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Difference thresholds for added sugar in chocolate-flavoured milk: Recommendations for gradual sugar reduction

Denize Oliveira [a], Felipe Reis [b], Rosires Deliza [c], Amauri Rosenthal [c], Ana Giménez [d], Gastón Ares [d,*]

[a] Instituto de Química, Universidade Federal do Rio de Janeiro, Av. Athos da Silveira Ramos 149, Cidade Universitária 21949-909, Rio de Janeiro, RJ, Brazil
[b] Departamento de Tecnología de Alimentos, Instituto de Tecnología, Universidade Federal Rural do Rio de Janeiro, BR 465 Road 7 km, 23890-000 Seropédica, RJ, Brazil
[c] Embrapa Agroindústria de Alimentos, Av. das Américas, 29501, CEP 23.020-470 Rio de Janeiro, RJ, Brazil
[d] Sensometrics & Consumer Science, Instituto Polo Tecnológico de Pando, Facultad de Química, Universidad de la República, By Pass de Rutas 8 y 101 s/n, C.P. 91000 Pando, Canelones, Uruguay

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ABSTRACT

Reducing the concentration of added sugar in processed foods is one of the most realistic strategies to reduce the intake of this nutrient in the short-term. In order to be effective, gradual sugar reduction strategies need to determine the maximum sugar reduction that can be unnoticed by consumers. In this context, the present work aimed at providing recommendations for gradual sugar reduction in chocolate-flavoured milk by determining difference thresholds for added sugar and evaluating consumers' sensory and hedonic perception of reduced-sugar products. Five studies were conducted with 50 consumers to determine five sequential difference thresholds. In each study consumers completed six paired-comparison tests. Each pair was composed of a reference chocolate-flavoured milk and a sample that was reduced in added sugar from the reference. Difference thresholds, corresponding to the smallest reduction in sugar concentration that is noticed by consumers, were determined using survival analysis. Then, a study was carried to with 100 consumers to evaluate their sensory and hedonic perception of chocolate-flavoured milk samples with different added sugar concentrations. Results suggested that sequential sugar reductions can be set at 6.7% without affecting consumers' sensory and hedonic perception. Sugar reduction in chocolate-flavoured milk without affecting consumers' perception seems feasible and easy to implement. The approach of the present work could be extended to design recommendations for gradual reduction of the added sugar concentration of other industrialized products, contributing to the development of more healthful products that meet current nutritional recommendations.

1. Introduction

Sweetness is a natural cue for edibility and energy-rich foods (Birch, 1999). Humans have an innate preference for sweet taste, which has motivated the food industry to add sugar to processed products to increase the pleasure of eating and consequently their product sales (Yebra-Biurrun, 2005). According to the Pan American Health Organization (2016), the majority of industrialized sweetened products commercialized in Latin American countries, such as breakfast cereals, sweetened milk, yogurt, ice-creams and sweetened beverages, contain an excessive amount of added sugar.

Sugar has become a major hidden source of calories in the diet and its intake has been strongly associated with the growing prevalence of several negative health conditions such as obesity, type 2 diabetes and dental caries (Johnson et al., 2009; Morenga, Mallard, & Mann, 2013; Popkin & Nielsen, 2003). This situation makes it necessary to develop strategic actions aimed at reducing sugar consumption worldwide (Lustig, Schmidt, & Brindis, 2012).

Considering the contribution of added sugar to total daily energy intake worldwide, one of the most realistic strategies that can be implemented to gradually reduce sugar consumption is to reduce the concentration of added sugar added of processed products (MacGregor & Hashem, 2014). This type of strategy has been successfully implemented in the UK for reducing salt consumption (Wyness, Butriss, & Stanner, 2011). According to the English Department of Health a 30 to 40% reduction in added sugar concentration can reduce calorie intake an average of 100 kcal per day per person, which could be effective in preventing obesity and diabetes (Department of Health, 2011).

The idea underlying gradual sugar reduction is to slowly and progressively reduce the sugar content of food products, so that consumers gradually get accustomed to products with lower sugar concentrations without noticing the changes (MacGregor & Hashem, 2014). By setting incremental targets for each food category with a specified deadline, a coordinated action among industries can reduce sugar intake without affecting the sales of commercial products.

* Corresponding author.
E-mail address: gares@fq.edu.uy (G. Ares).

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In order to be effective, gradual sugar reduction strategies need to determine the maximum sugar reduction that can be unnoticed by consumers. Therefore, information about consumer perception of products with reduced sugar content is a key tool for the establishment of targets for sugar reduction and for encouraging the industry to engage in sugar reduction programmes (Civille & Oftedal, 2012). However, few studies have evaluated the impact of lowering sugar concentration on consumer sensory and hedonic perception of processed products (Biguzzi, Schlich, & Lange, 2014; Chollet, Gille, Schmid, Walther, & Piccinali, 2013; Hoppert, Zahn, Puschmann, Ullmann, & Rohm, 2012; Pineli et al., 2016).

One of the most useful approaches to establish recommendations for sugar reduction on food products is the estimation of difference thresholds for sweetness, which are the smallest change in sugar concentration that causes a change in sweetness perception (Lawless & Heymann, 2010). Difference thresholds for sugar can be experimentally estimated as the smallest change in sugar concentration that causes a change in sweetness intensity that is perceived by 50% of the individuals (Boring, 1942). According to Weber's law, difference thresholds are a constant proportion of the stimulus intensity (Lawless & Heymann, 2010). Therefore, difference thresholds for a specific product with a particular sugar concentration could be used to determine the gradual sequential sugar reductions that can be implemented without consumer awareness. This approach has been recently applied by Bobowski and Vickers (2012) to salt reduction in water and broth.

Chocolate-flavoured milk is a popular product in many countries (Manners & Craven, 2003). Although chocolate-milk has similar nutritional characteristics than regular milk, the sugar content of commercial products has raised concerns that have led to banning chocolate-flavoured milks from school lunch systems in the USA (Hoag, 2011; Murphy et al., 2008). However, chocolate-flavoured milk consists of a nutritious alternative to soft drinks and fruit drinks, particularly for school-aged children, adolescents and young adults (Johnson, Frary, & Wang, 2002; Reedy & Krebs-Smith, 2010). Therefore, an improvement in the nutritional quality of chocolate-flavoured milk by reducing the added-sugar content of commercial products seems necessary (Cheese Market News, 2012).

In this context, the present work aimed at providing recommendations for gradual sugar reduction in chocolate-flavoured milk by determining difference thresholds for added sugar and evaluating consumers' sensory and hedonic perception of reduced-sugar products.

2. Materials and methods

2.1. Formulation of chocolate-flavoured milk

Chocolate-flavoured milk samples were formulated using UHT whole milk (Conaprole, Uruguay), 5.93–9.00% commercial sugar (Alcoholes del Uruguay S.A., Bella Unión, Uruguay), 2.5% alkaline cocoa powder (ARYES Aroma and Essences, Montevideo, Uruguay), 0.08% carrageenan (Ticaloid® 780 Stabilizer — Texture Innovation Center, TIC GUMS, Philadelphia, USA).

Chocolate-flavoured milk samples were prepared using a Thermomix TM 31 (Vorwerk Mexico S. de R.L. de C.V., Mexico D.F., Mexico). The solid ingredients were mixed with the milk, previously heated to 70 °C for 3 min. The dispersion was mixed for 1 min under gentle agitation (100 rpm), kept to 70 °C for 4 min and cooled to 20 °C in iced water. Then, the mix was placed in 1000 mL glass containers, the mix was manually agitated for 30 s and stored under refrigeration temperature (4 °C ± 1 °C) until their evaluation. Samples were served at 8 °C in identical plastic cups, coded using three-digit numbers, presented in monadic sequence following an experimental design that was balanced for order and carry-over effects (Williams' Latin Square).

2.2. Estimation of difference thresholds

Five sequential difference thresholds were determined as follows. In the first study, the difference threshold for sugar in chocolate-flavoured milk with an added sugar concentration similar to commercial products available in the Uruguayan marketplace (9%) was determined. In the second study, the difference threshold for sugar in chocolate-flavoured milk that was reduced in added sugar according to the threshold determined in the first study was estimated. This pattern was repeated until five difference thresholds were determined.

The studies involved a total of 250 consumers (68% female; 18–29 years old). Each of the five studies was carried out with a group of 50 consumers. All participants were recruited among students of the Universidad de la República (Montevideo, Uruguay) according to their frequency consumption of the product (at least once a week), interest and availability to participate in the study. The consumer sample intentionally comprised young people as they are, together with children, the main target consumers of the product. Participants signed an informed consent form and received a small gift for their participation.

In each study consumers completed six paired-comparison tests. Each paired comparison was composed of a reference chocolate-flavoured milk, corresponding to a specific added sugar concentration, and a sample that was reduced in added sugar from the reference. The reference remained constant in each study, while the sugar reduced sample increased over the series of 6 paired-comparisons. Therefore, the difficulty of the paired comparisons decreased with test progression, i.e. the first paired-comparison in a study was more difficult for consumers than the last one. Different reference samples were considered in each study. The sugar concentration of the reference and the sugar-reduced samples in each of the studies is shown in Table 1. Sugar concentrations in each of the studies were selected by pilot testing.

Consumers were asked to taste each of the samples in a pair and to select the sweeter one by choosing the corresponding number. Samples in each pair were presented following a balanced design. Testing took place in a sensory laboratory designed in accordance with ISO 8589 (ISO, 2007), under artificial daylight and temperature control (22 °C). Data collection was performed using Compusense-at-hand (Compusense Inc., Guelph, Canada).

2.3. Consumers' sensory and hedonic perception of chocolate-flavoured milks with different added sugar concentration

After difference thresholds were determined, a study was carried out to evaluate consumer sensory and hedonic perception of chocolate-flavoured milk samples with different added sugar concentrations. The following nine samples were considered: the reference samples considered in the difference threshold studies (Table 1), the sample with the sugar concentration determined in Study 5 (6.40%) and three additional samples. The added sugar concentration of these three last samples was intermediate between the concentration of the reference sample and the reduced ones, according to the thresholds determined in Studies 1, 3 and 5.

One hundred consumers participated in the test (74% female; 18–25 years old). As in the previous study, the consumer sample intentionally comprised young people recruited from University students. Consumers were asked to try the samples and to indicate their overall liking using a 9-point hedonic scale (1 = dislike very much, 9 = like very much) and to answer a check-all-that-apply (CATA) question composed of nine sensory characteristics: bitter, rough, chocolate, thick, sweet, fluid, greasy, milk flavour, and vanilla. The terms of the CATA question were selected based on results from previous consumer studies using open-ended questions.

Samples were presented following an experimental design that was balanced for order and carry-over effects (Williams' Latin Square design). Data were collected on laptops using Compusense at-hand (Compusense Inc., Guelph, Ontario, Canada). Testing took place in a sensory laboratory, as described in the previous section.