adultos. No segundo estudo, 105 crianças (6-12 anos) e 100 adultos avaliaram seis amostras contendo teores de açúcar adicionado entre 10 e 4,3%. Os participantes avaliaram a aceitação, utilizando uma escala hedônica de 9 pontos e responderam a uma questão CATA simples, composta por 6 termos (1:*Pouco doce, 2: doce, 3:muito doce, 4:sabor de uva, 5: gosto ácido e 6: aguado*). Os resultados do estudo confirmaram a viabilidade em reduzir o teor de açúcar adicionado em néctar de uva, sem afetar a percepção sensorial e hedônica de crianças e adultos. A crianças apresentaram menor capacidade de detectar mudanças nas características sensoriais dos néctares com menor teor de açúcar quando comparado aos adultos, mas apresentaram uma maior sensibilidade hedônica á redução do teor de açúcar adicionado. Os participantes de ambos grupos etários apresentaram grande heterogeneidade em relação a reação hedônica frente a redução de açúcar das amostras. Do ponto de vista prático, é esperado que os resultados do presente trabalho forneçam subsídios para o desenvolvimento de programas de redução gradual de açúcar em bebidas á base de frutas para crianças e adultos. De acordo com a estimativa de limiares de redução de açúcar, uma redução gradual no teor de açúcar adicionado poderia ser implementada considerando reduções sequenciais inferiores a 6,21% para assegurar que os consumidores não percebessem mudanças nas características sensoriais dos produtos. Considerando que pequenas reduções não afetariam a aceitação dos consumidores, o tempo entre cada uma das reduções sequenciais não precisaria ser muito longo.

CAPÍTULO IV

Comparação de duas estratégias de redução de açúcar com crianças: estudo de caso com néctar de uva[1]

[1] Artigo publicado no periódico **Food Quality and Preference,** n.71, p.163–167, 2019. (Apêndice IV)

RESUMO

O objetivo deste estudo foi comparar duas estratégias de redução de açúcar adicionado (sequencial vs. Gradual) sobre a percepção hedônica e sensorial de crianças em um néctar de uva. Para tal, 117 crianças entre 6-12 anos de idade participaram deste estudo de duas etapas: Um estudo que envolvia 9 semanas de participação e um teste final de aceitação no final da 11ª semana. Durante o estudo de 9 semanas, as crianças foram divididas de maneira aleatória em dois grupos, de acordo com o tipo de estratégia de redução de açúcar: Sequencial ou gradual. A percepção sensorial e hedônica foi avaliada a partir do uso da escala hedônica de 9 pontos e simples questões CATA (*pouco doce, doce, muito doce, gosto ácido, sabor de uva e aguado*). No teste final, realizado na 11ª semana de estudo, as crianças avaliaram três amostras com 10, 6 e 4,3% de açúcar adicionado, avaliando de maneira semelhante á realizada durante as 9 semanas. A análise de dados foi realizada por análise de variância (ANOVA), teste Q Cochran, *Sign test* e pelo modelo linear generalizado (GLM). Os resultados do estudo revelaram que não existiram grandes diferenças entre as reduções graduais e sequenciais em relação a percepção sensorial e hedônica das crianças. No entanto, a estratégia de redução gradual causa menores mudanças na percepção hedônica e sensorial do que a sequencial. Durante o teste final, as crianças que foram expostas a redução sequencial atribuíram notas significantemente maiores para as amostras do que as que foram expostas a redução gradual. Comparando a aceitação entre a primeira vez em que as crianças provaram os néctares de uva e o teste final, diferenças significativas foram observadas para a amostra com menor teor de açúcar adicionado, a qual foi maior na 11ª semana. Apesar das diferenças entre as estratégias de redução de açúcar serem pequenas, a redução gradual parece ser recomendada em relação a sequencial.

CAPÍTULO V

Não é somente informação! A experiência sensorial sobrepõe o impacto da informação nutricional durante a escolha de bebidas com redução de açúcar pelos consumidores.

[1] Artigo publicado no periódico **Food Quality and Preference**, n. 74, p. 1-9, 2019. (Apêndice V)

RESUMO

Os objetivos do presente estudo foram: avaliar a escolha de bebidas reduzidas em açúcar por adultos e crianças no contexto da implementação de modelos de rotulagem nutricional frontal (FOP) sob diferentes condições de avaliação, e comparar a influência de dois modelos FOP: Semáforo nutricional (TLS) e modelo de alertas nutricionais. Para tal, 400 adultos e 400 crianças (6-12 anos) foram divididos em 2 grupos (n=200), um grupo escolheu amostras de néctar de uva e o outro de bebida achocolatada (controle e duas níveis de redução de açúcar adicionado) contendo diferentes modelos FOP, sob diferentes condições experimentais: (a) ás cegas, provando as amostras sem qualquer tipo de informação, (b) expectativa, somente olhando as embalagens, e (c) informado, olhando para embalagens e provando as amostras. Em cada condição experimental, foi pedido aos participantes que escolhessem um dos três produtos. Os dados de escolha foram analisados separadamente para cada categoria de produto e grupo etário usando *logit model* com parâmetros aleatórios. Ambos modelos FOP encorajaram adultos e crianças a escolher o produto mais saudável sob a condição expectativa. No caso dos adultos, o modelo de alertas nutricionais apresentou performance superior ao TLS na tarefa de escolha do néctar de uva. No entanto, quando os participantes provaram os produtos (condições às cegas e informado), as escolhas foram definidas pelas características sensoriais, sendo as amostras controle e de menor redução de açúcar as mais frequentemente escolhida. Os resultados deste estudo indicaram que as experiências hedônicas sobrepuseram o efeito dos modelos FOP, sugerindo que esta política pública dificilmente terá um efeito real nas escolhas dos consumidores se não existir alternativas de alimentos saudáveis que atendam suas expectativas hedônicas e sensoriais.

CONCLUSÕES E RECOMENDAÇÕES

Os resultados dos estudos conduzidos nesta tese forneceram evidências sobre o potencial de diferentes estratégias visando a redução do consumo de açúcar pelo público infantil. Este fato é de extrema importância, considerando o interesse do governo brasileiro em implementar tais estratégias, além do número reduzido de estudos desta natureza com a população brasileira, especialmente com crianças.

Os estudos realizados nos capítulos I e II evidenciaram que a inclusão de modelos de rotulagem nutricional frontal semi-diretivos e diretivos como o semáforo nutricional e em especial os alertas possuem potencial para reduzir a percepção de saudabilidade e associações emocionais positivas de alimentos de baixa qualidade nutricional, sugerindo que as informações veiculadas pela rotulagem FOP sobre a composição nutricional dos produtos são de fácil compreensão, não só pelos adultos, mas também pelo público infantil. além disso, também podem modificar a percepção de alimentos com características positivas, como foi observado na avaliação dos pais em relação aos produtos que continham imagem de frutas em sua embalagem. Este potencial foi confirmado no estudo V, uma vez que a partir da observação das embalagens, a presença da rotulagem FOP encorajou adultos e crianças a escolher produtos com menor teor de açúcar durante a seleção de alimentos.

No entanto, produtos de marcas conhecidas, com os quais em geral o público infantil está familiarizado, fatores como a idade e características socioeconômicas tiveram um grande impacto, limitando o efeito da rotulagem FOP. A exposição das crianças a estes alimentos pode ter gerado expectativas e associações baseadas em experiências anteriores e, consequentemente, ter reduzido o efeito da informação do FOP. Nesse sentido, com o objetivo de aumentar o efeito FOP frente a esses produtos, ações educativas visando aumentar os potenciais benefícios desta política devem ser estimuladas no ambiente escolar desde a primeira infância, contribuindo assim para despertar o interesse das crianças em observar as informações nutricionais dos alimentos, e favorecer a escolha de produtos mais saudáveis. A implementação de leis efetivas para o controle da publicidade de alimentos infantis também é uma importante medida para o aumento do impacto da rotulagem nutricional frontal e consequente redução do consumo de alimentos inadequados nutricionalmente, uma vez que a utilização de apelos infantis em alimentos não saudáveis contribui para aumentar o interesse das crianças por estes produtos.

O limiar de redução de açúcar determinado no capítulo II, permitiu comparar dois métodos de reformulação de alimentos, demonstrando que a maneira como que a redução de açúcar é implementada influencia significativamente a percepção hedônica e sensorial de adultos e crianças. Mesmo apresentando boa aceitação em ambos os grupos etários, a experiência conduzida no capítulo IV indicou que apesar dos benefícios da exposição repetida apresentada pelo método de redução sequencial, a redução gradual (utilizando os limiares de redução de açúcar) causou menores impactos na aceitação e percepção sensorial dos alimentos, permitindo o desenvolvimento de alimentos mais saudáveis a médio prazo. Tal resultado foi corroborado pelo estudo conduzido no capítulo V, no qual os maiores níveis de redução influenciaram a escolha dos alimentos por adultos e crianças, e reduziram o efeito de outras estratégias, como a inclusão da rotulagem nutricional frontal. Neste estudo, foi observado que que adultos e crianças não se mostraram dispostos a escolher produtos mais saudáveis no mercado se não atenderem às expectativas sensoriais, uma vez que a maioria dos consumidores selecionou os produtos com maior teor de açúcar ao prová-los, mesmo na presença da embalagem.

Portanto, a aplicação dos limiares de redução de açúcar no processo de reformulação de alimentos é essencial para o sucesso desta política, uma vez que permitirá a redução no teor de açúcar causando mínimo impacto na percepção sensorial das crianças. A política de reformulação de alimentos contribui não só para a redução do consumo de açúcar pelo público infantil, mas também para a modificação da preferência em relação ao gosto doce a

longo prazo. No entanto, para que essa política seja de fato efetiva, a mesma deverá ser implementada como ação obrigatória por todas as indústrias de alimentos, beneficiando não só as crianças, mas também a população como um todo, uma vez que acordos voluntários, apesar de contribuírem para o processo de reformulação de alimentos, geralmente são adotados somente por uma parcela das indústrias, não alcançando sua totalidade, limitando, portanto, sua abrangência e consequentemente o seu efeito. A ação combinada destas duas estratégias (informação nutricional FOP e reformulação) pode ser a mais adequada, uma vez que a rotulagem nutricional frontal promoverá o rápido acesso às características nutricionais dos produtos, facilitando a escolha de alimentos mais saudáveis, e a reformulação de alimentos reduzirá o consumo de açúcar de forma gradual pelas crianças.

Estudos futuros devem investigar o papel de diferentes fatores (idade, nível socioeconômico, categoria, marca dos produtos (conhecida vs. desconhecida)) e o efeito de intervenções educativas na utilização da rotulagem FOP durante a seleção e consumo de alimentos. Tais respostas contribuirão para o desenvolvimento de medidas que minimizem o efeito destes fatores, aumentando a efetividade da rotulagem nutricional frontal.

APÊNDICE I

How do front of pack nutrition labels affect healthfulness perception of foods targeted at children? Insights from Brazilian children and parents

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Abstract

The inclusion of front of pack (FOP) nutrition labels is one of the strategies that has been proposed to encourage people to make healthful food choices, helping to cope with the increasing burden of overweight and obesity among adults and children. The aim of this study was to evaluate the effect of different FOP labels on Brazilian children and parents' healthfulness perception. Children aged 6-12 years (n=318) and parents (n=278) with different socio-economic status rated their perceived healthfulness of eight food products targeted at children using a 7-point scale (1=not healthful and 7= very healthful). Participants were randomly allocated into one of the three groups of FOP nutrition labels: Daily Guideline Amounts (GDA), Traffic Light System (TLS) and warning system. Data were analyzed using analysis of variance. For parents, products with the warning system were rated significantly less healthful than those containing the GDA, whereas the TLS did not significantly differ from the other two systems. Age and socio-economic status influenced the effect of FOP labels on children's perceived healthfulness. Only 9-12 years old children from middle/high socio-economic status were influenced by FOP labels: the warning system and TLS reduced healthfulness perception of frosted corn flakes compared to the GDA system. These results suggest that directive and semi-directive FOP have the potential to modify healthfulness perception of products targeted at children and stress the need to study the modulating effect of individual variables such as age and socio-economic status on the perception of FOP labels.

Keywords: *Front-of-pack labels; warnings; traffic light system; children; healthfulness*

1. INTRODUCTION

The prevalence of childhood obesity has significantly increased in the last decades (De Onis; Blössner, & Borghi, 2010; Gupta et al., 2012). It has been estimated that the number of overweight children around the world will reach 70 million by 2025 if preventive and control measures are not taken (WHO, 2015). This situation highlights the need to change the environmental and behavioral determinants that drive the obesity epidemic (World Health Organization, 2013; Zobel et al., 2016). Considering that unhealthy eating habits are one of the main causes of the obesity epidemic, public policies aimed at promoting dietary change have been extensively recommended (Ebbeling, Pawlak & Ludwig, 2002 Han, Lawlor & Kimm, 2010)

Eating habits are strongly influenced by the environment (Zobel et al., 2016). In developed and developing countries the environment surrounding most children has been regarded as "obesogenic", due to the high exposure and easy access to caloric and nutrition-poor foods in their diet (Nielsen, Siega-Riz & Popkin, 2010). Most of the food products targeted at children have been reported to contain high sugar, sodium and fat content and are usually marketed using cartoon characters and direct references to fun and play on their package (Chapman, Nicholas, Banovic, & Supramaniam, 2006; Elliot, 2007; Giménez, de Saldamando, Curutchet, & Ares, 2017). A survey conducted by Ferreira et al. (2015) in the Brazilian market pointed out that 66% of the products targeted at children had excessive content of those nutrients. In addition, about 80% of the evaluated products had nutritional claims and/or images of natural products, even though they were not healthful. In general, this is a resource used by the food industry to encourage children and adults to perceive nutritionally inadequate products as healthy (Wirtz et al., 2013; Couste et al., 2012). Studies signal that this is one of the strategies used by parents to select healthy products for their children (Elliott, 2008; Abrams et al., 2015).

Although parents wish to offer healthy products to their children, they found some constraints such as time, price, children's pressure and difficulty to assess the information contained on the labels (Maubach, Hoek & McCreanor, 2009). In this context, food labeling has an important role in trying to guide consumers on food nutritional features. However, the nutrition facts located on the back of the label are reported as confusing and difficult to understand (Cowborn & Stockley, 2005; Grunert & Wills, 2007). Front-of-pack (FOP) labels were developed to assist consumers to choose more healthful products. These labels can be classified into three categories according to the level in which they guide consumers to food healthfulness: non-directive, semi-directive and directive (Hodgkins et al., 2012). Some of the main FOPs used are: the guideline daily amounts [GDA] system (non-directive), which indicates the proportion (%) that each nutrient present in a serving represents in the total daily amount recommended for an adult, and the traffic light system [TLS] (semi-directive), that uses the traffic light colors (red, yellow and green) to indicate the level of nutrients present in the food (Hawley et al, 2013). More recently, the Chilean government implemented a new directive FOP label based on warnings, which consists of mandatory octagonal black signs that indicate excessive levels of key nutrients (salt, sugar, saturated fats and/ or Kcal) to discourage the purchase of unhealthy products (Ministry of Health, 2015).

Several studies have investigated the effectiveness of different FOP systems (Crosetto, Muller & Ruffieux, 2016; Watson et al., 2014; Méjean et al., 2014; Borgmeier & Westenhoefer, 2009). Experimental evidence suggests that directive and semi-directive systems outperform non-directive systems, as they improve consumers' ability to correctly identify healthful products and encourage more healthful food choices (Feunekes et al., 2008;

Roberto et al., 2012; Antúnez et al., 2015; Arrúa et al., 2017b; van Herpen & van Trijp, 2011). For this reason, semi-directive and directive FOP labels are being increasingly implemented in different countries worldwide (EUFIC, 2017).

Parents, and particularly mothers, are the main responsible for food purchasing decisions in the household and have a great influence on the eating behaviors of their children by providing (un)healthful foods at home, encouraging/discouraging consumption of specific foods and being the earliest example of actions towards food (Grier et al., 2007; Palfreyman, Haycraft, & Meyer, 2015; Watts, Loth, Berge, Larson, Neumark-Sztainer, 2017). However, children exert a great influence on the purchase decisions of parents, particularly for unhealthy foods (O'Dougherty, Story, & Stang, 2006; Spake, 2003). This reinforces the need to study the influence of FOP labels on the perception of both children and parents. It can be hypothesized that parents would be interested in providing healthful foods to their children and, consequently, would be more influenced by FOP labels than children, who are expected to be more influenced by hedonic aspects of food consumption (Russell et al., 2017; Arrúa et al., 2017c). Studies involving the influence of FOP labels on children's perception are still limited and report inconsistent results. Ellis & Ellis (2007) reported that the use of the TLS in an elementary school reduced children's frequency of orders of foods with red light. However, other authors have reported that nutrition did not significantly influence children's food choices (Dodds et al., 2014; Ares et al., 2016; Arrúa et al., 2017c). Therefore, further studies evaluating the influence of FOP systems on children's perception of unhealthful foods and their food choices are necessary for evaluating the efficacy of this public policy

Income is one of the socio-economic variables that influences the way people perceive and choose food (Hough & Sosa, 2015). Differences in food selection between low- and high-income consumers have been reported in several studies (Inglis, Ball & Crawford, 2009; Sosa et al., 2015; Vilaro et al., 2016). Regarding nutrition information, low-income populations usually have less nutrition knowledge than middle/high income people, and face additional barriers to identify and select healthful foods (Elliot, 2007; Kapoor & Moorthy, 2010; Hough & Sosa, 2015). In the specific case of children, Arrúa et al. (2017c) have recently reported that low-income children perceive labels of unhealthful snack foods more positively than middle-high income children. Therefore, low-income people can be expected to gain additional benefit from simplified FOP labels than middle/high income people. In this sense, Machín et al. (2017) reported that the efficacy of the TLS in modifying healthfulness perception of unhealthful products was higher for low-income participants than for those from middle-high income.

In this context, the objective of the present study was to evaluate the effect of different front-of-pack (FOP) labels in healthfulness perception of foods for children by Brazilian children and their parents.

2. MATERIALS AND METHODS

2.1. Participants

The study was conducted with two groups of participants: children aged 6-12 years and parents of children of the same age. A total of 316 children were recruited from two organizations located in Rio de Janeiro - RJ, Brazil with different socio-economic contexts: a private school located in a region with high human development index (IBGE, 2010) and a non-governmental organization that develops activities for low-income children from public schools. A total of 278 parents of 6-12 years old children were recruited by a marketing agency specialized in consumer studies. The socio-economic level of the parents was estimated using the type of school the children attended considering that according to the

Brazilian school census middle/high income children mainly attend private schools, whereas low income children mainly attend public schools (MEC, 2016). Table 1 presents the socio-demographic characteristics of the participants. Children and parents gave written informed consent before starting the study. A small gift (equivalent to US$ 0.5) was given to the children for their participation. The study was performed from October to December 2016 and was approved by the Brazilian Committee of Ethics in Research (*Plataforma Brasil - CAAE 55023416.0.0000.5285*).

Table 1. Socio-demographic characteristics of the participants.

Parents (n=278)			**Children (n=316)**		
Characteristic	**n**	**%**	**Characteristic**	**n**	**%**
Gender			**Gender**		
Female	230	83	Female	155	49
Male	48	17	Male	161	51
Age			**Age**		
18-25 years	20	7	6 - 8 years	112	35
26-35 years	86	31	9 - 10 years	156	50
36-45 years	135	49	11 - 12 years	48	15
> 45 years	37	13			
Education					
Elementary school	10	4			
High school	75	27			
Incomplete higher education	29	10			
Higher education	94	34			
Post-graduate studies	70	25			
Type of school of the children			**Type of school**		
Public	108	39	Public	136	42
Private	170	61	Private	180	58

2.2. Front-of-pack nutrition labeling schemes

Three front-of-pack (FOP) nutrition labeling schemes were considered in the present study: monochromatic guideline daily amounts (GDA), traffic light system (TLS), and warning system. The GDA system included information about calories (Kcal), sugar, saturated fat and sodium, expressed as content per serving and percentage of the recommended daily intake. The traffic light system included information about the same nutrients expressed as content per serving and their corresponding classification into low, medium and high. Text descriptors and a color code (green, yellow and red) were used to indicate nutrient content. Calorie content only included text descriptors and color code when it was high. The warning system was only included when the content of the nutrients was high using an octagonal black sign (Ministry of Health, 2015). The criteria of the Food Standards Agency (2007) were used to classify nutrient content as low, whereas Chilean regulations were used to classify nutrient content as high (Ministry of Health, 2015). Nutrient content was classified as medium when it was not low nor high. Calorie content was only classified when it was high, as low calorie is not necessarily better than medium calorie content. Figure 1

shows a description of the three systems. The GDA system is included on a voluntary basis in the label of some products available in the Brazilian marketplace, whereas no products including the traffic-light system or the Chilean warning system are available. In addition, it is important to highlighted that the information shown in the GDA system is currently included on a compulsory basis on the back-of-package of products commercialized in Brazil.

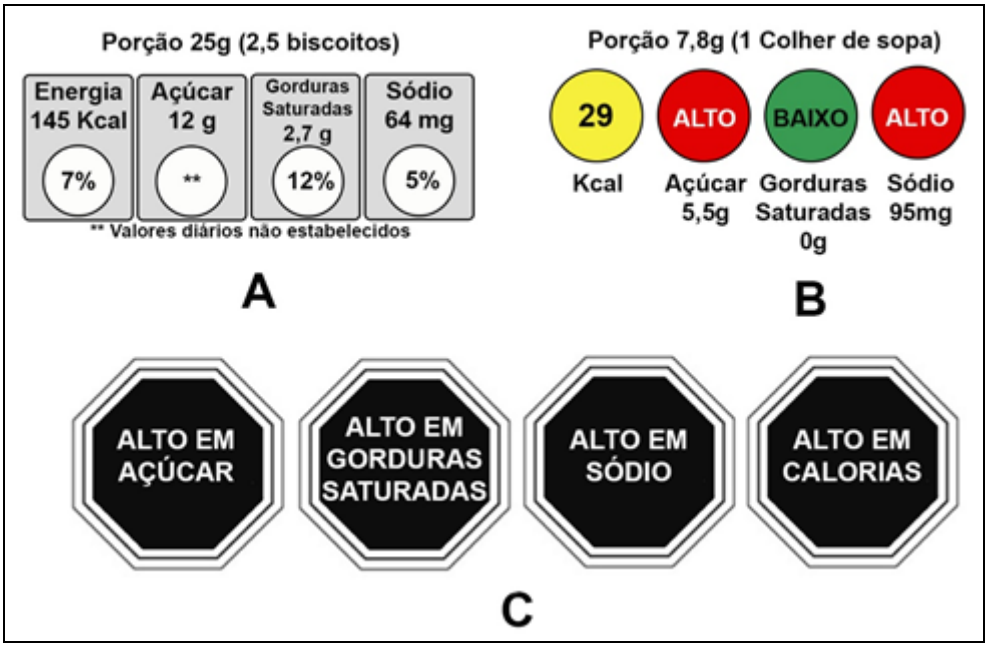

Figure 1. Front-of-pack nutrition labelling schemes included in the study: (A) monochromatic guideline daily amounts (GDA) system, (B) traffic light system, and (C) warning system.

2.3. Products targeted at children

Packages of eight processed products targeted at children were considered: c*hocolate flavored milk, sandwich cookies, sponge cake, frosted corn flakes, gelatin, yogurt, fruit-flavored beverage* and *corn snack.* Products were selected among the most popular categories targeted at children in the Brazilian marketplace (Ferreira et al., 2015). Packages from well-recognized brands were selected for the study. All products had high content of at least one nutrient, in agreement with the low nutritional quality of products targeted at children commercialized in the region (Ferreira et al., 2015; Giménez et al., 2017). The nutritional composition of the products and the classification of nutrient content is shown in Table 2.

Table 2. Nutritional composition of the processed products targeted at children included in the study and classification of calories, sugar, saturated fat and sodium content in low/medium/high.

Product	***Portion Size***	***Calories*** *Kcal/portion*	***Sugar*** *g/ portion*	***Saturated Fat*** *g/ portion*	***Sodium*** *mg/ portion*
Chocolate flavored milk	200mL	130 (MEDIUM)	18 (HIGH)	2 (MEDIUM)	115 (HIGH)
Corn snack	25g	114(HIGH)	0.7(LOW)	0.7(MEDIUM)	173 (HIGH)
Frosted corn flakes	30g	116 (HIGH)	12 (HIGH)	0 (LOW)	75 (MEDIUM)
Fruit-flavored beverage	200mL	78 (MEDIUM)	13 (HIGH)	0 (LOW)	8.5 (LOW)
Gelatin	7.8g	29 (MEDIUM)	5.5 (HIGH)	0 (LOW)	95 (HIGH)
Sandwich cookies	30g	145(HIGH)	12(HIGH)	2.7(HIGH)	64 (MEDIUM)
Sponge cake	60g	216 (HIGH)	21(HIGH)	3.5(HIGH)	135 (MEDIUM)
Yogurt	170g	101 (MEDIUM)	12(HIGH)	1.5 (LOW)	76 (MEDIUM)

Note: The classification of nutrient content was not shown in the Guidelines Daily Amounts (GDA) system. In the traffic-light system nutrient content was highlighted with the text descriptor (HIGH, MEDIUM or LOW) and the corresponding colour (red, yellow and green, respectively). In the warning system, separate octagonal black signs were included for nutrients with HIGH content.

Original packages from the commercial products were used and were modified to include the three FOP nutrition labelling schemes described in the previous section on an empty space of the packages. No additional information was modified. FOP schemes were always located on the bottom of the packages but their exact position (left/center/right) depended on the design of the labels. In addition, for each of the labels, the three FOP schemes were located in the exact same within the package. All images were displayed in a similar size. Figure 2 shows examples of how the labels were presented to participants.

Figure 2. Examples of how the packages of products targeted at children including different front-of-pack nutrition labeling schemes were presented to participants: (A) yogurt package with the monochromatic guideline daily amounts (GDA), (B) corn snack with the traffic light

system (TLS), and (C) sandwich cookies with the warning system. Brands were presented to participants and they are blurred for publication purposes**.**

2.4. Experimental procedure

Participants were randomly allocated into one of the three groups, each of which evaluated products using one of the FOP nutrition labelling schemes (GDA, TLS and warning system). The number of participants in each group ranged between 104 and 108 for children and between 92 and 93 for parents. No significant differences were identified using the chi-square test in the distribution of age, gender and type of school between the groups of children and parents that completed the task with different FOP labels ($p>0.38$ and $p>0.25$, respectively).

Participants were explained that they would be presented with a series of packages of food products. They were asked to look at the packages and to rate their perceived healthfulness using a 7-point scale varying from 1: not healthful to 7: very healthful. Parents were also asked to rate the ideal consumption frequency of the products by their children using a 7-point scale (1= almost never, 2= once a month, 3= twice a month, 4= once a week, 5= several times a week, 6= every day and 7= more than once a day). Packages were presented one by one on the screen of the computer, following a Williams' Latin Square experimental design. No additional information about the products or the FOP nutrition labelling schemes was provided during the task.

After package evaluation, participants were asked to complete a series of questions related to their personal data (gender, age and education level). Children completed the task in their classrooms using computers in small groups under the supervision of a researcher or a teacher, who were available to assist them if they had any doubt. Parents received an email with the link to the study and completed the task online.

2.5. Data analysis

Analysis of variance (ANOVA) was used to analyze healthfulness ratings and ideal consumption frequency of products targeted at children with different FOP nutrition labelling scheme. Although the data did not meet homoscedasticity and normality assumptions, ANOVA was used given that it has been shown to be robust to small violations of such assumptions (Meyners, Jaeger, & Ares, 2016; Schmider, Ziegler, Danay, Beyer, & Bühner, 2010).

Data from children and parents were analyzed separately. For each group, FOP nutrition labeling scheme, product, type of school and their interactions were considered as fixed sources of variation. In the case of children, age group (6-8 years old vs. 9-12 years old) and its interaction with the other variables was also considered in the ANOVA model. When the interaction between FOP nutrition labelling scheme and type of school was significant, ANOVA was performed separately for each type of school. Tukey's test was used for *post-hoc* comparison of the means. A significance level of 5% ($p <0.05$) was considered. All analyses were performed using R software (R Core Team, 2016).

3. RESULTS

3.1. Children's perceived healthfulness

Children's perceived healthfulness was significantly influenced by type of school, product, age and the interaction between FOP labels and age (Table 3). Differences in

perceived healthfulness between the products were found for the two age groups (6-8 years old vs. 9-12 years old), suggesting that they were able to discriminate products according to their healthfulness using the scale. For children, yogurt (average 5.2), fruit-flavored beverage (4.8) and frosted corn flakes (4.8) received the highest average healthfulness scores, whereas stuffed cookies (2.6) and corn snacks (2.2) received the lowest scores.

Regarding age differences, 6-8 year old children gave slightly higher ratings than 9-12 year old children. The larger differences were found for fruit-flavored beverage (4.9 vs. 4.1), frosted corn flakes (4.8 vs. 4.1) and sponge cake (3.0 vs. 2.3). In addition, children from public schools gave significantly higher average healthfulness ratings than children from private schools. For children from public schools, average healthfulness ratings ranged from 2.4 to 5.2, whereas for children from private school ratings ranged between 1.6 and 4.9. The largest differences between the two groups were found for chocolate-flavored milk (4.2 vs. 3.0), frosted corn flakes (4.8 vs. 3.6) and fruit-flavored beverage (4.8 vs. 3.4), whereas the smallest difference was found for yogurt (5.0 vs. 4.5).

Regarding the influence of FOP labels, they did not have any significant effect on the healthfulness perception of 6-9 years old children or in the perception of 9-12 years old children from public schools (Table 3). However, perceived healthfulness of 9-12 years old children from private school was significantly influenced by FOP labels. Children who evaluated products featuring the GDA system (overall average 3.1) gave significantly higher healthfulness ratings than those who evaluated products using the TLS (2.7) or the warning system (2.8). When differences were evaluated for individual products, they were significant only for frosted corn (Table 4).

Table 3. F-values from the analysis of variance performed on children's perceived healthfulness ratings for products featuring different front-of-pack (FOP) nutrition labelling schemes. Data were analyzed considering all children and separately for children of different age groups (6-8 years old vs. 9-12 years old), attending public and private schools.

Effect	All children (n=318)	6-8 years old children		9-12 years old children	
		Public school (n= 47)	Private school (n= 67)	Public school (n= 87)	Private school (n= 117)
Product	101.519*	13.024*	24.996*	23.075*	48.645*
FOP Label	0.794 ns	2.449 ns	1.450 ns	1.941 ns	5.108*
School	118.041*	-	-	-	-
Age	42.183 *	-	-	-	-
Product*FOP Label	0.704 ns	0.383 ns	0.594 ns	0.484 ns	0.651 ns
Product*School	1.602 ns	-	-	-	-
FOP Label*School	1.765 ns	-	-	-	-
Product*Age	1.505 ns	-	-	-	-
FOP Label*Age	4.558 *	-	-	-	-
School*Age	2.265 ns	-	-	-	-
Product*FOP Label*School	0.932 ns	-	-	-	-
Product*FOP Label*Age	0.479 ns	-	-	-	-
Product*School*Age	0.501 ns	-	-	-	-
FOP Label* School*Age	1.821 ns	-	-	-	-
Product*FOP Label*School*Age	0.404 ns	-	-	-	-

Table 4. Average and standard deviation (between parentheses) of healthfulness ratings* of products featuring different front-of-pack nutrition labelling scheme for 9-12 year old children attending to public and private schools.

Product	9-12 year old children					
	Public schools (n= 87)			Private school (n= 117)		
	GDA (n= 31)	TLS (n=26)	Warning System (n= 30)	GDA (n= 42)	TLS (n= 37)	Warning System (n= 38)
Chocolate flavored milk	4.5 (2.1) ^{aA}	4.1 (2.3) ^{abcA}	3.9 (1.9) ^{abA}	3.4 (1.8) ^{bcA}	2.9 (1.6) ^{bA}	2.6 (1.7) ^{bcdA}
Corn snack	2.6 (1.9) ^{bA}	2.5 (1.7) ^{cA}	2.8 (2.1) ^{bA}	1.9 (1.7) ^{dA}	1.8 (1.0) ^{dA}	1.9 (1.5) ^{cdA}
Frosted corn flakes	4.7 (1.7) ^{aA}	5.3 (2.1) ^{aA}	4.5 (1.7) ^{aA}	4.1 (1.7) ^{abA}	3.2 (1.5) ^{bB}	3.5 (1.9) ^{abB}
Fruit-flavored beverage	4.6 (1.9) ^{aA}	5.1 (1.9) ^{aA}	4.6 (2.2) ^{aA}	3.6 (1.9) ^{bcA}	3.3 (1.6) ^{abA}	3.4 (2.1) ^{abA}
Gelatin	4.4 (1.9) ^{aA}	4.6 (2.1) ^{abA}	3.7 (2.0) ^{abA}	2.9 (1.6) ^{cdA}	2.8 (1.5) ^{bcA}	3.0 (1.7) ^{bcA}
Sandwich cookies	2.6 (1.8) ^{bA}	2.8 (1.7) ^{cA}	2.8 (2.1) ^{bA}	2.0 (1.3) ^{dA}	1.6 (0.9) ^{dA}	1.6 (1.0) ^{dA}
Sponge cake	2.8 (2.0) ^{bA}	3.2 (1.8) ^{bcA}	2.7 (1.6) ^{bA}	1.9 (1.1) ^{dA}	1.9 (1.2) ^{cdA}	1.8 (1.1) ^{dA}
Yogurt	5.0 (1.9) ^{aA}	5.1 (2.0) ^{aA}	4.8 (2.1) ^{aA}	4.8 (1.8) ^{aA}	4.2 (1.6) ^{aA}	4.5 (1.8) ^{aA}

*Perceived healthfulness was assessed using a 7-point scales (1: not healthful, 7: very healthful).

GDA indicates guideline daily amount. TLS indicates traffic light system. Average values in the same column with different lowercase letters are significantly different according to Tukey's test ($p<0.05$). Average values with different capital letters in the same line for a type of school are significantly different according to Tukey's test ($p<0.05$).

3.2. Parents' healthfulness perception

As shown in Table 5, parents' perceived healthfulness was significantly influenced by product, FOP nutrition labelling scheme, the type of school their children attended, and the interaction between product and FOP nutrition labelling scheme. Parents whose children attended public schools gave significantly higher healthfulness ratings than those whose children attended private school (overall average scores: 2.8 vs 2.4). However, both groups of parents agreed on product ranking: sandwich cookies, corn snacks and sponge cake were the least healthful products whereas yogurt, gelatin and frosted corn flakes were the most healthful (Table 5).

Table 5. F-values from the analysis of variance performed on parents' perceived healthfulness and ideal consumption frequency ratings for products featuring different front-of-pack (FOP) nutrition labelling schemes.

	F-value	
Effect	**Healthfulness**	**Ideal consumption frequency**
Product	123.283*	95.301*
FOP Label	5.200*	2.105^{ns}
Type of school	33.173*	8.219*
FOP Label * Type of school	0.219^{ns}	5.783*
Product * Type of school	2.003^{ns}	1.085^{ns}
Product * FOP Label	1.908*	0.602^{ns}
Product* FOP Label * Type of school	0.947 ^{ns}	0.858^{ns}

* indicates a significant effect at $p<0.05$, whereas ns indicates that the effect was non-significant.

At the aggregate level, parents who evaluated packages with the warning system gave significantly lower healthfulness ratings than those who evaluated products with the GDA system (2.4 vs 2.7). Meanwhile, parents who evaluated products with the traffic-light system did not significantly differ from the other two groups. However, differences between FOP labels were not significant for all products. As shown in Table 6, significant differences among the three groups were only found for yogurt and gelatin. For both products, parents who evaluated packages with the GDA system gave significantly higher healthfulness ratings than those who evaluated the packages with the traffic-light system or the warning system.

Table 6. Parents' average and standard deviation (between parentheses) of healthfulness ratings* of products featuring different front-of-pack nutrition labelling scheme.

Product	**FOP nutrition labelling scheme**		
	GDA (n=93)	**TLS (n=93)**	**Warning system (n=92)**
Chocolate flavored milk	2.7(1.6) ^{dA}	2.7(1.8) ^{cA}	2.3(1.7) ^{cA}
Corn snack	1.3(0.8) ^{fA}	1.5(1.4) ^{eA}	1.3(0.9) ^{eA}
Frosted corn flakes	3.2(1.7) ^{cA}	3.3(1.8) ^{bA}	3.3(1.8) ^{bA}
Fruit-flavored beverage	2.2(1.5) ^{eA}	2.2(1.7) ^{dA}	1.9(1.3) ^{cA}
Gelatin	3.8(1.7) ^{bA}	3.3(1.8) ^{bB}	3.2(1.7) ^{bB}
Sandwich cookies	1.4(1.2) ^{eA}	1.6(1.2) ^{eA}	1.5(1.3) ^{deA}
Sponge cake	1.9(1.1) ^{deA}	1.9(1.4) ^{deA}	1.9(1.3) ^{cdA}
Yogurt	4.3(1.7) ^{aA}	3.8(1.7) ^{aB}	3.8(1.6) ^{aB}

*Perceived healthfulness was assessed using a 7-point scale (1= not healthful, 7= very healthful).
GDA indicates guideline daily amount. TLS indicates traffic light system. Average values in the same column with different lowercase letters are significantly different according to Tukey's test ($p<0.05$). Average values with different capital letters in the same line are significantly different according to Tukey's test ($p<0.05$).

Regarding perceived ideal consumption frequency, ANOVA revealed that this variable was significantly affected by type of product, type of school attended by the children and the interaction between FOP nutrition labeling scheme and type of school (Table 5). Average ideal consumption frequency ratings ranged between 1.2 and 4.3 (Table 7), which correspond to "once a month" and "several times a week", respectively. Products were sorted according to their ideal consumption frequency similarly than they did according to perceived healthfulness (cf. Tables 5 and 7).

FOP nutrition labeling scheme only significantly affected perceived ideal consumption frequency of parents whose children attended public schools. As shown in Table 7, average perceived ideal consumption frequency was significantly lower for parents who evaluated two of the products with the warning system: gelatin and corn snacks. In the case of the first product, average ratings for the warning system were significantly lower than those for the GDA system, whereas in the second one there was a significant difference between the warning and the traffic-light system. Meanwhile, for corn snacks the traffic light system increased ideal consumption frequency compared to both the GDA and the warning system.

Table 7. Average ideal consumption frequency* and standard deviation (between parentheses) of products featuring different front-of-pack nutrition labelling schemes** for parents whose children attending public and private schools.

Product	Public schools (n=131)			Private school (n=147)		
	GDA (n=43)	TLS (n=45)	Warning System (n=43)	GDA (n=50)	TLS (n=48)	Warning System (n=49)
Chocolate flavored milk	2.6(1.5) ^{bA}	2.9(2.1) ^{aA}	3.1(1.6) ^{aA}	2.7(1.5) ^{cA}	2.6(1.6) ^{fA}	2.3(1.3) ^{cA}
Corn snack	1.5(0.6) ^{dB}	1.9(1.4) ^{cA}	1.6(0.8) ^{bB}	1.2(0.7) ^{eA}	1.7(1.3) ^{fA}	1.4(0.6) ^{eA}
Frosted corn flakes	3.5(1.4) ^{aA}	3.0(1.9) ^{aA}	3.4(1.9) ^{aA}	2.8(1.7) ^{cA}	3.2(1.7) ^{bA}	2.9(1.7) ^{bA}
Fruit-flavored beverage	2.4(1.4) ^{bcAB}	2.7(1.9) ^{abA}	2.1(1.8) ^{bB}	2.0(1.4) ^{dA}	2.3(1.3) ^{dfA}	1.9(1.2) ^{cdA}
Gelatin	3.7(1.7) ^{aA}	3.4(2.2) ^{aAB}	3.1(1.7) ^{aB}	3.6(1.8) ^{bA}	3.1(1.7) ^{bcA}	2.9(1.8) ^{bA}
Sandwich cookies	1.8(0.8) ^{cdA}	1.9 (1.4) ^{bcA}	1.9(0.9) ^{bA}	1.6(0.8) ^{deA}	1.5(0.9) ^{fA}	1.6(0.9) ^{deA}
Sponge cake	1.6(1.1) ^{dA}	1.9(1.6) ^{cA}	1.8(1.1) ^{bA}	1.8(1.1) ^{dA}	1.9(1.0) ^{efA}	1.8(1.2) ^{cdeA}
Yogurt	3.7(1.7) ^{aA}	3.6(1.9) ^{aA}	3.8(1.8) ^{aA}	4.3(1.5) ^{aA}	3.9(1.5) ^{aA}	3.8(1.7) ^{aA}

*Ideal consumption frequency was assessed using a 7-point scale (1= almost never; 7= more than once a day).

**GDA indicates guideline daily amount. TLS indicates traffic light system. Average values in the same column with different lowercase letters are significantly different according to Tukey's test ($p<0.05$).

Average values with different capital letters in the same line for a type of school are significantly different according to Tukey's test ($p<0.05$).

4. DISCUSSION

The inclusion of front-of-pack nutrition labelling is one of the public policies that can be implemented to improve consumer ability to identify unhealthful food products (Hawley et al., 2013). This is particularly relevant in the case of foods targeted at children given their unfavorable nutrient content (Giménez et al., 2017; Ferreira et al., 2015). Most research on the

efficiency of FOP labels have been conducted with adults (Hawley et al., 2013). However, considering that children have a strong influence on their parents' food purchases and are also able to make independent purchases with their own money (Mazzonetto & Fiates, 2014; Marshall, O'Donohoe, & Kline, 2007; Wilson & Wood, 2004; McNeal, 2000), studying the impact of FOP labels on children healthfulness perception is a relevant input for policy makers.

In the present study, three front-of-package nutrition labelling schemes were compared in terms of their influence on children and parents' healthfulness perception of packages of foods targeted at children.

4.1. Influence of front-of-pack nutrition labelling schemes on healthfulness perception of parents and children

The present study focused on three FOP nutrition labelling schemes that differ in the extent to which they assist consumers for evaluating product healthfulness: GDA, traffic-light and warning systems. FOP nutrition labelling scheme had a significant effect on parents' healthfulness perception, which was modulated by type of product. The traffic light and warning system significantly decreased healthfulness perception compared to the GDA system for yogurt and gelatin, whereas for the rest of the products no significant differences were found. As shown in Table 2, yogurt and gelatin did not largely differ from the other products in the type and number of nutrients with high content. However, they were perceived by parents as the healthiest products when evaluated using the GDA system, which suggests that these products had strong healthful association for parents. The healthful image of these products can be explained by the fact that they are usually marketed by food companies using health and nutrition claims (e.g. Ferreira et al., 2015; Giménez et al., 2017). Therefore, results from the present work suggest that the inclusion of directive and semi-directive FOP labeling schemes are expected to mainly influence parents' perception of products that are inaccurately regarded as healthful. Similar results have been reported by Arrúa et al. (2017b) when evaluating the effect of the warning system on adult consumers' healthfulness perception of unhealthful processed products. Maubach & Hoek (2008) reported that the traffic-light system decreased parents' perceived healthfulness of a low-nutrient cereal compared to the nutritional information panel or the GDA system. In addition, Pettigrew et al. (2017) have recently shown that children and adults prefer semi-directive FOP labels to non-directive FOP labels, such as the GDA, which are perceived as complicated and difficult to understand.

At the aggregate level, the effect of warnings on parents' perceived healthfulness and ideal consumption frequency was larger than for the traffic light system. Similar results have been recently reported by Arrúa et al. (2017a, b) when comparing warnings and the traffic light system. According to these authors, warnings had a larger effect than traffic-light system on consumers' perceived healthfulness of products with unfavorable nutrient profile, and were more efficient to discourage choice of unhealthful products. This difference can be explained considering that warnings only highlight high nutrient content and, therefore, clearly communicate the idea that products are not healthful. On the contrary, the traffic light system classifies the content of four nutrients in low/medium/high and can communicate contradictory information, as products can have high content of one nutrient and low content of other nutrients. Therefore, the traffic-light system requires consumers to reach an overall assessment of product healthfulness based on the simultaneous evaluation of the content of different nutrients, which has been reported to be a difficult task (Black & Rayner, 1992). In the present work, all products had low content of at least one nutrient, which was highlighted in green in the traffic-light system. This information about low nutrient content may have increased perceived healthfulness (Cabrera et al., 2017) and could explain the fact that

warnings were more efficient in reducing healthfulness perception than the traffic light system.

Children were less influenced by FOP labelling schemes than parents, in agreement with Arrúa et al. (2017a), who reported that the traffic light system did not influence healthfulness perception of school-aged children. FOP schemes only influenced the perception of 9-12 years old children who attended private school (middle/high socio economic status). A possible explanation for the lack of effect of FOP labels on the healthfulness perception of most children is that they based their ratings on their previous preconceived perception of the products and label design, instead of relying on nutrition information. In this sense, Arrúa et al. (2017a) showed that cartoon characters, fruit drawings and vitamin claims had higher relative importance compared to the TLS or warnings in school-aged children's choice of labels of snack foods. The importance of label design to attract children's attention and shift their perception of the products has been extensively recognized (Institute of Medicine, 2006; Letona, 2015). Products targeted at children are usually promoted using cartoon characters, nutrition claims, images of natural foods, references to fun and health, as well as depictions of physical activity (implying force or strength from product consumption) (Zimmerman & Shimoga, 2013; Valkenburg & Peter, (2013); Harris et al., 2012). Given that children have been reported to be highly susceptible to these marketing strategies (Elliot, 2009), scientific and governmental organizations have suggested the need to implement regulations and educational campaigns to minimize the misleading influence of the information included on the packages of unhealthful products targeted at children (Castonguay et al., 2013; Institute of Medinice, 2006; Letona, 2015). Further research is necessary to study children and parents' trade-offs when evaluating packages of food products including both FOP nutritional labelling schemes and marketing strategies (e.g. cartoon characters, nutrition claims, fruit pictures).

In the present work, the influence of FOP nutrition labelling schemes on perceived healthfulness was relatively small. Different factors may be responsible for these results. Firstly, most of the participants were probably not familiar with directive and semi-directive systems (TLS and warnings, respectively) as they are not available in the Brazilian marketplace. Therefore, for the great majority of them it was the first contact with this simplified nutrition information format. According to Grunert & Wills (2007), familiarity with labeling systems is probably one of the most important factors influencing consumer willingness to use them. This may be particularly relevant in the case of children, as they do not frequently use nutrition information to guide their food choices (Zucchi & Fiates, 2016). Secondly, the products included in the study were available in the Brazilian market and therefore participants may have based their healthfulness judgments on their previous experiences with the products and not in the nutritional information included on the packages. Lastly, most of the products included in the present research are already perceived as unhealthful by both parents and children. However, previous research has stressed that FOP labels are expected to mainly influence consumer perception of products that are wrongfully perceived as healthful (e.g. gelatin or yogurt with high sugar content), as previously reported by Arrúa et al. (2017c).

4.2. Influence of individual characteristics on healthfulness perception of parents and children

Socio-economic status had a large influence on healthfulness perception of parents. Parents whose children attended private school were more critical about product healthfulness compared to those whose children attended public schools. The same tendency was observed among children. Similar results have been reported by Machín et al. (2017) and Arrúa et al.

(2017c) when comparing healthfulness perception of low and middle income adults and children in Uruguay. This suggests that people from low socio-economic status may be more vulnerable to the marketing strategies of food companies and may rely on simple cues rather than objective nutritional information to evaluate product healthfulness. In this sense, Machín et al. (2016) reported that low-income mothers relied on vitamin claims to evaluate the healthfulness of products targeted at children. In addition, the association of products with identity, image and social status may create a positive halo that could override the effect of their unfavorable nutritional profile (Tivadar & Luthar, 2005). For this reason, increasing nutritional knowledge and awareness of the nutritional composition of products of low socio-economic status (SES) people, as well as regulation of marketing strategies, seem necessary to discourage consumption of unhealthful foods (Trabashkina, Quester & Crouch, 2016). In this sense, semi-directive and directive FOP nutrition labeling schemes had a larger influence on the perceived ideal consumption frequency of parents whose children attended public schools (low SES) compared to those whose children attended private school. It has been extensively reported that consumers with higher SES have higher education and knowledge about nutrition than those with lower SES (Hough & Sosa, 2015). For this reason, FOP labeling systems may have a larger effect on the perception of low socio-economic populations by providing them with simple information that can improve their ability to evaluate product healthfulness (McArthur, Chamberlain & Howard, 2001; Besler, Buyuktuncer & Uyar, 2012; Machín et al. 2017).

Although SES influenced healthfulness perception of children, age also modulated the influence of FOP nutrition labelling schemes. The TLS system and warnings only significantly influenced healthfulness perception of 9-12 years old children who attended private school. This result can be explained considering that older children from private school (mostly from middle/high SES) had higher cognitive skills and paid more attention to the labels than younger who attended public schools (low socio-economic status). According to Guinard (2001), 5-7 years old children are considered 'preoperational', and have limited logical thinking abilities and are more affected by irrelevant dimensions of complex stimuli than older children and adults. Therefore, FOP labels may not have a strong influence on the perception of small children unless educational strategies to increase their awareness of FOP labels are implemented.

4.3. Limitations of the study

The present study had several limitations. First, although the sample was diverse in terms of age and socio-economic status, participants were selected using a small convenience sample of two institutions from one Brazilian city (Rio de Janeiro). This limits the generalizability of the findings and stresses the need to conduct further studies that more broadly represent other consumer populations in the country. Secondly, the influence of gender and attitudinal variables (e.g. health consciousness and nutrition knowledge) that have been reported to influence the nutrition information use (Visschers, Hartmann, Leins-Hess, Dohle & Siegrist, 2013) was not considered in the present study. These variables may modulate the influence of FOP nutrition labelling schemes on children and parents' healthfulness ratings. Thirdly, all the products included in the present research had low nutritional quality, which reflects the characteristics of the foods targeted at children available in the marketplace (Gimenez et al., 2016, Ferreira et al., 2015, Elliot, 2007). Further research should focus on the influence of FOP labels on children and parents' healthfulness perception including medium and high nutritional quality products.

Finally, it is important to stress that the present work focused exclusively on healthfulness perception. Considering that the ultimate goal of FOP nutrition labelling

schemes is encouraging more healthful food choices (EUFIC, 2017), further research should focus on the influence of FOP nutrition labelling schemes on the food choices of children and parents.

5. CONCLUSIONS

Results from the present work provided insights on the influence of three schemes (GDA, traffic light system and warnings) on Brazilian children and parents' healthfulness perception. The traffic-light system and warnings decreased parents' healthfulness perception of products with a positive health image compared to the GDA system; being the effect higher for warnings than for the traffic light system. In the case of children, both systems only decreased healthfulness perception for 9-12 year old children who attended private school. Although these results suggest that the use of directive FOP labels such as warning logos can reduce healthfulness perception of products with unfavorable nutritional profile, further studies evaluating the influence of FOP labels on the food choices of parents and children are still necessary.

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APÊNDICE II

Can front-of-pack nutrition labeling modify children's emotional associations with unhealthy food products? An experiment using *emoji*

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ABSTRACT

Food products targeted at children are usually marketed using persuasive elements aimed at creating positive hedonic and emotional associations. For this reason, changes in children's emotional associations with unhealthy food products can discourage their consumption. In this context, the aim of the present study was to compare children's emotional associations with food products featuring different front-of-pack (FOP) nutrition labelling schemes. A total of 492 children (6-12 years old) were randomly divided into three groups, each of which evaluated a series of packages featuring different FOP nutrition labelling schemes: guidelines daily amount (GDA), traffic light system (TLS) and nutritional warnings. For each of the six packages and three unpackaged products, children were asked to select all the *emoji* from a list that described how they would feel eating the product. Data were analyzed using generalized linear models. FOP nutrition labelling significantly affected the frequency of use 5 of the 16 *emoji*. In general, the inclusion of directive and semi-directive schemes caused a reduction in the frequency of use of *emoji* associated with positive emotions. The effect of FOP nutrition labelling scheme on emotional associations was moderated by age and type of school. The effect of directive and semi-directive FOP nutritional schemes, in special nutritional warnings, tended to be higher for younger children and children from public schools. These results suggest that FOP nutrition labelling may contribute to discouraging consumption of products with high content of nutrients associated with non-communicable diseases among children.

Keywords: *nutrition information; traffic-light system; nutritional warnings; emotions; emotional responses.*

1. INTRODUCTION

The prevalence of childhood overweight and obesity has significantly increased worldwide and has become one of the most important public health problems (De Onis, Blössner, & Borghi, 2010; Gupta, Goel, Shah, & Misra, 2012). Excessive weight gain in childhood is a risk factor for the development of non-communicable diseases, such as type 2 diabetes, dyslipidemia, hypertension, and cardiovascular diseases (Casagrande, Waib, & Sgarbi, 2017; De Meneck, Victorino de Souza, Oliveira, & do Franco, 2018). Unhealthy food habits, characterized by excessive intake of calories, fat and sugar, have been identified as one of the main determinants of this situation (Rivera, de Cossio, Pedrazza, Aburto, Sánchez, & Martorell, 2014)

The current food environment is characterized by the wide availability of palatable and energy dense foods (Swinburn et al., 2011). In particular, the great majority of the foods and beverages targeted at children have shown excessive content of sugars, fat or sodium (Chapman, Nicholas, Banovic, & Supramaniam, 2006; Elliot, 2007; Ferreira, Silva, Moraes, & Tancredi, 2015). These products are usually marketed using persuasive elements aimed at creating positive hedonic and emotional associations, such as cartoon characters, celebrities, toys and collectables, movie and TV shows tie-ins, and appeals to taste and fun (Jenkin, Madhvani, & Bowers, 2014). Emotional appeals often associate food consumption with happiness, fun and feelings of being grown-up, powerful, cool, or popular(Page & Brewster, 2015) and have been reported to have a large influence on children's food preferences and purchase behavior (Hastings, McDermott, Angus, Stead, & Thomson, 2006).

Given the influence of emotions on food consumption (Jiang, King, & Prinyawiwatkul, 2014), changes in children's emotional associations with unhealthy food products can discourage their consumption. One of the strategies that can be used for this purpose is to make the negative aspects of products more salient by highlighting their nutritional composition. Children (6-12 years old) have been shown to understand information about the nutritional composition of foods and to be able to use it to classify foods as healthful and unhealthful (Brierley & Elliot, 2015; Slaughter & Ting, 2010; Soldavini, Crawford, & Ritchie, 2012; Heard et al., 2016). In this sense, recent research has shown that simplified nutrition information can be easily understood by children and can trigger changes in their food choices (Ares et al., 2016; Arrúa et al., 2017; Privitera, Phillips, Zuraikar, & Paque, 2015; Pettigrew, Talati, Miller, Dixon, Kelly, & Ball, 2017). However, the influence of nutrition information on children's emotional associations has not been studied yet.

Front-of-pack (FOP) nutrition labeling aims at making the nutritional composition of food products easy to find and understandable for consumers (Hawley, Roberto, Bragg, Liu, Schwartz, & Brownell, 2013), with the purpose of encouraging more healthful food choices (Reisch & Sunstein, 2016; Scrinis & Parker, 2016). Several FOP nutrition labeling schemes have been developed worldwide, which differ in the extent to which they guide healthfulness judgments: non-directive, semi-directive and directive (Hodgkins et al., 2012). Non-directive schemes, such as the guideline daily amount (GDA) system, only provide numerical information about nutrient content, and do not provide additional interpretational aids to facilitate understanding of nutritional information. On the contrary, semi-directive and directive systems include interpretation aids that convey information about product healthfulness. The present work focuses on two of such schemes: the traffic-light system (TLS) and nutritional warnings. The TLS includes quantitative information about nutrient content, and its corresponding classification in low/medium/high using text descriptors and a color code (red, yellow and green) (Food Standards Agency, 2007). Meanwhile, nutritional warnings only highlight high nutrient content using octagonal black signs with the expression "High in" (Ministerio de Salud, 2015).

The effect of FOP nutrition labeling is expected to be moderated by children's individual characteristics. In this sense, age is expected to influence children's ability to understand nutritional information due to differences in their cognitive development (Popper & Kroll, 2011). In addition, socio-economic status has been reported to be one of the main determinants of food choice and eating habits (Hough & Sosa, 2015). Previous studies have shown that people from low socio-economic status have lower consumption of healthy foods and higher intake of fat, added sugar and salt than those from medium/high socio-economic status and, therefore, are less likely to meet dietary recommendations (Evans, Wells, & Schamberg, 2010, Inglis, Ball, & Crawford, 2009, Sosa, Cardinal, & Contarini, 2015, Vilaro, Barnett, Mathews, Pomeranz, & Curbow, 2016). In addition, considering that food consumption can be regarded as an expression of social status (Tivadar & Luthar, 2005), differences in the emotional and conceptual associations of food products with socio-economic status are also expected (Fonseca, Ares, & Deliza, 2018). In this sense, children from low socio-economic status have been recently reported to have a more positive association with snack products with high sugar content than those from middle/high socio-economic status (Arrúa et al., 2017; Yoo et al., 2017).

In this context, the aim of the present study was to compare children's emotional associations with food products featuring different FOP nutrition labeling schemes. Two schemes that highlight high nutrient content, the traffic-light system and nutritional warnings, were compared with the GDA system, which only provides numeric information.

2. MATERIAL AND METHODS

2.1. Participants

A total of 492 children aged between 6-12 years participated in the study. Children were recruited from four schools located in two cities in Brazil: Rio de Janeiro/RJ and Rio Pomba/MG. One private school and one public school were selected in each city. The type of school was considered as indicator of the socio-economic status of the children. According to the Brazilian school census middle/high income children mainly attend private schools, whereas low income children mainly attend public schools (MEC, 2016). Table 1 presents the socio-demographic characteristics of the participants.

Parents signed informed consent forms to allow their children's participation in the test and children gave oral assent to participate. A small gift was given to children as a compensation for their participation. The study was performed between March and April 2018 and was approved by the Brazilian Committee of Ethics in Research (*Plataforma Brasil - CAAE 55023416.0.0000.5285*).

Table 1. Socio-demographic characteristics of the total participants and of the three experimental groups whom evaluated packages featuring different front-of-package nutrition labeling schemes.

	Total (n= 492)		**GDA** (n= 157)		**TLS** (n=163)		**Nutritional Warnings** (n=172)	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Gender								
Female	238	48	66	42	81	49	91	53
Male	254	52	91	58	82	51	81	47
Age								
6-10 years	329	67	102	65	107	66	120	70
11- 12 years	163	33	55	35	56	34	52	30
Type of School								
Public	266	54	91	58	82	51	93	54
Private	226	46	66	42	81	49	79	46

2.1. Food products

Six food products targeted at children were included in the study based on their wide availability on the Brazilian marketplace (Ferreira et al., 2015): *chocolate flavored milk, sandwich cookies, frosted corn flakes, gelatin, yogurt, and corn snack.* Packages from well-recognized brands were used and pictures were obtained from the Internet. All products had high content of at least one nutrient.

In addition, three un-packaged products were included (ice cream, banana and broccoli) to evaluate the validity and discriminative ability of the questionnaire. These products were expected to elicit different emotional associations in children: ice-cream and banana were expected to be associated with positive emotions, whereas broccoli was expected to be associated with negative emotional associations.

2.3. Front-of-package nutrition labeling schemes

Three FOP nutritional labeling schemes were selected: GDA system, traffic-light system (TLS) and nutritional warnings (Figure 1). The GDA included quantitative information about the content per serving of calories, sugar, saturated fat and sodium, and their corresponding percentage of the recommended daily intake. The TLS presented information about the same nutrients (expressed as content per serving) and their corresponding classification into low/medium/high using text descriptors and a color code (green, yellow and red). The criteria of the Food Standards Agency (2007) were used to classify the content of sugar, saturated fat and sodium. Calorie content was only classified when it was high using the criterion of the Chilean Ministry of Health (Ministerio de Salud, 2015). Finally, nutritional warnings were included when the content of calories, sugar, saturated fat and sodium exceeded the criteria established by the Chilean Ministry of Health using separate octagonal black sign (Ministry of Health, 2015). The pictures of the packages described in the previous section were digitally modified to include each of the FOP nutrition labeling schemes, as exemplified in Figure 2.

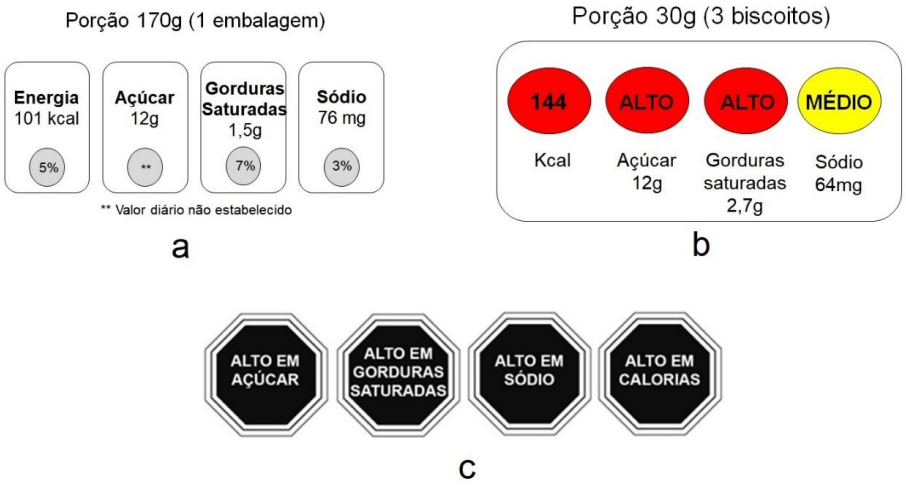


Figure 1. Front-of-pack nutrition labellng schemes included in the study: (a) monochromatic guideline daily amounts (GDA), (b) traffic light system (TLS), and (c) nutritional warnings

Figure 2. Examples of how the packages of products targeted at children including different front-of-pack nutrition labeling schemes were presented to participants: (a) gelatin package with the monochromatic guideline daily amounts (GDA), (b) yogurt with the traffic light system (TLS), and (c) corn snack with the nutritional warnings.

2.4. Experimental procedure

A between-subjects design was used to compare the emotional associations of the products featuring the three FOP nutrition labeling schemes. Children were randomly divided into three groups, each of which evaluated products featuring one of the FOP nutrition labeling schemes (GDA, TLS or nutritional warnings). The three groups did not significantly differ in their age (p=0.600), gender (p=0.132) and type of school (p=0.389) distribution (Table 1).

*Emoji*s were used for capturing participants emotional associations given their simplicity and popularity among children (Gallo et al. 2017ab; Schouteten et al., 2018;

Schouteten et al., 2019). They were explained that they would be presented with a series of food products. They were asked to look at each of the images and to select all the *emoji*s that described how they would feel eating the product. A total of 16 facial *emoji*s were included in the present work, selected from those used by Jaeger, Lee, & Ares, G. (2018): *face savoring delicious food* (😋), *relieved face* (😌),*smiling face with heart shaped eyes* (😍),*smiling face with open mouth* (😄) *smiling face with smiling eyes* (😊), *smiling face with sunglasses* (😎), *winking face* (😉), *neutral face* (😐), *confounded face* (😖), *confused face* (😕), *disappointed face* (😞), *face screaming in fear* (😱), *flushed face* (😳), *loudly crying face* (😭), *unamused face* (😒), *weary face* (😩).

Packages were presented on a computer screen in monadic sequence, following a Williams' Latin Square experimental design. Children completed the task in their classrooms using computers in small groups under the supervision of a researcher or a teacher, who were available to assist them. Data were collected using Compusense Cloud (Compusense Inc., Guelph, Canada).

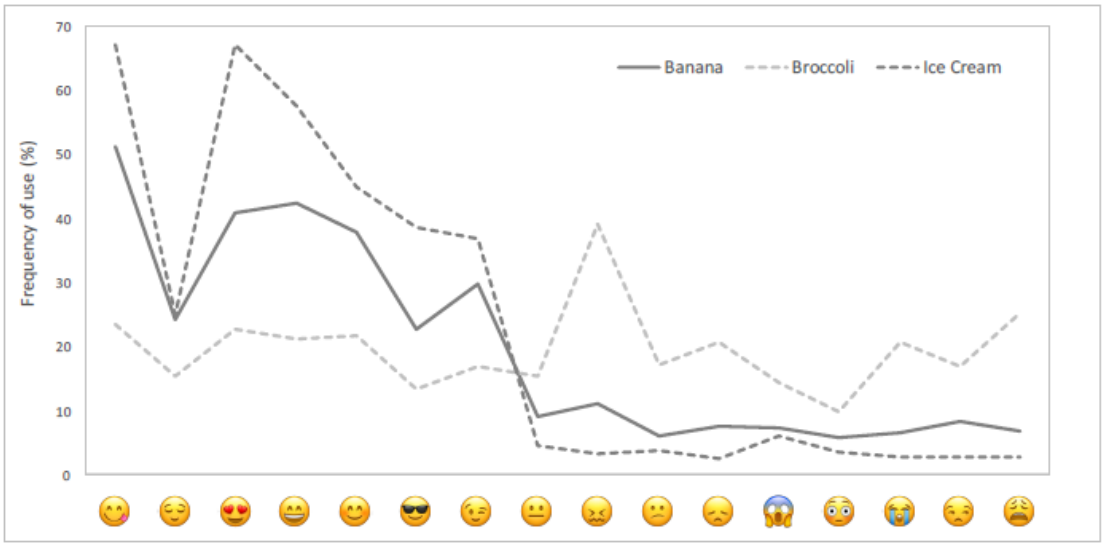
2.5. Data analysis

The frequency of use of each *emoji* to describe each stimulus was calculated at the aggregate level and for each experimental condition, type of school and age group. The frequency of use of the *emoji* to describe unpackaged products was used to evaluate the validity of the *emoji* questionnaire. Data were analyzed separately for packaged and unpackaged products using generalized linear models (GLM) (Cardinal, Zamora, Chambers, Carbonel Barrachina, & Hough, 2015)., Product, nutrition labelling schemes, age, type of school and their interaction were considered as independent variables in the model for the unpackaged products. All data analyses were carried out using R software version 3.2.3 (R Core Team, 2017).

3. RESULTS

3.1. Emotional associations of unpackaged products - Validation of the emoji questionnaire

Figure 3 shows the frequency of use of the *emoji* for describing the emotional associations with the three un-packaged products. Significant differences between the products were found for all *emoji*s. The profiles showed face validity, as the ice cream was mainly described using *emoji*s associated with positive emotions, such *as face savoring delicious food* (😋), *face with heart shaped eyes* (😍), *smiling face with open mouth* (😄) *and smiling face with smiling eyes* (😊). Banana was also described using positive *emoji*s but the frequency of use of most of them was significantly lower compared to ice-cream. On the contrary, broccoli showed the lowest frequency of use of the *emoji*s associated with positive emotions, and the highest frequency of use of those associated with negative emotions (*confused face* (😖), *weary face* (😩), *crying face* (😭) and *disappointed face*(😞)).



Note: Significant differences among samples were significant for all the emoji.

Figure 3. Percentage of consumers who used each of the *emoji* to describe each of the unpackaged products used to check the validity of the *emoji* questionnaire

3.2. Emotional associations of packaged products - Influence of FOP nutrition labeling schemes, age and type of school.

At the aggregate level, the frequency of use the *emoji* to describe the packaged products varied from 6.1% *(Disappointed face* (😞)*)* to 47.6% (*Face savoring delicious* (😋)). As expected, *emoji*s associated with positive emotions were the most frequently used: *face savoring delicious food* (😋), *smiling face with heart shaped eyes* (😍), *smiling face with open mouth* (😄), *smiling face with smiling eyes* (😊) and *winking face* (😉). As shown in Figure 4, the emotional associations of all the evaluated products were very similar, being mainly described using *emoji* associated with positive emotions: *face savoring delicious food* (😋), *smiling face with heart shaped eyes* (😍), *smiling face with open mouth* (😄), *smiling face with sunglasses* (😎), and *winking face* (😉). The emotional associations of the packaged products were similar to those from banana (c.f. Figures 3 and 4).

Significant differences between products were found for the *emoji face savoring delicious food* (😋), *smiling face with heart shaped eyes* (😍), *smiling face with open mouth* (😄), *smiling face with sunglasses* (😎), *winking face* (😉), *disappointed face* (😞), *unamused face* (😒) and *weary face* (😩) (Table 2). Chocolate milk and corn snacks showed the highest frequency of use of the *emoji face savoring delicious food* (😋), *smiling face with heart shaped eyes* (😍) and *smiling face with smiling eyes* (😄), whereas yogurt showed the lowest frequency of use.

Table 2. Results of the generalized linear model used to analyze the influence of product, front-of-package nutrition labeling scheme, age and type of school on the frequency of use of *emoji* to describe children's emotional associations with packaged products targeted at children.

Emoji	**p-value**												
	Product	Front of Pack (FOP)	Age	School type	Product * FOP	Product * Age	FOP * Age	Product * School	FOP * School	Product * FOP * Age	Product * FOP * School	FOP * Age * School	Product * Age * School
Face savoring delicious food (😋)	**0.000**	**0.017**	0.122	**< 0.001**	0.445	0.490	0.982	0.285	**0.005**	0.797	0.224	**0.000**	**0.040**
Relieved face (😌)	0.066	0.791	**<0.001**	0.000	0.908	0.976	**0.003**	0.432	0.699	0.674	0.884	0.601	0.651
Smiling face with heart shaped eyes (😍)	**0.000**	**0.007**	0.915	**<0.001**	0.519	0.280	0.254	0.142	**0.004**	0.892	0.945	**0.000**	0.736
Smiling face with open mouth (😄)	**0.002**	**0.031**	**<0.001**	**<0.001**	0.966	0.102	**0.003**	0.266	**0.018**	0.774	0.701	**0.004**	0.218
Smiling face with smiling eyes (😊)	0.166	0.547	**0.001**	**<0.001**	0.670	0.810	0.196	0.473	0.393	0.609	0.745	**0.003**	0.252
Smiling face with sunglasses (😎)	**0.011**	**<0.001**	**<0.001**	**<0.001**	0.896	0.793	0.086	0.474	0.383	0.988	0.812	0.644	0.709
Winking face (😉)	**0.005**	0.405	**<0.001**	0.092	0.787	0.945	0.546	0.480	0.262	0.924	0.945	**0.038**	0.220
Neutral face (😐)	0.547	0.895	**0.001**	**<0.001**	0.709	0.915	0.373	0.149	0.722	0.654	0.443	0.704	0.309
Confounded face (😖)	0.000	0.359	0.102	0.563	0.602	0.281	0.495	0.765	0.746	0.576	0.955	0.441	0.642
Confused Face (😕)	0.852	0.102	**0.043**	**<0.001**	0.510	0.921	0.245	0.821	0.060	0.646	0.432	0.156	**0.010**
Disappointed but relieved face (😓)	**0.010**	0.468	**0.000**	0.106	0.327	0.693	**0.042**	0.454	0.463	0.582	0.979	0.809	0.588
Face screaming in fear (😱)	0.293	0.265	**<0.001**	0.139	0.998	0.917	0.212	0.317	**0.005**	0.888	0.778	**0.004**	0.538
Flushed face (😳)	0.471	0.192	**<0.001**	0.535	0.272	0.614	0.359	0.731	0.563	0.313	0.628	0.422	0.438
Loudly crying face (😭)	0.045	**0.036**	**<0.001**	0.137	0.855	0.964	0.976	0.440	0.649	0.738	0.203	0.137	0.777
Unamused face (😒)	**0.038**	0.570	0.087	**0.042**	0.498	0.954	0.501	0.294	0.215	0.150	0.747	**0.033**	0.288
Weary face (😩)	**0.009**	0.810	**<0.001**	0.327	0.845	0.698	0.902	0.335	0.263	0.790	0.752	**0.033**	0.457

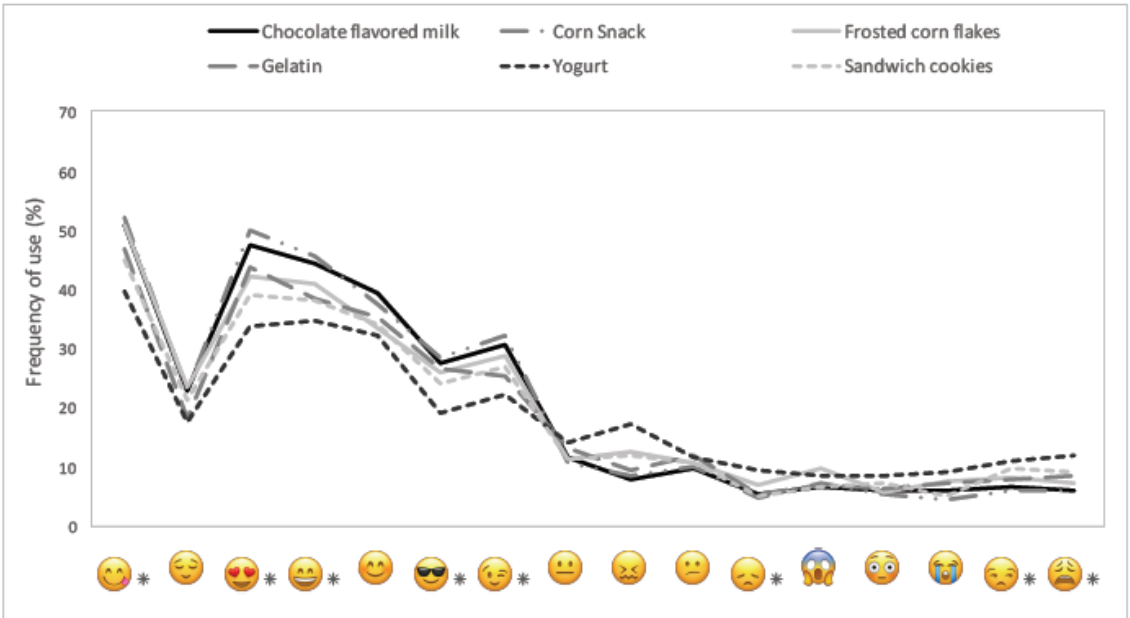


Figure 4. Percentage of consumers who used each of the *emoji* to describe the six packaged products of the study.

Age significantly affected the frequency of use of most *emoji*s. In general, younger children (6-10 years) tended to use more frequently most of the *emoji*s (both positive and negative) to describe how they would feel eating the products compared to older children (11-12 years) (Table 2). Type of school attended by children also affected the frequency of use of half of the *emoji*s: face savoring delicious (😋), smiling face with hearted shaped eyes (😍), smiling face with open mouth (😄), smiling face with smiling eyes (😊), smiling face with sunglasses (😎). neutral face (😐), confused face (😕) and unamused face (😒) (Table 2). Children from public schools used the *emoji*s associated with positive emotions more frequently than those from private schools, whereas the opposite trend was found for the *emoji*s associated with neutral or negative emotions: *emoji* neutral face (😐), confused face (😕) and unamused face (😒).

FOP nutrition labelling significantly affected the frequency of use 5 of the 16 *emoji*s (*face savoring delicious food* (😋), *smiling face with heart shaped eyes* (😍), *smiling face with open mouth* (😄), *smiling face with smiling eyes* (😊), *smiling face with sunglasses* (😎) and *loudly crying face* (😭)) (Table 1). The inclusion of nutritional warnings and TLS on the packages slightly decreased the use of the *emoji face savoring delicious food* (😋) compared to GDA (45%, 48% and 51% respectively), as well as the *emoji smiling face with heart shaped eyes* (😍), *(*40%, 41% and 47% respectively*)*, and *smiling face with sunglasses* (😎) *(*21%, 25% and 30% respectively*)*. In addition, the frequency of use of the *emoji loudly crying face* (😭) decreased with the inclusion of the TLS and nutritional warnings compared to the GDA system but differences were smaller than 3%.

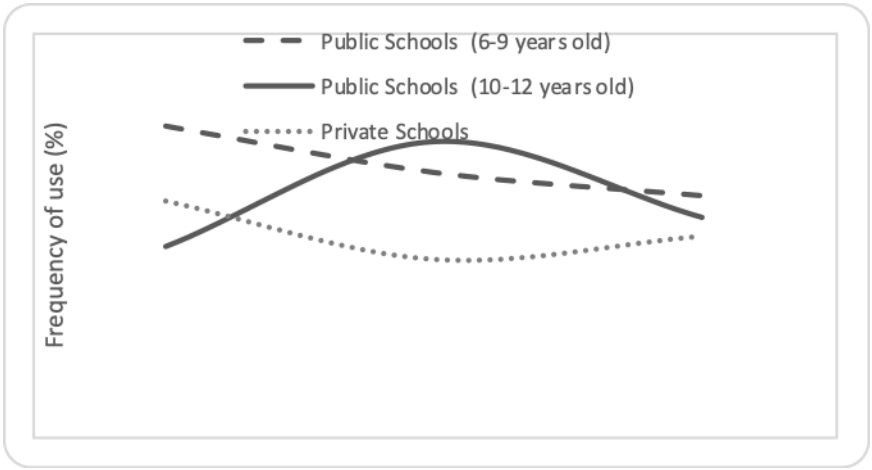
Significant interactions between age, type of school and FOP nutrition labeling scheme were found for the *emoji* smiling face with open mouth (😄), smiling face with heart shaped eyes (😍), smiling face with smiling eyes (😊) and face savoring delicious food (😋). This result suggests that the influence of FOP nutrition labeling schemes on children's

emotional associations were modulated by age and type of school. For 6-10 years old children from public schools and for those from private schools (regardless of age), nutritional warnings and the TLS decreased the frequency of use of the *emoji smiling face with open mouth* (😄) compared to the GDA system (Figure 5a). On the contrary, for 10-12 years old children from public schools, the TLS increased the frequency use of this *emoji*.

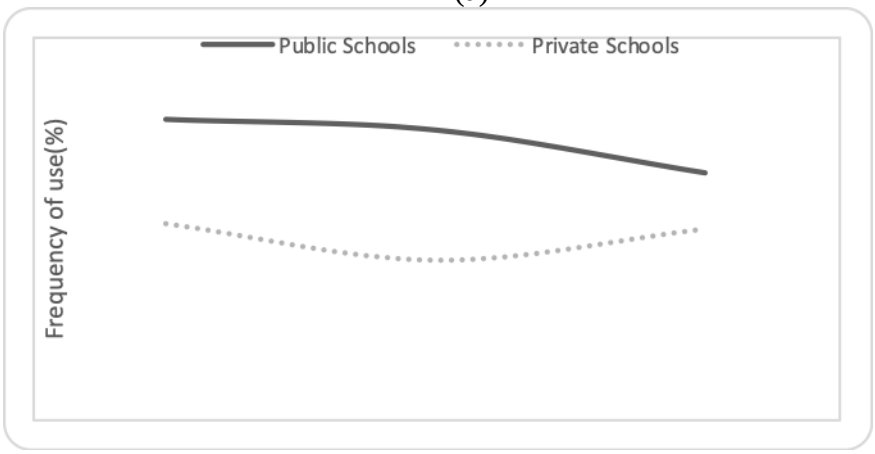
For the *emoji smiling face with heart shaped eyes* (😍), the inclusion of nutritional warnings on the packages tended to decrease its frequency of use for children from public school (Figure 5b). However, for children from private schools FOP nutrition labelling schemes did not have a significant effect on the frequency of use of this *emoji* (Figure 5b).

In the case of the *emoji smiling face with smiling eyes* (😊), its frequency of use was only influenced by FOP nutrition labeling schemes for children from private schools. As shown in Figure 5c, 11-12 years old children from private schools slightly increased the frequency of use of this *emoji* when nutritional warnings and the TLS were included on the packages compared to GDA, whereas for 6-10 years old children the inclusion of nutritional warnings decreased the frequency use of this *emoji* (Figure 5c).

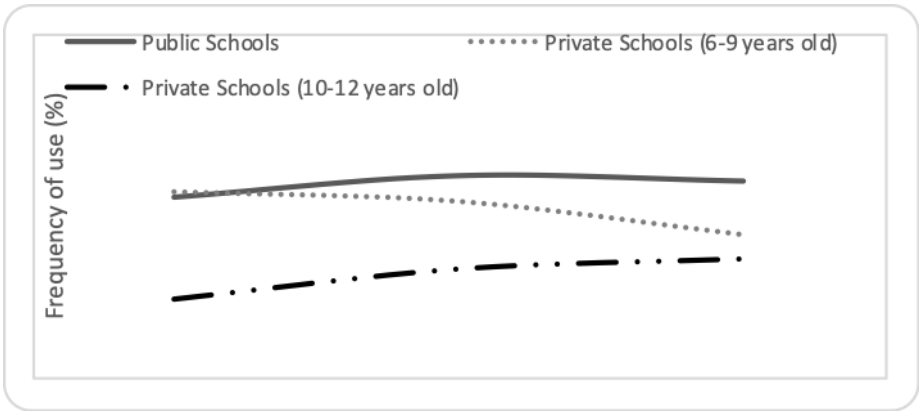
For the *emoji face savoring delicious food* (😋), the effect of FOP nutrition labeling was also modulated by type of school. For children from public schools, warnings tended to decrease the frequency of use of this *emoji* compared to the GDA and TLS, whereas for children from private schools both Nutritional Warnings and the TLS decreased its frequency of use (Figure 5d).



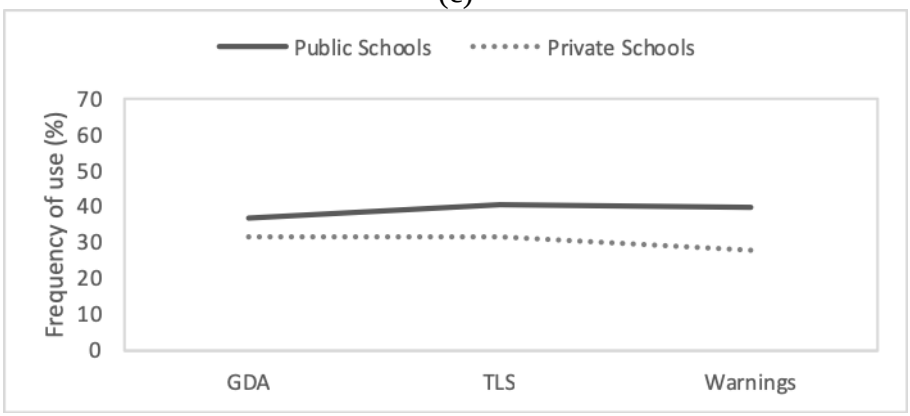
(a)



(b)



(c)



(d)

Figure 5. Percentage of consumers who used the *emoji* (a) Smiling face with open mouth (😄), (b) Smiling face with heart shaped eyes (😍), (c) Smiling face with smiling eyes (😊) and (d) Face savoring delicious food (😋) in each group that presented significantly differences (P<0.05).

4. DISCUSSION

FOP nutrition labeling has gained increasing attention worldwide to promote healthier eating habits (EUFIC, 2017). Although several studies have investigated the effect of different FOP nutrition labeling schemes on consumer's perception and food choice (Hawley et al., 2013), research on the impact of this public policy on children's perception is still limited (Lobstein, 2013). In this context, the present study compared the emotional associations of products targeted at children featuring three different FOP nutrition labeling schemes using *emoji*.

*Emoji*s are being increasingly used to measure children's emotional associations with foods (Gallo et al., 2017a; Gallo et al., 2017b; Schouteten et al. 2018; Schouteten et al., 2019). The validity of this approach was confirmed in the present work, as they discriminated between three unpackaged foods: ice cream, banana and broccoli. As expected, ice cream and banana were mostly described using *emoji* associated with positive emotion, whereas broccoli was mostly described using *emoji* associated with negative *emoji*. In this sense, Gallo et al. (2017a) reported that children used positive *emoji*s such as *smiling face with open mouth* (😄), *smiling face with heart-shaped* (😍), *smiling face with smiling eyes* (😊) and *face savoring delicious food* (😋) for describing how they feel about their favorite foods.

Regardless of the FOP nutrition labeling scheme displayed on the packages, children mostly used *emoji*s associated with positive emotions to describe how they would feel when eating the products. This suggests a positive emotional reaction towards products targeted at children with high content of sugar, fat or sodium, in agreement with their popularity in the Brazilian marketplace (Ferreira et al., 2015), and the frequent inclusion of persuasive elements on the packages as well as marketing campaigns (Jenkin et al., 2014). The emotional associations of the packaged products were similar to those from banana, one of the most popular fruit in Brazil.

The frequency of use of some of the *emoji*s was affected by type of school. Children from public schools tended to use several positive *emoji*s (*face savoring delicious food* (😋), *smiling face with heart shaped eyes* (😍), *smiling face with open mouth* (😄), *smiling face with smiling eyes* (😊)) more frequently than those from private schools, suggesting a more positive emotional reaction. This difference can be explained by differences in children's socio-economic status. Similar results have been recently presented by Arrúa et al. (2017) and Yoo et al. (2017), who reported that low income children had a more positive attitude towards unhealthful snack foods than middle-high income children. These differences may be related to the lower accessibility to this type of products of low-income children (Moratoya, Carvalhaes, Wander, & Almeida, 2013), as well as differences in the associations related to identity and social status conveyed by their marketing campaigns (Tivadar & Luthar, 2005).

Results from the present study showed that the inclusion of the TLS and nutritional warnings caused slight changes in children's emotional associations compared to the GDA system. Both the TLS and nutritional warnings tended to reduce the frequency of use of *emoji* associated with positive emotions, which indicates less positive emotional associations with packaged products with high content of sugar, fat and sodium. This result can be explained considering that the salience of information about high nutrient content reduced the positive associations towards the products. In this sense, previous studies have reported that the inclusion of directive or semi-directive FOP nutrition labeling schemes can modify children's food choices (Arrúa et al., 2016; Privitera, Vogel, & Antonelli, 2013).

Despite the general trend towards a reduction in the frequency of use of *emoji* related to positive emotion with the inclusion of the TLS and nutritional warnings, the use of *smiling face with smiling eyes* (😊) was significantly higher for children who evaluated the packages featuring the TLS and nutritional warnings compared to those who assessed products featuring the GDA system. This *emoji* has been associated with both happy and embarrassed (Jaeger et al., 2018). Therefore, the increase in the frequency of use may suggest that children would feel somehow more ashamed when eating products with high content of fat, sugar and sodium. However, further studies are necessary to obtain a more in-depth insight on how FOP nutrition labeling schemes influence children's emotional reactions.

A previous study involving the same products showed that FOP nutrition labeling schemes only influenced healthfulness perception of older children from private schools (Lima et al., 2018). Differences between the two studies may be related to the type of task performed by children: rating healthfulness using a scale vs. selecting *emoji*s that apply to describe a product. Scales may be more difficult for children to understand compared to selecting *emoji* from a list, which can also be easier and more natural from them (Laureati et al., 2015).

Regarding differences between the schemes, nutritional warnings tended to have a slightly higher effect than the TLS. Arrúa et al. (2016) has recently reported that nutritional warnings were more effective than the TLS in discouraging children's choice of snack products. The difference between both schemes can be related to the fact that the traffic-light system simultaneously included information about high and low nutrient content in most products, which may have reduced negative perceptions about product healthfulness (Machín

et al, 2018). On the contrary, nutritional warnings only highlight high nutrient content, which may be easier to interpret.

The effect of FOP nutrition labeling scheme on emotional associations was moderated by age and type of school. The effect of directive and semi-directive FOP nutritional schemes, in special nutritional warnings, tended to be higher for younger children and children from public schools. This result can be related to the fact that these groups had a more positive perception of the products due to the fact that they are more susceptible to marketing strategies of food companies (John, 1999; Livingstone & Helsper, 2006; Arrúa et al., 2017). Therefore, the inclusion of FOP nutrition labeling schemes may have made negative aspects of products salient for this group of children. In addition, studies have reported that small children are capable to identify simple logos (Ward, Wackman, & Wartella, 1977; Letona, Chacon, Roberto, & Barnoya, 2014).

Despite the fact that FOP nutrition labeling had a significant effect on the frequency of use of several *emoji*s, differences were small. Several factors may have contributed to this result. First, hedonic perception has been reported to be a key determinant of children's emotional reactions towards food products (Gallo et al., 2017a; Schouteten et al. 2018). Second, children were not familiar with the FOP nutrition labeling schemes used in this study and, therefore, they could have missed them when evaluating the products. In this sense, familiarity with FOP nutritional labeling has been reported to be a key determinant of their use (Grunert & Wills, 2007). This is expected to be even more relevant in the case of children, who may find difficult to understand nutrition information. Third, the food products included in this study were available in the Brazilian marketplace and included persuasive elements, which have been reported to attract children's attention, improve product recognition, create positive attitudes towards the brands, as well as emotional associations (Committee on Food Marketing and the Diets of Children and Youth, 2006; Connor, 2006; Mizerski,1995)

5. CONCLUSIONS

The inclusion of directive and semi-directive FOP nutritional information schemes, and particularly nutritional warnings, on the packages of food products targeted at children had a significant influence on emotional associations, particularly for 6-10 years old children, and those from public schools. Although the effect was small, results of the present work suggest that directive and semi-directive FOP nutrition labeling schemes have potential to modify the emotional response of children. This public policy, accompanied with restrictions of marketing strategies targeted at children, and advertisement at popular communication channels about the referred FOP nutrition labeling schemes may contribute to discouraging consumption of products with high content of nutrients associated with non-communicable diseases among children.

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APÊNDICE III

Children and adults' sensory and hedonic perception of added sugar reduction in grape nectar

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ABSTRACT

Reducing the added sugar content of sugar-sweetened beverages is one of the most cost-effective strategies to achieve short-term changes in added sugar intake. The present study aimed at evaluating children and adults' sensory and hedonic perception of added sugar reduction in grape nectar. For this purpose, two studies were carried out. In the first study, five sequential difference thresholds for added sugar in grape nectar were determined with school-aged children and adults using paired comparisons. In the second study 105 children (6-12 years old) and 100 adults evaluated six samples with different added sugar content. They were asked to rate their overall liking and to answer a check-all-that-apply CATA) question. Results confirmed the feasibility of reducing the added sugar concentration of grape nectar without affecting the sensory and hedonic perception of both children and adults. Children were less able to detect changes in the sensory characteristics of the added sugar reduced nectar samples than adults but showed higher hedonic sensitivity to added sugar reduction. Large heterogeneity in hedonic reaction towards added sugar-reduced nectar samples was found in both age groups.

Practical applications

Results from the present work are expected to provide insights for the development of gradual added sugar reduction programs in fruit nectar for both children and adults. According to the estimated difference thresholds, gradual added sugar reduction could be implemented considering sequential reductions lower than 6.21% to assure that consumers do not perceive changes in the sensory characteristics of the product. Considering that such small reductions would not affect consumer liking, the time elapsed between sequential added sugar reduction steps would not require long waiting times.

Keywords: *reformulation; sugar reduction; sugar-sweetened beverages; check-all-that-apply*

1. INTRODUCTION

High consumption of added sugar has been identified as one of the main dietary determinants of obesity, being linked to several chronic diseases such as type 2 diabetes and cardiovascular diseases (Ambrosini, Johns, Northstone, Emmett, & Jebb, 2016; Malhotra, 2013; Johnson et al. 2009). Sugar-sweetened beverages (SSB) represent one of the main sources of added sugar in the diet, being associated with a higher risk of weight gain and obesity (Martin-Calvo et al., 2014; Miller et al., 2013; Zheng, Allman-Farinelli, Heitmann, & Rangan, 2015; Zheng et al., 2014; Louie, Moshtaghian, Rangan, Flood, & Gill, 2015).

Consumption of SSB have markedly increased worldwide in the last two decades in both children and adults (Brownell et al., 2009). Global SSB intakes were estimated in 132 mL per day among adults in 2010 (Singh et al., 2015). In the specific case of Brazil, fruit juice/nectars and soft drinks are the sixth and ninth most consumed foods in the country, with a per capita consumption of 145 mL/day and 95 mL/day respectively (Brazilian Institute of Geography and Statistics, 2010). These products are often introduced during the first years of life and are frequently consumed by Brazilian children (Longo-Silva et al., 2015; Silva, Muniz & Vieira, 2012). Nectars are formulated by diluting fruit juices in water and adding sugar, which makes them cheaper than fruit juices and, therefore, more accessible to the Brazilian population (Brazilian Department of Agriculture, 2009; Longo-Silva et al., 2015).

Reducing consumption of SSB, particularly among children, has been regarded as one of the priorities to reduce the burden of obesity and non-communicable diseases (World Health Organization, 2013). Different alternatives have been suggested for this purpose, including public awareness campaigns, nutrition labelling, restriction of marketing and commercialization, increased access to potable water and reduction of the sugar content of commercial beverages (Vargas-Garcia et al., 2017). Considering that changes in dietary habits are difficult to achieve (Verplanken & Wood, 2006), reducing the added sugar content of SSB is one of the most cost-effective strategies to achieve short-term changes in added sugar intake (MacGregor & Hashem, 2014).

In order to be effective, sugar reduction should not be perceived by consumers. For this reason, information about consumer's perception of products with low added sugar content is essential for establishing targets for sugar reduction, and for encouraging the industry to engage in sugar reduction programs (Civille & Oftedal, 2012). Therefore, consumer hedonic perception of sugar-reduced products is relevant for the design of gradual sugar reduction strategies as they can be used to estimate the time elapsed between sequential sugar reduction steps. Changes in added sugar concentration that cause no changes in consumers' hedonic perception can be implemented in short time frames. On the contrary, changes that modify consumer hedonic perception require longer waiting time as consumers need to develop preference for the reformulated products.

The implementation of gradual reduction programs requires the estimation of difference thresholds (Bobowski & Vickers, 2012), which can be experimentally estimated as the smallest change in sugar concentration that causes a change in sweetness intensity that is perceived by 50% of the individuals (Boring, 1942). According to Weber's law, difference thresholds are a constant proportion of the stimulus intensity (Lawless & Heymann, 2010). Difference thresholds for added sugar in processed products could be used to design gradual sequential sugar reductions outside of consumer awareness. This approach has been recently proposed by Pineli et al. (2016) for sugar reduction in orange nectar and by Oliveira et al. (2016) for sugar reduction in chocolate flavored milk.

Consumer perception of sugar-reduced products has focused on adult consumers (Oliveira et al., 2016; Pineli et al., 2016; Chollet, Gille, Schmid, Walther, & Piccinali, 2013; Biguzzi, Schlich & Lange, 2014). However, children are the population most at risk for excessing recommended sugar intakes as they have been reported to have a heightened preference for sweetness compared to adults (Desor & Beauchamp, 1987; Zandstra & De Graaf, 1998). Longitudinal and cross-sectional studies have shown that sweetness preference decreases from childhood to adulthood, with the sharpest decline observed during adolescence (Desor, Greene & Maller, 1975; Desor & Beauchamp, 1987; De Graaf & Zandstra, 1999). This suggests that children may be less willing to accept sugar-reduced products than adults. However, previous studies have reported that 5-10 years old children had lower sweet taste sensitivity than adults, being less able to discriminate between samples with different sugar

concentration (Glanville et al., 1964; Yasaki, 1976; James et al., 1997). Understanding children perception of sugar-reduced products is particularly relevant in developing markets given that most products targeted at children contain excessive sugar content (Giménez, de Saldamando, Curutchet, & Giménez, 2017).

In this context, the aim of the present work was to study children and adults' sensory and hedonic perception of added sugar reduction in grape nectar. Two studies were carried out. In the first study, five sequential difference thresholds for added sugar in grape nectar were determined with children and adults using paired comparisons to determine the concentration of added sugar that can be reduced without being perceived by children and adults. In the second study, grape nectar samples with different added sugar content were evaluated using hedonic scales and check-all-that-apply questions to evaluate the influence of reducing the added sugar content of the nectars on the sensory and hedonic perception of both age groups. Results from the present work are expected to provide insights for the development of gradual sugar reduction programs in fruit nectar for both children and adults.

2. MATERIALS AND METHODS

2.1. Nectar formulation

Grape nectar samples were formulated by diluting a commercial grape juice with no added sugar (Del Valle, Brazil) to 35% using mineral water (Minalba, Brazil). After dilution, the nectar contained a total of 5.5 grams of sugars from the fruit. The nectars were added with 5.46 – 10% of sucrose (commercial sugar - União, Brazil). The ingredients were weighed in a semi analytical balance and manually mixed.

2.2. Difference thresholds for added sugar in grape nectar

Five sequential difference thresholds for added sugar in grape nectar were determined for children and adults using paired comparisons. In the first test, the difference threshold for added sugar in grape nectar with an added sugar concentration similar to commercial nectars available in the Brazilian marketplace (10%) was determined. In the second test, the difference threshold in a grape nectar that was reduced in added sugar according to the threshold determined in the first test was estimated. This procedure was repeated until five difference thresholds were determined.

2.2.1. Participants

A total of 250 children (6-12 years old, 59% female) and 250 adults (18-65 years old, 63% female) participated in the study. Children were recruited at a non-governmental organization, whereas adults were recruited among employees of Embrapa Agroindústria de Alimentos (Rio de Janeiro, Brazil). All participants were recruited according to their consumption frequency of fruit beverages (at least once a week), as well as their interest and availability to participate in the study. Adult participants signed an informed consent form. Children and their parents signed informed consent forms to participate in the study. Ethical approval was obtained from the ethics committee of Universidade Federal do Estado do Rio de Janeiro (Plataforma Brasil CAAE: 55023416.0.0000.5285).

Participants in each age group were divided into five groups of 50, each of which evaluated one of the tests to estimate difference thresholds. No significant differences in the age and gender distribution of the groups were found.

2.2.2. Experimental procedure

Paired comparisons were used to estimate difference thresholds for added sugar in grape nectar given their higher perceived ease of task (Reis et al., 2016) and the fact that they have been claimed to be easily understood by children (Guinard, 2001).

In each test, participants received six pair of samples. Each pair was composed of a control nectar and a sample that was reduced in added sugar from the control. The control remained constant in each test, while the added sugar concentration of the sample decreased over the six paired-comparisons. The added sugar concentration of the control sample differed in each test according to results of the previous difference threshold. In each test, the percentage of added sugar reduction of the samples in the six paired comparisons was determined by pilot testing and corresponded to: 3.3, 6.4, 9.4, 12.4, 15.2 and 18%. Table 1 shows the added sugar concentration of the control and the added sugar-reduced samples in each of the tests conducted with children and adults.

Participants were requested to taste each of the samples in a pair and to indicate the sweetest by selecting the corresponding code number. Presentation order of the samples in each pair was balanced. Participants were instructed to clean their palate with water after tasting each sample.

Table 1. Added sugar concentration of grape nectar samples considered in the five tests for estimating sequential difference thresholds for added sugar with children and adults.

Age group	Test	Added sugar concentration* of the reference sample (%)	Reduction in added sugar for the six samples included in the test					
			3.3%	6.4%	9.4%	12.4%	15.2%	18%
Children	1	10.00	9.67	9.36	9.06	8.76	8.48	8.2
	2	9.00	8.71	8.42	8.15	7.88	7.63	7.38
	3	7.84	7.58	7.34	7.10	6.87	6.64	6.43
	4	6.97	6.74	6.52	6.31	6.11	5.91	5.72
	5	6.31	6.10	5.91	5.71	5.53	5.35	5.17
Adults	1	10.00	9.67	9.36	9.06	8.76	8.48	8.2
	2	9.48	9.17	8.87	8.58	8.31	8.04	7.77
	3	9.03	8.74	8.45	8.18	7.91	7.65	7.40
	4	8.43	8.16	7.89	7.63	7.39	7.15	6.91
	5	7.95	7.69	7.44	7.20	6.96	6.74	6.52

*Added sugar concentrations correspond to the percentage of sucrose added to the nectars. All samples also contained 5.5g of sugars from the fruit.

2.2.3. Data analysis

Difference thresholds were estimated using survival analysis, following an adaptation of the procedure proposed by Hough et al. (2003) (Oliveira et al., 2016). For each of the six paired comparisons, participants' responses were coded as "No" if the control was identified as sweeter than the added sugar-reduced sample and as "Yes" otherwise. The difference threshold was estimated as the concentration at which a consumer starts to consistently perceive the added sugar-reduced sample as less sweet than the control and, therefore, to consistently answer "Yes".

A random variable R was defined as the added sugar reduction percentage at which a participant started consistently perceiving the added sugar-reduced sample as less sweet than the control, which corresponded to his/her difference threshold. The probability of a participant having his/her difference threshold at added sugar-reduction percentage lower or equal than r, that is $F(r) = P(R \leq r)$ was modelled using a lognormal distribution. The parameters of the lognormal distribution (μ and σ) for F(r) were obtained by maximizing the likelihood function for the given experimental data using the R scripts provided by Hough (2010). Difference thresholds were determined as the added sugar-reduction percentage at which 50% of the consumers had their difference thresholds. Comparison of difference thresholds was performed using the following formula (Meeker & Escobar, 1998):

$$\text{Difference} = \text{Threshold}_1 - \text{Threshold}_2 \pm \sqrt{\frac{1}{2}\frac{n_{1+}n_2}{n_1 n_2}}\sqrt{se_1^2 n_1 + se_2^2 n_2}$$

where $Z_{(1-\alpha/2)}$ is the $(1-\alpha/2)$ quantile of the standard normal distribution, n_1 and n_2 are the number of assessors considered in the estimation of each threshold, and se are the standard errors of the thresholds. If the confidence interval of the difference did not include 0, significant differences ($p<0.05$) between the thresholds existed.

2.3. Hedonic and sensory perception of added sugar-reduced grape nectar

After difference thresholds for added sugar in grape nectar were determined, children and adults' sensory and hedonic perception of added sugar-reduced samples were evaluated. Six grape nectar samples were considered: a control nectar with 10% added sugar concentration and five samples reduced in added sugar according to the difference thresholds determined in the previous study with children. The decision to consider children's thresholds for added sugar was made considering that they enabled to achieve a lower added sugar concentration than adults' thresholds.

2.3.1. Participants

A total of 105 children (6-12 years old, 62% female) and 100 adults (18-65 years old, 67% female) participated in the study. They were recruited as described in section 2.2.1. The study was approved by the ethic committee of Universidade Federal do Estado do Rio de Janeiro (Plataforma Brasil CAAE: 55023416.0.0000.5285). All the participants in this study had also participated in the one of the difference threshold tests.

2.3.2. Samples

Grape nectar samples were formulated as described in 2.1. The added sugar percentage corresponded to: 10.00%, 9.00%, 7.84%, 6.97%, 6.31% and 5.46%.

2.3.3. Experimental procedure

Participants were asked to try the samples and to indicate their overall liking using a 9-point hedonic scale anchored with super bad (1) to super good (9) (Kroll, 1990). The same scale was used with children and adults to enable comparison of the results. Participants were also asked to answer a simple check-all-that-apply (CATA) questions composed of six sensory characteristics: grape flavor, very sweet, sweet, barely sweet, acid, and watery. The terms were selected by the researchers and pilot tested with children to ensure understanding.

The order in which terms were listed was balanced among participants, following a Williams' Latin square experimental design. Samples were presented according to an experimental design that was balanced for order and carry-over effects (Williams' Latin Square design).

2.2.4. Data analysis

Analysis of variance (ANOVA) was used to evaluate the existence of significant differences among samples in the overall liking scores of children and adults separately. Sample was specified as fixed effect, whereas participant was specified as a random effect. Tukey's test was used for post-hoc pairwise comparisons at a significance level of 5%. In addition, ANOVA was performed on overall liking scores of the two age groups considering sample, age group and their interaction as fixed sources of variation.

K-means cluster analysis was used to identify groups of participants with similar hedonic perception of the samples. The analysis was performed separately on children and adults' centered data (Næs, Brockhoff, & Tomic, 2010). Overall liking scores of each group were analyzed using a mixed linear model.

Frequency of use of each CATA term was determined by counting the number of children and adults who used that term to describe each sample. Cochran's Q test (Manoukian, 1986) followed by the sign test for each pair of products (Meyners, Castura, & Carr, 2013) was used to identify significant differences among samples in each of the sensory terms. A Generalized Linear Model (GLM) was used to evaluate differences in the frequency of use of the CATA terms between clusters and age groups.

All data analyses were carried out using R software version 3.2.3 (R Core Team, 2017).

Table 2. Difference thresholds and 95% confidence intervals for added sugar in grape nectar with respect to reference samples with different added sugar concentration for children and adults.

Age group	Test	Added sugar concentration* of the control (%)	Difference threshold (expressed as added sugar concentration) (%)	Difference threshold (expressed as sugar reduction percentage from the control sample) (%)	95% confidence interval
Children	1	10.00	9.00	10.00	7.60 – 13.06
	2	9.00	7.84	12.89	9.79 – 16.99
	3	7.84	6.97	11.09	7.51 – 16.46
	4	6.97	6.31	9.47	6.92 – 12.76
	5	6.31	5.46	13.47	9.54 – 19.10
Adults	1	10.00	9.48	5.20	3.25 - 8.46
	2	9.48	9.03	4.74	3.51 - 6.46
	3	9.03	8.43	6.64	4.60 - 9.68
	4	8.43	7.95	5.69	3.91- 8.43
	5	7.95	7.25	8.80	4.97 - 15.78

*Added sugar concentrations correspond to the percentage of sucrose added to the nectars. All samples also contained 5.5g of sugars from the fruit.

3. RESULTS

3.1. Difference thresholds for added sugar in grape nectar

Average difference thresholds for added sugar in grape nectar were determined using survival analysis as the added sugar-reduction percentage at which 50% of the consumers had their difference threshold. As shown in Table 2, the difference thresholds for added sugar ranged from 9.47% to 13.47% of the added sugar concentration of the control sample. For adults, the difference thresholds ranged from 4.74 to 8.80% (Table 3). For both children and adults there were no significant differences between the difference thresholds estimated for different added sugar concentrations, which indicates that difference thresholds could be regarded as a constant proportion of the added sugar concentration of the nectars. Considering the average values from the five studies, the Weber fraction for added sugar reduction in grape nectar can be estimated in 11.38% for children and 6.21% for adults.

The average difference threshold for children almost doubled the average threshold of adults (Table 2). In the specific case of grape nectar with the maximum added sugar concentration (10%), the difference between the threshold estimated for children and adults was (4.80±3.69)%, which could be regarded as significantly different from 0 ($p<0.05$). This suggests that adults would be able to detect smaller differences in added sugar in grape nectar than children. For this reason, the maximum added sugar reduction achieved after five sequential thresholds was higher for children than for adults: 45.4% and 26.3%, respectively.

3.2. Hedonic and sensory perception of added sugar reduced grape nectar

3.2.1. Children's hedonic and sensory perception

Children's overall liking scores significantly decreased with added sugar reduction (p=0.029). However, significant differences from the control nectar were only found when sugar reduction reached 45.4% (Table 3).

Heterogeneity in children's hedonic reaction towards added sugar reduction was found, as evidenced by differences in the overall liking scores of the two groups of children identified using hierarchical analysis. Children in Group 1 (n= 47, relative size 45%) significantly decreased their overall liking with added sugar reduction (Table 3). This group gave significantly lower hedonic scores to the sample reduced 30.3% in added sugar compared to the control. Meanwhile, no significant differences among samples were found for children in Group 2 (n=58, relative size 55%), whose overall liking scores ranged between 6.9 and 7.7 (Table 3). No significant differences were found in the gender (p=0.42), age (p =0.16) and consumption frequency of fruit juice/nectar (p=0.87) distributions of the two groups.

Table 3. Average overall liking scores (and standard deviations between parentheses) of grape nectar samples with different added sugar concentration for children and adults. Results are presented for the whole sample and for the two identified groups using hierarchical cluster analysis.

Added-sugar content (%)	Added sugar reduction with respect to the control (%) (*)	Children			Adults		
		All (n=105)	Group 1 (n= 47)	Group 2 (n=58)	All (n=100)	Group 1 (n=59)	Group 2 (n= 41)
10.00	0.0	7.4 (1.9)^{a}	7.9 (1.3)^{a}	7.0 (2.3)^{a}	6.5 (1.7)^{a}	7.1 (1.3)^{a}	5.6 (1.7)^{c}
9.00	10.0	7.0 (2.2)^{a,b}	7.0 (2.0)^{a,b}	6.9 (2.4)^{a}	6.4 (1.6)^{a}	7.0 (1.3)^{a}	5.6 (1.6)^{c}
7.84	21.6	7.1(2.1)^{a,b}	7.1 (2.0)^{a,b}	7.1 (2.2)^{a}	6.8 (1.5)^{a}	7.1 (1.4)^{a}	6.2 (1.5)^{b,c}
6.97	30.3	6.7 (2.1)^{a,b}	6.1 (1.9)^{b,c}	7.2 (2.2)^{a}	6.9 (1.2)^{a}	7.1 (1.4)^{a}	6.7 (1.0)^{ab}
6.31	36.9	6.6 (2.2)^{a,b}	5.6 (2.1)^{c}	7.4 (2.0)^{a}	6.7 (1.3)^{a}	6.4 (1.4)^{a,b}	7.1 (1.2)^{a}
5.46	45.4	6.5 (2.2)^{b}	5.1 (1.9)^{c}	7.7 (1.6)^{a}	6.5 (1.4)^{a}	6.2 (1.5)^{b}	7.1 (1.1)^{a}

(*) The added sugar concentration of the reference sample (0.0% sugar reduction) corresponded to 10% of sugar (sucrose). All samples also contained 5.5g of sugars from the fruit.
Values within a column with different letters are significantly different according to Tukey's test ($p < 0.05$).

Significant differences among samples were identified in the frequency of use of all the terms of the CATA question, except for *grape flavor*. As expected, the first change in the sensory characteristics of the nectars caused by added sugar reduction was a decrease in sweetness intensity. As shown in Table 4, differences in sweetness were perceived from an added sugar reduction of 10.0%. Children used the term *very sweet* less frequently to describe the sample reduced 10.0% in added sugar than to describe the control sample (Table 4). Changes in the other sensory characteristics were perceived for samples reduced more than 10% in added sugar concentration.

The two groups with different hedonic reaction towards added sugar reduction did not largely differ in how they used the terms of the CATA questions to describe the samples. The only difference between the groups was found for the term *acid*, which was more frequently used by children in Group 1 to describe samples with 36.9% and 45.4% added sugar reduction compared to children in Group 2 (data not shown).

Table 4. Frequency of use (%) of the terms of the CATA questions for describing six grape nectar samples with different added sugar concentration for children and adults.

Age group	Added sugar concentration (%)	Added sugar reduction with respect to the control (%) (*)	CATA term					
			Very sweet	Sweet	Barely sweet	Watery	Grape flavor	Acid
Chlidren	10.00	0.0	47^{a}	$32^{a,b}$	14^{b}	7^{d}	55^{a}	7^{b}
	9.00	10.0	33^{b}	38^{a}	15^{b}	$12^{c,d}$	53^{a}	$9^{a,b}$
	7.84	21.6	$24^{b,c}$	40^{a}	24^{ab}	$13^{c,d}$	60^{a}	$11^{a,b}$
	6.97	30.3	31^{b}	$35^{a,b}$	25^{ab}	$16^{b,c}$	55^{a}	$9^{a,b}$
	6.31	36.9	$25^{b,c}$	$30^{a,b}$	28^{a}	$24^{a,b}$	53^{a}	17^{a}
	5.46	45.4	19^{c}	24^{b}	28^{a}	32^{a}	48^{a}	$13^{a,b}$
Adults	10.00	0.0	69^{a}	27^{c}	3^{c}	16^{c}	79^{a}	5^{b}
	9.00	10.0	58^{a}	$40^{b,c}$	3^{c}	$22^{b,c}$	$72^{a,b}$	6^{b}
	7.84	21.6	40^{b}	54^{a}	7^{bc}	29^{b}	$75^{a,b}$	$9^{a,b}$
	6.97	30.3	$29^{b,c}$	$53^{a,b}$	14^{b}	28^{b}	83^{a}	13^{a}
	6.31	36.9	24^{c}	$46^{a,b,c}$	24^{a}	35^{a}	$78^{a,b}$	14^{a}
	5.46	45.4	11^{d}	41^{ab}	34^{a}	45^{a}	66^{b}	16^{a}

(*) The added sugar concentration of the reference sample (0.0% sugar reduction) corresponded to 10% of sugar. All samples also contained 5.5g of sugars from the fruit.
Values within a column for an age group with different letters are significantly different according to the sign test ($p < 0.05$).

3.2.2. Adults' hedonic and sensory perception

No significant differences between samples were found in the overall liking scores (p=0.536). As shown in Table 3, average overall liking scores ranged from 6.4 to 6.9 for all samples. However, large heterogeneity in adults' hedonic reaction towards added sugar reduction was found. Hierarchical cluster analysis enabled the identification of two groups: Group 1 (n= 59, relative size=59%), comprised of adults who gave the highest overall liking scores to the samples with the highest added sugar content, and Group 2 (n=41, relative size=41%) with the opposite behavior. As shown in Table 3, adults in Group 1 gave the highest scores to samples with 0.0-36.9% added sugar-reduction, whereas adults in Group 2 gave the highest scores to samples with 30.3%-45.4% added sugar reduction.

No significant differences in the gender (p=0.337), age (p=0.464), income (p=0.554) and nectar consumption frequency (p=0.672) were found between the two groups of adults. However, Group 2 were composed of a higher proportion of adults who have completed high school and University (68% vs. 48%, *p=0.047*) than Group 1. In addition, adults in Group 2 reported higher liking for grape than adults in Group 1 (p=0.048).

Significant differences between samples were found in the frequency of use of all the terms included in the CATA (Table 4). As expected, added sugar reduction caused a decrease in the frequency of use of the terms *very sweet* and *grape flavor*, and an increase in the frequency of use of the terms *barely sweet, watery* and *acid.*

The two groups of adults identified in hierarchical cluster analysis only differed in the frequency of use of the terms barely sweet and acid for the samples with the highest added sugar reduction. Adults in Group 1 used the terms *barely sweet* and *acid* more frequently than those in Group 2 for describing the samples with 30.5-45.4% added sugar reduction.

3.2.3. Differences in children and adults' hedonic and sensory perception

Overall liking scores were significantly affected by the interaction between age groups ($p=0.0077$), suggesting that differences in the hedonic reaction of children and adults were sample-dependent. For the control sample the average overall liking score of children was significantly higher than the average score of adults ($p<0.001$). Differences in the overall liking scores of children and adults decreased with added sugar reduction, being marginally significant for the samples reduced 10% ($p=0.052$) and 21.6% in added sugar ($p=0.052$) and non-significant for the rest of the samples ($p>0.42$) (Table 3).

Regarding responses CATA question, an interaction between sample and age group was found for the terms related to sweetness. Children used the term *very sweet* less frequently and the term *barely sweet* more frequently than adults for describing samples reduced 21.6-45.4% in added sugar. In addition, children used the term *grape flavor* significantly less frequently than adults (Table 4).

4. DISCUSSION

Sugar-sweetened beverages are a major source of added sugar in the diet and have been associated with excessive weight gain and obesity among children, adolescents and adults (Tucker et al., 2015; Malik et al., 2013; Reedy & Krebs-Smith, 2010). Therefore, reducing the added sugar content of these products can contribute to improving the health status of the Brazilian population. Gradual added sugar reduction has been proposed as one of the cost-effective and potentially successful strategies to reduce sugar consumption in the short term (MacGregor & Hashem, 2014). In this context, the present work explored children and adults' sensory and hedonic perception of added sugar reduction in grape nectar.

Difference thresholds for added sugar in grape nectars for children and adults

Difference thresholds for added sugar are crucial for the design of sugar reduction programs, as they correspond to the maximum added sugar content that would be unnoticed by consumers. In the present work, five sequential difference thresholds for added sugar were determined with adults and children. For both age groups difference thresholds were a constant proportion of the added sugar content of the nectars, in agreement with Weber's law (Lawless & Heymann, 2010).

The average difference threshold for adults corresponded to 6.21% of the added sugar content of the grape nectar. This result is in agreement with the values reported by other authors in different food matrices: 8.5% in orange nectar (Pineli et al., 2016), 6.7% in chocolate-flavoured milk (Oliveira et al., 2016), 6.7-7.0% for dairy based emulsions and 5.7-6.2% for sucrose solutions (Hoppert et al., 2012), 7.0-11.0% for pound cakes (Chang & Chiou, 2006).

Children have been reported to show higher preference for sweetness and to be less sensitive to sweet taste than adults (Cox, Hendrie, & Carty, 2016; De Graaf & Zandstra, 1999; Desor & Beauchamp, 1987; Desor, Greene, & Maller, 1975; James, Laing, Oram & Hutchinson, 1997; Zanstra & De Graaf, 1998). However, no study has been found reporting children's difference thresholds for added sugar in processed food products. In the present work, the average difference threshold of added sugar in grape nectar for children corresponded to 11.38%, which was larger than the average difference threshold for adults. This result can be related to the fact that children have been reported to show lower taste sensitivity than adults, as well as lower ability to discriminate between different sucrose concentrations (De Graaf & Zandstra, 1999; James et al., 1997). However, differences in the thresholds of children and adults can also be related to differences in cognitive skills. Although paired comparisons have been reported to provide consistent data with children (Leon, Marcuz, Couronne & Köster, 1999), younger children are expected to face more cognitive difficulties to complete the task than adults (Liem, Mars, de Graaf, 2004). In this sense, it is worth highlighting that the present work involved 6-12 years old children, who largely differed in their cognitive skills (Guinard, 2001). Further research should look into age-differences in children's ability to detect changes in the added sugar content of processed foods.

Children and adults' sensory perception of added sugar-reduced nectars

Added sugar reduction in grape nectar led to changes in their perceived sensory characteristics for both children and adults. As expected, the main changed caused by added sugar reduction was a decrease in sweetness intensity, as evidenced by the significant decrease in the frequency of use of the terms *sweet* and *very sweet*. Added sugar reduction also caused a significant increase in the frequency of use of the terms *acid* and *watery*. The increase in the frequency of use of the term watery could be explained by a decrease in viscosity and/or total flavor intensity due to the reduction of sugar content.

Interestingly, although children had larger difference thresholds than adults, their responses to the CATA question showed the opposite pattern. Children's data showed that the control sample (0.0% added sugar reduction) and the sample reduced in 10% were discriminated according to their sweetness, whereas no discrimination between these two samples was found for adults. In addition, children and adults were similarly able to discriminate samples according to their added sugar content using the CATA questions. This result stresses the appropriateness of CATA questions to obtain insights on children's perception of food products, as recently reported by Laureati et al. (2017).

Children and adults' hedonic perception of added sugar-reduced nectars

Although added sugar reduction caused marked changes in the sensory perception of the nectar samples, it only had a small influence on average overall liking scores. This suggests that although small changes in added sugar concentration would be noticeable by both children and adults, relatively large reductions would be necessary to modify their hedonic reaction.

Children and adults differed in how they reacted to added sugar reduction in grape nectars. For the nectar samples with the highest added sugar concentration, children tended to give higher liking scores than adults. In addition, at the aggregate level, children showed higher hedonic sensitivity to sugar reduction than adults. These results are in line with the extensively reported heightened sweet preference during childhood and its subsequent decrease with age (Cox et al., 2016; de Graaf et al., 1999). Therefore, although children showed larger difference thresholds for added sugar than adults, the opposite trend was found for hedonic sensitivity. The hedonic reaction towards the sugar reduction in grape nectars was more pronounced for children than for adults. This could be explained considering differences in preferences and familiarity with the target product. Children reported a significantly higher consumption frequency of grape nectar than adults ($p<0.001$): everyday consumption was reported by 63% of the children and 42% of the adults.

Heterogeneity in hedonic reaction towards added sugar reduction in grape nectars was found for both children and adults. Individual differences in hedonic reaction to increasing sweetness levels have been extensively reported and have encouraged researchers to classify consumers as sweet likers or dislikers (Pangborn, 1970; Moskowitz, 1971; Kim, Prescott, & Kim, 2014). In the present work, these two groups of adults were clearly identified: the overall liking scores of one the groups decreased with added sugar reduction, whereas the scores of the other group increased. Although two groups of children with different hedonic reaction towards sugar reduction were identified, none was characterized as sweet disliker. One of the group of children decreased their overall liking scores as added sugar content decreased, whereas the other was not affected by sugar reduction. These differences in the patterns of sweet liking among adults and children can be related to children's heightened preference for sweetness.

Responses to the CATA questions were not largely affected by sweet liker status for both adults and children, which suggests that differences in the hedonic reaction towards sugar reduction of the groups may not be related to differences in sensitivity. Similar results have been reported by Garneau, Nuessle, Mendelsberg, Shepard, & Tucker (2017), and Methven, Xiao, Cai, & Prescott (2016). In addition, no differences in socio-demographic variables between the groups were found, which suggests that differences in sweet liking might be related to differences in dietary habits. In this sense, Garneau et al. (2017) has recently reported that adult sweet likers consumed more sweetened juice and tea and less water than neutral consumers and sweet dislikers.

5. CONCLUSIONS

Results of the present work confirmed the feasibility of reducing the added sugar concentration of grape nectar without affecting the sensory and hedonic perception of both children and adults. According to the estimated difference thresholds, gradual sugar reduction could be implemented considering sequential reductions lower than the average difference threshold for adults (6.21%) to assure that consumers do not perceive changes in the sensory characteristics of the product. Considering that such small reductions would not affect consumer liking, the time elapsed between sequential sugar reduction steps would not require long waiting times.

Children were less able to detect changes in the sensory characteristics of the sugar-reduced nectar samples than adults but showed higher hedonic sensitivity to sugar reduction. Large heterogeneity in hedonic reaction towards added sugar-reduced nectar samples was found in both age groups, which suggests the need to consider individual differences in the design of strategies to sugar reduction in processed products.

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APÊNDICE IV

Short communication for submission to Food Quality and Preference

Comparison of two sugar reduction strategies with children: Case study with grape nectars

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ABSTRACT

Excessive sugar consumption has been identified as the main dietary determinants of obesity among children and adolescents. Sugar sweetened beverages are one of the main sources of added sugar in the diet. Therefore, gradual sugar reduction in these products can contribute to decreasing sugar intake and encourage children to slowly develop preference for products with lower sugar concentration. However, specific recommendations on how to implement gradual sugar reduction programs are still lacking. The aim of the present study was to compare two sugar reduction strategies (stepwise vs. gradual) on children's sensory and hedonic perception of grape nectar. One hundred and seventeen 6-12 years old children participated in a two-part study: a 9-week study and a final liking test at the end of 11 weeks. In the 9-week study, children were divided in two sugar reduction strategies: stepwise and gradual. Children's' sensory and hedonic perception was evaluated using 9-point hedonic scales and check-all-that-apply questions. There were no major differences between the gradual and stepwise reduction groups in children's sensory and hedonic perception. However, results showed that the gradual reduction strategy led to smaller changes in children's sensory and hedonic perception than the stepwise strategy. In the final test, children in the stepwise group gave significantly higher liking scores to the samples than those in the gradual sugar reduction strategy. Comparing the overall liking between the first time the children tasted the grape nectars and the final test, a significant difference was observed for the sample with lower sugar content only for the stepwise group, which was higher in the 11th week. Although differences between the sugar reduction strategies were small, the gradual reduction strategy seems to be recommended over the step-wise strategy.

Keywords: *children; added-sugar reduction; sugar-sweetened beverages; check-all-that-apply.*

1.INTRODUCTION

Excessive sugar consumption has been identified as the major cause of excessive caloric intake and the main dietary determinant of obesity and among children and adolescents (Ambrosini, Johns, Northstone, Emmett, & Jebb, 2016; Te Morenga, Mallard, & Mann, 2013). In particular, sugar-sweetened beverages (SSB), including soda, fruit-flavored drinks, and sport drinks, are one of the main sources of sugars in children's diets (Malik et al., 2013). According to Garriguet (2008), consumption of sugar from SSB alone accounts for the total recommended daily free sugar intake (10% of the total energy intake; World Health Organization, 2015), suggesting that SSB should be a prime target for reducing sugar intake among children.

Considering that changes in eating habits are difficult to achieve, strategies that do not require consumers' willpower to change have the greatest chance of succeeding at the population level in the short term (Dobbs et al., 2014). For this reason, reformulation of products has been proposed as one of the most effective strategies to encourage changes in nutrient intake (van Raaij, Hendriksen, & Verhagen, 2009). If the added sugar content of products is reduced without consumers' awareness, it can lead to a reduction in their sugar intake even if they do not change their eating behavior (MacGregor & Hashem, 2014).

The main challenge for reducing the added sugar content of food products, particularly in the case of sweetened beverages, is that it causes changes in their sensory characteristics, which are key determinants of consumers' liking (van Raaij, Hendriksen, & Verhagen, 2009). This is particularly relevant in the case of children due to their heightened preference for sweet taste (Ventura & Menella, 2011).

There are two main strategies for sugar reduction without substitution: abrupt sugar reduction, which consists of reducing sugar in a single step, and gradual sugar reduction, which consists of consecutive small reductions. Gradual sugar reduction has been shown to be more effective than the abrupt sugar reduction, as consumers do not notice changes in the sensory characteristics of the products, and they slowly become accustomed to lower sugar concentration (MacGregor & Hashem, 2014). However, specific recommendations on how to implement gradual sugar reduction programs are still lacking. Reductions lower than the difference threshold for added sugar have been recommended as they assure that the great majority of the consumers would not notice the change (MacGregor & Hashem, 2014). However, this could entail several reduction steps to achieve the sugar reduction target, which would not be practical for food companies, and would require long implementation times. Therefore, a stepwise sugar reduction strategy based on larger reduction steps would provide practical advantages over gradual reduction programs based on difference thresholds. However, this strategy could lead to larger changes in consumers' sensory and hedonic product perception.

In this context, the aim of the present study was to compare two sugar reduction strategies (stepwise vs. gradual) on children's sensory and hedonic perception of grape nectar. It was hypothesized that the implementation of cumulative unnoticeable reductions in the added sugar content of the nectars would have a smaller impact on children's sensory and hedonic perception than stepwise reductions.

2. MATERIALS AND METHODS

2.1. Participants

A total of 147 children, aged 6-12 years old (46% female), were recruited in a private elementary school in Rio de Janeiro (Brazil). Children and their parents signed informed consent forms to participate in the study. Ethical approval was obtained from the ethics committee of Universidade Federal do Estado do Rio de Janeiro (Plataforma Brasil CAAE: 55023416.0.0000.5285). Children received a small gift for their participation in each session.

2.2. Nectar formulation

Grape nectar samples were formulated by diluting a commercial grape juice with no added sugar (Del Valle, Brazil) to 35% using mineral water (Minalba, Brazil). The dilution of grape juice was determined based on the characteristics of commercial products available in the marketplace and pilot testing. The nectars were added with 4.3 – 10% commercial sugar (União, Brazil). The ingredients were weighed in a semi analytical balance and manually mixed. The nectars were stored under refrigeration for one day before being served to children.

The initial added-sugar concentration of the nectars (10%) was selected based on commercial grape nectars available in the Brazilian marketplace, whereas the lowest concentration (4.3%) was expected to cause a significant decrease in children's hedonic perception (Lima et al., 2018). The added-sugar concentration of the nectars was reduced according to two strategies: stepwise and gradual (Table 1). In the gradual strategy, added-sugar content was reduced from 10% to 4.3% according to the difference thresholds for added sugar estimated in a previous study (Lima et al., 2018). In the stepwise strategy, added-sugar content was reduced from 10.0 to 4.3 in two steps (Table 1).

2.3. Experimental procedure

A between-subjects experimental design was used to compare the stepwise and gradual sugar reduction strategies. Children (6-12 years old) were randomly allocated to two groups of similar size: stepwise sugar reduction (n=74) and gradual sugar reduction (n=73). Participants were asked to attend 10 tasting sessions over an 11-week period. During the first 9 consecutive weeks, they evaluated the sugar-reduced grape nectar samples. Two weeks later, they performed a final liking test. A total of 30 participants did not attend all the sessions, giving as a result 66 children in the stepwise reduction group and 51 children in the gradual reduction group. No significant differences between the two groups of children were found in their gender ($p=0.82$) and age ($p=0.86$). In addition, the groups did not significantly in their nectar consumption frequency (p=0.67) and stated nectar liking (p=0.56), reported at the beginning of the test.

Sensory and hedonic perception of grape-nectars over a 9-week period.

Participants attended one session per week over a 9-week period. Children in the stepwise sugar reduction strategy received the same nectar for three consecutive weeks. As shown in Table 1, they evaluated three nectars with different sugar concentration. Participants in the gradual sugar reduction strategy evaluated the sugar with the maximum sugar concentration (10%) at the first two weeks, and then received different nectar each week

(Table 1). At the ninth week both groups received the nectar with the lowest sugar concentration (4.3%).

In each session, they received a white plastic cup containing 100mL of grape nectar. They were asked to drink as much as they wanted and to rate their overall liking using a 9-point hedonic scale (1=super bad, 9=super good) (Kroll, 1990). They were also asked to answer a simple check-all-that-apply (CATA) questions composed of six sensory terms: grape flavor, very sweet, sweet, barely sweet, acid, and watery. Terms were selected by the researchers and a pilot test was conducted with children prior to the study to ensure understanding. The meaning of the six terms included in the CATA question was explained to the children in the beginning of the study.

2.3.1. Sensory and hedonic perception of grape-nectars two weeks after the 9-week period

Two weeks after the 9-week period, an additional session was held, in which children evaluated the three nectar samples included in the stepwise sugar reduction strategy (added sugar concentration: 10.0%, 6.3% and 4.3%). The samples were evaluated by the two experimental groups following the same procedure described in the previous section. Samples were presented according to an experimental design that was balanced for order and carry-over effects (Williams' Latin Square design).

2.4. Data analysis

Analysis of variance (ANOVA) was used to analyze overall liking scores in both studies. Over the 9-week period, data were analyzed considering experimental group, week and their interaction as fixed sources of variation. ANOVA was also used to analyze overall liking scores of each group, considering week as fixed source of variation. In the test performed at the 11^{th} week, experimental group, sample and their interaction were considered as fixed sources of variation. Tukey's test was used for post-hoc pairwise comparisons at a significance level of 5%.

Frequency of use of each CATA term was determined in both experiments by counting the number of children who used that term to describe each sample. Cochran's Q test followed by the sign test (Meyners, Castura & Carr, 2013) were used to identify significant differences among samples for each of the sensory terms for each experimental group. In the 9-week period, a Generalized Linear Model (GLM) was used considering the use of the term (0/1) as dependent variable, and experimental group, week and their interaction as independent variables. The 11^{th} week data were analyzed using a GLM considering sample, experimental group and their interaction as independent variables.

All data analyses were carried out using R software version 3.2.3 (R Core Team, 2017).

3. RESULTS

3.1. Influence of sugar reduction strategies on children's hedonic and sensory perception of grape nectars over a 9-week period.

Hedonic perception

Average overall liking scores ranged from 8.1 to 6.5 for the stepwise sugar reduction strategy and from 7.9 to 6.8 for the gradual sugar reduction strategy (Table 1). Children's overall liking scores were significantly affected by week ($F= 6.75$, $p<0.001$), but did not

significantly differ between groups (F=1.04, p=0.308) or the interaction between group and week (F=0.87, p=0.543)

As expected, overall liking scores significantly decreased with sugar reduction for both experimental groups. However, gradual sugar reduction caused smaller changes in children's hedonic perception than the stepwise sugar reduction (Table 1). For children in the stepwise strategy, the first significant decrease in liking with respect to the control sample (10% sugar, week 1) occurred in the fifth week (37% sugar reduction), whereas for children in the gradual reduction strategy overall liking significantly decreased in the eighth week (52% sugar reduction).

Table 1. Sugar concentration and overall liking of grape nectars served during a longitudinal study with children, following two added sugar-reduction strategies: stepwise and gradual

Week	Experimental Group			
	Stepwise (n=66)		Gradual (n=51)	
	Added sugar concentration (g/100mL) of the grape nectars	Overall Liking	Added sugar concentration (g/100mL) of the grape nectars	Overall Liking
1	10.0	8.2(1.2)^{a}	10.0	8.0(1.7)^{a}
2	10.0	7.9 (1.3)^{a}	10.0	7.9(1.7)^{a}
3	10.0	7.6(1.9)^{ab}	9.0	7.6(1.8)^{ab}
4	6.3	7.6(1.4)^{abc}	7.8	7.6(2.0)^{ab}
5	6.3	7.0(2.1)^{bcd}	7.0	7.7(1.8)^{ab}
6	6.3	7.4 (2.0)^{abc}	6.3	7.3(2.3)^{ab}
7	4.3	6.5(2.3)^{d}	5.5	7.2(2.3)^{ab}
8	4.3	6.8(2.2)^{cd}	4.8	6.9(2.4)^{b}
9	4.3	6.9(2.2)^{bcd}	4.3	6.8(2.5)^{b}

Samples with different lowercase letters in the same column are significantly different according to Tukey's test ($p<0.05$).

Sensory perception

For both groups, significant differences were found in the frequency of use of some of the terms of the CATA questions between the nectars tasted in different weeks. As shown in Table 2, children in the stepwise group increased their frequency of use of the terms *watery* (3rd week), *acid taste* (5th week) and *barely sweet* (8th week), and decreased their frequency of use of the terms *grape flavor* (6th week), *very sweet* (8th week) and *sweet* (7th week). Children in this group did not notice changes in the sensory characteristics of the nectars when sugar concentration decreased from 10.0% to 6.3% (weeks 3 and 4). However, when the sugar content of the grapes was further reduced to 4.3% (weeks 6 and 7), they perceived changes in the sensory characteristics of the nectars, as evidenced by the decrease in the frequency of use of the term *sweet* and the increase in the frequency of use of the term *watery*.

For children in the gradual sugar reduction group smaller differences in the frequency of use of the terms were found, which indicate that they perceived smaller differences in the

sensory characteristics of samples. This group of children increased their frequency of use of the terms *watery* (3rd week) and *acid taste* (6th to 8th weeks), and decreased the frequency of use of the terms *very sweet* (7th week) compared to the first sample.

The two groups did not largely differ in how they used the terms of the CATA questions to describe the samples (Table 2). According to the Generalized Linear Model (GLM), significant differences between the groups were found for the frequency of use of the terms *sweet* ($p=0.017$), *barely sweet* ($p<0.001$) and *grape flavor*.($p<0.001$), whereas the interaction between experimental group and week was not significant for all terms ($p>0.21$). On average, children in the gradual reduction group used more frequently the terms *sweet* (51% vs 44%) and *grape flavor* (78% vs. 67%), and less frequently the term *barely sweet* than those in the stepwise reduction (13% vs 22%).

Table 2. Percentage of children who used each of the terms of the CATA question in the 9-week experiment in the stepwise and gradual added sugar reduction scheme.

Experimental group	Week	Added sugar concentration	Acid taste	Very sweet	Sweet	Barely sweet	Grape flavor	Watery
Stepwise	1	10.0%	2^{c}	13^{a}	34^{a}	6^{b}	51^{a}	3^{c}
	2	10.0%	4^{abc}	16^{a}	32^{a}	9^{b}	51^{a}	8^{bc}
	3	10.0%	6^{abc}	8^{ab}	35^{a}	10^{b}	48^{a}	11^{b}
	4	6.3%	7^{abc}	14^{a}	27^{ab}	14^{ab}	46^{a}	10^{b}
	5	6.3%	9^{ab}	13^{a}	27^{ab}	19^{ab}	44^{a}	15^{b}
	6	6.3%	8^{ab}	8^{a}	32^{a}	12^{ab}	40^{bc}	16^{b}
	7	4.3%	10^{a}	5^{abc}	22^{b}	21^{ab}	34^{bc}	35^{a}
	8	4.3%	10^{a}	2^{cd}	25^{ab}	23^{a}	40^{bc}	31^{a}
	9	4.3%	9^{a}	9^{ab}	25^{ab}	17^{ab}	43^{abc}	27^{a}
Gradual	1	10.0%	1^{b}	7^{b}	28^{ab}	5^{ab}	42^{a}	3^{c}
	2	10.0%	4^{b}	12^{a}	30^{a}	3^{b}	42^{a}	4^{bc}
	3	9.0%	5^{ab}	14^{a}	28^{ab}	3^{b}	39^{a}	8^{b}
	4	7.8%	5^{ab}	9^{b}	22^{ab}	3^{b}	41^{a}	10^{b}
	5	7.0%	6^{ab}	5^{bc}	27^{ab}	4^{b}	39^{a}	10^{b}
	6	6.3%	9^{a}	8^{b}	20^{b}	6^{ab}	40^{a}	18^{a}
	7	5.5%	8^{a}	1^{c}	28^{ab}	11^{a}	39^{a}	17^{a}
	8	4.8%	8^{a}	1^{c}	25^{ab}	12^{a}	39^{a}	19^{a}
	9	4.3%	6^{ab}	4^{bc}	26^{ab}	12^{a}	39^{a}	21^{a}

The frequency of use of terms with different lowercase letters within a column and experimental group are significantly different between weeks according to the sign test ($p < 0.05$).

3.2. Sensory and hedonic perception of grape nectars with different sugar concentration evaluated after the 9-week period.

Overall liking scores were significantly affected by sample ($F=11.22$, $p<0.001$) and experimental group ($F=4.57$, $p=0.033$), whereas no significant interaction was found between sample and experimental group ($F=1.80$, $p=0.166$). As expected, the sample with the lowest added sugar content (4.3%) showed the lowest overall liking score for both experimental groups (Table 3). At the aggregate level, children in the stepwise sugar reduction strategy

gave significantly higher overall liking scores than those in the gradual sugar reduction strategy.

Differences among samples were found in the frequency of use of the majority of the terms. As expected, the sample formulated with 4.3% of added sugar showed lower frequency of use of the terms *very sweet* and *grape flavor* intensity, and a higher frequency of use of the terms *barely sweet*, *acid taste* and *watery* than the control sample (10.0% added sugar). The two experimental groups did not significantly differ in how they used the terms of the CATA questions to describe the samples ($p>0.12$). In addition, the interaction between experimental group and sample was not significant for all terms ($p>0.66$).

Table 3. Overall liking and percentage of children who used each of the terms of the CATA questions for the grape samples with different added sugar concentration (% of nectar weight) submitted to the stepwise and gradual sugar reduction scheme two weeks after the 9-week period.

Group	Added sugar concentration	Overall liking	Acid taste	Very sweet	Sweet	Barely sweet	Grape flavor	Watery
Stepwise	10.0%	8.2(1.1)^{a}	2^{b}	26^{a}	34^{a}	1^{c}	53^{a}	1^{c}
	6.3 %	7.8(1.5)^{a}	5^{a}	7^{b}	41^{a}	7^{b}	54^{a}	7^{b}
	4.3 %	7.3 (1.8)^{b}	14^{a}	3^{b}	27^{a}	18^{a}	40^{b}	22^{a}
Gradual	10.0%	7.6 (2.0)^{a}	1^{b}	20^{a}	25^{a}	1^{b}	42^{a}	1^{c}
	6.3 %	7.9 (1.7)^{a}	5^{ab}	4^{b}	25^{a}	5^{a}	41^{a}	7^{b}
	4.3 %	6.5 (2.6)^{b}	12^{a}	1^{b}	15^{b}	17^{a}	31^{b}	21^{a}

Overall liking scores with different lowercase letters within an experimental group are significantly different between added sugar concentrations according to Tukey's test ($p<0.05$). The frequency of use of terms within a column and experimental group with different letters is significantly different according to the sign test ($p < 0.05$).

4. DISCUSSION AND CONCLUSIONS

One of the main challenges of sugar reduction is maintaining consumers' hedonic perception. This is particularly relevant in the case of children, who have a heightened preference for sweet taste (Ventura & Menella, 2011). Sugar reduction should be unnoticeable for consumers, who slowly become accustomed to the sugar-reduced products. In the present work, the influence of two sugar reduction strategies on children's sensory and hedonic perception were studied, using grape nectar as target product.

Reducing the added sugar content of the grape nectars from 10.0% to 4.3% led to changes in the sensory characteristics perceived by children. In particular, a decrease in sweetness and an increase in acidity and watery was observed. The increase in the frequency of use of the term *watery* for describing sugar-reduced grape nectars can be explained by a reduction in grape flavor intensity perception and viscosity, which can be related to both the reduction in sweetness and the increased concentration of water caused by the reduction of added sugar. These changes in the sensory characteristics of the nectars led to a decrease in overall liking. However, average overall liking scores were always higher than 6.5, which suggest that children had a positive hedonic attitude towards the sugar-reduced nectars. Despite the reduction of 57% in the added sugar concentration of grape nectars commercialized in Brazil (from 10.0% to 4.3%) caused a significant decrease in the overall

liking, the average score still indicated a positive hedonic attitude towards the product. This stresses the feasibility of sugar reduction to decrease sugar intake at the population level.

Although there were no major differences between the gradual and stepwise reduction, results showed that the gradual reduction strategy led to smaller changes in children's sensory and hedonic perception than the stepwise strategy. Therefore, gradual reduction could be regarded as more effective for maintaining children's satisfaction with the product. Food companies should not be concerned about children disliking their product and switch to the competitors if gradual sugar reduction programs based on difference thresholds are implemented, as they would not perceive the difference. According to results from previous studies conducted with children and adults, difference thresholds for added sugar in beverages correspond to 6.2-8.5% (Lima et al., 2018; Pineli et al., 2016; Oliveira et al., 2016; Hoppert et al., 2012), which would correspond to the sugar reduction of each step.

The advantages of gradual reformulation programs have been extensively explored for salt. In this sense, Bobowski, Rendahl and Vickers (2015) reported that gradual salt reduction in tomato juice was more effective than an abrupt reduction for maintaining consumers liking throughout 16-week period. Gradual salt reduction programs have proven to be successfulat both the commercial (Bratt & Tamman, 2010) and the population levels (He, Brinsden & MacGregor, 2014; Public Health England, 2017).

Two weeks after the longitudinal study, children in the stepwise sugar reduction strategy showed higher liking for the nectars than children in the gradual sugar reduction strategy. This difference can be explained considering differences in their expectations. Children in the stepwise reduction strategy were more times exposed to the nectar with the lowest sugar content (4.3%) than those in the gradual reduction and, therefore, expected to receive nectars with low sugar. However, when they received nectars with higher sugar content, their expectations were disconfirmed and they increased their liking. It is also possible to suggest that the learning process played a role. In this sense, the overall liking of the nectar sample with the lowest added sugar content significantly increased for the stepwise group after the 9^{th} week period compared to the first time they taste it. This suggests that exposure to this sample over a 3-week period led to an increase in liking for the sample with the lowest sugar content. Several studies have consistently demonstrated that liking for foods increases with repeated exposure, for both adults and children (Cooke, 2007). Considering that children were only exposed to the nectars once a week, a 3-week waiting period between gradual sugar reduction steps seems reasonable.

However, it should be stressed that the 3-week waiting time implemented in the stepwise reduction was not enough to modify children's preference for sweet taste in grape nectar. Similar results have been reported by Biguzzi, Lange & Schlich (2015) when studying changes in liking after exposure to sugar-reduced cookies over 5 testing sessions conducted once a week with adult consumers. Further research in this respect should be carried out for providing recommendations for the design of gradual sugar reduction programs. In addition, different results could have achieved whether the children have tried the nectars more than once a week. Therefore, this limitation has to be taken into account and in future studies participants have to try the product more times, as reported by Bobowski, Rendahl & Vickers (2015).

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APÊNDICE V

It is not all about information! Sensory experience overrides the impact of nutrition information on consumers' choice of sugar-reduced drinks

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ABSTRACT

Excessive sugar intake is a global public health concern, and sugar-sweetened beverages (SSB) represent one of the main sources of added sugar in the diet. In this sense, the inclusion of front of pack (FOP) nutritional schemes and food reformulation are strategies that could contribute to reduce sugar consumption and improve population health status. The aims of this work were to evaluate adults and children's choice of sugar-reduced drinks in the context of the implementation of FOP nutrition labelling under different evaluation conditions, and to compare the influence of two FOP nutrition labelling schemes: the traffic-light system (TLS) and nutritional warnings. For that, 400 adults and 400 children (6-12 years old) divided in 2 groups (n=200) each chose samples of grape nectar or chocolate flavoured milk (control and two sugar reduction levels) featuring different FOP nutritional schemes, under three experimental conditions: (a) blind, tasting the samples without any information, (b) expected, looking at the packages, and (c) informed, looking at the packages and tasting the samples. In each experimental condition, participants were asked to choose one of the three products. Both FOP schemes encouraged adults and children's to choose for healthier products under the expected condition. In the case of adults, nutritional warnings outperformed the traffic light system in the task involving grape nectars. However, when participants tasted the products (blind and informed conditions), choices were defined by their sensory characteristics and the control samples without sugar reduction were the most frequently selected. These results indicate that consumers' hedonic experience overrode the effect of FOP nutrition labelling and suggest that this public policy is unlikely to have a real effect on consumers' choices if there are no healthy alternatives that meet their sensory and hedonic expectations.

Keywords: Front of pack; nutrition information; traffic-light system; nutritional warnings; sugar reduction; children.

1. INTRODUCTION

Excessive sugar intake is a global public health concern given its association with the increasing prevalence of obesity and several non-communicable diseases (World Health Organization, 2015). Sugar-sweetened beverages (SSB) represent one of the main sources of added sugar in the diet and have been identified as a major target for the development of policies and interventions aimed at reducing sugar intake at the population level (Louie, Moshtaghian, Rangan, Flood, & Gill, 2015; Martin-Calvo et al., 2014; Miller et al., 2013; Zheng, Allman-Farinelli, Heitmann, & Rangan, 2015; Zheng, Finkelstein, Nonnemaker, Karns, & Todd, 2014).

Reduction of the sugar content of products available in the marketplace has been claimed to be one of the most cost-effective policies to reduce sugar intake (MacGregor & Hashem, 2014). One of the main challenges of this approach is related to the changes in the sensory characteristics of products caused by sugar reduction (van Raaij, Hendriksen, & Verhagen, 2009). Previous research has shown that in the specific case of SSB, the sugar content of commercial products can be reduced by 5-8% without consumers' awareness (Hoppert, Zahn, Puschmann, Ullmann, & Rohm, 2012; Oliveira, Reis, Deliza, Rosenthal, Giménez, & Ares, 2016; Pineli, Aguiar, Fiusa, Botelho, Zandonadi, & Melo, 2016; Lima et al., 2018). Such small gradual reductions in sugar content can modify sugar intake even if consumers do not change their individual food choices (van Raaij et al., 2009; MacGregor & Hashem, 2014). However, larger sugar reductions have been reported to cause changes in consumers' hedonic reaction to products, although large individual differences exist (Bobowski, Rendahl, & Vickers, 2015; Bobowski, & Vickers, 2012; Lima et al., 2018).

Information provisioning is another strategy that can encourage consumers to select products with lower sugar content (Capacci et al., 2012). In this sense, the inclusion of nutrition information on food packages has been regarded as one of the most important public policies to enable informed and more healthful food choices (Grunert & Wills, 2007). Given the complexity of conventional back-of-pack nutrition information, the inclusion of simplified front-of-pack (FOP) nutrition labelling schemes has gained increased interest worldwide to facilitate consumers' understanding (EUFIC, 2017). These schemes can nudge consumers to select more healthful products due to their salience on the labels and their ease of understanding (Reisch & Sunstein, 2016; Scrinis & Parker, 2016).

Several FOP nutrition labelling schemes differing in the degree to which they assist consumers in judging product healthfulness have been developed and implemented worldwide (EUFIC, 2017). Experimental evidence suggests that schemes that include interpretational cues are more efficient in improving consumers' ability to accurately judge product healthfulness and in encouraging healthier food choices than schemes that communicate quantitative nutrient information, such as the guidelines daily amounts system (e.g. Antúnez, Giménez, Maiche, & Ares, 2015;Feunekes, Gortemaker, Willems, Lion, & Van Den Kommer, 2008; van Herpen & Van Trijp, 2011; Machín et al.,2017; Roberto, Shivaram, Martinez, Boles, Harris, & Brownell, 2012). However, there is still lack of agreement on which is the most effective FOP nutrition labelling scheme.

The traffic-light system (TLS) is one of the most widely studied schemes (Hawley, Roberto, Bragg, Liu, Schwartz, Brownell, 2013) that has been strongly advocated by consumer organizations (Consumers International, 2015). This scheme includes quantitative information about the content of key nutrients (usually sugars, saturated fat and sodium) and classifies them as low, medium or high, using text descriptors and a colour code (Food Standards Agency, 2007). However, the TLS still requires consumers to arrive at their own overall healthful judgment based on the simultaneous evaluation of the content of several nutrients, which has been reported to be a challenging task (Black & Rayner, 1992). In

addition, recent research has shown that information about low nutrient content can increase healthfulness perception of food products with high content of other nutrients associated with non-communicable diseases (Machín, Aschemann-Wtizel, Curutchet, Giménez, & Ares, 2018b), which can decrease its efficacy to stimulate healthier food choices. Furthermore, the inclusion of the traffic light system has been reported to not necessarily improve consumers' ability to differentiate healthful from unhealthful products (Talati et al.,2017).

Nutritional warnings are a new type of FOP nutrition labelling scheme that has gained popularity in the Americas to facilitate identification of products with high content of nutrients associated with non-communicable diseases (Ministerio de Saludo, 2015; Government of Canada, 2017; Ministerio de Salud de Perú, 2018; Ministerio de Salud Pública, 2018). This scheme has already been implemented in Chile, where products should include octagonal black signs with the expression "High in" if the content of content of calories, sugars, saturated fat and sodium exceed pre-determined criteria (Ministerio de Salud, 2015). Nutritional warnings have been shown to be efficient at discouraging consumers' choice of products with high content of key nutrients and to have advantages over other FOP labelling schemes (Acton & Hammond, 2018; Ares et al., 2018a; Ares et al., 2018b; Arrúa, Curutchet et al., 2017; Arrúa, Machín et al., 2017; Machín, Aschemann-Witzel, Curutchet, Giménez, & Ares, 2018a; Machín, Aschemann-Witzel, Curutchet, Giménez, & Ares, 2018b; Khandpur et al., 2018).

Labelling information is not the only determinant of food choice and eating patterns (Köster, 2009). Sensory and hedonic characteristics of products play a major role in shaping consumers' food choices (Tuorila, 2007). Consumers have been long reported to be unlikely to compromise on their hedonic experience with products for potential health benefits (Civille & Oftedal, 2012; Tuorila & Cardello, 2002; Verbeke, 2006). For this reason, the influence of FOP nutrition labelling on consumers' food choices is expected to strongly depend on the sensory characteristics of the products available in the marketplace.

Food choice, like most behaviors, can be conceptualized as a mean to achieve a specific goal (Moskowitz & Grant, 2009). Given the choice between a regular and a sugar-reduced product, consumers are expected to evaluate their characteristics and select the one that is associated with the most desirable outcome in terms of the goal they want to achieve. However, a conflict between two incompatible goals may exist: healthy eating and pleasure of eating, as postulated by Stroebe (2002) in the goal conflict model of eating. In this case, inhibitory mechanisms are expected to inhibit alternative goals that compete for cognitive resources, making only one of the goals salient in consumers' mind (Wegner & Wenzlaff, 1996). In the specific case of sugar-sweetened beverages, the pleasure goal is expected to be more salient for consumers' choices. However, the inclusion of FOP nutrition labelling highlighting high sugar content can make the goal of eating healthily more salient in consumers' mind and can potentially inhibit the mental representation of the pleasure goal (Shah, Friedman & Kruglanski, 2002).

Goals can be activated by the specific context in which a choice is made, as different aspects of the products may become salient in consumers' mind (Stroebe, 2002). In this sense, when consumers evaluate packages, non-sensory characteristics and sensory expectations are expected to be the main drivers underlying their choices. However, the relevance of sensory characteristics is expected to increase when they taste the product. In this sense, extensive research has shown differences in how consumer perceive products with and without information (Piqueras-Fiszman & Spence, 2015). Despite the importance of sensory characteristics on food choices, most research on the influence of FOP nutrition labelling schemes on consumers' food choices has been conducted under experimental settings with product packages or labels (Hawley et al., 2013; van Kleef & Dagevos, 2015).

Most research involving product reformulation and FOP nutrition labelling has focused on adult consumers, whereas studies with children are still limited (Hawley et al., 2013). However, children are major influencers of food-related decisions within the family (Coughlin & Wong, 2002). In the context of sugar reduction, children are expected to be less willing to accept sugar-reduced products compared to adults, given their heightened preference for sweetness (Desor & Beauchamp, 1987; Desor, Greene, & Maller, 1975; Zandstra & De Graaf, 1998). In addition, health has not been identified as a major goal for children, who mainly select the food they want to consume based on hedonics (Heard, Harris, Liu, Schwartz, & Li, 2016). School-aged children have been reported to be able to use nutritional composition to classify foods as healthful and unhealthful although nutritional information is not usually read or considered for making their food choices (Brierley & Elliot, 2015; Slaughter & Ting, 2010; Soldavini, Crawford, & Ritchie, 2012; Heard et al., 2016). However, recent research has shown that the inclusion of simple FOP nutrition labelling schemes can influence children's food choices, discouraging the selection of products with high content of nutrients associated with non-communicable diseases (Ares et al., 2016; Arrúa et al., 2017; Privitera, Phillips, Zuraikar, & Paque, 2015; Pettigrew, Talati, Miller, Dixon, Kelly, & Ball, 2017). Nevertheless, research on the impact of FOP nutrition labelling schemes on children's perception and choice is still limited (Lobstein, 2013).

The aims of the present work were to evaluate adults and children's choice of sugar-reduced drinks in the context of the implementation of FOP nutrition labelling under different evaluation conditions and to compare the influence of two FOP nutrition labelling schemes: the traffic-light system and nutritional warnings.

2. MATERIALS AND METHODS

A choice experiment was implemented with groups of adults and children, each of which evaluated one target product: grape nectar and chocolate flavoured milk. For each product, participants were randomly divided into two sub-groups, each of which was assigned to a FOP nutrition labelling scheme: traffic light system and nutritional warnings. Participants had to complete a choice task involving three samples in three experimental conditions: blind tasting, evaluation of packages and informed testing (tasting with the corresponding packages)

2.1. Participants

The study was conducted in the city of Rio de Janeiro (Brazil) with a total of 800 participants: 400 adults and 400 children. Participants of each age group were divided in two groups that evaluated one food product: grape nectar (200 adults and 200 children) or chocolate flavoured milk (200 adults and 200 children). For each food product, they were randomly divided in two groups, each of which evaluated the samples using a different FOP nutrition labelling scheme: traffic light system (n=100) and nutritional warnings (n=100). The groups of adults and children who evaluated the samples featuring different FOP nutrition labeling schemes did not significantly differ in their gender and age distribution for both grape nectar ($p>0.15$) and chocolate flavoured milk ($p>0.06$);

Adults (61% female, 18-65 years old) were recruited in a supermarket while doing their shopping. They should be responsible for shopping for food in their household and to consume the target products at least weekly. Children (48% girls, 6-12 years old) were recruited in private schools. They all consumed the target products at least weekly.

Adults gave written informed consent before starting the study. Children were authorized to participate by their parents, who signed an informed consent form. Children gave oral consent to participate in the test. No compensation was given to adults, whereas a small gift (equivalent to US$ 0.5) was given to children for their participation. The study was approved by the Brazilian Committee of Ethics in Research (Plataforma Brasil – CAAE 55023416.0.0000.5285).

2.2. Stimuli

Grape nectar and chocolate-flavoured milk were selected as target sugar sweetened drinks given their frequent consumption in Brazil (Brazilian Institute of Geography and Statistics, 2010). For each product category, the added-sugar content of the control samples was selected based on the formulation of commercial samples available in the Brazilian marketplace. The added-sugar concentrations of the sugar-reduced samples were selected based on Uruguayan legislation for the inclusion of nutritional warnings on food packages (Ministerio de Salud Pública, 2018). For both product categories, at least one sample without nutritional warnings was formulated. In the case of grape nectar this implied the formulation of a product without added sugar, whereas in the case of chocolate flavored milk added sugar should be lower than 7 g/100g. The added-sugar concentration of the third sample within each product category was selected based on results from previous studies to obtain samples with clearly different sensory characteristics, and that would elicit different hedonic reactions (Lima, Ares, & Deliza, 2018; Oliveira et al. 2016).

Formulation of grape nectar and chocolate flavoured milk

Grape nectar samples were formulated by diluting a commercial whole grape juice with no added sugar (Del Valle, Brazil) to 35% using mineral water (Minalba, Brazil). Three samples were formulated by adding different concentrations of commercial sugar (União, Brazil) to the nectars: 10% (control sample, corresponding to the added sugar content of commercial products in the Brazilian market), 4.3% (small sugar reduction), and no added sugar (large sugar reduction). Samples were stored under refrigeration temperature (4 °C± 1 °C) until their evaluation. Chocolate-flavoured milk samples were formulated using UHT whole milk (Elegê, Brazil), 2.5% alkaline cocoa powder (Garoto, Brazil), 0.08% carrageenan (AgarGel, Brazil), and sugar (União, Brazil), following the procedure reported by Oliveira, et al. (2016). The solid ingredients were mixed with the milk, previously heated to 70 °C for 3 min. The mixture was agitated at 1000 rpm for 1 min, heated to 70 °C for 4 min and then cooled to 20 °C in iced water. The mixture was then placed in 1000 mL glass containers and manually agitated for 30 s. Three samples with different concentrations of added sugar were produced: 9% (control, usual sugar concentration of commercial products in the Brazilian market), 6% (small sugar reduction) and 4% (large sugar reduction). Samples were stored under refrigeration temperature (4 °C± 1 °C) until their evaluation.

Packages

Real packages were designed by a professional graphic designer from Embrapa Agroindústria de Alimentos (Brazil) with previous experience in the design of food labels. All the information required by Brazilian legislation was included on the packages. Fictitious brands were used to avoid any potential bias due to consumers' previous experiences with commercial products. Cartoon characters were included on the package of the milk given their frequent use in this food category in Brazil. Information about sugar content was included in

the nutrition panel and in the front of the pack using two FOP nutrition labelling schemes: the traffic light system and nutritional warnings. None of these schemes have been implemented in Brazil and, therefore, they were not familiar for participants. The traffic light system included quantitative information about the content of calories, sugar, saturated fat and sodium per serving and the corresponding classification of the content of the three latter nutrients into low, medium and high using text descriptors (low, medium and high) and color code (green, yellow and red) (Figures 1a and 1c). The criteria of the Food Standards Agency (2007) were used to classify sugar, saturated fat and sodium content. The classification of the sugar content of the samples is shown in Table 1. All samples of grape nectar had low content of saturated fat and sodium, whereas all samples of chocolate flavoured milk had medium content of saturated fat and low sodium content (Figures 1a and 1c).

Nutritional warnings composed of octagonal black signs with the expression "High in sugar" were only included when the content of sugar was high according to Uruguayan project for implementing this public policy (Ministerio de Salud Pública, 2018). Samples featuring nutritional warnings on the front-of-pack are indicated in Table 1. None of the samples included any other warning sign (Figure 2).

Using the labels, real packages made of couche paper (i.e. a type of paper coated with a polymer to impart specific characteristics) were prepared and filled with water were produced to simulate real products. Figure 2b shows images of the grape nectar packages as they were presented to participants.

Table 1. Added sugar concentration of grape nectar and chocolate flavoured milk samples used in the study and the classification of their sugar content according to two front-of-pack nutrition labelling schemes: the traffic-light system and nutritional warnings.

Product	**Sample**	**Added sugar content (%)**	**Classification of sugar content**	
			Traffic-light system	**Nutritional warnings**
Grape nectar	Control	10	High	High
	Small sugar reduction	4.3	Medium	High
	Large sugar reduction	0	Medium	No warning
Chocolate flavoured milk	Control	9.0	High	High
	Small sugar reduction	6.0	Medium	No warning
	Large sugar reduction	4.0	Medium	No warning

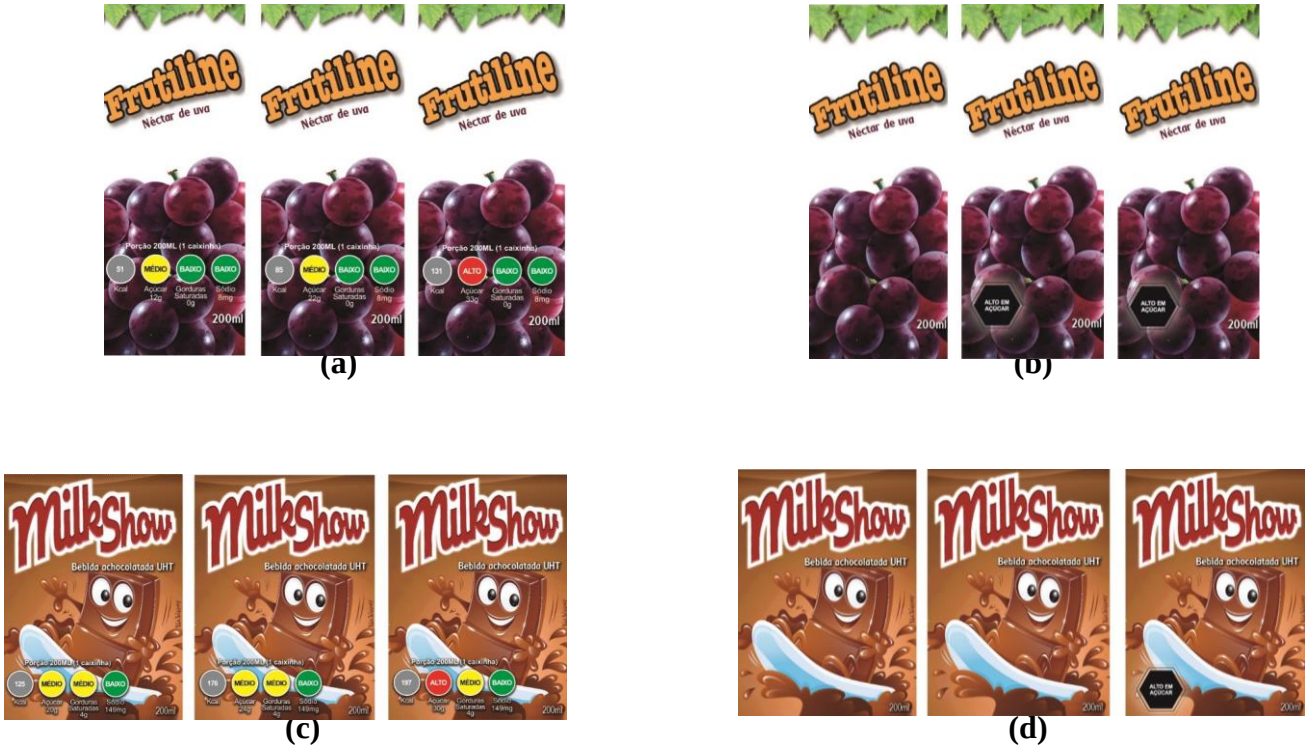


Figure 1. Labels with different front-of-pack nutrition labelling schemes included in the study: (a) grape nectar labels featuring the traffic light system, (b) grape nectar labels featuring nutritional warnings, (c) chocolate flavoured milk labels featuring the traffic light system and (d) chocolate flavoured milk labels featuring nutritional warnings.

2.3. Experimental Procedure

The experimental procedure involved three evaluation conditions: blind, expected and informed, in that order. In each of the three evaluation conditions, the three samples (control, small sugar reduction, and large sugar reduction) were presented simultaneously in balanced order, following a Williams' Latin square experimental design (MacFie et al., 1989). In the blind evaluation condition, participants received samples in disposable plastic cups, and were asked to taste them (Figure 2a). In the expected condition, participants only received the three packages (Figure 2b), whereas in the informed condition they received the packages accompanied by disposable plastic cups containing the corresponding sample (Figure 2c). In each condition, participants had to answer the question "*Which product would you choose to consume?*". In the blind and informed conditions, samples were served in 30 mL portions at refrigeration temperature (6°C ± 2 °C). Three-digit random numbers were used for sample identification in the three evaluation conditions. For adults, the test was performed in a separate area of a supermarket. Children completed the test in a separate room in their own school. The test was completed by groups of five children under the supervision of three researchers, who explained the test and were available to assist children if needed. Before the test, the questionnaire was pilot tested with 12 children (6-12 years old) in the same conditions as the real test to ensure understanding.

(a) **(b)** **(c)**

Figure 2. Example of how samples were presented in each of the three evaluation conditions: (a) blind; (b) expected and (c) informed.

2.4. Data analyses

The frequency of selection of each sample in each choice task was determined for each FOP nutrition labeling schemes, product category and age group. Choice data were analyzed separately for each product category and age group using a logit model with random parameters (Scarpa, Ferrini, & Willis, 2005). This model assumes that, when facing a choice situation, each consumer selects the alternative from which he/she can derives more utility (i.e. benefit). The utility of alternative *j* for each consumer *n* can be calculated using the following formula (Greene, Hensher, & Rose, 2005):

$$U_{nj} = b_n x_{nj} + imat_{nj}$$

where x_{nj} are variables that characterize the alternative and the consumer, β_n is a vector of coefficients of these variables for consumer n and $\square_{nj}$ is a random term. The following variables of the choice set were considered in the model: sugar reduction level, FOP nutrition labeling schemes and evaluation condition, as well as their two-way interactions. It was assumed that the coefficients of the model varied across consumers following a normal distribution. The average coefficient across consumers and their significance were calculated. The analysis was performed using the gmnl package in R language (R Core Team, 2017).

3. RESULTS

The average coefficients of the logit models used to estimate the effect of sugar reduction level, type of FOP nutrition labelling scheme and evaluation condition on adults and children's choice of grape nectar and chocolate flavoured milk are shown in Table 2. For both products, the coefficients of sugar reduction in the model were significant, suggesting that this variable significantly affected the choice, as expected. However, the influence of sugar reduction on choice was moderated by evaluation condition, as evidenced by the significant coefficient of the interaction between large sugar reduction and the expected evaluation condition for both products and age groups. Meanwhile, the coefficient for FOP nutrition labelling scheme and those for its interactions with the other variables were not significant, except for grape nectar in the expected condition for adults. Results are presented in detail below separately for each product category.

Table 2. Average coefficients of the effects included in the logit model for adults and children's choice of grape nectar and chocolate flavoured milk samples.

Effect	Coefficient			
	Grape nectar		Chocolate Flavoured Milk	
	Adults	Children	Adults	Children
Small sugar reduction	1.087***	-0.497*	-1.239***	-1.050***
Large sugar reduction	-1.788***	-2.533***	-2.482***	-3.268***
Small sugar reduction: Informed	-0.504	0.271	0.918*	0.207
Small sugar reduction: Expected	-1.709**	0.498	0.770	0.196
Large sugar reduction: Informed	0.473	20.140	0.546	0.684
Large sugar reduction: Expected	3.821***	2.752***	2.877***	2.401***
Small sugar reduction: TLS	-0.391	-0.595	0.774	-0.113
Large sugar reduction: TLS	0.902	0.182	-0.376	-0.029
Small sugar reduction: Informed: TLS	0.703	0.278	-0.462	-0.622
Small sugar reduction: Expected: TLS	1.483*	0.797	-0.618	0.742
Large sugar reduction: Informed: TLS	-0.094	-19.829	0.121	-0.147
Large sugar reduction: Expected: TLS	-1.615*	0.403	0.165	0.819

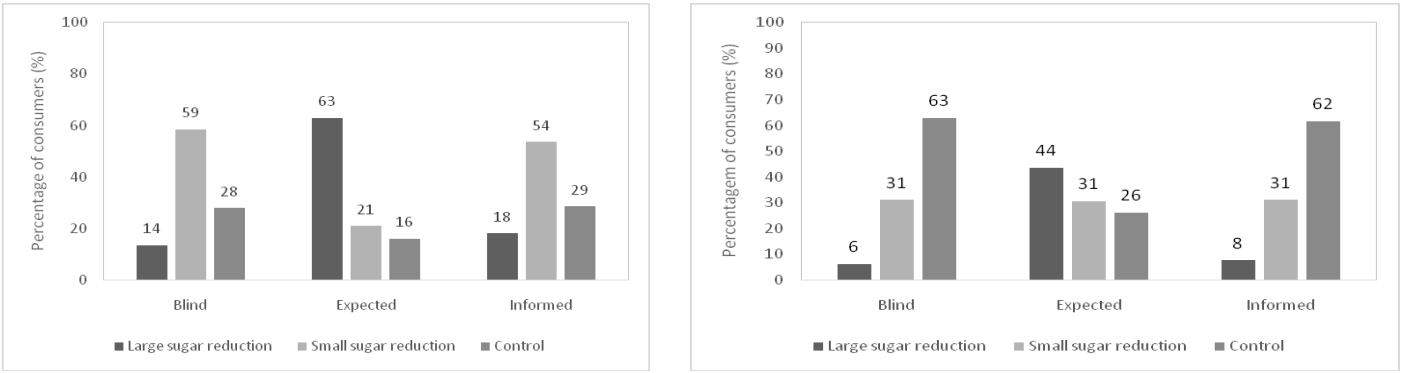
Notes: One level of each variable was considered as reference in the analysis. TLS indicates traffic-light system. The significance of the coefficients is indicated by the following codes: *$p < 0.05$; ** $p \leq 0.01$; *** $p < 0.001$.

3.1. Grape nectar

In the case of adults, the choice of the two samples with sugar reduction was moderated by the evaluation condition, as evidenced by the significant coefficient of the following interactions in the model: Small sugar reduction: Expected and Large sugar reduction: Expected (Table 2). As shown in Figure 5a, the sample with small sugar reduction (4.3% added sugar) was the most frequently chosen in the blind and informed evaluation conditions. However, in the expected evaluation condition, the majority of the adult participants selected the sample with large sugar reduction (0% added sugar) (Figure 3a).

Choice of grape nectars in the expected evaluation condition differed between participants who observed packages with different FOP nutrition labelling schemes (nutritional warnings and the traffic-light system), as evidenced by the significant coefficient of the interactions between sugar reduction, the expected evaluation condition and traffic light system (c.f. Table 2). As shown in Figure 4, the percentage of participants who chose the sample with large sugar reduction was higher when packages featured nutritional warnings compared to when they featured the traffic-light system, whereas the opposite trend was found for the sample with small sugar reduction. This difference can be explained by the fact that the sample with large sugar reduction was the only that did not feature any warning,

whereas in the case of the traffic-light system the sugar content of both sugar-reduced samples was classified as ‘medium’ (c.f. Table 1).



(a) (b)

Figure 3. Percentage of adults (a) and children (b) who chose each of the grape nectar samples with different added-sugar content in three evaluation conditions (blind, expected and informed) across the two front-of-pack nutrition labelling schemes.

For children, the coefficients for small and large sugar reduction were negative (Table 2), suggesting that sugar reduction had a negative effect on children’s choice of grape nectar. However, there was a significant interaction between large sugar reduction and evaluation condition (Table 2). As shown in Figure 3b, choice of the sample with large sugar reduction (0% added sugar) was significantly more likely in the expected evaluation condition compared to both the blind and informed conditions. In the expected evaluation condition 44% of children selected the sample with large sugar reduction, whereas this percentage was lower than 10% in the blind and informed conditions.

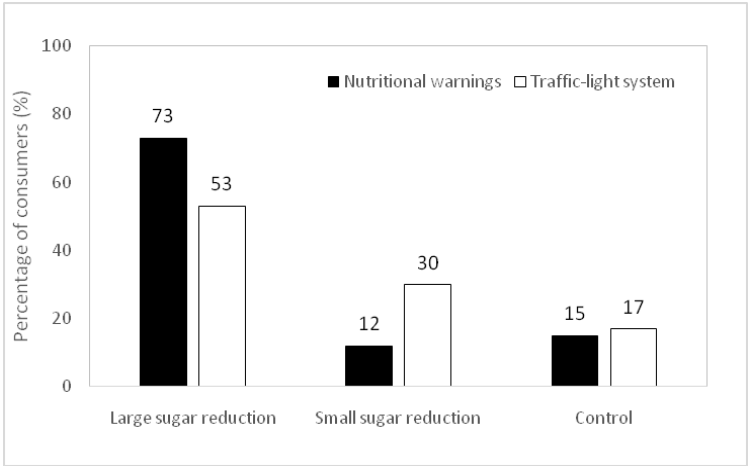
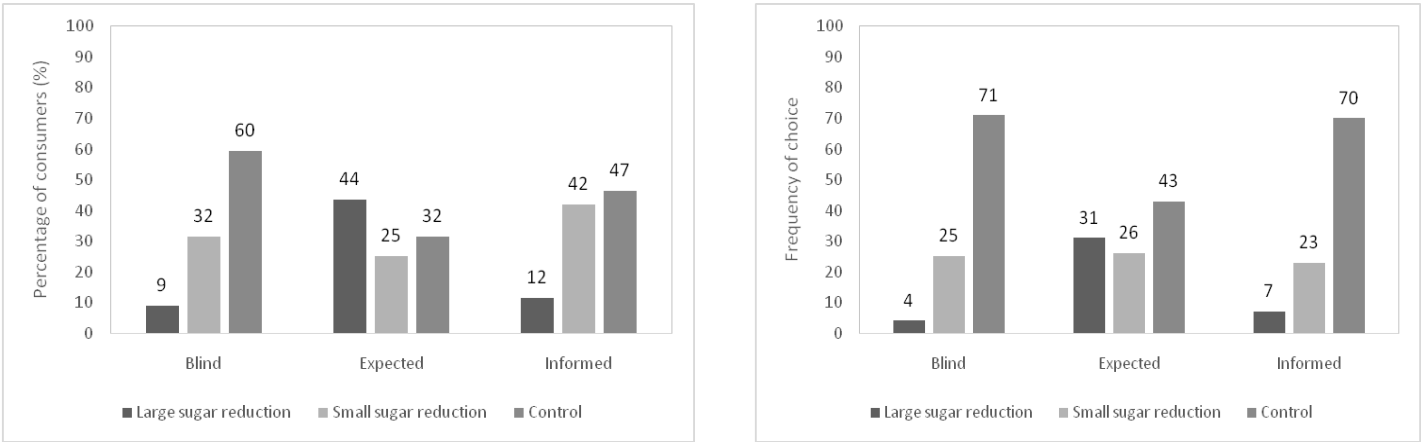


Figure 4. Percentage of adults who chose each of the grape nectar samples with different added-sugar content for packages featuring two front-of-pack nutrition labeling schemes (traffic light system and nutritional warning) in the expected evaluation condition.

3.2. Chocolate flavoured milk

In the case of chocolate flavoured milk, results did not largely differ between adults and children. For both age groups, the logit model showed significant coefficients for both

small and large sugar reduction, as well as for the interaction between large sugar reduction and the expected evaluation condition (Table 2). This suggests that choice of sugar-reduced samples differed between the expected evaluation condition and the blind and expected conditions. The positive coefficient indicates that the likelihood of choosing the sample with large sugar reduction significantly increased in the expected evaluation condition with respect to the other two conditions. As shown in Figure 5, the majority of adults and children selected the control sample (9% added sugar) in the blind and informed evaluation conditions. Meanwhile, in the expected evaluation condition 44% of adults and 31% of children chose the sample with large sugar reduction (4% added sugar) compared to 9-12% and 4-7% respectively in the blind and informed conditions.



(a) (b)

Figure 5. Percentage of adults (a) and children (b) who chose each of the chocolate flavoured milk samples with different added-sugar content in three evaluation conditions (blind, expected and informed) across the two front-of-pack nutrition labelling schemes.

4. DISCUSSION

FOP nutrition labelling and product reformulation have been suggested as two of the most cost-effective policies to promote healthier dietary patterns at the population level (Hawkes et al., 2015). Understanding how different consumer segments would react to these policies can provide useful insights for both policy makers and the food industry. In this context, the present work evaluated adults and children's reaction to sugar reduction in the context of the implementation of two FOP nutrition labelling schemes in two product categories: grape nectar and chocolate flavoured milk.

Results showed that when adults and children were faced with the decision of selecting packages featuring FOP nutrition labelling schemes that highlighted high sugar content (i.e. expected evaluation condition), they tended to select the reformulated product version with the largest sugar reduction in both product categories. This is in agreement with results from previous experimental studies showing the potential of FOP nutrition labelling to encourage more healthful choices (Acton & Hammond, 2018; Arrúa, Curutchet et al., 2017; Dodds et al., 2014; Khandpur et al., 2018; Machín, Aschemann-Witzel, Curutchet, Giménez, & Ares, 2018b; Talati et al. 2017).

FOP nutrition labelling has raised increasing interest worldwide and several countries have already approved its compulsorily inclusion on food labels, including United Kingdom, Chile, Israel, Peru and Uruguay (FSA, 2007; EUFIC 2017, Ministerio de Salud, 2015,

Ministerio de Salud Pública, 2018, Ministry of Health of Israel, 2017). The present work involved two FOP nutrition labelling schemes (the traffic light and nutritional warnings) but found no significant differences between them, except for grape nectars for adult consumers. Despite differences in the information provided by the two schemes (c.f. Figure 1 and Table 1), both encouraged adults and children to select the package of the product with the lowest sugar concentration. Consensus on the relative performance of different FOP nutrition labelling schemes does not exist in the literature as studies conducted with adults and children have shown different results. Previous studies have reported no significant or marginal differences between the influence of these FOP nutrition labelling schemes on consumers' perception and behavior (e.g. Machín et al., 2018a; Lima, Ares, & Deliza, 2018). However, others have shown that nutritional warnings have a larger effect than the traffic light system on adults and children's healthfulness perception and choice of unhealthful products compared to the traffic light system (Ares et al., 2016; Arrúa, Curutchetd et al., 2017; Arrúa, Machín et al., 2017; Khandpur et al., 2018). Differences between FOP nutrition labelling schemes are expected to strongly depend on the task consumers are asked to complete. In this sense, it is worth highlighting that the present work involved the evaluation of a limited number of alternatives in two specific product categories.

In the case of grape nectars, the warning system was more effective than the traffic-light system at encouraging consumers to choose the healthiest alternative in the expected condition (i.e. when they evaluated only the packages). This difference can be explained by differences in the information conveyed by the schemes and the nutrient profile model that underlid the classification of products according to their nutritional composition. The traffic light system classifies nutrient content in three categories, high/medium/low, whereas nutritional warnings only highlights products with high nutrient content. In the present work, the nutrient profiles associated with each scheme in the regulations of countries that had implemented them were used (UK for the traffic light system and Uruguay for nutritional warnings). For this reason, the sample with the largest sugar reduction (formulated without added sugar) was clearly differentiated from the rest in the warning system as it was the only sample that did not include any nutritional warning. Meanwhile, in the traffic-light system the sugar content of the two sugar-reduced samples was classified 'medium' in the traffic-light system. This difference may have facilitated the selection of the sample with the largest sugar reduction for consumers that made a choice among packages featuring nutritional warning compared to those who chose among packages featuring the traffic light system.

Although packages sugar-reduced samples were the most frequently, when the samples were tasted (both in the expected and informed evaluation), the majority of the consumers preferred the control sample without sugar reduction. The difference in consumers' acceptance of sugar-reduction in grape nectar and chocolate-flavoured milk can be explained considering a shift in their goals caused by the salience of the information. In the expected evaluation consumers made their choice based on the information included on the packages. In this situation, the nutritional information included on the packages was the only difference between samples and, therefore, a health-related goal was activated in their responses. Across the two product categories, consumers selected the most healthful option, i.e. the one with the largest sugar reduction. On the contrary, in the blind evaluation the only difference between samples was related to their sensory characteristics, which may have activated a pleasure-related goal. In this situation, consumers are expected to have chosen the sample they liked the most. In the informed condition, consumers also based their choices on the sensory characteristics of the products and selected the control sample without sugar reduction most often. Therefore, information did not modify consumers' choice of products with respect to the blind evaluation condition. This result can be attributed to the fact although consumers may be interested in avoiding products with high sugar content, they cannot be

expected to consume sugar-reduced products if they don't like them. The sensory characteristics of products have been extensively shown to play a key role in food choice, as consumers are unlikely to compromise their hedonic experience for potential health benefits (Civille & Oftedal, 2012). The lack of influence of information about sugar content on consumers' choices in the informed condition is in agreement with previous research reporting that health claims have shown a limited effect on consumers' hedonic perception (e.g. Kähkönen & Tuorila, 1998; Norton, Fryer, and Parkinson, 2013; Vázquez, Curia, & Hough, 2009). However, it is worth highlighting that research on the influence of information on consumer sensory and hedonic perception has focused on positive health-related information. On the contrary, most FOP nutrition labelling schemes also focus on negative aspects as they highlight products with high content of nutrients associated with non-communicable diseases.

In addition, it is worth highlighting that the characteristics of the choice task may have induced participants to consider the sensory characteristics of the products when making their choices without looking at the information on the packages. Consumers were presented with the cups containing the samples along with the packages, whereas in real-life, consumers would not simultaneously taste the products when making their food choices in the supermarket by looking at packages. In addition, in real-life consumers would face a wide range of options that differ in several characteristics apart from sugar content. Once FOP nutrition labelling is implemented, consumers would choose among a wide range of products based on their previous experience and several non-sensory characteristics, inclining FOP nutrition labelling. The sensory characteristics of the product would determine consumers' willingness to re-purchase the product again after their first purchase. In this sense, it is important to highlight that research on the influence of FOP nutrition labelling schemes on consumers' choice after they are compulsorily implemented in the marketplace is still lacking.

In the present work, children and adults' reaction towards sugar-reduced products was compared. In general, both age groups behaved similarly as the tended to select the same samples across evaluation conditions. The only exception was the blind evaluation of the case of grape nectar. Children showed a higher preference for the control product (without sugar reduction) compared to adults, who mostly selected the sample with small sugar reduction. This result agrees with previous studies that highlighted children's higher preference for sweetness compared to adults (Cox, Hendrie, & Carty, 2016; De Graaf, & Zandstra, 1999; Desor & Beauchamp, 1987; Desor, Greene, & Maller, 1975; Lima, Ares,& Deliza, 2018). This highlights the importance of implementing gradual sugar reduction strategies that slowly modify children's sweetness preference through repeated exposure (MacGregor & Hashem, 2014).

5. CONCLUSIONS

The findings of the present work provide additional evidence that FOP nutrition labelling schemes, such as the traffic light system and nutritional warnings, can encourage adults and children to make more healthful choices at the point of purchase. However, despite the fact that consumers demonstrated interest in consuming products with lower sugar content when looking at the packages, FOP nutrition labelling did not modify their choices when they tasted the product. Therefore, FOP nutrition labelling cannot be expected to have a large effect on consumers' food choices if the healthful alternatives available in the marketplace do not meet their sensory expectations. This stresses the importance of implementing gradual sugar reduction together with FOP nutrition labelling to get consumers slowly accustomed to products with lower sugar content.

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