


REVIEW

Sugar reduction in products targeted at children: Why are we not there yet?

Ana Laura Velázquez^{1,2}  | Leticia Vidal¹  | Paula Varela³  | Gastón Ares¹

¹Sensometrics & Consumer Science, Instituto Polo Tecnológico de Pando, Facultad de Química, Universidad de la República, Pando, Uruguay

²Graduate Program in Chemistry, Facultad de Química, Universidad de la República, Pando, Uruguay

³Nofima AS, Ås, Norway

Correspondence

Paula Varela, Nofima AS, P.O. Box 210, 1431 Ås, Norway.

Email: paula.varela.tomasco@nofima.no

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Abstract

Sugar intake among children has raised concern worldwide as it exceeds nutritional recommendations. Sugar contributes to the daily energy intake, without providing additional nutritional value and is associated with several negative health outcomes. Sugars added to foods during industrial processing have been identified as the main source of sugar in children's diets. The present work critically discusses the role of the food industry in contributing to children's excessive sugar intake worldwide, and the strategies that have been encouraged or implemented to reduce the sugar content in products targeted at children. The risk of the current sugar reduction practices in products targeted at children is discussed based on recent scientific evidence. Children's heightened preference for sweetness may not justify the availability of highly sugary products for children. Although research suggests that children readily accept less sweet products, there is still some wariness in the food industry to reduce sweetness intensity. This has strengthened the use of non-nutritive sweeteners (NNS), focusing on maintaining the sweetness level. However, emerging evidence suggests that this may not be the best approach.

Practical applications

Research shows that significant sugar reduction is feasible in products targeted at children without affecting hedonic perception, even if sweetness is reduced. The scientific evidence discussed in the present work challenges traditional approaches to sugar reduction and gives real life, practical recommendations for practitioners. All stakeholders (industry, food and health researchers, and policy makers) involved in the reformulation of products targeted at children are encouraged to prioritize children's best interest and protect their right to a healthy diet.

1 | INTRODUCTION

Childhood overweight and obesity is one of the most important public health problems worldwide, affecting 5.9% of children under 5 and 18.4% of 5–19 year old children (UNICEF, 2019). Overweight and obesity during childhood has negative short-term and long-term effects on health and wellbeing, including increased risk for

cardiovascular diseases, type 2 diabetes, and cancer, as well as increased likelihood of suffering depression and other psychological disorders (Sutaria, Devakumar, Yasuda, Das, & Saxena, 2019; Weihrauch-Blüher, Schwarz, & Klusmann, 2019). The magnitude of the adverse consequences of childhood overweight and obesity will only become fully visible in several years (Ludwig, 2007). Despite global concern, no country has been successful yet in reducing the

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prevalence of childhood overweight and obesity in the last 20 years (Garrido-Miguel et al., 2019; UNICEF, WHO, & The World Bank, 2020). This stresses the need to urgently develop effective multifaceted approaches to curb the pandemic.

The global childhood obesity pandemic is the result of the complex interaction of socioeconomic, cultural, and demographic changes that have created an obesogenic environment that promotes unhealthy diets and a sedentary lifestyle (Meldrum, Morris, & Gambone, 2017). Children's diets are far from optimal, being characterized by a low consumption of fruits and vegetables and an excess of products high in sugar, saturated fat and sodium (UNICEF, 2019). In particular, sugar intake among children has raised concern worldwide as it exceeds recommendations (Perrar, Schmitting, Della Corte, Buyken, & Alexy, 2020; Powell, Smith-Taillie, & Popkin, 2016; Wittekind & Walton, 2014).

The World Health Organization recommends that adults and children should limit their daily intake of free sugars to less than 10% of their total energy intake and emphasizes that a reduction below 5% would provide additional health benefits (World Health Organization, 2015). However, despite differences in the estimation of dietary sugars among countries (Wittekind & Walton, 2014), published data shows that this recommendation is not met in most countries (Afeiche, Koyratty, Wang, Jacquier, & Lê, 2018; Cediél et al., 2018; Farro, Montero, Vergara, & Ríos-Castillo, 2018; Powell et al., 2016). For example, added sugar accounted for 16% of total energy intake of 6–11 years old children in the United States (Powell et al., 2016) and for 12% of the total energy intake of 4–13 years Mexican children (Afeiche et al., 2018), whereas in European countries the intake of added sugars varies between 11 and 17% of the total dietary energy intake (Wittekind & Walton, 2014). Sugar contributes to the daily energy intake, without providing additional nutritional value. In addition, sugar intake has been associated with numerous negative health outcomes (Paglia, Friuli, Colombo, & Paglia, 2019), including increased cardiovascular risk factors such as adiposity and dyslipidemia (Vos et al., 2017), dental caries (Chi & Scott, 2019), and metabolic syndrome (Wang et al., 2013). Overconsumption of sugar may represent a threat to children's mental health as it has been linked to changes in neural systems, altered emotional processing, anxiety and depression (Jacques et al., 2019).

Although sugars are naturally present in foods (e.g., fruits, vegetables, milk and honey), 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). In particular, sweetened beverages, sweet bakery products, confectionary and dairy products have been identified as the main contributors to children's sugar intake in European countries (Azaïs-Braesco, Sluik, Maillot, Kok, & Moreno, 2017), the United States (Bailey, Fulgoni, Cowan, & Gaine, 2018; Herrick, Fryar, Hamner, Park, & Ogden, 2020), Australia (Lei, Rangan, Flood, & Louie, 2016) and Latin American countries (Popkin & Reardon, 2018).

In this commentary, we aim to critically discuss the role of the food industry in contributing to children's excessive sugar intake worldwide and the strategies that have so far been encouraged or

implemented to revert this situation. We raise awareness of the risk of following current practices to reduce sugar in products targeted at children in the light of emerging scientific evidence and call for the need to tackle this complex challenge from a new perspective, based on children's rights.

2 | FOODS TARGETED AT CHILDREN: WHY DO THEY HAVE SO MUCH SUGAR?

Children's heightened preference for sweetness is universal across cultures (Mennella & Bobowski, 2015). Children have been reported to prefer higher sweetness intensities compared to adults, which has been explained by their high energy requirements in a period of rapid growth (Drewnowski, 2000; Liem & Mennella, 2002). This explanation is supported by the association between sweetness preference and growth markers. Coldwell, Oswald, and Reed (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 plasma leptin than adolescents with low sweetness preference.

Modern societies have normalized children's consumption of sugary products as a consequence of their preference for sweet taste. Since the 19th century, sugary products started to be positioned as a treat for children, who many times are encouraged to learn the value of money by selecting and purchasing candies (Woloson, 2002). Already decades ago, the food industry identified a market niche and started manufacturing a wide range of products containing high concentrations of sugar, an inexpensive ingredient, and marketing them as fun and appropriate for children (Elliott, 2015; Moss, 2013). The global market of child-oriented food and beverages is posed to reach 146.7 billion US dollars by the year 2025, with an annual growth rate of 5% (ReportLinker, 2020).

A recent review by Elliott and Truman (2020) showed that the vast majority of the products targeted at children available in the market cannot be regarded as suitable for them due to their high energy density and added sugar and fat. Sugar has been reported to be the most common nutrient exceeding nutritional recommendations among products targeted at children. According to Giménez, Saldamando, Curutchet, and Ares (2017) 92% of the products targeted at children commercialized in the Uruguayan marketplace contained an excessive amount of free sugars according to the nutrient profile model of the Pan American Health Organization. Similarly, Elliott (2019) reported that 77% of the child-targeted products in Canadian supermarkets were high in sugar.

Nowadays, products with high sugar content targeted at children can be found across a wide range of food categories, including confectionary, cookies, dairy products, cereals and sweetened beverages (Elliott & Truman, 2020). Products are targeted at children through packaging and are also frequently formulated specifically for them; the problem is that such products are not actually healthier. Products targeted at children have been reported to have higher sugar content than those targeted at the non-children population (Moore, Sutton, &

Hancock, 2020; Rito et al., 2019). However, children's heightened sweetness preference does not fully justify the sugar content of commercial products targeted at them. Velázquez, Vidal, Varela, and Ares (2020) reduced 40% the sugar content of vanilla milk desserts respect to commercial products targeted at children available in the Uruguayan marketplace. They reported that, despite some changes in the sensory profile, school-aged children liked the sugar-reduced products as much as they liked the regular product. Moreover, they found that a proportion of children disliked the samples with the highest sugar content. Similarly, Lima, Ares, and Deliza (2019) showed that the added sugar content of grape nectars could be reduced 21.6% without affecting children's liking. These results suggest that the general belief that children may prefer excessively sweet products may not be completely true as they may regard the products available in the market as too sweet. Similar results have been recently reported among adults by Reed, Mainland, and Arayata (2019). According to these authors, who analyzed consumers' reviews of commercial products sold on-line, consumers are more likely to perceive commercial products excessively sweet rather than with a lack of sweetness.

3 | DIRECT SUGAR REDUCTION: A FEASIBLE BUT FEARED STRATEGY

The major 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 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, even if they continue eating the same products (Hashem, He, & MacGregor, 2019; Muth, Karns, Mancino, & Todd, 2019; Yeung et al., 2017).

Although several countries have implemented voluntary sugar reduction programs (Belc, Smeu, Macri, Vallauri, & Flynn, 2019; Breda et al., 2020), progress in reducing sugar across the food assortment has been slow. For example, in 2015 the UK implemented a sugar reduction program which aims to gradually decrease 20% of the sugar content by 2020 in food products regarded as important contributors to children's sugar intake (Public Health England, 2017). According to the latest progress report, the target will be unlikely accomplished as the overall reduction achieved between 2015 and 2019 was only 3% (Public Health England, 2020). The highest reductions in sugar content were achieved for yogurts and breakfast cereals, reaching 13% (Moore et al., 2020; Public Health England, 2020).

The low cost and versatility of sugar, as well as concerns over the consumer rejection of sugar-reduced products are some of the factors underlying the modest achievements of voluntary sugar reduction programs (World Health Organization, 2017). One of the main concerns of the food industry regarding sugar reduction is that consumers may find the reformulated product unacceptable, putting at risk the

company competitiveness and profit (World Health Organization, 2017). Children's heightened preference for sweetness (Mennella, Finkbeiner, & Reed, 2012) and the key role that pleasure plays in their food choices (Nicklaus, Boggio, Chabanet, & Issanchou, 2004; Nicklaus & Remy, 2013) may reinforce this idea in the case of products targeted at children. However, this concerns is not fully justified by experimental evidence.

Several studies have reported that 5–10 years old children have lower sweet taste sensitivity compared to adults, suggesting that they may be less capable of perceiving differences in the sugar content of products (Glanville, Kaplan, & Fischer, 1964; James, Laing, & Oram, 1997; Yasaki, 1976). In addition, recent studies have shown that sugar reduced products may still be liked by children. The feasibility of direct sugar reduction with minor effects on children's hedonic perception has been documented in sweetened beverages and dairy products (Li, Lopetcharat, Qiu, & Drake, 2015; Lima et al., 2019; Velázquez, Vidal, Varela, & Ares, 2020). Recently, Velázquez, Vidal, Alcaire, Varela, and Ares (2020) showed that a sugar reduction up to 25% was possible in chocolate milk, vanilla yogurt, and vanilla milk desserts without significant changes on the liking of 8–13 years old children. However, there is still a need to explore the impact of direct sugar reduction in a wider range of product categories. So far, most of the studies exploring the impact of direct sugar reduction have focused on beverages and semi-solid foods and few information is available regarding their application in solid matrices (e.g., bakery products), where sugar seems to play a role beyond sweet taste (Sahin, Zannini, Coffey, & Arendt, 2019; Struck, Jaros, Brennan, & Rohm, 2014).

Despite reductions of up to approximately 20% seem feasible without affecting children's hedonic perception, gradual and progressive reductions may contribute to minimize any potential negative reactions toward sugar reduction. The rationale behind this approach is that sugar content of the product is reduced in such a way that consumers slowly get used to products with lower sugar content, without noticing the changes (Macgregor & Hashem, 2014). Lima et al. (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. Further research is needed to confirm that these results can be escalated and reproduced in the long term (Hutchings, Low, & Keast, 2019). Nevertheless, it should be noted that a gradual salt reduction program in the UK achieved a reduction of 15% in salt intake at the population level over a 7 years' time span (Macgregor & Hashem, 2014). This successful implementation suggests that gradual reduction of critical nutrients has a high potential in a large-scale level.

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, He, Yin, Hashem, & MacGregor, 2016). This is particularly relevant in the case of children, given that during this period of life they acquire long-lasting preferences (Mennella & Bobowski, 2015). Through

exposure and associative learning children learn what foods should taste sweet and how sweet they should be (Forestell & Mennella, 2007; Rozin, 1984; Sullivan & Birch, 1990).

4 | A CALL FOR REDUCING SUGAR AND SWEETNESS INTENSITY IN PRODUCTS TARGETED AT CHILDREN

Sugar reduction has long been positioned as the impossible dream: reducing sugar without modifying the sensory characteristics of products (Hutchings et al., 2019). Considering that sweetness is the most important contribution of sugar in food products, sugar reduction efforts have been mainly focused on maintaining the sweetness level of the products (Di Monaco, Miele, Cabisidan, & Cavella, 2018; Hutchings et al., 2019; McCain, Kaliappan, & Drake, 2018; Sahin et al., 2019). This strategy does not only contribute to a reaffirmation of children's preference for highly sweet products (Liem & de Graaf, 2004), it may also hinder the potential of alternatives that target at modifying children's preferences by reducing the exposure to sweet taste.

Children shape their preferences through experience (Sullivan & Birch, 1990). Although humans have an innate preference for sweetness, preference for products with high sugar content is also learned over repeated experiences (Liem & de Graaf, 2004; Marty, Chambaron, Nicklaus, & Monnery-Patris, 2018). In a longitudinal study with 4–6 years old children, Vennerød, Nicklaus, Lien, and Almi (2018) showed that sweet preferences increase with age. Furthermore, exposure to high sweet food has been associated with higher preference for sweetness (Vennerød, Almi, Berget, & Lien, 2017). In this sense, maintaining sweetness may reaffirm and promote children's preference for highly sweet products of poor nutrient content. This not only adversely impacts children's current dietary patterns but also their preferences as adults (Nicklaus et al., 2004; Nicklaus & Remy, 2013).

Emerging evidence on the metabolic role of sweetness, further stresses the need to reduce both sugar content and sweetness intensity. The physiological role of sweetness has been traditionally associated with its ability to generate reward to promote the ingestion of foods containing sugar (Saper, Chou, & Elmquist, 2002). However, the activation of the sweet receptors in the mouth may act as a cue for sugar arriving to the gut, triggering a series of anticipatory automatic physiological responses related to the metabolism of carbohydrates (Burke & Small, 2015; Veldhuizen et al., 2017). In addition, the body has sweet taste receptors in extra-oral tissues, whose activation also triggers the secretion of hormones that exert multiple physiological effects, including the regulation of insulin secretion (Han, Bagenna, & Fu, 2019). This suggests that reduction of sugar while maintaining sweetness intensity may have metabolic consequences in the body.

When products are sweetened with non-nutritive sweeteners (NNS), the body receives the signal corresponding to sweet taste, uncoupled from energy load and its associated physiological responses. A growing body of evidence suggests that uncoupling 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 (Burke & Small, 2015; Han et al., 2019; Veldhuizen et al., 2017). This effect may be of utmost importance in the case of children, who are still learning the relationship between sweetness intensity and energy. According to a recent study this effect may be particularly relevant when NNS are consumed together with carbohydrates, for example, cookies or fruit juice sweetened with NNS. Dalenberg et al. (2020) showed that consuming sucralose in the presence of carbohydrates decreases insulin sensitivity and brain responses to sweet taste. Although further research in this area is needed, concerns should be raised about exposing children to products sweetened with NNS.

5 | THE POTENTIAL NEGATIVE CONSEQUENCES OF REPLACING SUGAR BY NON-NUTRITIVE SWEETENERS IN PRODUCTS TARGETED AT CHILDREN

The use of NNS has become the default option for reducing the sugar content of foods and beverages (Di Monaco et al., 2018; Hutchings et al., 2019; McCain et al., 2018; Sahin et al., 2019). Since NNS have a higher sweetening power, significant sugar reductions are possible with minor effects on sweet taste (Edwards, Rossi, Corpe, Butterworth, & Ellis, 2016). Although NNS usually have bitter and metallic aftertaste which may negatively impact children's acceptance (Li et al., 2015; Li, Lopetcharat, & Drake, 2014), their consumption has largely increased. Sylvetsky, Welsh, Brown, and Vos (2012) showed that the number of children consuming products with NNSs has almost doubled from 1999–2000 to 2007–2008 in the United States. Although worldwide children's intake of the main NNS appears to be within international recommendations, this age group seems to be particularly vulnerable to exceed acceptable daily intakes (Martyn et al., 2018). In addition, it should be highlighted that consumption of NNS among children is expected to increase, as sugar reduction programs continue to prioritize partial or total substitution of sugar while maintaining sweetness. According to a recent study conducted in Chile, 55.5% of the processed products contain at least one sweetener as a consequence of the response of the food industry to the implementation of nutritional warnings highlighting products with high sugar content (Sambra et al., 2020). After enforcement of the Chilean regulation, Martínez et al. (2020) evaluated consumption of NNS among 250 school-aged children (6–12 years old). They reported that all children consumed at least one NNS during the month prior to the study, mainly as ingredients in beverages, dairy products and desserts. Sucralose was the most frequently consumed NNS, followed by acesulfame-K and stevia. However, consumption of none of the NNS exceeded acceptable daily intakes.

Although several recent documents stress the safety of NNS (Ashwell et al., 2020), consensus has not been reached yet (Toews, Lohner, de Gaudry, Sommer, & Meerpohl, 2019). Concerns over the methodological and reporting quality of studies conducted with humans (Toews et al., 2019) and the potential influence of conflicts of

interest on recommendations regarding NNS (Mandrioli, Kearns, & Bero, 2016) stress the need to conduct further independent research on the topic. This is particularly relevant in the case of children, as research focused on this population is still scarce and contradictory (Brown, De Banate, & Rother, 2010).

However, emerging evidence justifies increasing concerns about the potential negative effects of NNS on children's health (Swithers, 2015). A recent systematic meta-analysis has shown that consumption of NNS during childhood and adolescence is associated with a significant increase in body mass index, with an odd-ratio of 1.15 (Karalexi, Mitrogiorgou, Georgantzi, Papaevangelou, & Fessatou, 2018). Similarly, exposure to NNS during pregnancy has been also linked with increased body mass index in the offspring (Azad et al., 2016). Moreover, increasing concerns have been raised over the bacteriostatic properties of NNS and their potential negative impact on the gastro-intestinal environment (Suez et al., 2014). Although results from animal studies have shown that NNS alter the gut microbiota, evidence from studies involving humans are still inconclusive (Khan, Ayoub-Charette, Sievenpiper, & Comelli, 2020). Therefore, current evidence is not enough to fully disregard potential negative effects of NNS on children's health.

6 | THE NEED FOR A CHILD RIGHTS-BASED APPROACH TO REDUCING SUGAR IN PRODUCTS TARGETED AT CHILDREN

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).

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, Bekkers, & Tummers, 2015).

In addition, it should be highlighted that this isolated policy is unlikely to be enough to tackle the problems associated to a high consumption of added sugar (Bes-Rastrollo, Sayon-Orea, Ruiz-Canela, & Martinez-Gonzalez, 2016). Instead, a multicomponent sugar reduction strategy seems necessary to reduce sugar consumption and lessen their associated health and economic costs (Amies-Cull, Briggs, & Scarborough, 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 availability of poor nutrient quality products in 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 synergistic effect, contributing to more effectively achieve the objectives they seek.

7 | CONCLUSIONS

Although the need for reducing sugar intake among children has been widely acknowledged, progress in reducing the sugar content of products targeted at children has been slow and insufficient. In the present work, we advocate for a change in how products targeted at children are conceptualized, highlighting the need to adopt a child-rights view. Food scientists should take into account the best interests of children when engaging in the development of products targeted at them, avoiding high content of sugar, as well as the use of any ingredient with potential negative effects on their health and wellbeing. In this sense, emerging evidence stresses the need to avoid the use of non-nutritive sweeteners as part of the efforts to reduce the sugar content of products targeted at children, as well as of any other product frequently consumed by them. We encourage food scientists to promote a new approach to sugar reduction by putting aside the premise of avoiding changes in the sensory characteristics of products and focusing on reducing both sugar content and sweetness intensity.

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ORCID

Ana Laura Velázquez  <https://orcid.org/0000-0002-1550-5170>

Leticia Vidal  <https://orcid.org/0000-0001-6781-9852>

Paula Varela  <https://orcid.org/0000-0003-2473-8678>

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