Strategies to reduce the sugar content of dairy products targeted at children

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Ana Laura Velázquez Mendoza

Thesis Directors:

Dr. Gastón Ares

Dra. Leticia Vidal

Dra. Paula Varela

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ABSTRACT

Children's sugar intake has raised concern worldwide as it exceeds nutritional recommendations. Although sugars are naturally present in food, sugars added to foods during industrial processing are currently the main source of sugar in children's diets. In particular, dairy products, which are generally recommended to be part of children diets, have drawn attention due to their high content of sugar. In this context, the main objective of this thesis was to explore different sugar reduction strategies in dairy products targeted at children. Results showed that sugar reduction of dairy products targeted at children available in the Uruguayan marketplace is possible. A direct sugar reduction up to 25% did not have a significant impact on children hedonic perception in three dairy products. Meanwhile the use of taste-odor-texture cross-modal interactions allowed to minimize the impact of sugar reduction on the sensory characteristics of dairy desserts. Co-creation with children was identified as a feasible approach to develop innovative healthy dairy products with high acceptance among children. Finally, package information influenced parent's healthiness perception and choice of snacks for their children, stressing that packaging regulations should play a key role as part of the comprehensive set of strategies that should be implemented to reduce children's sugar intake. Overall, results from this work provide useful insights to food scientists for the development of sugar reduced products targeted at children, as well as valuable information for policy makers to design programs to reduce children's sugar intake at population level.

RESUMEN

El consumo de azúcar de los niños ha suscitado preocupación en todo el mundo ya que supera las recomendaciones nutricionales. Aunque los azúcares están presentes de forma natural en los alimentos, los azúcares añadidos a los alimentos durante el procesamiento industrial son actualmente la principal fuente de azúcar en la dieta de los niños. En particular, los productos lácteos, que generalmente son recomendados para formar parte de la dieta infantil, han llamado la atención por su alto contenido en azúcar. En este contexto, el objetivo general de esta tesis fue explorar diferentes estrategias de reducción de azúcar en productos lácteos dirigidos a niños. Los resultados mostraron que es posible reducir el contenido de azúcar de los productos lácteos dirigidos a los niños disponibles en el mercado uruguayo. Una reducción directa de azúcar de hasta un 25% no tuvo un impacto significativo en la percepción hedónica de los niños de tres categorías de productos lácteos. Mientras tanto, el uso de interacciones entre modalidades sensoriales de gusto-aroma-textura permitió minimizar el impacto de la reducción de azúcar en las características sensoriales de postres lácteos. La co-creación con niños fue identificada como un enfoque viable para desarrollar productos lácteos saludables e innovadores con una alta aceptabilidad entre los niños. Finalmente, la información contenida en las etiquetas influyó en la percepción de saludable y las decisiones que toman los padres al elegir un producto para sus hijos, lo que sugiere que las regulaciones sobre etiquetado deben jugar un papel fundamental como parte del amplio conjunto de estrategias que debe implementarse para reducir el consumo de azúcar de la población infantil. En general, los resultados de este trabajo brindan información útil a los científicos de alimentos para el desarrollo de productos con bajo contenido de azúcar dirigidos a los niños, así como información valiosa para que los formuladores de políticas públicas de salud diseñen programas orientados a reducir la ingesta de azúcar en los niños a nivel poblacional.

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LIST OF PUBLICATIONS

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- **Velázquez, A. L.**, Alcaire, F., Vidal, L., Varela, P., Næs, T., & Ares, G. (2021). The influence of label information on the snacks parents choose for their children: Individual differences in a choice based conjoint test. *Food Quality and Preference*, 104296.
- **Velázquez, A. L.**, Galler, M., Vidal, L., Varela, P., & Ares, G. (2022). Co-creation of a healthy dairy product with and for children. *Food Quality and Preference*, 96, 104414. https://doi.org/https://doi.org/10.1016/j.foodqual.2021.104414
- Ares, G., **Velázquez, A. L.**, Vidal, L., Curutchet, M. R., & Varela, P. (2022). The role of food packaging on children's diet: Insights for the design of comprehensive regulations to encourage healthier eating habits in childhood and beyond. Food Quality and Preference, 95, 104366. https://doi.org/https://doi.org/10.1016/j.foodqual.2021.104366

The following abstracts were presented in scientific congress during the development of this thesis:

- **Velázquez, A. L.**, Vidal, L., Varela, P., & Ares, G. "Can children use temporal check-all-that-apply (TCATA) and temporal dominance of sensations (TDS)?". Flash poster presentation at the 15th Sensometrics Meeting, Online event, 6 - 9 October 2020.
- **Velázquez, A. L.**, Alcaire, F., Vidal, L., Varela, P., Næs, T., & Ares, G. "¿Cómo influye la información de la etiqueta en las elecciones de alimentos para la merienda escolar que realizan las madres?". Poster presented at the 1st Congreso Latinoamericano de Ciencias Sensoriales y del Consumidor (SenseLatam), Online event, 24 – 26 November 2020.
- **Velázquez, A. L.**, Vidal, L., Varela, P., & Ares, G. "Can children complete A-not A test?". Poster presented at the 9th European Conference on Sensory and Consumer Research (Eurosense), Online event, 13 - 16 December 2020.
- **Velázquez, A. L.**, Vidal, L., Varela, P., & Ares, G. "Reducing sugar in products targeted at children: Why aren't we there yet?". Oral presentation at the Food reformulation – Regulation and Marketing Conference, Online event, 17 - 18 June 2021.
- **Velázquez, A. L.**, Galler, M., Vidal, L., Varela, P., & Ares, G. "Co-creation of a healthy dairy product with children". Oral presentation at the 14th Pangborn Sensory Science Symposium - Early Career Researchers (ECR) seminar, Online event, 9 – 12 August 2021.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
Ca^{2+}	Calcio ion
CRD	Cysteine-Rich Domain
FAO	Food and Agriculture Organization
FAS	Foreign Agricultural service
FOP	Front-Of-Package
GLUT	Glucose Transporter
HDL	High-Density Lipoprotein
HFCS	High Fructose Corn Syrup
IISD	International Institute for Sustainable Development
NCDs	Non-Communicable Diseases
NNS	Non-Nutritive Sweeteners
NPD	New Product Development
OECD	Organization for Economic Co-operation and Development
PCA	Principal Component Analysis
TCA	Tricarboxylic Acid
TCATA	Temporal Check-All-That-Apply
TDS	Temporal Dominance of Sensations
TMD	Transmembrane Domain
UHT	Ultra-High Temperature
UK	United Kingdom
UNICEF	United Nations International Children's Emergency Fund
USA	United States of America
USDA	United States Department of Agriculture.
VFD	Venus Flytrap Domain

INTRODUCTION

Childhood overweight and obesity is one of the biggest public health problems worldwide (UNICEF, 2019). Overweight and obesity during childhood have negative short-term and long-term effects on children's health and wellbeing (Abbasi et al., 2017; Black et al., 2013; Dooley & Pillai, 2021; Smith et al., 2014; Sutaria et al., 2019; Weihrauch-Blüher et al., 2019). Despite global concern, no country has been successful in reducing the prevalence of childhood overweight and obesity (Obesity World Federation, 2019). This stresses the need to urgently develop effective multifaceted approaches to curb the pandemic.

Childhood overweight and obesity is a complex problem derived from multiple factors that promote unhealthy diets and a sedentary lifestyle (UNICEF, 2019). While children's intake of fruits and vegetables is below recommendations, they frequently consume products high in sugar, saturated fat, and sodium (UNICEF, 2019). In particular, sugar intake among children has raised concern worldwide as it largely exceeds recommendations (Perrar et al., 2020; Powell et al., 2016; Wittekind & Walton, 2014). The sugar intake of school-aged children in Uruguay is twice the daily intake recommended by the World Health Organization: they consume almost 3 kg of sugar per month (UNICEF, 2020).

Although sugars are a source of energy in the human body (Stylianopoulos, 2013b), an excess consumption of free sugars has been associated to the development of NCDs and mental disorders in children and adults (Jacques et al., 2019; Malik & Hu, 2015; Paglia et al., 2019; Tappy & Rosset, 2019). While sugars are naturally present in foods (e.g., fruits, vegetables, milk, and honey), the role of sugar in human diet has changed throughout history from a rare and exclusive ingredient to a mass commodity widespread in processed food (Eggleston, 2019; Minz, 1985). Today, sugars added to foods during industrial processing have been identified as the main source of sugar in children's diets (Afeiche et al., 2018; Powell et al., 2016; Rauber et al., 2019). Sweetened beverages, sweet bakery products, confectionary and dairy products have been identified as the main contributors to children's sugar intake around the world (Azaïs-Braesco et al., 2017; Bailey et al., 2018; Lei et al., 2016; Popkin & Reardon, 2018). In this sense, food categories traditionally recommended in children's diet, such as dairy products, have drawn attention due to their high amount of sugar behind their healthy halo (Garcia et al., 2020; Giménez et al., 2017; Mahato et al., 2020; Moore et al., 2018, 2020).

This panorama has motivated international and local health authorities to encourage governments to implement public policies to reduce free sugars intake at population level (Pan American Health Organization, 2020; World Health Organization, 2013, 2017a). For this purpose, several public policies have been proposed (Popkin & Hawkes, 2016).

Product reformulation is one of the cost-effective strategies that can be implemented to reduce children's sugar intake (MacGregor & Hashem, 2014). However, sugar reduction is a great challenge due to its multiple functional properties that play a critical role in food processing and the product's sensory profile (Goldfein & Slavin, 2015). One of the main concerns of sugar reduction strategies is to avoid abrupt changes that may impact the perception and acceptance of the product (Civille & Oftedal, 2012). This is particularly important for the reformulation of products targeted at children since they often prefer higher sweetness levels than adults (Drewnowski et al., 2012; Marty et al., 2018).

Several sugar reduction strategies have been proposed to reformulate food products targeted at children: partial or total replacement of sugar, cross-modal interactions, gradual sugar reduction, and other product-specific strategies (Di Monaco et al., 2018; Hutchings et al., 2019; McCain et al., 2018). Although partial or total replacement of sugar has been the default strategy to reduce the sugar content in food products, the negative health outcomes associated to non-nutritive sweeteners (NNS) have discouraged their use in product targeted at children (Swithers, 2015). Therefore, alternative sugar reduction strategies such as gradual sugar reduction have gained great attention. Gradual sugar reduction has been encouraged since it may have a positive long-lasting impact on children's dietary patterns and health outcomes (Ma et al., 2016). This strategy aims to modify children's sweetness preference by implementing unnoticeable and gradual sugar reductions allowing children to slowly get used to products with lower sugar content (Macgregor & Hashem, 2014). However, there are few studies exploring the feasibility of direct and gradual sugar reduction in products targeted at children (Li et al., 2015b; Lima et al., 2018a, 2019).

In this context, the main objective of this thesis is to explore different sugar reduction strategies in dairy products targeted at children. This thesis attempts to provide stakeholders involved in the development of products targeted at children recommendations to reduce the sugar content of their products, as well as to provide to public policy makers information that serves as the basis for the design of sugar reduction programs.

LITERATURE REVIEW

1. Chemical, sensory, and nutritional properties of sugar

Sugar is a generic term for a group of carbohydrates that comprises monosaccharides, disaccharides, and sugar alcohols (polyols) (Brouns, 2020). Monosaccharides are the simplest carbohydrate units. Structurally, they are polyhydroxy-aldehydes or polyhydroxy-ketones, frequently found in cyclic hemiacetal forms (Izydorczyk, 2005). The most important monosaccharides from a nutritional point of view are pentoses (e.g. ribose) and hexoses (e.g. glucose, fructose, and galactose) (Stylianopoulos, 2013a). Disaccharides are formed by two monosaccharide units joint by α or β glycosidic bonds (Izydorczyk, 2005), being sucrose and lactose the most common in nature.

Sucrose has the highest economic relevance among sugars as the main sweetening agent in the world (Belitz et al., 2009). Structurally, sucrose is a disaccharide formed by glucose and fructose units linked by an α-1,2 bond (Figure 1) (Izydorczyk, 2005). The main commercial sources of sucrose are sugar cane, accounting for the 86% of the global production, and sugar beet (OECD/FAO, 2020).

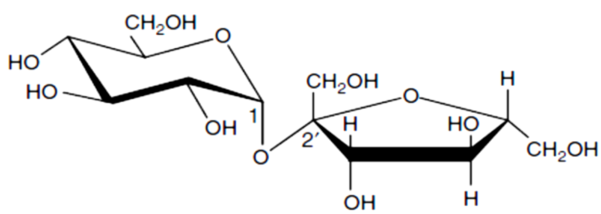

Figure 1. Chemical structure of sucrose

Sugar alcohols or polyols are formed by the reduction of aldo and keto groups in carbohydrates (Izydorczyk, 2005). For example, the reduction of d-glucose produces sorbitol, a sugar alcohol highly used in the food industry. Other relevant sugar alcohols are mannitol, xylitol and erythritol (Belitz et al., 2009). Sugar alcohols are less sweet than their corresponding carbohydrate; however, they are highly used in the food industry due their low caloric value, little or no effect on plasma glucose, anti-cariogenic properties and prebiotic properties (Park et al., 2016).

1.1. Sugar and sweet taste

One of the most relevant properties of sugars is their sweet taste (Belitz et al., 2009). Taste is the sensory experience that involves the interaction between chemical molecules and taste receptors cells (Breslin, 2013). Taste receptors are located in the membrane of taste buds, which are groups of 30-50 epithelial cells mainly found in the tongue, soft palate and pharynx (Breslin, 2013; Lawless & Heymann, 2010). In the tongue, taste buds are enclosed in specialized structures called papillae. Although multiple types or papillae are spread in the tongue, only fungiform, foliate and circumvallate papillae contains taste buds; filiform papillae are limited to tactile functions (Lawless & Heymann, 2010). In the soft palate and pharynx, taste receptors are in the flat epithelium instead of on the papillae (Breslin, 2013).

Sweet taste perception, one of the basic taste qualities, is mediated by the T1Rs family receptors, specifically a heterodimer of two G-protein coupled receptors T1R2/T1R3 (Li et al., 2002; Nelson et al., 2001). The T1R2/T1R3 sweet receptors are composed by three main subunits: N-terminal domain called Venus flytrap domain (VFD), a seven-helix transmembrane domain (TMD), and a cysteine-rich domain (CRD) (Chéron et al., 2017). Taste perception occurs when the G-protein coupled taste receptors are stimulated by the sweet molecules in the oral cavity.

Although all sweet molecules stimulate the sweet taste receptor, each receptor's subunit shows a distinct affinity to different sweet molecules. For example, the VFD subunit of the T1R2/T1R3 sweet receptor binds glucose, sucrose, sucralose and saccharine (Meyers & Brewer, 2008; Nie et al., 2005); meanwhile sweeteners such as cyclamate bind only to the TMD subunit of T1R3 and sweet proteins such as brazzein to the CRD subunit of T1R3 (Cui et al., 2006; Jiang et al., 2004). Moreover, some sweet molecules may activate other coexisting receptors in the papillae. For example, sweeteners such as saccharine and acesulfame k bind to bitter receptors (TAS2Rs) and produce bitter taste (Meyers & Brewer, 2008).

The stimulation of the taste receptors triggers several reactions that activate the release of neurotransmitter molecules (Lawless & Heymann, 2010). Two mechanisms have been proposed for the transduction of sweet taste. If the receptors are activated by sugars, adenyl cyclase is activated. This compound stimulates the generation of cyclic adenosine monophosphate which, either directly (via ion channel) or indirectly (via activation of a protein kinase) depolarizes the cell by releasing Ca^{2+}, which leads to the neurotransmitter release (Meyers & Brewer, 2008). Non-sugar sweeteners activate phospholipase which generates inositol 1,4,5-triphosphate and diacylglycerol. These compounds also induce the release of Ca^{2+} that triggers the depolarization of the cell and neurotransmitter release (Meyers & Brewer, 2008).

Taste signals are transmitted to the brain through different cranial nerves: facial nerves (VII), glossopharyngeal nerves (IX), and vagus nerve (X) (Behrens & Meyerhof, 2011; Lawless & Heymann, 2010); which activate complex hedonic (liking), wanting and learning brain systems (Berridge & Kringelbach, 2011). For instance, studies in rodents have shown the existence of hedonic hotspots in the nucleus accumbens, ventral pallidum, and brainstem that coordinate to intensify pleasure reactions to sweetness (Berridge et al., 2010;Berridge & Kringelbach, 2015; Nguyen et al., 2021). In this sense, tasting sucrose has shown to have a calming effect on infants and to decrease the perception of pain in children (Mennella et al., 2016).

Apart from the oral cavity, the body has sweet taste receptors in extra-oral tissues such as the respiratory epithelia and the gastrointestinal tract (Behrens & Meyerhof, 2011). In particular, the presence of sweet taste receptors in the gastrointestinal tract have drawn attention due to their impact on metabolic processes (Han et al., 2019). For instance, the activation of the sweet receptors in the enteroendocrine cells activates the secretion of hormones that exert multiple physiological effects, including the regulation of insulin secretion and subsequent blood glucose uptake (Han et al., 2019).

1.2. Sweetness and food preference

Humans have an innate preference for sweetness (Ventura & Mennella, 2011). Early studies on infant's behavioral responses to sugars solutions demonstrate that humans can detect, differentiate and like sweetness innately (Desor et al., 1973; Rosenstein & Oster, 1988; Steiner et al., 2001; Tatzer et al., 1985). However, the reason behind human's innate preference for sweet taste is still under debate. From an evolutionary perspective, a recent proposal argues that preference for sweet taste exists as a means of assessing the edibility of food plants (Beauchamp, 2016); a decision perhaps modulated by bitter taste as a toxicity cue in foods.

Children have been reported to prefer higher sweetness intensities compared to adults (Liem & Mennella, 2002; Drewnowski, 2000). This heightened preference for sweetness persists during childhood and decreases towards adulthood (Mennella et al., 2012). This trend has been explained by their high energy requirements in a period of rapid growth (Liem & Mennella, 2002; Drewnowski, 2000). In this sense, Coldwell et al. (2009) reported that adolescents with high sweetness preference showed higher levels of a growth marker in urine (bone resorption marker type I collagen cross-linked N-telopeptides) and food intake regulation hormones (leptin) than adolescents with low sweetness preference.

Although children's heightened preference for sweetness is universal across cultures (Mennella & Bobowski, 2015), children learn what foods should taste sweet and how sweet they should be through experience (Sullivan & Birch, 1990; Forestell & Mennella, 2007). Recently, Vennerød et al (2018) carried out a longitudinal study with 4 to 6 year old children which showed that exposure to high sweet food has been associated with higher preference for sweetness.

Considering that pleasure plays a key role in food choice, sweet taste is one of the most important drivers of food choices and preferences in children (Ares et al., 2010; Laureati et al., 2017; Nicklaus et al., 2004; Nicklaus & Remy, 2013). For instance, bitter taste and lack of sweetness are the main drivers of children's low liking for vegetables (Poelman et al., 2017); meanwhile sweetness has shown to be a driver for the preference of vegetable and other food groups (Divert et al., 2017; van Stokkom et al., 2018).

1.3. Metabolism of sugar

Physiologically, carbohydrates are the main source of dietary energy in the human body (Stylianopoulos, 2013b). Monosaccharides and disaccharides are metabolized to provide approximately 4 kcal/g. In comparison, the energy value of sugar alcohols is considerably lower due to their limited absorption and metabolism. For example, mannitol provides only 1.6 kcal/g due to its poor absorption, whereas erythritol is considered a zero-calorie sweetener since it is not metabolized (Grembecka, 2015).

The digestion of disaccharides occurs in the microvilli of the upper small intestine, where they are enzymatically hydrolyzed to their analogous monosaccharides (Evans & Heather, 2019). For example, sucrase hydrolyzes sucrose to glucose and fructose, whereas lactase hydrolyzes lactose to galactose and glucose. Then, monosaccharides are absorbed into the intestinal mucosa. Glucose and galactose are transported into the enterocytes through a sodium-glucose transporter (GLUT), whereas fructose is carried by a specific transporter called GLUT5 via facilitated diffusion. Subsequently, all monosaccharides are delivered to the bloodstream and to the liver by a glucose transporter (GLUT2) (Clemens et al., 2016).

Although monosaccharides are mainly metabolized in the liver, some glucose is supplied to other organs and tissues such as muscle, brain, kidneys and adipose tissue (Gropper & Smith, 2012). Glucose can follow different metabolic pathways depending on the requirements of the body: energy storage, energy production or simply return to the blood stream to maintain glucose levels in the body (Gropper & Smith, 2012).

Glucose can be converted to glycogen for energy storage (glycogenesis), or it can be oxidized to provide energy (glycolysis). For energy production, glucose is metabolized in the cytosol to pyruvate via glycolysis. Then, pyruvate is transported to the mitochondria to produce acetyl CoA; if there is an excess of glucose, the later can be used for lipid synthesis in the liver (novo lipogenesis pathway) (Evans & Heather, 2019). The produced acetyl CoA is fully converted to carbon dioxide, water and energy via the tricarboxylic acid cycle (TCA cycle) and electron transport chain (Evans & Heather, 2019).

Fructose and galactose are converted to glucose intermediaries via enzymatic reactions before they can follow a similar metabolic pathway to glucose (Malik & Hu, 2015). However, these differences may lead to different health outcomes. For instance, high consumption of fructose has been associated to higher risk of suffering NCDs compared to sugar which is a mix of glucose and fructose (Malik & Hu, 2015; Sun & Empie, 2012; Taskinen et al., 2017). Although the mechanism behind this phenomenon is still unclear, it has been attributed to the higher efficiency of fructose to stimulate novo lipogenesis and gluconeogenesis compared to glucose (Malik & Hu, 2015; Tappy & Rosset, 2019). Therefore, a basic knowledge of the metabolism of different sugars in the body is needed to comprehend their impact on health.

1.4. Health risks associated with excessive sugar intake

Sugar contributes to the daily energy intake, without providing additional nutritional value (World Health Organization, 2015). Excessive free sugar intake has been associated with a series of negative health outcomes (Malik & Hu, 2015; Paglia et al., 2019; Tappy & Rosset, 2019).Free sugar intake is particularly relevant during childhood, as this period is critical for the development of non-communicable diseases (NCDs) in later life (Buyken et al., 2010; Mahoney et al., 1996; The et al., 2010).

The concept of free sugars differentiates sugars naturally present inside the food matrix (e.g., lactose in milk or sugars in whole fruits) from sugars readily available in the food (free sugars). The later includes the industrially added sugars and naturally free sugars in food (e.g. honey, syrups, fruit juices, purées, and pastes) (Mela, 2020).

Children and adults with high free sugars intake are at risk of suffering micronutrient deficiencies (Fujiwara et al., 2020; Fulgoni III et al., 2019; González-Padilla et al., 2020; Øverby et al., 2004; Wang et al., 2015; Wong et al., 2019). In addition, excessive added sugar consumption is the main dietary factor for the development of dental caries in children and adults (Chi & Scott, 2019; Moynihan & Kelly, 2014; Peres et al., 2016). Dental caries is a progressive disease that affects over 530 million children and 2.4 billion adults globally (GBD 2017 Disease and Injury Incidence and Prevalence Collaborators, 2018). Dental caries damages the tooth by the action of the acids produced during the bacterial fermentation of carbohydrates contained in foods (Peres et al., 2019). Therefore, it is suggested that reducing the intake of added sugar to less than 5% of the total energy intake may reduce the risk of dental caries (Moynihan & Kelly, 2014).

A high intake of added sugar has been associated with metabolic syndrome in children and adults (Kelishadi et al., 2014; Luger et al., 2017; Wang et al., 2013), whereas its association with obesity is still under debate (Aumueller et al., 2019; Te Morenga et al., 2013; Welsh & Cunningham, 2011). Metabolic syndrome is a collection of risk factors (e.g., insulin resistance, central obesity, dyslipidemia, hypertension, and high plasma glucose) that can increase the risk of some NCDs (Rodríguez-Monforte et al., 2017). In this sense, high sugar intake has been associated to increased cardiovascular risk factors such as adiposity and dyslipidemia in children and adults (Malik & Hu, 2015; Vos et al., 2017). For example, Lee et al. (2014) showed that girls with an added sugar intake <10% of the total energy had higher levels of high-density lipoprotein (HDL) than girls with a higher added sugar intake. In addition, Yang et al. (2014) showed that adults with an intake of added sugar higher than 10% of the total energy had almost 40% higher risk for cardiovascular mortality than those with lower added sugar intake.

Overconsumption of sugar may also represent a threat to children and adult's mental health (Jacques et al., 2019; A. O'Neil et al., 2014). Excessive sugar intake has been linked to changes in neural systems and molecular substates that alter emotional processing, which may contribute to emotional disorders such as anxiety, depression, and fear (Jacques et al., 2019). According to the World Health Organization (2020), a burden of mental disorders exists across all ages groups with significant impact on health, social and economic consequences.

2. Sugar in human's diet

For thousands of years, humans only consumed sugars naturally present in foods. For instance, sucrose, glucose, and fructose are the most abundant sugars in fruits, vegetables, and honey, whereas lactose is the main sugar in milk (4 -6 %). Meanwhile, sugar alcohols are only present in small quantities in some fruits and vegetables (Belitz et al., 2009).

Today, the popularization of added sugars (e.g., sucrose) in food and beverages has increased and diversified the sources of sugars in human's diets (Deliza et al., 2021). Sugarcane was first cultivated in New Guinea more than ten thousand years ago and gradually spread to north Asia and India (Eggleston, 2019). However, sugar only arrived in Europe until the Crusades in the 12th century and in America in the 15th century with Columbus' expeditions (Minz, 1985). According to Minz (1985), the consumption of sugar through the human history can be described in terms of five main uses: medicine, spice-condiment, decorative material, sweetener, and preservative. The use of sugar as spice and medicine was popular in eastern Mediterranean and North Africa countries even before its introduction to Europe, where it was introduced as an exotic and luxurious spice. English cookbooks from the 14th century recorded sugar as a masking and flavor enhancer ingredient; it was used in multiple dishes which were not limited to sweet food (Minz, 1985). The use of sugar as a decorative material spread from African countries to Europe. Sugar was combined with nuts, oils, and vegetable gums to make sculpture-like confections firstly introduced in royal and wealthy class feasts (Minz, 1985).

The use of sugar as medicinal ingredient was introduced in Europe by the Arabian medicine; Arabian pharmacology manuscripts from the 9th century described multiple medicinal preparations with sugar. The medicinal properties of sugar (e.g., digestive and pain relieve properties) persisted until the 18th century when their validity began to be questioned (Minz, 1985). Today, sugar is used in medicinal formulations for children and adults for its functional properties and to increase their palatability (Mennella et al., 2015). The use of sugar as sweetener was connected to the popularization of imported bitter taste beverages in the United Kingdom during the 17th century. Sugar was used in chocolate, tea, and coffee to reduce their bitter taste and later it was incorporated in baked products and pastries that were eaten along with those beverages (Minz, 1985).

Before the 18th century, in Europe and America, sugar was regarded as a luxury commodity reserved for the wealthy classes due to its limited availability and excessive price (Minz, 1985). Sugar became a mass commodity with the increase of its affordability and availability. Particularly, after the modernization of sugar production in the 19th century, it became an essential part of the population's diet (Eggleston, 2019). A major increase in sugar intake occurred after the industrialization of food, which increased the availability of ultra-processed products with high content of added sugar and other sweeteners such as high fructose corn syrup (HFCS) (Eggleston, 2019; Wiss et al., 2018). Today around 75% of the world production of sugar cane is destinated to the food industry (IISD, 2020). Sugar production is forecasted to reach 186 million metric tons in 2021-2022 (FAS/USDA, 2021).

2.1. Functional properties of sugar in processed foods

The physical and sensory properties of sugar, as well as its interactions with other food ingredients, derivate in multiple technological applications in food products (Goldfein & Slavin, 2015). Apart from providing sweet taste, sugar balances flavor; provides texture properties; contributes to food preservation; inhibits protein coagulation; and adds color (McCain et al., 2018).

Sugar plays and important role in the overall flavor perception of food. Sugar can balance the flavor of food through the moderation of other basic tastes (Clemens et al., 2016). For instance, sugar reduces perceived sourness in high acidity foods, such as yogurt and fruit-based products (Pineli et al., 2016; Savant & McDaniel, 2004) and lowers bitterness in foods like chocolate and vegetables (Beck et al., 2014; Prawira & Barringer, 2009). Although the mechanism behind sugar modulation of other tastes is still unclear, it seems that sugar suppression of bitterness and sourness may be related to a perceptual process that integrates both tastes (Drewnowski, 2001; Green et al., 2010; Mennella et al., 2015; Savant & McDaniel, 2004; Schifferstein & Frijters, 1991).

Sugar has the ability to interact with water through the formation of hydrogen bonds between sugar hydroxyl groups and water molecules (Bubník & Kadlec, 1995), which has several technological implications. First, sugar impacts food texture by increasing viscosity in food products such as beverages and dairy products, which may influence mouthfeel perception (Sodini et al., 2004; Torrico et al., 2020; Wagoner et al., 2018). Sugar also depresses the freezing point in ice cream and frozen desserts, which minimizes the formation of large ice crystals and improves their texture (Clemens et al., 2016).

Food preservation and shelf life is related to the water binding capacity of sugar (Clemens et al., 2016). Sugar can reduce the water activity of food which delays microbial growth and enzymatic reactions due to the restriction of free water in the food matrix (Belitz et al., 2009). These properties are relevant to avoid spoilage and discoloration in jams, jellies, preserves, and frozen fruit based products (Goldfein & Slavin, 2015).

Sugar also provides color and flavor to foods through Maillard and caramelization reactions. Maillard reactions occur between amino groups on proteins, peptides and amino acids and carbonyl groups on reducing sugars (Lund & Ray, 2017). The compounds derived from Maillard reactions impact the aroma, flavor, and color profile, as well as protein functionality in foods such as bread, coffee, cacao, roasted meat, dark beer and UHT milk (Lund & Ray, 2017). Caramelization occurs due to the heating of sugars above 120°C, which results in the formation of dark brown components and caramel aroma and flavor components. Caramelization is relevant in the process of candies, desserts, breads, jams and dessert wines (Kroh, 1994).

3. Children's sugar intake

Overweight and obesity in children and adolescents is one of the biggest health problems that modern societies face (World Health Organization, 2017b). In only four decades it has rose more than tenfold globally (Abarca-Gómez et al., 2017). In 2019, 5.9% of children under 5 years old and 18.4% of 5 -19 year-old children were suffering from overweight and obesity (UNICEF, 2019). This scenario is no different in Latin America where overweight in children under 5 years old reached 7.5 % in 2020 (UNICEF, WHO & The World Bank, 2021). In Uruguay over the last 15 years the percentage of overweight children has almost doubled. Currently, 40% of the children over 5 years old suffer from overweight (22%) or obesity (17%) (UNICEF, 2020).

The current childhood overweight and obesity rates are alarming due to their association to a higher risk of suffering NCDs and psychological problems at an early age (Abbasi et al., 2017; Black et al., 2013; Dooley & Pillai, 2021; Smith et al., 2014; Sutaria et al., 2019; Weihrauch-Blüher et al., 2019). To address this problematic, the World Health

Organization (WHO) in 2013 set a global target to achieve a no increase in childhood overweight and obesity by 2025 (World Health Organization, 2014). Unfortunately, trends indicate that almost all countries are bound to miss this target (Obesity World Federation, 2019). For instance, Uruguay has only 12% chance to meet WHO 2025 target; it is predicted that 22.4% of 5-9 year-old children and 17.2% of 10-19 year-old children will be obese by 2030 (Obesity World Federation, 2019).

Childhood overweight and obesity is a complex problem which has derivated from multiple factors, for example, a rising intake of calories, a shift from traditional to modern diets, urbanization and falling levels of physical activity (UNICEF, 2019). However, dietary patterns have been identified as one of the most important determinats of childhood overweight and obesity. Children's diets are far from optimal, being characterized by a low consumption of fruits and vegetables and a frequent consumption of products high in sugar, saturated fat and sodium (Azaïs-Braesco et al., 2017; Louie et al., 2016). In particular, the high intake of sugar among children has raised concern worldwide as it largely exceeds recommendations (Perrar et al., 2020; Powell et al., 2016; Wittekind & Walton, 2014).

The World Health Organization suggests that children and adults reduce their free sugar intake to <10% of their total energy intake, while they stress that a reduction below 5% may result in major health benefits (World Health Organization, 2015). However, current children's sugar intake is far from these recommendations (Afeiche et al., 2018; Cediel et al., 2018; Perrar et al., 2020; Powell et al., 2016; Wittekind & Walton, 2014). In European countries children's added sugar intake ranges between 11 and 17% of the total dietary energy (Azaïs-Braesco et al., 2017), meanwhile added sugar accounted for 16% of total energy intake of 6-11 year-old children in the USA (Powell et al., 2016). This panorama is no different in Latin America, where young people are highly vulnerable to high sugar consumption (Fisberg et al., 2018). For example, in Uruguay sugar accounted for approximately 20% of total energy intake of 4-12 year-old children, which means Uruguayan children consume almost 3 kg of sugar per month (UNICEF, 2020).

Ultra-processed products have been identified as the main source of added sugars in children's diets (da Costa Louzada et al., 2015; Machado et al., 2020; Steele et al., 2016; Neri et al., 2019; Onita et al., 2021; Rauber et al., 2019). For instance, sweetened beverages, sweet bakery products, confectionary and dairy have been identified as the main sources of children's added sugar intake in European countries (Azaïs-Braesco et al., 2017;

Griffith et al., 2020), the United States (Bailey et al., 2018), Australia (Lei et al., 2016) and Latin American countries (Popkin & Reardon, 2018).

A similar pattern is observed in Uruguay, where over 70% of the sugar intake of school-aged children comes from ultra-processed products such as sweetened beverages, *alfajores*, cookies, breakfast cereals and dairy products; while home-made and processed food are the sources of remaining sugar (UNICEF, 2020).

3.1. Added sugar in products targeted at children

Product targeted at children often have a poorer nutritional quality than those aimed at adults (Schwartz et al., 2008; Song et al., 2014). For instance, commercial breakfast cereals and yogurts targeted at children have shown a higher sugar content than their adult version (Moore et al., 2018; Potvin Kent et al., 2017). Recently, Elliott & Truman (2020) reviewed the current literature available regarding the nutritional quality of products targeted at children in the market. They showed that despite the vast criteria used to classify the products, up to 97% of the products available in the market fail to meet the criteria to be suitable for children consumption due to the high content of energy, added sugar and fat. This panorama is no different in Uruguay. Giménez et al. (2017) evaluated the nutritional quality of products targeted at children in the Uruguayan marketplace. They found that 92% of the products targeted at children contained an excessive content of free sugars according to the nutrient profile model of the Pan American Health Organization.

Two food categories that have drawn attention due to their high content of sugar and often association to healthy products are breakfast cereals (Lavriša & Pravst, 2019; Maschkowski et al., 2014; Soo et al., 2016) and dairy products (Moore et al., 2020; Moore et al., 2018). For instance, a recent study assessing the adequacy of products targeted at children in European countries according to the WHO nutrient profile model reported that over 75% of the commercial breakfast cereal and yogurts were ineligible to be marketed at children (Storcksdieck genannt Bonsmann et al., 2019).

3.2. Dairy products as a source of sugar in children's diets

The inclusion of dairy products in children's diets is a common recommendation in dietary guidelines across the globe (Dror & Allen, 2014). Dairy products are considered an important source of vitamins, minerals and high quality proteins (Campmans-Kuijpers et al., 2016; Dror & Allen, 2014; C. E. O'Neil et al., 2018). For instance, Auestad et al. (2015) reported that dairy products made a significant contribution to children's daily intake of calcium, vitamin D and vitamin A in developed countries.

The intake of dairy products has been associated to increased growth and bone mineral content in early childhood (de Lamas et al., 2019), as well as to a better bone health in children and adults (Rizzoli, 2014). In addition, increased dairy intake has been linked to better diet quality (Hobbs et al., 2019; Iglesia et al., 2020; Josse et al., 2020), and lower adiposity and cardiometabolic risk in children and adolescents (Dougkas et al., 2019; Moreno et al., 2015).

In 2017, the per capita dairy consumption worldwide was 113 kg (International Dairy Federation, 2018), whereas the consumption of dairy product in Uruguay is almost the double of the average world consumption (Oficina de Estadísticas Agropecuarias, 2020). Children's intake of dairy products is highly variable across countries and it is influenced by multiple factors such as age, sex, parental influence and their subtitution with other beverages (Dror & Allen, 2014). For example, Hohoff et al. (2021) evaluated the trends in dairy intake of German children and adoslescents. They reported a decrease in total dairy consumption with age and a higher intake of high sugary dairy products in younger children. Households with children have been reported to be more likely to purchase dairy products than those without children (Ortez et al., 2021). In line with this, Machado et al. (2018) reported that over 88% of Uruguayan school-aged children consume dairy products at least three times per week.

Commercial dairy products targeted at children often have a high content of sugar and fat (Garcia et al., 2020; Giménez et al., 2017; Mahato et al., 2020; Moore et al., 2018, 2020). Moore et al. (2018) evaluated the nutritional profile of 900 yogurt products in five major supermarket chains in the United Kingdom. Their results revealed that yogurts targeted at children were among the products with the highest sugar content. In addition, a recent study by Fox et al. (2021) showed that flavored skim milk was the main source of added sugar in children's school meals in the United States. Chocolate flavored milk contributed a third of the added sugar in school breakfast and half of the added sugar in school lunches. The nutritional quality of commercial dairy products targeted at children is no better in Uruguay where most of the dairy products targeted at children have an excessive content of sugar according to the criteria of the nutrient profile model of the Pan American Health Organization (Giménez et al., 2017).

4. Strategies to reduce children's sugar intake

In 2013, the World Health Organization called member states to implement public polices to reduce children and adults' free sugars intake (World Health Organization, 2015), in an effort to achieve the objectives set in the Global Action Plan for NCDs 2013-2020 and the Commission on Ending Childhood Obesity Plan. These initiatives aim to reduce the risk factors for non-communicable diseases and stop the rise in childhood obesity through the creation of health-promoting environments (World Health Organization, 2013, 2017a). In the region of the Americas, the recent Strategic Plan of the Pan American Health Organization (PAHO) 2020-2025, which sets the regional goals and strategies that support the Sustainable Health Agenda for the Americas 2018-2030, reinforces the call to implement multilevel public polices to reduce consumption of sugary foods and beverages among children and adolescents (Pan American Health Organization, 2020).

A wide range of public policies to tackle the excessive sugar intake have been implemented around the globe in response to international and local sugar reduction calls (Popkin & Hawkes, 2016). These include taxation of food and beverages with added sugar, restrictions on the availably of poor nutrient quality product on schools, restrictions of marketing strategies targeted at children, front-of package labeling and reformulation of food products (Popkin & Hawkes, 2016).

Uruguay has implemented a series of public polices to reduce the risk factors associated with the high prevalence of NCDs, which are intimately connected to children's exposure to and consumption of food products high in sugar (Ministerio de Salud Pública, 2019). These include the regulation of healthy eating habits in schools and high-schools (Law No. 19,140) and front-of-package nutrition labeling of products with excessive content of fats, saturated fats, sugar and sodium (Ministerio de Salud Pública, 2019). However, product reformulation has not been a relevant part of the governmental strategies to reduce sugar intake among children and adolescents.

4.1 Product reformulation

The high contribution of processed products to children's sugar intake suggests that product reformulation is one of the cost-effective strategies that can be implemented to reduce sugar intake at the population level (MacGregor & Hashem, 2014). Recent modelling studies have shown that reformulation of products targeted at children may be a feasible way to reduce children's sugar intake and to improve the nutritional quality of their diets (Hashem et al., 2019; Muth et al., 2019; Yeung et al., 2017).

Food reformulation is a complex task that requires the consideration of multiple dimensions such as consumers, food industry and policy makers (Belc et al., 2019; Gressier et al., 2021). Nevertheless, one of the key factors to successfully reduce the sugar content of food products is to avoid sudden changes in consumer perception (Civille & Oftedal, 2012). This is particularly important for the reformulation of products targeted at children since their food choices are mainly driven by pleasure and they may only eat what the like (Drewnowski et al., 2012; Marty et al., 2018). However, from a technological point of view this is a real challenge since sugar has multiple functional properties that impact the overall sensory profile of the product (Di Monaco et al., 2018; Hutchings et al., 2019).

Currently, several sugar reduction strategies have been proposed to reduce the sugar content of food products. For example, partial or total replacement of sugar, cross-modal interactions, gradual sugar reduction, and other product-specific strategies (Di Monaco et al., 2018; Hutchings et al., 2019; McCain et al., 2018).

Partial or total sugar replacement

Partial or total sugar replacement is the most common strategy to reduce the sugar content in food and beverages (Hutchings et al., 2019). Natural (e.g., stevia, thaumatin, monk fruit) and synthetic (e.g., sucralose, aspartame, neotame, saccharin acesulfame K) non-nutritive sweeteners (NNS) are often used to maintain the sweetness level in food and beverages without additional calories. Meanwhile, sugar alcohols, oligosaccharides and polysaccharides are added as bulking agents to compensate volume and textural losses in sugar reduced products (Hutchings et al., 2019; McCain et al., 2018; Sahin et al., 2019).

Although NNS often have bitter and metallic aftertaste which may negatively impact children's acceptance (Li et al., 2015a; Zorn et al., 2014), their consumption has largely increased. Children seem to be particularly vulnerable to exceed NNS acceptable daily intakes (Martyn et al., 2018). Sylvetsky et al. (2012) showed that the number of children consuming products with NNSs has almost doubled from 1999–2000 to 2007–2008 in the United States. Unfortunately, consumption of NNS among children is expected to grow in the future, as partial or total substitution of sugar is the default strategy in sugar reduction programs. Sambra et al. (2020) reported that over 55% of the processed products contained at least one sweetener after the implementation of nutritional warnings highlighting products with high sugar content in Chile. These authors highlighted that the prevalence of NNS was particularly high in food categories targeted at children such as powders juices (more than 98%) and dairy products (79 - 91%).

The lack of studies with humans, as well as methodological issues in current studies about the safety of NNS, have risen a hot debate regarding the suitability of using NNS in products targeted at children (Brown et al., 2010; Mandrioli et al., 2016; Toews et al., 2019). Nevertheless, recent evidence has emphasized the potential negative effects of NNS on children's health (Swithers, 2015). In this sense, Karalexi et al. (2018) conducted a systematic meta-analysis which showed a significant association between high body mass index and the consumption of NNS during childhood and adolescence. Meanwhile, Suez et al. (2014) reported the development of gut microbiota disorders related to the intake of NNS and their bacteriostatic properties. In addition, there is growing concern regarding the negative effect of NNS on body metabolism due to the uncoupling of sweet taste and energy load (Swithers, 2015). Recent research suggests that dissociating sweetness from energy load could interfere with the learned relationships between sweet taste and the regulation of glucose metabolism, leading to the development of glucose intolerance (Veldhuizen et al., 2017, Burke & Small, 2015; Han et al., 2019).

The increase in children's NNS intake and the association of these ingredients with several negative health effects have questioned their suitability in products targeted at children. Therefore, new alternatives need to be developed to reduce the sugar content of products targeted at children.

Cross-modal interactions

Food perception is a holistic experience born from the integration of multiple sensory modalities such as taste, smell, hearing, sight, and touch (Thomas-Danguin et al., 2016). A change in one sensory modality may influence the perception of other sensations and modify the overall food experience (Lawless & Heymann, 2010). For example, previous studies have shown that congruent odors such as vanilla, caramel, and other fruity notes can increase the sweetness perception in sucrose solutions and food systems (Boakes & Hemberger, 2012; Charles et al., 2017; Djordjevic et al., 2004; Frank et al., 1989; Frank &

Byram, 1988; Stevenson, 1999). For example, Bertelsen et al. (2021) showed that the addition of vanilla aroma enhanced the sweetness perception of sucrose and non-caloric sweetener solutions among Chinese and Danish adults consumers; similar results were observed in sucrose sweetened milks (Wang et al., 2018, 2019).

Texture is another sensory modality that impacts sweet taste perception (Thomas-Danguin et al., 2016). The addition of hydrocolloids, which increases the food system viscosity, decreases the sweetness perception of liquid and semi-solid food model systems (Cook et al., 2002; Wagoner et al., 2018). Nevertheless, this effect is not universal and greatly depends on the food matrix and the physicochemical characteristics of the hydrocolloids (Arancibia et al., 2013; Bayarri et al., 2007; Boland et al., 2006; Cook et al., 2018; Ferry et al., 2006; Han et al., 2014; Lethuaut et al., 2005). In this sense, Wagoner et al. (2019) reported that increasing the concentration of carboxymethyl cellulose increased the sweetness perception of milk protein systems. Similarly, starch is reported to enhance the sweetness perception of aqueous solutions (Kanemaru et al., 2002).

Although the mechanism behind this phenomenon is still unclear, physicochemical, and perceptual mechanisms have been proposed to explain the impact of cross-modal interactions on flavor perception (Thomas-Danguin et al., 2016). From a physicochemical perspective, aroma-taste interactions are explained by the influence that food ingredients may have in the concentration of volatile compounds in the headspace (Poinot et al., 2013). Meanwhile, texture-taste interactions may arise from the structural changes that food ingredients induce in the food matrix and their impact on the interaction between sweet-tasting molecules and taste receptors (Poinot et al., 2013). In addition, cross-modal interactions may arise from perceptual mechanisms. The co-exposure to specific sensory qualities may form associations in the memory that are likely to arouse specific sensory and hedonic responses in later encounters with the individual qualities (Prescott, 2015).

The use of cross-modal interactions has been proposed as an alternative to minimize the sensory changes in sugar reduced food products through the modulation of other sensory modalities (Di Monaco et al., 2018; Hutchings et al., 2019). For example, Alcaire et al. (2017) reported that the increase of vanilla aroma and starch concentration was able to minimize the sensory changes in sugar reduced vanilla milk desserts among adults.

Gradual sugar reduction

The rationale behind this strategy is to implement a gradual and progressive reduction of the sugar content in foods in such a way that consumers slowly get used to products with lower sugar content, without noticing the changes (Macgregor & Hashem, 2014). To implement this strategy, it is important to determine the quantity of sugar that can be reduced without being noticed by the consumer. In this sense, the estimation of difference thresholds could provide useful information for the design of gradual sugar reduction programs. Difference thresholds are defined as the minimum change in the stimuli needed to be detected 50% of the time (Lawless & Heymann, 2010). This approach was used by Delk & Vickers (2007) to increase the bran content of breads without affecting the sensory perception of children, thus increasing their acceptability of whole wheat bread.

Recent studies have shown that direct sugar reduction is feasible in food products with minor effects on children and adult's hedonic perception (Chollet et al., 2013; Li et al., 2015b; Lima et al., 2018a, 2019; Pineli et al., 2016). However, it has been observed that children may be more sensitive in their hedonic response to sugar reduction than adults (Lima et al., 2018a). Lima, Ares & Deliza (2019) studied the impact of direct sugar reduction in grape nectars on children's hedonic perception by comparing a gradual strategy versus a stepwise strategy over 9 weeks. They found that the gradual sugar reduction strategy produced smaller changes in children's hedonic perception compared to the stepwise strategy.

Gradual sugar reduction intends to shift children's sweetness preference rather than maintaining current behavior, which may have a long-lasting impact on dietary patterns and health outcomes (Ma et al., 2016). This is especially relevant in the case of children, given that during this period of life they acquire long-lasting preferences through exposure and associative learning (Mennella & Bobowski, 2015; Sullivan & Birch, 1990). Repeated exposure to products with high sugar content can lead to an increased preference for sugar during childhood, which can also impact food preferences later in life (Divert et al., 2017; Nicklaus et al., 2004; Nicklaus & Remy, 2013).

Although gradual sugar reduction strategies are desired due their major impact on the development of children's dietary habits, there is a concern regarding the feasibility to escalate and reproduce lab-based results in the long term (Hutchings et al., 2019). Nevertheless, the success of the gradual salt reduction program in the UK, which achieved a reduction of 15% in salt intake at the population level over a 7 years' time span (Macgregor & Hashem, 2014), suggests that this approach has a high potential to reduce the sugar intake at population level.

4.2 Package information as a strategy to reduce sugar intake

Children and adult's food choices are influenced by intrinsic and extrinsic factors of food products (Blissett & Fogel, 2013; Motoki & Suzuki, 2020; Piqueras-Fiszman & Spence, 2015). While taste is one of the main drivers of children's food liking, extrinsic factors such as food packaging, price, brand, and social information play a relevant role in children's food choice. In particular, food packaging has drawn attention due to their high influence on children and adults' food perception and choice (Dial & Musher-Eizenman, 2020; Gutjar et al., 2014). The main role of food packaging is to protect the quality of food during transportation, storage, and use (Rundh, 2016). Nevertheless, food packaging has become a fundamental part in the marketing strategy of food products targeted at children (Elliott & Truman, 2020). Food packaging is an effective way to attract, communicate and persuade the consumer at the point of sale (Rundh, 2016).

Food packaging may impact children's diet through parent's food choices for their children and children's direct or indirect food choices – pester power (Ares et al., submitted). Ares et al. (submitted) have proposed a model that describe how food packaging impacts children's diets. According to the model, first the product needs to attract consumer attention through multiple design features that differentiate the product from the competence (e.g., color, shape, graphics). After the consumer is aware of this information, they process it through immediate affective associations or rational judgments based on the available information; both processes may be influenced by children pester power (nag factor). This may result in product purchase and subsequent children consumption, which may lead to multiple health outcomes in the long term.

Food packages of products targeted at children include a wide range of visual and textual cues to attract children and convey the idea that they are appropriate for them. For example, colored packages, cartoon characters, merchandising tie-ins, photos of celebrities, and references to fun, play or sports (Chacon et al., 2013; Elliott, 2015; Giménez et al., 2017; Mehta et al., 2012). Cartoon characters are one of the most common used strategies to market food products at children (Elliott & Truman, 2020; Karageuzián et al. 2021). Research shows that children usually prefer food products with cartoon characters than those without them (Ares, Arrúa, et al., 2016; Arrúa, Vidal et al., 2017; Enax et al., 2015; Letona et al., 2014; Levin & Levin, 2010; McGale et al., 2016; Pires & Agante, 2011; Roberto et al., 2010). Children create emotional bonds with cartoon characters, which may be transferred to the product and increase the desire for them (Kraak & Story, 2015).

In addition, visual design and textual references are often used in food packages to create positive health-related associations (Karageuzián et al., 2021). For instance, health claims are often found in products targeted at children despite their poor nutritional quality (Elliott & Truman, 2020). This is highly relevant since qualitative research have shown that parents often rely on health claims to evaluate the healthiness of food products for their children (Abrams et al., 2015; Maubach et al., 2009; Tan et al., 2016).

The regulation of food packaging has been proposed as a possible way to help parents and children to make better informed food choices, which may reduce the consumption of high sugary food products (Hawkes, 2010). For instance, the implementation of front-of-package (FOP) nutrition labelling regulations has drawn attention worldwide (Jones et al., 2019) as a feasible way to assist consumers to make better informed food choices. FOP nutrition labelling provides a simple summary of the nutritional composition of foods (Dean et al., 2015). Although multiple FOP nutrition labelling schemes have been developed, the use of nutritional warnings have gained popularity in Latin America (Jones et al., 2019; Pan American Health Organization, 2020). Nutritional warnings highlight products with high content of nutrients associated with NCDs (Pan American Health Organization, 2020). Nutritional warnings have been reported to discourage the choice of unhealthy products among children and adults (Lima et al., 2019; Ares et al., 2021; Arrúa, Curutchet et al., 2017). Besides FOP nutrition labelling regulations, the prohibition of elements that attract children attention in products high in energy density, sodium, fat and sugar has been implemented Chile and Mexico as part of a comprehensive package regulation (Ministerio de Salud, 2017; Secretaría de Economía, 2020).

OBJECTIVES

General objective

The general objective of this thesis was to evaluate different strategies to reduce the sugar content of dairy products targeted at children from a sensory point of view.

Specific objectives

- To develop recommendations for gradual reduction of sugar content in three dairy products targeted at children.
- To evaluate alternatives for the development of sugar reduced dairy products through sensory cross-modal interactions.
- To develop and characterize a sugar reduced dairy product targeted at children.
- To evaluate the impact of the information on parents' food choices and healthiness perception of food products targeted at children.

STRUCTURE OF THE THESIS

To achieve the objectives of the thesis, research activities were carried out in three stages (Figure 1). The first stage, which comprises **CHAPTER 1** and **CHAPTER 2**, was focused on the evaluation of sugar reduction strategies in dairy products targeted at children available in the Uruguayan market. To develop recommendations for gradual sugar reduction, children's hedonic sensitivity to sugar reduction in three dairy products was evaluated by means of a standard A-Not A test (**CHAPTER 1**). In addition, the feasibility of cross modal interactions (taste-odor-texture) for sugar reduction in products targeted at children was evaluated in vanilla milk desserts as a case study (**CHAPTER 2**). The second stage was focused on the development of a sugar reduced dairy product (**CHAPTER 3**), where co-creation with children was explored as a potential approach to involve children in the development process of a healthy dairy product. Since the regulation of food packaging has been proposed as an alternative strategy to reduce children's sugar intake, **CHAPTER 4** focused on the impact of food label design and information on parent's food choices and healthiness perception of food products targeted at children.

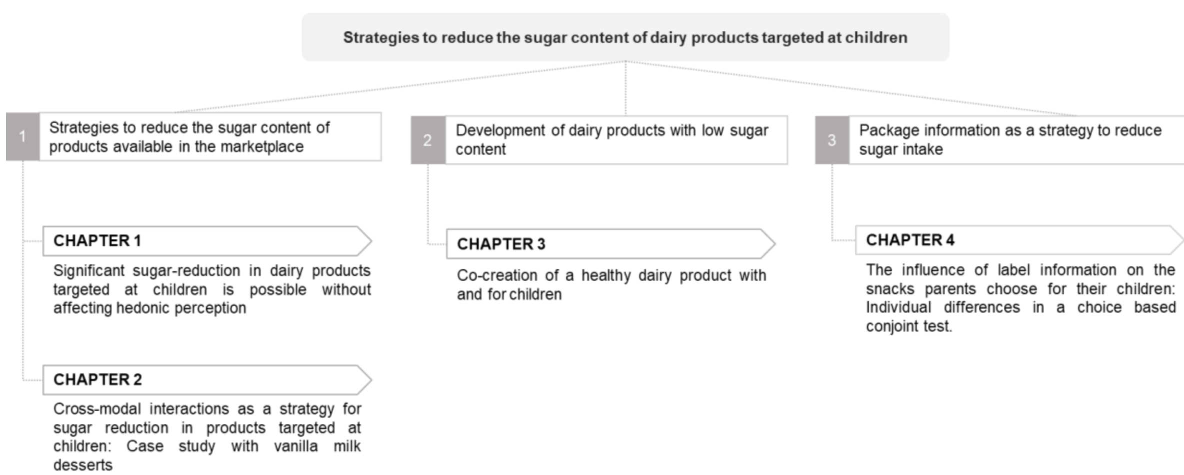

Figure 1. Overview of the structure of the thesis

CHAPTER 1

Significant sugar-reduction in dairy products targeted at children is possible without affecting hedonic perception

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Author contributions:

- Velázquez, A.L: Conceived and designed the study, collected the data, analyzed and interpreted the data, wrote the paper.
- Vidal, L: Contributed to the conception and design of the study, as well as to data interpretation, performed a critical revision of the article.
- Alcaire, F: Contributed to the data collection, performed a critical revision of the article.
- Varela, P: Contributed to the conception and design of the study, performed a critical revision of the article.
- Ares, G: Contributed to the conception and design of the study, as well as to data interpretation, performed a critical revision of the article.

Abstract

The objective of the present study was to evaluate children's hedonic sensitivity to sugar reduction in three dairy products: vanilla milk desserts, chocolate-flavored milk, and vanilla yoghurt. For each product, a regular sample and five samples with different reduction in added-sugar content were formulated. The regular sample contained the sugar content of commercial products available in the marketplace. The reduction in added-sugar content ranged between 10.0 and 41.0%. A total of 126 children (8–13 years old) participated in the study. An A-not A test was used to evaluate children's hedonic sensitivity to sugar reduction. Sugar reductions up to 27% in chocolate flavored milk and vanilla yoghurt, and up to 19% in vanilla milk desserts, did not cause significant changes in children's hedonic reaction. These results confirm that sugar-reduction strategies can be easily implemented in the dairy industry without significant risk of affecting sample appreciation and market share.

1.1. Introduction

Sugar intake has been identified as one of the most important dietary factors for childhood overweight and obesity (Newens & Walton, 2016; World Health Organization, 2015). Children frequently consume processed products with high added sugar concentration (Azaïs-Braesco, Sluik, Maillot, Kok, & Moreno, 2017; Louie, Moshtaghian, & Rangan, 2016). Thus, most of processed products targeted at children have been reported to contain excessive sugar content (Boulton et al., 2016; Elliott, 2008; Giménez, Saldamando, Curutchet, & Ares, 2017).

Dairy products are an important source of added sugar in children's diet (Azaïs-Braesco et al., 2017; Boulton et al., 2016; Poti, Slining, & Popkin, 2014). Recently, Moore, Horti, and Fielding (2018) reported that only 2% of the yoghurts targeted at children in British supermarkets can be categorized as low in sugar, whereas dairy desserts aimed at children's lunch boxes had a high content of sugar (over 16%). Considering that dairy products are recommended as part of children's diets due to their nutritional value (Campmans-Kuijpers, Singh-Povel, Steijins, & Beulens, 2016; Dror & Allen, 2014), a reduction in added sugar seems necessary to reduce children's sugar intake.

Sugar content of dairy products can be gradually reduced so that consumers get used to lower sugar concentrations without noticing any differences (Macgregor & Hashem, 2014). Implementation of this approach requires estimation of difference thresholds, i.e., the reduction in added sugar concentration that causes a perceivable change in 50% of consumers' (McCain, Kaliappan, & Drake, 2018). Despite advances by the food industry in the field of sugar reduction (Moore, Sutton, & Hancock, 2020), open information regarding implementation of sugar reduction strategies remains scarce. Previous studies conducted with adult consumers have shown that sugar reductions of 20–30% may be achieved without compromising acceptance (Alcaire, Antúnez, Vidal, Giménez, & Ares, 2017; Hoppert et al., 2013; Li, Lopetcharat, & Drake, 2015; Lima, Ares, & Deliza, 2018a; Oliveira et al., 2016). However, information about children's hedonic sensitivity to sugar reduction in dairy products is limited. Only a few studies have been published assessing sugar reduction in chocolate-flavoured milk (Li, Lopetcharat, & Drake, 2015; Li, Lopetcharat, Qiu, & Drake, 2015) and vanilla milk desserts (Velázquez, Vidal, Varela, & Ares, 2020).

In this context, the objective of the present study was to evaluate children's hedonic sensitivity to sugar reduction in three highly consumed dairy products: vanilla milk desserts, chocolate-flavoured milk, and vanilla yoghurt.

1.2. Materials and Methods

1.2.1. Samples

Three highly consumed dairy products among children were studied: vanilla milk desserts, chocolate-flavoured milk, and vanilla-flavoured yoghurt. For each product, a regular sample and five samples with different reductions in added-sugar content were formulated. The regular sample contained the sugar content of commercial products available in the Uruguayan marketplace. Reduction in added-sugar content ranged between 10.0 and 41.0% (Table 1.1). Also, for each product category, a warm-up sample was formulated, identical to the regular sample but with a different vanilla flavouring or different vanilla concentration, with the purpose of sample familiarisation before the actual test.

Table 1.1. Added sugar concentration of the samples, for each of the three categories of dairy products considered in the study.

Added sugar reduction (% w/w)	**Added sugar content (% w/w)**		
	Vanilla milk desserts	**Chocolate-flavored milk**	**Vanilla yogurt**
0 (reference)	12.0	7.0	11.0
10	10.8	6.3	9.9
19	9.7	5.7	8.9
27.1	8.7	5.1	8.0
34.4	7.9	4.6	7.2
41.0	7.1	4.1	6.5

1.2.1.1. Vanilla milk desserts

All samples were prepared using a base formulation containing UHT whole milk (3.2% fat and 4.7% carbohydrates) (Conaprole, Uruguay), 4.3% (w/w) starch (Purity HPC, Ingredion, Brazil), 0.4% v/w vanilla (Aryes, Jaraguá do Sul, Brazil), 0.1% (w/w) polyphosphate and 0.02% (w/w) carrageenan (Ticaloid® 710H Stabilizer - Texture Innovation Center, TIC GUMS, PA, USA). Sugar (Alcoholes del Uruguay S.A., Bella Unión, Uruguay) concentration was varied as detailed in Table 1.1. Samples were prepared using a Thermomix (Vorwerk Mexico S. de R.L. de C.V., Mexico City, Mexico). Powdered ingredients were mixed with the whole milk and heated at 90 °C under constant stirring for

5 min. After heating process, the vanilla was added to the mixture and stirred for 1 min. Desserts were placed in glass jars and stored for 24 h at 6–8 °C prior to the evaluation.

1.2.1.2. Chocolate-flavored milk

Chocolate-flavoured milk was prepared using UHT whole milk, 1% (w/w) alkaline cocoa powder (Aryes, Montevideo, Uruguay), 0.08% (w/w) carrageenan, 0.05% (v/w) vanilla and varying concentrations of sugar (Table 1.1). Samples were prepared using a Thermomix by adding the powdered ingredients to whole milk, previously heated at 70 °C for 3 min, and dispersed for 1 min. The mixture was kept at 70 °C for 4 min under constant stirring. Then, vanilla was added to the mixture and stirred for 1 min. Finally, the samples were cooled down to 20 °C in ice water and placed in glass jars. Samples were stored for 24 h at 6–8 °C until their evaluation.

1.2.1.3. Vanilla yogurt

Samples were prepared using plain skimmed yoghurt (Conaprole, Uruguay), 0.4% (v/w) vanilla flavouring and varying concentrations of powdered sugar (Table 1.1). All ingredients were mixed in a Thermomix for 10 min under gently stirring. Then, samples were placed in glass jars and stored for 24 h at 6–8 °C until their evaluation.

1.2.2. Participants

A total of 126 children (8–13 years old (m = 10.6 years old, SD = 1.3), 52% girls) were recruited from three institutions in Montevideo, Uruguay (one school and two social clubs). For every child, one of the parents signed an informed consent form to allow their children to participate in the study, whereas children provided informed assent to participate through the software used for data collection. It was explained that their participation was voluntary and that they could withdraw at any time. Ethical approval was obtained from the Ethics Committee of the School of Chemistry of Universidad de la República (Protocol No 101900-000090-19).

Children were invited to participate in three tasting sessions, one per product category. Since sessions took place on different days, some children were unable to complete all sessions. The number of children who tasted each of the products was 54 for vanilla milk desserts, 64 for chocolate-flavoured milk and 76 for vanilla yoghurt. The order in which children evaluated the three product categories was balanced across the three institutions.

1.2.3. Experimental procedure

A standard A-Not A test was used to evaluate children's hedonic sensitivity to sugar reduction in the three product categories. This test was regarded as a good methodological option for children due to its simplicity and its lower cognitive load compared with other discriminative tests. The A-not A test is an overall difference test where participants are first familiarised with the reference product. Then, they evaluate one product at a time and decide if the test product is the same or different from the reference (Van Hout, Hautus, & Lee, 2011).

Tasting sessions were divided into two sections: a familiarisation step and sample tasting. The study took place at the school or social club. Children performed the study in groups of 5–6 children with the assistance of 3 researchers. Each session lasted maximum 15 min.

The test was presented as a memory game using Compusense Cloud (Compusense Inc., Guelph, Canada) on Ipads (Apple Inc., Cupertino, USA). The instructions were given using explanatory videos featuring a cartoon character. After each video, a researcher verbally repeated the instructions and asked children if they had any questions.

Samples were presented in plastics cups, coded with 3-digit random numbers at 8°C. For evaluation of milk desserts, children received a plastic spoon for each of the samples. Still mineral water was used as palate cleaner. A text was added to the test to remind children of rinsing their mouth after assessing each of the samples. Children completed the test at their own pace, as no specific timing was set.

1.2.3.1. Task Familiarization

Children were familiarised with the methodology through the evaluation of apple images. First, an image of a reference apple was presented. Children were asked to watch it carefully and to try to remember its characteristics. Then, the reference apple image and a defective apple image were presented one by one. For each of the images, they were asked to indicate if they liked the apple image as much as they liked the reference apple image, using the response options “Yes”, “No” or “I don't know”.

1.2.3.2. Sample familiarization

Before the actual sample tasting, children had to complete a warm-up task for sample familiarisation. Children were presented with the reference sample, named “secret formula”. They were asked to try it and to remember its characteristics. Then, two samples (again the reference and the warm-up sample) were presented. For each of the samples, they were asked to indicate if they liked the sample as much as they liked the reference sample using the response options “Yes”, “No” or “I don't know”.

1.2.3.3. Sample tasting

After completing the warm-up task, children were asked to taste the reference sample again. Then, they were presented with six samples (the reference and the five sugar-reduced samples; Table 1.1) one by one, following a Williams' Latin square balanced design. For each of the samples, they were asked if they liked the sample as much as they liked the reference sample. Children could re-taste the reference sample if needed. Researchers were available to assist children during the test.

1.2.4. Data analysis

A Thurstonian approach was used to estimate underlying sensory difference (d’) between the control and the sugar reduced samples using the sensR package for R software (Brockhoff & Christensen, 2010). For each product category, the d’ values between the reference sample and each of the sugar reduced samples were estimated using a standard A-Not A model. The calculation was performed using the number of children who stated that they liked the sugar-reduced sample as much as the reference (“Yes” responses). For the reference sample, pooled data from the warm-up and main task were used. The “Don't know” responses were not considered in the analysis (<14% of the total responses).

1.3. Results and Discussion

The present work aimed at providing insights for the design of sugar-reduction strategies of dairy products targeted at children. For this purpose, children's sensitivity to sugar reduction was studied, in three highly consumed dairy products, using the A-not-A test. Results from the familiarisation step with apple images showed that children understood the task: the percentage of children who reported liking the reference apple (when it was presented blind) as much as the reference was higher than 80% across the three sessions.

Table 1.2 shows the d' estimates and their corresponding standard errors, which measure the sensory difference between each of the sugar reduced samples and the reference sample (without sugar reduction) (Lee & O'Mahony, 2004). As expected, d' values were not significantly different from 0 for the smallest added sugar reductions for the three product categories. For vanilla milk desserts, d' was significantly different from 0 when added sugar reduction was 27.1% or higher. This suggest that sugar reductions up to approximately 25% would be possible without significantly affecting children's hedonic perception. Similar results were obtained for chocolate-flavoured milk and vanilla yoghurt. As shown in Table 1.2, d' values were significantly different from 0 when sugar reduction was 34.4% or higher, suggesting that in these products added sugar can be reduced up to 34% without affecting children's hedonic perception.

Table 1.2. Estimates of d' and their standard error for the comparison of the added sugar reduced samples and the reference sample in the A-not A test for the three product categories.

Product category	**Added sugar reduction (%)**	**N***	**d'**	**Standard error**	**p-value**
Vanilla milk desserts (n=54)	10.0	50	0.174	0.227	0.280
	19.0	50	0.320	0.227	0.110
	27.1	49	**0.582**	0.224	0.008
	34.4	49	**1.018**	0.226	<0.001
	41.0	51	**1.072**	0.227	<0.001
Chocolate-flavored milk (n=64)	10.0	63	0.188	0.216	0.853
	19.0	61	0.121	0.209	0.340
	27.1	62	0.302	0.202	0.092
	34.4	59	**0.611**	0.201	0.002
	41.0	63	**0.771**	0.199	<0.001
Vanilla yogurt (n=76)	10.0	71	0.219	0.194	0.165
	19.0	70	0.066	0.198	0.430
	27.1	72	0.074	0.195	0.413
	34.4	69	**0.373**	0.191	0.036
	41.0	70	**0.539**	0.189	0.003

Notes: * Children answering "Don't know" were excluded from the analysis. The d' estimates of samples highlighted in bold are significantly different from 0.

Results from the present work are similar to those reported by other authors when evaluating adults and children's hedonic sensitivity to sugar reduction in different food matrices, including dairy products (Alcaire et al., 2017; Chang & Chiou, 2006; Chollet, Gille, Schmid, Walther, & Piccinali, 2013; Hoppert et al., 2013; Lima et al., 2018a; Oliveira et al., 2016; Pineli et al., 2016; Velázquez et al., 2020). Although children have been reported to have a heightened preference for sugar as compared with adults (Zandstra & de Graaf, 1998), evidence from this work suggests that the added sugar content of dairy products targeted at children can be reduced up to 25–30% without affecting acceptability.

Interestingly, hedonic sensitivity to sugar reduction was largely similar across the three product categories. As shown in Table 1.2, children were slightly less tolerant to sugar reduction in vanilla milk desserts as compared with chocolate-flavored milk and vanilla yoghurt. This difference could be explained by changes in thickness and creaminess caused by sugar reduction in milk desserts (Alcaire et al., 2017; Velázquez et al., 2020), which might not be so relevant in yoghurt and flavored milk.

Until now, one of the most popular strategies to reduce sugar content in dairy products has been the use of non-nutritive sweeteners to maintain sweet taste (Moore et al., 2020). Results from the present work suggest that relevant straight sugar reductions, without compensating with extra sweeteners, could be rapidly achieved in products targeted at children. Apart from its contribution to lowering sugar intake, gradual sugar reduction in dairy products could reduce children exposure to sweet taste, contributing to reducing their sweetness preferences (Mennella & Bobowski, 2015; Nicklaus & Remy, 2013).

1.4. Conclusions

Results from the present work suggest that added sugar can be reduced up to 25% in dairy products targeted at children without affecting their hedonic perception. This information is highly valuable for sensory scientists and food technologists and confirms that sugar-reduction strategies can be swiftly implemented in the dairy industry without significant risks of affecting market share. In this sense, these results stress the lack of justification of the slow response of some dairy industries worldwide to reducing the sugar content and sweet taste of their products targeted at children.

CHAPTER 2

Cross-modal interactions as a strategy for sugar reduction in products targeted at children: Case study with vanilla milk desserts

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Author contributions:

- Velázquez, A.L: Conceived and designed the study, collected the data, analyzed and interpreted the data, wrote the paper.
- Vidal, L: Contributed to the conception and design of the study, as well as to data collection and interpretation, performed a critical revision of the article.
- Varela, P: Contributed to the conception and design of the study, performed a critical revision of the article.
- Ares, G: Contributed to the conception and design of the study, as well as to data interpretation, performed a critical revision of the article.

Abstract

The high availability of products with high sugar content, particularly among those targeted at children, has been identified as one of the factors that contribute to the childhood obesity epidemic. For this reason, product reformulation has been recommended as one of the strategies that can be implemented to achieve short-term reductions in children's sugar intake. In this context, the objective of this study was to evaluate the feasibility of using cross-modal (taste-odor-texture) interactions as a strategy for reducing the sugar content of products targeted at children, using milk desserts as case study. A series of 5 vanilla milk desserts were formulated: a control sample with 12% added sugar and 4 sugar-reduced samples (7% added sugar) prepared following a 2 × 2 experimental design by varying vanilla (0.4% and 0.6% w/w) and starch (4.3% and 4.7% w/w) concentrations. A total of 112 children (8–12 years old) tasted the desserts and performed a dynamic sensory characterization task using either temporal check-all-that-apply or temporal dominance of sensations. In addition, they assessed the overall liking of all samples. Results showed that sugar-reduced samples did not significantly differ from the control sample in terms of their average overall liking scores. However, individual differences in children's hedonic reaction were found; three clusters of children with distinctive liking patterns were identified. The increase in vanilla and starch concentration led to an increase in overall liking for over 80% of the children. Sensory dynamic profiles revealed significant but subtle differences among samples. Results from the present work suggest that cross-modal interactions could contribute to minimizing the sensory changes caused by sugar reduction, which could enable to achieve larger reductions if implemented in the context of gradual sugar reduction programs.

2.1 Introduction

Childhood overweight and obesity are one of the most serious health problems of the 21st century (World Health Organization, 2017b). High sugar intake has been identified as one of the main dietary determinants of childhood overweight and obesity, being also a risk factor for several non-communicable diseases (Ambrosini et al., 2016). This has motivated the World Health Organization to recommend the implementation of public policies to reduce sugar intake (World Health Organization, 2017b).

Children are growing in an obesogenic environment that promotes the consumption of high energy-dense and poor-nutrient food (World Health Organization, 2016). Products marketed at children have been reported to have excessive sugar content (Kavey, 2010, Lavriša and Pravst, 2019). Recently, Elliott and Scime (2019) evaluated the nutritional profile of food products targeted at children in the Canadian market. They found that nearly 60% of them had a poor nutritional quality, with generally a high content of sugar. Repeated exposure to these products can lead to an increased preference for sugar during childhood, which can also impact food preferences later in life (Haller et al., 1999, Nicklaus and Remy, 2013, Nicklaus et al., 2004). For this reason, product reformulation towards lower sugar content is one of the most cost-effective strategies that can be implemented to rapidly reduce sugar intake (MacGregor & Hashem, 2014).

However, reducing the sugar content of products targeted at children can be challenging due to the multiple functional properties of sugar (Goldfein & Slavin, 2015) and the importance of pleasure in children's food choices (Marty et al., 2018, Nguyen et al., 2015). Therefore, in order to be effective, reformulation efforts should avoid abrupt changes in consumers' perception (Civille & Oftedal, 2012).

The use of non-nutritive sweeteners (NNS) has been the most common strategy to reduce the sugar content of food (Hutchings, Low, & Keast, 2018). However, NNS can provide undesirable sensory characteristics (DuBois and Prakash, 2012, Zorn et al., 2014) and their consumption has been linked to negative health-related outcomes (Brown et al., 2010, Karalexi et al., 2018, Pepino, 2015, Swithers et al., 2010). Another strategy that can be used for minimizing the effects of sugar reduction in the sensory characteristics of products is the use of cross-modal interactions.

Flavor perception is the result of the integration of olfactory and gustatory inputs (Thomas-Danguin, Sinding, Tournier, & Saint-Eve, 2016). However, it is recognized that smell has a major role in the perception of flavor (Spence, 2015) and that certain aromas can modulate taste intensity (Burseg et al., 2010, Labbe et al., 2006). It has been documented that the addition of congruent aromas such as vanilla, caramel or fruity notes, increase sweetness perception in model solutions (Boakes and Hemberger, 2012, Schifferstein and Verlegh, 1996, Stevenson, 1999, Tournier et al., 2009).

Smell and flavor may be influenced by other sensory inputs such as texture, sound and color (Thomas-Danguin et al., 2016). Texture-taste interactions have demonstrated to affect the flavor perception of food (González-Tomás, Bayarri, Taylor, & Costell, 2007). It is known that many thickening agents induce a reduction in sweetness perception (Poinot et al., 2013, Ruth et al., 2004). However, it is also accepted that the magnitude of this effect is highly dependent of the type of agent (Poinot et al., 2013). For example, starch has been shown to have a lower impact on the sweetness perception compared to carboxymethyl cellulose (CMC) and guar gum (Vaisey, Brunon, & Cooper, 1969) and has been reported to increase the sweetness perception of sucrose water solutions (Kanemaru, Harada, & Kasahara, 2002).

Cross-modal interactions can be explained by multiple physicochemical and cognitive mechanisms. Taste compounds influence the concentration of volatiles in the headspace and the presence of structuring agents may hinder or facilitate their release (Poinot et al., 2013). In addition, molecular interactions between compounds and matrix structure changes could affect their diffusion during oral processing (Thomas-Danguin et al., 2016, Tournier et al., 2007). For instance, Ruth et al. (2004) showed that different types and concentrations of texturing agent modified the sweetness perception and the flavor release in milk desserts.

Cross-modal interactions may also be explained through experience (Spence, 2015). Stevenson, Prescott, and Boakes (1995) showed the role of associative learning in the formation of odor-taste qualities by pairing unfamiliar odors with sucrose or citric acid solutions. They demonstrated that those aromas were perceived sweeter or sourer in posterior sniffing tests. Prior co-exposure of particular aromas, tastes and textures encodes specific associations in the memory which can be evoked in later encounters with the individual qualities (Prescott, 2015). For example, Saint-Eve, Paçi Kora, and Martin (2004) found that the addition of coconut and butter aromas to low-fat yogurts had a major impact on thickness perception compared to those considered smoother but containing green apple and almond aromas.

Recently, Alcaire, Antúnez, Vidal, Giménez, and Ares (2017) reported the use of cross-modal interactions to enhance the sweetness perception in sugar reduced milk desserts. The increase of vanilla aroma and starch concentration was able to minimize the sensory changes in sugar reduced samples among adults. Despite the potential of cross-modal interactions in the context of sugar reduction, limited studies have been published. In particular, to the authors' knowledge no studies have been reported assessing the impact of cross-modal interactions with children. The effectiveness of this strategy could diverge from the results reported for adults due to the distinctive traits governing children's sensory perception and because of the shorter prior co-exposure in children as compared to adults. For instance, differences in aroma and taste sensitivity between children and adults may impact their ability to identify changes in the sensory characteristics of sugar reduced foods (Popper & Kroll, 2011). Moreover, taking into consideration that differences in sweetness perception and preference between children and adults have been documented (Mennella, Finkbeiner, Lipchock, Hwang, & Reed, 2014), the topic is worth of investigation.

In this context, the objective of this study was to evaluate the feasibility of applying cross-modal interactions (taste-odor-texture) for sugar reduction in products targeted at children. Milk desserts were considered as case study given that they are an important source of added sugar in children's diets (Bailey, Fulgoni, Cowan, & Gaine, 2018) and that they are frequently marketed as healthful alternatives for snack and dessert.

The effect of sugar reduction and cross-modal interactions on both hedonic response and sensory perception of children was studied. Current sensory methods to analyze cross-modals interactions include both static and dynamic methods (Poinot et al., 2013). The last ones have drawn attention since they consider how perception evolves during food consumption (Cadena, Vidal, Ares, & Varela, 2014), which could better capture the complexity of food perception and its relationship to consumer liking. Temporal Dominance of Sensations (TDS) is one of the most popular methods for dynamic sensory characterization and consists of presenting a list of attributes to the assessors, who should indicate which one is perceived as dominant over consumption (Pineau et al., 2009).

Another dynamic method that has gained popularity is Temporal Check-All-That-Apply (TCATA). TCATA was introduced by Castura, Antúnez, Giménez, and Ares (2016) as an extension of Check-All-That-Apply questions. In this method a list of attributes is presented to the assessors, and they are asked to select all the terms they consider applicable to describe the sample at each moment of product evaluation and uncheck them when they are no longer applicable. To the best of the author's knowledge, none of these methods have been used with children before. As there was no available evidence of the superiority of one method or the other for the current application, both TCATA and TDS were used for dynamic sensory characterization of the samples.

2.2. Materials and methods

2.2.1. Samples

A control sample was formulated with an added sugar concentration similar to the most popular milk desserts targeted at children in the Uruguayan market (12% w/w). Then, a series of sugar-reduced samples were developed with an added sugar concentration of 7% w/w, which corresponds to a reduction of 41.6% of added sugar or 30% of total sugar (added sugar + lactose in milk). This added sugar concentration was selected based on the Uruguayan front-of-package regulation to avoid the inclusion of a warning label for "excess of sugar" (Ministerio de Salud, 2018).

A 2 × 2 experimental design considering vanilla and starch concentration was used to obtain different sugar-reduced samples and to assess cross-modal (taste-odor-texture) interactions. Starch concentration was increased from 4.3% w/w to 4.7% w/w to evaluate the impact of increasing firmness on children's sensory and hedonic perception. Concentrations were selected based on preliminary studies.

The effect of increasing vanilla concentration was also assessed to evaluate the influence of flavor on children's sweetness and hedonic perception of the desserts. Two approaches were tested in preliminary studies: increasing the concentration of vanilla from 0.4% w/w to 0.6% w/w by adding an extra amount (0.2% w/w) of the same vanilla flavoring (Vanilla A -Aryes, Brazil-) and adding the same amount (0.2% w/w) of a different vanilla flavoring (Vanilla B -PLUS 3, Brun & Cía., Uruguay-). The volatile composition of the vanilla flavorings is shown in the Appendix 1. Paired comparisons with a panel of 11 assessors were used to evaluate the effect of the increase of Vanilla A and the addition of Vanilla B on the sweetness of the desserts. Evaluations were performed in duplicate. Results showed that increasing the concentration of Vanilla A did not lead to a significant increase in sweetness perception ($p = 0.584$), whereas the addition of vanilla B increased sweetness intensity ($p < 0.05$). Based on these results, it was decided to select the addition of Vanilla B as the high level of Vanilla (Table 2.1).

Table 2.1. Sugar, starch, and vanilla concentrations of the samples included in the study.

Sample (*)	Total sugar (%) (**)	Added sugar (%)	Starch (%)	Vanilla A (%) (***)	Vanilla B (%) (***)
Control	16	12	4.3	0.4	-
Sugar Reduced	11	7	4.3	0.4	-
SR.Vanilla	11	7	4.3	0.4	0.2
SR.Starch	11	7	4.7	0.4	-
SR.Vanilla+Starch	11	7	4.7	0.4	0.2

(*) SR stands for sugar-reduced sample.

(**) Sugar corresponding to lactose in milk plus added sugar

(***) Vanilla A and B correspond to different flavorings. Appendix 1 shows the volatile profile of the two flavorings.

The sugar, starch and vanilla concentrations of the samples included in the research are shown in Table 2.1. All samples were prepared using a base formulation containing whole milk (3.2% fat and 4.7% carbohydrates) (Ta-Ta SA, Uruguay), 0.1% w/w polyphosphate, 0.02% w/w carrageenan (Ticaloid® 710H Stabilizer - Texture Innovation Center, TIC GUMS, Philadelphia). Samples were prepared using a Thermomix (Vorwerk Mexico S. de R.L. de C.V., Mexico D.F., Mexico). Powdered ingredients were mixed with the whole milk and heated at 90 °C under constant stirring for 5 min. After the heating process, the vanilla was added to the mixture and stirred for 1 min. Desserts were placed in glass jars and stored for 24 h at refrigeration temperature prior to the evaluation.

2.2.2. Participants

A total of 112 children (8–12 years old, 54% girls) were recruited from two elementary schools in Montevideo (Uruguay). One of the parents signed informed consent forms to allow their children to participate in the study, whereas children provided written assent to participate. Children were explained that their participation was voluntary and that they could withdraw at any time. Ethical approval was obtained from the Ethics Committee of the School of Chemistry of Universidad de la República.

2.2.3. Experimental procedure

The study took place in a separate quiet room in each elementary school between 10 am and 12:30 pm. Groups of 5–7 children performed the study at a time, with the assistance of 3 researchers. The whole study lasted between 15 and 20 min per child.

Data were collected on Ipads (Apple Inc., Cupertino, California, USA) using Compusense Cloud (Compusense Inc, Guelph, Canada). The study was presented to children as a “secret mission” to fulfill. The secret mission framework was intended to gamify the task and make it more attractive to children. The instructions were given by a cartoon character (a detective monkey).

The study consisted of two tasks: a familiarization step and a sample testing, involving dynamic sensory characterization and hedonic evaluation of the samples. Children were divided into two groups, each of which used a different method for evaluating the temporal sensory characteristics of the desserts: TCATA (n = 53) or TDS (n = 59). Chi-square tests showed no significant differences in age (p = 0.596) and gender (p = 1.000) distribution of the two groups.

2.2.3.1. Familiarization task

Children individually watched a video with the instructions of the familiarization task. After this video, a researcher verbally repeated the instructions and answered any question children might have. For the familiarization task, children were requested to watch another video, which was designed to convey the idea of temporal description to children, without the use of food cues (Figure 2.1). The video showed circles of different colors, which appeared and disappeared at different points in time and they had to describe the sequence using either TCATA or TDS. Children were instructed to use a list of colors to describe all those they saw on the screen (TCATA) or the color that caught their attention (TDS) at each time.

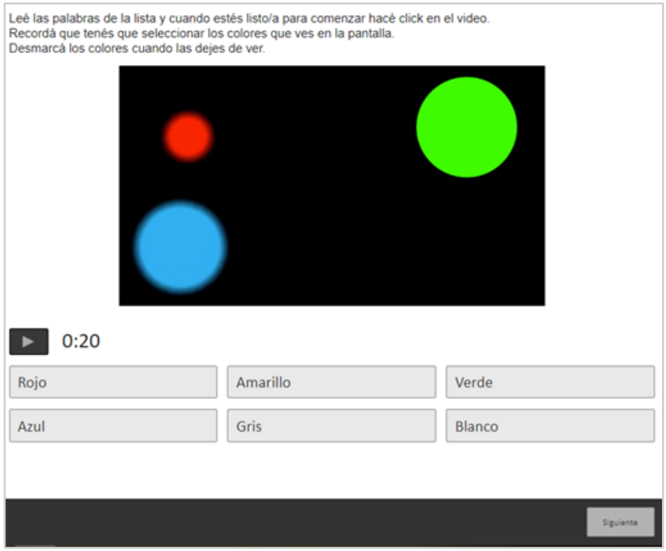

Figure 2.1. Example of the video shown in the familiarization task.

2.2.3.2. Sample tasting

Instructions were given for the sample tasting using a similar procedure (monkey character) to the familiarization task. Children received six milk dessert samples and were asked to describe them using a TCATA or TDS task. Desserts (20 g) were served in black plastic cups coded with 3-digit random numbers at 8 °C. They were presented following a Williams' Latin Square design to avoid order and carry over effects. Still mineral water was used for rinsing between samples. A warm-up sample was included to familiarize the children with the tasting protocol. The warm-up sample was identical to the 7% w/w added sugar dessert identified as “Sugar Reduced” in Table 2.1, but with a different vanilla.

Children were asked to carefully read the list of words before starting the test and to indicate if they had any doubt about their meaning. Attribute definitions were verbally provided if children expressed that their meaning was not clear. Then, they had to place a spoonful of sample in their mouths and immediately touch the “start” button in the screen to describe the sensory characteristics of samples using either TCATA or TDS. Children were instructed to eat the whole spoonful of sample at once and they were not allowed to taste it again. TCATA was performed as described by Castura et al. (2016). Children were instructed to check all the words that applied to describe what they perceived at each time while consuming the sample. They were free to select several attributes concurrently. If a word was no longer perceived, children had to uncheck it. For the TDS task children were instructed to select the word that described the sensation that caught their attention the most at a given time (Pineau et al., 2009).

Six words were included in the list for both methods: sweet, vanilla flavor, off-flavor, creamy, soft and hard. Attributes were selected based on results from previous studies (Alcaire et al., 2017, Ares et al., 2010, Bruzzone et al., 2015) and pilot testing with children. The duration of the temporal evaluations was fixed at 40 s, based on pilot tasting. The recorded evaluation time was equal for all children (40 s), and a stopping button was not provided. Swallowing time was not recorded either.

After the dynamic sensory characterization task, children were asked to rate their overall liking using a 9-point hedonic scale (1 = dislike very much and 9 = like very much) with emoji anchors (😩= dislike very much and 😍= like very much). All categories in the scale were labeled with their corresponding numbers, while emojis were used only at the extreme anchors to avoid redundancy between similar looking emojis. The final version of the evaluation protocol was based on results of a pilot test with 4 children.

2.2.4. Data analysis

All data analyses were performed using R software version 3.5.2 (R Core Team, 2018). For the dynamic sensory data, children who failed to select at least one attribute were excluded from the analysis: TCATA (n = 1) and TDS (n = 7).

2.2.4.1. Overall liking

Overall liking data were analyzed using a mixed linear model considering sample, temporal method and their interaction as fixed effects, and children as random effect. When significant differences were found, Fisher's test was used for post-hoc comparison of means. A significance level of 5% was considered.

Hierarchical cluster analysis considering Euclidean distance and Ward's method was applied on standardized overall liking data to explore segmentation. A linear mixed model was used to evaluate the existence of significant differences among samples within each cluster. In addition, the effect of the factors considered in the 2 × 2 experimental design on overall liking was of interest. In order to evaluate this, both for the whole sample of children and for each cluster, a mixed linear model was used on the overall liking data of the four samples formulated using the experimental design considering vanilla, starch and their interaction as fixed effects.

The identified groups were compared in terms of their gender distribution and the temporal method used to evaluate samples using chi-square test. In addition one-way ANOVA was used to compare the groups in terms of their age.

2.2.4.2. Analysis of TCATA data

The analysis was done with standardized time data (Lenfant, Loret, Pineau, Hartmann, & Martin, 2009), by taking into account the time from selection of the first attribute (time = 0%) to the end of the evaluation (time = 100%). The end of the evaluation was fixed for all participants, as data were always recorded until 40 s were reached. TCATA curves were constructed for each sample as recommended by Castura et al. (2016). Citation proportions were calculated per attribute as the number of children that selected a term as applicable to describe a sample at each moment of the evaluation. TCATA curves were smoothed using a spline type polynomial. For each term and each pair of products, a sign test was used at each time point to evaluate the existence of significant differences in the citation proportions.

2.2.4.3. Analysis of TDS data

TDS curves were constructed using standard procedures (Cadena et al., 2014). Seven children were excluded from the analysis because they did not select any attribute for describing the sample. Time standardization was used as mentioned in 2.2.4.2. The attribute selected as dominant at each time of the evaluation was computed. The dominance rate for each attribute was calculated as the proportion of children that selected that attribute as dominant at each moment of the evaluation. The dominance rate for each attribute was smoothed using a spline type polynomial and plotted versus time to obtain TDS curves. Chance level and significance levels were calculated as suggested by Pineau et al. (2009). Significant differences between pairs of samples in the citation proportions of all attributes were evaluated using the sign-test.

2.3. Results

2.3.1. Overall liking

When data were analyzed considering the whole sample of children, no significant differences (p = 0.14) among milk dessert samples were found in terms of their overall liking. As shown in Table 2.2, the average liking scores for all samples were close to 7 in the 9-point hedonic scale. This suggests that, on average, children showed a highly positive hedonic reaction to samples, regardless of their sugar content and concentration of vanilla and starch. However, when only the data of the four sugar-reduced samples was analyzed, a significant main effect of vanilla was found (Table 2.3). The increase of vanilla concentration led to an increase in liking (Figure 2.2a).

Further exploration of the data using agglomerative hierarchical clustering analysis revealed the existence of segmentation based on the overall liking. Children were clustered into three groups, with clearly different liking patterns (Table 2.2). No significant differences between the clusters were found in their age (p = 0.643) or the temporal method used for evaluating samples (p = 0.368). However, a significant difference in the gender distribution of the samples was found (p = 0.035). Cluster 1 and 3 were composed by a higher percentage of girls compared to Cluster 2 (63% and 78% vs 43%).

Children in Cluster 1 (n = 24) gave the lowest overall liking score to the sample formulated with the highest concentration of vanilla and starch (SR.Vanilla + Starch), followed by the Sugar Reduced sample (Table 2.2). The linear mixed model performed on the overall liking data of the four samples of the design of experiments revealed a significant interaction effect between vanilla and starch (Table 2.3). As shown in Figure 2.2b, increasing vanilla concentration (by adding vanilla B) led to an increase in liking at low starch concentration, whereas the opposite effect was observed at high starch concentrations.

For children in Cluster 2 (n = 70), the sample formulated with the increase of vanilla and starch (SR.Vanilla + Starch) did not significantly differ from the control sample. All the other samples showed a significantly lower overall liking score (Table 2.2). According to the design of experiment, only the main effect of vanilla B showed a significant effect on overall liking of the sugar reduced samples (Table 2.3). As shown in Figure 2.2c, increasing the vanilla B concentration led to an increase in liking. The effect of starch was marginal (p =

0.053). For children in this cluster, samples with higher starch concentration tended to have higher liking scores.

Children in Cluster 3 (n = 18) gave the lowest overall liking score to the control sample, whereas the sugar-reduced sample showed the lowest overall liking score among the four samples included in the experimental design (Table 2.2). In this case, the linear mixed model focused on the experimental design was not able to identify any significant effect (Table 2.3). However, vanilla B concentration had a marginal effect ($p = 0.062$). Children in Cluster 3 tended to give higher liking scores to the samples with more vanilla.

Table 2.2. Average overall liking scores (and standard error) for the evaluated samples for the whole sample and the three clusters identified in the Hierarchical cluster analysis.

Sample (*)	**Whole sample (n=112)**	**Cluster 1 (n=24)**	**Cluster 2 (n=70)**	**Cluster 3 (n=18)**
Control	7.2 ± 0.2 a	7.6 ± 0.3 b,c	7.9 ± 0.2 b	3.7 ± 0.5 a
Sugar Reduced	6.8 ± 0.2 a	6.8 ± 0.5 b	6.9 ± 0.3 a	6.2 ± 0.6 b
SR.Vanilla	7.4 ± 0.2 a	7.9 ± 0.3 c	7.3 ± 0.2 a	6.9 ± 0.6 b,c
SR.Starch	7.0 ± 0.2 a	7.0 ± 0.5 b,c	7.1 ± 0.3 a	6.8 ± 0.6 b,c
SR.Vanilla+Starch	7.1 ± 0.2 a	4.5 ± 0.4 a	7.8 ± 0.2 b	7.8 ± 0.3 c

(*) SR stands for sugar-reduced sample.

Sample descriptions are provided in Table 2.1. Overall liking scores were evaluated using a 9-point hedonic scale. Average values with different letters within a column are significantly different according to Fisher's test ($p < 0.05$).

Table 2.3. Results (p-value) of the mixed linear model testing the effect of vanilla, starch, and their interaction on the overall liking of milk desserts formulated using an experimental design for the whole sample and for the clusters identified in the hierarchical cluster analysis.

Effect	**Whole sample (n=112)**	**Cluster 1 (n=24)**	**Cluster 2 (n=70)**	**Cluster 3 (n=18)**
Vanilla	0.028*	0.014*	<0.001***	0.062
Starch	0.862	<0.001***	0.053	0.104
Vanilla:Starch	0.105	<0.001***	0.251	0.800

Note: Significant effects are shown with *: * p < 0.05, *** p < 0.001.

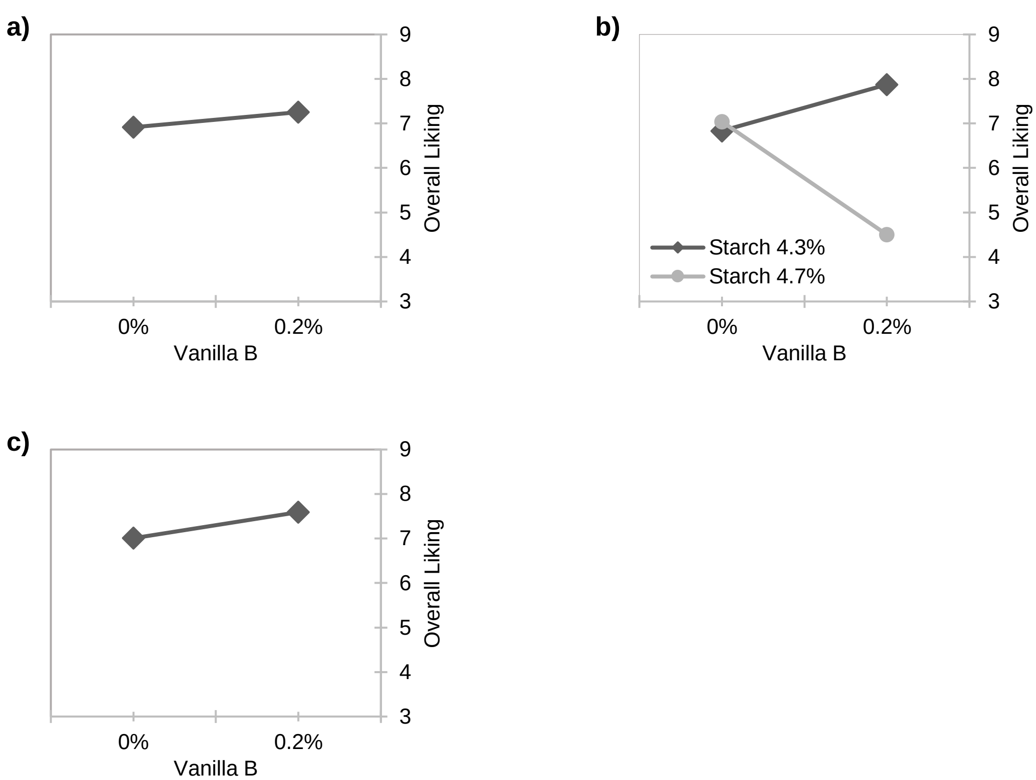

Figure 2.2. Significant effects of the factors of the experimental design for: a) the whole sample (n=112), b) Cluster 1 (n=24), and c) Cluster 2 (n=70).

2.3.2. Temporal evaluation using TCATA

Figure 2.3 shows the TCATA curves for the five evaluated samples. The citation proportion of the attributes increased rapidly at the beginning of the evaluation, mostly in the first quarter. Later, only modest changes were observed, which suggests that children rarely unchecked the attributes or selected new ones. The terms creamy, sweet and vanilla flavor showed the highest citation proportions for all samples, whereas the term hard always showed citation proportions lower than 0.1. As shown in Figure 2.3a, the Control sample was mainly characterized by a high citation proportion of the terms sweet and creamy over the whole evaluation period. Vanilla flavor and soft showed maximum citation proportions close to 0.60 around in the first fifth of the evaluation period and then slightly decreased.

Compared to the Control, all samples except for SR.Vanilla + Starch showed significantly lower citation proportions for the term sweet at some point of the evaluation (Table 2.4). The SR.Vanilla sample also differed from the Control in the citation proportion of the term vanilla flavor, whereas the SR.Starch sample showed a higher citation proportion of the term off-flavor during a small period of time and a lower citation proportion of the term soft for a considerable part of the evaluation (Table 2.4). Finally, the sample with increased starch and vanilla concentrations did not significantly differ from the Control sample in any sensory attribute (Table 2.4).

Small differences between the other pairs of samples were found. No significant differences between the sugar-reduced samples were found in the citation proportions of the terms sweet and vanilla flavor. Differences were only found for the attributes off-flavor, creamy and soft. The Sugar Reduced sample showed a lower citation proportion of the term creamy for a considerable part of the evaluation compared to the samples with higher starch concentration: SR.Starch and SR.Vanilla + Starch. In addition, the Sugar Reduced sample showed a significantly higher citation proportion of the term soft than the SR.Starch sample. Meanwhile, the SR.Starch sample showed a higher citation proportion of the term off-flavor compared to the SR.Vanilla + Starch sample for a short period of time, as well as a lower proportion citation of the term soft

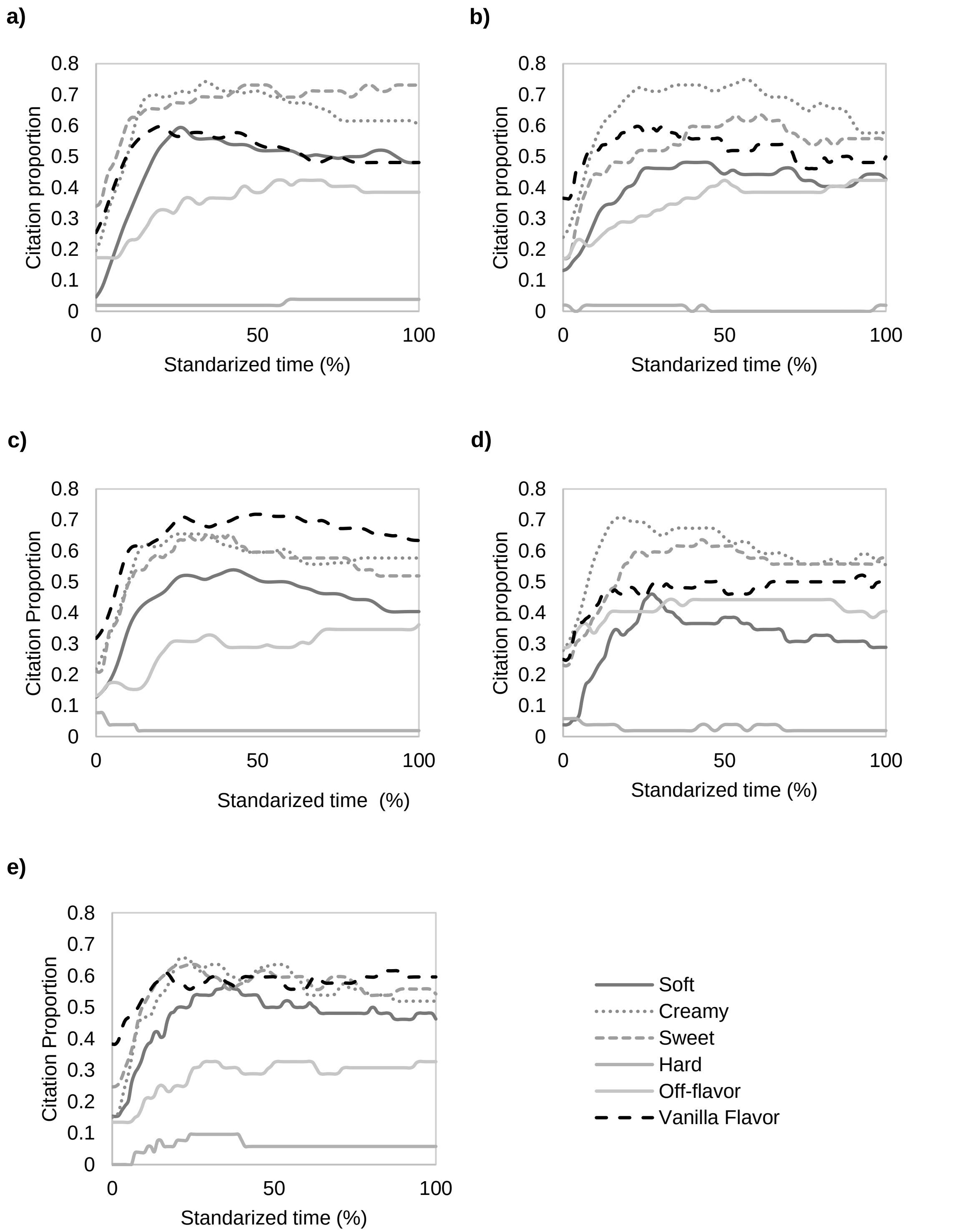

Figure 2.3. Temporal check-all-that-apply curves for five vanilla milk dessert samples: A) control, B) Sugar Reduced, C) SR.Vanilla, D) SR.Starch and E) SR.Vanilla+Starch. SR stands for sugar-reduced sample. The description of the samples is provided in Table 2.1.

Table 2.4. Average difference in citation proportions (± standard deviation) and time periods at which these occur for pairs of samples showing significant differences in TCATA curves. Only differences significant at a significance level of 5% are shown.

Attribute & Sample Pair (*)	**Citation proportion difference (**)**	**Time periods**
Sweet		
Control vs. Sugar Reduced	0.19 ± 0.01	0-4, 83-85, 100
Control vs SR.Vanilla	0.20 ± 0.01	83-100
Control vs. SR.Starch	0.21 ± 0.01	7-11
Vanilla flavor		
Control vs SR.Vanilla	-0.19 ± 0.01	49, 52-54, 58-63, 65-72, 78-84
Off-flavor		
Control vs. SR.Starch	-0.18 ± 0.01	7-11
Starch vs. SR.Vanilla+Starch	0.21 ± 0.02	3-8
Creamy		
Sugar Reduced vs. SR.Starch	-0.17 ± 0.001	64-100
Sugar Reduced vs SR.Vanilla+Starch	-0.17 ± 0.001	69-100
Soft		
Control vs. SR.Starch	0.20 ± 0.01	19-21, 69-74,76, 84-100
Sugar Reduced vs. SR.Starch	0.13 ± 0.001	93-100
SR.Starch vs. SR.Vanilla+Starch	-0.16 ± 0.04	0-2, 4-5, 95-99

(*) SR stands for sugar-reduced sample.

(**) The citation proportion differences were calculated by averaging the differences in citation proportion between pairs of samples across all the time periods showing a significant difference ($p<0.05$) when their TCATA curves were compared.

2.3.3. Temporal evaluation using TDS

The TDS task was not able to capture the temporal evolution of the attributes for most of the samples. As shown in Figure 2.4, the curves were mostly flat, suggesting that most children selected only one attribute during the whole evaluation. In addition, the citation proportions of all the attributes were lower than 0.35 for all samples. For this reason, few attributes were found to be significantly dominant.

The control sample was characterized by the dominance of the term sweet during the majority of the evaluation period and by the dominance of creamy at the beginning of the evaluation. In addition, off-flavor was on the limit of dominance in the first half of the evaluation time (Figure 2.4).

The TDS curve of the reduced sample showed that off-flavor and creamy were dominant but only at the beginning of the evaluation. In the case of the SR.Vanilla sample, none of the attributes reached significance. The SR.Starch sample was only characterized by the dominance of creamy, whereas in the case of the SR.Vanilla + Starch sample, the terms creamy and sweet were significantly dominant during most of the evaluation period.

Differences in the citation proportions of all attributes between pairs of samples were small, as shown in Table 2.5. In terms of sweetness, only the sample SR.Vanilla + Starch showed a difference from the control at some point of the evaluation time (Table 2.5). The Sugar Reduced and SR.Vanilla samples showed lower citation proportions of the term soft compared to the Control. However, the last sample only showed this difference for a small period of time. The SR.Vanilla sample also had a higher citation proportion of the term vanilla flavor. No significant differences between the SR.Starch sample and the control sample were found.

Regarding differences among the sugar-reduced samples (Table 2.5), the SR.Vanilla sample showed a higher citation proportion of the term vanilla flavor than the Sugar Reduced and SR.Starch samples, which lasted for the longest period of time, whereas it showed a lower citation proportion of the term off-flavor than the SR.Starch sample. This last sample also showed a higher citation of the term off-flavor than the SR.Vanilla + Starch sample, though this difference was observed for a smaller period of time. In addition, a difference in the citation proportion of the term soft was also found for this pair, the SR.Starch sample was less soft. Finally, a difference in the citation proportion of the term hard was observed between the SR.Vanilla and SR.Vanilla + Starch samples but it was brief and small.

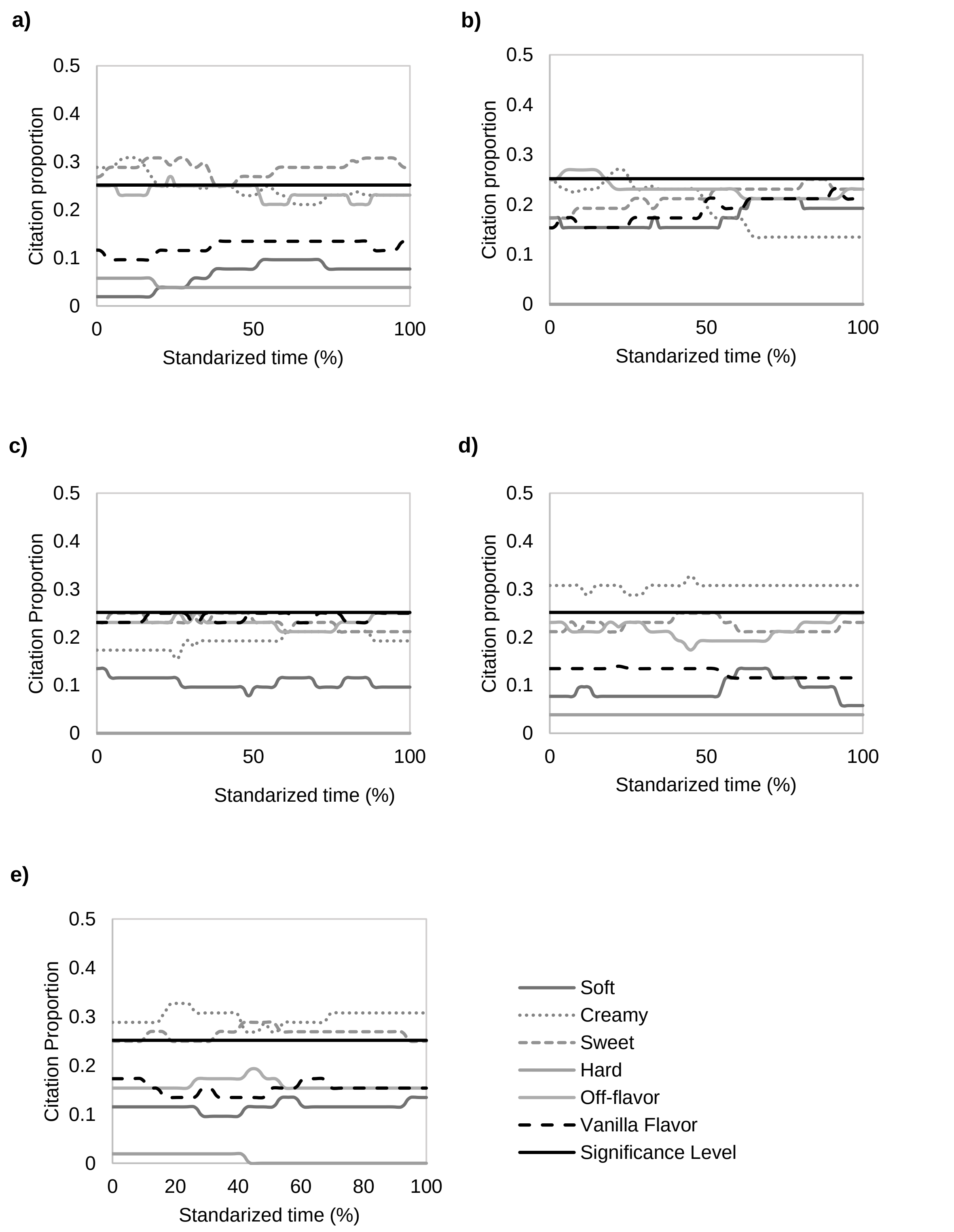

Figure 2.4. TDS smooth curves for five dessert samples: A) Control, B) Sugar Reduced, C) SR.Vanilla, D) SR.Starch and E) SR.Vanilla+Starch. SR stands for sugar-reduced sample.

Table 2.5. Average difference in citation proportions (± standard deviation) and time periods at which these occur for pairs of samples showing significant differences in TDS curves. Only differences significant at a significance level of 5% are shown.

Attribute & Sample Pair (*)	Citation proportion difference (**)	Time periods
Sweet		
Control vs. SR.Vanilla+Starch	0.19 ± 0.003	83-86, 100
Vanilla flavor		
Control vs SR.Vanilla	-0.15 ± 0.002	16-18
Sugar Reduced vs SR.Vanilla	-0.20 ± 0.01	50-59, 70, 72-80, 82-83
SR.Vanilla vs SR.Starch	0.22 ± 0.02	22-72
Off-flavor		
SR.Vanilla vs. SR.Starch	-0.20 ± 0.02	4-17
SR.Starch vs. SR.Vanilla+Starch	0.21 ± 0.02	3-8
Soft		
Control vs. Sugar Reduced	-0.13 ± 0.01	0-29
Control vs. SR.Vanilla	-0.11 ± 0.002	0-3
SR.Starch vs. SR.Vanilla+Starch	-0.16 ± 0.04	0-5, 95-99
Hard		
SR.Vanilla vs. SR.Vanilla+Starch	0.08 ± 0.00	0-3

(*) SR stands for sugar-reduced sample.

(**) The citation proportion differences were calculated by averaging the differences in citation proportion between pairs of samples across all the time periods showing a significant difference ($p<0.05$) when their TDS curves were compared.

2.4. Discussion

Results from the present work showed that a reduction up to 40% of added sugar had no relevant effect on children's hedonic reaction and only minor effects on sensory perception. On average, children liked the straight sugar reduced sample as much as the benchmark sample, though the impact on the dynamics of sensory perception is less clear. This suggests that there is room for reducing the sugar content of this type of product without affecting liking, and, at first glance, with no need for compensation strategies. Other studies have shown that the sweetness of commercial products available in the marketplace is usually higher than consumers' preferred sweetness level (Chollet et al., 2013, Reed et al., 2019). The feasibility of reducing the sugar content of dairy products has also been reported by other authors (Harwood et al., 2013, Li et al., 2015b). Still, the conclusion reached when analyzing results for the whole sample of children should be taken with care, as subtle but significant differences among samples' sensory profiles were found, as well as individual differences in children's liking patterns.

2.4.1. Cross-modal interactions for reducing the sugar content of products targeted at children

In the present work, sugar reduction mainly impacted the texture and sweet taste of the milk desserts, which fits expectations (Chollet et al., 2013, Goldfein and Slavin, 2015, Pineli et al., 2016). Aroma/texture/taste interactions can be used to counteract these changes and achieve larger sugar reductions in shorter periods of time (Alcaire et al., 2017, Oliveira et al., 2015, Thomas-Danguin et al., 2016).

Results from the present work showed that increasing the concentration of vanilla aroma led to an enhancement of vanilla flavor perception. An increase in sweetness was detected in a paired comparison with trained assessors, in agreement with previous studies (Labbe et al., 2006, Oliveira et al., 2015). Although most of the children tended to increase their liking with increasing vanilla concentration, results from the dynamic sensory methods did not show differences in sweetness. The discrepancy between trained assessors and the dynamic sensory methods with the children could be explained by the fact that cross-modal interactions between vanilla aroma and sweet taste are expected to be small in real food (Wang, Hayes, Ziegler, Roberts, & Hopfer, 2018), which could have prevented the identification of significant differences in a dynamic sensory characterization task with children. In addition, children have been reported to be likely to attend to only one attribute (James et al., 1999, Popper and Kroll, 2011), which may make it hard to find differences in several attributes at the same time. Still the enhancement of sweetness with vanilla cannot be ruled out, though dynamic sensory methods did not show this effect. Another method focused on attribute intensity may have led to a different result.

The increase of starch impacted texture attributes, as expected. The increase in starch concentration led to an increase in creaminess and a decrease in perceived thickness (evaluated using the terms soft and hard), in agreement with previous studies (de Wijk et al., 2006, de Wijk et al., 2003). According to de Wijk et al. (2003), the addition of starch decreased the sweetness perception due to a possible interference with the diffusion of taste compounds. However, Kanemaru et al. (2002) reported that the addition of starch could increase sweetness due to molecular interaction with sugar. In the present study, the increase in starch concentration did not seem to modify flavor perception.

The combined increase of vanilla and starch concentration minimized the sensory changes caused by sugar reduction, probably due to an increase in sweetness perception. The SR.Vanilla + Starch sample was the only sugar-reduced sample for which sweet was significantly dominant in the TDS task. This is in line with the findings reported by Alcaire et al. (2017), who found that the increase of vanilla aroma and starch increased the sweetness perception and reduced the changes in liking for sugar reduced milk desserts among adults. Although the sweetness enhancement due to the increase of vanilla was modest, its effect may have been boosted by the increment of starch due to its role in facilitating the release of volatiles from the matrix (Arancibia et al., 2011, González-Tomás et al., 2007). Also, it is possible that a perceptual interaction took place: the boost of creaminess and vanilla flavor could have triggered an overall sensory experience closer to a regular product.

2.4.2. Heterogeneity in children's reaction to cross-modal interactions

Careful interpretation of the impact of sugar reduction should be paid since it is known that food preferences in children are influenced by multiple genetic and environmental factors (Wardle & Cooke, 2008). This leads to individual differences in food preference and choice, which are likely to influence success of sugar reduction strategies. Despite the majority of children liked all the samples, three groups were identified with distinctive liking patterns.

One small group tended to strongly dislike the sample with the highest concentration of sugar which was highly liked by the rest of the children. Differences in sweet preferences among children have been identified due to early experiences, genetic variances and cultural components (Liem and Mennella, 2002, Mennella et al., 2006, Pepino and Mennella, 2005). For instance, the existence of sweet dislikers among children has been reported by Garneau, Nuessle, Mendelsberg, Shepard, and Tucker (2018). These authors reported that, in contrast to showing a greater preference for high sweetness levels, their liking decreased as the concentration of sucrose increased.

Considering that the aim of product reformulation is to at least maintain liking of the control sample, it is interesting to note that added sugar reduction of around 40% led to maintained or increased liking for 37.5% of the children (Clusters 1 and 3), while for the remaining 62.5% (Cluster 2) liking decreased but could be restored by the addition of high starch and vanilla levels. Another relevant point is that, even though around 80% of the children gave the highest overall liking to the dessert formulated with the highest levels of vanilla and starch, one group of children showed a strong dislike for this sample.

Although the findings regarding individual differences were interesting, it is important to take into account that the number of children in each cluster was small. Future studies should be conducted with a larger consumer sample to confirm the trends found here. In addition, whether the individual differences found in hedonic perception are due to differences in sensory perception, or if they are just the result of differences in children's preference patterns, deserves further investigation.

Individual differences could also be related to the nutritional status of children. In this sense, Proserpio et al. (2016) showed that certain aromas had a higher impact on the sensory perception of obese adult woman than normal weight ones. Although in the present study data on children's body mass index were not collected, this information could be valuable for future research.

2.4.3. Methodological considerations

The present study is the first to report the use of dynamic sensory methods with children. Although children reported to understand both methods and were able to complete the tasks, results showed that children mostly used the methods as static. As shown in Figure 4, TDS curves were mostly flat, suggesting that children tended to select only one attribute during the whole evaluation period. In the case of TCATA, although Figure 3 showed larger variability of citation proportions over time, children tendency to unselect attributes was limited. This tendency, although less pronounced, has been reported with adults, both trained and untrained (Ares et al., 2015; Castura et al., 2016). Future studies should evaluate if the implementation of a fading variant could improve children's performance in dynamic sensory characterization tasks. In this approach, terms are automatically de-selected after a fixed period of time and assessors are asked to select them again if they are still applicable. Ares, Castura, et al., 2016 reported that TCATA and its fading variant showed similar results in eight studies with trained assessors and consumers, but the fading variant may result in a more accurate dynamic profile and higher discriminability.

Alternatively, van Bommel, Stieger, Schlich, and Jager (2019) recently introduced a hold-down variant for temporal dominance methodologies as a way to capture non dominance periods. In this methodology, participants actively hold down the button of the attribute that is perceived dominant and release it when it is no longer perceived. Although the authors reported that this variant did not outperform the classic methods with adults, it might improve children's performance since it could keep their attention for longer, as participants are more actively involved during the evaluation. Moreover, it might help to eliminate false dominance periods at the end of the mastication period or due to hesitation.

In addition, it could be interesting to evaluate the application of dynamic sensory methods with solid products that undergo larger changes in their sensory characteristics throughout consumption. The fact that most variation in TCATA curves occurred in the first fifth or quarter of the evaluation period also suggest that children tended to use this method as static: once attributes were selected no further changes were registered.

Despite the limited changes observed throughout consumption, the sensory profiles of the evaluated samples fitted expectations. The terms with the highest citation proportion were similar to those reported in previous studies dealing with the same product category (Ares et al., 2010, Bruzzone et al., 2015, de Wijk et al., 2003, Vidal et al., 2013). In addition, significant differences among samples that fitted expectations were identified. These results point towards children's ability to describe the sensory characteristics of products, in agreement with previous studies (Laureati et al., 2017, Schouteten et al., 2017, Verwaeren et al., 2019).

Regarding the comparison of TCATA and TDS, both methodologies showed similar results regarding the most salient sensory characteristics of the samples and differences among them. Similar results have been reported with adult assessors (Ares, Jaeger, et al., 2016). As expected, the main difference between the methods was related to the citation proportion of the individual attributes. In particular, the low dominance rates of all the attributes in TDS points towards heterogeneity in how children selected the sensory attribute that caught their attention. In this sense, further exploration of children's understanding of the concept of dominance is warranted.

Another methodological consideration of this study is the sugar reduction level that was used. Although ~40% reduction in added sugar led to a decrease in overall liking for the majority of the children, the sugar reduced sample was not disliked. Future studies should consider higher reduction levels in order to achieve children's' rejection of the reformulated product, in which compensation strategies such as cross-modal interaction would be more relevant to achieve reformulation goals.

2.5. Conclusions

Results from the present work suggest that it is feasible to reduce the added sugar concentration in vanilla milk desserts without largely affecting children's hedonic perception. The use of cross-modal interactions based on vanilla flavor and texture modification was effective at minimizing the changes in the sensory characteristics of samples caused by sugar reduction. This strategy should be implemented in the context of gradual sugar reduction programs in order to achieve a long-term reduction in children's preference for products with high sweetness intensity.

Large heterogeneity was found in how children reacted to the changes in the sensory characteristics of samples caused by the increase in the concentration of vanilla and starch. Future research should be conducted to further understand the factors responsible for individual differences in children's reaction to cross-modal interactions in sugar-reduced milk products.

CHAPTER 3

Co-creation of a healthy dairy product with and for children

This chapter has been published as a research article in Food Quality and Preference:

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Author contributions:

- Velázquez, A.L: Conceived and designed the study, collected the data, analyzed and interpreted the data, wrote the paper.
- Galler, M: Conceived and designed the study, wrote the paper.
- Vidal, L: Contributed to the conception and design of the study, as well as to data collection and interpretation, performed a critical revision of the article.
- Varela, P: Contributed to the conception and design of the study, performed a critical revision of the article.
- Ares, G: Contributed to the conception and design of the study, as well as to data interpretation, performed a critical revision of the article.

Abstract

Children's involvement in new product development may contribute to ensure that healthy alternatives meet their wants and needs. Co-creation is a potential approach to bridge the world of the child and the grown-up product developer. In this context, the objective of the present work was to explore the potential of a co-creation approach with children to develop a healthy dairy product. A total of 52 school-aged children (54% girls, 6-13 year old) recruited from an after-school club in Montevideo (Uruguay) participated in co-creation workshops. Two sessions were carried out. In the first session, children developed a dairy product using a set of ingredients and proposed strategies to promote their product. Children showed a high level of engagement during the activity and provided actionable ideas for product development. Three key factors drove the product formulation (familiarity, hedonics, and healthiness), whereas common communication strategies were proposed by the participants to promote their products. In the second session, children evaluated four products developed by the researchers based on children's ideas. The products showed high overall liking scores (5.9 to 7.9) despite the inclusion of novel and healthy ingredients and the lower sugar content compared to similar commercial products available in the Uruguayan marketplace. These results show the potential of involving children in the co-creation of healthy dairy products. Considering the lack of published studies regarding the use of co-creation approaches with children in the food domain, the present work provides useful insights for the implementation of co-creation to develop innovative products with and for children

3.1. Introduction

Shifting to a healthier food environment is a major challenge our society is faced with, calling for new approaches by food science and technology (Lillford & Hermansson, 2020). Unfortunately, to this date, healthy food is particularly underrepresented in the child segment (Chacon et al., 2013; Gimenez et al., 2017; Lavrisa & Pravst, 2019; Mehta et al., 2012), indicating a need to develop healthy alternatives that children will actively choose. Healthiness alone is not a strong driver of children's food choice and can even have an adverse effect if it leads children to assume a reduced pleasurable experience (Marty et al., 2018). Children should therefore be closely involved in new product development (NPD) in order to ensure that healthy alternatives meet their needs.

In the early-20th century NDP was mainly a closed process that took place within companies. However, the need to respond quickly to the ever changing consumer demands has led companies to adopt an open innovation model, which assumes that good ideas come from both inside and outside the company (Chesbrough, 2003). This has been linked to co-creation practices, where consumers play a central role in the creation process (Prahalad & Ramaswamy, 2002).

In the NPD context, co-creation is defined as a collaborative activity in which consumers and other potential stakeholders play an active role in the creation and selection of new products to be launched in the market (Ind & Coates, 2013; OHern & Rindfleisch, 2010). Through active involvement, it allows participants to reflect creatively on their own practices, making it a promising approach to tackle public health issues, where the reassessment of current practices is necessary, and the top-down solutions fall short (Leask et al., 2019). At the same time, it allows companies to launch products that fit consumer needs better which may increase the success of NPD (Roberts & Darler, 2017).

A co-creation process ensures to the highest degree that children's voices are heard (Druin, 2002) in the shift to healthier food environments. Beyond the ideas themselves, co-creative methods allow to generate extensive insights on children's eating practices and needs (Waddingham et al., 2018). The often-stressed need for consumer involvement in early stages of product development (Busse & Siebert, 2018; Schifferstein, 2015; van Kleef et al., 2005) might be particularly relevant for child-focused products, to bridge the world of the child and the grown-up product developer. Further, as children are still developing their food preferences, an active and creative involvement can potentially empower them to find their own way to healthy and pleasurable diets.

Co-creation with children has been used in multiple areas, for example, architecture and urban environment design (Gennari et al., 2019; Ghaziani, 2021; Jelic et al., 2020), technology (Arnold et al., 2016; Havukainen et al., 2020), education (Borum et al., 2015; Kangas, 2010; Mack et al., 2019; Parsons et al., 2015) and marketing (Daems et al., 2017). In a first application in food product development by co-creation with preadolescents, Galler et al. (2020) showed that they were able to suggest actionable new food product ideas, using enabling and creative techniques in workshop-style and online settings. In their work, empowerment appeared as an interesting added value from co-creative approaches. Being in charge of their food choices, fulfilling their needs of autonomy, and the social connection in co-creation activities make this age group enjoy them, and potentially has an effect of encouraging them and their peers to acquire new and healthier practices.

Dairy products are regarded as healthy foods due to their high-quality protein and micronutrients content (Campmans-Kuijpers, Singh-Povel, Steijns, & Beulens, 2016). Their intake has been associated with bone health in children and adolescents (Rizzoli, 2014). Several dietary guidelines around the world recommend the inclusion of dairy products in children's diets (Dror & Allen, 2014). Although children's intake of dairy products is highly variable across countries, households with children have been reported to be more likely to purchase dairy products than those without children (Ortez et al., 2021). Due to their nutritional composition and frequent consumption, dairy products have been regarded as an important carrier for the delivery of bioactive compounds with health benefits and functional properties (Kanekanian, 2019).

However, commercial dairy products targeted at children usually have a high content of sugar (Moore, Horti, & Fielding, 2018). In this sense, Giménez et al. (2017) found that most of the dairy products targeted at children in Uruguayan supermarkets have an excessive content of sugar according to the criteria of the nutrient profile model of the Pan American Health Organization. This suggests the need to develop healthier dairy products with low sugar content targeted at children. Although the development of low sugar dairy products has been regarded as a major challenge for the food industry (Hutchings, Low & Keast, 2019), recent research shows that sugar reductions up to 20-30% are feasible without affecting adults and children's hedonic perception (Alcaire et al., 2017; Oliveira et al., 2016; Velázquez et al., 2020).

In this context, the objective of the present work was to explore the use of co-creation with children in the development of a healthy dairy products. Currently, food product development by co-creation with children is limited to the generation of new product ideas in a sketch, verbal, or written format (Galler et al., 2020), while food prototyping is rare even with adult consumers (Filieri, 2013). Food prototyping is regarded as a valuable tool since it facilitates the communication and improvement of ideas in the early stages of the NPD process (Olsen, 2015). The present study aimed to integrate food prototyping in the co-creation workshops to allow children to better express and improve their ideas. To go beyond regular products available in the Uruguayan market, vegetables and nuts were included as potential novel and healthy ingredients to encourage children to think out of the box. Considering that involving children in cooking activities improve children's acceptance of novel and healthier foods (Allirot et al., 2016; van der Horst et al., 2014), the co-creation of a healthy dairy product with children was approached as a cooking workshop. Given its exploratory nature, the study had no a priori hypotheses.

3.2. Methods

Building on the approach proposed by Galler et al. (2020) a multiple stage setup was used for co-creating a healthy dairy product with children: Exploring – Prototyping – Refining -Validating (Figure 3.1). Drawing on design thinking, prototype iterations were included to enable a rapid collaborative learning without the need of abstraction or sensory knowledge (Olsen, 2015). A brief explanation of each of the stages is provided below, followed by the detailed description of how they were implemented.

Exploring: Children were given the chance to experiment with a series of diverse ingredients, which encouraged them to reflect about their characteristics and potential use in a new healthy product. In this step, children were able to taste some ingredients, observe different textures, and discuss their sensory characteristics within their group.

Prototyping by children: This stage involved two different steps: Product prototyping and Concept prototyping. In the first step, children selected individual ingredients to create a product prototype. Once the prototypes were created, children tasted and analysed them, making suggestions for additional improvement. In the Concept prototyping step, children developed potential concepts and communication strategies to encourage other children to consume the product they had developed.

Refining by researchers: Researchers developed four final product prototypes based on children's ideas in a second prototyping iteration.

Validating with children: To measure children's acceptance of the products prototyped during the refining step, children tasted and evaluated the four products in a second session.

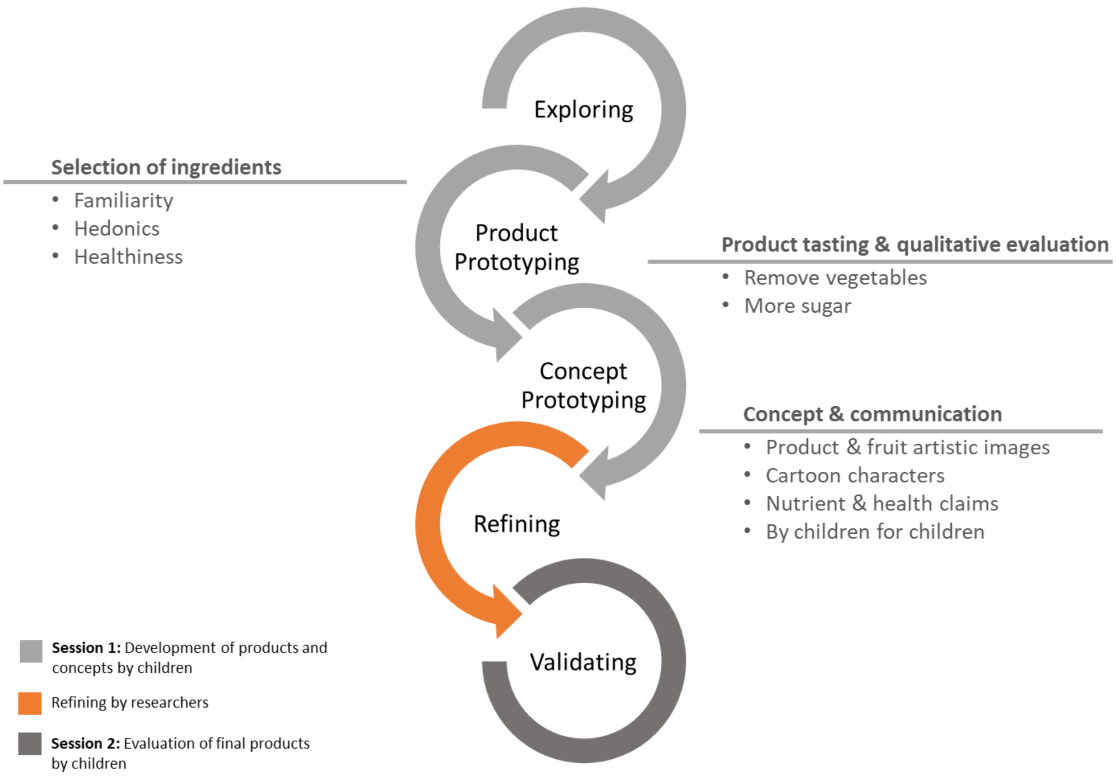

Figure 3.1. Workflow of the development of the dairy products co-created with children.

Three researchers were involved in the data collection. Two researchers acted as the moderators and interacted with the children, whereas the third researcher supported the logistics of the activity and observed the session. In a preliminary session, children were introduced to the topic of healthy eating in a discussion format (Appendix 2). Results of the preliminary session are not shown in the present work. Then, two sessions were carried out to co-create healthy dairy products with children and to evaluate the developed products. Each session lasted a maximum of 45 minutes. All the sessions were audio recorded. The script for the sessions is presented in Appendix 3.

3.2.1. Participants

Purposive convenience sampling was used to recruit children. A total of 52 school-aged children were recruited from an after-school club in Montevideo, Uruguay. All children (54% girls, 44% 6-8-years old, 56% 9-13-years old) participated in the first session, whereas 43 children (49% Girls, 44% 6-8-years old, 56% 9-13-years old) attended the second session. One of the parents of each child signed an informed consent form to allow his/her participation in the study. All children provided verbal assent to participate which was recorded. Ethical approval was obtained from the Ethics Committee of the School of Chemistry of Universidad de la República (Uruguay).

3.2.2. Co-creation of dairy products

The age ranges were selected based on how usual activities were organized in the club. This enabled collaboration between children within a short time frame dedicated to the co-creation workshops. Due to the restrictions associated with the COVID-19 pandemic, children worked in their usual groups to maintain the social bubbles at the club. Groups corresponded to children in the same age range: 6 to 8 years old or 9 to 13 years old. Children worked in small groups (3-5 children) to assure that all children in the group could participate in the activities. The activity was conducted in a separate quiet room at the social club.

3.2.2.1. Exploring and Prototyping: Development of products and concepts by children

A wide range of ingredients were selected for the study, including dairy products, vegetables, fruits, spices, grains, and nuts (Table 3.1). Ingredients were selected by the researchers based on availability in the country. Most children were expected to be familiar with the selected fruits and vegetables, as they are among the most consumed in the country (Observatorio Granjero, 2021). Recipes of dairy products (e.g. smoothies, mousses, etc.) available in websites and blogs were also considered for ingredient selection. Except for sugar, all the ingredients are recommended by the Uruguayan dietary guidelines (Ministerio de Salud Pública, 2016). Detailed information about the ingredients presented to children is shown in the Appendix 4.

Table 3.1. Ingredients given to children to develop a healthy dairy product prototype.

Base dairy product	Vegetables	Fruits	Spices & sugar	Grains & nuts
Milk	Pumpkin puree	Banana	Vanilla	Oats
Yogurt	Cucumber	Strawberries	Cinnamon	Puffed quinoa
Dairy dessert	Beetroot puree	Blueberries	Lemon juice & peel	Chia
Yogurt gel	Carrot puree	Orange	Peppermint	Flax
Yogurt mousse	Spinach puree	Apple	Cocoa	Nuts
Chia milk dessert	Tomato	Pineapple	Sugar	Grated coconut

3.2.2.1.1. Exploring and product prototyping

First, children were asked to create their own healthy dairy product and were told they should work as a team to develop the product. One of the researchers asked children what a dairy product was and which dairy products they knew. Then, children were presented with the six base dairy products with different textures. They were asked to observe them in order to identify what each product was and to indicate if they had tried each of the products before. They were also presented with the other ingredients in the following order: vegetables, fruits, spices & sugar, and grains & nuts. Children were free to touch, smell and taste these four groups of ingredients, but they were not forced to do it. Given that the study was performed in the context of the COVID-19 pandemic, tasting was mediated by the researcher in charge of the group. When a child asked to try an ingredient, the researcher handed a small portion to each child to avoid the sharing of utensils. The researcher encouraged all children to describe and discuss the ingredients and share their previous experiences.

After the exploration step, children engaged in the creation of the product prototype. Each group of children received a set of kitchen utensils which included: a hand mixer, a blender, a spatula, a set of measuring spoons, two bowls (large and medium), a cutting board, four tablespoons and one knife (supervised by a researcher). Children were free to choose as many ingredients as they wanted for developing their product. The following rules applied: 1) only one dairy base should be used, and 2) at least one ingredient from the other groups should be included. Once the children in each group had selected the ingredients, they started to prepare their product. Although children were mostly autonomous in the development stage, the researchers closely monitored the activity and helped children in some activities without interfering with their decisions. For example, they cut ingredients for young children or moderated the discussions within the group.

After children finished the development part, they evaluated and refined their products (Product tasting & qualitative evaluation, Figure 3.1). The researcher served a small portion to each child so they could taste and evaluate their own product prototype. Children were prompted to discuss how they perceived the product, whether they liked it or not, and if they would make any improvements.

3.2.2.1.2. Concept prototyping

Children developed a concept prototype as communication strategy for their created products, by creating a poster similar to those usually found in bus stops. The poster was an adaptation from the newspaper brainstorming technique (Gray et al., 2010) used by Galler et al. (2020) to a more realistic context of a bus stop commercial, mimicking bus-stop posters ubiquitous in the area. The template included multiple fields that covered different product promotion aspects: product name, ingredients, sensory characteristics, promotional image, and product benefits (Appendix 5).

3.2.3. Refining: development of the final products by researchers.

Four final products were developed using the ideas developed by the children (most frequent ingredients and combinations used in the different groups, as well as children's comments during the co-creation workshop). Only the milk dessert and the yogurt were considered for the formulation of the new products, since most of the groups selected one of them as dairy base. One of the most used vegetables (carrot, pumpkin or beetroot) was used as a central ingredient of the final products. Then, the ingredients that were more frequently used in combination with these specific vegetables were selected, considering a maximum of 6 ingredients per product. Grains and nuts were not included (except for grated coconut in one final product) given heterogeneity in children's views on their inclusion during the first session. Six percent of added sugar was used for all products given that this quantity was observed to be enough for children to create well-accepted products during the prototyping step. This represents more than 40% sugar reduction compared to commercial milk desserts targeted at children (approximately 12% added sugar) and 10-20% sugar reduction compared to yogurts targeted at children (approximately 7-9% added sugar) in Uruguay. Based on a pilot tasting by the research team, four final dairy products were developed (Table 3.2).

Table 3.2. Formulation of the final products developed by researchers based on children's ideas.

Ingredients	D001	D002	D003	Y001
Milk dessert base	74	74	74	-
Yogurt	-	-	-	74
Sugar	6	6	6	6
Beetroot puree	-	5	-	5
Carrot puree	-	-	5	-
Pumpkin puree	5	-	-	-
Strawberry puree	13.7	15	7.5	7.5
Blueberries puree (big chunks)	-	-	7.5	-
Banana puree	-	-	-	7.5
Cocoa	1	-	-	-
Vanilla	0.3	-	-	-

Notes: Ingredient's quantities are expressed in percentage (w/w)

3.2.4. Validating: evaluation of the refined product prototypes by children.

In the second session, the validation of the refined product prototypes developed by the researchers was carried out. The concept prototypes and communication strategies proposed by children will be validated in future studies. Samples (20 g) were served in black plastic cups coded with 3-digit random numbers at 8°C. Four different sample presentation orders were considered. Due to practical aspects of the evaluation set up, all children in the same group evaluated the samples in the same presentation order. Still mineral water was used as palate cleanser.

The tasting session took place in the dining hall/courtyard of the social club. Children performed the activity in groups of up to 12 children. Children were distributed to two large tables and seated with space in between them, but no physical divider was used. They were invited to evaluate the four samples. They were told the products were developed based on the products they created during the first session. Children received a paper questionnaire and the samples one by one. They were asked to try each of the products and to rate their overall liking individually, using a 9-point hedonic scale (1=dislike very much and 9=like very much) with emoji anchors. The same scale was used for all children, regardless of their age. Although 9-point hedonic scales are not the most frequent for 6-7 year old children (Laureati et al., 2015), previous studies have shown that children in this age range are capable of using such scales (Divert et al., 2017; Popper & Kroll, 2011). The researchers monitored that children performed the evaluation individually and assisted them if they had any question. Once all children finished their evaluation, they were allowed to interact with each other. After children completed the questionnaire each sample individually, they were asked to guess the ingredients in the product. Then, one of the researchers revealed the actual ingredients in the sample. The session lasted between 15 and 20 min.

3.2.5. Data analysis

The frequency of use of the each of the ingredients in the prototypes developed by children was calculated. In the validation step, overall liking scores for the four refined product prototypes were analyzed using a mixed linear model considering sample as a fixed effect and children as random effect. In addition, descriptive statistics and histograms were performed. Statistical analyses were performed using R software version 3.6.2 (R core Team, 2019).

Children's comments during the sessions were analyzed to obtain an overview of their decision-making process and their perception of the prototypes. For this purpose, qualitative content analysis, based on a deductive-inductive coding approach, was used (Bengtsson, 2016; Elo & Kyngäs, 2008; Krippendorff, 2004). Qualitative content analysis is a method to systematically evaluate written, verbal or visual communication material which aims to keep the systematic nature of content analysis without quantification (Mayring, 2004). Raw data consisted of the transcripts of the audio recordings of all the sessions. First, a deductive approach was used to qualitative analyze children's comments according to four main themes: i) selection of the ingredients and product prototyping, ii) prototype tasting, iii) concept prototyping, and iv) tasting of the refined product prototypes. Then, the information within each theme was qualitatively coded based on an inductive approach, i.e., categories were identified as they emerged after reading the transcript of children's comments.

Three researchers participated in the data analysis, two of the researchers involved in the data collection and an additional researcher (not blinded to the objective of the study).

One researcher performed an initial coding by reviewing the raw data several times, which was then independently checked by the other two researchers. Quotes for each category were selected and translated from Spanish to English for illustrative purposes.

3.3. Results

3.3.1 Co-creation of healthy dairy products with children

Based on researchers' observations, children showed a high level of engagement during the activity. During the exploration and product prototyping stage, age-differences in the expected outcome of the activity were observed. Older children were more pessimistic about obtaining a healthy and tasty product. The researchers often noticed facial and verbal expressions of disgust among the older children during the product prototyping step (e.g., *"So disgusting! Ugh!"*), whereas younger children were more positive and excited (e.g., "*This will be delicious! It looks delicious!"*).

Although children were guided by a researcher along the activity, they organized themselves efficiently. Children adopted different strategies to ensure the participation of all the members of the team, such as dividing tasks among team members and creating a voting system to make decisions (e.g., "*Let's vote! The candidate yogurt. The candidate milk" or "Who votes for carrot?"*). Many times, some participants encouraged their peers to taste new ingredients (e.g*., "Have you tried it?"* or *"How long ago did you try it? Try again"*). Groups of older children were more autonomous than groups of younger children when manipulating ingredients with utensils, but apart from preparation skills, no major differences in the ability to participate in the co-creation process were observed.

Exploration of the ingredients

Product prototypes developed by children

A total of 13 product prototypes were developed during the activity. Children used between 7 and 13 ingredients in their prototypes, as shown in Table 3.3. Yogurt and milk desserts were the most used dairy bases, whereas only two of the groups developed their prototypes using a different dairy base (yogurt mousse and milk). As shown in Table 3.3, the most frequently used ingredient was strawberry, which was present in over 90% of the products, followed by vanilla (69%), sugar (69%), blueberries (62%) and coconut (62%). Regarding vegetables, pumpkin (46%), carrot (39%) and beetroot (39%) were the most frequently used.

Table 3.3. Ingredients included in the prototypes developed by children.

Ingredient	Products (translated to English)													Frequency of use* (%)
	Double Mix	Fruity Fruity	Pumpchoco	Fruity Tutti	Delicious and Healthy Smoothie	Fruity Yogurt	Strawgur	Healing Yogurt	Maxi smoothie/ Multi Fruit	Healthy Yogurt	Pink Yogurt	The Fruiterer	Multi Fruit	
Dairy														
Yogurt	-	-	-	-	-	1	1	1	-	1	1	1	-	46
Dairy dessert	1	1	-	1	-	-	-	-	1	-	-	-	1	39
Yogurt Mousse	-	-	1	-	-	-	-	-	-	-	-	-	-	8
Milk	-	-	-	-	1	-	-	-	-	-	-	-	-	8
Yogurt gel	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Chia milk dessert	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Vegetables														
Pumpkin	1	1	1	-	-	1	-	-	-	1	-	-	1	46
Carrot	-	-	-	1	-	-	1	-	1	-	-	1	1	39
Beetroot	-	-	-	1	1	-	1	-	-	1	1	-	-	39
Spinach	-	-	-	-	-	-	1	-	-	-	-	-	-	8
Tomato	-	-	-	-	-	-	-	1	-	-	-	-	-	8
Cucumber	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Fruits														
Strawberries	1	1	1	1	1	1	1	-	1	1	1	1	1	92
Blueberries	1	-	-	1	1	-	-	1	1	-	1	1	1	62
Pineapple	-	-	1	1	-	-	1	1	1	-	-	1	1	54
Banana	-	-	1	1	-	1	1	-	-	-	1	-	-	39
Apple	-	-	-	1	-	-	-	-	-	-	-	1	-	15
Orange	-	-	-	1	-	-	1	-	-	-	-	-	-	15
Spices & sugar														
Vanilla	1	1	1	1	1	1	-	1	1	-	-	-	1	69
Sugar	1	-	1	1	-	-	1	1	1	1	-	1	1	69
Lemon juice	-	1	-	-	-	-	1	-	-	-	1	-	1	31
Cocoa	-	1	1	1	-	-	-	-	-	-	-	-	-	23
Peppermint	-	1	-	-	1	-	-	-	-	-	-	-	-	15
Cinnamon	-	-	-	-	-	-	-	-	-	-	1	-	-	8
Lemon peel	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Grains & nuts														
Coconut	1	-	1	-	1	1	1	1	-	-	1	-	1	62
Chia	-	-	-	1	-	1	-	-	-	-	-	-	-	15
Nuts	-	-	-	-	-	-	-	-	1	-	-	-	-	8
Quinoa	-	-	-	-	-	-	-	-	-	1	-	-	-	8
Oats	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Flax	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Total number of ingredients	7	7	9	13	7	7	11	7	8	6	8	7	10	

Notes: *Percentage of products that included the ingredient. Oats was only added individually as decoration.

Factors underlying the selection of the ingredients

The analysis of children's comments during the activity provided insights on why ingredients were selected. Three factors emerged as drivers of product formulation: hedonics, familiarity, and healthiness.

When exploring the ingredients, children frequently referred to their liking (e.g. *"Pineapple is delicious", "This is mint, yummy!"*) or disliking of the ingredients (e.g. *"Yuck! I don't like cucumber", "Beetroot, gross!"*). Although many children showed a strong aversion to vegetables, others expressed positive hedonic reactions (Table 3.4). Children often mentioned the influence of cartoon characters or a role model when discussing their liking of vegetables (e.g. *"I like carrots because of Bugs Bunny..."* or *"My grandfather always ate cucumber in the morning, he loved it, and I also like cucumber like my grandfather"*).

For the creation of the products, children tended to select or avoid ingredients based on their liking (Table 3.4). Hedonics influenced the type of vegetables children selected. They tended to use vegetables with a light flavor and to avoid vegetables with a strong flavor. In addition, children tried to minimize the quantity of vegetables they used in their products (e.g. *"Beetroot, but just little… Half spoon, otherwise is too much… "* or *"An invisible spoon!"*). Children also relied on flavor masking to reduce the intensity of vegetable flavor (e.g. *"Add all (*the banana*), then it won't taste like pumpkin"*) (Table 3.4).

Familiarity was another relevant factor underlying the selection of the ingredients, particularly the selection of the dairy base. Although new textures (e.g., yogurt gel or chia milk dessert) triggered children's curiosity, they mainly selected familiar dairy products for their prototype development, i.e. yogurt and milk dessert. As shown in Table 3.4, when discussing the selection of the dairy base, children often referred back to commercial dairy products or products prepared by their parents. Similarly, children often selected vegetables that were quickly recognized (pumpkin and carrot purees: *"This smells like pumpkin", "This is carrot!"*) compared to vegetables they struggled to identify (spinach puree*: "It smells like grass", "I don't eat grass!"*). In addition, children felt more comfortable with well-known ingredient combinations. As shown in Table 3.4, children frequently mentioned typical fruit combinations, whereas they tended to reject unfamiliar combination of fruits and vegetables or dairy products with vegetables. Furthermore, children expressed disliking for ingredients they had never tasted (e.g., *"I don't like chia because I've never tried it"*).

Finally, children also considered healthiness to decide their product formulation by minimizing the amount of sugar added to their products as they perceived it as an unhealthy ingredient, as exemplified by the following conversation:

Child A: Sugar! Sugar! Who votes for sugar?
Child B - Eh… I don't know… sugar isn't healthy
Child C - If it is not healthy, we'd better not add it...
Child A - Then why did you say sugar?
Researcher - Well, you can add a little
Child A - It will be sweet…
Child C - I want a healthy yogurt!
Child B - We could add a little….

Interestingly, children had a very clear idea of how they wanted their product to be in terms of texture and appearance when served. For this reason, they frequently reserved part of the ingredients to modify the final product (e.g., adding pieces of fruit) or to decorate it.

Tasting and qualitative evaluation of the product prototypes

After children tasted their developed prototype, they frequently compared it with well-known commercial products. A 62% of the groups stated that they were happy with their developed prototypes. However, all the groups identified several improvement opportunities, which were mostly related to flavor. For instance, 69% of the groups wanted to increase sugar quantity, as exemplified by the following quotes:

I think we should have added sugar...
…it lacks a lot of sugar.
Mmm… I love it, we just need to add sugar
I didn't hate the pumpkin, but it lacks sugar

Other frequent modification was the removal of vegetables, even if they were not perceived in the final prototype:

I didn't like it… because it has too much carrot.
From the beginning, I said no pumpkin

Child A - We should have not added pumpkin…

Child B – The pumpkin isn't even perceived!

Table 3.4. Example of quotes related to the main factors influencing children product development.

Factor	Example quotes
Hedonics	*Because the milk dessert is tasty*
	Yogurt, because I love it!
	Strawberry, it is my favorite fruit!
	We can add strawberry, which people usually like…
	I would add spinach… I love spinach
	I love beetroot!
	Pumpkin, it's ok…
	That's so disgusting! I don't like beetroot…
	… must we add a vegetable? ... it's what I hate the most
	You know! I don't like vegetables
	That's so disgusting! I don't like cucumber…
	…I think carrot because it has a light flavor, and the fruit will be more noticeable…
	Add all (the banana), then it won't taste like pumpkin
	Yes! We add all, we made a fruit salad and there is no pumpkin flavor
	This one! It doesn't have flavor!
	If we add lemon peel, it will cover up the vegetable flavor
Familiarity	*My grandmother/mother makes it*
	Like Danone…
	I remember that my mother bought me a big pot (of yogurt) *and I ate it all!*
	Ah ... Danette ... Like that?
	Milk, because I know what to combine it with…
	Blueberry and strawberry, the typical dessert combination.
	No! How are we going to put pumpkin with strawberry? Where have you seen that?
	Yogurt with vegetables?
	*No, that doesn't go well with yogurt, not at all (*Talking about vegetables)
Healthiness	*Two spoons, if we add four it will be too sweet …*
	For me it is healthy yogurt because it doesn't have sugar
	Listen, the strawberry and all of it already have sugar…

Children also mentioned adjustments to the quantity of other ingredients, including changing sourness (e.g., by reducing or increasing the quantity of lemon juice), reducing bitterness (e.g., by reducing the quantity of cocoa) or enhancing flavor (e.g., by adding more vanilla). The addition of other ingredients as topping or to modify the flavor were also mentioned. For instance, many children added cocoa to their cup or expressed they would like a version with cocoa. However, heterogeneous views on the inclusion of ingredients within the category grains & nuts were observed: some children wanted to include those ingredients as toppings, whereas others preferred not to. The specific reasons for not wanting to include these ingredients in the final formulation were rarely verbalized beyond disliking (e.g., "Disgusting!", "I don't like chia because I've never tried it").

Concept prototypes developed by children: strategies to promote a healthy dairy product among children

All teams gave a name to the product they created. Table 3.3 shows the selected names, translated from Spanish to English. As shown, most of the prototypes were named after the ingredients included in the formulation.

In the description of their prototype, children referred to the dairy base and familiar ingredients included in the formulation (e.g., strawberry, cocoa). On the contrary, they were skeptical about mentioning the inclusion of vegetables. Children mentioned that the presence of vegetables could discourage other children to try the prototypes:

> *Don't tell them about the beetroot because they may not want it*
> *If we tell them that it has that (vegetable), maybe they won't want to try it and it's delicious.*

When asked to think of the content of a poster, children often wanted to include images that showed the product and the fruit in an artistic way or children consuming the product:

> *A light purple background, then a river of the liquid appears… with pieces of strawberry and blueberries… and the brand is there... floating … we add "delicious"*
> *I would put a cup, a delicious one ... with a person eating it*
> *The poster has some children eating and running… like a happy story…*
> *The photo of the dessert… with a child eating the dessert*

The use of images of cartoon characters or animals was also frequently suggested as a potential strategy to promote their prototypes:

> *A cartoon character, like a tiger that says (product name)*
> *I want a picture of a rabbit with a yogurt in its hand… because I like rabbits and penguins… I want a rabbit or an animal…I want something that draws attention, something that says I want to try it…*

When discussing how to motivate other children to try the prototype, the use of nutrient and health claims was frequently mentioned:

> *...that it doesn't have sugar…*
> *…because it has lots of vitamins*
> *…because it has lots of fruits and it doesn't have chemicals like other yogurts*
> *…it gives you strength, it makes you grow up healthy*

In addition, the fact that the prototypes were developed by children was identified as potential strategy to motivate children to try them (e.g. *It's made by us, it's the best!*). References to the delicious flavor and the novelty of the product were common as well (e.g., *"It is yummy", "It is delicious", "Tired of the same yogurt? Then try the new yogurt"*). Additionally, children made references to promotions and discounts (e.g., *"Do it like the (supermarket name), 20% discounts on purchases" o "Tastings, as in the (supermarket name) that give you samples", "The promotion would be a discount all year long", "It brings a keychain as a gift"*).

3.3.2 Validation: evaluation of the final products developed based on children's ideas

All the products received average overall liking scores close or higher than 6 in the 9-point hedonic scale. For exploratory purposes, average overall liking scores were calculated and compared using ANOVA. Results showed that there were no statistically significant differences ($p=0.69$) between the four products developed based on children's ideas. Product D001 received an overall liking score of (7.9 ± 1.6), followed by Y001 (7.1 ± 2.4), D002 (6.9 ± 2.8) and finally product D003 (5.9 ± 3.1) (Figure 3.2).

Children often described the samples using positive hedonic terms (e.g., "*I gave all of them a nine. I loved them"* or *"This is really awesome, it has banana"*). Based on qualitative feedback, product D001 was one of the most liked products. Children used references to ice cream, chocolate, and cocoa to describe it. Products Y001 and D002 were described using words such as strawberry, banana flavor and ice cream. In addition, children referred to acidity and yogurt to describe product Y001 and usually mentioned lemon or orange as ingredient. Children found it difficult to identify the ingredients of product D003 and some of them described it as weird. Some children disliked the small pieces of blueberries as they confused them with seeds, chia, or leaves. However, based on qualitative feedback, the product tended to be popular among older children. Although some children did not remember the name of the blueberries, they remembered the fruit.

Children rarely mentioned vegetables when trying to guess ingredients. They were extremely surprised to learn that the samples had indeed vegetables, as exemplified in the following quotes:

And I didn't perceive the beetroot flavor… and I don’t like beetroot
Does it have pumpkin? Oh no! Can I give it a one?
I liked them all ... even the ones with horrible vegetables

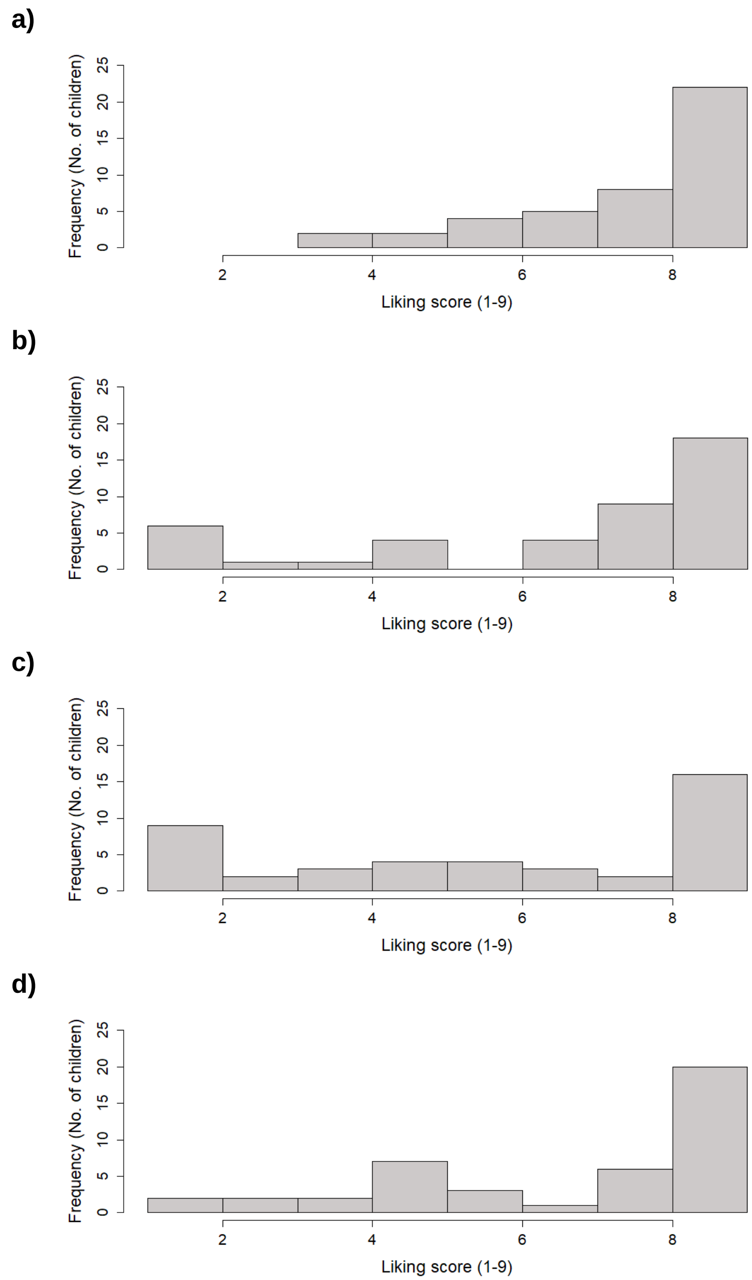

Figure 3.2. Distribution of liking scores given by children (n=43) to each of the four final products developed based on their ideas: D001 (a), D002 (b), D003 (c), and Y001 (d). The description of the products is provided in Table 3.2.

3.4. Discussion

Involving children in the development of new products can contribute to encourage healthier eating patterns. Although co-creation with children has gained relevance in several areas of knowledge, examples in the food domain are still scarce. In this context, the present work explored the use of a multiple stage prototyping process (Exploring – Prototyping – Refining – Validating). Results showed that with the proposed approach, starting from individual ingredients and comprising tasting, experimenting, and creating, children were able to generate actionable ideas that allowed the development of dairy recipes which were well accepted by the involved children. These results show the potential of involving children in the co-creation of healthy dairy products.

Children encouraged each other to try ingredients they would normally reject. As previous studies have shown, a creative and hands-on involvement can enhance children's willingness to expand their acceptance of food (Galler et al., 2020; Heim et al., 2009; Hojer et al., 2020; Walters & Stacey, 2009). It should be highlighted that the creative involvement was highly engaging for participants, and, in accordance to the previous study from Galler et al. (2020), peer influence might play a positive role in these type of settings. Hojer et al. (2020) highlighted that helping each other in activities around fish preparation had a positive effect on children's fish acceptance helping them to overcome aversions. Similarly, a collaborative creation of a food blog led children to taste and cook things that their peers had posted (Galler et al., 2020).

Although children showed a positive attitude to try novel dairy products with fruits and vegetables, familiarity had a central role in the development process. Children chose ingredients and combinations they had tried before. Early studies have shown that familiarity and previous experience with food are major determinants of children's food preferences, whereas they tend to reject unfamiliar foods (Birch and Marlin 1982; Lafraire et al. 2016; Russell and Russell 2018). Recently, Hwang et al. (2020) showed that children were more likely to choose familiar over unfamiliar innovative vegetable-based products. In the present study, the use of rules that pushed children to think outside the box was one of the critical factors to develop novel dairy products. In this sense, gamification has been shown to have potential to improve fruit and vegetable intake among adolescents (Yoshida-Montezuma, Ahmed, and Ezezika 2020).

Children selected ingredients based on hedonics, which matches the strong influence of liking on children's food choices (Marty et al. 2018b; Nguyen, Girgis, and Robinson 2015). It is worth mentioning that younger children showed a more positive attitude towards the idea of including vegetables in the development of dairy products, whereas older children showed a stronger aversion towards vegetables. Previous studies have reported a high heterogeneity in children's food preferences with age (Alfaro et al. 2020; Pagliarini, Gabbiadini, and Ratti 2005). As children grow, their food choices become more selective and complex (Cooke and Wardle 2005; Latorres, Mitterer-Daltoé, and Queiroz 2016). In this perspective, it has been reported that older children tend to decrease their intake of fruit and vegetables (Albani et al. 2017; Birch, Savage, & Ventura 2007), which may be linked to the strong rejection of vegetables observed in older children. Despite the initial rejection, older children were willing to develop and taste innovative dairy products with vegetables. Previous studies have shown that providing children choice options increases their liking and intake of healthy foods, such as vegetables and fish (Altintzoglou et al., 2015; Rohlfs Domínguez et al., 2013). Having the opportunity of experimenting with the ingredients and actively choosing the ones to be included in their product prototypes is expected to have increased liking and willingness to try. Previous studies have shown that being able to freely choose increases the perception of autonomy, which can lead to increased motivation of engaging in a behaviour, such as eating healthy foods (Katz and Assor, 2006). Another factor that could have played a role in motivating children to overcome rejection to taste products with new ingredients is peer influence (Russell and Russell, 2018).

Interestingly, children implemented several well-known strategies to mask the flavour of vegetables they disliked, such as adding well-liked ingredients. Masking the taste of disliked foods or presenting them in a way that they are not recognizable has been previously reported to be a successful strategy to increase children's vegetable intake (Poelman, Delahunty, and de Graaf 2015; Rollins et al. 2021; Spill et al. 2011). In this sense, results from the present work suggest that dairy products containing pumpkin, beetroot and carrot may be well-accepted by children. Although children accepted products with vegetables, it is important to emphasize that they stressed that vegetables should not be a central factor in the promotion of the products as this would raise negative sensory and hedonic expectations.

Sweetness was a key factor for children's liking of the developed dairy products, although they were aware of the potential negative health effects of sugar. These findings are in agreement with Takemi & Woo (2017), who showed that multiple factors influenced children preference for high sugary dairy drinks, regardless of children's consciousness of the negative health outcomes of sugar intake. However, it is important to highlight that the products developed based on children's ideas had high overall liking scores, even if the added sugar content was lower than those commonly found in the Uruguayan market. In the case of the dairy desserts, added sugar reduction was approximately 40% compared to commercial products targeted at children. This agrees with results from previous studies (Velázquez et al. 2020, 2021) and stresses the feasibility of substantially reducing the added sugar content of dairy products without affecting children's product acceptance.

Children's ideas on how to promote the developed products were similar to those frequently used by the food industry to target their products at children (Elliott 2015; Elliott and Truman 2020; Qutteina et al. 2019), including the use of cartoon characters, nutrient and health claims and references to fun and emotional aspects of food consumption. Although these strategies are commonly used to promote products of poor nutritional quality (Elliott and Truman 2020; Giménez et al. 2017), results from the present work suggest that they hold potential to promote healthy products. For instance, the use of cartoon characters has been reported to increase the attractiveness of fruit and vegetables snacks among children (Hémar-Nicolas et al. 2021; Pires and Agante 2011). Regulatory approaches restricting the use of these marketing strategies to healthy products may contribute to improve children's eating habits (Taillie et al. 2019).

3.4.1 Limitations of the study

The present work is one of the few published studies that explores the use of co-creation with children, providing them an active role in the generation of ideas and concrete prototypes of healthy food products. However, some limitations are worthy to highlight for future studies. In the present study, children in each group knew each other, as social bubbles were maintained due to the measures implemented by the club in the context of the Covid-19 pandemic. Although more heterogeneous groups may have generated more diverse ideas (Van Mechelen et al., 2014), group cohesiveness facilitated groups dynamics. Children encouraged each other to participate and implemented strategies which allowed a well-balanced participation (e.g., take turns). Nevertheless, future studies should consider the exploration of co-creation approaches with more heterogeneous groups. Such approaches should consider the inclusion of a phase where children get to know each other in order to make collaboration and interactions easier.

The lack of teamwork or peer pressure have been mentioned as group dynamics challenges during co-creation workshops with children (Van Mechelen et al., 2014; Vaajakallio et al., 2009). Although these behaviors were not observed in the present work, it is important to highlight that the flexibility of the facilitator to adjust to children's needs played a major role to ensure good group dynamics during the sessions. Therefore, future research should pay close attention to the facilitator's specific skills required to meet children's needs in a diverse co-creation context. Considering that personality traits have been regarded as an important factor influencing co-creation process in NPD (Füller, 2010; Mandolfo et al., 2020), the influence of children personality traits and other demographic characteristics is also worthy of consideration in future research.

A strength of the present study was that children actively participated in the development of product prototypes. This was feasible because product preparation required a low level of cooking skills, which allowed younger children to be mostly autonomous during the prototyping phase. However, children's developmental skills may be a major limitation to implement co-creation approaches in more complex food products that require more advanced cooking skills, especially if younger children are involved (Dean et al., 2021). Co-creation of more complex products may require a higher involvement of the moderator and may limit children's autonomy. Future studies are needed to explore the use of co-creation with children for the development of more complex products.

Another limitation of the study was that the evaluation of the developed products was performed with the same groups of children. This means that children may have been biased towards high overall liking scores. Thus, additional validation of the developed products with other groups of children is needed.

3.5. Conclusions

The present study is one of the first to report the feasibility of co-creation with children in the food domain, where children could create and taste their own food prototypes. Results showed the potential of co-creation with children to develop actionable ideas and concrete prototypes of healthy products with high overall liking. Innovative dairy products with novel and healthy ingredients and low added sugar content were developed. Familiarity, hedonics and healthiness were identified as key drivers of children's choice of ingredients during the development of their prototypes. The potential of well-known marketing and communication strategies to promote healthier products targeted at children was highlighted. Results also suggest the potential of co-creation approaches as a way to encourage children to think out of the box and develop preferences for new and healthy products. In particular, the hereby proposed process of exploring-prototyping-refining-validating, starting from the sensory exploration of novel ingredients and textures, was deemed as successful for the objective and engaging and fun for the participants. Further research is needed to extrapolate results of the present work to other children age groups and complex food product categories in order to evaluate the applicability of the proposed approach in the NPD process of healthy foods targeted at children.

CHAPTER 4

The influence of label information on the snacks parents choose for their children: Individual differences in a choice based conjoint test.

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Author contributions:

- Velázquez, A.L: Conceived and designed the study, analyzed and interpreted the data, wrote the paper.
- Alcaire, F: Conceived and designed the study, collected the data, performed a critical revision of the article.
- Vidal, L: Contributed to the conception and design of the study, as well as to data interpretation, performed a critical revision of the article.
- Varela, P: Contributed to data analysis and interpretation, performed a critical revision of the article.
- Næs, T: Contributed to data analysis and interpretation, performed a critical revision of the article.
- Ares, G: Contributed to the conception and design of the study, as well as to data interpretation, performed a critical revision of the article.

Abstract

Labels have been reported to influence children's perception and choice of foods. However, the influence of label information on parents' food choices for their children has not received as much attention in the literature yet. In this context, the objectives of the present study were: i) to evaluate the impact of label information on parents' healthiness perception and choice of two popular snack products, and ii) to explore individual differences in how label design influences parents' healthiness perception and their choice of snack products for their children. A total of 1213 Uruguayan mothers participated in an online survey. A choice-based conjoint test was performed to study the influence of cartoon characters, nutritional claims and nutrient content information on the choice and healthiness perception of chocolate milk and sponge cake labels. Half of the parents were asked to indicate which of the products they would choose as a snack for their children and the other half were asked which of the products was healthier. Data was analyzed by means of a Mixed Logit Model followed by multivariate approaches to explore individual differences (Hierarchical Cluster Analysis and Principal Component Analysis). Results showed that, regardless of the product, nutrient claim had the strongest effect, increasing healthiness perception and encouraging mothers' choice. For both choice and healthiness perception, two groups of mothers who differed in the relative importance attached to cartoon characters and nutrient content were identified, highlighting the need to investigate individual differences. Results stress the need to regulate the use of nutritional claims, cartoon characters, and other persuasive elements in products of poor nutritional quality targeted at children.

4.1. Introduction

The increased availability and affordability of products with high energy density and excessive content of sugar, fat and sodium has been identified as one of the main contributors to unhealthy diets and the global childhood obesity pandemic (Lakshman, Elks, & Ong, 2012; Popkin, 2017; Swinburn et al., 2019). These products are frequently marketed as adequate for children using several persuasive and misleading marketing strategies (Giménez et al., 2017; Lapierre et al., 2017; Lavriša & Pravst, 2019; Mehta et al., 2012).

Product packaging is one of the most relevant components of the marketing mix, as well as an important source of information for consumers at the point of purchase (Gil-Pérez, Rebollar, & Lidón, 2020; Simmonds & Spence, 2017). Previous research has shown that the packages of products targeted at children include a wide range of cues to attract children and convey the idea that they are appropriate for them (Mehta et al., 2012). Most of the packages of these products are coloured and frequently include cartoon characters, merchandising tie-ins, photos of celebrities, and references to fun, play or sports (Chacon et al., 2013; Hebden et al., 2011). In addition, nutritional claims or references to health are usually included to create positive health-related associations, even if products are high in sugar, fat and/or sodium. These marketing strategies have been shown to encourage children to perceive products as healthy, fun, and appropriate for them, and influence their liking, persuasion power and willingness to consume (Arrúa, Vidal, et al., 2017; Letona et al., 2014; McGale et al., 2016; Roberto et al., 2010; Cairns et al., 2013; Sadeghirad et al., 2016). However, the information included on food packages is also expected to influence parents' perception and choice.

Parents are usually the final purchase decision makers and exert a highly relevant role in the formation of their children's food preferences (DeCosta et al., 2017; Scaglioni et al., 2011). Although parents regard healthiness as one of the most important factors when they select products for their children (Russell et al., 2015), research has shown that they frequently invest little time and cognitive effort when making their food choices (Maubach et al., 2009; Machín, Curutchet, et al., 2020). Instead, they largely rely on heuristics, i.e. simplified decision-making strategies. Parents tend to rely on health claims, brands, or realistic visuals to identify products that may be appropriate for their children (Abrams et al., 2015). In addition, Machín, Antúnez, et al. (2020) has recently reported that people judge the healthiness of ultra-processed products based on simple cues, such as the presence of nutritional claims, references to natural foods, and even price, brand or packaging material. These simple cues may lead parents to unintentionally make unhealthy choices for their children. Moreover, some cues (i.e. cartoon characters or colorful packages) encourage parents to select products for their children when they look for a product to please or reward their children, even if they may be unhealthy (Abrams et al., 2015).

The present research intends to contribute to filling a research gap by studying the influence of labelling on parents' healthiness perception and choice of snack products for their children. Focus on snacks is justified by the increased contribution of snacking to the daily energy intake of children (Fayet-Moore, Peters, McConell, Petocz, & Eldridge, 2017; Piernas & Popkin, 2010). In this sense, previous studies have reported that children frequently consume products with excessive content of sugars, fat and sodium as a snack, which contributes to their total energy, added sugars, total fat and sodium intake (Loth et al., 2020a; Shriver et al., 2017; Taillie, Afeiche, Eldridge, & Popkin, 2015).

Most of the previous studies on the influence of packaging on choice have explored parents’ behavior as a homogenous population, which is unlikely to represent the reality. Consumer behavior is highly influenced by individual differences that derivates from factors such as personality traits, demographics, lifestyle, and attitudes (Næs et al., 2018). The literature shows that parents' snack choices for their children are largely influenced by their own eating practices, time-constraints, as well as their education and socio-economic status (Blaine, Kachurack, Davison, Klabunde, & Fisher, 2017; Curtis, James, & Ellis, 2010; Damen, Luning, Fogliano, & Steenbekkers, 2019; Nepper & Chai, 2016; Gibson et al., 2020; Rafferty et al., 2018). For example, Li, Lopetcharat, and Drake (2014) studied the influence of extrinsic attributes on parent’s purchase decisions of chocolate milk. They found three segments of parents with distinctive purchase behaviors who differed in terms of income, ethnic origin, and number of children. For example, health-conscious parents were characterized by a higher income.

In this context, the objectives of the present work were: i) to evaluate the impact of label information on parents’ healthiness perception and choice of two popular snack products targeted at children in Uruguay (chocolate milk and sponge cake), and ii) to explore individual differences in how label design influences parents' healthiness perception and their choice of snack products for their children.

4.2. Materials and Methods

An online study was conducted to investigate the effect of labelling information on parents' healthiness perception and choice of snacks for their school-aged children. A choice-conjoint analysis was designed. Participants were presented with a series of choice sets and were asked to make a choice (Almli & Næs, 2018). This methodological decision was made considering that choice experiments may represent better the situation consumers face when purchasing a product (Asioli, Næs, Øvrum, & Almli, 2016). Ethical approval was obtained from the Ethics Committee of the School of Chemistry of Universidad de la República (Uruguay).

4.2.1. Participants

Participants were recruited using social media given its widespread penetration among the Uruguayan population (Instituto Nacional de Estadística, 2019). Recruitment followed the recommendations provided by Tuten (2010) for conducting online surveys. A Facebook and Instagram advertisement targeted at Uruguayan adults aged between 21 and 50 years old was launched in November 2019. The advertisement included the text "If you have school-aged children, answer some questions and enter a raffle for a voucher worth $1000 (Uruguayan pesos). Help us understand how you select snacks", accompanied by a picture of a child at school. As an incentive, participants who completed the study were given the chance of entering a raffle for a supermarket voucher worth 30 US dollars.

The advertisement was delivered to 48,864 users, shown as an ad to participants selected by Facebook software. A total of 2,209 participants clicked on the advertisement and 1,990 agreed to participate after reading the study description and the informed consent form. After excluding participants who did not complete the whole questionnaire (n=755) and some male participants, because of being to few to be analyzed as a separate group (n=22), a sample of 1213 Uruguayan mothers was obtained. The underrepresentation of fathers in the study fits expectations given that mothers are the main responsible of selecting and preparing food for children in the country (Cabella et al., 2014). Table 4.1 shows the sociodemographic characteristics of the mothers who completed the study. Mothers whose children attend both public (free of cost and funded by the State) and private schools (paid by parents) were included (Table 4.1).

Table 4.1. Sociodemographic characteristics of the mothers who completed the study (n=1213)

Characteristic	**n**	**Percentage (%)**
Age		
21-35	743	61
36-50	470	39
Socioeconomic level		
Low	518	43
Middle/High	695	57
Occupation		
Employed	742	61
Housewife	471	39
Number of children		
1	347	29
2	723	60
≥ 3	143	12
Type of school children attend		
Public	1015	84
Private	198	16

4.2.2. Experimental Design

Two popular snack products targeted at children in Uruguayan market were used: chocolate milk and sponge cake. For each product, eight labels were designed using a 2^3 full factorial design with the following variables: cartoon character, nutrient content and nutritional claim. Cartoon characters and nutritional claim were selected given their high prevalence on the food packages of products targeted at children available in the Uruguayan marketplace (Giménez et al., 2017). A licensed cartoon character was used in the chocolate milk labels (lion), whereas a non-licensed cartoon character was used in the sponge cake labels (skater boy). The selection of the characters was based on the characteristics of products available in the Uruguayan market. Nutrient content was selected as an objective cue for product healthiness. This variable was operationalized by modifying front-of-package information about the content of a key nutrient associated with non-communicable diseases (sugar for chocolate milk and saturated fat for sponge cake) in two levels, high and low according to Uruguayan regulations (Ministerio de Salud Pública, 2018). Nutrient content was presented on the labels using the guideline daily amount (GDA) front-of-package nutrition labeling scheme. Table 4.2 shows the variables and levels for each of the products.

Labels were designed by a professional graphic designer. In order to avoid the influence of participants' previous experiences, labels corresponded to fictious products.

Using the labels, four choice sets were created for each product category following a rotation design using the package support.CEs (v0.4.1; Aizaki, 2012) in R version 3.6.2 (R Core Team, 2019). Two alternatives per choice set and one block were specified to build the choice set design. The characteristics of the choice sets are shown in the Appendix 6. Figure 4.1 shows an example of the labels presented in the choice set.

Table 4.2. Variables and levels of the experimental design for the two product categories.

Variable	**Chocolate milk**	**Sponge cake**
Cartoon character	Present (1) Absent (-1)	Present (1) Absent (-1)
Nutrient content	High sugar content: 28 g / 200 ml (1) Low sugar content: 22 g / 200 ml (-1)	High saturated fat content: 6.2 g / 60 g (1) Low saturated fat content: 2 g / 60 g (-1)
Nutritional claim	"*Source of calcium and vitamin D"* (1) Absent (-1)	"With all the fiber of cereals" (1) Absent (-1)

a)

b)

Figure 4.1. Example of how choice sets of labels were presented to participants for the two products: a) chocolate milk, b) sponge cake. For the two products, the choice set displayed alternative 2 (cartoon character= absent, nutrient content= high, nutritional claim= present) versus alternative 1 (cartoon character= present, nutrient content= low, nutritional claim= absent).

4.2.3 Experimental procedure

The study was implemented using Compusense-Cloud (Compusense Inc., Guelph, Canada). Written instructions were provided at the beginning of the task. First, participants provided Informed consent using an online form. Then, they were presented with the eight choice sets, corresponding to four choice sets for each of the two products. For each choice set, they were asked to look at the two labels and answer a question. Participants were randomly divided in two groups: one of the groups (n=603) was asked to select the product they would choose as a snack for their children (choice), whereas the other group (n=610) was asked to select the healthier product (healthiness perception). The two groups of participants were compared in terms of their socio-demographic characteristics by means of equivalence tests for two proportions, considering a margin of 10% and a 5% significance level (Tunes da Silva, Logan & Klein, 2008). The groups were found statistically equivalent in all socio-demographic characteristics (all p-values < 0.001). This suggests that differences between the two groups were not expected to be due to differences in their socio-demographic characteristics.

The 8 choice sets (4 for each product category) were presented monadically following a Williams' Latin square design. The presentation order of the labels within each choice set was randomized between participants. After completing the choice-conjoint task, participants were asked to answer a series of sociodemographic questions (age, gender, occupation, place of residence, education, number of income earners, household size, number of children, type of children’s school and children’s age). Socio-economic status was calculated using a standard methodology in Uruguay (Centro de Investigaciones Económicas, 2018).

4.2.4. Data analysis

All data analyses were performed using R software version 3.6.2 (R Core Team, 2019). Only data from mothers who completed the whole study (n=1213) were analyzed.

4.2.4.1 Choice-based conjoint analysis

Data from each product category and type of response (choice or healthiness perception) were analyzed separately. A mixed logit utility model was built considering the main effects of the variables of the conjoint analysis: cartoon character, nutrient content and nutrient claim (Table 4.1). The utility for product *j* for individual *i* and choice occasion *t* in the mixed logit model can be described by:

$$U_{ijt}= \beta_{1i}CartoonCh_{ijt} + \beta_{2i}Nutrient_{ijt}+ \beta_{3i}Claim_{ijt} +\varepsilon_{ijt}$$

where β_{ni} are the individual random coefficients for the conjoint factors and ε_{ijt} is the random error. It was assumed that all random coefficients followed a normal distribution and that the random coefficients of the individuals were the same for all their choice occasions. Correlation between the coefficients was allowed in order to accommodate possible interactions between factors. The analysis was performed using the mlogit package in R (v1.0-2; Croissant, 2019).

The parameters of the mixed logit model were estimated using an iterative process, which involves the generation of pseudo-random sequences that intend to mimic draws from a uniform distribution (Henswher & Greene, 2003). In the present work, a quasi-random maximum likelihood method, commonly known as Halton draws, was used in the iterative process to obtain more uniformly distributed sequences (Zheng, 2016). Considering that there is no standard number of draws to obtain stable parameters (Hensher & Greene, 2003), the model was run over a range of Halton draws (50 – 3000). For all the data sets, similar estimate values were observed across the series of draws tested, especially from 200 Halton draws onwards. Moreover, the signs and significance of the coefficients were consistent across the different number of draws. For this reason, 200 Halton draws was selected for further analysis in the present work.

4.2.4.2 Individual differences

Individual differences among mothers were studied using a multi-step strategy based on *a posteriori* unsupervised clustering. The raw individual coefficients from the mixed logit models for each product and type of response were extracted. For each type of response (choice and healthiness perception) individual differences were analyzed considering the individual model coefficients for both products. Hence, the data consisted of two matrices of six variables each, three for the chocolate milk individual coefficients (Cartoon character, Sugar content and Nutrient claim) and three for the sponge cake individual coefficients (Cartoon character, Fat content and Nutrient claim). Hierarchical cluster analysis considering Euclidean distances and Ward's method was applied on each matrix of raw individual coefficients. The clusters obtained through hierarchical cluster analysis were also interpreted using Principal Component Analysis (PCA) on the raw individual coefficients of the six variables (Appendix 7 and Appendix 8). Unstandardized coefficients were used to maintain the coefficients scale variation.

The average estimates of the coefficients for each of the variables were computed for each of the identified groups. To evaluate the coherence between the segmentation and the raw data, the percentage of participants who selected each label for each choice set was computed for each of the groups.

The groups were characterized in terms of age, occupation, type of school and socioeconomic level. Chi-squared test for independence was used to explore statistical relationships between the groups of participants and each socio-demographic characteristic, considering a 5% statistical significance level.

4.3. Results

4.3.1. Effect of label information on mothers' choice of snacks for their children

Table 4.3 shows the mean estimate and standard deviation of the coefficients of the mixed logit model used for estimating the effect of three variables on mothers' choice of chocolate milk and sponge cake for their children. For both products, the coefficient of the nutritional claim was the largest, suggesting that it was the factor with the highest relative importance. For the chocolate milk, only nutritional claim had a coefficient that statistically significantly differed from zero. As expected, the coefficient effect was positive, indicating that mothers preferred labels featuring a nutritional claim. The coefficients of cartoon character and nutrient content were small and not statistically significantly different from zero.

For sponge cake labels, all coefficients were statistically significantly different from zero, suggesting that mothers' choices were influenced by the three variables. The positive coefficients of the factors nutrition claim and cartoon character indicated that mothers preferred the sponge cake labels featuring these elements over those without them. Meanwhile, the negative coefficient of the factor nutrient content suggests that mothers preferred the sponge cakes with the lowest saturated fat content (Table 4.3).

The results presented above correspond to the average coefficients. However, as shown in Table 4.3, the standard deviations of the estimates of the three variables were high for the two products. This indicates the existence of large individual differences in how the variables influenced participants' choices for both products. Therefore, the effect of all the variables is worthy of consideration. In addition, a strong positive correlation coefficient was found between the random individual coefficients of the nutrient content and nutritional claim, both in the chocolate milk (r=0.78) and the sponge cake (r=0.80).

Table 4.3. Mean value and standard deviations of the coefficients of the mixed logit model used for estimating the effect of label information on mothers' choice of snacks for their children in the choice conjoint task for the two product categories.

Product	*Variable*	*Mean*	*Standard deviation*	*95% Confidence interval*	*p-value*
Chocolate milk	Cartoon character	0.047	1.358	[-0.098, 0.191]	0.527
	Nutrient content	-0.073	0.578	[-0.223, 0.077]	0.341
	Nutritional claim	2.115	1.953	[1.434, 2.797]	<0.001
Sponge cake	Cartoon character	0.114	0.810	[0.021, 0.206]	0.016
	Nutrient content	-0.185	0.350	[-0.279, -0.091]	<0.001
	Nutritional claim	0.972	1.266	[0.749, 1.191]	<0.001

4.3.1.1 Individual differences in the effect of label information on mothers' choices

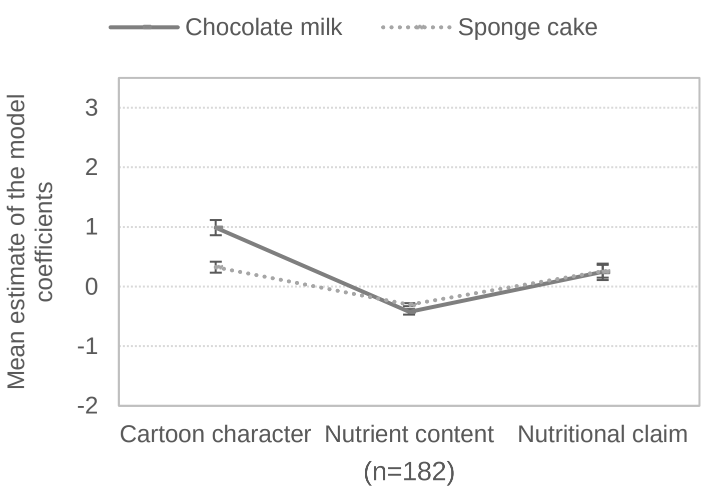
Individual differences in mothers' choices of snacks for their children were explored using hierarchical cluster analysis on the coefficients of the mixed logit models for the variables of the experimental design for each of the two products (sponge cake and chocolate milk). Two groups of mothers with distinct behavior were identified. The mean estimates of the coefficients of the three factors included in the experimental design are shown in Figure 4.2 for the two groups of mothers.

Mothers in Group 1 (n=182) showed a positive attitude towards the labels featuring a cartoon character, whereas. mothers in Group 2 (n=421) were characterized by their strong preference for labels with nutritional claims. Although mothers behaved similarly regardless of the products, these tendencies were stronger for the chocolate milk.

The behavior of the groups identified by the hierarchical cluster analysis were coherent with the raw data in terms of the labels selected for each of the choice sets. Mothers in Group 1 frequently selected the labels featuring the cartoon character, while mothers in Group 2 frequently selected the labels featuring the nutritional claim (Appendix 9).

The representation of the groups obtained from the hierarchical cluster analysis on the PCA score plot was coherent (Appendix 7). Both groups were clearly separated in the first two components, which explained 80.5% of the variability of the coefficients of the mixed logit model[1].

a)



b)

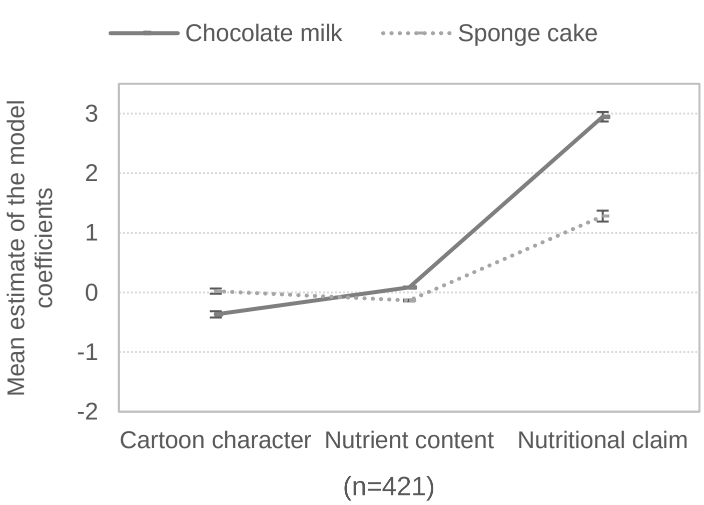


Figure 4.2. Mean estimates (and confidence interval) of the mixed logit model used for estimating the effect of label information on mothers' choice of snacks for their children for the two groups identified in the Hierarchical Cluster Analysis for the chocolate milk and sponge cake: (a) Group 1 and (b) Group 2.

[1] The variability refers to the coefficients of the mixed logit model and not the variability among participants according to the raw data.

No statistically significant differences in terms of sociodemographic variables were identified between the two groups. Group 1 and Group 2 showed similar distribution in terms age (56 and 63% of young mothers, respectively), occupation (64 and 60% of employed mothers, respectively), type of school (81 and 85% of mothers had children attending public schools) and socioeconomic level (43% of mothers from low socioeconomic level).

4.3.2. Effect of label information on mothers' healthiness perception of snacks

As shown in Table 4.4, the coefficients of nutrient content and nutritional claim statistically significantly differed from zero for both chocolate milk and sponge cake. This suggests that mothers' healthiness perception of both products was influenced by nutrient content and nutritional claim. Based on the positive coefficient for the nutritional claim and the negative coefficient for the nutrient content, it can be concluded that labels with nutritional claims and low nutrient content (sugar or saturated fat) were perceived as healthier than those without claims and high nutrient content. Large individual variation in the effect of the experimental variables was found, as evidenced by the high standard deviations of all the coefficients (Table 4.4). Moreover, a high correlation between the random individual coefficients of the nutrient content and nutritional claim was identified for both the chocolate milk (r=0.69) and the sponge cake (r=0.76).

Table 4.4. Mean value and standard deviations of the coefficients of the mixed logit model used for estimating the effect of label information on healthiness perception of snacks for their children in the choice conjoint task for two product categories: chocolate milk and sponge cake.

Product	*Variable*	*Mean*	*Standard deviation*	*95% Confidence interval*	*p-value*
Chocolate milk	Cartoon character	-0.035	0.535	[-0.148, 0.078]	0.544
	Nutrient content	-0.641	1.005	[-0.830, -0.453]	<0.001
	Nutritional claim	1.425	1.644	[1.008, 1.841]	<0.001
Sponge cake	Cartoon character	-0.030	0.529	[-0.118, 0.058]	0.498
	Nutrient content	-0.364	0.752	[-0.467, -0.262]	<0.001
	Nutritional claim	0.786	1.066	[0.593, 0.979]	<0.001

4.3.2.1 Individual differences in the effect of label information on mothers' healthiness perception of snacks

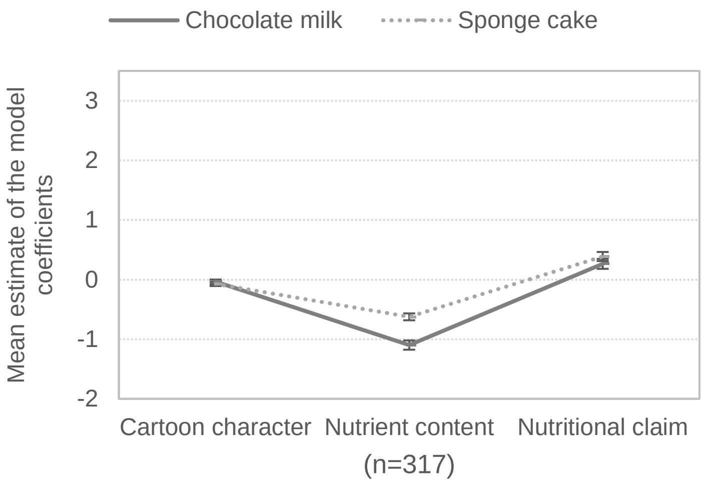
Hierarchical cluster analysis was used to explore individual differences on mothers' healthiness perception. Two groups of mothers who gave different relative importance to the variables of the experimental design when assessing the healthiness of the sponge cake and the chocolate milk were identified. The mean estimates for the three factors studied for each group are shown in Figure 4.3. Regardless of the product, mothers in Group 1 (n=317) were mainly influenced by the nutrient content and perceived labels with high sugar/saturated fat content as less healthy than the rest (Figure 4.3). Meanwhile, mothers in Group 2 (n=293) mainly based their healthiness perception on the nutritional claim: they regarded the products with nutritional claims as healthier than the products without claims. This effect was stronger for the chocolate milk than the sponge cake. These results were coherent with the raw data, i.e. the labels selected by mothers in the choice conjoint task. Mothers in Group 1 highly selected the labels featuring a low nutrient content, whereas Group 2 highly selected the labels with the nutritional claims (Appendix 10).

Mothers were not widely distributed along the first two components of the PCA (which explained 87% of the variability of the coefficients of the mixed logit model[2]). Instead, they were represented along a series of transverse lines (Appendix 8), which may be related to the lack of existence of marked differences in the relative importance attached to the experimental variables when assessing the healthiness of sponge cake and chocolate milk labels. However, the position of the groups identified in the Hierarchical Cluster Analysis in the first two components was in agreement with the average coefficients of the two groups.

Regarding differences between the groups in terms of socioeconomic variables, there was a slightly lower proportion of mothers whose children attend public schools in Group 1 (79%) compared to Group 2 (88%) (p=0.003). No statistically significant differences were observed in age, occupation, and socioeconomic level.

a)

[2] The variability refers to the coefficients of the mixed logit model and not the variability among participants according to the raw data.



b)

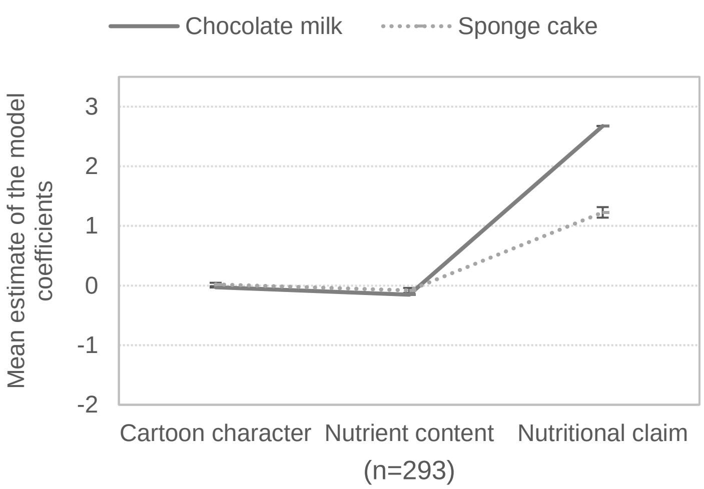


Figure 4.3. Mean estimates (and confidence interval) of the mixed logit model used for estimating the effect of label information on mothers' healthiness perception of snacks for the two groups identified in the Hierarchical cluster analysis for the chocolate milk and sponge cake: (a) Group 1 and (b) Group 2.

4.4. Discussion

4.4.1 Influence of label design on the parents' preference and healthiness perception

Results from the present work suggested that, regardless of the product category, the nutritional claim had a strong impact on mothers' healthiness perception and choice of snacks for their children. This is in line with previous research showing that parents perceive claims as healthiness cues and regard them as one of the most relevant attributes when selecting a product for their children (Abrams et al., 2015; Machín et al., 2016; Maubach et al., 2009). Previous studies with Uruguayan school-aged children have shown similar results. Nutritional claims have been identified as one of the most relevant attributes for children's choice of snack products in choice-based conjoint tasks (Ares et al., 2016; Arrúa, Curutchet, et al., 2017).

Results of the present work showed that nutritional claims had a higher relative importance than sugar and fat content in shaping mothers' healthiness perception and snack choice. This suggests that nutritional claims may override the effect of objective information about the content of nutrients with potential negative effects on health, i.e. sugar, fat and sodium. This is in agreement with the fact that nutrient declarations are regarded as difficult to find and understand by Uruguayan mothers (Machín et al. 2016). According to Harris et al. (2011), mothers are likely to misinterpret and overgeneralize claims which may lead them to select poor nutrient quality products.

Although in the present work the influence of the nutrient content on mothers' choices and healthiness perception was small, the tendency fitted expectations. In line with the present results, Li, Lopetcharat and Drake (2014) reported that parents found more attractive a chocolate milk when it is low in fat and sugar. In the present work, the significance of nutrient content differed between products. For the chocolate milk, the effect of sugar content was only significant when the parents selected the healthiest label. Meanwhile, for the sponge cake fat content was relevant for both healthiness perception and choice. It is likely that parents considered the chocolate milk as a relatively healthy product and therefore they paid more attention to the nutrient information content only when they had a health motivation (Van Herpen and Van Trijp 2011). The sponge cake, however may have been perceived as an indulgent option, with different reasons underlying choice. The larger effect of fat content on sponge cake labels compared to the sugar content in chocolate milk could also be attributed to the absolute difference between the two levels of the nutrient content variable. The difference in sugar content between the two levels was only 27% (22g vs. 28g), whereas for fat content it was 310% (2.0g vs. 6.2g). Mothers could have perceived the difference in fat content as more relevant than the difference in sugar content.

The low importance attached to objective nutritional information suggests the need to implement simplified front-of-package nutrition labelling schemes, such as nutritional warnings, to facilitate the identification of products with excessive content of sugar, fat and sodium. In this sense, recent research has shown that the implementation of this scheme in Uruguay improved consumer ability to interpret nutritional information (Ares et al., 2021). These simplified cues may be accessible for parents in all age ranges and socioeconomic levels and could help them making healthy snack choices for their children.

The cartoon character had the lowest impact on mother’s choice and healthiness perception for both product categories. Similar results were reported by Russell et al. (2017) who found that the presence of a cartoon character was one of the least important factors driving parent’s choices of breakfast cereals in a discrete choice experiment. Although the presence of cartoon characters positively influences children food choices (Ares, Arrúa et al., 2016; Arrúa, Vidal, et al., 2017; Hémar-Nicolas et al., 2021; Letona et al., 2014; McGale et al., 2016), nutritional quality seems to be a more relevant driver of parent’s food choices for their children (Oellingrath et al., 2013; Russell et al., 2015). Therefore, it is likely that parents prioritize the cues closely related to healthiness during their selection (e.g. claims). Another feasible explanation is that mothers may have provided socially desirable responses during the choice task, as parents are expected to provide healthy foods for their children.

4.4.2 Individual differences in mothers’ healthiness perception and choice

Results from the present work showed that the effect of nutritional claims, nutrient content information and cartoon characters on mothers' choice and healthiness perception cannot be generalized to the whole population since different groups with distinctive choice behavior were found. One segment of mothers (Group 2) was strongly influenced by the nutritional claim, both in the choice and in healthiness perception tasks. This is in line with the results observed at the aggregate model. It is worth highlighting that this behavior was more salient for the chocolate milk, which may be related to the understanding and familiarity of this claim due to its frequent use in the product category.

Nutritional claims had less weight for Group 1, who gave more importance to the presence of a cartoon character when choosing a snack product for their children. This group of mothers tended to select products with cartoon characters for their children. Although a previous study reported that cartoon characters had a low influence on parents' choices (Russell et al. ,2017), other studies have reported that parents perceive products with cartoon characters as more appealing for children (Abrams et al., 2015). In the present study, the effect of cartoon character was larger for the chocolate milk than for the sponge cake. The difference may be related to the fact that the character included in the chocolate milk labels was licensed and familiar to parents, compared to the non-licensed character included in the sponge cake labels (c.f. Figure 4.1). Nuances in the effect of different types of cartoon characters on children's perception and choice have been reported (Ogle et al., 2017; De Droog et al., 2011; Arrúa, Curutchet et al., 2017), which can be attributed to the associations raised by the characters.

The sociodemographic characteristics explored in this study were not able to differentiate the groups of mothers. Considering that parents usually select products that are less healthy but visually attractive to deliberately entertain or reward their children, future studies should investigate the influence of parental practices on the relative importance attached to labelling information when making snack choices.

Regarding healthiness perception, one segment of mothers (Group 1) selected the healthiest product based on the objective nutritional information in the label (i.e. sugar or fat content). This group was composed by a larger percentage of mothers with children in private schools. In line with these results, Lima, Ares, and Deliza (2018b) showed that parents whose children attended to private schools were more health conscious of the products targeted at children. These parents gave lower healthiness rating to snacks targeted at children compared to parents whose children attended public schools. Although parents sometimes disregard nutritional information, consumers with higher socioeconomic status/income are more likely to read the label information (Blitstein, Guthrie, & Rains, 2020; Hough, & Sosa, 2015; Machín et al., 2016; Ollberding, Wolf, & Contento, 2010; Satia, Galanko, & Neuhouser, 2005).

4.4.3 Limitations of the study

The present work is one of the few studies that explores individual differences in how labelling information influences parents' healthiness perception and choice of snacks for their children using a choice-based conjoint task. Although results were coherent with previous studies that applied other qualitative and quantitative methods, some methodological considerations are worthy to highlight. In this study, a limited number of choice sets were presented to the parents, which only allowed to study the main effects of the conjoint factors. Although interactions were considered by allowing correlation between the coefficients in the model, future studies should consider a larger number of choice sets to obtain more robust data to explore these interactions.

Although clear clusters of parents were found, differences in the socio-demographic characteristics of the groups were small. This limitation was also mentioned by Asioli, Almli & Næs (2016), who applied a multi-step strategy to investigate the individual differences among consumers in a choice-based experiment for iced coffee. These authors observed that despite the clearly distinct patterns in consumer behavior, differences in consumer attributes such gender or age were difficult to quantify. Considering that behavioral and attitudinal characteristics have been reported to have more explicative power on consumers' food purchase decisions than demographics (Hollywood et al., 2007), it is advisable that future studies consider additional parents’ characteristics.

4.5. Conclusions

Results from the present work showed that nutritional claims have a strong effect on mothers' healthiness perception and choice of snacks for their children, overriding the effect of the content of sugar and saturated fat. However, relevant individual differences on the effect of label elements on mothers' choice and healthiness perception were identified. In this sense, the choices of one group of mothers was influenced by the presence of cartoon characters on the labels. These results stress the need to regulate the use of claims, cartoon characters and other persuasive elements on the food labels of products of poor nutritional targeted at children.

CONCLUSIONS

Despite the need to reduce children's sugar intake, progress in reducing the sugar content of products targeted at children has been slow and insufficient. One of the main concerns of the food industry regarding sugar reduction is that children may find the reformulated product unacceptable. This idea has been reinforced by children's heightened preference for sweetness, leading to modern societies to normalize children's consumption of highly sugary products. Results from **CHAPTER 1** and **CHAPTER 2** seems to refute the general belief that children may prefer excessively sweet products.

Although it may seem harmless, manufacture and marketing of products targeted at children with excessive content of sugar can be regarded as a breach to some of the principles of the convention of the rights of the child. According to Article 3, the best interests of the child should be taken into consideration in all actions concerning children (UNICEF, 1989), which includes marketing of unhealthy products as appropriate for them (UNICEF, 1989). In addition, Article 24 recognizes children's' right to health, which can be interpreted as "an inclusive right, extending not only to timely and appropriate prevention, health promotion, curative, rehabilitative and palliative services, but also to a right to grow and develop to their full potential and live in conditions that enable them to attain the highest standard of health through the implementation of programs that address the underlying determinant of health" (Committee on the Rights of the Child, 2013). This suggests that governments should implement appropriate actions to guarantee that children grow and develop in an environment that enables them to achieve their full potential, addressing the underlying determinants of health. In this sense, policies targeted at reducing the availability of products targeted at children with high sugar content are needed.

International experience suggests that relying on the commitment of the food industry to reduce the sugar content of products targeted at children will not be enough (Hashem et al., 2019). Governmental action seems necessary to achieve a substantial sugar reduction. For this purpose, responsive regulatory approaches that progress from voluntary reformulation programs to mandatory if the expected results are not achieved have been recommended (Reeve & Magnusson, 2015).

Results from **CHAPTER 1** showed that a direct sugar reduction up to 25% was possible in chocolate milk, vanilla yogurt, and vanilla milk desserts without significant changes on the liking of 8 to 13 years old children. In line with these results, **CHAPTER 2** showed that despite some changes in the sensory profile of 40% sugar-reduced vanilla milk desserts, school-aged children liked the sugar-reduced products as much as they liked the regular product.

Results from **CHAPTER 2** confirmed that taste-aroma-texture sensory cross-modal minimized the sensory changes due to reduction of sugar content in vanilla milk desserts. However, future research is still needed to explore the potential of cross-modal interactions in products in which sugar content has a stronger negative impact on children hedonic perception. Results from **CHAPTER 1** and **CHAPTER 2** provided valuable information on how much sugar is possible to reduce in dairy products targeted at children available in the marketplace which may serve as a basis for the development of gradual sugar reduction programs.

Today the default strategy to reduce the sugar content in food products is the use of NNS in order to minimize changes in the sensory profile of the product. However, results from the present thesis suggest that sugar-reduction strategies without the addition of NNS can be rapidly implemented in dairy products targeted at children without any risk of affecting market share due to children rejection. Given that repeated exposure to highly sugary products may reinforce children preferences for those products, food scientists should move away from the premise of avoiding changes in the sensory characteristics to achieve a long term change in children's dietary patterns. Therefore, food scientists should focus on reducing both sugar content and sweetness intensity.

In this work, the impact of direct sugar reduction on children's hedonic perception was only studied in liquid and semi-solid foods. Therefore, future research is needed to explore the impact of direct sugar reduction in a wider range of product categories. For example, there is few information available regarding their application in solid matrices (e.g., bakery products), where sugar plays a critical role beyond sweet taste. In addition, a large heterogeneity was observed in children's liking of sugar reduced product which highlights the need of future research that explore additional factors underlying the individual differences among children.

Although results showed that reformulation of products targeted at children available in the marketplace is possible, another venue to reduce the sugar intake of children is the development of innovative sugar reduced products. Article 12 of the Convention states that children have the right to express their views, particularly in matters related to their health and wellbeing (UNICEF, 1989). This suggests that children and adolescents should be provided with the opportunity to be part of the development of more effective strategies to reduce sugar intake, as previously stressed in the context of health promotion (Spencer, 2014). Co-creation of low-sugar products with children and adolescents is an interesting avenue for further research, which may contribute to the development of more innovative healthy products, accepted by the target population (Voorberg et al., 2015). Exploratory results from **CHAPTER 3** suggested that co-creation is indeed a feasible approach to develop healthy dairy products with high acceptance among children. Still, the use of co-creation approaches during the development of healthier food products deserves further research to provide more detailed methodological recommendations that are open to the public. In addition, results from **CHAPTER 3** highlighted the potential of marketing strategies currently used in the food industry to promote healthy products among children. However, there is a need to validate these results with a wider sample size.

Moreover, it should be highlighted that isolated policies are unlikely to be enough to tackle the problems associated to a high consumption of added sugar (Bes-Rastrollo et al., 2016). Instead, a multicomponent sugar reduction strategy seems necessary to reduce sugar consumption and lessen their associated health and economic costs (Amies-Cull et al., 2019; Huang et al., 2019; Vyth et al., 2012; Yeung et al., 2017). For instance, taxation of food and beverages with added sugar, restriction of availably of poor nutrient quality product on schools, restrictions of marketing strategies targeted at children, front-of package labeling and reformulation of food products have been encouraged by international public health organizations (Popkin & Hawkes, 2016). These policies are expected to have a synergetic effect, contributing to more effectively achieve the objectives they seek. Results from **CHAPTER 4** confirmed that food package design strongly influences mothers' healthiness perception and choice of snacks for their children, which highlights the need to strengthen regulations of food packaging to aid parents to make better informed decisions. Although in this work the impact of package design on children food choices and preferences was not explored, results from **CHAPTER 3** highlighted that current marketing strategies are deeply engraved in children minds.

Overall, results from this thesis provide useful insights to food scientists for the development of sugar reduced products targeted at children, as well as valuable information for health policy makers to design programs to reduce children’s sugar intake at population level.

REFERENCES

Abarca-Gómez, L., Abdeen, Z. A., Hamid, Z. A., Abu-Rmeileh, N. M., Acosta-Cazares, B., Acuin, C., ... & Cho, Y. (2017). Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128· 9 million children, adolescents, and adults. *The lancet, 390*(10113), 2627-2642. https://doi.org/10.1016/S0140-6736(17)32129-3

IISD. (2020). *Global Market Report: Sugar*. https://www.iisd.org/system/files/publications/ssi-global-market-report-sugar.pdf

Abbasi, A., Juszczyk, D., van Jaarsveld, C. H. M., & Gulliford, M. C. (2017). Body Mass Index and Incident Type 1 and Type 2 Diabetes in Children and Young Adults: A Retrospective Cohort Study. *Journal of the Endocrine Society, 1*(5), 524–537. https://doi.org/10.1210/js.2017-00044

Abrams, K. M., Evans, C., & Duff, B. R. L. (2015). Ignorance is bliss. How parents of preschool children make sense of front-of-package visuals and claims on food. *Appetite, 87*, 20–29. https://doi.org/https://doi.org/10.1016/j.appet.2014.12.100

Afeiche, M. C., Koyratty, B. N. S., Wang, D., Jacquier, E. F., & Lê, K.-A. (2018). Intakes and sources of total and added sugars among 4 to 13-year-old children in China, Mexico and the United States. *Pediatric Obesity, 13*(4), 204–212. https://doi.org/https://doi.org/10.1111/ijpo.12234

Albani, V., Butler, L. T., Traill, W. B., & Kennedy, O. B. (2017). Fruit and vegetable intake: change with age across childhood and adolescence. *British Journal of Nutrition, 117*(5), 759–765. https://doi.org/DOI: 10.1017/S0007114517000599

Alcaire, F., Antúnez, L., Vidal, L., Giménez, A., & Ares, G. (2017). Aroma-related cross-modal interactions for sugar reduction in milk desserts: Influence on consumer perception. *Food Research International*, *97*, 45–50. https://doi.org/https://doi.org/10.1016/j.foodres.2017.02.019

Alfaro, B., Rios, Y., Arranz, S., & Varela, P. (2020). Understanding children's healthiness and hedonic perception of school meals via structured sorting. *Appetite, 144*, 104466. https://doi.org/https://doi.org/10.1016/j.appet.2019.104466

Allirot, X., da Quinta, N., Chokupermal, K., & Urdaneta, E. (2016). Involving children in cooking activities: A potential strategy for directing food choices toward novel foods containing vegetables. *Appetite, 103*, 275–285. https://doi.org/https://doi.org/10.1016/j.appet.2016.04.031

Almli, V.L., and Næs, T. (2018). 19 - Conjoint Analysis in Sensory and Consumer Science: Principles, Applications, and Future Perspectives. In Ares, G., & Varela, P. (Eds.). *Methods in Consumer Research, Volume 1: New Approaches to Classic Methods* (pp. 486-524). Woodhead Publishing.

Altintzoglou, T., Skuland, A. V, Carlehög, M., Sone, I., Heide, M., & Honkanen, P. (2015). Providing a food choice option increases children's liking of fish as part of a meal. *Food Quality and Preference, 39,* 117–123. https://doi.org/https://doi.org/10.1016/j.foodqual.2014.06.013

Ambrosini, G. L., Johns, D. J., Northstone, K., Emmett, P. M., & Jebb, S. A. (2016). Free Sugars and Total Fat Are Important Characteristics of a Dietary Pattern Associated with Adiposity across Childhood and Adolescence. *The Journal of nutrition*, *146*(4), 778–784. https://doi.org/10.3945/jn.115.224659

Amies-Cull, B., Briggs, A. D. M., & Scarborough, P. (2019). Estimating the potential impact of the UK government's sugar reduction programme on child and adult health: modelling study. *BMJ, 365*, l1417. https://doi.org/10.1136/bmj.l1417

Arancibia, C., Costell, E., & Bayarri, S. (2013). Impact of Structural Differences on Perceived Sweetness in Semisolid Dairy Matrices. *Journal of Texture Studies, 44*(5), 346–356. https://doi.org/https://doi.org/10.1111/jtxs.12019

Arancibia, C., Jublot, L., Costell, E., & Bayarri, S. (2011). Flavor release and sensory characteristics of o/w emulsions. Influence of composition, microstructure and rheological behavior. *Food Research International*, *44*(6), 1632–1641. https://doi.org/10.1016/j.foodres.2011.04.049

Ares, G., Antúnez, L., Curutchet, M.R., Galicia, L., Moratorio, X., Giménez, A., et al. (2021). Immediate effects of the implementation of nutritional warnings in Uruguay: awareness, self-reported use and increased understanding. *Public Health Nutrition*, 24, 364-375. https://doi.org/10.1017/S1368980020002517

Ares, G., Arrúa, A., Antúnez, L., Vidal, L., Machín, L., Martínez, J., Curutchet, M. R., & Giménez, A. (2016). Influence of label design on children's perception of two snack foods: Comparison of rating and choice-based conjoint analysis. *Food Quality and Preference, 53*, 1–8. https://doi.org/https://doi.org/10.1016/j.foodqual.2016.05.006

Ares, G., Castura, J. C., Antúnez, L., Vidal, L., Giménez, A., Coste, B., … Jaeger, S. R. (2016). Comparison of two TCATA variants for dynamic Sensory characterization of food products. *Food Quality and Preference*, *54*, 160-172. https://doi.org/10.1016/j.foodqual.2016.07.006

Ares, G., Giménez, A., Barreiro, C., & Gámbaro, A. (2010). Use of an open-ended question to identify drivers of liking of milk desserts. Comparison with preference mapping techniques. *Food Quality and Preference*, *21*(3), 286–294. https://doi.org/10.1016/j.foodqual.2009.05.006

Ares, G., Jaeger, S. R., Antúnez, L., Vidal, L., Giménez, A., Coste, B., …. Castura, J. C. (2016). Comparison of TCATA and TDS for dynamic sensory characterization of food products. *Food Research International*, *78*, 148-158. https://doi.org/10.1016/j.foodres.2015.10.023

Arnold, L., Lee, K. J., & Yip, J. C. (2016). Co-designing with children: An approach to social robot design. *ACM Human-Robot Interaction (HRI).*

Arrúa, A., Curutchet, M.R., Rey, N., Barreto, P., Golovchenko, N., Sellanes, A., et al. (2017). Impact of front-of-pack nutrition information and label design on children's choice of two snack foods: Comparison of warnings and the traffic-light system. *Appetite, 116*, 139-146. https://doi.org/10.1016/j.appet.2017.04.012

Ares, G., Velázquez, A.L., Galler, M., Vidal, L., Curutchet, M. R., & Varela, P. (submitted). The role of food packaging on children's diet: Insights for the design of comprehensive regulations to encourage healthier eating habits in childhood and beyond.

Arrúa, A., Vidal, L., Antúnez, L., Machín, L., Martínez, J., Curutchet, M. R., Giménez, A., & Ares, G. (2017). Influence of Label Design on Children's Perception of 2 Snack Foods. *Journal of Nutrition Education and Behavior, 49*(3), 211-217. https://doi.org/https://doi.org/10.1016/j.jneb.2016.10.021

Asioli, D, Næs, T., Øvrum, A., & Almli, V. L. (2016). Comparison of rating-based and choice-based conjoint analysis models. A case study based on preferences for iced coffee in Norway. *Food Quality and Preference, 48*, 174–184. https://doi.org/https://doi.org/10.1016/j.foodqual.2015.09.007

Asioli, D., Almli, V. L., & Næs, T. (2016). Comparison of two different strategies for investigating individual differences among consumers in choice experiments. A case study based on preferences for iced coffee in Norway. *Food Quality and Preference, 54*, 79–89. https://doi.org/10.1016/j.foodqual.2016.07.005

Auestad, N., Hurley, J. S., Fulgoni 3rd, V. L., & Schweitzer, C. M. (2015). Contribution of Food Groups to Energy and Nutrient Intakes in Five Developed Countries. *Nutrients, 7*(6), 4593–4618. https://doi.org/10.3390/nu7064593

Aumueller, N., Gruszfeld, D., Gradowska, K., Escribano, J., Ferré, N., Rousseaux, D., Hoyos, J., Verduci, E., ReDionigi, A., & Koletzko, B. (2019). Associations of sugar intake with anthropometrics in children from ages 2 until 8 years in the EU Childhood Obesity Project. *European Journal of Nutrition*, 1–9. https://doi.org/10.1007/s00394-019-02107-0

Azaïs-Braesco, V., Sluik, D., Maillot, M., Kok, F., & Moreno, L. A. (2017). A review of total & added sugar intakes and dietary sources in Europe. *Nutrition Journal*, *16*(1), 6. https://doi.org/10.1186/s12937-016-0225-2

Bailey, R. L., Fulgoni, V. L., Cowan, A. E., & Gaine, P. C. (2018). Sources of Added Sugars in Young Children, Adolescents, and Adults with Low and High Intakes of Added Sugars. *Nutrients, 10*(1), 102. https://doi.org/10.3390/nu10010102

Bayarri, S., Rivas, I., Izquierdo, L., & Costell, E. (2007). Influence of texture on the temporal perception of sweetness of gelled systems. *Food Research International, 40*(7), 900–908. https://doi.org/https://doi.org/10.1016/j.foodres.2007.03.003

Beauchamp, G. K. (2016). Why do we like sweet taste: A bitter tale? *Physiology & Behavior, 164*, 432–437. https://doi.org/https://doi.org/10.1016/j.physbeh.2016.05.007

Beck, T. K., Jensen, S., Bjoern, G. K., & Kidmose, U. (2014). The Masking Effect of Sucrose on Perception of Bitter Compounds in Brassica Vegetables. *Journal of Sensory Studies, 29*(3), 190–200. https://doi.org/https://doi.org/10.1111/joss.12094

Behrens, M., & Meyerhof, W. (2011). Gustatory and extragustatory functions of mammalian taste receptors. *Physiology & Behavior, 105*(1), 4–13. https://doi.org/https://doi.org/10.1016/j.physbeh.2011.02.010

Belc, N., Smeu, I., Macri, A., Vallauri, D., & Flynn, K. (2019). Reformulating foods to meet current scientific knowledge about salt, sugar and fats. *Trends in Food Science & Technology, 84*, 25–28. https://doi.org/https://doi.org/10.1016/j.tifs.2018.11.002

Belitz, H.-D., Grosch, W., & Schieberle, P. (2009). *Food Chemistry* (4th ed.). Springer Verlag Berlin Heidelberg. https://doi.org/10.1007/978-3-540-69934-7

Bengtsson, M. (2016). How to plan and perform a qualitative study using content analysis. *NursingPlus Open, 2*, 8–14. https://doi.org/https://doi.org/10.1016/j.npls.2016.01.001

Berridge, K. C., & Kringelbach, M. L. (2011). Building a neuroscience of pleasure and well-being. Psychology of Well-Being: *Theory, Research and Practice*, 1(1), 3. https://doi.org/10.1186/2211-1522-1-3

Berridge, K. C., & Kringelbach, M. L. (2015). Pleasure Systems in the Brain. *Neuron, 86*(3), 646–664. https://doi.org/https://doi.org/10.1016/j.neuron.2015.02.018

Berridge, K. C., Ho, C.-Y., Richard, J. M., & DiFeliceantonio, A. G. (2010). The tempted brain eats: Pleasure and desire circuits in obesity and eating disorders. *Brain Research, 1350*, 43–64. https://doi.org/https://doi.org/10.1016/j.brainres.2010.04.003

Bertelsen, A. S., Zeng, Y., Mielby, L. A., Sun, Y.-X., Byrne, D. V, & Kidmose, U. (2021). Cross-modal Effect of Vanilla Aroma on Sweetness of Different Sweeteners among Chinese and Danish Consumers. *Food Quality and Preference, 87*, 104036. https://doi.org/https://doi.org/10.1016/j.foodqual.2020.104036

Bes-Rastrollo, M., Sayon-Orea, C., Ruiz-Canela, M., & Martinez-Gonzalez, M. A. (2016). Impact of sugars and sugar taxation on body weight control: A comprehensive literature review. *Obesity, 24*(7), 1410–1426. https://doi.org/https://doi.org/10.1002/oby.21535

Birch, L. L., & Marlin, D. W. (1982). I don't like it; I never tried it: Effects of exposure on two-year-old children's food preferences. *Appetite, 3*(4), 353–360. https://doi.org/https://doi.org/10.1016/S0195-6663(82)80053-6

Birch, L., Savage, J. S., & Ventura, A. (2007). Influences on the Development of Children's Eating Behaviours: From Infancy to Adolescence. *Canadian Journal of Dietetic Practice and Research* : A Publication of Dietitians of Canada = Revue Canadienne de La Pratique et de La Recherche En Dietetique : Une Publication Des Dietetistes Du Canada, *68*(1), s1–s56. https://pubmed.ncbi.nlm.nih.gov/19430591

Black, M. H., Zhou, H., Takayanagi, M., Jacobsen, S. J., & Koebnick, C. (2013). Increased Asthma Risk and Asthma-Related Health Care Complications Associated With Childhood Obesity. *American Journal of Epidemiology, 178*(7), 1120–1128. https://doi.org/10.1093/aje/kwt093

Blaine, R. E., Kachurak, A., Davison, K. K., Klabunde, R., & Fisher, J. O. (2017). Food parenting and child snacking: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 14*(1), 146. https://doi.org/10.1186/s12966-017-0593-9.

Blissett, J., & Fogel, A. (2013). Intrinsic and extrinsic influences on children's acceptance of new foods. *Physiology & Behavior, 121*, 89–95. https://doi.org/https://doi.org/10.1016/j.physbeh.2013.02.013

Blitstein, J. L., Guthrie, J. F., & Rains, C. (2020). Low-Income Parents' Use of Front-of-Package Nutrition Labels in a Virtual Supermarket. *Journal of Nutrition Education and Behavior*, *52*(9), 850-858. https://doi.org/10.1016/j.jneb.2020.04.003

Boakes, R., & Hemberger, H. (2012). Odour-modulation of taste ratings by chefs. *Food Quality and Preference*, *25*, 81–86. https://doi.org/10.1016/j.foodqual.2012.01.006

Boland, A. B., Delahunty, C. M., & van Ruth, S. M. (2006). Influence of the texture of gelatin gels and pectin gels on strawberry flavour release and perception. *Food Chemistry, 96*(3), 452–460. https://doi.org/https://doi.org/10.1016/j.foodchem.2005.02.027

Borum N., Brooks E.P., Brooks A.L. (2015). Designing with Young Children: Lessons Learned from a Co-creation of a Technology-Enhanced Playful Learning Environment. In: A. Marcus (Ed.), *Design, User Experience, and Usability: Interactive Experience Design. DUXU 2015. Lecture Notes in Computer Science* (vol 9188). Springer, Cham. https://doi.org/10.1007/978-3-319-20889-3_14

Boulton, J., Hashem, K. M., Jenner, K. H., Lloyd-Williams, F., Bromley, H., & Capewell, S. (2016). How much sugar is hidden in drinks marketed to children? A survey of fruit juices, juice drinks and smoothies. *BMJ Open*, *6*(3), e010330. https://doi.org/10.1136/bmjopen-2015-010330

Breslin, P. A. S. (2013). An Evolutionary Perspective on Food and Human Taste. *Current Biology, 23*(9), R409–R418. https://doi.org/https://doi.org/10.1016/j.cub.2013.04.010

Brockhoff, P. B., & Christensen, R. H. B. (2010). Thurstonian models for sensory discrimination tests as generalized linear models. *Food Quality and Preference*, *21*(3), 330–338. https://doi.org/https://doi.org/10.1016/j.foodqual.2009.04.003

Brouns, F. (2020). Saccharide Characteristics and Their Potential Health Effects in Perspective. *Frontiers in Nutrition, 7*, 75. https://doi.org/10.3389/fnut.2020.00075

Brown, R. J., de Banate, M. A., & Rother, K. I. (2010). Artificial sweeteners: a systematic review of metabolic effects in youth. *International Journal of Pediatric Obesity : IJPO : An Official Journal of the International Association for the Study of Obesity*, *5*(4), 305–312. https://doi.org/10.3109/17477160903497027

Bruzzone, F., Vidal, L., Antúnez, L., Giménez, A., Deliza, R., & Ares, G. (2015). Comparison of intensity scales and CATA questions in new product development : Sensory characterisation and directions for product reformulation of milk desserts. *Food Quality and Preference*, 44, 183–193. https://doi.org/10.1016/j.foodqual.2015.04.017

Bubník, Z., & Kadlec, P. (1995). Sucrose solubility. In M. Mathlouthi & P. Reiser (Eds.), *Sucrose*. Springer.

Burke, M. V., & Small, D. M. (2015). Physiological mechanisms by which non-nutritive sweeteners may impact body weight and metabolism. *Physiology & behavior, 152*, 381-388. https://doi.org/10.1016/j.physbeh.2015.05.036

Burseg, K. M. M., Camacho, S., Knoop, J., & Bult, J. H. F. (2010). Sweet taste intensity is enhanced by temporal fluctuation of aroma and taste, and depends on phase shift. *Physiology & Behavior*, *101*(5), 726–730. https://doi.org/10.1016/J.PHYSBEH.2010.08.014

Busse, M., & Siebert, R. (2018). The role of consumers in food innovation processes. *European Journal of Innovation Management, 21*(1), 20-43. https://doi.org/10.1108/ejim-03-2017-0023

Buyken, A. E., Mitchell, P., Ceriello, A., & Brand-Miller, J. (2010). Optimal dietary approaches for prevention of type 2 diabetes: a life-course perspective. *Diabetologia, 53*(3), 406–418. https://doi.org/10.1007/s00125-009-1629-8

Cabella, W., De Rosa, M., Failache, E., Fitermann, P., Katzkowicz, N., Medina, M., et al. (2014). *Salud, Nutrición y Desarrollo en la Primera Infancia en Uruguay. Primeros Resultados de la ENDIS*. Montevideo: Instituto Nacional de Estadística.

Cadena, R. S., Vidal, L., Ares, G., & Varela, P. (2014). Dynamic sensory descriptive methodologies: Time-intensity and temporal dominance of sensations. In P. Varela, & G. Ares (Eds.), *Novel techniques in sensory characterization and consumer profiling* (pp. 333–364). Boca Raton, FL: CRC Press.

Cairns, G., Angus, K., Hastings, G., & Caraher, M. (2013). Systematic reviews of the evidence on the nature, extent and effects of food marketing to children. A retrospective summary. *Appetite, 62*, 209–215. https://doi.org/https://doi.org/10.1016/j.appet.2012.04.017

Campmans-Kuijpers, M. J. E., Singh-Povel, C., Steijns, J., & Beulens, J. W. J. (2016). The association of dairy intake of children and adolescents with different food and nutrient intakes in the Netherlands. *BMC Pediatrics*, *16*, 2. https://doi.org/10.1186/s12887-015-0524-3

Castura, J. C., Antúnez, L., Giménez, A., & Ares, G. (2016). Temporal Check-All-That-Apply (TCATA): A novel dynamic method for characterizing products. *Food Quality and Preference*, 47, 79–90. https://doi.org/https://doi.org/10.1016/j.foodqual.2015.06.017

Cediel, G., Reyes, M., da Costa Louzada, M. L., Martinez Steele, E., Monteiro, C. A., Corvalán, C., & Uauy, R. (2018). Ultra-processed foods and added sugars in the Chilean diet (2010). *Public Health Nutrition, 21*(1), 125–133. https://doi.org/10.1017/S1368980017001161

Centro de Investigaciones Económicas. (2018). *Índice de nivel socioeconómico.* Montevideo: Centro de Investigaciones Económicas.

Chacon, V., Letona, P., & Barnoya, J. (2013). Child-oriented marketing techniques in snack food packages in Guatemala. *BMC Public Health, 13*(1), 1-6. https://doi.org/10.1186/1471-2458-13-967

Chang, M. H., & Chiou, W. B. (2006). Differential threshold and psychophysical power function of sweetness sensation: Applied psychophysics and prospect theory on formulating baking products. *Journal of Sensory Studies*, *21*(5), 534-551. https://doi.org/10.1111/j.1745-459X.2006.00078.x

Charles, M., Endrizzi, I., Aprea, E., Zambanini, J., Betta, E., & Gasperi, F. (2017). Dynamic and static sensory methods to study the role of aroma on taste and texture: A multisensory approach to apple perception. *Food Quality and Preference, 62,* 17–30. https://doi.org/https://doi.org/10.1016/j.foodqual.2017.06.014

Chéron, J. B., Golebiowski, J., Antonczak, S., & Fiorucci, S. (2017). The anatomy of mammalian sweet taste receptors. *Proteins: Structure, Function, and Bioinformatics, 85*(2), 332–341. https://doi.org/https://doi.org/10.1002/prot.25228

Chesbrough, H. W. (2003). *Open innovation: The new imperative for creating and profiting from technology*. Harvard Business Press

Chi, D. L., & Scott, J. M. (2019). Added Sugar and Dental Caries in Children: A Scientific Update and Future Steps. *Dental Clinics, 63*(1), 17–33. https://doi.org/10.1016/j.cden.2018.08.003

Chollet, M., Gille, D., Schmid, A., Walther, B., & Piccinali, P. (2013). Acceptance of sugar reduction in flavored yogurt. *Journal of Dairy Science, 96*(9), 5501–5511. https://doi.org/https://doi.org/10.3168/jds.2013-6610

Civille, G. V., & Oftedal, K. N. (2012). Sensory evaluation techniques - Make “good for you” taste “good.” *Physiology and Behavior*, *107*(4), 598–605. https://doi.org/10.1016/j.physbeh.2012.04.015

Clemens, R. A., Jones, J. M., Kern, M., Lee, S., Mayhew, E. J., Slavin, J. L., & Zivanovic, S. (2016). Functionality of sugars in foods and health. *Comprehensive Reviews in Food Science and Food Safety, 15*(3), 433–470. https://doi.org/10.1111/1541-4337.12194

Coldwell, S. E., Oswald, T. K., & Reed, D. R. (2009). A marker of growth differs between adolescents with high vs. low sugar preference. *Physiology & behavior, 96*(4-5), 574-580. https://doi.org/10.1016/j.physbeh.2008.12.010

Committee on the Rights of the Child. (2013). *General Comment No. 15 on the Right of the Child to the Enjoyment of the Highest Attainable Standard of Health*, CRC/C/GC/15. New York: United Nations.

Cook, D. J., Hollowood, T. A., Linforth, R. S. T., & Taylor, A. J. (2002). Perception of taste intensity in solutions of random-coil polysaccharides above and below c∗. *Food Quality and Preference, 13*(7), 473–480. https://doi.org/https://doi.org/10.1016/S0950-3293(02)00066-6

Cook, S. L., Methven, L., Parker, J. K., & Khutoryanskiy, V. V. (2018). Polysaccharide food matrices for controlling the release, retention and perception of flavours. *Food Hydrocolloids, 79,* 253–261. https://doi.org/https://doi.org/10.1016/j.foodhyd.2017.12.023

Cooke, L. J., & Wardle, J. (2005). Age and gender differences in children's food preferences. *British Journal of Nutrition, 93*(5), 741–746. https://doi.org/DOI: 10.1079/BJN20051389

Cui, M., Jiang, P., Maillet, E., Max, M., Margolskee, R. F., & Osman, R. (2006). The heterodimeric sweet taste receptor has multiple potential ligand binding sites. *Current pharmaceutical design, 12*(35), 4591-4600. https://doi.org/10.2174/138161206779010350

Curtis, P., James, A., & Ellis, K. (2010). Children's snacking, children's food: food moralities and family life. *Children's Geographies, 8,* 291-302. https://doi.org/10.1080/14733285.2010.494870

da Costa Louzada, M. L., Baraldi, L. G., Steele, E. M., Martins, A. P. B., Canella, D. S., Moubarac, J.-C., Levy, R. B., Cannon, G., Afshin, A., & Imamura, F. (2015). Consumption of ultra-processed foods and obesity in Brazilian adolescents and adults. *Preventive Medicine, 81*, 9–15. https://doi.org/10.1016/j.ypmed.2015.07.018

Daems, K., Moons, I., & De Pelsmacker, P. (2017). Co-creating advertising literacy awareness campaigns for minors. *Young Consumers, 18*(1), 54–69. https://doi.org/10.1108/YC-09-2016-00630

Damen, F.W.M., Luning, P.A., Fogliano, V., & Steenbekkers, B.L.P.A. (2019). What influences mothers' snack choices for their children aged 2-7*? Food Quality and Preference, 74*, 10-20. https://doi.org/10.1016/j.foodqual.2018.12.012

De Droog, S. M., Valkenburg, P. M., & Buijzen, M. (2011). Using brand characters to promote young children's liking of and purchase requests for fruit. *Journal of Health Communication,* 16, 79–89.

de Lamas, C., de Castro, M. J., Gil-Campos, M., Gil, Á., Couce, M. L., & Leis, R. (2019). Effects of Dairy Product Consumption on Height and Bone Mineral Content in Children: A Systematic Review of Controlled Trials. *Advances in Nutrition, 10*(suppl_2), S88–S96. https://doi.org/10.1093/advances/nmy096

de Wijk, R. A., Terpstra, M. E. J., Janssen, A. M., & Prinz, J. F. (2006). Perceived creaminess of semi-solid foods. *Trends in Food Science and Technology*, *17*(8), 412–422. https://doi.org/10.1016/j.tifs.2006.02.005

de Wijk, René A., van Gemert, L. J., Terpstra, M. E. J., & Wilkinson, C. L. (2003). Texture of semi-solids; sensory and instrumental measurements on vanilla custard desserts. *Food Quality and Preference*, *14*(4), 305–317. https://doi.org/10.1016/S0950-3293(02)00107-6

Dean, M., O'Kane, C., Issartel, J., McCloat, A., Mooney, E., Gaul, D., Wolfson, J. A., & Lavelle, F. (2021). Guidelines for designing age-appropriate cooking interventions for children: The development of evidence-based cooking skill recommendations for children, using a multidisciplinary approach. *Appetite, 161*, 105125. https://doi.org/https://doi.org/10.1016/j.appet.2021.105125

DeCosta, P., Møller, P., Frøst, M. B., & Olsen, A. (2017). Changing children's eating behaviour - A review of experimental research. *Appetite, 113*, 327–357. https://doi.org/https://doi.org/10.1016/j.appet.2017.03.004

Deliza, R., Lima, M. F., & Ares, G. (2021). Rethinking sugar reduction in processed foods. *Current Opinion in Food Science, 40*, 58-66. https://doi.org/10.1016/j.cofs.2021.01.010

Delk, J., & Vickers, Z. (2007). Determining a series of whole wheat difference thresholds for use in a gradual adjustment intervention to improve children's liking of whole-wheat bread rolls. *Journal Of Sensory Studies, 22*(6), 639–652. https://doi.org/https://doi.org/10.1111/j.1745-459X.2007.00117.x

Desor, J. A., Maller, O., & Turner, R. E. (1973). Taste in acceptance of sugars by human infants. *Journal of comparative and physiological psychology, 84*(3), 496. https://doi.org/10.1037/h0034906

Di Monaco, R., Miele, N. A., Cabisidan, E. K., & Cavella, S. (2018). Strategies to reduce sugars in food. *Current Opinion in Food Science, 19*, 92–97. https://doi.org/https://doi.org/10.1016/j.cofs.2018.03.008

Dial, L. A., & Musher-Eizenman, D. R. (2020). Power of packaging: Evaluations of packaged fruits and vegetables by school-age children in the U.S. *Appetite, 148*, 104591. https://doi.org/https://doi.org/10.1016/j.appet.2020.104591

Divert, C., Chabanet, C., Schoumacker, R., Martin, C., Lange, C., Issanchou, S., & Nicklaus, S. (2017). Relation between sweet food consumption and liking for sweet taste in French children. *Food Quality and Preference, 56*, 18–27. https://doi.org/https://doi.org/10.1016/j.foodqual.2016.09.009

Djordjevic, J., Zatorre, R. J., & Jones-Gotman, M. (2004). Effects of Perceived and Imagined Odors on Taste Detection. *Chemical Senses, 29*(3), 199–208. https://doi.org/10.1093/chemse/bjh022

Domínguez, P. R., Gámiz, F., Gil, M., Moreno, H., Zamora, R. M., Gallo, M., & de Brugada, I. (2013). Providing choice increases children's vegetable intake. *Food Quality and Preference, 30*(2), 108-113. https://doi.org/10.1016/j.foodqual.2013.05.006

Dooley, A. A., & Pillai, D. K. (2021). Paediatric obesity-related asthma: Disease burden and effects on pulmonary physiology. *Paediatric Respiratory Reviews,* 37, 15–17. https://doi.org/https://doi.org/10.1016/j.prrv.2020.04.002

Dougkas, A., Barr, S., Reddy, S., & Summerbell, C. D. (2019). A critical review of the role of milk and other dairy products in the development of obesity in children and adolescents. *Nutrition Research Reviews, 32*(1), 106–127. https://doi.org/DOI: 10.1017/S0954422418000227

Drewnowski, A. (2000). Sensory control of energy density at different life stages. *Proceedings of the Nutrition Society, 59*(2), 239-244. https://doi.org/10.1017/S0029665100000264

Drewnowski, A. (2001). The science and complexity of bitter taste. *Nutrition Reviews, 59*(6), 163–169. https://doi.org/10.1111/j.1753-4887.2001.tb07007.x

Drewnowski, A., Mennella, J. A., Johnson, S. L., & Bellisle, F. (2012). Sweetness and Food Preference. *The Journal of Nutrition, 142*(6), 1142S-1148S. https://doi.org/10.3945/jn.111.149575

Dror, D. K., & Allen, L. H. (2014). Dairy product intake in children and adolescents in developed countries: trends, nutritional contribution, and a review of association with health outcomes. *Nutrition Reviews*, *72*(2), 68–81. https://doi.org/10.1111/nure.12078

Druin, A. (2002). The role of children in the design of new technology. *Behaviour & Information Technology, 21*, 1 - 25. https://doi.org/10.1080/01449290110108659

DuBois, G. E., & Prakash, I. (2012). Non-Caloric Sweeteners, Sweetness Modulators, and Sweetener Enhancers. *Annual Review of Food Science and Technology*, 3(1), 353–380. https://doi.org/10.1146/annurev-food-022811-101236

Eggleston, G. (2019). History of sugar and sweeteners. In *Chemistry's Role in Food Production and Sustainability: Past and Present* (pp. 63-74). American Chemical Society. https://doi.org/doi:10.1021/bk-2019-1314.ch005

Elliott, C. (2008). Assessing 'fun foods': nutritional content and analysis of supermarket foods targeted at children. *Obesity Reviews*, *9*(4), 368–377. https://doi.org/10.1111/j.1467-789X.2007.00418.x

Elliott, C. (2015). ‘Big Food’ and ‘gamified’ products: promotion, packaging, and the promise of fun. *Critical Public Health, 25*(3), 348–360. https://doi.org/10.1080/09581596.2014.953034

Elliott, C., & Scime, N. (2019). Nutrient Profiling and Child-Targeted Supermarket Foods: Assessing a “Made in Canada” Policy Approach. *International Journal of Environmental Research and Public Health*, *16*(4), 639. http://dx.doi.org/10.3390/ijerph16040639

Elliott, C., & Truman, E. (2020). The Power of Packaging: A Scoping Review and Assessment of Child-Targeted Food Packaging. *Nutrients, 12*(4), 958. https://doi.org/10.3390/nu12040958

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing, 62(*1), 107–115. https://doi.org/https://doi.org/10.1111/j.1365-2648.2007.04569.x

Enax, L., Weber, B., Ahlers, M., Kaiser, U., Diethelm, K., Holtkamp, D., ... & Kersting, M. (2015). Food packaging cues influence taste perception and increase effort provision for a recommended snack product in children. *Frontiers in Psychology, 6*, 882. https://www.frontiersin.org/article/10.3389/fpsyg.2015.00882

Evans, R. D., & Heather, L. C. (2019). Human metabolism: pathways and clinical aspects. *Surgery (Oxford), 37*(6), 302–309. https://doi.org/10.1016/j.mpsur.2019.03.006

FAS/USDA. (2021). *Sugar: World Markets and Trade (May 2021).* https://apps.fas.usda.gov/psdonline/circulars/sugar.pdf

Fayet-Moore, F., Peters, V., McConnell, A., Petocz, P., & Eldridge, A.L. (2017). Weekday snacking prevalence, frequency, and energy contribution have increased while foods consumed during snacking have shifted among Australian children and adolescents: 1995, 2007 and 2011–12 National Nutrition Surveys. *Nutrition Journal, 16*, 65. https://doi.org/10.1186/s12937-017-0288-8

Ferry, A.-L., Hort, J., Mitchell, J. R., Cook, D. J., Lagarrigue, S., & Valles Pamies, B. (2006). Viscosity and flavour perception: Why is starch different from hydrocolloids? *Food Hydrocolloids, 20*(6), 855–862. https://doi.org/https://doi.org/10.1016/j.foodhyd.2005.08.008

Filieri, R. (2013). Consumer co-creation and new product development: a case study in the food industry. *Marketing Intelligence & Planning, 31*(1), 40–53. https://doi.org/10.1108/02634501311292911

Fisberg, M., Kovalskys, I., Gómez, G., Rigotti, A., Sanabria, L. Y. C., García, M. C. Y., Torres, R. G. P., Herrera-Cuenca, M., Zimberg, I. Z., Koletzko, B., Pratt, M., Aznar, L. A.

M., Guajardo, V., Fisberg, R. M., Sales, C. H., Previdelli, Á. N., & Group, E. S. (2018). Total and Added Sugar Intake: Assessment in Eight Latin American Countries. *Nutrients, 10*(4), 389. https://doi.org/10.3390/nu10040389

Forestell, C. A., & Mennella, J. A. (2007). Early determinants of fruit and vegetable acceptance. *Pediatrics, 120*(6), 1247-1254. https://doi.org/10.1542/peds.2007-0858

Fox, M. K., Gearan, E. C., & Schwartz, C. (2021). Added sugars in school meals and the diets of school-age children. *Nutrients, 13*(2), 471. https://doi.org/10.3390/nu13020471

Frank, R. A., & Byram, J. (1988). Taste–smell interactions are tastant and odorant dependent. *Chemical Senses, 13*(3), 445–455. https://doi.org/10.1093/chemse/13.3.445

Frank, R. A., Ducheny, K., & Mize, S. J. S. (1989). Strawberry odor, but not red color, enhances the sweetness of sucrose solutions. *Chemical Senses, 14*(3), 371–377. https://doi.org/10.1093/chemse/14.3.371

Fujiwara, A., Okada, E., Okada, C., Matsumoto, M., & Takimoto, H. (2020). Association between free sugars intake and nutrient dilution among Japanese adults: the 2016 National Health and Nutrition Survey, Japan. *European Journal of Nutrition, 59*(8), 3827–3839. https://doi.org/10.1007/s00394-020-02213-4

Fulgoni III, V. L., Gaine, P. C., Scott, M. O., Ricciuto, L., & DiFrancesco, L. (2019). Association of Added Sugars Intake with Micronutrient Adequacy in US Children and Adolescents: NHANES 2009–2014. *Current Developments in Nutrition, 3*(12). https://doi.org/10.1093/cdn/nzz126

Füller, J. (2010). Refining Virtual Co-Creation from a Consumer Perspective. *California Management Review, 52*(2), 98–122. https://doi.org/10.1525/cmr.2010.52.2.98

Galler, M., Gonera, A., & Varela, P. (2020). Children as food designers: The potential of co-creation to make the healthy choice the preferred one. *International Journal of Food Design, 5*(1–2), 125–131. https://doi.org/10.1386/ijfd_00015_3

Garcia, A. L., Ronquillo, J. D., Morillo-Santander, G., Mazariegos, C. V, Lopez-Donado, L., Vargas-Garcia, E. J., Curtin, L., Parrett, A., & Mutoro, A. N. (2020). Sugar Content and Nutritional Quality of Child Orientated Ready to Eat Cereals and Yoghurts in the UK and Latin America; Does Food Policy Matter? *Nutrients, 12*(3), 856. https://doi.org/10.3390/nu12030856

Garneau, N. L., Nuessle, T. M., Mendelsberg, B. J., Shepard, S., & Tucker, R. M. (2018). Sweet liker status in children and adults: Consequences for beverage intake in adults. *Food Quality and Preference*, *65*, 175–180. https://doi.org/10.1016/J.FOODQUAL.2017.10.005

GBD 2017 Disease and Injury Incidence and Prevalence Collaborators. (2018). Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet, 392*(10159), 1789–1858. https://doi.org/10.1016/S0140-6736(18)32279-7

Gennari, R., Matera, M., Melonio, A., & Roumelioti, E. (2019). A Board-Game for Co-Designing Smart Nature Environments in Workshops with Children. In A. Malizia, S. Valtolina, A. Morch, A. Serrano, & A. Stratton (Eds.). *End-User Development* (pp. 132–148). Springer International Publishing.

Ghaziani, R. (2021). Primary school design: co-creation with children. *Archnet-IJAR: International Journal of Architectural Research, 15*(2), 285–299. https://doi.org/10.1108/ARCH-07-2020-0132

Gibson, E. L., Androutsos, O., Moreno, L., Flores-Barrantes, P., Socha, P., Iotova, V., ... & Manios, Y. (2020). Influences of parental snacking-related attitudes, behaviours and nutritional knowledge on young children's healthy and unhealthy snacking: The ToyBox Study. *Nutrients, 12*(2), 432. https://doi.org/10.3390/nu12020432

Gil-Pérez, I., Rebollar, R., & Lidón, I. (2020). Without words: the effects of packaging imagery on consumer perception and response. *Current Opinion in Food Science, 33*, 69-77. https://doi.org/10.1016/j.cofs.2019.12.006

Giménez, A., Saldamando, L. de, Curutchet, M. R., & Ares, G. (2017). Package design and nutritional profile of foods targeted at children in supermarkets in Montevideo, Uruguay. *Cadernos de Saude Publica*, *33*(5), e00032116. https://doi.org/10.1590/0102-311X00032116

Goldfein, K. R., & Slavin, J. L. (2015). Why Sugar Is Added to Food: Food Science 101. *Comprehensive Reviews in Food Science and Food Safety*, *14*(5), 644–656. https://doi.org/10.1111/1541-4337.12151

González-Padilla, E., A. Dias, J., Ramne, S., Olsson, K., Nälsén, C., & Sonestedt, E. (2020). Association between added sugar intake and micronutrient dilution: a cross-sectional study in two adult Swedish populations. *Nutrition & Metabolism, 17*(1), 15. https://doi.org/10.1186/s12986-020-0428-6

González-Tomás, L., Bayarri, S., Taylor, A. J., & Costell, E. (2007). Flavour release and perception from model dairy custards. *Food Research International*, *40*(4), 520–528. https://doi.org/10.1016/j.foodres.2006.10.002

Gray, D., Brown, S., & Macanufo, J. (2010). *Gamestorming: A Playbook for Innovators, Rulebreakers, and Changemakers.* USA: O'Reilly Media, Inc.

Green, B. G., Lim, J., Osterhoff, F., Blacher, K., & Nachtigal, D. (2010). Taste mixture interactions: Suppression, additivity, and the predominance of sweetness. *Physiology & Behavior, 101*(5), 731–737. https://doi.org/https://doi.org/10.1016/j.physbeh.2010.08.013

Grembecka, M. (2015). Sugar alcohols—their role in the modern world of sweeteners: a review. *European Food Research and Technology, 241*(1), 1–14. https://doi.org/10.1007/s00217-015-2437-7

Gressier, M., Swinburn, B., Frost, G., Segal, A. B., & Sassi, F. (2021). What is the impact of food reformulation on individuals' behaviour, nutrient intakes and health status? A systematic review of empirical evidence. *Obesity Reviews, 22*(2), e13139. https://doi.org/https://doi.org/10.1111/obr.13139

Griffith, R., O'Connell, M., Smith, K., & Stroud, R. (2020). What's on the Menu? Policies to Reduce Young People's Sugar Consumption. *Fiscal Studies, 41*(1), 165–197. https://doi.org/10.1111/1475-5890.12194

Gropper, S. S., & Smith, J. L. (2012). *Advanced nutrition and human metabolism* (6th ed.). Cengage Learning.

Gutjar, S., de Graaf, C., Palascha, A., & Jager, G. (2014). Food choice: The battle between package, taste and consumption situation. *Appetite, 80*, 109–113. https://doi.org/https://doi.org/10.1016/j.appet.2014.05.006

Haller, R., Rummel, C., Henneberg, S., Pollmer, U., & Köster, E. P. (1999). The Influence of Early Experience with Vanillin on Food Preference Later in Life. *Chemical Senses*, *24*(4), 465–467. https://doi.org/10.1093/chemse/24.4.465

Han, J. H. (2014). A Review of Food Packaging Technologies and Innovations. In J. H. B. T.-I. in F. P. (Second E. Han (Ed.), *Food Science and Technology* (pp. 3–12). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-394601-0.00001-1

Han, P., Bagenna, B., & Fu, M. (2019). The sweet taste signalling pathways in the oral cavity and the gastrointestinal tract affect human appetite and food intake: A review. *International Journal of Food Sciences and Nutrition, 70*(2), 125-135. https://doi.org/10.1080/09637486.2018.1492522

Han, X., Xu, S.-Z., Dong, W.-R., Wu, Z., Wang, R.-H., & Chen, Z.-X. (2014). Influence of carboxymethyl cellulose and sodium alginate on sweetness intensity of Aspartame. *Food Chemistry, 164,* 278–285. https://doi.org/https://doi.org/10.1016/j.foodchem.2014.05.040

Harris, J. L., Thompson, J. M., Schwartz, M. B., & Brownell, K. D. (2011). Nutrition-related claims on children's cereals: what do they mean to parents and do they influence willingness to buy? *Public Health Nutrition, 14*(12), 2207–2212. https://doi.org/DOI:10.1017/S1368980011001741

Harwood, M. L., Loquasto, J. R., Roberts, R. F., Ziegler, G. R., & Hayes, J. E. (2013). Explaining tolerance for bitterness in chocolate ice cream using solid chocolate preferences. *Journal of Dairy Science*, *96*(8), 4938–4944. https://doi.org/10.3168/jds.2013-6715

Hashem, K. M., He, F. J., & MacGregor, G. A. (2019). Effects of product reformulation on sugar intake and health—a systematic review and meta-analysis. *Nutrition Reviews, 77*(3), 181–196. https://doi.org/10.1093/nutrit/nuy015

Havukainen, M., Laine, T. H., Martikainen, T., & Sutinen, E. (2020). A Case Study on Co-designing Digital Games with Older Adults and Children: Game Elements, Assets, and Challenges. *The Computer Games Journal, 9*(2), 163–188. https://doi.org/10.1007/s40869-020-00100-w

Hawkes, C. (2010). Food packaging: the medium is the message. *Public Health Nutrition, 13*(2), 297–299. https://doi.org/DOI: 10.1017/S1368980009993168

Hebden, L., King, L., Kelly, B., Chapman, K., & Innes-Hughes, C. (2011). A Menagerie of Promotional Characters: Promoting Food to Children through Food Packaging. *Journal of Nutrition Education and Behavior, 43*(5), 349–355. https://doi.org/https://doi.org/10.1016/j.jneb.2010.11.006

Heim, S., Stang, J., & Ireland, M. (2009, Jul). A garden pilot project enhances fruit and vegetable consumption among children. *J Am Diet Assoc, 109*(7), 1220-1226. https://doi.org/10.1016/j.jada.2009.04.009

Hémar-Nicolas, V., Putri Hapsari, H., Angka, S., & Olsen, A. (2021). How cartoon characters and claims influence children's attitude towards a snack vegetable – An explorative cross-cultural comparison between Indonesia and Denmark. *Food Quality and Preference, 87*, 104031. https://doi.org/https://doi.org/10.1016/j.foodqual.2020.104031

Hensher, D. A., & Greene, W. H. (2003). The mixed logit model: the state of practice. *Transportation, 30*(2), 133-176. https://doi.org/10.1023/A:1022558715350

Hobbs, D. A., Givens, D. I., & Lovegrove, J. A. (2019). Yogurt consumption is associated with higher nutrient intake, diet quality and favourable metabolic profile in children: a cross-sectional analysis using data from years 1–4 of the National diet and Nutrition Survey, UK. *European Journal of Nutrition, 58*(1), 409–422. https://doi.org/10.1007/s00394-017-1605-x

Hohoff, E., Perrar, I., Jancovic, N., & Alexy, U. (2021). Age and time trends of dairy intake among children and adolescents of the DONALD study. *European Journal of Nutrition*. 1-12. https://doi.org/10.1007/s00394-021-02555-7

Hojer, R., Wistoft, K., & Frost, M. B. (2020, Oct 17). Play with Your Food and Cook It! Tactile Play with Fish as a Way of Promoting Acceptance of Fish in 11- to 13-Year-Old Children in a School Setting-A Qualitative Study. *Nutrients, 12*(10). https://doi.org/10.3390/nu12103180

Hollywood LE, Armstrong GA, Durkin MG (2007) Using behavioural and motivational thinking in food segmentation. *Int J Retail Distr Manag 35*, 691-702. https://doi.org/10.1108/09590550710773246 .

Hoppert, K., Zahn, S., Jänecke, L., Mai, R., Hoffmann, S., & Rohm, H. (2013). Consumer acceptance of regular and reduced-sugar yogurt enriched with different types of dietary fiber. *International Dairy Journal*, *28*(1), 1–7. https://doi.org/https://doi.org/10.1016/j.idairyj.2012.08.005

Hough, G., & Sosa, M. (2015). Food choice in low income populations – A review. Food *Quality and Preference, 40*, 334–342. https://doi.org/https://doi.org/10.1016/j.foodqual.2014.05.003

Huang, Y., Kypridemos, C., Liu, J., Lee, Y., Pearson-Stuttard, J., Collins, B., ... & Mozaffarian, D. (2019). Cost-effectiveness of the US Food and Drug Administration added sugar labeling policy for improving diet and health. *Circulation, 139*(23), 2613-2624. https://doi.org/10.1161/CIRCULATIONAHA.118.036751

Hutchings, S. C., Low, J. Y. Q., & Keast, R. S. J. (2018). Sugar reduction without compromising sensory perception. An impossible dream? *Critical Reviews in Food Science and Nutrition*, *59*(14), 2287-2307. https://doi.org/10.1080/10408398.2018.1450214

Hwang, S. M., Alfalah, S., Kwon, J. M., & Kudrowitz, B. (2020). Familiarity trumps playfulness: Exploring children's preferences for playful design of vegetables. *International Journal of Food Design, 5*(1-2), 43-64. https://doi.org/10.1386/ijfd_00009_1

Iglesia, I., Intemann, T., Miguel-Etayo, D., Pala, V., Hebestreit, A., Wolters, M., ... & Moreno, L. A. (2020). Dairy consumption at snack meal occasions and the overall quality of diet during childhood. Prospective and cross-sectional analyses from the IDEFICS/I. Family cohort*. Nutrients, 12*(3), 642. https://doi.org/10.3390/nu12030642

Ind, N., & Coates, N. (2013). The meaning of co-creation. *European Business Review, 25*. https://doi.org/10.1108/09555341311287754

Instituto Nacional de Estadística (2019). *Encuesta de Usos de Tecnologías de la Información y la Comunicación 2019.* Montevideo: Instituto Nacional de Estadística.

International Dairy Federation. (2018) *The world dairy situation 2018. Bulletin of the International Dairy Federation* (494/2018). https://fil-idf.org/wp-content/uploads/2018/10/WDS2018Preview-1.pdf

Izydorczyk, M. (2005). Understanding the chemistry of food carbohydrates. In S. W. Cui (Ed.), *Food Carbohydrates: Chemistry, Physical Properties, and Applications* (pp. 1–65). CRC Press.

Jacques, A., Chaaya, N., Beecher, K., Ali, S. A., Belmer, A., & Bartlett, S. (2019). The impact of sugar consumption on stress driven, emotional and addictive behaviors. *Neuroscience & Biobehavioral Reviews, 103*, 178–199. https://doi.org/https://doi.org/10.1016/j.neubiorev.2019.05.021

James, C. E., Laing, D. G., Oram, N., & Hutchinson, I. (1999). Perception of sweetness in simple and complex taste stimuli by adults and children. *Chemical Senses*, *24*(3), 281–287. https://doi.org/10.1093/chemse/24.3.281

Jelic, A., Martin, M., Laursen, L., Tvedebrink, T., Fich, L., & Oehlwein, L. (2020). *Children, play, and the built environment: What can we learn from co-creation and embodied cognitive science?* https://doi.org/10.13140/RG.2.2.11436.28803

Jiang, P., Ji, Q., Liu, Z., Snyder, L. A., Benard, L. M. J., Margolskee, R. F., & Max, M. (2004). The Cysteine-rich Region of T1R3 Determines Responses to Intensely Sweet Proteins*. *Journal of Biological Chemistry, 279*(43), 45068–45075. https://doi.org/https://doi.org/10.1074/jbc.M406779200

Jones, A., Shahid, M., Neal, B. (2018). Uptake of Australia's Health Star Rating System. *Nutrients, 30*, 997. https://doi.org/10.3390/nu10080997

Josse, A. R., Ludwa, I. A., Kouvelioti, R., Calleja, M., Falk, B., Ward, W. E., & Klentrou, P. (2020). Dairy product intake decreases bone resorption following a 12-week diet and exercise intervention in overweight and obese adolescent girls. *Pediatric Research, 88*(6), 910–916. https://doi.org/10.1038/s41390-020-0834-5

Kanekanian, A. (2014) The health benefits of bioactive compounds from milk and dairy products. In A. Kanekanian (Ed.), *Milk and dairy products as functional foods* (pp.1-22). John Wiley & Sons, Ltd.

Kanemaru, N., Harada, S., & Kasahara, Y. (2002). Enhancement of Sucrose Sweetness with Soluble Starch in Humans. *Chemical Senses, 27*(1), 67–72. https://doi.org/10.1093/chemse/27.1.67

Kanemaru, Norizaki; Harada, Shuitsu; Kasahara, Y. (2002). Enhancement of Sucrose Sweetness with Soluble Starch in Humans. *Chemical Senses*, *27*(1), 67–72. https://doi.org/10.1093/chemse/27.1.67

Kangas, M. (2010). Creative and playful learning: Learning through game co-creation and games in a playful learning environment. *Thinking Skills and Creativity, 5*(1), 1–15. https://doi.org/https://doi.org/10.1016/j.tsc.2009.11.001

Karageuzián, G., Vidal, L., de León, C., Girona, A., & Ares, G. (2021). Marketing of commercial foods for infant and young children in Uruguay: sugary products, health cues on packages and fun social products on Facebook. *Public Health Nutrition*, 1–13. https://doi.org/DOI:10.1017/S1368980021002780

Karalexi, M. A., Mitrogiorgou, M., Georgantzi, G. G., Papaevangelou, V., & Fessatou, S. (2018). Non-Nutritive Sweeteners and Metabolic Health Outcomes in Children: A Systematic Review and Meta-Analysis. *The Journal of Pediatrics*, *197*, 128-133.e2. https://doi.org/https://doi.org/10.1016/j.jpeds.2018.01.081

Katz, I., & Assor, A. (2006). When Choice Motivates and When It Does Not. Educational *Psychology Review, 19*(4), 429. https://doi.org/10.1007/s10648-006-9027-y

Kavey, R.-E. W. (2010). How Sweet It Is: Sugar-Sweetened Beverage Consumption, Obesity, and Cardiovascular Risk in Childhood. *Journal of the American Dietetic Association*, *110*(10), 1456–1460. https://doi.org/10.1016/j.jada.2010.07.028

Kelishadi, R., Mansourian, M., & Heidari-Beni, M. (2014). Association of fructose consumption and components of metabolic syndrome in human studies: A systematic review and meta-analysis. *Nutrition, 30*(5), 503–510. https://doi.org/https://doi.org/10.1016/j.nut.2013.08.014

Kraak, V. I., & Story, M. (2015). Influence of food companies’ brand mascots and entertainment companies’ cartoon media characters on children’s diet and health: a systematic review and research needs. *Obesity Reviews, 16*(2), 107–126. https://doi.org/https://doi.org/10.1111/obr.12237

Krippendorff, K. (2004). *Content analysis: An introduction to its methodology* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Kroh, L. W. (1994). Caramelisation in food and beverages. *Food Chemistry, 51*(4), 373–379. https://doi.org/https://doi.org/10.1016/0308-8146(94)90188-0

Labbe, D., Damevin, L., Vaccher, C., Morgenegg, C., & Martin, N. (2006). Modulation of perceived taste by olfaction in familiar and unfamiliar beverages. *Food Quality and Preference*, *17*(7–8), 582–589. https://doi.org/10.1016/j.foodqual.2006.04.006

Lafraire, J., Rioux, C., Giboreau, A., & Picard, D. (2016). Food rejections in children: Cognitive and social/environmental factors involved in food neophobia and picky/fussy eating behavior. *Appetite, 96*, 347–357. https://doi.org/https://doi.org/10.1016/j.appet.2015.09.008

Lakshman, R., Elks, C. E., & Ong, K. K. (2012). Childhood obesity. *Circulation, 126*(14), 1770-1779. https://doi.org/10.1161/CIRCULATIONAHA.111.047738

Lapierre, M. A., Brown, A. M., Houtzer, H. V, & Thomas, T. J. (2017). Child-directed and nutrition-focused marketing cues on food packaging: links to nutritional content. Public *Health Nutrition, 20*(5), 765–773. https://doi.org/DOI: 10.1017/S1368980016002317

Latorres, J. M., Mitterer-Daltoé, M. L., & Queiroz, M. I. (2016). Hedonic and Word Association Techniques Confirm a Successful Way of Introducing Fish into Public School Meals. *Journal of Sensory Studies, 31*(3), 206–212. https://doi.org/https://doi.org/10.1111/joss.12204

Laureati, M., Cattaneo, C., Lavelli, V., Bergamaschi, V., Riso, P., & Pagliarini, E. (2017). Application of the check-all-that-apply method (CATA) to get insights on children's drivers of liking of fiber-enriched apple purees. *Journal of Sensory Studies*, *32*(2), 1–9. https://doi.org/10.1111/joss.12253

Laureati, M., Pagliarini, E., Toschi, T. G., & Monteleone, E. (2015). Research challenges and methods to study food preferences in school-aged children: A review of the last 15years. *Food Quality and Preference, 46*, 92–102. https://doi.org/https://doi.org/10.1016/j.foodqual.2015.07.010

Lavriša, Ž., & Pravst, I. (2019). Marketing of Foods to Children through Food Packaging Is Almost Exclusively Linked to Unhealthy. *Foods. Nutrients*, *11*(5), 1128. https://doi.org/10.3390/nu11051128

Lawless, H. T., & Heymann, H. (2010). *Sensory evaluation of food: principles and practices.* Springer Science & Business Media.

Leask, C. F., Sandlund, M., Skelton, D. A., Altenburg, T. M., Cardon, G., Chinapaw, M. J. M., De Bourdeaudhuij, I., Verloigne, M., Chastin, S. F. M., GrandStand, S. S., & Teenage Girls on the Move Research, G. (2019). Framework, principles and recommendations for utilising participatory methodologies in the co-creation and evaluation of public health interventions. *Res Involv Engagem, 5*, 2. https://doi.org/10.1186/s40900-018-0136-9

Lee, A. K., Binongo, J. N. G., Chowdhury, R., Stein, A. D., Gazmararian, J. A., Vos, M. B., & Welsh, J. A. (2014). Consumption of less than 10% of total energy from added sugars is associated with increasing HDL in females during adolescence: a longitudinal analysis.

Journal of the American Heart Association, 3(1), e000615–e000615. https://doi.org/10.1161/JAHA.113.000615

Lee, H.-S., & O'Mahony, M. (2004). Sensory difference testing: Thurstonian models*. Food Science and Biotechnology*, *13*, 841–847.

Lei, L., Rangan, A. M., Flood, V. M., & Louie, J. C. Y. (2016). Dietary intake and food sources of added sugar in the Australian population – CORRIGENDUM. *British Journal of Nutrition, 116*(6), 1136. https://doi.org/DOI: 10.1017/S0007114516003093

Lenfant, F., Loret, C., Pineau, N., Hartmann, C., & Martin, N. (2009). Perception of oral food breakdown. The concept of sensory trajectory. *Appetite*, *52*(3), 659–667. https://doi.org/10.1016/j.appet.2009.03.003

Lethuaut, L., Brossard, C., Meynier, A., Rousseau, F., Llamas, G., Bousseau, B., & Genot, C. (2005). Sweetness and aroma perceptions in dairy desserts varying in sucrose and aroma levels and in textural agent. *International Dairy Journal, 15*(5), 485–493. https://doi.org/https://doi.org/10.1016/j.idairyj.2004.09.002

Letona, P., Chacon, V., Roberto, C., & Barnoya, J. (2014). Effects of licensed characters on children's taste and snack preferences in Guatemala, a low/middle income country. *International Journal of Obesity, 38*(11), 1466–1469. https://doi.org/10.1038/ijo.2014.38

Levin, A., & Levin, I. (2010). Packaging of healthy and unhealthy food products for children and parents: The relative influence of licensed characters and brand names*. Journal of Consumer Behaviour, 9*, 393–402. https://doi.org/10.1002/cb.326

Li, X. E., Lopetcharat, K., & Drake, M. (2014). Extrinsic Attributes That Influence Parents' Purchase of Chocolate Milk for Their Children. *Journal of Food Science, 79*(7), S1407–S1415. https://doi.org/10.1111/1750-3841.12515

Li, X. E., Lopetcharat, K., & Drake, M. A. (2015a). Parents' and Children's Acceptance of Skim Chocolate Milks Sweetened by Monk Fruit and Stevia Leaf Extracts. *Journal of Food Science*, *80*(5), S1083–S1092. https://doi.org/10.1111/1750-3841.12835

Li, X. E., Lopetcharat, K., Qiu, Y., & Drake, M. A. (2015b). Sugar reduction of skim chocolate milk and viability of alternative sweetening through lactose hydrolysis. *Journal of Dairy Science*, *98*(3), 1455–1466. https://doi.org/https://doi.org/10.3168/jds.2014-8490

Li, X., Staszewski, L., Xu, H., Durick, K., Zoller, M., & Adler, E. (2002). Human receptors for sweet and umami taste. *Proceedings of the National Academy of Sciences, 99*(7), 4692 LP – 4696. https://doi.org/10.1073/pnas.072090199

Liem, D. G., & Mennella, J. A. (2002). Sweet and sour preferences during childhood: role of early experiences. *Developmental psychobiology*, 41(4), 388–395. doi:10.1002/dev.10067

Lillford, P., & Hermansson, A. M. (2021). Global missions and the critical needs of food science and technology. *Trends in Food Science & Technology, 111*, 800-811. https://doi.org/https://doi.org/10.1016/j.tifs.2020.04.009

Lima, M., Ares, G., & Deliza, R. (2018a). Children and adults' sensory and hedonic perception of added sugar reduction in grape nectar. *Journal of Sensory Studies, 33*(2), e12317. https://doi.org/https://doi.org/10.1111/joss.12317

Lima, M., Ares, G., & Deliza, R. (2018b). How do front of pack nutrition labels affect healthfulness perception of foods targeted at children? Insights from Brazilian children and parents. *Food Quality and Preference*, *64*, 111–119. https://doi.org/10.1016/j.foodqual.2017.10.003

Lima, M., Ares, G., & Deliza, R. (2019). Comparison of two sugar reduction strategies with children: Case study with grape nectars. *Food Quality and Preference, 71*, 163–167. https://doi.org/https://doi.org/10.1016/j.foodqual.2018.07.002

Loth, K.A., Tate, A., Trofholz, A., Fisher, J.O., Neumark-Stzainer, D., & Berge, J.M. (2020). The contribution of snacking to overall diet intake among a ethnically/racially diverse population of boys and girls. *Journal of the Academy of Nutrition and Dietetics, 120*, 270-279. https://doi.org/10.1016/j.jand.2019.08.173

Louie, J. C. Y., Moshtaghian, H., Rangan, A. M., Flood, V. M., & Gill, T. P. (2016). Intake and sources of added sugars among Australian children and adolescents. *European Journal of Nutrition*, *55*(8), 2347–2355. https://doi.org/10.1007/s00394-015-1041-8

Luger, M., Lafontan, M., Bes-Rastrollo, M., Winzer, E., Yumuk, V., & Farpour-Lambert, N. (2017). Sugar-Sweetened Beverages and Weight Gain in Children and Adults: A Systematic Review from 2013 to 2015 and a Comparison with Previous Studies. *Obesity Facts, 10*(6), 674–693. https://doi.org/10.1159/000484566

Lund, M. N., & Ray, C. A. (2017). Control of Maillard Reactions in Foods: Strategies and Chemical Mechanisms. *Journal of Agricultural and Food Chemistry, 65*(23), 4537–4552. https://doi.org/10.1021/acs.jafc.7b00882

Ma, Y., He, F. J., Yin, Y., Hashem, K. M., & MacGregor, G. A. (2016). Gradual reduction of sugar in soft drinks without substitution as a strategy to reduce overweight, obesity, and type 2 diabetes: a modelling study. *The Lancet Diabetes & Endocrinology, 4*(2), 105–114. https://doi.org/10.1016/S2213-8587(15)00477-5

MacGregor, G.A., & Hashem, K.M. (2014). Action on sugar—lessons from UK salt reduction programme. *Lancet*, *383*(9921), 929-931. https://doi.org/10.1016/S0140-6736(14)60200-2

Mack, N. A., Rembert, D. G. M., Cummings, R., & Gilbert, J. E. (2019). Co-Designing an Intelligent Conversational History Tutor with Children. *Proceedings of the 18th ACM International Conference on Interaction Design and Children*, 482–487. https://doi.org/10.1145/3311927.3325336

Maschkowski, G., Hartmann, M. & Hoffmann, J. (2014). Health-related on-pack communication and nutritional value of ready-to-eat breakfast cereals evaluated against five nutrient profiling schemes. *BMC Public Health 14,* 1178. https://doi.org/10.1186/1471-2458-14-1178

Machado, K., Teylechea, P., Bermúdez, A., Lara, J., Geymonat, M., Girardi, F., ... & Pírez, C. (2018). Consumo de bebidas en niños de cuarto año escolar y su relación con sobrepeso-obesidad. *Archivos de Pediatría del Uruguay, 89*, 26-33. http://dx.doi.org/10.31134/ap.89.s1.3

Machado, P. P., Steele, E. M., Louzada, M. L. da C., Levy, R. B., Rangan, A., Woods, J., Gill, T., Scrinis, G., & Monteiro, C. A. (2020). Ultra-processed food consumption drives excessive free sugar intake among all age groups in Australia. *European Journal of Nutrition, 59*(6), 2783–2792. https://doi.org/10.1007/s00394-019-02125-y

Machín, L., Antúnez, L., Curutchet, M. R., & Ares, G. (2020a). The heuristics that guide healthiness perception of ultra-processed foods: a qualitative exploration. *Public Health Nutrition,* 1-9. doi:10.1017/S1368980020003158

Machín, L., Curutchet, M. R., Gugliucci, V., Vitola, A., Otterbring, T., de Alcantara, M., & Ares, G. (2020b). The habitual nature of food purchases at the supermarket: Implications for policy making. *Appetite, 155*, 104844. https://doi.org/10.1016/j.appet.2020.104844

Machín, L., Giménez, A., Curutchet, M. R., Martínez, J., & Ares, G. (2016). Motives Underlying Food Choice for Children and Perception of Nutritional Information Among Low-Income Mothers in a Latin American Country. *Journal of Nutrition Education and Behavior, 48*(7), 478-485. https://doi.org/https://doi.org/10.1016/j.jneb.2016.04.396

Mahato, D. K., Keast, R., Liem, D. G., Russell, C. G., Cicerale, S., & Gamlath, S. (2020). Sugar Reduction in Dairy Food: An Overview with Flavoured Milk as an Example. *Foods, 9*(10), 1400.

Mahoney, L. T., Burns, T. L., Stanford, W., Thompson, B. H., Witt, J. D., Rost, C. A., & Lauer, R. M. (1996). Coronary risk factors measured in childhood and young adult life are associated with coronary artery calcification in young adults: the Muscatine Study. *Journal of the American College of Cardiology, 27*(2), 277–284. https://doi.org/10.1016/0735-1097(95)00461-0

Malik, V. S., & Hu, F. B. (2015). Fructose and Cardiometabolic Health. *Journal of the American College of Cardiology, 66*(14), 1615–1624. https://doi.org/10.1016/j.jacc.2015.08.025

Mandolfo, M., Chen, S., & Noci, G. (2020). Co-creation in new product development: Which drivers of consumer participation? *International Journal of Engineering Business Management, 12*, 1847979020913764.

Mandrioli, D., Kearns, C. E., & Bero, L. A. (2016). Relationship between research outcomes and risk of bias, study sponsorship, and author financial conflicts of interest in reviews of the effects of artificially sweetened beverages on weight outcomes: a systematic review of reviews. *PloS One, 11*(9), e0162198.

Marty, L., Chambaron, S., Nicklaus, S., & Monnery-Patris, S. (2018). Learned pleasure from eating: An opportunity to promote healthy eating in children? *Appetite, 120*, 265-274. https://doi.org/10.1016/j.appet.2017.09.006

Martyn, D., Darch, M., Roberts, A., Lee, H. Y., Yaqiong Tian, T., Kaburagi, N., & Belmar, P. (2018). Low-/No-Calorie Sweeteners: A Review of Global Intakes. *Nutrients, 10*(3), 357. https://doi.org/10.3390/nu10030357

Maubach, N., Hoek, J., & McCreanor, T. (2009). An exploration of parents' food purchasing behaviours. *Appetite, 53*(3), 297–302. https://doi.org/https://doi.org/10.1016/j.appet.2009.07.005

Mayring, P. (2004). Qualitative content analysis. In U. Flick, E. von Kardoff, & I. Steinke (Eds.), *A companion to qualitative research* (Vol. 1, Issue 2, pp. 159–176).

McCain, H. R., Kaliappan, S., & Drake, M. A. (2018). Invited review: Sugar reduction in dairy products. *Journal of Dairy Science*, *101*(10), 8619–8640. https://doi.org/https://doi.org/10.3168/jds.2017-14347

McGale, L. S., Halford, J. C. G., Harrold, J. A., & Boyland, E. J. (2016). The Influence of Brand Equity Characters on Children's Food Preferences and Choices. *The Journal of Pediatrics, 177*, 33–38. https://doi.org/10.1016/j.jpeds.2016.06.025

Mehta, K., Phillips, C., Ward, P., Coveney, J., Handsley, E., & Carter, P. (2012). Marketing foods to children through product packaging: prolific, unhealthy and misleading. *Public*

Health Nutrition, 15(9), 1763–1770. https://doi.org/DOI: 10.1017/S1368980012001231

Mela, D. J. (2020). A proposed simple method for objectively quantifying free sugars in foods and beverages. *European journal of clinical nutrition, 74*(9), 1366-1368. https://doi.org/10.1038/s41430-020-0575-x

Mennella, J. A., & Bobowski, N. K. (2015). The sweetness and bitterness of childhood: Insights from basic research on taste preferences. *Physiology & Behavior*, *152*(Pt B), 502–507. https://doi.org/10.1016/j.physbeh.2015.05.015

Mennella, J. A., Bobowski, N. K., & Reed, D. R. (2016). The development of sweet taste: From biology to hedonics. *Reviews in Endocrine and Metabolic Disorders, 17*(2), 171-178. https://doi.org/10.1007/s11154-016-9360-5

Mennella, J. A., Finkbeiner, S., Lipchock, S. V., Hwang, L. D., & Reed, D. R. (2014). Preferences for salty and sweet tastes are elevated and related to each other during childhood. *PloS one*, *9*(3), e92201. https://doi.org/10.1371/journal.pone.0092201

Mennella, J. A., Pepino, M. Yanina, and Reed, D. R. (2006). Genetic and Environmental Determinants of Bitter Perception and Sweet Preferences. *Pediatrics*, *115*(2), e216–e222.

Mennella, J. A., Reed, D. R., Mathew, P. S., Roberts, K. M., & Mansfield, C. J. (2015). "A Spoonful of Sugar Helps the Medicine Go Down": Bitter Masking by Sucrose Among *Children and Adults. Chemical Senses, 40*(1), 17–25. https://doi.org/10.1093/chemse/bju053

Meyers, B., & Brewer, M. S. (2008). Sweet Taste in Man: A Review. *Journal of Food Science, 73*(6), R81–R90. https://doi.org/https://doi.org/10.1111/j.1750-3841.2008.00832.x

Ministerio de Salud. (2017). *Directriz para la vigilancia y fiscalización de la composición nutricional de los alimentos y su publicidad, de acuerdo al reglamento sanitario de los alimentos*. Santiago: Ministerio de Salud.

Ministerio de Salud Pública. (2016). *Guía alimentaria para la población uruguaya*. Montevideo: Ministerio de Salud Pública.

Ministerio de Salud Pública. (2019*). Interpelaciones y respuestas a las Enfermedades No Transmisibles en Uruguay*. https://www.paho.org/es/documentos/interpelaciones-respuestas-enfermedades-no-transmisibles-uruguay

Ministerio de Salud. (2018). *Manual para la aplicación del Decreto No 272/018 sobre rotulado frontal de alimentos*. https://www.gub.uy/ministerio-salud-publica/comunicacion/publicaciones/manual-para-la-aplicacion-del-decreto-no-272018-sobre-rotulado-frontal

Minz, S. W. (1985). Sweetness and Power: The Place of Sugar in Modern History. Penguin Books.

Moore, J. B., Horti, A., & Fielding, B. A. (2018). Evaluation of the nutrient content of yogurts: a comprehensive survey of yogurt products in the major UK supermarkets. *BMJ Open*, *8*(8), e021387. https://doi.org/10.1136/bmjopen-2017-021387

Moore, J. B., Sutton, E. H., & Hancock, N. (2020). Sugar Reduction in Yogurt Products Sold in the UK between 2016 and 2019. *Nutrients*, *12*(1), 171. https://doi.org/10.3390/nu12010171

Moreno, L. A., Bel-Serrat, S., Santaliestra-Pasías, A., & Bueno, G. (2015). Dairy products, yogurt consumption, and cardiometabolic risk in children and adolescents. *Nutrition Reviews, 73*(suppl_1), 8–14. https://doi.org/10.1093/nutrit/nuv014

Motoki, K., & Suzuki, S. (2020). Extrinsic factors underlying food valuation in the human brain. *Frontiers in Behavioral Neuroscience, 14*, 131. https://www.frontiersin.org/article/10.3389/fnbeh.2020.00131

Moynihan, P. J., & Kelly, S. A. M. (2014). Effect on caries of restricting sugars intake: systematic review to inform WHO guidelines. *Journal of Dental Research, 93*(1), 8–18. https://doi.org/10.1177/0022034513508954

Muth, M. K., Karns, S. A., Mancino, L., & Todd, J. E. (2019). How Much Can Product Reformulation Improve Diet Quality in Households with Children and Adolescents? *Nutrients, 11*(3), 618. https://doi.org/10.3390/nu11030618

Næs, T., Varela, P., & Berget, I. (2018). *Individual Differences in Sensory and Consumer Science: Experimentation, Analysis and Interpretation*. Woodhead Publishing.

Nelson, G., Hoon, M. A., Chandrashekar, J., Zhang, Y., Ryba, N. J. P., & Zuker, C. S. (2001). Mammalian Sweet Taste Receptors. *Cell, 106*(3), 381–390. https://doi.org/https://doi.org/10.1016/S0092-8674(01)00451-2

Nepper, M. J., & Chai, W. (2016). Parents' barriers and strategies to promote healthy eating among school-age children. *Appetite, 103*, 157-164. https://doi.org/10.1016/j.appet.2016.04.012

Neri, D., Martinez-Steele, E., Monteiro, C. A., & Levy, R. B. (2019). Consumption of ultra-processed foods and its association with added sugar content in the diets of US children, NHANES 2009-2014. *Pediatric Obesity, 14*(12), e12563. https://doi.org/https://doi.org/10.1111/ijpo.12563

Newens, K. J., & Walton, J. (2016). A review of sugar consumption from nationally representative dietary surveys across the world. *Journal of Human Nutrition and Dietetics*, *29*(2), 225–240. https://doi.org/10.1111/jhn.12338

Nguyen, D., Naffziger, E. E., & Berridge, K. C. (2021). Positive affect: nature and brain bases of liking and wanting. *Current Opinion in Behavioral Sciences, 39*, 72–78. https://doi.org/https://doi.org/10.1016/j.cobeha.2021.02.013

Nguyen, S. P., Girgis, H., & Robinson, J. (2015). Predictors of children's food selection: The role of children's perceptions of the health and taste of foods. *Food quality and preference*, 40 Pt A, 106–109. doi:10.1016/j.foodqual.2014.09.009

Nicklaus, S., & Remy, E. (2013). Early Origins of Overeating: Tracking Between Early Food Habits and Later Eating Patterns. *Current Obesity Reports*, *2*(2), 179–184. https://doi.org/10.1007/s13679-013-0055-x

Nicklaus, S., Boggio, V., Chabanet, C., & Issanchou, S. (2004). A prospective study of food preferences in childhood. *Food Quality and Preference*, *15*(7), 805–818. https://doi.org/https://doi.org/10.1016/j.foodqual.2004.02.010

Nie, Y., Vigues, S., Hobbs, J. R., Conn, G. L., & Munger, S. D. (2005). Distinct Contributions of T1R2 and T1R3 Taste Receptor Subunits to the Detection of Sweet Stimuli. *Current Biology, 15*(21), 1948–1952. https://doi.org/https://doi.org/10.1016/j.cub.2005.09.037

O'Neil, A., Quirk, S. E., Housden, S., Brennan, S. L., Williams, L. J., Pasco, J. A., Berk, M., & Jacka, F. N. (2014). Relationship between diet and mental health in children and adolescents: a systematic review. *American Journal of Public Health, 104*(10), e31–e42. https://doi.org/10.2105/AJPH.2014.302110

O'Neil, C. E., Nicklas, T. A., & Fulgoni, V. L. 3rd. (2018). Food Sources of Energy and Nutrients of Public Health Concern and Nutrients to Limit with a Focus on Milk and other Dairy Foods in Children 2 to 18 Years of Age: National Health and Nutrition Examination Survey, 2011−2014. *Nutrients, 10*(8). https://doi.org/10.3390/nu10081050

Obesity World Federation. (2019). *Atlas of Childhood Obesity.* https://data.worldobesity.org/publications/11996-Childhood-Obesity-Atlas-Report-ART-V2.pdf

Observatorio Granjero. (2021). *Mercado Modelo. Anuario estadístico 2020*. Montevideo: Ministerio de Ganadería, Agricultura y Pesca.

OECD/FAO. (2020). *OECD-FAO Agricultural Outlook 2020-2029, FAO*, Rome/OECD Publishing, Paris. https://doi.org/10.1787/1112c23b-en

Oellingrath, I. M., Hersleth, M., & Svendsen, M. V. (2013). Association between parental motives for food choice and eating patterns of 12- to 13-year-old Norwegian children. *Public Health Nutrition, 16*(11), 2023–2031. https://doi.org/10.1017/S1368980012004430

Oficina de Estadísticas Agropecuarias. (2020). *Estadísticas del Sector Lácteo 2019*. https://www.gub.uy/ministerio-ganaderia-agricultura-pesca/datos-y-estadisticas/estadisticas/estadisticas-del-sector-lacteo-2019

Ogle, A.D., Graham, D.J., Lucas-Thompson, R.G., Roberto, C.A. (2017). Influence of cartoon media characters on children's attention to and preference for food and beverage products. *Journal of the Academy of Nutrition and Dietetics*, 117, 265–270.

OHern, M. S., & Rindfleisch, A. (2010). Customer Co-Creation. In N. K. Malhotra (Ed.), *Review of Marketing Research* (Vol. 6, pp. 84–106). Emerald Group Publishing Limited. https://doi.org/10.1108/S1548-6435(2009)0000006008

Oliveira, D., Antúnez, L., Giménez, A., Castura, J. C., Deliza, R., & Ares, G. (2015). Sugar reduction in probiotic chocolate-flavored milk: Impact on dynamic sensory profile and liking. *Food Research International*, *75*, 148–156. https://doi.org/10.1016/j.foodres.2015.05.050

Oliveira, D., Reis, F., Deliza, R., Rosenthal, A., Giménez, A., & Ares, G. (2016). Difference thresholds for added sugar in chocolate-flavoured milk: Recommendations for gradual sugar reduction. *Food Research International*, *89*, 448–453. https://doi.org/https://doi.org/10.1016/j.foodres.2016.08.019

Ollberding, N. J., Wolf, R. L., & Contento, I. (2010). Food label use and its relation to dietary intake among US adults. *Journal of the American Dietetic Association, 110*(8), 1233-1237. https://doi.org/10.1016/j.jada.2010.05.007

Olsen, N. V. (2015). Design Thinking and food innovation. *Trends in Food Science & Technology, 41*(2), 182-187. https://doi.org/10.1016/j.tifs.2014.10.001

Onita, B. M., Azeredo, C. M., Jaime, P. C., Levy, R. B., & Rauber, F. (2021). Eating context and its association with ultra-processed food consumption by British children. *Appetite, 157*, 105007. https://doi.org/https://doi.org/10.1016/j.appet.2020.105007

Ortez, M., Bir, C., Olynk Widmar, N., & Townsend, J. (2021). Dairy product purchasing in households with and without children. *JDS Communications, 2*(1), 7–12. https://doi.org/10.3168/jdsc.2020-19305

Øverby, N. C., Lillegaard, I. T. L., Johansson, L., & Andersen, L. F. (2004). High intake of added sugar among Norwegian children and adolescents. *Public Health Nutrition, 7*(2), 285–293. https://doi.org/DOI: 10.1079/PHN2003515

Paglia, L., Friuli, S., Colombo, S., & Paglia, M. (2019). The effect of added sugars on children's health outcomes: Obesity, Obstructive Sleep Apnea Syndrome (OSAS), Attention-Deficit/Hyperactivity Disorder (ADHD) and Chronic Diseases. *European Journal of Paediatric Dentistry, 20*(2), 127–132. https://doi.org/10.23804/ejpd.2019.20.02.09

Pagliarini, E., Gabbiadini, N., & Ratti, S. (2005). Consumer testing with children on food combinations for school lunch. *Food Quality and Preference, 16*(2), 131–138. https://doi.org/https://doi.org/10.1016/j.foodqual.2004.03.001

Pan American Health Organization. (2020). *Front-of-Package Labeling as a Policy Tool for the Prevention of Noncommunicable Diseases in the Americas*. Washington DC: Pan American Health Organization.

Pan American Health Organization. (2020). *Strategic Plan of the Pan American Health Organization 2020-2025: Equity at the Heart of Health. PAHO.* https://iris.paho.org/bitstream/handle/10665.2/52473/9789275173619_eng.pdf?sequence=5&isAllowed=y

Park, Y. C., Oh, E. J., Jo, J. H., Jin, Y. S., & Seo, J. H. (2016). Recent advances in biological production of sugar alcohols. *Current Opinion in Biotechnology, 37*, 105–113. https://doi.org/https://doi.org/10.1016/j.copbio.2015.11.006

Parsons, S., Guldberg, K., Porayska-Pomsta, K., & Lee, R. (2015). Digital stories as a method for evidence-based practice and knowledge co-creation in technology-enhanced learning for children with autism. *International Journal of Research & Method in Education, 38*(3), 247–271.

Pepino, M. Y. (2015). Physiology & Behavior Metabolic effects of non-nutritive sweeteners. *Physiology & Behavior*, *152*, 450–455. https://doi.org/10.1016/j.physbeh.2015.06.024

Pepino, M. Y., & Mennella, J. A. (2005). Factors contributing to individual differences in sucrose preference. *Chemical Senses*, *30* SUPPL. (suppl 1), 319–320. https://doi.org/10.1093/chemse/bjh243

Peres, M. A, Sheiham, A., Liu, P., Demarco, F. F., Silva, A. E. R., Assunção, M. C., Menezes, A. M., Barros, F. C., & Peres, K. G. (2016). Sugar consumption and changes in dental caries from childhood to adolescence. *Journal of Dental Research, 95*(4), 388–394. https://doi.org/10.1177/0022034515625907

Peres, M. A, Macpherson, L. M. D., Weyant, R. J., Daly, B., Venturelli, R., Mathur, M. R., Listl, S., Celeste, R. K., Guarnizo-Herreño, C. C., Kearns, C., Benzian, H., Allison, P., &

Watt, R. G. (2019). Oral diseases: a global public health challenge. *The Lancet, 394*(10194), 249–260. https://doi.org/10.1016/S0140-6736(19)31146-8

Perrar, I., Schmitting, S., Della Corte, K. W., Buyken, A. E., & Alexy, U. (2020). Age and time trends in sugar intake among children and adolescents: results from the DONALD study. *European Journal of Nutrition, 59*(3), 1043–1054. https://doi.org/10.1007/s00394-019-01965-y

Piernas, C., & Popkin, B.M. (2010). Snacking increased among U.S. adults between 1977 and 2006. *The Journal of Nutrition, 140*, 325–332. https://doi.org/10.3945/jn.109.112763

Pineau, N., Schlich, P., Cordelle, S., Mathonnière, C., Issanchou, S., Imbert, A., … Köster, E. (2009). Temporal Dominance of Sensations: Construction of the TDS curves and comparison with time-intensity. *Food Quality and Preference*, *20*(6), 450–455. https://doi.org/10.1016/j.foodqual.2009.04.005

Pineli, L. de L. de O., Aguiar, L. A. de, Fiusa, A., Botelho, R. B. de A., Zandonadi, R. P., & Melo, L. (2016). Sensory impact of lowering sugar content in orange nectars to design healthier, low-sugar industrialized beverages. *Appetite, 96*, 239–244. https://doi.org/https://doi.org/10.1016/j.appet.2015.09.028

Piqueras-Fiszman, B., & Spence, C. (2015). Sensory expectations based on product-extrinsic food cues: An interdisciplinary review of the empirical evidence and theoretical accounts. *Food Quality and Preference, 40*, 165–179. https://doi.org/https://doi.org/10.1016/j.foodqual.2014.09.013

Pires, C., & Agante, L. (2011). Encouraging children to eat more healthily: The influence of packaging. *Journal of Consumer Behaviour, 10*(3), 161–168. https://doi.org/10.1002/cb.362

Poelman, A. A. M., Delahunty, C. M., & de Graaf, C. (2015). Vegetable preparation practices for 5–6 years old Australian children as reported by their parents; relationships with liking and consumption. *Food Quality and Preference, 42*, 20–26. https://doi.org/https://doi.org/10.1016/j.foodqual.2015.01.005

Poinot, P., Arvisenet, G., Ledauphin, J., Gaillard, J., Poinot, P., Arvisenet, G., … Prost, C. (2013). How can aroma–related cross–modal interactions be analysed? A review of current methodologies. *Food Quality and Preference*, *28* (1), 304-316.

Popkin, B. M., & Reardon, T. (2018). Obesity and the food system transformation in Latin America. *Obesity Reviews, 19*(8), 1028–1064. https://doi.org/https://doi.org/10.1111/obr.12694

Popkin, B.M. (2017). Relationship between shifts in food system dynamics and acceleration of the global nutrition transition. *Nutrition Reviews*, *75*, 73–82. https://doi.org/10.1093/nutrit/nuw064

Popkin, B. M., & Hawkes, C. (2016). Sweetening of the global diet, particularly beverages: patterns, trends, and policy responses. *The Lancet. Diabetes & Endocrinology, 4*(2), 174–186. https://doi.org/10.1016/S2213-8587(15)00419-2

Popper, R., & Kroll, J. J. (2011). 9 - Consumer testing of food products using children. In D. Kilcast & F. Angus (Eds.), *Woodhead Publishing Series in Food Science, Technology and Nutrition, Developing Children's Food Products* (pp. 163–187). Woodhead Publishing. https://doi.org/https://doi.org/10.1533/9780857091130.3.163

Poti, J. M., Slining, M. M., & Popkin, B. M. (2014). Where Are Kids Getting Their Empty Calories? Stores, Schools, and Fast-Food Restaurants Each Played an Important Role in Empty Calorie Intake among US Children During 2009-2010. *Journal of the Academy of Nutrition and Dietetics*, *114*(6), 908–917. https://doi.org/https://doi.org/10.1016/j.jand.2013.08.012

Potvin Kent, M., Cameron, C., & Philippe, S. (2017). The healthfulness and prominence of sugar in child-targeted breakfast cereals in Canada. Les bienfaits pour la santé et la prédominance du sucre dans les céréales pour déjeuner destinées aux enfants au Canada. *Health promotion and chronic disease prevention in Canada : research, policy and practice*, *37*(9), 266–273. https://doi.org/10.24095/hpcdp.37.9.02. https://doi.org/10.24095/hpcdp.37.9.02

Powell, E. S., Smith-Taillie, L. P., & Popkin, B. M. (2016). Added sugars intake across the distribution of US children and adult consumers: 1977-2012. *Journal of the Academy of Nutrition and Dietetics, 116*(10), 1543–1550. https://doi.org/10.1016/j.jand.2016.06.003

Prawira, M., & Barringer, S. A. (2009). Effects of conching time and ingredients on preference of milk chocolate. *Journal of Food Processing and Preservation, 33*(5), 571–589. https://doi.org/https://doi.org/10.1111/j.1745-4549.2008.00272.x

Prahalad, C. K., & Ramaswamy, V. (2002). The co-creation connection*. Strategy and Business*, 50–61.

Prescott, J. (2015). Multisensory processes in flavour perception and their influence on food choice. *Current Opinion in Food Science*, *3*, 47–52. https://doi.org/10.1016/j.cofs.2015.02.007

Proserpio, C., Laureati, M., Invitti, C., Pasqualinotto, L., Bergamaschi, V., & Pagliarini, E. (2016). Cross-modal interactions for custard desserts differ in obese and normal weight Italian women. *Appetite*, *100*, 203–209. https://doi.org/10.1016/j.appet.2016.02.033

Qutteina, Y., Hallez, L., Mennes, N., De Backer, C., & Smits, T. (2019). What do adolescents see on social media? A diary study of food marketing images on social media. *Frontiers in psychology, 10*, 2637. https://doi.org/10.3389/fpsyg.2019.02637

R Core Team (2020). A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing.

Rafferty, A., Gray, V.B., Nguyen, J., Nguyen-Rodriguez, S., Barrack, M., & Lin, S. (2018). Parents Report Competing Priorities Influence Snack Choice in Youth Sports. *Journal of Nutrition Education and Behavior, 50*, 1032-1039. https://doi.org/10.1016/j.jneb.2018.04.275

Rauber, F., Louzada, M., Martinez Steele, E., Rezende, L., Millett, C., Monteiro, C. A., & Levy, R. B. (2019). Ultra-processed foods and excessive free sugar intake in the UK: a nationally representative cross-sectional study. *BMJ open, 9*(10), e027546. https://doi.org/10.1136/bmjopen-2018-027546

Reed, D. R., Mainland, J. D., & Arayata, C. J. (2019). Sensory nutrition: The role of taste in the reviews of commercial food products. *Physiology and Behavior*, *209*. https://doi.org/10.1016/j.physbeh.2019.112579

Reeve, B., & Magnusson, R. (2015). Food reformulation and the (neo)-liberal state: new strategies for strengthening voluntary salt reduction programs in the UK and USA. *Public health, 129*(4), 351–363. https://doi.org/10.1016/j.puhe.2015.01.007.

Rizzoli, R. (2014). Dairy products, yogurts, and bone health. *The American Journal of Clinical Nutrition, 99*(5), 1256S-1262S. https://doi.org/10.3945/ajcn.113.073056

Roberto, C. A., Baik, J., Harris, J. L., & Brownell, K. D. (2010). Influence of licensed characters on children's taste and snack preferences. *Pediatrics, 126*(1), 88-93. https://doi.org/10.1542/peds.2009-3433

Roberts, D. L., & Darler, W. (2017). Consumer Co-Creation: An Opportunity to Humanise the New Product Development Process. *International Journal of Market Research, 59*(1), 13–33. https://doi.org/10.2501/IJMR-2017-003

Rodríguez-Monforte, M., Sánchez, E., Barrio, F., Costa, B., & Flores-Mateo, G. (2017). Metabolic syndrome and dietary patterns: a systematic review and meta-analysis of observational studies. *European Journal of Nutrition, 56*(3), 925–947. https://doi.org/10.1007/s00394-016-1305-y

Rollins, B. Y., Stein, W., Keller, K. L., & Savage, J. S. (2021). Preschoolers will drink their GREENS! Children accept, like, and drink novel smoothies containing dark green vegetables (DGVs). *Appetite, 162*, 105148. https://doi.org/https://doi.org/10.1016/j.appet.2021.105148

Rosenstein, D., & Oster, H. (1988). Differential Facial Responses to Four Basic Tastes in Newborns. *Child Development, 59*(6), 1555–1568. https://doi.org/10.2307/1130670

Rundh, B. (2016). The role of packaging within marketing and value creation. *British Food Journal, 118*(10), 2491–2511. https://doi.org/10.1108/BFJ-10-2015-0390

Russell, C. G., & Russell, A. (2018). Biological and Psychosocial Processes in the Development of Children's Appetitive Traits: Insights from Developmental Theory and Research. *Nutrients, 10*(6), 692. https://doi.org/10.3390/nu10060692

Russell, C. G., Burke, P. F., Waller, D. S., & Wei, E. (2017). The impact of front-of-pack marketing attributes versus nutrition and health information on parents' food choices. *Appetite, 116*, 323-338. https://doi.org/10.1016/j.appet.2017.05.001

Russell, C. G., Worsley, A., & Liem, D. G. (2015). Parents' food choice motives and their associations with children's food preferences. *Public Health Nutrition, 18*(6), 1018–1027. https://doi.org/10.1017/S1368980014001128

Ruth, S.M., Witte, L.D., Uriarte, A. R. (2004). Volatile Flavor Analysis and Sensory Evaluation of Custard Desserts Varying in Type and Concentration of Carboxymethyl Cellulose. *Journal of Agricultural and Food Chemistry*, *52* (26), 8105–8110.

Sadeghirad, B., Duhaney, T., Motaghipisheh, S., Campbell, N. R. C., & Johnston, B. C. (2016). Influence of unhealthy food and beverage marketing on children's dietary intake and preference: a systematic review and meta-analysis of randomized trials. *Obesity Reviews, 17*(10), 945–959. https://doi.org/10.1111/obr.12445

Sahin, A. W., Zannini, E., Coffey, A., & Arendt, E. K. (2019). Sugar reduction in bakery products: Current strategies and sourdough technology as a potential novel approach. *Food Research International, 126*, 108583. https://doi.org/https://doi.org/10.1016/j.foodres.2019.108583

Saint-Eve, A., Paçi Kora, E., & Martin, N. (2004). Impact of the olfactory quality and chemical complexity of the flavouring agent on the texture of low fat stirred yogurts assessed by three different sensory methodologies. *Food Quality and Preference*, *15*(7), 655–668. https://doi.org/https://doi.org/10.1016/j.foodqual.2003.09.002

Sambra, V., López-Arana, S., Cáceres, P., Abrigo, K., Collinao, J., Espinoza, A., ... & Gotteland, M. (2020). Overuse of non-caloric sweeteners in foods and beverages in

Chile: a threat to consumers' free choice?. *Frontiers in nutrition, 7*, 68. https://doi.org/10.3389/fnut.2020.00068

Satia, J. A., Galanko, J. A., & Neuhouser, M. L. (2005). Food nutrition label use is associated with demographic, behavioral, and psychosocial factors and dietary intake among African Americans in North Carolina. *Journal of the American Dietetic Association, 105*(3), 392-402. https://doi.org/10.1016/j.jada.2004.12.006

Savant, L., & McDaniel, M. R. (2004). Suppression of sourness: a comparative study involving mixtures of organic acids and sugars. *Perception & Psychophysics, 66*(4), 642–650.

Scaglioni, S., Arrizza, C., Vecchi, F., & Tedeschi, S. (2011). Determinants of children’s eating behavior. *The American Journal of Clinical Nutrition, 94*(suppl_6), 2006S-2011S. https://doi.org/10.3945/ajcn.110.001685

Schifferstein, H. N. J. (2015). Employing consumer research for creating new and engaging food experiences in a changing world. *Current Opinion in Food Science, 3*, 27-32. https://doi.org/10.1016/j.cofs.2014.11.004

Schifferstein, H. N. J., & Frijters, J. E. R. (1991). The effectiveness of different sweeteners in suppressing citric acid sourness*. Perception & Psychophysics, 49*(1), 1–9.

Schifferstein, H. N. J., & Verlegh, P. W. J. (1996). The role of congruency and pleasantness in odor-induced taste enhancement. *Acta Psychologica*, *94*(1), 87–105. https://doi.org/10.1016/0001-6918(95)00040-2

Schouteten, J. J., De Steur, H., Lagast, S., De Pelsmaeker, S., & Gellynck, X. (2017). Emotional and sensory profiling by children and teenagers: A case study of the check-all-that-apply method on biscuits. *Journal of Sensory Studies*, *32*(1), 1–11. https://doi.org/10.1111/joss.12249

Schwartz, M. B., Vartanian, L. R., Wharton, C. M., & Brownell, K. D. (2008). Examining the Nutritional Quality of Breakfast Cereals Marketed to Children. Journal of the American *Dietetic Association, 108*(4), 702–705. https://doi.org/https://doi.org/10.1016/j.jada.2008.01.003

Secretaría de Economía. (2020, April). *Modificación a la Norma Oficial Mexicana NOM-051-SCFI/SSA1-2010*. https://www.dof.gob.mx/2020/SEECO/NOM_051.pdf

Shriver, L.H., Marriage, B.J., Bloch, T.D., Spees, C.K., Ramsay, S.A. Watowicz, R.P., et al. (2017). Contribution of snacks to dietary intakes of young children in the United States. *Maternal & Child Nutrition, 14*, e12454. https://doi.org/10.1111/mcn.12454

Simmonds, G., & Spence, C. (2017). Thinking inside the box: How seeing products on, or through, the packaging influences consumer perceptions and purchase behaviour. *Food Quality and Preference, 62*, 340-351. https://doi.org/10.1016/j.foodqual.2016.11.010

Smith, S. M., Sumar, B., & Dixon, K. A. (2014). Musculoskeletal pain in overweight and obese children. *International Journal of Obesity*, *38*(1), 11–15. https://doi.org/10.1038/ijo.2013.187

Sodini, I., Remeuf, F., Haddad, S., & Corrieu, G. (2004). The Relative Effect of Milk Base, Starter, and Process on Yogurt Texture: A Review. *Critical Reviews in Food Science and Nutrition, 44*(2), 113–137. https://doi.org/10.1080/10408690490424793

Song, H., Halvorsen, B., & Harley, A. (2014). Marketing cereal to children: content analysis of messages on children's and adults' cereal packages. *International Journal of Consumer Studies, 38*(6), 571–577. https://doi.org/10.1111/ijcs.12116

Soo, J., Letona, P., Chacon, V., Barnoya, J., & Roberto, C. A. (2016). Nutritional quality and child-oriented marketing of breakfast cereals in Guatemala. *International Journal of Obesity, 40*(1), 39–44. https://doi.org/10.1038/ijo.2015.161

Spence, C. (2015). Multisensory Flavor Perception. *Cell*, *161*(1), 24–35. https://doi.org/10.1016/J.CELL.2015.03.007

Spencer, G. (2014). *Empowerment, health promotion, and young people – A critical approach.* New York, NY: Routledge.

Spill, M. K., Birch, L. L., Roe, L. S., & Rolls, B. J. (2011). Hiding vegetables to reduce energy density: an effective strategy to increase children's vegetable intake and reduce energy intake. *The American Journal of Clinical Nutrition, 94*(3), 735–741. https://doi.org/10.3945/ajcn.111.015206

Steele, E. M., Baraldi, L. G., da Costa Louzada, M. L., Moubarac, J. C., Mozaffarian, D., & Monteiro, C. A. (2016). Ultra-processed foods and added sugars in the US diet: evidence from a nationally representative cross-sectional study. *BMJ open, 6*(3), e009892. http://dx.doi.org/10.1136/bmjopen-2015-009892

Steiner, J. E., Glaser, D., Hawilo, M. E., & Berridge, K. C. (2001). Comparative expression of hedonic impact: affective reactions to taste by human infants and other primates. *Neuroscience & Biobehavioral Reviews, 25*(1), 53–74. https://doi.org/https://doi.org/10.1016/S0149-7634(00)00051-8

Stevenson, R. J. (1999). Confusing Tastes and Smells: How Odours can Influence the Perception of Sweet and Sour Tastes. *Chemical Senses, 24*(6), 627-63. https://doi.org/10.1093/chemse/24.6.627

Stevenson, Richard J, Prescott, J., & Boakes, R. A. (1995). The acquisition of taste properties by odors. *Learning and Motivation*, *26*(4), 433–455. https://doi.org/https://doi.org/10.1016/S0023-9690(05)80006-2

Storcksdieck genannt Bonsmann, S., Robinson, M., Wollgast, J., & Caldeira, S. (2019). The ineligibility of food products from across the EU for marketing to children according to two EU-level nutrient profile models. *PloS one, 14*(10), e0213512. https://doi.org/10.1371/journal.pone.0213512

Stylianopoulos, C. (2013a). Carbohydrates: Chemistry and Classification. In E. Caballero (Ed.) *Encyclopedia of Human Nutrition* (pp. 265–271). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-375083-9.00041-6

Stylianopoulos, C. (2013b). Carbohydrates: Regulation of Metabolism. In E. Caballero (Ed.) *Encyclopedia of Human Nutrition* (pp. 265–271). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-375083-9.00042-8

Suez, J., Korem, T., Zeevi, D., Zilberman-Schapira, G., Thaiss, C. A., Maza, O., Israeli, D., Zmora, N., Gilad, S., Weinberger, A., Kuperman, Y., Harmelin, A., Kolodkin-Gal, I., Shapiro, H., Halpern, Z., Segal, E., & Elinav, E. (2014). Artificial sweeteners induce glucose intolerance by altering the gut microbiota. *Nature, 514*(7521), 181–186. https://doi.org/10.1038/nature13793

Sullivan, S. A., & Birch, L. L. (1990). Pass the sugar, pass the salt: Experience dictates preference. *Developmental Psychology, 26*(4), 546.

Sun, S. Z., & Empie, M. W. (2012). Fructose metabolism in humans – what isotopic tracer studies tell us. *Nutrition & Metabolism, 9*(1), 89. https://doi.org/10.1186/1743-7075-9-89

Sutaria, S., Devakumar, D., Yasuda, S. S., Das, S., & Saxena, S. (2019). Is obesity associated with depression in children? Systematic review and meta-analysis. *Archives of Disease in Childhood, 104*(1), 64–74.

Swinburn, B.A., Kraak, V.I., Allender, S., Atkins, V.J., Baker, P.I., Bogard, J.R., et al. (2019). The Global Syndemic of Obesity, Undernutrition, and Climate Change: The Lancet Commission report. *The Lancet*, *393*, 791-846. https://doi.org/10.1016/S0140-6736(18)32822-8

Swithers, S. E. (2015). Artificial sweeteners are not the answer to childhood obesity. *Appetite, 93*, 85–90. https://doi.org/https://doi.org/10.1016/j.appet.2015.03.027

Swithers, S. E., Martin, A. A., & Davidson, T. L. (2010). High-intensity sweeteners and energy balance. *Physiology and Behavior*, *100*(1), 55–62. https://doi.org/10.1016/j.physbeh.2009.12.021

Sylvetsky, A. C., Welsh, J. A., Brown, R. J., & Vos, M. B. (2012). Low-calorie sweetener consumption is increasing in the United States. *The American Journal of Clinical Nutrition, 96*(3), 640–646. https://doi.org/10.3945/ajcn.112.034751

Taillie, L. S., Busey, E., Stoltze, F. M., & Dillman Carpentier, F. R. (2019). Governmental policies to reduce unhealthy food marketing to children. *Nutrition Reviews, 77*(11), 787–816. https://doi.org/10.1093/nutrit/nuz021

Taillie, L.S., Afeiche, M.C., Eldridge, A.L., & Popkin, B.M. (2015). Increased snacking and eating occasions are associated with higher energy intake among Mexican children aged 2–13 years. *Journal of Nutrition. 145*, 2570–2577. https://doi.org/10.3945/jn.115.213165

Takemi, Y., & Woo, T. (2017). Comparison of sweetness preference and motivational factors between Korean and Japanese children. *Journal of Nutrition and Health, 50*(1). https://doi.org/10.4163/jnh.2017.50.1.53

Tan, K. Y. M., van der Beek, E. M., Kuznesof, S. A., & Seal, C. J. (2016). Perception and understanding of health claims on milk powder for children: A focus group study among mothers in Indonesia, Singapore and Thailand. *Appetite, 105*, 747–757. https://doi.org/https://doi.org/10.1016/j.appet.2016.06.034

Tappy, L., & Rosset, R. (2019). Health outcomes of a high fructose intake: the importance of physical activity. *The Journal of Physiology, 597*(14), 3561–3571. https://doi.org/https://doi.org/10.1113/JP278246

Taskinen, M. R., Söderlund, S., Bogl, L. H., Hakkarainen, A., Matikainen, N., Pietiläinen, K. H., ... & Boren, J. (2017). Adverse effects of fructose on cardiometabolic risk factors and hepatic lipid metabolism in subjects with abdominal obesity. *Journal of internal medicine, 282*(2), 187-201. https://doi.org/https://doi.org/10.1111/joim.12632

Tatzer, E., Schubert, M. T., Timischl, W., & Simbruner, G. (1985). Discrimination of taste and preference for sweet in premature babies. *Early Human Development, 12*(1), 23–30. https://doi.org/https://doi.org/10.1016/0378-3782(85)90133-1

Te Morenga, L., Mallard, S., & Mann, J. (2013). Dietary sugars and body weight: systematic review and meta-analyses of randomised controlled trials and cohort studies. *BMJ, 346*. https://doi.org/10.1136/bmj.e7492

The, N. S., Suchindran, C., North, K. E., Popkin, B. M., & Gordon-Larsen, P. (2010). Association of adolescent obesity with risk of severe obesity in adulthood. *JAMA, 304*(18), 2042–2047. https://doi.org/10.1001/jama.2010.1635

Thomas-Danguin, T., Sinding, C., Tournier, C., & Saint-Eve, A. (2016). Multimodal interactions. In P. Etievant, P., E. Guichard, C. Salles, & A. E. Voilley (Eds.), *Flavor: From Food to Behaviors, Wellbeing and Health* (pp. 121-141). Woodhead Publishing. https://doi.org/10.1016/B978-0-08-100295-7.00006-2

Toews, I., Lohner, S., de Gaudry, D. K., Sommer, H., & Meerpohl, J. J. (2019). Association between intake of non-sugar sweeteners and health outcomes: systematic review and meta-analyses of randomised and non-randomised controlled trials and observational studies*. Bmj, 364*. https://doi.org/10.1136/bmj.k4718

Torrico, D. D., Tam, J., Fuentes, S., Gonzalez Viejo, C., & Dunshea, F. R. (2020). Consumer rejection threshold, acceptability rates, physicochemical properties, and shelf-life of strawberry-flavored yogurts with reductions of sugar. *Journal of the Science of Food and Agriculture, 100*(7), 3024–3035. https://doi.org/https://doi.org/10.1002/jsfa.10333

Tournier, C., Sulmont-Rossé, C., Guichard, E. (2007). Flavour perception: aroma, taste and texture interactions. In: N. Benkeblia (Ed.), *Food* (p. 246-257). Takamatsu, JPN : Global Science Books. https://prodinra.inra.fr/record/25814

Tournier, C., Sulmont-Rossé, C., Sémon, E., Vignon, A., Issanchou, S., & Guichard, E. (2009). A study on texture-taste-aroma interactions: Physico-chemical and cognitive mechanisms. *International Dairy Journal*, *19*(8), 450-458. https://doi.org/10.1016/j.idairyj.2009.01.003

Tunes da Silva, G., Logan, B.R., & Klein, J.P. (2008). Methods for Equivalence and Noninferiority Testing. *Biology of Blood Marrow Transplant, 15*(1), 120-127.

Tuten, T.L. (2010). Conducting online surveys. In SD Gosling, J.A. Johnson (Eds.), *Advanced methods for conducting online behavioral research*, pp. 179-192. Washington DC: sAmerican Psychological Association.

UNICEF, WHO, The World Bank. (2021). *Levels and trends in child malnutrition: key findings of the 2021 edition*. Geneva: World Health Organization.

UNICEF. (1989). *Convention on the rights of the child*. New York: UNICEF.

UNICEF. (2019). *The state of the world's children 2019. Children, food and nutrition. Growing well in a changing world*. New York: UNICEF.

UNICEF. (2020*). Una mirada a la alimentación de los escolares. El primer paso para comer mejor.* https://www.unicef.org/uruguay/media/4331/file/Una mirada a la alimentación de los escolares.pdf

Vaajakallio, K., Lee, J.-J., & Mattelmäki, T. (2009). “It Has to Be a Group Work!”: Co-Design with Children. *Proceedings of the 8th International Conference on Interaction Design and Children*, 246–249. https://doi.org/10.1145/1551788.1551843

Vaisey, M., Brunon, R., & Cooper, J. (1969). Some Sensory Effects of Hydrocolloid Sols on Sweetness. *Journal of Food Science*, *34*(5), 397–400. https://doi.org/10.1111/j.1365-2621.1969.tb12788.x

van Bommel, R., Stieger, M., Schlich, P., & Jager, G. (2019). Dutch consumers do not hesitate: Capturing implicit ‘no dominance’ durations using Hold-down Temporal Dominance methodologies for Sensations (TDS) and Emotions (TDE). *Food Quality and Preference*, *71*, 332-342. https://doi.org/10.1016/j.foodqual.2018.08.008

van der Horst, K., Ferrage, A., & Rytz, A. (2014). Involving children in meal preparation. Effects on food intake. *Appetite, 79*, 18–24. https://doi.org/https://doi.org/10.1016/j.appet.2014.03.030

Van Herpen, E., & Van Trijp, H. C. (2011). Front-of-pack nutrition labels. Their effect on attention and choices when consumers have varying goals and time constraints. *Appetite, 57*(1), 148-160. https://doi.org/10.1016/j.appet.2011.04.011

Van Hout, D., Hautus, M. J., & Lee, H. S. (2011). Investigation of test performance over repeated sessions using signal detection theory: Comparison of three nonattribute-specified difference tests 2-AFCR, A-NOT A and 2-AFC. *Journal of Sensory Studies, 26*(5), 311-321. https://doi.org/10.1111/j.1745-459X.2011.00346.x

van Kleef, E., van Trijp, H. C. M., & Luning, P. (2005). Consumer research in the early stages of new product development: a critical review of methods and techniques. *Food Quality and Preference, 16*(3), 181-201. https://doi.org/10.1016/j.foodqual.2004.05.012

Van Mechelen, M., Gielen, M., vanden Abeele, V., Laenen, A., & Zaman, B. (2014). Exploring Challenging Group Dynamics in Participatory Design with Children. *Proceedings of the 2014 Conference on Interaction Design and Children*, 269–272. https://doi.org/10.1145/2593968.2610469

van Stokkom, V. L., Poelman, A. A. M., de Graaf, C., van Kooten, O., & Stieger, M. (2018). Sweetness but not sourness enhancement increases acceptance of cucumber and green capsicum purees in children. *Appetite, 131*, 100–107. https://doi.org/https://doi.org/10.1016/j.appet.2018.08.034

Velázquez, A. L., Vidal, L., Alcaire, F., Varela, P., & Ares, G. (2021). Significant sugar-reduction in dairy products targeted at children is possible without affecting hedonic perception. *International Dairy Journal*, 104937. https://doi.org/https://doi.org/10.1016/j.idairyj.2020.104937

Velázquez, A. L., Vidal, L., Varela, P., & Ares, G. (2020). Cross-modal interactions as a strategy for sugar reduction in products targeted at children: Case study with vanilla milk desserts. *Food Research International*, *130*, 108920. https://doi.org/https://doi.org/10.1016/j.foodres.2019.108920

Veldhuizen, M. G., Babbs, R. K., Patel, B., Fobbs, W., Kroemer, N. B., Garcia, E., ... & Small, D. M. (2017). Integration of sweet taste and metabolism determines carbohydrate reward. *Current Biology, 27*(16), 2476-2485. https://doi.org/10.1016/j.cub.2017.07.018

Vennerød, F. F. F., Nicklaus, S., Lien, N., & Almli, V. L. (2018). The development of basic taste sensitivity and preferences in children. *Appetite, 127*, 130-137. https://doi.org/10.1016/j.appet.2018.04.027

Ventura, A. K., & Mennella, J. A. (2011). Innate and learned preferences for sweet taste during childhood. *Current Opinion in Clinical Nutrition & Metabolic Care, 14*(4). https://journals.lww.com/co-clinicalnutrition/Fulltext/2011/07000/Innate_and_learned_preferences_for_sweet_taste.12.aspx

Verwaeren, J., Gellynck, X., Lagast, S., & Schouteten, J. J. (2019). Predicting children's food choice using check-all-that-apply questions. *Journal of Sensory Studies, 34*(1). https://doi.org/10.1111/joss.12471

Vidal, L., Barreiro, C., Gómez, B., Ares, G., & Giménez, A. (2013). Influence of Information on Consumers' Evaluations Using Check-All-That-Apply Questions and Sorting: A Case Study with Milk Desserts. *Journal of Sensory Studies*, *28*(2), 125–137. https://doi.org/10.1111/joss.12030

Voorberg, W.H., Bekkers, V.J.J.M., Tummers, L.G. (2015). A Systematic Review of Co-Creation and Co-Production: Embarking on the social innovation journey. *Public Management Review*, 17, 1333-1357

Vos, M. B., Kaar, J. L., Welsh, J. A., Van Horn, L. V., Feig, D. I., Anderson, C. A. M., Patel, M. J., Cruz Munos, J., Krebs, N. F., Xanthakos, S. A., & Johnson, R. K. (2017). Added sugars and cardiovascular disease risk in children: A scientific statement from the *American Heart Association. Circulation, 135*(19), e1017–e1034. https://doi.org/10.1161/CIR.0000000000000439

Vyth, E. L., Hendriksen, M. A. H., Roodenburg, A. J. C., Steenhuis, I. H. M., van Raaij, J. M. A., Verhagen, H., Brug, J., & Seidell, J. C. (2012). Consuming a diet complying with front-of-pack label criteria may reduce cholesterol levels: a modeling study. *European Journal of Clinical Nutrition, 66*(4), 510–516. https://doi.org/10.1038/ejcn.2011.193

Waddingham, S., Shaw, K., Van Dam, P., & Bettiol, S. (2018). What motivates their food choice? Children are key informants. *Appetite, 120*, 514-522. https://doi.org/10.1016/j.appet.2017.09.029

Wagoner, T. B., McCain, H. R., Foegeding, E. A., & Drake, M. A. (2018). Food texture and sweetener type modify sweetness perception in whey protein-based model foods. *Journal of Sensory Studies, 33*(4), e12333. https://doi.org/https://doi.org/10.1111/joss.12333

Wagoner, T. B., Çakır-Fuller, E., Drake, M., & Foegeding, E. A. (2019). Sweetness perception in protein-polysaccharide beverages is not explained by viscosity or critical overlap concentration. *Food Hydrocolloids, 94*, 229–237. https://doi.org/https://doi.org/10.1016/j.foodhyd.2019.03.010

Walters, L. M., & Stacey, J. E. (2009). Focus on food: development of the Cooking with Kids experiential nutrition education curriculum. *Journal of Nutrition Education and Behavior, 41*(5), 371-373. https://doi.org/10.1016/j.jneb.2009.01.004

Wang, G., Bakke, A. J., Hayes, J. E., & Hopfer, H. (2019). Demonstrating cross-modal enhancement in a real food with a modified ABX test. *Food Quality and Preference, 77*, 206–213. https://doi.org/https://doi.org/10.1016/j.foodqual.2019.05.007

Wang, G., Hayes, J., Ziegler, G., Roberts, R., & Hopfer, H. (2018). Dose-Response Relationships for Vanilla Flavor and Sucrose in Skim Milk: Evidence of Synergy. *Beverages*, *4*(4), 73. https://doi.org/10.3390/beverages4040073

Wang, J. W., Mark, S., Henderson, M., O'Loughlin, J., Tremblay, A., Wortman, J., Paradis, G., & Gray-Donald, K. (2013). Adiposity and glucose intolerance exacerbate components of metabolic syndrome in children consuming sugar-sweetened beverages: QUALITY cohort study. *Pediatric Obesity, 8*(4), 284–293. https://doi.org/10.1111/j.2047-6310.2012.00108.x

Wang, J., Shang, L., Light, K., O'Loughlin, J., Paradis, G., & Gray-Donald, K. (2015). Associations between added sugar (solid vs. liquid) intakes, diet quality, and adiposity indicators in Canadian children. *Applied Physiology, Nutrition, and Metabolism, 40*(8), 835–841.

Wardle, J., & Cooke, L. (2008). Genetic and environmental determinants of children's food preferences. *British Journal of Nutrition*, *29*(SUPPL.1), 15–21. https://doi.org/10.1017/S000711450889246X

Weihrauch-Blüher, S., Schwarz, P., & Klusmann, J.-H. (2019). Childhood obesity: increased risk for cardiometabolic disease and cancer in adulthood. *Metabolism, 92*, 147–152. https://doi.org/10.1016/j.metabol.2018.12.001

Welsh, J. A., & Cunningham, S. A. (2011). The Role of Added Sugars in Pediatric Obesity. *Pediatric Clinics of North America, 58*(6), 1455–1466. https://doi.org/https://doi.org/10.1016/j.pcl.2011.09.009

Wiss, D. A., Avena, N., & Rada, P. (2018). Sugar addiction: from evolution to revolution. *Frontiers in psychiatry, 9*, 545. https://www.frontiersin.org/article/10.3389/fpsyt.2018.00545

Wittekind, A., & Walton, J. (2014). Worldwide trends in dietary sugars intake. *Nutrition Research Reviews, 27*(2), 330–345. https://doi.org/DOI: 10.1017/S0954422414000237

Wong, T. H. T., Mok, A., Ahmad, R., Rangan, A., & Louie, J. C. Y. (2019). Intake of free sugar and micronutrient dilution in Australian children and adolescents. *European Journal of Nutrition, 58*(6), 2485–2495. https://doi.org/10.1007/s00394-018-1801-3

World Health Organization (2015*). Guideline: sugars intake for adults and children.* https://apps.who.int/iris/handle/10665/149782

World Health Organization. (2013). *Global action plan for the prevention and control of noncommunicable diseases 2013-2020.* https://www.who.int/publications/i/item/9789241506236

World Health Organization. (2014). *Global nutrition targets 2025: policy brief series* (WHO/NMH/NHD/14.2). https://www.who.int/publications/i/item/WHO-NMH-NHD-14.2

World Health Organization. (2017a). *Report of the Commission on Ending Childhood Obesity. Implementation plan: executive summary.* https://apps.who.int/iris/bitstream/handle/10665/259349/WHO-NMH-PND-ECHO-17.1-eng.pdf?sequence=1#:~:text=In 2016 an estimated 42,5 were overweight or obese.&text=The report of the Commission,countries to address childhood obesity.

World Health Organization. (2017b). *WHO | Childhood overweight and obesity.* https://www.who.int/dietphysicalactivity/childhood/en/

World Health Organization. (2020). *Mental health*. https://www.who.int/health-topics/mental-health#tab=tab_3

Yang, Q., Zhang, Z., Gregg, E. W., Flanders, W. D., Merritt, R., & Hu, F. B. (2014). Added Sugar Intake and Cardiovascular Diseases Mortality Among US Adults. *JAMA Internal Medicine, 174*(4), 516–524. https://doi.org/10.1001/jamainternmed.2013.13563

Yeung, C. H. C., Gohil, P., Rangan, A. M., Flood, V. M., Arcot, J., Gill, T. P., & Louie, J. C. Y. (2017). Modelling of the impact of universal added sugar reduction through food reformulation. *Scientific Reports, 7*(1), 17392. https://doi.org/10.1038/s41598-017-17417-8

Yoshida-Montezuma, Y., Ahmed, M., & Ezezika, O. (2020). Does gamification improve fruit and vegetable intake in adolescents? a systematic review*. Nutrition and Health, 26*(4), 347–366. https://doi.org/10.1177/0260106020936143

Zandstra, E. H., & de Graaf, C. (1998). Sensory perception and pleasantness of orange beverages from childhood to old age. *Food Quality and Preference, 9*(1), 5–12. https://doi.org/https://doi.org/10.1016/S0950-3293(97)00015-3

Zheng, T. (2016). Using Halton Sequences in Random Parameters Logit Models. *Journal of Statistical and Econometric Methods*, 5, 59-86

Zorn, S., Alcaire, F., Vidal, L., Giménez, A., & Ares, G. (2014). Application of multiple-sip temporal dominance of sensations to the evaluation of sweeteners. *Food Quality and Preference*, *36*, 135–143. https://doi.org/10.1016/j.foodqual.2014.04.003

APPENDIXES

Appendix 1. Volatile compounds identified by Static Head Space Gas Chromatography in two vanilla flavorings (A and B)

Compound[1]	LRI	% Peak Area	
		Vanilla A	Vanilla B
Anisole	1319	20.0	2.4
p-Methylanisole	1415	2.4	0.3
Furfural	1447	33.9	1.8
Benzaldehyde	1493	7.4	59.4
5-methyl furfural	1553	0.4	nd
4-Propylanisole	1587	0.5	0.1
Ethyl levulinate	1592	4.0	nd
3-Methylbenzaldehyde	1614	9.1	nd
Furfuryl alcohol	1646	1.5	0.1
p-Dimethoxybenzene	1712	0.4	nd
Benzene-1,3-dimethyoxy-	1719	0.8	nd
Ethyl salicylate	1773	5.7	nd
Phenol, 2-ethoxy-	1825	5.0	28.0
Benzyl alcohol	1849	6.6	0.4
gamma.-Butylbutyrolactone	1878	nd	3.2
NI (124)	1914	0.1	0.9
Benzaldehyde, 4-methoxy-	1985	2.2	0.9
Ethyl vainillin 137 166	2481	0.0	2.5

[1]Compounds identified by comparison of their linear retention indices (LRI) and fragmentation patterns with those of published data and databases (Wiley FFNSC library 2015, NIST08, version 2.0, National Institute of Standards and Technology, Gaithersburg, MD, USA).

Appendix 2. Question guide of the preliminary session

Question guide of the preliminary session held to introduce children to the topic of healthy eating through a group discussion

- What foods are healthy? Why?
- What foods are unhealthy? Why?
- *A series of 4 labels of fictious foods were presented to children. For each product, the following questions are asked*: Do you think this product is healthy? Why?
- *An example of a nutrient declaration is shown, and the following questions are asked:* Do you know what this information means? Have you read it?
- *Front-of package nutritional warning signs are shown and the following questions are asked:* Do you know these symbols? What do you think they mean? What would you do if you find these symbols on a food?

Appendix 3. Workshops scripts

SESSION 1

1. Welcome & moderator introduction

Hello! How are you? Did you know we were coming today? We came last week. Do you remember us? (Guessing name game). I am (moderator’s name), I am (moderator's name) and this is (assistant’s name).

2. Introduction to the purpose of the workshop

Do you know what are we going to do today?

The idea is that you can create your own healthy dairy product with the ingredients we have here. At the end, you'll be able to taste your products.

- *Verbal assent: Children are asked if they want to participate and if there are any questions, emphasizing that the activity is voluntary.*

You'll work as a team to create your own dairy product. First, you'll choose the ingredients for your product. Everybody must agree with the chosen ingredients. So, you will have to convince your team members if they don’t want to add something you want.

3. Dairy products definition

Do you know what is a dairy product? (Prompt children to participate)

- *A brief explanation is provided after children's answer: Dairy products are products that are made with milk.*

Which products made with milk do you know? (Prompt children to participate)

4. Ingredient’s exploration

- *Present the ingredients in the following order: dairy base, vegetables, fruits, spices & sugar and grains & nuts. Let children guess the name of the ingredients. Allow children to observe and smell the ingredients. If they want to taste them, distribute a portion of the ingredient to each child.*

Dairy products:

Today we brought different dairy products, which have different textures, to give you some examples of the types of dairy products you can create.

The ingredients are shown, and the following questions are asked: What is it? Do you know it? Have you tried it before? (Prompt children to participate)

- *Ask children to guess which ingredients were added to produce the texture (e.g., dairy gel, chia dessert, mousse). Complement children’s discussion with a brief explanation of the ingredients added to the dairy bases.*

Other ingredients:

We also brought other groups of ingredients. You should choose at least one ingredient from the other groups.

The ingredients are shown, and the following questions are asked: What it is? Do you know it?

5. Product development

Now that you have explored everything, you should choose which ingredients you want to use to create your own healthy dairy product.

First, you must choose the dairy base you want to use. You should choose only one dairy base. Discuss with your team which dairy product you want to use.

- *Allow children to discuss and select the dairy base on their own. Prompt all children to participate. If necessary, help children to reach a consensus.*

You should choose at least one ingredient from the other groups. You can choose more than one of each ingredient's group. How much you add of each ingredient is up to you. You will decide everything by yourself. Are there any questions?

- *Allow children to prepare the product on their own. Prompt all children to participate. If necessary, help children to reach a consensus during the process.*

Let's get started…

- *Help children if needed (e.g. cutting ingredients)*

6. Product tasting

Let's taste your product!

- *Help children to serve the product*

Now that you tasted your product... Did you like it? Why?

If you could prepare the product again, would you like to change something?

- *Prompt all children to participate in the discussion*

7. Poster creation

You have created your new healthy dairy product. Now, you will create a poster like those you find in bus stops to promote your product among other children.

- *Use the template to guide the poster creation. Help children to fill the template and prompt all children to participate in the discussion*

8. Session closure

- *Ask children if they enjoyed the session and thank them for participating*

SESSION 2

1. Welcome & moderator introduction

Hello! How are you? Did you know we were coming today? We came last week. Do you remember us? I am (moderator's name), I am (moderator's name) and this is (assistant's name).

2. Introduction to the purpose of the workshop

Do you remember what we did last week?

- *Give a summary of session 1 after children answer.*

Did you like the products you created?

Some of you liked the products, but some of you said you didn't like them. You told us some things you would like to change. We took all your ideas and thought how we could make some products that you would like. Then, we created four products based on your ideas, but we want to know if you like them or not. So, today you will be the judges.

- *Verbal assent: Children are asked if they want to participate and if there are any questions, emphasizing that the activity is voluntary.*

3. Product evaluation

Let's get started…

- *Distribute questionnaires and explain the scale to the children. Ask if there are any questions*
- *Evaluate the products one by one. Ensure children evaluate each product individually*

How much did you like it?

How does it taste? Do you know which ingredients we added?

- *Allow children to guess the ingredients and then tell children the ingredients of the product. Prompt all children to participate in the discussion*

4. Session closure

- *Ask children if they enjoyed the session and thank them for participating*

Appendix 4. Ingredients presented to children

Children were presented with dairy products with different textures: UHT whole milk (Conaprole, Uruguay), commercial plain skimmed unsweetened yogurt (Conaprole, Uruguay), dairy milk dessert, yogurt gel, yogurt mousse and chia milk dessert. The dairy milk dessert was prepared using UHT whole milk, 5.2% w/w starch (Purity HPC, Ingredion, Brazil), 0.1% w/w polyphosphate and 0.02% w/w carrageenan (Ticaloid® 710H Stabilizer - Texture Innovation Center, TIC GUMS, PA, USA). Powdered ingredients were mixed with the whole milk and heated at 90°C under constant stirring for 5 min using a Thermomix (Vorwerk Mexico S. de R.L. de C.V., Mexico City, Mexico). The yogurt gel was prepared using 65% w/w plain skimmed yogurt, 32% w/w UHT whole milk and 3% w/w gelatin (Bloom 220, Abastecimientos, Uruguay). All ingredients were stirred for 5 min using a hand mixer (Robert Bosch, München, Germany). The yogurt mousse was prepared by whipping the plain skimmed yogurt for 8 min with a hand mixer. The chia dessert was prepared by hydrating 11% w/w chia seeds in UHT whole milk over 24 h. All dairy bases were stored for 24 h at 6-8°C prior to the workshop.

For the workshop, 300 mL of each base dairy product were served in a transparent disposable plastic cup with lid. All the vegetables, fruits, spices, cereals, and nuts were provided in small portions. For the vegetables, purees of pumpkin, beetroot, carrot, and spinach were made. Individual portions of 50 ml of vegetable puree were placed in transparent disposable plastic cups with lids and stored for 24 h at 6-8°C prior to the workshop. Tomato and cucumber were not processed. The fruits were packaged in individual portions before the session. Five medium strawberries (~150g) and three pineapple slices (~150g) were provided in disposable trays covered with transparent plastic film. Blueberries (60g) were placed in transparent disposable plastic cups. A whole piece of banana, orange and apple were included in each ingredient set. All vegetables and fruits were washed before use. Children received the cacao, cinnamon, peppermint and all the grains and nuts (70-80g) in resealable plastic bags. Vanilla, lemon juice, lemon peel and sugar (18g) were given in plastic cups with lids. Sugar was pre-weighed to provide children with 6g per 100 ml of base dairy product to ensure a lower sugar content compared to the most popular commercial products in Uruguay (7 – 12% added sugar). However, the restriction on sugar quantity was not mentioned to the children during the development of the activity.

Appendix 5. Poster template

How would you invite other children to try your product?
Make a poster to promote the product you created.

Product name

What is it?

Which are the ingredients? What does it taste like? How does it feel? How does it look? What does it smell like?

What image would you include to promote your product?

Describe it here

Why should other children try it?

Team

Name	Age

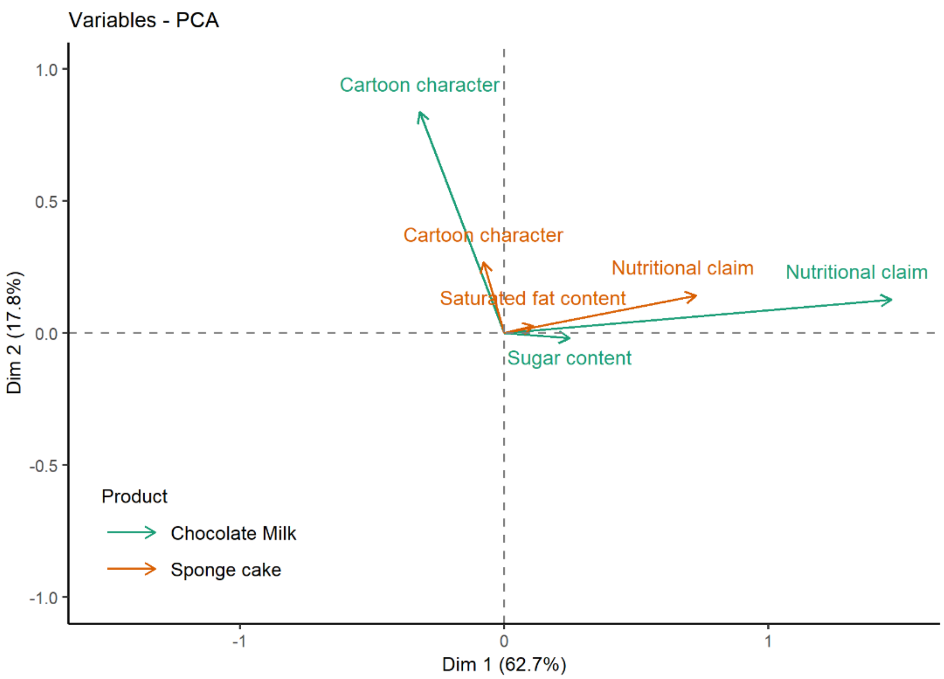
Appendix 6. Characteristics of choice sets used in the study.

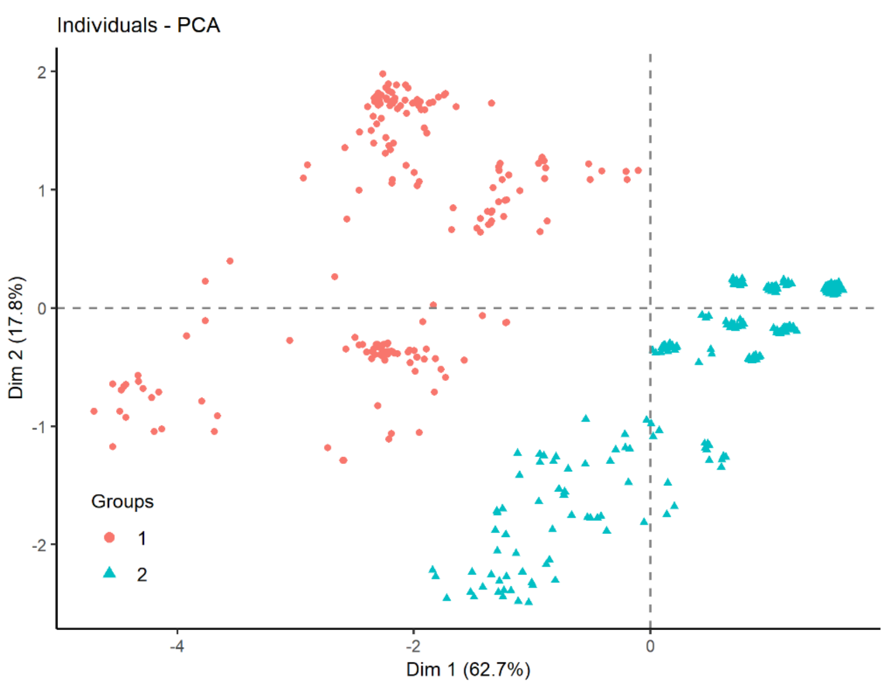
Choice Set	**Alternative***	**Cartoon character**	**Nutrient content**	**Nutritional claim**
1	1 CC/LN	Present	Low	Absent
	2 HN/CL	Absent	High	Present
2	3 LN/CL	Absent	Low	Present
	4 CC/LN	Present	High	Absent
3	5 HN	Absent	High	Absent
	6 CC/LN/CL	Present	Low	Present
4	7 CC/HN/CL	Present	High	Present
	8 LN	Absent	Low	Absent

Note: Details of the variables and the levels are shown in Table 4.2.

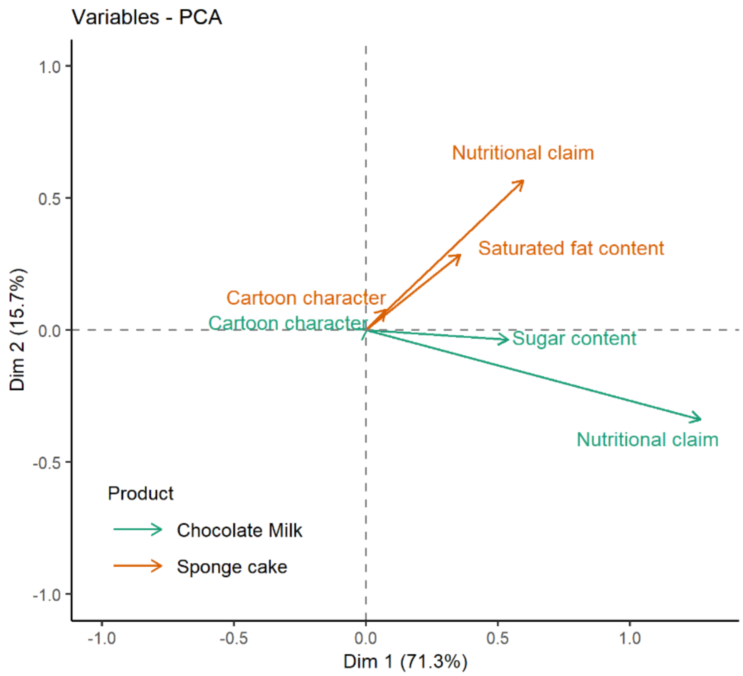
* CC: presence of the cartoon character; LN: low nutrient content; HN: high nutrient content; CL: presence of nutritional claim.

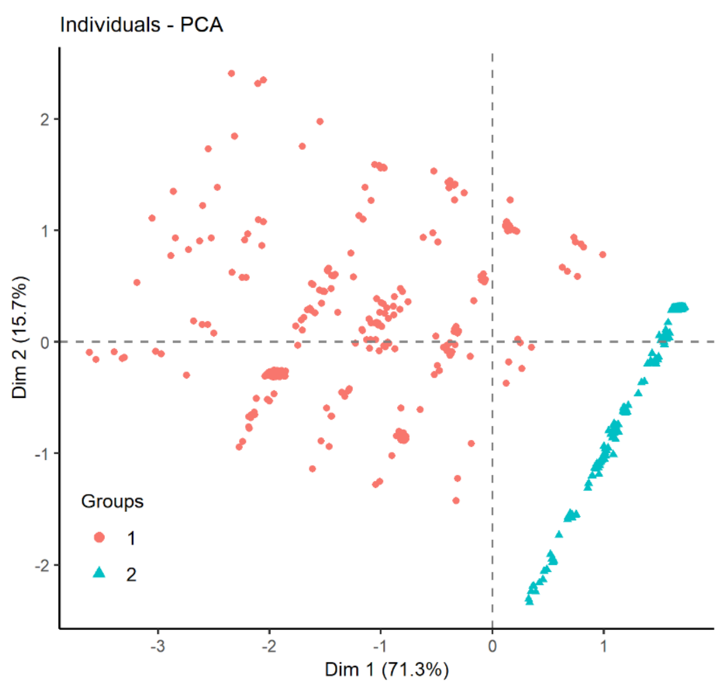
Appendix 7. Representation of the coefficients and the individuals in the first two dimensions of the Principal Component Analysis performed on the individual coefficients extracted from the mixed logit model used for estimating the effect of label information on mothers' choice of snacks for their children. Variables corresponding to coefficients of the two products (chocolate milk and sponge cake) are shown with different colors in the variables plot. The two groups of mothers identified by hierarchical cluster analysis are shown in the score plot of the individuals with different markers and colors.





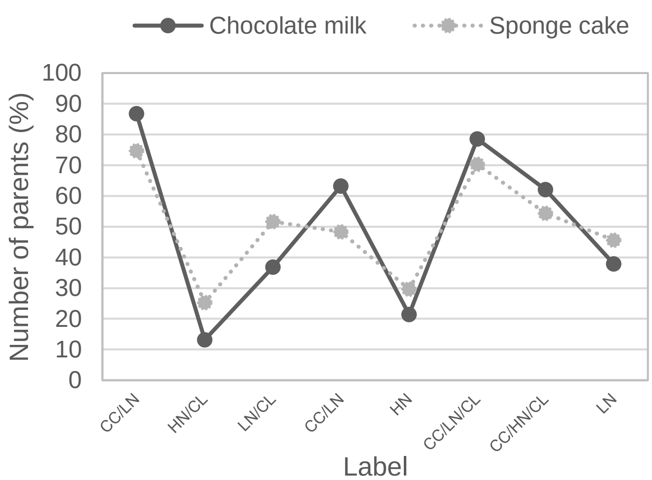
Appendix 8. Representation of the coefficients and the individuals in the first two dimensions of the Principal Component Analysis performed on the individual coefficients extracted from the mixed logit model used for estimating the effect of label information on mothers' healthiness perception of snacks. Variables corresponding to coefficients of the two products (chocolate milk and sponge cake) are shown with different colors in the variables plot. The two groups of mothers identified by hierarchical cluster analysis are shown in the score plot of the individuals with different markers and colors.



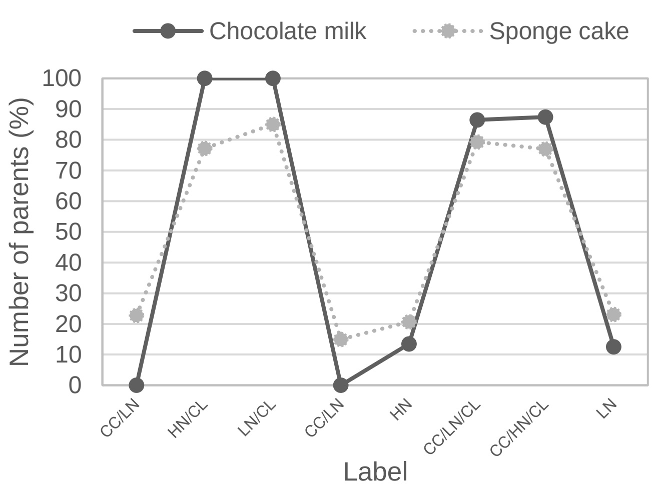


Appendix 9. Frequency of selection of labels in the choice conjoint task on mothers' choice of snacks for their children for the groups identified in the Hierarchical cluster analysis: a) Group 1, b) Group 2. Abbreviations in the name of the labels indicate presence of the cartoon character (CC), low nutrient content (LN), high nutrient content (HN) and presence of nutritional claim (CL).

a)

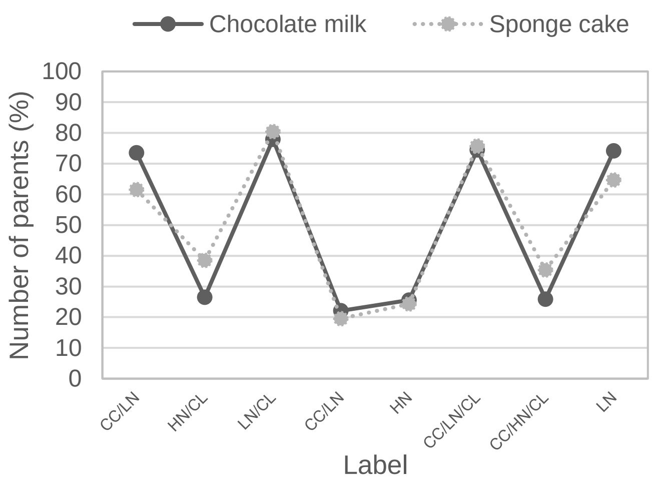


b)



Appendix 10. Frequency of selection of labels in the choice conjoint task mothers' healthiness perception of snacks for the groups identified by the hierarchical cluster analysis: a) Group 1, b) Group 2. Abbreviations in the name of the labels indicate presence of the cartoon character (CC), low nutrient content (LN), high nutrient content (HN) and presence of nutritional claim (CL).

a)



b)