h e d s
Haute école de santé
Genève
Filière Nutrition et diététique

Rue des Caroubiers 25
CH-1227 Carouge

T +41 22 388 34 60
F +41 22 388 34 50

diet.heds@hesge.ch
www.hesge.ch/heds

Sweet taste

Is the preference for "sweet taste" innate and unchangeable?

Final report

Geneva, August 2017

Prepared by:

Department of Nutrition and Dietetics, University of Applied Sciences of Western Switzerland, Geneva

Author: Dr Corinne Jotterand Chaparro, dietician

Co-authors: Clémence Moullet, dietician and Eddy Farina, dietician

Commissioned by:

Federal Food Safety and Veterinary Office, Bern, Switzerland

Contract No. 714000521

Approved by:

Esther Infanger, Federal Food Safety and Veterinary Office

Liliane Bruggmann, Federal Food Safety and Veterinary Office

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1. SUMMARY

Introduction and aim: Reduction of the salt content of food has been a successful approach for reducing the salty taste preference and salt consumption of a population. Given the excessively high sugar consumption worldwide, including in Switzerland, the Federal Food Safety and Veterinary Office wished to investigate whether lowering the sugar content of food would lead to comparable results. We conducted a systematic review of the literature to assess the effects of modifying the sugar contents of food and drink on the sweet taste preference of the healthy population *(primary question)*. The association between intake of sweet foods, including artificially sweetened foods, and sweet taste preference was also investigated *(secondary question)*.

Methods: We searched electronic databases, including Medline PubMed, CINAHL, EMBASE, Web of Science and Cochrane Library, for relevant literature published in any year in English, French, German or Italian. Bibliographies of retrieved articles were searched by hand. Grey literature was searched by using different sources. At least two researchers independently conducted all steps of the systematic review, including the identification and selection of eligible studies, extraction of data and assignment of a quality grade to each article. Data were analysed by a descriptive synthesis method. No meta-analysis was performed due to heterogeneity of the data. Studies funded by food industries were included, but this aspect was taken into account when assessing study quality.

Results: Of the 1129 publications identified, 155 full-text articles were read for eligibility, and 21 original studies were included in the systematic review. Eight studies, with heterogeneous interventions and outcomes, investigated the effect of sugar content modification on sweet taste preference. Most studies found that altering the sugar contents of foods did not modify sweet taste preference, except in subgroups including children. Reducing the sugar contents of flavoured milk and fruit purees did not change food consumption by children. Seven of the 12 studies that assessed the association between sweet food intake and sweet taste preference observed a positive association. Three studies found a positive association between early sugar water intake by infants and sweet taste preference. Only one study addressed the issue of artificial sweetener intake.

Conclusion: Based on the few available data, it remains unclear whether modifying the sugar contents of food and drink influences sweet taste preference. The data suggest that reducing sugar content does not alter the palatability of or preference for sweet food products among children. Existing data are encouraging and require further research. Finally, children seem to be vulnerable to excessive intake of sweet foods, especially sweetened beverages, probably because of their inborn preference for sweet taste.

RESUME

Introduction et but: La consommation de sucre est excessive au niveau mondial, et notamment en Suisse. La réduction du contenu en sel dans les aliments semble être efficace afin de diminuer la préférence pour le goût salé de la population et ainsi sa consommation en sel. L'Office Fédéral de la Sécurité Alimentaire et des Affaires Vétérinaires (OSAV) a donc souhaité évaluer si une réduction en sucre dans les aliments mènerait à des résultats similaires. Pour se faire, nous avons mené une revue systématique de la littérature afin d'évaluer les effets d'une modification du contenu en sucre des aliments et boissons sur la préférence au goût sucré de la population en santé (question primaire). De plus, l'association entre la consommation d'aliments sucrés, incluant les édulcorants artificiels, et la préférence au goût sucré a été étudiée (questions secondaires).

Méthode: Une stratégie de recherche a été menée sur les bases de données électroniques Medline PubMed, CINAHL, EMBASE, Web of Science et the Cochrane Library, sans limite de dates de publication. Les publications en anglais, français, allemand et italien étaient éligibles. Les études ont également été identifiées dans les bibliographies des articles retenus. La littérature grise a été recherchée par le biais de différentes sources. Toutes les étapes de la revue systématique, incluant l'identification et la sélection des études, l'extraction des données et l'évaluation de la qualité de chaque article, ont été réalisées par au moins deux chercheurs de manière indépendante. Les données ont été analysées et synthétisées par une méthode descriptive. Une méta-analyse n'a pu être réalisée en raison de l'hétérogénéité des données. Les études financées par l'industrie alimentaire ont été incluses, mais cet aspect a été pris en compte dans l'évaluation de leur qualité.

Résultats: Sur les 1129 publications identifiées, 155 articles ont été lus et un total de 21 études originales a pu être inclus dans la revue systématique. Huit études, ayant des interventions et issues hétérogènes, ont évalué l'effet d'une modification du contenu en sucre sur la préférence au goût sucré. La réduction ou supplémentation en sucre ne modifiait pas la préférence au goût sucré dans la plupart des études, sauf dans des sous-groupes tels que les enfants. La réduction en sucre dans des laits aromatisés et dans des purées de fruit ne modifiait pas la consommation des enfants. Sur les douze études ayant évalué l'association entre la consommation en produits sucrés et la préférence au goût sucré, sept d'entre elles ont observé une association positive. Trois études ont observé une association positive entre la consommation précoce d'eau sucrée chez les enfants et leur préférence au goût sucré. Seule une étude a traité la question de la consommation en édulcorants artificiels.

Conclusion: En se basant sur le peu de données disponibles, il est difficile de déterminer si une modification du contenu en sucre des aliments et boissons influence la préférence pour le goût sucré. Les résultats suggèrent qu'une réduction du contenu en sucre n'altère pas la palatabilité et la consommation des produits alimentaires chez les enfants. Les données

existantes sont encourageantes et requièrent de futures recherches. Finalement, les enfants semblent clairement être vulnérables à un apport excessif en produits sucrés, en particulier en boissons sucrées, probablement à cause de leur préférence innée pour le goût sucré.

ÜBERBLICK

Einleitung und Ziel: Der Zuckerkonsum ist weltweit überhöht, darunter auch in der Schweiz. Die Verringerung des Salzgehalts in Lebensmitteln scheint die Vorliebe für salzigen Geschmack in der Bevölkerung und damit dessen Salzkonsum wirksam zu reduzieren. Das Bundesamt für Lebensmittelsicherheit und Veterinärwesen (LFV) wollte daher beurteilen, ob eine Verringerung des Zuckergehalts in Lebensmitteln zu ähnlichen Ergebnissen führen würde. Wir führten zu diesem Zweck eine systematische Auswertung der vorhandenen Literatur durch, um die Auswirkungen einer Änderung des Zuckergehalts in Lebensmitteln und Getränken auf die Vorliebe für süßen Geschmack in der gesunden Bevölkerung (primäre Frage) zu beurteilen. Darüber hinaus wurde der Zusammenhang zwischen dem Konsum zuckerhaltiger Lebensmittel, einschließlich künstlicher Süßstoffe, und der Vorliebe für süßen Geschmack untersucht (sekundäre Frage).

Methode: Die Recherche wurde anhand der elektronischen Datenbanken Medline PubMed, CINAHL, EMBASE, Web of Science und der Cochrane Library ohne Einschränkung des Veröffentlichungsdatums durchgeführt. Es kamen Veröffentlichungen in englischer, französischer, deutscher und italienischer Sprache in Frage. Die Studien werden auch in den Bibliographien der ausgewählten Artikel angeführt. Graue Literatur wurde anhand verschiedener Quellen recherchiert. Alle Stufen der systematischen Auswertung, einschließlich der Identifizierung und Auswahl der Studien, Datenextraktion und Qualitätsbewertung der einzelnen Artikel, wurden unabhängig von mindestens zwei Forschern durchgeführt. Die Daten wurden durch ein beschreibendes Verfahren analysiert und zusammengefasst. Aufgrund der Heterogenität der Daten konnte keine Meta-Analyse durchgeführt werden. Studien, die von der Lebensmittelindustrie finanziert wurden, wurden miteinbezogen, aber dies wurde bei der Bewertung ihrer Qualität berücksichtigt.

Ergebnisse: Von 1.129 angeführten Publikationen wurden 155 Artikel gelesen und es konnten insgesamt 21 Originalstudien in die systematische Auswertung einbezogen werden. Acht Studien mit heterogenen Interventionen und Ergebnissen, bewerteten die Wirkung einer Änderung des Zuckergehalts auf die Vorliebe für süßen Geschmack. Die Verringerung oder Supplementierung von Zucker hat beim Großteil der Studien zu keiner Änderung der Vorliebe für süßen Geschmack geführt, mit Ausnahme von Untergruppen wie Kindern. Die Verringerung des Zuckergehalts in aromatisierter Milch und Fruchtpürees veränderte den Konsum bei Kindern nicht. Von zwölf Studien, die den Zusammenhang zwischen dem Konsum zuckerhaltiger Produkte und die Vorliebe für süßen Geschmack ausgewertet haben, haben sieben einen positiven Zusammenhang festgestellt. Drei Studien stellten einen positiven Zusammenhang zwischen einem frühen Konsum von Zuckerwasser bei Kindern und ihrer Vorliebe für süßen Geschmack fest. Nur eine Studie befasste sich mit der Frage des Konsums künstlicher Süßstoffe.

Schlußfolgerung: Es ist schwierig anhand der begrenzt zur Verfügung stehenden Daten zu bestimmen, ob eine Änderung des Zuckergehalts in Lebensmitteln und Getränken die Vorliebe für süßen Geschmack beeinflusst. Die Ergebnisse legen nahe, dass eine Verringerung des Zuckergehalts die Schmackhaftigkeit und den Verzehr von Lebensmitteln bei Kindern nicht verändert. Die vorhandenen Daten sind anspornend und bedürfen weiterer Forschung. Schließlich scheinen Kinder für einen überhöhten Konsum süßer Speisen deutlich anfälliger zu sein, insbesondere zuckerhaltige Getränke, was wahrscheinlich auf ihre angeborene Vorliebe für süßen Geschmack zurückzuführen ist.

SOMMARIO

Introduzione e scopo: Il consumo di zucchero è eccessivo in tutto il mondo e in particolare in Svizzera. La riduzione del contenuto di sale negli alimenti sembra essere efficace nel ridurre la preferenza della popolazione per il gusto salato e di conseguenza il suo consumo di sale. L'Ufficio federale della sicurezza alimentare e di veterinaria (USAV) ha quindi cercato di valutare se una riduzione della quantità di zucchero nei prodotti alimentari porterebbe a risultati simili. Per farlo, abbiamo condotto una revisione sistematica della letteratura per valutare gli effetti che un cambiamento del contenuto di zucchero in alimenti e bevande avrebbe sulla preferenza della popolazione sana verso il sapore dolce (questione principale). Inoltre, è stata studiata l'associazione tra il consumo di alimenti dolci, compresi i dolcificanti artificiali, e la preferenza per il gusto dolce (questioni secondarie).

Metodo: Una strategia di ricerca è stata condotta sui database elettronici Medline PubMed, CINAHL, EMBASE, Web of Science e the Cochrane Library, senza limiti relativi alle date di pubblicazione. Sono state ammesse le pubblicazioni in inglese, francese, tedesco e italiano. Gli studi sono stati identificati nelle bibliografie degli articoli selezionati. La letteratura grigia è stata oggetto di ricerca attraverso diverse fonti. Tutte le fasi della revisione sistematica, comprese l'identificazione e la selezione degli studi, l'estrazione dei dati e la valutazione della qualità di ogni articolo, sono state condotte da almeno due ricercatori in modo indipendente. I dati sono stati analizzati e sintetizzati con un metodo descrittivo. Non è stato possibile realizzare una meta-analisi a causa dell'eterogeneità dei dati. Sono stati inclusi gli studi finanziati dall'industria alimentare, ma si è tenuto conto di questo aspetto nella valutazione della loro qualità.

Risultati: Su 1129 pubblicazioni identificate, sono stati letti 155 articoli e si è potuto includere un totale di 21 studi originali nella revisione sistematica. Otto studi, con interventi e risultati eterogenei, hanno valutato l'effetto che una variazione nel contenuto di zucchero può avere sulla preferenza per il sapore dolce. Nella maggior parte degli studi, la riduzione o l'integrazione di zucchero non ha modificato la preferenza per il sapore dolce, tranne che in alcuni sotto-gruppi come i bambini. La riduzione della quantità di zucchero nel latte aromatizzato e nelle puree di frutta non ha modificato il consumo da parte dei bambini. Sui dodici studi che hanno valutato l'associazione tra il consumo di prodotti zuccherati e la preferenza per il sapore dolce, sette hanno riscontrato un'associazione positiva. Tre studi hanno osservato un'associazione positiva tra il consumo precoce di acqua e zucchero da parte dei bambini e la loro preferenza per il gusto dolce. Solo uno studio ha affrontato la questione del consumo di dolcificanti artificiali.

Conclusione: Sulla base dei pochi dati disponibili, è difficile stabilire se un cambiamento nel contenuto di zucchero in cibi e bevande influenzi la preferenza per il gusto dolce. I risultati suggeriscono che una riduzione del contenuto di zucchero non alteri l'appetibilità e il consumo dei prodotti alimentari nei bambini.

I dati esistenti sono incoraggianti e richiedono ulteriori ricerche. Infine, i bambini sembrano essere chiaramente vulnerabili a un'eccessiva assunzione di prodotti dolci, in particolare le bevande zuccherate, probabilmente a causa della loro preferenza innata per il gusto dolce.

2. LIST OF ABBREVIATIONS

BMI: body mass index

CI: confidence interval

FSVO: Federal Food Safety and Veterinary Office

IQR: interquartile range

MESH: medical subject headings

NCD: noncommunicable disease

PICO: Population/Intervention-Exposure/Comparison and Outcome

PRISMA: Preferred Reporting Items for Systematic review and Meta-Analysis protocols

RCT: randomised controlled trial

WHO: World Health Organisation

3. PREAMBLE

Added sugar contributes a considerable proportion of the total energy intake of populations in both industrialised and developing countries. There is increasing concern that sugar intake, especially in the form of sugar-sweetened beverages, leads to an unhealthy diet, weight gain and increased risk of noncommunicable diseases (NCDs)[1]. Thus, the latest guidelines of the World Health Organisation (WHO) strongly recommend reducing intake of free sugars to less than 10% of the total energy intake for adults and children, with the further suggestion of reducing sugar intake to less than 5% of the total energy intake[2]. In Switzerland, the Sixth Report on Nutrition showed that the mean sugar intake was nearly double the WHO-recommended value[3]. On 4 August 2015 in Milan, 10 Swiss food companies and the Federal Councillor Alain Berset signed a Memorandum of Understanding aimed at gradually reducing the added sugar contents of yoghurts and breakfast cereals by the end of 2018[1].

Several strategies aimed at reducing salt consumption have been implemented in many countries, including Switzerland. Reduction of salt content in food products has been a successful approach for reducing the salty taste preference and salt consumption of different populations[4]. When individuals adopt lower-salt intake for several weeks, they may perceive a given concentration of salt in food to taste saltier than it did before the diet, or they may come to prefer lower concentrations of salt[5, 6]. In addition, no repercussions in terms of sales losses, product switching or addition of table salt were observed after implementing strategies to reduce salt content[4]. These latter aspects are important for both public health and food industries.

It is not clear whether lowering the sugar contents of food products would lead to comparable benefits. From birth, humans have a preference for sweet taste[7]. Thus, reducing the sugar contents of foods and beverages might decrease their palatability and consumer acceptance. In this setting, the Federal Food Safety and Veterinary Office (FSVO) wished to investigate whether reducing sugar content of food may be successful in reducing the sweet taste preference of individuals. Therefore, a systematic review was conducted to assess the effects of modifying the sugar contents of food and drink on sweet taste preference in the healthy population.

[1] https://www.blv.admin.ch/blv/fr/home/lebensmittel-und-ernaehrung/ernaehrung/massnahmen-ernaehrungsstrategie/zuckerreduktion.html

4. QUESTIONS OF THE FSVO

The FSVO sought to answer the following seven questions:

1) Is it possible for humans to change their preference for sweet taste? Specifically, is it possible for humans to become accustomed to and to prefer a less sweet taste than their previously preferred sweeter taste?
2) What are the arguments for/against a progressive or abrupt reduction in sugar intake?
3) Are preferences for sweet taste similar or different among food categories?
4) How do the habits of sugar intake of a person influence his/her sweet taste preference?
5) What are the roles of artificial sweeteners? For instance, would the consumption of artificially sweetened products prevent the decrease of sweet taste preference?
6) Is age or sex associated with a difference in or ease of modifying sweet taste preference?
7) Is body mass index (BMI) associated with a difference in sweet taste preference?

Questions 1–5 were addressed by conducting the systematic review. Questions 6 and 7 are general questions on sweet taste preference, which were addressed in the background of the present report but not through a systematic review. Several publications have already synthesised data on the last two questions.

5. BACKGROUND

5.1 NCDs, overweight and obesity in Switzerland

Heart disease, stroke, cancer and other NCDs are the main causes of death worldwide, accounting for 68% of all deaths in 2012[8]. In Switzerland, approximately 30,000 deaths due to acute coronary heart disease and 12,500 deaths due to cerebral disease occur each year[3]. Researchers have identified several risk factors for developing NCDs, including hypertension, elevated cholesterol level, overweight and obesity, lack of physical activity, excessive alcohol consumption and smoking habit[3].

Incidences of overweight and obesity are rapidly increasing worldwide[1]. In Switzerland, prevalences of overweight and obesity have increased continuously over the last 30 years (Figure 1). According to the Swiss Survey on Health conducted by the Swiss Federal Statistical Office in 2012, the prevalence of overweight, defined as a BMI of 25.0–29.9 kg/m^2, was higher in men (39%) than in women (23%)[9]. For obesity, defined as a BMI ≥ 30.0 kg/m^2, the difference between men and women was smaller (11% vs 9%). In children of different ages, studies have reported prevalences ranging 5–20% for overweight and 0.4–6% for obesity. Prevalences of overweight and obesity differ markedly between cantons in Switzerland and between populations with different demographic characteristics (socioeconomic status, professional category, etc.)[9].

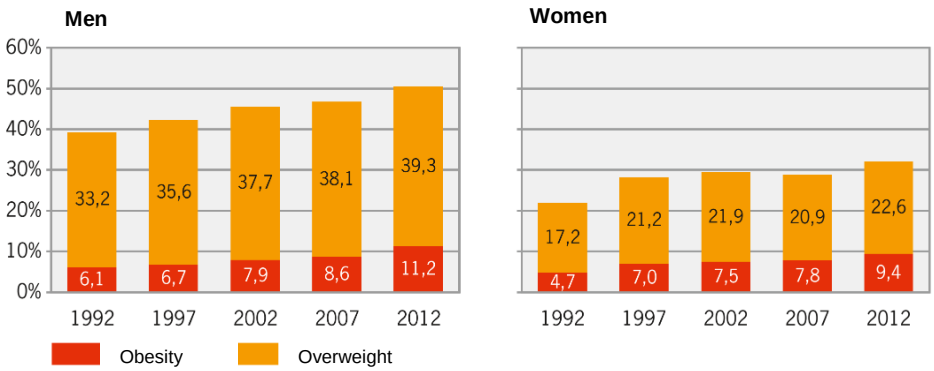

Figure 1: Evolution of prevalences of overweight and obesity in Switzerland (Source: Swiss Federal Statistical Office - Swiss Survey on Health 2015)[9]

Development of obesity is related to poor diet, which is an independent risk factor for many NCDs[1]. For instance, a person's consumption of salt or fatty acids may have a direct effect on their risk of developing arterial hypertension and hyperlipidaemia, respectively. Unhealthy diet, specifically excessive energy intake, may cause a person to become overweight or obese, further increasing their risk of developing NCDs. Consumption of sugar, which is high-calorie but nutrient-poor, may contribute to the overall energy density and energy balance in a person's diet[10-12]. There is increasing concern about excessive sugar intake, especially from sugar-sweetened beverages[10,13].

5.2 Definitions and recommendations for sugar intake

Total sugars as declared on food labels are defined by the Swiss legislation as the sum of all mono- and disaccharides (except polyols) in a food[14]. Thus, the total sugar value includes both naturally occurring and added sugars. By contrast, the definition for added (or free) sugars is not standardised. In Switzerland, the FSVO has chosen to follow the definitions of the High Level Group on Nutrition and Physical Activity of the European Commission[15]:

- The term *"added sugars"* refers to sucrose, fructose, glucose, starch hydrolysates (glucose syrup, high-fructose syrup) and other isolated sugar preparations used as such or added during food preparation and manufacturing, as well as sugars present in honey, syrups, and fruit juices and fruit juice concentrates. Sugar alcohols (polyols) such as sorbitol, xylitol, mannitol, and lactitol, are usually not included in the term "sugars"[16].

The FSVO considers sugars from other foods with a sweetening power (fruit powder, malt extract) as added sugars. This approach ensures that the current definition is consistent with the new food law, in particular with the nutritional claim of "without added sugars" [16]. The WHO defines "free sugars" as "monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook or consumer, and sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates"[17].

Based on the available body of evidence, the WHO published new recommendations in 2015 regarding intake of free sugars by adults and children[2]. Specifically, they recommended:

1. a reduced intake of free sugars throughout the life course *(strong recommendation),*
2. a reduced intake of free sugars to less than 10% of total energy intake *(strong recommendation)*,
3. a further reduction of the intake of free sugars to less than 5% of total energy intake *(conditional recommendation)*.

5.3 Sugar intake in Switzerland and current strategies

The Sixth Report on Nutrition in Switzerland published in 2012 showed that the mean sugar intake, including sucrose and honey, was 127 g per day per person[3], similar to the intake in the Fifth Report on Nutrition[18]. Despite excluding all added or free sugars, this value already represents 17% of the total energy intake, which is nearly double the intake recommended by the WHO[2]. Strategies to reduce this high sugar intake have already been implemented. As part of the Nutrition Strategy in Switzerland, the FSVO is committed to working with Swiss companies to reduce the amount of sugar in foods.

On 4 August 2015, the Federal Councillor Alain Berset and 10 Swiss food companies signed the Declaration of Milan. In this Memorandum of Understanding, the companies committed to revising their recipes to reduce progressively the sugar contents of yoghurts and breakfast cereals by the end of 2018[2]. In an initial assessment[19] of the effectiveness of the Declaration in 2016, the FSVO analysed added sugar contents of 348 yoghurts from seven companies (Société coopérative COOP, Cremo S.A., Emmi Group, Fédération des coopératives Migros, Molkerei Lanz AG, Nestlé Suisse SA) and 186 sweetened breakfast cereals from nine companies (Bio-familia AG, Bossy Céréales SA, Société coopérative COOP, Fédération des coopératives Migros, Nestlé Suisse SA, Schweizerische Schälmühle E. Zwicky AG Wander SA). Yoghurts contained a mean added sugar content of 9.4 g of added sugar per 100 g of yoghurt. The smallest amount of added sugar was 9.9 g per portion, and the largest amount was 30.6 g per portion. In breakfast cereals, the mean amount of added sugar was 17.6 g/100 g, reaching nearly 50% of the product content. Based on these data, the FSVO plans to define intermediate goals for companies to reach and will renew its assessment every year.

Several steps are planned to increase the chance of success of reducing added sugar contents of food products. A 2017 round table is planned between the Federal Councillor, representatives of signatories of the Declaration of Milan[19] and other companies wanting to reduce the added sugar contents of yoghurts and breakfast cereals. To assist food companies in their efforts, the FSVO initiated two research projects to determine how to reduce added sugar contents in yoghurts and breakfast cereals while maintaining their quality and safety[19]. Furthermore, motivated by the success of initiatives aimed at reducing salt content in food products, the FSVO wants to assess the effects of modifying the sugar contents of food and drink on the sweet taste preference of the general population.

5.4 Example of salt reduction

As is the case with excessive sugar intake, excessive salt intake is associated with numerous NCDs, including hypertension, cardiovascular disease and stroke. Reducing salt intake may lead to reductions in blood pressure and risks of developing NCDs[20]. The strategy of reducing salt intake has an ideal cost-effectiveness ratio for preventing NCDs[21]. In response to data suggesting that salt consumption was far above recommendations[22], the WHO recommended a reduction of salt intake to less than 5 g/day in adults, with similar reductions for children according to their lower energy needs[21].

[2] https://www.blv.admin.ch/blv/fr/home/lebensmittel-und-ernaehrung/ernaehrung/massnahmen-ernaehrungsstrategie/zuckerreduktion.html

Some data for national programs aimed at reducing salt consumption are already available. For example, a 2011 review of 32 initiatives in primarily European countries showed that five countries (Finland, UK, France, Ireland, Japan) reported positive effects on salt intake of the population, salt levels in foods, consumer awareness of salt intake or overall health of the population[23]. In these cases, governments led different strategies, including food reformulation, consumer awareness initiatives and labelling strategies. Reducing the salt content of foods was successful in reducing the salty taste preference and salt consumption of the population[4]. Individuals who adopted a lower-salt diet for several weeks often perceived a given salt content in food to be saltier than it was before their diet, or came to prefer lower concentrations of salt[5, 6]. Programs to reduce salt content in food did not result in unwanted repercussions, such as sales losses, product switching or addition of table salt[4]. These aspects are important considerations for public health and food industries.

In Switzerland, the national Salt Strategy 2008–2012 and Salt Strategy 2013–2016 were conducted with five objectives[24]. Preliminary results of these strategies are promising. The FSVO analysed salt contents of 335 bread samples and found a mean salt content of 1.46 g of salt per 100 g of bread. This value is lower than the salt content recommended by the FSVO and lower than the value measured in 2011 by the School of Agriculture of the Bern University of Applied Sciences.[25]

5.5 Sweet taste preference

Sensory attributes, such as texture, appearance, smell and taste, strongly influence dietary choices and intake, with taste having the strongest influence on food acceptance[26-28]. Taste can be a source of pleasure or pain and ensures that animals correctly accept or reject a food or liquid. Sweet is one of five taste modalities, which also include salty, bitter, sour and umami. Evidence shows that humans have an inborn preference for sweetness. Even before birth, the capacity to detect sweet taste functions and interacts with systems controlling affect and suckling[29]. Neonates respond to even dilute sweet tastes, are able to differentiate varying degrees of sweetness and will consume more of a sugar solution than they will consume of water. These attributes are probably explained by the need for mother's milk[7]. When a sweet solution is placed in an infant's mouth, their face relaxes and they may smile[30]. Sweet taste can act as an analgesic in infants and children[31, 32]. Neonates also prefer the taste of glutamate, which is found in breast milk[33]. By contrast, they react negatively to most bitter and sour tastes[7] and are unable to taste salt until they are about 4 months old.

A general preference for sweetness remains throughout the course of life but decreases in intensity. Numerous cross-sectional[34-37] and longitudinal[38,] studies showed that sweet preference is high in children and declines across childhood, adolescence and adulthood.

The most preferred concentration of sugar in children is approximately 0.54–0.60 M sucrose[7], where 0.60 M sucrose corresponds to about 5 teaspoons of sugar or 21 g/100 ml of water. For comparison, a standard soft drink contains about 0.34 M sugar (12 g/100 ml of water), which is closer to the sweet taste preference in adults. Sweet taste preference seems to decline to adult levels during middle to late adolescence, which coincides with the cessation of physical growth[39]. The reason for the decline in sweet taste preference has not been elucidated, but the same phenomenon has been observed in mammals[40]. The sweet taste preference of children may be due to the high caloric requirement during phases of extremely rapid growth[7]. Recent works have demonstrated a positive association between sweet taste preference and levels of cross-linked N-telopeptides of type I collagen, a biomarker for bone resorption and growth that is present at higher levels during growth spurts[39, 41].

As concluded by Mennella et al[7], the available scientific evidence suggests that the ability to detect and prefer sweet taste is evident early in life and is strongly explained by biology. However, the data also show that children learn the context in which the sweet taste experience occurs. During childhood and through familiarisation, children learn how sweet a food is supposed to taste[42]. In our modern world where sweetened foods are plentiful, including sweetened commercial foods for toddlers, the inborn sweet taste preference of children makes them vulnerable to sugar overconsumption.

Finally, research has not addressed whether the inborn preference for sweet foods can be shifted to allow a child to prefer less-sweet foods[7]. Besides the effect of age, other physiologic factors may influence sweet taste preference. Several studies demonstrated that sweet taste preference differs between sexes, with men tending to have greater liking for sweets than women[35, 43-47]. Several studies in children and adults have evaluated sweet taste preference in participants with different BMI categories, providing inconsistent results[41, 48,49]. Some studies found that BMI was related to sweet taste preference, with obese subjects having a more intense sweet taste preference than normal-weight subjects, whereas other studies did not observe this positive association[41, 48]. One study found that the preference for added sugar and sweet foods was positively linked to BMI in women but not in men[49]. In conclusion, the evidence shows that sweet taste preference is affected by physiological factors and differs in intensity between children and adults.

6. AIMS AND OBJECTIVES

The FSVO wished to investigate numerous questions (cf page 10). For methodological and clarity purposes, we have defined primary and secondary aims. The primary aim of the systematic review was to assess effects of modifying the sugar contents of foods and drinks on the sweet taste preference in the healthy population. The secondary aim was to examine the relationship between the intake of sweet foods, including artificially sweetened foods, and sweet taste preference.

Objectives of the systematic review were as follows:

- to develop a pertinent search strategy, allowing the identification of studies on the primary and secondary research questions,
- to identify eligible studies and document reasons for study exclusion,
- to extract data from included studies,
- to assess the quality of included studies,
- to analyse and present data on the primary and secondary questions,
- to discuss the results, and
- to make recommendations for research and practice.

7. METHODS

A systematic review was performed by following the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA) 2015 Checklist and the recommendations of the Academy of Nutrition and Dietetics[50, 51]. At least two researchers (Dr Corinne Jotterand Chaparro, Clémence Moullet or Eddy Farina) independently performed all steps of the systematic review, including the search of literature, selection of eligible studies, extraction of data and assignment of a quality grade to each article. Results of the researchers were compared. In the case of disagreement, a third researcher was involved to reach consensus.

7.1 Inclusion and exclusion criteria

Research question: After exploring the literature, we developed our research questions using the Population/Intervention-Exposure/Comparison and Outcome (PICO) method[52].

The primary research question was:

- Do modifications of the sugar contents of foods/beverages influence sweet taste preference in the healthy population?

Secondary research questions were:

- Is there a relationship between intake of sweet foods and sweet taste preference in the healthy population?
- Is there a relationship between intake of artificial sweeteners and sweet taste preference in the healthy population?

Inclusion criteria: Studies were eligible for the systematic review if they investigated: i) the effect of the modification of sugar content on sweet taste preference or sugar intake in healthy children and adults, or ii) the relationship between sweet food intake, including artificial sweetener intake, and sweet taste preference. Inclusion criteria are summarised in Table 1.

Table 1: Inclusion criteria for identifying studies on our primary and secondary questions

Inclusion criteria	Primary research question	Secondary research question
Population	Healthy population of any ages	Healthy population of any ages
Intervention or exposure	Modification of sugar content in foods and drinks	Sweet foods intake including artificial sweeteners intake
Comparison	Habitual or standard sugar content	Different sweet food intakes
Outcome	Sweet taste preference If available, sugar intake and health outcomes[52]	Sweet taste preference
Study design	Primary research	Primary research

In terms of study design, we only included primary experimental and observational studies. We did not restrict inclusion to experimental studies because the initial literature search performed on Medline PubMed demonstrated that only a few experimental studies addressed our question. Studies financed by food companies were included, but this aspect was taken into consideration in the assessment of study quality.

Exclusion criteria

Studies conducted in animals and populations with specific diseases were excluded. The first literature search on Medline PubMed showed that many observational cross-sectional studies, especially studies from the food industry, tested different concentrations of sugar in participants to determine their preferred sugar concentration but did not assess the evolution of sweet taste preference with time. Therefore, we excluded and documented studies that only evaluated the preferred sugar concentration at one point in time. Secondary reports (reviews, meta-analyses, syntheses of previously reported studies, opinions, etc) were excluded.

7.2 Search strategy and selection of studies

The literature search was performed according to the Evidence Analysis Process guidelines of the Academy of Nutrition and Dietetics[50, 51]. Three independent researchers completed searches of Medline PubMed, CINAHL, EMBASE, Web of Science and Cochrane Library for all available dates. Publications in English, French, German and Italian were eligible for inclusion. The limit "humans" was used because many studies on animals were available.

Search strategies for different electronic databases were developed in collaboration with a librarian from the University of Applied Sciences of Western Switzerland. Several search strategies for Medline PubMed were developed, with two strategies, using Medical Subject Headings (MeSH) and free keywords, respectively, ultimately being selected. We used general MeSH terms and keywords and intentionally did not restrict the search to ensure that we would find all potential studies that examined our primary and secondary questions.

We combined general MeSH terms or keywords about food habits, sugar and taste, and restricted findings to human studies. The MeSH term search strategy in Medline PubMed was as follows: (((Feeding Behaviour [MeSH Terms] OR Food Preferences [MeSH Terms] OR Food Habits [MeSH Terms])) **AND** ((((carbohydrates [MeSH Terms]) OR dietary sucrose [MeSH Terms]) OR Sweetening Agents [MeSH Terms]) OR sugar)) **AND** ((taste [MeSH Terms]) OR taste perception [MeSH Terms]) **AND** Humans [MeSH]). The free keyword search strategy was as follows: sugar AND (reduc* OR less* OR target$ OR cutback* OR decreas* OR limit* OR formulat* OR reformulate OR control OR adjust*))) AND (intake OR consum* OR content OR eat*) AND (food* OR beverage* OR drink*) AND (sweet taste OR pleasant* OR preference OR ((dependence OR Addiction) NOT Drug* NOT alcohol))).

The search strategy for Medline PubMed was used to develop strategies for CINAHL, EMBASE, and Web of Science (see Appendix I). Results from Medline PubMed were excluded on CINAHL and EMBASE. In Web of Science, no simple function exists to exclude Medline PubMed results; therefore, all publications with a Medline PubMed ID (PMID) were excluded.

Titles and abstracts of identified eligible studies were screened, followed by the full text when necessary. To identify appropriate studies, a checklist with the inclusion criteria was developed (Appendix II) and used by each researcher. Bibliographies of retrieved articles were searched by hand. Secondary reports were searched for original research that addressed the question of sweet taste preference. Grey literature was searched by using websites of key governments and organisations, including:

- American Heart Association, www.heart.org
- US Academy of Nutrition and Dietetics, www.eatright.org
- Swiss Association of Registered Dieticians, www.svde-asdd.ch
- Federal Commission for Nutrition in Switzerland, www.eek.admin.ch
- European Food Safety Authority, www.efsa.europa.eu
- France Observatory for Eating Habits, www.lemangeur-ocha.com
- France National Nutrition Health Program, http://www.mangerbouger.fr
- Swiss Society for Clinical Nutrition, www.geskes.ch
- Swiss Society for Nutrition, www.sge-ssn.ch
- WHO, www.who.int.

We also searched the recommended dietary intakes of different countries:

- Germany – Austria – Switzerland (DACH), 2015: Valeurs de référence pour les apports nutritionnels[53]
- France, 2001: Apports nutritionnels conseillés pour la population française[54]
- US, 2005: Dietary Reference Intakes[54]
- US: Dietary guidelines for Americans 2015–2020[55]

We conducted a general search in Google. Finally, we contacted experts in the field of sugar from the ETH of Zurich, University of Bern and Swiss Toothfriendly Association to identify unpublished and ongoing studies.

A PRISMA flowchart[56] was used to document the number of studies that were identified during the search process, the number of studies that were included in the study and the number of studies that did not meet the inclusion criteria and were excluded. Reasons for exclusion were documented. In addition to the PRISMA flow chart, tables listing the excluded studies were developed.

7.3 Data extraction

Two researchers independently extracted data from the selected studies. A standardised data extraction form was developed in Excel (Appendix III) based on the worksheet template from the Academy of Nutrition and Dietetics[51]. This form was piloted before use and did not require any adaptation. Extracted data included information on:

- Study: citation, country, research design, link to food industry. To determine the research design of included studies, we used two algorithms developed by the Academy of Nutrition and Dietetics[51] to classify experimental studies (Figure 2a) and observational studies (Figure 2b);
- Participants: number, sex, age, anthropometric parameters;
- Intervention or exposure: modification (reduction, supplementation, consumption) of sugar content, type of sweet food product, duration of intervention and quantity and frequency of intake of sweet foods, including artificial sweeteners;
- Comparison: habitual or standard sweet food content or intake; and
- Outcomes: primary outcome was sweet taste preference. As an alternative to sweet taste preference, some studies provided liking or intake of food, two variables that we also extracted. We initially planned to extract daily sugar intake and health outcomes, but no study reported these variables.

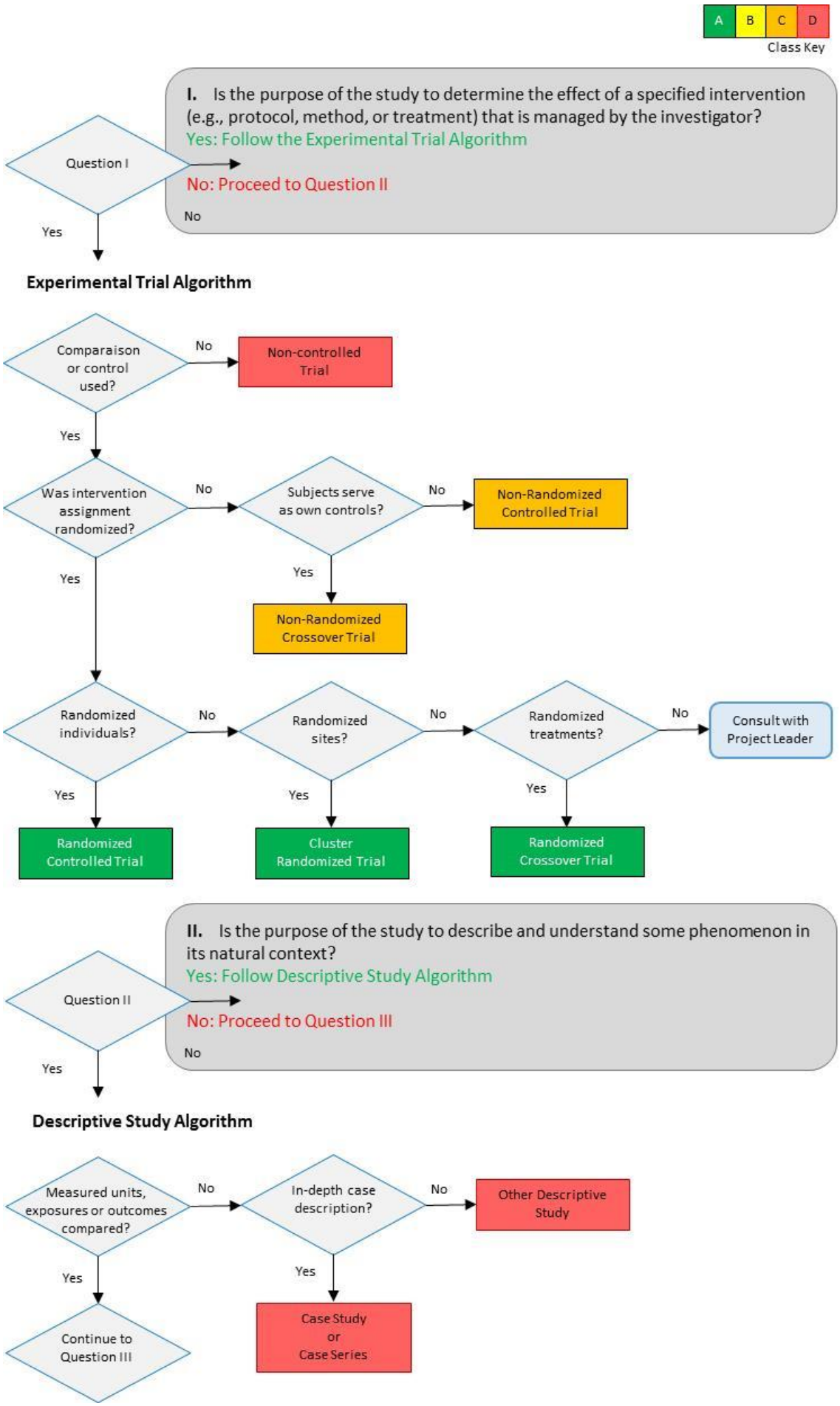

Figure 2a: Experimental trial algorithm (Source: Academy of Nutrition and Dietetics)[51]

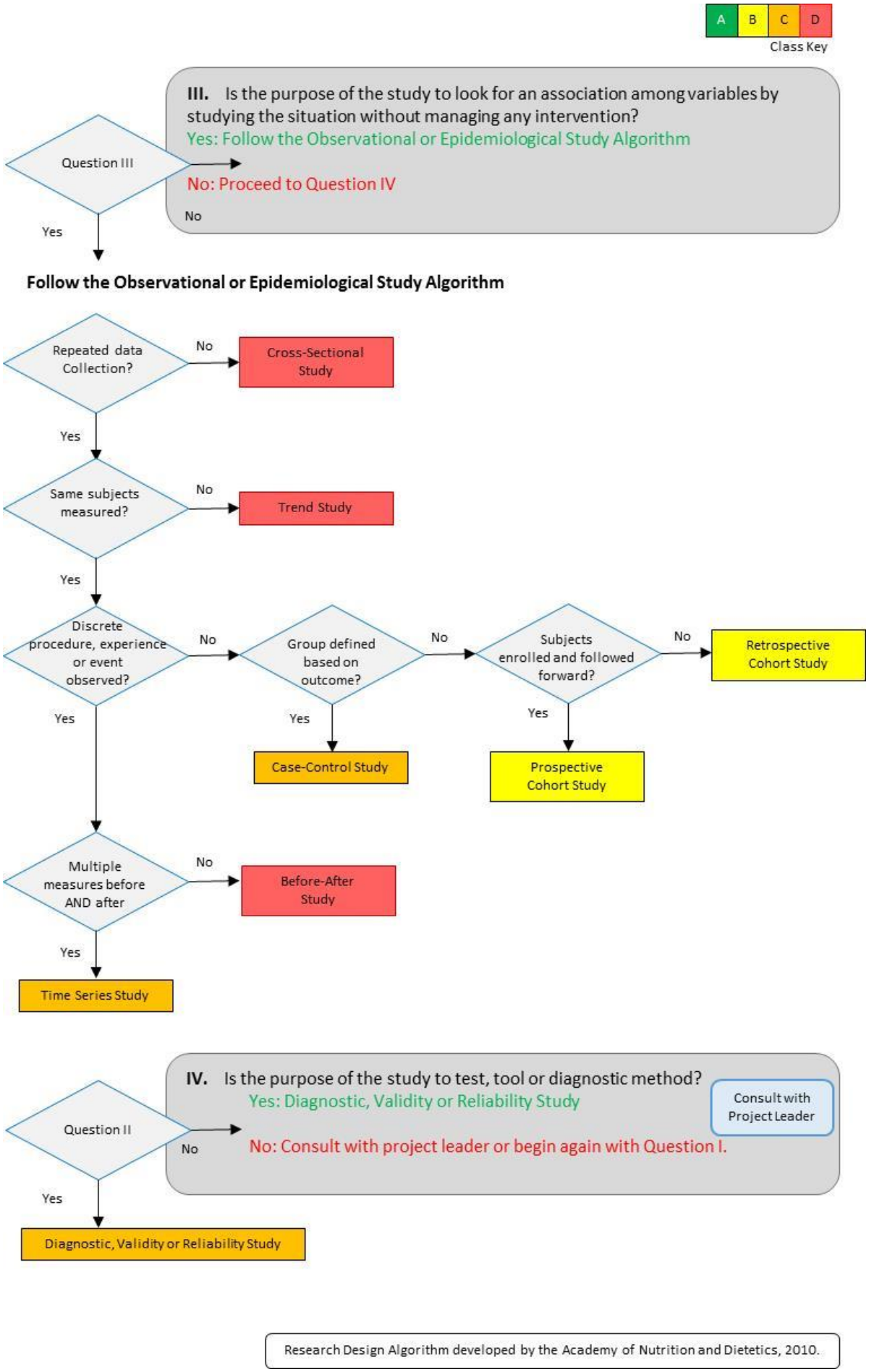

Figure 2b: Observational algorithm (Source: Academy of Nutrition and Dietetics)[51]

7.4 Assessment of study quality

Each included study was assigned a quality grade (positive, negative or neutral) by using the 10-question checklist and subquestions developed by the Academy of Nutrition and Dietetics[50, 51]. Appendix IV provides the primary research form with detailed questions. We used the ready-to-fill-in form on the Academy of Nutrition and Dietetics website (https://www.andeal.org/evidence-analysis-manual). This analysis was performed independently by at least two researchers.

Ten areas need to be evaluated before assigning a quality rating:

1. Clarity of the research question(s)
2. Absence of bias in subject selection
3. Comparability of study groups
4. Description of withdrawal method
5. Prevention of introduction of bias by using blinding
6. Description of intervening factors
7. Clear definition of outcomes and use of valid and reliable measurements
8. Appropriateness of statistical analysis
9. Support of conclusion by results
10. Absence or minimal likelihood of funding or sponsoring bias

Each study was rated on the 10-question checklist provided by the Academy of Nutrition and Dietetics (Table 2).

Table 2: Rating criteria for determining the quality grade of studies

Grade	Criteria
Positive	If most of the answers to the above validity questions are “Yes” i.e. criteria 2, 3, 6, 7 and at least one additional “Yes” the report should be designated with a positive symbol (+) on the Evidence Worksheet.
Neutral	If the answers to validity criteria questions 2, 3, 6, and 7 do not indicate that the study is exceptionally strong, the report should be designated with a neutral (∅) symbol on the Evidence Worksheet.
Negative	If most (six or more) of the answers to the above validity questions are “No,” the report should be designated with a negative (-) symbol on the Evidence Worksheet.

The Academy of Nutrition and Dietetics defined different quality ratings, as follows:

- Positive: Report clearly addresses issues of inclusion/exclusion, bias, generalisability, and data collection and analysis.
- Negative: Report does not adequately address the above issues.
- Neutral: Report is neither exceptionally strong nor exceptionally weak in quality.

7.5 Data synthesis and analysis

Data were analysed through a narrative synthesis method. We initially analysed data on the primary question, followed by the secondary questions. Results of the analysis were presented in the following order:

1) Effects of modifying food/beverage sugar content on sweet taste preference, including influences of modification type (progressive vs abrupt), age, sex, BMI and food category;
2) Association between sweet food intake and sweet taste preference;
3) Association between artificial sweetener intake and sweet taste preference.

We were unable to perform a meta-analysis because of the limited amount of available data and the heterogeneity of the interventions and outcomes.

7.6 Ethics

Approval from the ethics committee was not necessary because this project was a systematic review that did not involve data collection or measurements in humans.

8. RESULTS

8.1 Study selection

The literature search of different sources provided 1129 results, of which 975 records were excluded based on their title or abstract. We read 154 full-text articles for eligibility and excluded 82 articles that did not meet the inclusion criteria (see Appendix V for reasons for exclusion). Eight papers that addressed the main question were excluded because they were secondary reports (type A articles; see Appendix V). We excluded 44 articles that addressed the question of sweet taste preference according to BMI, age and gender, but without studying our primary or secondary questions[7, 26, 27, 34-39, 41, 43-49, 57-92]. These articles are documented in Appendix V and presented partly in the background of this report (type B articles). One study[93] on artificial sweeteners was excluded because it included participants with an obese BMI of 35 kg/m^2 and we decided to only include healthy participants. Searches of sources other than electronic databases provided only one eligible study, which was found by a Google search (Appendix VI).

The final analysis included 21 original studies (Figure 3), which were identified mainly by using MeSH terms in Medline PubMed (n = 14). One study was identified in Embase, six were identified in references of retrieved articles and one was found on Google (Table 3).

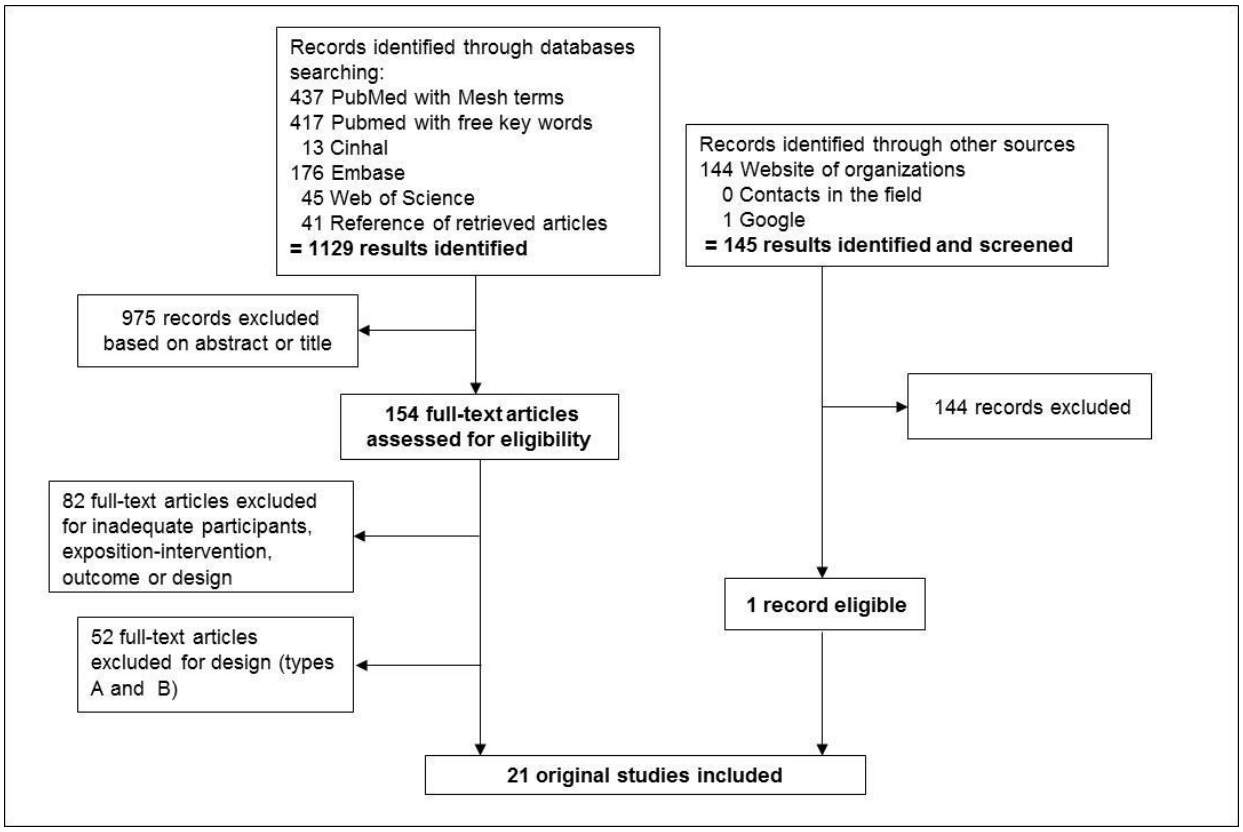

Figure 3: PRISMA flow chart for study selection process[56]

Table 3: Summary of results of the literature search

	Results (n)	Read articles (n)	Included (n)	Excluded (n)	Excluded types A and B (n)	Total excluded (n)
Medline PubMed – MeSH terms	437	81	14	34	33	67
Medline PubMed – keywords	417	9	0	8	1	9
CINAHL	13	4	0	4	0	4
Embase	176	17	1	11	5	16
Web of Science	45	5	0	2	3	5
References	41	38	5	23	10	33
Sub-total	**1129**	**154**	**20**	**82**	**52**	**134**
Other sources	145	145	1	144	0	144
Total	**1274**	**299**	**21**	**226**	**52**	**278**

Among the 21 studies included in the current review:

- 8 studies (7 experimental trials[42, 94-99] and 1 observational cross-sectional study[100]) addressed the main question of the effect of modification of sugar content on sweet taste preference or sugar intake.
- 13 observational studies addressed secondary questions on the association of sweet taste preference with sweet food intake (12 studies)[41, 87, 101-110] or artificial sweetener intake (1 study)[76].

8.2 Effects of modification of sugar content on sweet taste preference, liking or intake

8.2.1 Study characteristics

The eight studies that addressed the primary question were conducted between 1980 and 2016, mostly since 2011. Three studies were conducted in adults[94-96], four studies were conducted in children[42, 97, 98, 100] and one study included both adults and children[99]. Seven studies were experimental studies[42, 94-99], mostly randomised controlled trials (RCTs). One study was observational[100]. In adults, the sample size ranged from 12 to 219 participants and mean age ranged from 22 to 37 years. One study did not provide BMI. In the three other adult studies, BMI ranged 21.7–27.4 kg/m^2. In children, the number of participants ranged from 39 to 793. Two studies did not provide age but specified that only infants or elementary school children, respectively, were included[98, 100]. In the three other studies, age varied between 2.5 and 9.2 years[42, 97, 99].

Interventions and outcomes were very heterogeneous. Studies assessed the effects of one of the following interventions: reduction in sugar intake (n = 2)[94, 95], consumption of foods with or without added sugar (n = 4)[42, 97, 98, 100] or supplementation with sugar-containing beverages (n = 2)[96, 99]. One study[94] reduced the sugar content of the overall diet, whereas other studies reduced sugar contents of specific foods (biscuit, fruit purees, tofu, ricotta cheese or jicama). In two studies[96, 99], a sweet beverage was added to the normal diet of participants. In terms of outcomes, studies assessed the effect of the intervention on sweet taste preference (n = 3)[94, 96, 99], liking (n = 3)[42, 95, 98] or intake of the food (n = 2)[97, 100]. Table 4 summarises interventions and outcomes of the eight studies. Tables 5a and 5b show detailed characteristics of these studies, including their design, sample, intervention and outcome.

Table 4: Studies according to type of intervention and outcome

		Outcomes		
		Sweet taste preference	**Liking of the food**	**Intake of the food**
Interventions	**Reduction in sugar**	Wise et al. 2016[94]	Biguzzi et al. 2015[95]	
	Supplementation with sugar	Sartor et al. 2011[96] Liem et al. 2004[99]		
	Consumption with or/and without sugar		Sullivan et al. 1990[42] Brown et al. 1980[98]	Yon et al. 2012[100] Bouhlal et al. 2011[97]

Table 5a: Characteristics of studies on the effect of the modification of sugar content on sweet taste preference, liking or intake: design and sample

Author, Year	Design	Quality	Financing	Purpose of the study	Sample
Wise et al. 2016[94]	Experimental: RCT	Positive	Food industry	To determine how a substantial reduction in dietary intake of simple sugars affects sweetness intensity and pleasantness of sweet foods and beverages.	29 adults: 13 males and 16 females Age: 36.7 and 34.4 (21-54) years BMI: 26.1 and 27.4 kg/m^2
Biguzzi et al. 2015[95]	Experimental: RCT	Neutral	Not declared	To study the effect of exposure to biscuits reduced in fat or sugar content, and to compare two strategies of exposure.	219 adults: 61 males and 158 females Age: 37.0 ± 12.2 years BMI: Not specified
Yon et al. 2012[100]	Observational: cross-sectional study	Neutral	Food industry	To compare elementary school students' consumption of standard and reformulated lower-calorie flavoured milk.	793 children: 403 boys and 390 girls Age: Not specified BMI: Not specified
Sartor et al. 2011[96]	Experimental: non-controlled trial	Positive	Not declared	To test the effects of soft drink consumption on sweet taste, explicit preference and implicit attitude toward sweet in normal-weight subjects.	12 adults: 5 females and 7 males Age: 26 years BMI: 21.7 kg/m^2
Bouhlal et al. 2011[97]	Experimental: non-randomised crossover trial	Positive	Not by food industry	To evaluate the impact of salt, fat or sugar levels in common foods on children's intake, during a normal meal in a familiar environment.	61 children: 32 boys and 42 girls Age: 2.5 years BMI: 15·9 (SE 0.1) kg/m^2
Liem et al. 2004[99]	Experimental: RCT	Positive	Not declared	To investigate whether the preference for sweet and sour tastes in two different foods can be changed in children and adults after a short repeated exposure to sweet or sour taste in orangeade.	46 adults: 11 males and 35 females. Age: 22 ± 2.0 years, BMI: 22.2 kg/m^2 59 children: 28 boys and 31 girls Age: 9.2 ± 0.9 years BMI: 16.7 kg/m^2

Table 5a *(continued):* Characteristics of studies on the effect of the modification of sugar content on sweet taste preference, liking or intake: design and sample

Author, Year	Design	Quality	Financing	Purpose of the study	Sample
Sullivan et al. 1990[42]	Experimental: RCT	Negative	Not declared	To explore the role of experience with a novel food, eaten sweetened, salty, or plain, on the development of a preference for those three versions of that food.	39 children: 21 boys and 18 girls Age: 4.6 (3.7-5.9) years BMI: Not specified
Brown et al. 1980[98]	Experimental: non-randomised controlled trial	Neutral	Purees provided by food companies	To determine whether early exposure to refined sugar would increase the chances that an infant would later display preference for sweetened foods.	40 infants Age: Not specified BMI: Not specified

Table 5b: Characteristics of studies on the effect of the modification of sugar content on sweet taste preference, liking or intake: intervention and outcome

Author, Year	Intervention / Exposure	Measure of intervention / exposure	Outcome	Measure of outcome
Wise et al. 2016[94]	Reduction of 40% in calories from simple sugars in diet for 3 months while maintaining energy balance	Diet record completed by participants	1. Sweet taste preference 2. Sweet taste intensity 3. Sucrose detection thresholds	1. 23-point category scale 2. General labelled magnitude scales (gLMSs) [111] 3. Efficient version of the forced-choice ascending method of limits [112, 113]
Biguzzi et al. 2015[95]	Consumption of 16 biscuits each week during 4 weeks: standard biscuit, most reduced sugar variant (28% sugar-reduced biscuit) or stepwise reduction in sugar	No information on compliance	Liking of the biscuit	Continuous scale
Yon et al. 2012[100]	Reduction of sugar in flavoured milk served in schools	Similar to the measure of outcome	Intake of flavoured milk	Each flavoured milk container was weighed twice using a calibrated digital scale to the nearest 1/8 oz.
Sartor et al. 2011[96]	Supplementation of soft drink during 4 weeks, of about 760 ml energy drink per day	Compliance was assessed by subjects' urine samples tested for energy drink specific markers and empty drink bottles were collected.	1. Sweet taste preference 2. Sweet taste intensity 3. Fasting plasma glucose and insulin, fat mass and resting respiratory exchange ratio	1. Sucrose preference score adapted from Liem & Menella[103] 2. General Labelled Magnitude Scales (gLMS) [114]
Bouhlal et al. 2011[97]	Modification of sugar content in the fruit puree i.e. without sugar, 5% = control and 10% at 3 snack times	Similar to the measure of outcome	Intake of fruit puree	Each puree was weighed before and after consumption to the nearest 1 g.

Table 5b *(continued)*: Characteristics of studies on the effect of the modification of sugar content on sweet taste preference, liking or intake: intervention and outcome

Author, Year	Intervention / Exposure	Measure of intervention / exposure	Outcome	Measure of outcome
Liem et al. 2004[99]	Consumption of 200 ml of orangeade as a midmorning snack for 8 days, either sweet or sour	In children, orangeades were weighed before and after consumption. Adults were instructed to mark how much was left of the orangeade.	Sweet taste preference	Adults divided the stimuli into three categories of preference. Children were asked to rank all stimuli within each category from most to least preferred [115]
Sullivan et al. 1990[42]	15 exposures during 9 weeks with one of three novel foods: tofu, ricotta cheese or jicama, either with added salt or sugar or plain, without added sugar or salt. Each exposure involved taking a small taste.	Not specified	Liking of the tofu	Children divided the stimuli into three categories “of preference using faces (smiling, neutral, dislike). Within each category, they ranked the food from most to least preferred [116]
Brown et al. 1980[98]	Consumption of sweetened versus unsweetened food during three months since the introduction of solid food. Consumption of unsweetened and sweetened fruits, randomly assigned, during 4 weeks.	Babies were frequently monitored at well-baby check-ups or by telephone.	Liking of the foods	Parents were asked to record the baby’s reactions to the various foods. Whatever food remained was collected and weighed by the researcher. Scale were used by parents at the end of each test week, to indicate with a score of 1 to 5 the baby’s degree of preference for the food offered that week.

8.2.2 Quality rating

Among the eight studies that addressed the main question, four had a positive quality rating[94,96,97,99], three had a neutral rating[95,100,98, 100] and one study had a negative rating[42] (Table 6). The criterion concerning study financing and possible conflicts of interest was the most problematic. In only one study[97] did the authors clearly state that financing was provided by public institutions. In four studies[95,96,99,42], there was no information on type of financing. Four studies had links to the food industry: financing was provided[100], some researchers were employed by a food industry[94] or the fruit purees used as intervention were provided by several food companies[98].

Table 6: Quality rating of studies on the effect of the modification of sugar content on sweet taste preference, liking or intake and responses to the 10 questions of the Academy of Nutrition and Dietetics[51]

Authors, year	Study design	Quality	1	2	3	4	5	6	7	8	9	10
Wise et al. 2016[94]	Experimental: RCT	Positive	yes	yes	yes	yes	yes	yes	yes	yes	yes	no: industry
Biguzzi et al. 2015[95]	Experimental: RCT	Neutral	yes	no	yes	?	?	no	yes	no	yes	no
Yon et al. 2012[100]	Observational: cross-sectional study	Neutral	yes	?	yes	yes	yes	?	yes	yes	yes	no: industry
Sartor et al. 2011[96]	Experimental: non-controlled trial	Positive	yes	yes	no	yes	yes	yes	yes	yes	yes	no
Bouhlal et al. 2011[97]	Experimental: non-randomised crossover trial	Positive	yes	yes	yes	yes	yes	yes	no	yes	yes	yes
Liem et al. 2004[99]	Experimental: RCT	Positive	yes	yes	yes	yes	yes	yes	yes	yes	yes	no
Sullivan et al. 1990[42]	Experimental: RCT	Negative	yes	no	?	?	?	yes	?	?	?	no
Brown et al. 1980[98]	Experimental: non-randomised control trial	Neutral	yes	?	yes	yes	yes	no	no	?	yes	no: partly industry
Number of studies with positive answer:			**8/8**	**4/8**	**6/8**	**6/8**	**6/8**	**5/8**	**5/8**	**5/8**	**6/8**	**1/8**

8.2.3 Findings

As described in Table 7a, modifications (reduction or supplementation) of sugar content did not alter the sweet taste preference in most studies of adults. However, a subgroup of initial sucrose-dislikers showed increased sweet taste preference after supplementation with one 760-ml energy drink per day for 4 weeks[96]. In 2015, Biguzzi et al[95] tested effects of reducing sugar content of biscuits on liking for these products. Participants consumed biscuits containing standard sugar content (31 g of sugar/100 g of biscuit; control group), biscuits with a 28% reduction in sugar (22 g/100 g; direct group), or biscuits with progressively lower sugar contents (31, 28, 26, 24, or 22 g/100 g; stepwise group). After a 5-week intervention, liking for the 9% and 16% reduced-sugar biscuits were increased in the direct group but not in other groups.

Table 7b summarises results obtained in children. Sullivan et al[42] exposed children to a food without sugar 15 times. They found that preference for the sugar-free food increased, while preference for the same food with sugar declined. Similarly, when children were exposed to a food with sugar, their preference for this food increased, while their preference for the same food without sugar decreased. In another study, Liem et al[99] used dietary supplementation with sweet beverages and found an increase in sweet taste preference[99]. Two studies[100,97] compared intakes of foods containing standard and reduced concentrations of sugar. In the observational study of Yon et al,[100] consumption levels of standard flavoured milk (170 kcal, 1% milk fat and up to 28 g of added sugar per 230-ml serving) and reformulated flavoured milk (150 kcal, 1% milk fat and 22–27 g of added sugar per 230-ml serving) were compared in 793 elementary school students. In the experimental study of Bouhlal et al[97], 74 toddlers at a day-care centre (mean age 2.5 years) consumed fruit purees at separate snack times with three different concentrations of sugar: no added sugar, 5% added sugar (standard concentration) and 10% added sugar. Neither study[97,100] found any difference of food intake between groups with standard vs reformulated products.

Detailed results, including statistical values, of these different studies are provided in Appendix VII. Due to the homogeneity of the BMI and sex distributions in different studies, we were not able to analyse the effect of sex or BMI on sweet taste preference.

Table 7a: Effects of modification of sugar content on sweet taste preference or liking in adults

Author, Year	Sample / Quality	Intervention	Findings
Wise et al. 2016[94]	29 adults Age: 36,7 and 34,4 (21-54) years Positive	Reduction of 40% in calories from simple sugars in diet for 3 months while maintaining energy balance	Sweet taste preference: ↔
Sartor et al. 2011[96]	12 adults Age: 26 years Positive	Supplementation of soft drink during 4 weeks, of about 760 ml energy drink per day	Sweet taste preference: ↔ - in the initial sucrose-dislikers group: ↑ - in the initial sucrose-likers group: ↔
Liem et al. 2004[99]	46 adults Age: 22 ± 2.0 years Positive	Supplementation of orangeade during 8 days, either sweet or sour, of 200 ml	Sweet taste preference: ↔
Biguzzi et al. 2015[95]	219 adults Age: 37.0 ± 12.2 years Neutral	Consumption of 16 biscuits / week during 4 weeks: standard biscuit, most reduced sugar variant (28% sugar-reduced biscuit) or stepwise reduction in sugar	Liking of the 28% reduced-sugar biscuits: ↔ - Control and stepwise groups: ↔ - Direct group: ↔ Liking of the 9% and 16% reduced-sugar biscuits: - Direct group: ↑

Meaning of symbols:

↔: no modification of sweet taste preference or liking; ↑: increase in sweet taste preference or liking

Table 7b: Effects of modification of sugar content on sweet taste preference, liking or intake in children

Author, Year	Sample / Quality	Intervention / Exposure	Findings
Liem et al. 2004[99]	59 children Age: 9.2 ± 0.9 years Positive	Supplementation of orangeade during 8 days, either sweet or sour, of 200 ml	Sweet taste preference: ↑
Yon et al. 2012[100]	793 children Age: *ns* Neutral	Exposure: reduction of sugar in flavoured milk in schools	Intake of standard and reformulated lower-sugar flavoured: identical in both groups
Bouhlal et al. 2011[97]	61 children Age: 2.5 years Positive	Consumption of fruit purée with 3 different sugar concentrations i.e. without sugar, 5% = control and 10% at three snacks times	Intake of fruit puree: ↔
Sullivan et al. 1990[42]	39 children Age: 4.6 (3.7-5.9) years Negative	15 exposures during 9 weeks with only one of three initially novel foods: added salt, sugar or plain tofu.	Liking in the three groups: ↑
Brown et al. 1980[98]	40 infants Age: *ns* Neutral	Consumption of sweetened or unsweetened food during 3 months since the introduction of solid food. (consumption of unsweetened and sweetened fruits, randomly assigned, during 4 week)	Liking of sweetened and unsweetened food: ↔ Intake of sweetened and unsweetened food: ↔

Meaning of symbols:

↔: no modification of sweet taste preference, liking or intake; ↑: increase in sweet taste preference or liking

Figures 4 show subanalyses by type of intervention. Figure 4a shows the effect of reducing or supplementing sugar content on sweet taste preference. In one study using supplementation of beverages with sugar[99], sweet taste preference increased. In three other studies, no modification of sweet taste preference was observed.

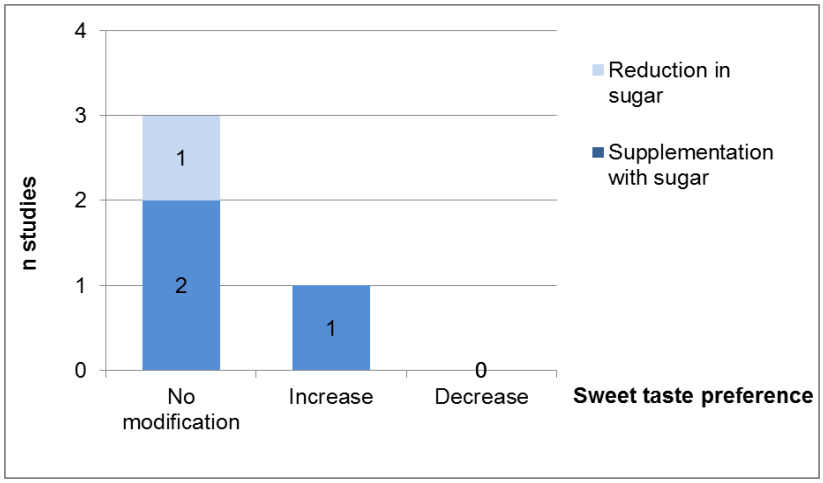

Figure 4a: Number of studies showing an increase, decrease or no modification of sweet taste preference after reduction of or supplementation with sugar

Figure 4b shows the results of the liking or intake of sweet foods after reduction of the sugar content or consumption of food without sugar. In four studies, the liking or intake of sweet foods did not change.

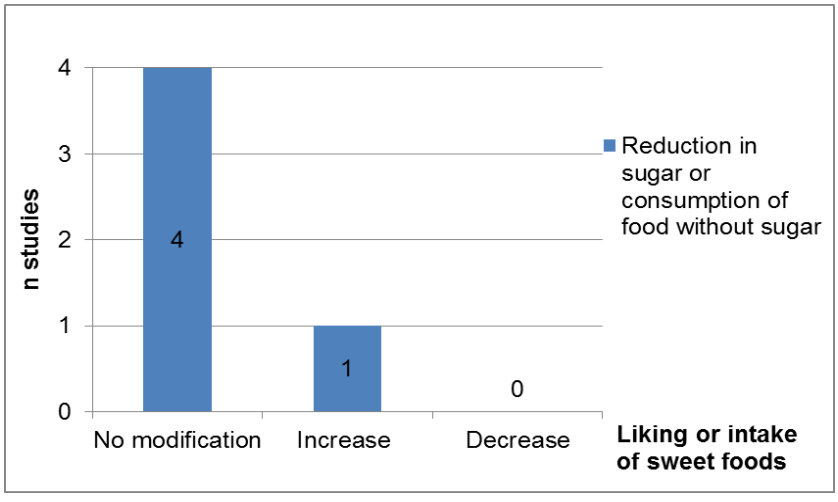

Figure 4b: Number of studies showing an increase, decrease or no modification in liking or intake of sweet foods after reduction of sugar content or consumption of food without sugar

8.3 Association between sweet food intake and sweet taste preference

8.3.1 Study characteristics

The 12 studies that addressed the association between sweet food intake and sweet taste preference were conducted between 1981 and 2016 (Tables 8a and 8b). Five studies were conducted in adults[101,104,105,106,107], six studies were conducted in children[87,102,103,109,108,110] and one study was conducted in children and their mothers[41]. In studies of adults, sample size ranged from 25 to 132 participants and age ranged from 17 to 36 years. Mean BMI was in the normal range in all but one study,[41] in which participants had a mean BMI of 28.3 kg/m^2. In studies of children, the number of participants ranged from 31 to 1593 and age ranged from 0.5 to 9 years.

Exposures and outcomes were similar in these studies. Exposure was sweet food intake in most studies. In three studies performed in young children, the exposure was early sugar water intake during infancy[102, 108, 109]. All studies measured sweet taste preference as the outcome, and one study assessed preference for sweetened juices[103].

Table 8a: Characteristics of studies of the association between sweet food intake and sweet taste preference: design and sample

Author, Year	Design	Quality	Financing	Purpose of the study	Sample
Jayasinghe et al. 2016[101]	Observational: cross-sectional study	Neutral	Not by food industry	To investigate the links between sweet taste perception, sweet food choices and eating behaviour in 20-40-year-old New Zealand European women.	45 females Age: median of 29 (IQR: 23-32.5) years BMI: 24.07 (95% CI: 23.1, 25.07) kg/m^2
Mennella et al. 2014[41]	Observational: cross-sectional study	Positive	Not by food industry	To examine individual differences in preference for sugars and salt between mothers and children.	76 mothers and 101 children Age: 36.1 ± 1.0 and 7.8 ± 0.2 years BMI adults: 28.3 ± 7.0 kg/m^2 Normal weight children: 64.4 %
Lanfer et al. 2012[87]	Observational: cross-sectional study	Positive	Not by food industry	To describe sweet preferences in relation to dietary habits.	1'593 children: 777 boys and 816 girls Age: 6-9 (range) years Overweight: n = 396
Pepino et al. 2005[102]	Observational: cross-sectional study	Neutral	Food industry	To explore whether early exposure to sweetened water modifies sweet preferences during childhood.	108 children Age: 7.8 ± 0.1 years BMI: 15.9 (range: 13.5 - 18.9) kg/m^2
Liem et al. 2002[103]	Observational: cross-sectional study	Neutral	Not by food industry	To determine whether early experience with hydrolysate formulas influences preferences for sour and sweetened apple juices in 4- to 5-year-old and 6- to 7-year-old children.	83 children: 41 boys and 42 girls Age: 4-7 (range) years BMI: 16.1 to 17.2 (range) kg/m^2
Holt et al. 2000[104]	Observational: cross-sectional study	Neutral	Not declared	To evaluate the intensity and the liking of the level of sweetness of a series of sucrose solutions in Malaysian and Caucasian Australian subjects and their dietary habits.	132 adults: 56 males and 76 females Australian group: Age: 22.8 ± 4.3 years, BMI: 22.7 ± 2.5 kg/m^2 Malaysian group: Age: 21.5 ± 1.2 years, BMI: 20.8 ± 2.2 kg/m^2

Table 8a *(continued)*: Characteristics of studies of the association between sweet food intake and sweet taste preference: design and sample

Author, Year	Design	Quality	Financing	Purpose of the study	Sample
Stone et al. 1990[105]	Observational: cross-sectional study	Negative	Not by food industry	To determine whether any of a large number of personality traits related to dietary intake of salty and sweet foods and/or to preferences for sweetness in lemonade and to saltiness in broth.	100 adults: 38 males and 62 females Age: 18-31 (range) years BMI: normal
Mattes et al. 1986[106]	Observational: cross-sectional study	Neutral	Not declared	To evaluate preferences under different testing conditions and their relationship to food choice and intake.	25 males Age: 17-34 (range) years BMI: normal
Pangborn et al. 1984[107]	Observational: cross-sectional study	Neutral	Food industry	To measure whether frequency of intake of sweets and expressed preferences for low- vs. high-sugar items were related to perceived intensity of sweetness or degree of liking for experimental lemonade.	51 adults: 32 males and 19 females Age: 18-31 (range) years BMI: normal
Beauchamp et al. 1984[109]	Observational: before-after study	Neutral	Not by food industry	To evaluate whether early exposure to sugar water was related to intake of plain water and sweetened beverage.	63 children: 28 boys and 35 girls Age: 2.0 (SEM: 0.0) years BMI: Not specified
Beauchamp et al. 1982[108]	Observational: prospective cohort study	Neutral	Not by food industry	To determine if sweet preference in infants differed at birth and at 6 months of age.	140 children Age: 0.5 year ± 0.0 BMI: Not specified
Olson et al. 1981[110]	Observational: longitudinal study	Neutral	Not by food industry	To determine whether there was a relationship between the level of sweetness preferred in sugar-water solutions in a taste test situation and the level of sweetness in individual foods selected by preschool-age children for snacks.	31 children: 13 boys and 18 girls Age: 4 – 5 (range) years BMI: Not specified

Table 8b: Characteristics of studies of the association between sweet food intake and sweet taste preference: exposure and outcome

Author, Year	Exposure	Measure of exposure	Outcome	Measure of outcome
Jayasinghe et al. 2016[101]	Sweet foods intake	Sweet food-food frequency questionnaire. Frequencies were converted to a daily frequency equivalent of each food item[117-120]	1. Sweet taste preference 2. Sweet taste intensity	1. General Labelled Magnitude Scales (gLMSc) [96] 2. Intensity ratings scale in millimetres[104]
Mennella et al. 2014[41]	Dietary intake (daily added sugar intake, caloric intake and daily sodium intake)	24-hour dietary recall for the mother and her child. Children also reported on snacks or foods eaten outside the home. Average of the 2 days of diet reports. Dietary intake data were collected and analysed using the Automated Self-Administered 24-Hour Recall system, developed by the National Cancer Institute (Bethesda, MD)[121].	Sweet taste preference	The Monell two-series, forced-choice, paired-comparison tracking method[91, 122]
Lanfer et al. 2012[87]	Sweet foods intake	The Children's Eating Habits Questionnaire [123]	Sweet taste preference	A paired comparison test to assess sweet preferences [124]
Pepino et al. 2005[102]	Practice of feeding sugar water during infancy	Questions to mothers on the practice of feeding sweetened water to their children when they were infants	Sweet taste preference	A forced-choice, paired comparison, tracking technique to assess sucrose preference[122].
Liem et al. 2002[103]	Formula history: milk versus hydrolysate formulas	Questionnaires completed by mothers about her child's feeding habits and preferences	Preference for sweetened juices	A test to determine the number of times (of 15) each child preferred the apple juices with added sugar[125]
Holt et al. 2000[104]	Dietary habits (sugar intake)	Food Frequency Questionnaire for Australian subjects [126] Food Frequency Questionnaire for the Malaysian subjects[127]	1. Sweet taste preference 2. Sweet taste intensity	1. Sweetness liking ratings scale 2. Intensity ratings scale

Table 8b *(continued)*: Characteristics of studies of the association between sweet food intake and sweet taste preference: exposure and outcome

Author, Year	Exposure	Measure of exposure	Outcome	Measure of outcome
Stone et al. 1990[105]	Sugar intake	The sugar-intake questionnaire, modified from a form used by Pangborn & Giovanni[107]	Sweet taste preference	20-point numerical scale, completed twice by all subjects
Mattes et al. 1986[106]	Percent of calories from foods identified by respondents as having a predominantly sweet taste	7 days record Questionnaires designed to elicit information on preferences for predominantly sweet tasting foods and their frequency of consumption	Sweet taste preference	Visual analogue scale. Rated with adjustment tasks too. A modification of the procedure employed by Mattes and Lawless [128]
Pangborn et al. 1984[107]	Sweet food intake Expressed preferences for low- versus high-sugar	Self-administered questionnaire with a record of frequency of consumption of 32 sweet foods and preference between high-sugar and low-sugar versions of 18 selected items.	Sweet taste preference Sweet taste intensity	Graphic scale
Beauchamp et al. 1984[109]	Early exposure to sugar water during infancy	7 days record	Sweet taste preference	Ad libitum intake of 75 ml of sweetened solutions at different concentration during 30 sec.
Beauchamp et al. 1982[108]	Early exposure to sugar water	7 days record	Sweet taste preference	Ad libitum intake of 75 ml of sugar water sweetened at different concentration during 1 min.
Olson et al. 1981[110]	Food choice and habitual consumption of sweet foods	Questionnaire on food habits and taste preferences. Choice between three snacks sweetened at different concentration was recorded every day.	Sweet taste preference	Participants ordered by preference four solutions of sweetened water at different concentrations.[35]

8.3.2 Quality rating

Of the 12 studies on the association between sweet food intake and sweet taste preference, two studies had a positive quality rating[41, 87], eight had a neutral quality rating[101,103,104,106-110] and two had a negative quality rating[102,105]. Reasons for a neutral quality rating were a lack of information on the selection of participants and sampling, the follow-up of participants, the descriptions of groups and the collection of variables that may act as potential confounding factors (Table 9). In some studies, the lack of information was probably explained by the early publication dates. The criterion concerning the potential for conflicts of interest was much less problematic than in studies on our primary question. Two studies were financed by the food industry[102, 107], and two studies did not declare their source of financing[104, 106].

Table 9: Quality rating of studies on the association between sweet food intake and sweet taste preference and responses to the 10 questions of the Academy of Nutrition and Dietetics[51]

Authors, year	Study design	Quality	1	2	3	4	5	6	7	8	9	10
Jayasinghe et al. 2016[101]	Cross-sectional study	Neutral	yes	no	NA	?	yes	yes	yes	yes	yes	yes
Menella et al. 2014[41]	Cross-sectional study	Positive	yes	no	yes	yes	yes	yes	yes	yes	yes	yes
Lanfer et al. 2012[87]	Cross-sectional study	Positive	yes	yes	?	yes	yes	yes	?	yes	yes	yes
Pepino et al. 2005[102]	Cross-sectional study	Negative	yes	no	?	?	?	no	?	no	no	no: industry
Liem et al. 2002[103]	Cross-sectional study	Neutral	yes	no	?	?	yes	yes	yes	yes	no	yes
Holt et al. 2000[104]	Cross-sectional study	Neutral	yes	no	no	?	yes	yes	yes	yes	yes	no
Stone et al. 1990[105]	Cross-sectional study	Negative	yes	?	?	?	?	yes	no	?	yes	yes
Mattes et al. 1986[106]	Cross-sectional study	Neutral	yes	no	NA	?	yes	yes	yes	no	no	no
Beauchamp et al. 1984[109]	Before-after study	Neutral	yes	no	?	?	?	yes	?	yes	no	yes
Pangborn et al. 1984[107]	Cross-sectional study	Neutral	yes	no	no	yes	yes	yes	no	?	yes	no: industry
Beauchamp et al. 1982[108]	Prospective cohort study	Neutral	yes	no	yes	yes	?	yes	no	yes	no	yes
Olson et al. 1981[110]	Longitudinal observational study	Neutral	yes	no	NA	?	yes	yes	?	yes	no	yes
Number of studies with positive answer:			**12/12**	**1/12**	**2/12**	**4/12**	**8/12**	**11/12**	**5/12**	**8/12**	**6/12**	**8/12**

8.3.3 Findings

Results of the 12 studies on the association between sweet food intake and sweet taste preference were quite discrepant (Figure 5 and Tables 10a and 10b). A positive association between higher sweet food intake and elevated sweet taste preference was found in seven studies.[102-104, 106-109] No association was observed in five studies[41, 87, 101, 103, 105, 110]. Considering separately the results obtained in adults vs children, we observed a positive association in three of the six studies in adults[104, 106, 107] and four of the seven studies in children[102, 103, 108, 109]. All three studies that assessed the association between early sugar water intake and sweet taste preference in children found a positive association (Figure 6)[102, 108, 109]. Detailed results of these different studies, including statistical values, are provided in Appendix VIII.

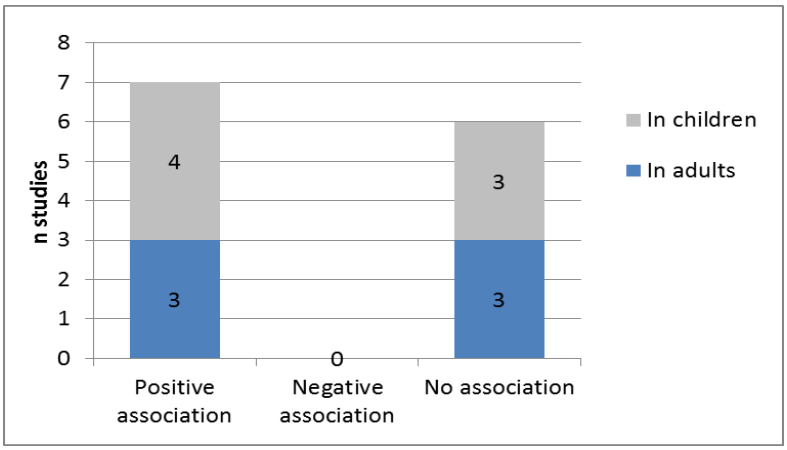

Figure 5: Number of studies showing an association or no association between sweet food intake and sweet taste preference in adults and children

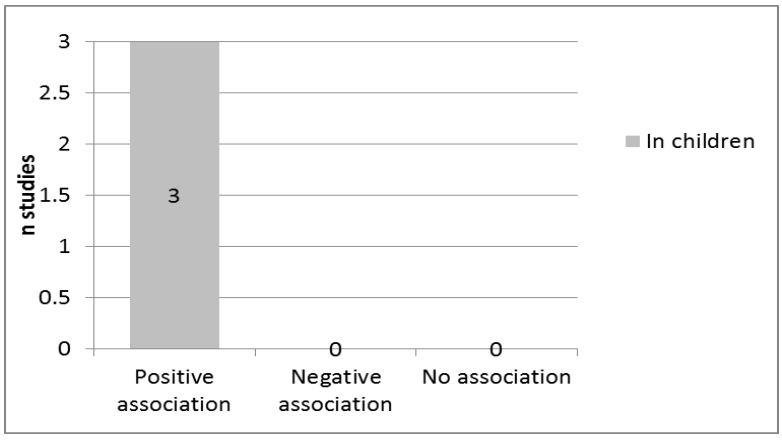

Figure 6: Number of studies showing an association or no association between early sugar water intake and sweet taste preference in children

Table 10a: Association between sweet food intake and sweet taste preference in adults

Author, Year	Sample / Quality	Exposure	Findings
Jayasinghe et al. 2016[101]	45 females Age: median of 29 (IQR: 23-32.5) years Neutral	Sweet foods intake	Association between sweet food intake and sweet taste preference: **Ø**
Mennella et al. 2014[41]	76 mothers Age: 36.1 ± 1.0 years0.2 Positive	Daily added sugar intake	Association between daily added sugar intake and sweet taste preference: **Ø**
Holt et al. 2000[104]	132 adults Australian: age: 22.8 ± 4.3 years Malaysian: age: 21.5 ± 1.2 years Neutral	Sweet foods and drinks intake and added sugar intake	Association between sweet food and drink intake and sweet taste preference: **+** Association between added sugar intake and sweet taste preference: **+**
Stone et al. 1990[105]	100 adults Age: 18-31 (range) years Negative	Sugar intake	Association between sugar intake and sweet taste preference: **Ø**
Mattes et al. 1986[106]	25 males Age: 17-34 (range) years Neutral	Percent of calories having a predominantly sweet taste	Association between percent calories from sweet foods and sweet taste preference: **+**
Pangborn et al. 1984[107]	51 adults Age: 18-31 (range) years Neutral	Sweet foods intake	Association between sweet food intake and sweet taste preference: **+**

Meaning of symbols:

Ø: no association between sweet food intake and sweet taste preference; **+**: positive association between sweet food intake and sweet taste preference

Table 10b: Association between sweet food intake and sweet taste preference in children

Author, Year	Sample / Quality	Exposure	Findings
Mennella et al. 2014[41]	101 children Age: 7.8 ± 0.2 years Positive	Daily added sugar intake	Association between daily added sugar intake and sweet taste preference: **Ø**
Lanfer et al. 2012[87]	1'593 children Age: 6-9 (range) years Positive	Sweet foods intake	Association between sweet food intake and sweet taste preference: **Ø**
Pepino et al. 2005[102]	108 children Age: 7.8 ± 0.1 years Neutral	Intake of sugar water during infancy	Association between early exposure to sugar water during infancy and sweet taste preference during childhood: **+**
Liem et al. 2002[103]	83 children Age: 4-7 (range) years Neutral	Formula history: milk versus hydrolysate formulas	Association between formula history and preference for sweetened juices: **Ø** Association between added sugar intake and preference for sweetened juices and cereals: **+**
Beauchamp et al. 1984[109]	63 children Age: 2.0 (SEM: 0.0) years Neutral	Early intake of sugar water during infancy	Association between early exposure to sugar water and sweet taste preference: **+**
Beauchamp et al. 1982[108]	140 children Age: 0.5 year ± 0.0 Neutral	Early exposure to sugar water during infancy	Association between early exposure to sugar water and sweet taste preference: **+**
Olson et al. 1981	31 children Age: 4 – 5 (range) years Neutral	Sweet foods intake and food choice and	Association between frequency of sweet food intake and sweet taste preference: **Ø**

Meaning of symbols:

Ø: no association between sweet food intake and sweet taste preference; **+**: positive association between sweet food intake and sweet taste preference

8.4 Association between artificial sweetener intake and sweet taste preference

8.4.1 Study characteristics

Only one observational study, conducted in 2007 by Mahar et al[76], addressed the association between artificial sweetener intake and sweet taste preference. The authors assessed whether consumption of artificial vs natural sweeteners affected sweet taste preference. A total of 64 women with a mean age of 25 years and mean BMI of 22.3 kg/m^2 were included (Tables 11a and 11b).

8.4.2 Quality rating

This study[76] was assessed as having a neutral quality rating mainly because of missing information on characteristics of the two groups and on the validity of the scales used to measure sweet taste preference (Table 12).

Table 11a: Characteristics of the study on the association between artificial sweetener intake and sweet taste preference: design and sample

Author, Year	Design	Quality	Financing	Purpose of the study	Sample
Mahar, 2007[76]	Observational: cross-sectional study	Neutral	Not by food industry	To determine liking of various sweetness levels using orange juice as a model, and to compare this liking between and among individuals categorised by consumption patterns of sweetened beverages.	64 females Age: 25 ± 9.2 years BMI: 22.3 ± 2.64 kg/m^2

Table 11b: Characteristics of the study on the association between artificial sweetener intake and sweet taste preference: intervention and outcome

Author, Year	Intervention / Exposure	Measure of intervention	Outcome	Measure of outcome
Mahar, 2007[76]	Exposure: consumption of artificial sweeteners versus consumption of natural sweeteners	Frequency of consumption of sweetened beverages by selecting an appropriate response category from a list	1. Sweet taste preference 2. Sweet intensity	1. 9-point hedonic scale 2. 9-point category scale

Table 12: Quality rating of the study on the association between artificial sweetener intake and sweet taste preference and responses to the 10 questions of the Academy of Nutrition and Dietetics[51]

Authors, year	Study design	Quality	1	2	3	4	5	6	7	8	9	10
Mahar, 2007[76]	Observational: cross-sectional study	Neutral	yes	no	?	yes	yes	yes	?	yes	no	yes
Number of studies with positive answer:			**1/1**	**0/1**	**0/1**	**1/1**	**1/1**	**1/1**	**0/1**	**1/1**	**0/1**	**1/1**

8.4.3 Findings

In the observational study of Mahar et al,[76] a positive association was observed between intake of artificially sweetened beverages and sweet taste preference (Table 13).

Table 13: Association between artificial sweetener intake and sweet taste preference

Author, Year	Sample / Quality	Exposure	Findings
Mahar, 2007[76]	64 females Age: 25 ± 9.2 years Neutral	Sweetened beverages intake	Association between a high intake of sweetened beverages and higher liking of the sweetness level in the juice: **+** Association between liking of sweetness and the 2 sweetener type groups: **Ø**

Meaning of symbols:

Ø: no association between sweet food intake and sweet taste preference; **+**: positive association between sweet food intake and sweet taste preference

9. CONCLUSIONS

9.1 Effects of modification of sugar content on sweet taste preference, liking or intake

The main aim of this research project was to determine whether modification of sugar content would lead to a change in sweet taste preference in the healthy population, such as allowing participants to prefer a less-sweet taste than before the study. The current systematic review showed that only eight studies have addressed this primary question[42, 94-100]. Five of these studies were published since 2011[94-97, 100]. Although these studies considered homogenous study populations, their study designs strongly differed, especially in terms of interventions and outcomes. These differences make it difficult to draw a firm conclusion.

Among the eight studies, only the RCT of Wise et al[94], published in 2016, investigated the effect of reducing sugar intake in the overall diet on sweet taste preference. A 40% reduction in calories from simple sugars in the diet for 3 months was studied in 29 adults. At the end of the intervention, no significant difference in sweet taste preference was observed. However, the perceived sweet taste intensity of participants increased, which is a very encouraging result. The authors concluded that the 3-month duration of the intervention may have been too short to produce a significant decrease in sweet taste preference[94].

The design of the study of Wise et al[94] seems particularly adequate because both the total sugar intake and 'total level of sweetness' in the diet were reduced. To control the level of sweetness of food, participants were instructed to replace foods high in sugar with foods high in complex carbohydrates, protein or fats. They were instructed to dilute sugary drinks (fruit juices, sodas, etc) by 50% with water or seltzer and to consume a similar total volume. Furthermore, they were instructed not to replace sugar with nonnutritive sweeteners. It has been argued that added sugar intake alone may not be a good proxy for the overall level of sweetness in the diet[41] because of the increasing use of nonnutritive sweeteners in foods[129].

Whether it is better to decrease sugar intake progressively or abruptly remains questionable, as concluded by Wise et al[94]:

> "*Would one obtain more robust and lasting effects with a more extended diet manipulation, with a more drastic reduction in sugar intake, or with a more gradual reduction in sugar intake? These are open questions, the answers to which will help determine the practical potential of using lower-sweet diet manipulations as a strategy for ultimately reducing added sugar in our diets while maintaining palatability."* [94]

These findings lead to our first conclusion, that reducing sugar intake in the overall diet for 3 months seems to allow better detection of sweet taste by adults. However, as this intervention did not modify preference for sweet taste, further investigations for longer than 3 months are warranted. Moreover, due to the lack of data, whether this preference can be shifted in children remains unanswered, as recently noted[7].

The two studies of Liem et al[99] and Sartor et al[96] provided complementary data on our primary question by assessing the effect of sugar supplementation in the diet on sweet taste preference[96, 99]. Liem et al[99] studied the effect of supplementation with 200 ml of a sweet orangeade for 8 consecutive days in 46 adults and 59 children aged 9.2 years on average. No significant difference was observed in adults, but a significant increase in sweet taste preference was observed in children. Similarly, Sartor et al[96] investigated the effect of daily supplementation with a 760-ml energy soft drink for 4 weeks in 12 adults. Considering the group as a whole, there was no significant modification in sweet taste preference. However, in a subgroup of participants who did not like sweet tastes at baseline, a significant increase in sweet taste preference was observed. We hypothesise that for people who are already accustomed to consuming sweet beverages, supplementation with a sweet drink does not change their sweet taste preference. In contrast, a change may be observed in people who are not accustomed to consuming sweet beverages.

The second conclusion of this work is that supplementation with sugar through sweetened beverages may increase the preference for sweet in certain subgroups, including children. If regular sweet beverage consumption can modify the preference for sweet taste within a short period, especially in children, the results of these two studies may have important implications. The results observed in children are not surprising. As described in the section 5 of this report, children have an inborn preference for sweet taste and generally prefer higher sugar concentrations than adults[7,34-38]. These factors make children vulnerable to sugar overconsumption.

In the other studies addressing our primary question, participants either consumed different concentrations of sugar or foods with and without sugar. In the experimental study of Bouhlal et al[97], 74 toddlers with a mean age of 2.5 years consumed fruit purees with no sugar, standard amounts of sugar (5%) or supplemented with sugar (10%) at separate snack times. No difference in fruit puree intake depending on sugar concentration was observed. The authors[97] hypothesised that the unsweetened puree may have been sweet enough for children to like and consume, due to the natural sweet taste of the fruits.

The recent observational study of Yon et al[100] compared consumption levels of standard vs reformulated flavoured milk in 793 elementary school students. The sugar content of the lower-sugar milk was still high (reduced to 22–27 g vs the standard 28 g of added sugar per serving).

The results revealed similar levels of consumption of standard and reformulated milk. The authors hypothesised that children may not have been able to detect the taste difference of the reformulated milk, representing what consumer psychologists refer to as the 'just unnoticeable difference'[130].

We conclude that it seems to be possible to avoid or reduce the amount of added sugar in sweet foods intended for children, without having a negative effect on palatability or intake. Sweet taste preference has an inverted U-shape relationship with sugar concentration in children and adults, although children prefer higher concentrations of sugar overall[102]. Thus, researchers have hypothesised the existence of a 'large tolerance plateau' to sweet taste[97]. These data confirm the need for further work to develop reduced-sugar food products. The FSVO has proposed several research projects to assist food companies in their efforts to reduce sugar contents in foods[19]. Among others, research projects are planned to determine how to reduce added sugar contents of yoghurts and breakfast cereals while maintaining their quality, safety and palatability[19].

Finally, in the study of Sullivan et al[42], 39 children were exposed 15 times to an initially new food that was either plain, sweet or salty. In all groups, the authors observed an increase in preference for the new version and a decline in preference for the older version of the food. These data show that through exposure, children are capable of increasing their preference for a specific food, either plain or with added sugar. The older version became less acceptable for children than it was when it was novel for them. Thus, adding sugar to a food initially to encourage a child to eat it does not seem to be useful and makes it less likely that the food will thereafter be accepted without added sugar.

We evaluated this latter study as having a negative quality rating due to the lack of information on various methodological aspects. In contrast, the other studies described above had a positive quality rating, except for the study of Yon et al which was given a neutral quality rating[100].

To conclude, only a few studies have addressed our primary question. Thus, we do not know whether the healthy population, especially children, is capable of shifting their sweet taste preference, nor do we know whether a progressive or rapid reduction in sugar content would be more efficient. Some data were convergent in terms of the effect of sugar, especially in children who seemed to be capable of liking foods without sugar or with reduced sugar levels, while still preferring sweet foods after supplementation with sugar. This finding is striking and needs careful attention. Furthermore, we were not able to conclude whether the shift in sweet taste preference differs depending on other physiological variables, such as sex or BMI category. Adult participants included in this review were all young adults ranging from 22 to 37 years old with similar sex and BMI distributions.

9.2. Association between sweet food intake and sweet food preference

This systematic review aimed to ascertain the possible association between sweet food intake and sweet taste preference. This question was addressed by 12 studies, which used homogeneous outcomes but had inconsistent results. Seven studies found a positive association between higher sweet food intake and elevated sweet taste preference,[102-104, 106-109] whereas five studies found no association[41, 87, 101, 103, 105, 110]. Considering separately the results obtained in adults and children, a positive association was observed in three of the six studies in adults[104, 106, 107] and four of the seven studies in children[102, 103, 108, 109]. Owing to these discrepant data, we were not able to determine conclusively whether a positive association exists between sweet food intake and sweet taste preference.

Different hypotheses may explain this discrepancy. One explanation is that the sweet food intake was not defined similarly in the 12 studies. Studies measured sweet food intake as, for instance, the total added sugar intake, the percentage of calories from foods identified by respondents as having a predominantly sweet taste or the practice of feeding sugar water during infancy. Due to the increasing use of nonnutritive sweeteners, especially in foods intended for children[129], use of added sugar intake alone may not be a good variable for measuring overall sweetness in the diet[41]. As a better variable, some researchers have suggested using the total amount of added extrinsic sweeteners, defined as all refined sugars and artificial sweeteners added to a food product by the manufacturer or consumer before consumption[104].

The second consideration is that the tools used to measure sweet food intake differed among the studies. These tools included 24-hour dietary recall, 7-day record and different questionnaires such as the Food Frequency Questionnaire. Information on validation of these instruments was only provided in some studies. As a consequence, sweet food intake was probably measured with different degrees of precision, which may have eventually affected the association between sweet food intake and sweet taste preference.

As a third consideration, the lack of positive association in three of the seven studies in children may be explained by the influence of parents on children's food choices. As already hypothesised[41], parents may exercise enough control over the sugar consumption of children to moderate the relationship between sweet food intake and sweet taste preference.

Interestingly, a subgroup of three studies performed in children consistently demonstrated a positive association between early sugar water intake and sweet taste preference[102,109,108]. Because these studies used an observational design, the causality may not be affirmed. Specifically, we do not know whether the practice of providing sugar water in infancy induces a higher sweet taste preference or whether children initially had an intense sweet taste preference that influenced the decision to give them sugar water. Nevertheless, these

consistent data suggest avoiding giving sugar water to infants, as this practice may impact their sweet taste preference.

To conclude on the secondary question regarding the association between sweet food intake and sweet taste preference, the available data are not consistent. In children, however, and in agreement with results obtained on our primary question, the data seem to demonstrate a more vulnerable response to sweet taste. This result suggests that sweet beverages should not be given to infants or young children.

9.3 Association between artificially sweetened food intake and sweet taste preference

The current systematic review only identified one relevant study on artificial sweeteners, an observational study[76] that showed a positive association between artificial sweetener intake and sweet taste preference. The authors concluded that regardless of the type of sweetener consumed in a beverage, it is the amount of sweetener (not only sugar) that increases an individual's liking of and preference for sweet taste[76]. This conclusion must be interpreted carefully due to the observational and cross-sectional design of this study. More research is needed on the long-term effects of artificial sweetener intake on sweet taste preference.

9.4 Answers to questions of the FSVO

1) Is it possible for humans to change their preference for sweet taste?

Due to the lack of studies that evaluated this question, we are not able to provide a definitive answer, although we did obtain encouraging results. Two trials evaluated the effect of a reduction of sugar content on sweet taste preference[94,95]. One study showed a better perception of sugar after a reduction in sugar in the diet of adults, but no effect on sweet taste preference[94]. The other study tested the effect of exposure to biscuits with reduced sugar content. This study observed an increase in preference for biscuits with slightly reduced sugar content, but only in the group that was directly exposed to the most sugar-reduced version of the biscuit[95].

2) What are arguments for/against a progressive or abrupt reduction in sugar intake?

As was the case with question 1, the lack of relevant studies makes it difficult to provide a firm answer to this question. Only one study design[95] compared exposure strategies of abrupt vs progressive reduction in sugar content in biscuits. The group that directly received the biscuit with the most reduced sugar content had an increased liking for the two versions of the biscuits that were less reduced in sugar content. Duration of exposure to reduced-sugar foods may be an important factor. The exposure period should be sufficiently long for participants to come to like the food with reduced sugar content.

3) Are preferences for sweet taste similar among food categories?

Different food products were used in the included studies. Strikingly, we found that daily short-term supplementation of the diet with a sweet beverage was able to increase sweet taste preference in a subgroup of adults and in children.

4) What roles do the frequency and quantity of sugar intake have in this context?

To address this complex question, we analysed data of 12 studies on the association between sweet food intake and sweet taste preference. Results were inconsistent and did not provide cut-offs for the frequency or quantity of sugar intake that influences sweet taste preference. In children, however, the data were more consistent and showed a positive association between early consumption of sugar water and sweet taste preference. Surprisingly, we observed in this population that sugar supplementation using sweet orangeade for only 8 days increased their sweet taste preference.

5) What is the role of artificial sweeteners?

Only one observational and cross-sectional study addressed this issue,[76] showing a positive association between artificial sweetener intake and sweet taste preference.

10. RECOMMENDATIONS

10.1 Recommendations for research

Our findings demonstrate that only a few studies have evaluated the effect of modifying sugar content on sweet taste preference. Only one experimental study reduced sugar intake in the entire diet for a period of 3 months, leading to encouraging results[94]. It would be useful to replicate this study in an RCT approach. Dietary intake of sugar should be reduced for all participants for longer than 3 months, to confirm the effect of diet on the perceived sweet taste intensity and to study long-term changes in sweet taste preference. As was the case in the study by Wise et al[94], participants should be instructed not to replace sugar with nonnutritive sweeteners, in order to decrease the 'total level of sweetness'. Despite the practical difficulty of such a design, a cross-over trial may be even more interesting and would eliminate intervariability among participants. Because children have an inborn preference for sweet taste and prefer sweeter foods than adults, it would be interesting to conduct such a study in this population.

In addition, it would be interesting to study the effect of artificial sweeteners on perceived sweet taste intensity and preference. Such a study could help to explain whether the increased perceived sweetness intensity observed after the intervention of Wise et al[94] was due to the decrease in the total level of sweetness or the decrease in simple sugar content. Determining whether replacing sugar with artificial sweeteners would be beneficial or ineffective in changing sweet taste preference is a crucial question.

Recently, it has been suggested that sugar content be reduced in a single food, rather than the whole diet, to make it easier for participants to maintain a palatable diet overall[95]. Therefore, it may be interesting to reduce the sugar content of one single food, such as yoghurt, while maintaining the sweetness level of the diet, and to evaluate the sweet taste preference and liking for this sweet product. As mentioned previously, the data of this systematic review seem to demonstrate that there is a large range of sweet taste that may be acceptable in adults and children. As suggested by the FSVO[19], research projects are required to determine the minimal added sugar content needed to maintain palatability in yoghurts and breakfast cereals. The same research in other food products, especially products for children, such as flavoured milk, would also be useful. Reducing sugar content in solid products may be more difficult than reducing salt content because sugar content affects the total weight of the food product, leading to technical issues.

One surprising observation was the lack of studies performed in children older than 9 years, in teenagers and in adults older than 40 years. Research in these populations, especially in children and adolescents, is required.

Finally, studies are needed to determine the effectiveness of reduced-sugar food and beverage reformulations in terms of reducing the sugar intake and improving the health of the general population. A recent protocol has been published to address this important issue[131].

10.2 Recommendations for practice

Results of this systematic review are not very consistent in the adult population, making it difficult to draw conclusions for practice. However, data regarding the primary and secondary questions showed that children react differently than adults to the modification of sugar and seem vulnerable to sweet food intake, probably because of their inborn sweet taste preference. Striking results in the paediatric population included the observed increase of sweet taste preference following a short-term supplementation with sweet beverages and the consistent positive association between the practice of providing sugar water to infants and their sweet taste preference. Preventing children from overconsuming of sugar, especially from sweet beverages, is an important public health issue. Different strategies include preventing parents from giving sweet water, tisanes or teas to their infants and avoiding the sale of sweet beverages to children at schools.

Another encouraging result in children was their similar consumptions of fruit purees and flavoured milk regardless of sugar content. No added sugar was needed for fruit purees to be accepted by children, probably because fruit purees are naturally sweet. Numerous fruit purees with added sugar are commercially available in Switzerland, in individual portions and very practical designs for children. The concentration of added sugar varies between products, ranging 6–15%. Although we did not analyse the added sugar contents of these fruit purees and their prices, we can observe that some sugar-free fruit purees are more expensive than the same purees containing added sugar. This discrepancy may encourage parents to buy the fruit purees containing added sugar. Data obtained in this systematic review suggest that naturally sweet food products designed for children may be sugar free or reduced in sugar, without leading to decreased consumption or loss of sales.

Finally, following exposure to a food, children showed increased preference for that food, regardless of whether it was plain or with added sugar, and a parallel decrease in preference for the food to which they were not exposed. Repeated exposure to a plain food during a sufficient period of time appears to be essential in children. In addition, the result seems to demonstrate that adding sugar to a new food to encourage the child to eat it should be avoided because the child may come to prefer the sweeter taste.

11. ACKNOWLEDGEMENTS

We are grateful to Dr Isabelle Carrard and Sophie Bucher Della Torre from the Department of Nutrition and Dietetics of the University of Applied Sciences of Western Switzerland, for providing us with their excellent expertise on nutrition and methodology of systematic reviews and for revising the report. We thank Corinne Kehl from the same department for her useful translation of scientific German documents and for sharing her knowledge on food products. We thank Jean-David Sandoz, librarian at the School of Health Sciences of the University of Applied Sciences of Western Switzerland, for his extremely helpful support in establishing the search strategies on the different electronic databases and providing excellent advice.

During the study, the precise feedback and reviews of Esther Infanger and Liliane Bruggmann from the Federal Food Safety and Veterinary Office in Bern were very helpful. We are grateful for their important work. We thank the authors who we contacted for identifying the grey literature and providing further contacts in the field. Finally, we thank Dr Kathryn Kadash–Edmondson (Write Science Right) for the revision of this report.

12. CONFLICT OF INTEREST

No conflicts of interest have been disclosed.

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14. APPENDICE

I. Search strategies for the identification of studies on electronic databases

Strategy on CINAHL

Strategy:

((MH "Food Habits") OR (MH "Food Preferences") OR (MH "Eating Behavior+")) AND ((MH "Sweetening Agents") OR (MH "Dietary Sucrose") OR (MH "Carbohydrates+") OR (MH "Dietary Carbohydrates+") OR sugar) AND ((MH "Taste")).

Exclude Pubmed results

Strategy on Embase

Strategy

('feeding behavior'/exp OR 'food preference'/exp) AND ('carbohydrate'/exp OR 'sugar intake'/exp OR 'sweetening agent'/exp OR sugar) AND ('taste'/exp OR 'taste perception') AND 'human'/exp

Exclude Pubmed results

Strategy on Web of Science

Strategy

((TS=(taste) OR TS=(taste perception)) AND (TS=(carbohydrates) OR TS=(dietary sucrose) OR TS=(Sweetening Agents) OR TS=(sugar)) AND (TS=(Feeding Behavior) OR TS=(Food Preferences) OR TS=(Food Habits))) AND (TS=sugar AND (TS=reduc* OR TS=less* OR TS=target$ OR TS=cutback* OR TS=decreas* OR TS=limit* OR TS=formulat* OR TS=reformulate OR TS=control OR TS=adjust*) AND (TS=intake OR TS=consum* OR TS=content OR TS=eat*) AND (TS=food* OR TS=beverage* OR TS=drink*) AND (TS=(sweet taste) OR TS=pleasant* OR TS=preference OR ((TS=dependence OR TS=Addiction) NOT TS=Drug* NOT TS=alcohol))) NOT PMID=(1*) NOT PMID=(2*) NOT PMID=(3*) NOT PMID=(4*) NOT PMID=(5*) NOT PMID=(6*) NOT PMID=(7*) NOT PMID=(8*) NOT PMID=(9*) NOT PMID=(0*)

II. Inclusion form for the selection of studies

Please assess each study with reference to the criteria below. Underline the statement that best describes the study.

Researcher‘s initials:

Reference study (authors, year, title)

STUDY DESIGN
1. Any type of publication is eligible.

Please specify the type of study:

POPULATION
2. Was the population healthy, either including children, adults or elderly participants?
Yes No
If no, please specify:

INTERVENTION – EXPOSURE
3. Did the study measure different content-concentration of sugar including sweet food intake?
Yes No

OUTCOMES
4. Did the study evaluate sweet taste preference (primary outcome) or liking or intake of the food modified in sugar?
Yes No

DECISION
Should this study be included in this systematic review?

Yes [questions 1 to 4 must ALL be answered"Yes"]
No [any of questions 1-4 answered with "No"]
Unsure [will need to be reviewed and decided after depth reading)

Final decision Yes No

Reason:

III. Extraction form

General description	Citation	
	Study design	
	Quality rating	
	Research purpose	
	Inclusion criteria	
	Exclusion criteria	
Description of study protocol	Recruitment	
	Explanation on design	
	Blinding used	
	Intervention	
	Statistical analysis	
Data collection summary	Timing of measurement	
	Dependant variables	
	Independent variables	
	Control variables	
Description of data sample	Initial n	
	Male (n)	
	Female (n)	
	Final n	
	Age (years)	
	Ethnicity	
	Weight (kg)	
	Height (cm)	
	Body mass index	
	Fat mass (%)	
	Fat free mass (%)	
	Location	
Summary of results	Primary outcome: Sweet taste preference	
	Secondary outcomes: sugar consumption, health outcomes	
	Other findings	
Conclusion	Authors conclusion	
	Reviewer comment	
Funding	Funding source	

IV. Quality Criteria Checklist from the Academy of Nutrition and Dietetics for primary research

Symbols Used

+ **Positive:** Indicates that the report has clearly addressed issues of inclusion/exclusion, bias, generalizability, and data collection and analysis.

-- **Negative:** Indicates that these issues have not been adequately addressed.

∅ **Neutral:** Indicates that the report is neither exceptionally strong nor exceptionally weak.

RELEVANCE QUESTIONS	
1. Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (NA for some Epi studies)	Yes No Unclear N/A
2. Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about?	Yes No Unclear N/A
3. Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to dietetics practice?	Yes No Unclear N/A
4. Is the intervention or procedure feasible? (NA for some epidemiological studies)	Yes No Unclear N/A
If the answers to all of the above relevance questions are "Yes," the report is eligible for designation with a plus (+) on the Evidence Quality Worksheet, depending on answers to the following validity questions.	
VALIDITY QUESTIONS	
1. Was the <u>research question</u> clearly stated? 1.1 Was the specific intervention(s) or procedure (independent variable(s)) identified? 1.2 Was the outcome(s) (dependent variable(s)) clearly indicated? 1.3 Were the target population and setting specified?	Yes No Unclear N/A
2. Was the <u>selection</u> of study subjects/patients free from bias? 2.1 Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study? 2.2 Were criteria applied equally to all study groups? 2.3 Were health, demographics, and other characteristics of subjects described? 2.4 Were the subjects/patients a representative sample of the relevant population?	Yes No Unclear N/A
3. Were <u>study groups comparable</u>? 3.1 Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT) 3.2 Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline? 3.3 Were concurrent controls used? (Concurrent preferred over historical controls.) 3.4 If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis?	Yes No Unclear N/A

3.5 If case control study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.) 3.6 If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")?	
4. Was method of handling <u>withdrawals</u> described? 4.1 Were follow up methods described and the same for all groups? 4.2 Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.) 4.3 Were all enrolled subjects/patients (in the original sample) accounted for? 4.4 Were reasons for withdrawals similar across groups? 4.5 If diagnostic test, was decision to perform reference test not dependent on results of test under study?	Yes No Unclear N/A
5. Was <u>blinding</u> used to prevent introduction of bias? 5.1 In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate? 5.2 Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.) 5.3 In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded? 5.4 In case control study, was case definition explicit and case ascertainment not influenced by exposure status? 5.5 In diagnostic study, were test results blinded to patient history and other test results?	Yes No Unclear N/A
6. Were <u>intervention</u>/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were <u>intervening factors</u> described? 6.1 In RCT or other intervention trial, were protocols described for all regimens studied? 6.2 In observational study, were interventions, study settings, and clinicians/provider described? 6.3 Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect? 6.4 Was the amount of exposure and, if relevant, subject/patient compliance measured? 6.5 Were co-interventions (e.g., ancillary treatments, other therapies) described? 6.6 Were extra or unplanned treatments described? 6.7 Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups? 6.8 In diagnostic study, were details of test administration and replication sufficient?	Yes No Unclear N/A
7. Were <u>outcomes</u> clearly defined and the <u>measurements valid and reliable</u>? 7.1 Were primary and secondary endpoints described and relevant to the question? 7.2 Were nutrition measures appropriate to question and outcomes of concern?	Yes No Unclear N/A

7.3 Was the period of follow-up long enough for important outcome(s) to occur? 7.4 Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures? 7.5 Was the measurement of effect at an appropriate level of precision? 7.6 Were other factors accounted for (measured) that could affect outcomes? 7.7 Were the measurements conducted consistently across groups?	
8. Was the <u>statistical analysis</u> appropriate for the study design and type of outcome indicators? 8.1 Were statistical analyses adequately described the results reported appropriately? 8.2 Were correct statistical tests used and assumptions of test not violated? 8.3 Were statistics reported with levels of significance and/or confidence intervals? 8.4 Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)? 8.5 Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)? 8.6 Was clinical significance as well as statistical significance reported? 8.7 If negative findings, was a power calculation reported to address type 2 error?	Yes No Unclear N/A
9. Are <u>conclusions supported by results</u> with biases and limitations taken into consideration? 9.1 Is there a discussion of findings? 9.2 Are biases and study limitations identified and discussed?	Yes No Unclear N/A
10. Is bias due to study's <u>funding or sponsorship</u> unlikely? 10.1 Were sources of funding and investigators' affiliations described? 10.2 Was there no apparent conflict of interest?	Yes No Unclear N/A
MINUS/NEGATIVE (-) If most (six or more) of the answers to the above validity questions are "No," the report should be designated with a minus (-) symbol on the Evidence Worksheet.	
NEUTRAL (∅) If the answers to validity criteria questions 2, 3, 6, and 7 do not indicate that the study is exceptionally strong, the report should be designated with a neutral (∅) symbol on the Evidence Worksheet.	
PLUS/POSITIVE (+) If most of the answers to the above validity questions are "Yes" (including criteria 2, 3, 6, 7 and at least one additional "Yes"), the report should be designated with a plus symbol (+) on the Evidence Worksheet.	

V. Excluded full-text articles and reasons for exclusion

Table I: Excluded full-text articles and reasons for exclusion

Code	N° database	Reference	Reasons for exclusion	Source
1	230	Intake, sweetness and liking during modified sham feeding of sucrose solutions. Klein DA, Schebendach JS, Devlin MJ, Smith GP, Walsh BT. Physiol Behav. 2006 Mar 30;87(3):602-6.	Excluded for design	Medline PubMed - MeSH
2	4	Individual Differences Among Children in Sucrose Detection Thresholds: Relationship With Age, Gender, and Bitter Taste Genotype. Joseph PV, Reed DR, Mennella JA. Nurs Res. 2016 Jan-Feb;65(1):3-12.	Excluded for outcome	Medline PubMed - MeSH
3	55	Ontogeny of taste preferences: basic biology and implications for health. Mennella JA. Am J Clin Nutr. 2014 Mar;99(3):704S-11S.	Excluded for outcome and design	Medline PubMed - MeSH
4	98	Breast-feeding duration: influence on taste acceptance over the first year of life. Schwartz C, Chabanet C, Laval C, Issanchou S, Nicklaus S. Br J Nutr. 2013 Mar 28;109(6):1154-61.	Excluded for exposure	Medline Pubmed - MeSH
5	102	Human sensory preconditioning in a flavor preference paradigm. Privitera GJ, Mulcahey CP, Orlowski CM. Appetite. 2012 Oct;59(2):414-8.	Excluded for intervention and outcome	Medline Pubmed - MeSH
6	116	Mere exposure and flavour-flavour learning increase 2-3 year-old children's acceptance of a novel vegetable. Hausner H, Olsen A, Møller P. Appetite. 2012 Jun;58(3):1152-9.	Excluded for outcome	Medline Pubmed - MeSH

8	126	Controlling what--and how much--we eat. Taste preferences can be changed so that we crave salty and sugary food less and learn to like vegetables and whole grains more. [No authors listed] Harv Health Lett. 2011 Oct;36(12):1-3.	Excluded for exposure and outcome	Medline Pubmed - MeSH
9	166	Is sweetness preference based in biology? [No authors listed] J Am Dent Assoc. 2010 Apr;141(4):387-8.	Excluded for outcome and design	Medline Pubmed - MeSH
10	204	Intense sweetness surpasses cocaine reward. Lenoir M, Serre F, Cantin L, Ahmed SH. PLoS One. 2007 Aug 1;2(8):e698.	Excluded for population	Medline Pubmed - MeSH
11	207	Individual differences in perceived bitterness predict liking of sweeteners. Kamerud JK, Delwiche JF. Chem Senses. 2007 Nov;32(9):803-10.	Excluded for outcome	Medline Pubmed - MeSH
12	228	Liking and exposure: first, second and tenth time around. Frøst MB. Physiol Behav. 2006 Aug 30;89(1):47-52	Excluded for intervention and outcome	Medline Pubmed - MeSH
13	252	Sugars and fats: the neurobiology of preference. Levine AS, Kotz CM, Gosnell BA. J Nutr. 2003 Mar;133(3):831S-834S.	Excluded for design and population	Medline Pubmed - MeSH
14	388	Sweetness of diet and food consumption by infants. Fomon SJ, Ziegler EE, Nelson SE, Edwards BB. Proc Soc Exp Biol Med. 1983 Jun;173(2):190-3.	Excluded for outcome	Medline Pubmed - MeSH
15	267	High-fat and low-fat phenotypes: habitual eating of high- and low-fat foods not related to taste preference for fat. Cooling J, Blundell JE. Eur J Clin Nutr. 2001 Nov;55(11):1016-21	Excluded for design	Medline Pubmed - MeSH
16	383	Sweeteners: consumer acceptance in tea. Sprowl DJ, Ehrcke LA. J Am Diet Assoc. 1984 Sep;84(9):1020-2.	Excluded for design	Medline Pubmed - MeSH
17	268	Taste perception with age: generic or specific losses in threshold sensitivity to the five basic tastes? Mojet J, Christ-Hazelhof E, Heidema J. Chem Senses. 2001 Sep;26(7):845-60.	Excluded for outcome	Medline Pubmed - MeSH

18	27	Sensory perception, nutritional role, and challenges of flavored milk for children and adults. Li XE, Drake M. J Food Sci. 2015 Apr;80(4):R665-70.	Excluded for design	Medline Pubmed - MeSH
19	34	Effects of sucrose detection threshold and weight status on intake of fruit and vegetables in children. Fogel A, Blissett J. Appetite. 2014 Dec;83:309-16.	Excluded for outcome	Medline Pubmed - MeSH
20	51	Bitter taste phenotype and body weight predict children's selection of sweet and savory foods at a palatable test-meal. Keller KL, Olsen A, Cravener TL, Bloom R, Chung WK, Deng L, Lanzano P, Meyermann K. Appetite. 2014 Jun;77:113-21.	Excluded for outcome	Medline Pubmed - MeSH
21	114	The role and requirements of digestible dietary carbohydrates in infants and toddlers. Stephen A, Alles M, de Graaf C, Fleith M, Hadjilucas E, Isaacs E, Maffeis C, Zeinstra G, Matthys C, Gil A. Eur J Clin Nutr. 2012 Jul;66(7):765-79.	Excluded for design	Medline Pubmed - MeSH
22	238	Genetic and environmental determinants of bitter perception and sweet preferences. Mennella JA, Pepino MY, Reed DR. Pediatrics. 2005 Feb;115(2):e216-22.	Excluded for outcome	Medline Pubmed - MeSH
23	250	Effect of sensory perception of foods on appetite and food intake: a review of studies on humans. Sørensen LB, Møller P, Flint A, Martens M, Raben A. Int J Obes Relat Metab Disord. 2003 Oct;27(10):1152-66.	Excluded for design	Medline Pubmed - MeSH
24	278	Factors affecting sweetness. Beauchamp GK. World Rev Nutr Diet. 1999;85:10-7. Review. No abstract available.	Excluded for design	Medline Pubmed - MeSH

25	281	Development of food preferences. Birch LL. Annu Rev Nutr. 1999;19:41-62.	Excluded for design	Medline Pubmed - MeSH
26	323	Individual differences in sensory preferences for fat in model sweet dairy products. Drewnowski A. Acta Psychol (Amst). 1993 Oct;84(1):103-10.	Excluded for design	Medline Pubmed - MeSH
27	329	Hedonic response of sucrose likers and dislikers to other gustatory stimuli. Looy H, Callaghan S, Weingarten HP. Physiol Behav. 1992 Aug;52(2):219-25.	Excluded for intervention	Medline Pubmed - MeSH
28	377	Sensory development in children: research in taste and olfaction. Lawless H. J Am Diet Assoc. 1985 May;85(5):577-82, 585.	Excluded for design	Medline Pubmed - MeSH
29	378	The role of taste in the infant diet. Kare MR, Beauchamp GK. Am J Clin Nutr. 1985 Feb;41(2 Suppl):418-22.	Excluded for design	Medline Pubmed - MeSH
30	395	Carbohydrates in early nutrition: are there effects in later life? Grütte FK, Noack R. Bibl Nutr Dieta. 1982;(31):112-20.	Excluded for design and outcome	Medline Pubmed - MeSH
31	425	Effect of taste on ingestion by human newborns. Maller O, Desor JA. Symp Oral Sens Percept. 1973;(4):279-91. Review. No abstract available.	Excluded for desing and outcome	Medline Pubmed - MeSH
32	209	Habitual high and low consumers of artificially-sweetened beverages: effects of sweet taste and energy on short-term appetite. Appleton KM, Blundell JE. Physiol Behav. 2007 Oct 22;92(3):479-86.	Excluded for outcome	Medline Pubmed - MeSH
33	285	Sensory responses to 6-n-propylthiouracil (PROP) or sucrose solutions and food preferences in young women. Drewnowski A, Henderson SA, Shore AB, Barratt-Fornell A. Ann N Y Acad Sci. 1998 Nov 30;855:797-801.	Excluded for outcome	Medline Pubmed - MeSH

34	286	Sensory and hedonic judgments of common foods by lean consumers and consumers with obesity. Cox DN, van Galen M, Hedderley D, Perry L, Moore PB, Mela DJ. Obes Res. 1998 Nov;6(6):438-47.	Excluded for intervention and outcome	Medline Pubmed - MeSH
35	343	Sensory evaluations of fat-sucrose and fat-salt mixtures: relationship to age and weight status. Warwick ZS, Schiffman SS. Physiol Behav. 1990 Nov;48(5):633-6.	Excluded for outcome	Medline Pubmed - MeSH
36	353	Separating the actions of sweetness and calories: effects of saccharin and carbohydrates on hunger and food intake in human subjects. Rogers PJ, Blundell JE. Physiol Behav. 1989 Jun;45(6):1093-9.	Excluded for outcome	Medline Pubmed - MeSH
37	354	Conditioned enhancement of human's liking for flavor by pairing with sweetness Debra A Zellner, Paul Rozin, Michael Aron, Carol Kulish Learning and Motivation Volume 14, Issue 3, August 1983, Pages 338–350	Excluded for outcome	Medline Pubmed - MeSH
38	3	The effect of repeated exposure to fruit drinks on intake, pleasantness and boredom in young and elderly adults. Essed NH, van Staveren WA, Kok FJ, Ormel W, Zeinstra G, de Graaf C. Physiol Behav. 2006 Oct 30;89(3):335-41. Epub 2006 Aug 2.	Excluded for intervention and outcome	Medline Pubmed - MeSH
39	8	The association of food characteristics and individual differences with ratings of craving and liking. Gearhardt AN, Rizk MT, Treat TA. Appetite. 2014 Aug;79:166-73. doi: 10.1016/j.appet.2014.04.013. Epub 2014 Apr 21.	Excluded for exposure and outcome	Medline Pubmed - MeSH
40	9	Factors that affect sugar sweetened beverage intake in rural, southern college in the US Kim Y, Chau TY, Rutledge JM, Erickson D, Lim Y Int J Vitam Nutr Res. 2015;85(1-2):5-13.	Excluded for intervention	Medline Pubmed - MeSH

41	10	The association of food characteristics and individual differences with ratings of craving and liking. Gearhardt AN, Rizk MT, Treat TA Appetite. 2014 Aug;79:166-73. doi: 10.1016/j.appet.2014.04.013. Epub 2014 Apr 21.	Excluded for exposure	Medline Pubmed - MeSH
42	1	Teaching approaches and strategies that promote healthy eating in primary school children: a systematic review and meta-analysis. Dudley DA1, Cotton WG2, Peralta LR3. Int J Behav Nutr Phys Act. 2015 Feb 25;12:28.	Excluded for intervention	Medline Pubmed - MeSH
43	2	An 'end-game' for sugar sweetened beverages? Sundborn G, Merriman TR, Thornley S, Metcalf P, Jackson R. Pac Health Dialog. 2014 Mar;20(1):22-30.	Excluded for design and outcome	Medline Pubmed - MeSH
44	4	Uncoupling sweet taste and calories: comparison of the effects of glucose and three intense sweeteners on hunger and food intake. Rogers PJ, Carlyle JA, Hill AJ, Blundell JE. Physiol Behav. 1988;43(5):547-52.	Excluded for outcome	Medline Pubmed - MeSH
45	5	Is pleasantness of biscuits and cakes related to their actual or to their perceived sugar and fat contents? Abdallah L, Chabert M, Le Roux B, Louis-Sylvestre J. Appetite. 1998 Jun;30(3):309-24.	Excluded for design	Medline Pubmed - MeSH
46	12	Responses to an intense sweetener in humans: immediate preference and delayed effects on intake. Monneuse MO, Bellisle F, Louis-Sylverstre J Physiol Behav. 1991 Feb;49(2):325-30.	Excluded for outcome	Bibliography Medline Pubmed
47	13	Development of chocolate dairy dessert with addition of prebiotics and replacement of sucrose with different high-intensity sweeteners. Morais EC, Morais AR, Cruz AG, Bolini HM J Dairy Sci. 2014 May;97(5):2600-9.	Excluded for design	Bibliography Medline Pubmed

48	14	Use of just-about-right scales and penalty analysis to determine appropriate concentrations of stevia sweeteners for vanilla yogurt. Narayanan P, Chinnasamy B, Jin L, Clark S J Dairy Sci. 2014;97(6):3262-72. doi: 10.3168/jds.2013-7365. Epub 2014 Mar 27.	Excluded for design	Bibliography Medline Pubmed
49	15	Sensory control of energy density at different life stages. Drewnowski A Proc Nutr Soc. 2000 May;59(2):239-44.	Excluded for design and outcome	Bibliography Medline Pubmed
50	16	Sweet tooth reconsidered: taste responsiveness in human obesity. Drewnowski A, Brunzell JD, Sande K, Iverius PH, Greenwood MR Physiol Behav. 1985 Oct;35(4):617-22	Excluded for outcome	Bibliography Medline Pubmed
51	17	Non-nutritive sweeteners: evidence for benefit vs. risk. Gardner C Curr Opin Lipidol. 2014 Feb;25(1):80-4.	Excluded for design and outcome	Bibliography Pubmed
52	18	The Effects of Mere Exposure on Liking for Edible Substances. Pliner P Appetite. 1982 Sep;3(3):283-90.	Excluded for design	Bibliography Medline Pubmed
53	19	Acceptance of sugar reduction in flavored yogurt. Chollet M, Gille D, Schmid A, Walther B, Piccinali P J Dairy Sci. 2013 Sep;96(9):5501-11.	Excluded for design	Bibliography Medline Pubmed
54	20	Sugar reduction of skim chocolate milk and viability of alternative sweetening through lactose hydrolysis. Li XE, Lopetcharat K, Qiu Y, Drake MA J Dairy Sci. 2015 Mar;98(3):1455-66.	Excluded for design	Bibliography Medline Pubmed
55	21	Non-Caloric Sweeteners, Sweetness Modulators, and Sweetener Enhancers. DuBois GE, Prakash I Annu Rev Food Sci Technol. 2012;3:353-80.	Excluded for design	Bibliography Medline Pubmed

56	22	Genetic and Environmental Variation in Taste: Associations with Sweet Intensity, Preference, and Intake. Duffy V, Peterson JM, Dinehart ME, Bartoshuk LM Topics in clinical nutrition 18(4):209–220	Excluded for design	Bibliography Medline Pubmed
57	23	Measurement of Taste Intensity and Degree of Liking of Beverages by Graphic Scales and Magnitude Estimation. Giovanni ME, Pangborn RM Food Science. Volume 48, Issue 4 July 1983 Pages 1175–1182	Excluded for design	Bibliography Medline Pubmed
58	24	Adolescent beverage habits and changes in weight over time: findings from Project EAT. Vanselow MS, Pereira MA, Neumark-Sztainer D, Raatz SK Am J Clin Nutr. 2009 Dec;90(6):1489-95.	Excluded for exposure and outcome	Bibliography Medline Pubmed
59	26	Use of artificial sweeteners and fat-modified foods in weight loss maintainers and always-normal weight individuals. Phelan S, Lang W, Jordan D, Wing RR Int J Obes (Lond). 2009 Oct;33(10):1183-90.	Excluded for outcome	Bibliography Medline Pubmed
60	28	The use of light foods and drinks in French adults: biological, anthropometric and nutritional correlates. Bellisle F, Altenburg de Assis MA, Fieux B, Preziosi P, Galan P, Guy-Grand B, Hercberg S J Hum Nutr Diet. 2001 Jun;14(3):191-206.	Excluded for exposure and outcome	Bibliography Medline Pubmed
61	1	Children's food intake following drinks sweetened with sucrose or aspartame: time course effects. Birch LL, McPhee L, Sullivan S. Physiol Behav. 1989 Feb;45(2):387-95.	Excluded for outcome	Bibliography Medline Pubmed
62	4	Comparison of the effects of aspartame and sucrose on appetite and food intake. Rolls BJ, Hetherington M, Laster LJ. Appetite. 1988;11 Suppl 1:62-7.	Excluded for outcome	Bibliography Medline Pubmed
63	35	Intense sweeteners, energy intake and the control of body weight. Bellisle F, Drewnowski AEur J Clin Nutr. 2007 Jun;61(6):691-700.	Excluded for outcome	Bibliography Medline Pubmed

64	36	Fueling the obesity epidemic? Artificially sweetened beverage use and long-term weight gain. Fowler SP1, Williams K, Resendez RG, Hunt KJ, Hazuda HP, Stern MP Obesity (Silver Spring). 2008 Aug;16(8):1894-900.	Excluded for outcome	Bibliography Medline Pubmed
65	38	Effect of sensory perception of foods on appetite and food intake: a review of studies on humans. Sørensen LB, Møller P, Flint A, Martens M, Raben A Int J Obes Relat Metab Disord. 2003 Oct;27(10):1152-66.	Excluded for design and outcome	Bibliography Medline Pubmed
66	39	Paradoxical effects of an intense sweetener (aspartame) on appetite J. E. Blundell, A. J. Hill The Lancet, may 10, 1986	Excluded for outcome	Bibliography Medline Pubmed
67	40	Uncoupling Sweetness and Calories: Methodological Aspects of Laboratory Studies on Appetite Control J. E. Blundell, P. J. Rogers, A. J. Hill Appetite, 1988, 11, Supplement, 54--61	Excluded for intervention and outcome	Bibliography Medline Pubmed
68	125	The association between perceived sweetness intensity and dietary intake in young adults. Cicerale S, Riddell LJ, Keast RS. J Food Sci. 2012 Jan;77(1):H31-5.	Excluded for intervention	Bibliography Medline Pubmed
69	33	Does diet-beverage intake affect dietary consumption patterns? Results from the Choose Healthy Options Consciously Everyday (CHOICE) randomized clinical trial. Piernas C, Tate DF, Wang X, Popkin BM Am J Clin Nutr. 2013 Mar;97(3):604-11.	Excluded for intervention	Bibliography Medline Pubmed
70	3	Managing and understanding sweetness: common-sense solutions based on the science of sugars, sugar substitutes, and sweetness. Gifford KD; Baer-Sinnott S; Heverling LN Nutrition Today: September/October 2009 - Volume 44 - Issue 5 - pp 211-217	Excluded for design, intervention and outcome	CINAHL
71	10	Taste Preferences Impact Health Today's Dietitian, Apr2013; 15(4): 53-53. 1p. (Journal Article - brief item) ISSN: 1540-4269	Excluded for intervention and outcome	CINAHL

72	12	Results of a Student Assignment in an Undergraduate Lifecycle Nutrition Class: Sweetness and Saltiness of Toddler Foods Sold in Bronx-Bbased Supermarkets... Samuel, L.; Aviva, L. 2014 Food & Nutrition Conference & Expo, October 18-21, 2014, Atlanta, GA	Excluded for intervention and outcome	CINAHL
73	87	Action on sugar - Lessons from UK salt reduction programme Macgregor G.A., Hashem K.M. The Lancet 2014 383:9921 (929-931)	Excluded for design and outcome	Embase
74	48	Non-nutritive sweeteners in breast milk: perspective on potential implications of recent findings Rother K.I., Sylvetsky A.C., Schiffman S.S. Archives of Toxicology 2015 89:11 (2169-2171)	Excluded for design and outcome	Embase
75	15	The importance of taste on dietary choice, behaviour and intake in a group of young adults Kourouniotis S., Keast R.S.J., Riddell L.J., Lacy K., Thorpe M.G., Cicerale S. Appetite 2016 103 (1-7)	Excluded for exposure and outcome	Embase
76	73	Taste and the regulation of food intake: It's not just about flavor Cummings D.E. American Journal of Clinical Nutrition 2015 102:4 (717-718)	Excluded for design and outcome	Embase
77	88	The history of sweetness: Bridging the gap between spirit and pleasure Schlienger J.-L., Monnier L. Medecine des Maladies Metaboliques 2014 8:3 (346-351)	Excluded for design and outcome	Embase
78	109	Genetic Predisposition and Taste Preference: Impact on Food Intake and Risk of Chronic Disease Dotson C.D., Babich J., Steinle N.I. Current Nutrition Reports 2012 1:3 (175-183)	Excluded for design and outcome	Embase
79	95	Sweetness, hedonic impact and food intake Finlayson G. Annals of Nutrition and Metabolism 2013 63 SUPPL. 1 (146-)	Excluded for design and outcome	Embase

80	110	Rationale for further medical and health research on high-potency sweeteners Schiffman S.S. Chemical Senses 2012 37:8 (671-679)	Excluded for intervention and outcome	Embase
81	52	The importance of the chemical senses during early life Mennella J.A. Chemical Senses 2015 40:7 (540-)	Excluded for design and intervention	Embase
82	71	Development of flavour perception and preference Prescott J. Chemical Senses 2015 40:3 (212-)	Excluded for intervention and outcome	Embase
83	20	Commercial complementary food consumption is prospectively associated with added sugar intake in childhood Foterek K., Buyken A.E., Bolzenius K., Hilbig A., Nöthlings U., Alexy U. British Journal of Nutrition 2016 115:11 (2067-2074)	Excluded for outcome	Embase
84	34	Taste and attraction to sweetness in children and adolescents Leon, F. Sciences des aliments Volume: 27 Issue: 4-5 Pages: 285-295 Published: 2007	Excluded for design	Web of Science

Table II: Excluded secondary reports

Code	N° database	Reference	Topic	Source
1	21	Intense Sweeteners, Appetite for the Sweet Taste, and Relationship to Weight Management. Bellisle F. Curr Obes Rep. 2015 Mar;4(1):106-10.	Narrative review on the association between sweeteners and appetite for sweetness. *Funded by the International Sweeteners Association and grant from General Mills*	Medline Pubmed - MeSH
2	27	The plausibility of sugar addiction and its role in obesity and eating disorders. Benton D. Clin Nutr. 2010 Jun;29(3):288-303.	Narrative review on feeding practice and sugar taste preference *Partially Funded by the World Sugar Research Organization*	Medline Pubmed Reference
3	8	Effect of flavored milk vs plain milk on total milk intake and nutrient provision in children. Fayet-Moore F. Nutr Rev. 2016 Jan;74(1):1-17.	Systematic review on flavored milk in children *Funded by Nestlé*	Medline Pubmed - MeSH
4	22	The sweetness and bitterness of childhood: Insights from basic research on taste preferences. Mennella JA, Bobowski NK. Physiol Behav. 2015 Dec 1;152(Pt B):502-7. Epub 2015 May 20.	Narrative review on sweet taste preference. Concludes that we do not know whether children preference can be shifted	Medline Pubmed - MeSH
5	18	Does Consuming Sugar and Artificial Sweeteners Change Taste Preferences? Bartolotto C. Perm J. 2015 Summer;19(3):81-4.	Personal comment on : association between sugar consumption, non-nutritive sweeteners and sweet taste preference	Medline Pubmed - MeSH
6	372	Congenital and experiential factors in the development of human flavor preferences. Beauchamp GK, Cowart BJ. Appetite. 1985 Dec;6(4):357-72. Review.	Review on the effect of exposure to sugar on sweet taste preference in children	Medline Pubmed - MeSH
7	139	Innate and learned preferences for sweet taste during childhood. Ventura AK, Mennella JA. Curr Opin Clin Nutr Metab Care. 2011 Jul;14(4):379-84	Narrative review on association between repeated exposure to sugary foods and preference for sweet taste in children.	Medline Pubmed - MeSH
8	22	Effects of sugar and fat consumption on sweet and fat taste Keast R.S.J. Current Opinion in Behavioral Sciences 2016 9 (55-60)	Narrative review: association between sugar consumption and sweet taste preference	Embase

Table III: Excluded articles that addressed the question of preference with age, gender and BMI

Code	N° database	Reference	Topic	Source
1	2	Preferred sweetness of a lime drink and preference for sweet over non-sweet foods, related to sex and reported age and body weight. Conner MT, Booth DA. Appetite. 1988 Feb;10(1):25-35.	Age, gender and BMI	References
2	403	Contributions of age, sex and degree of fatness on preferences and magnitude estimations for sucrose in humans. Enns MP, Van Itallie TB, Grinker JA. Physiol Behav. 1979 May;22(5):999-1003.	Age and gender	Medline Pubmed - MeSH
3	416	Preferences for sweet and salty in 9- to 15-year-old and adult humans. Desor JA, Greene LS, Maller O. Science. 1975 Nov 14;190(4215):686-7	Age and gender	Medline Pubmed - MeSH
4	418	Heredity and experience: their relative importance in the development of taste preference in man. Greene LS, Desor JA, Maller O. J Comp Physiol Psychol. 1975 May;89(3):279-84.	Age and gender	Medline Pubmed - MeSH
5	336	Impact of sex and age on sensory evaluation of sugar and fat in dairy products. Monneuse MO, Bellisle F, Louis-Sylvestre J. Physiol Behav. 1991 Dec;50(6):1111-7.	Age and gender	Medline Pubmed - MeSH
6	120	The taste for children aged 5-10 years Dridi L., Oulamara H., Agli A. Fundamental and Clinical Pharmacology 2012 26 SUPPL.1 (53-)	Age and gender	Embase

7	29	Sociodemographic, psychological, and lifestyle characteristics are associated with a liking for salty and sweet tastes in French adults. Lampuré A, Schlich P, Deglaire A, Castetbon K, Péneau S, Hercberg S, Méjean C. J Nutr. 2015 Mar;145(3):587-94.	Age	Medline Pubmed - MeSH
8	280	Sweetness intensity and pleasantness in children, adolescents, and adults. De Graaf C, Zandstra EH. Physiol Behav. 1999 Oct;67(4):513-20.	Age	Medline Pubmed - MeSH
9	368	Age-related differences in the pleasantness of chemosensory stimuli. Murphy C, Withee J. Psychol Aging. 1986 Dec;1(4):312-8.	Age	Medline Pubmed - MeSH
10	8	Longitudinal changes in sweet preferences in humans. Desor JA, Beauchamp GK Physiol Behav. 1987;39(5):639-41.	Age	References
11	9	The proof is in the pudding: children prefer lower fat but higher sugar than do mothers. Mennella JA, Finkbeiner S, Reed DR Int J Obes (Lond). 2012 Oct;36(10):1285-91.	Age	References
12	186	A marker of growth differs between adolescents with high vs. low sugar preference. Coldwell SE, Oswald TK, Reed DR. Physiol Behav. 2009 Mar 23;96(4-5):574-80.	Age	Medline Pubmed - MeSH
13	197	Sex differences in preferences for coffee sweetness among Japanese students. Yamazawa K, Hirokawa K, Shimizu H. Percept Mot Skills. 2007 Oct;105(2):403-4.	Gender	Medline Pubmed - MeSH
14	320	Pleasantness of a sweet taste during hunger and satiety: effects of gender and "sweet tooth". Laeng B, Berridge KC, Butter CM. Appetite. 1993 Dec;21(3):247-54.	Gender	Medline Pubmed - MeSH

15	375	The relationship of attitudes and experiences of Finnish youths to their hedonic responses to sweetness in soft drinks. Tuorila-Ollikainen H, Mahlamäki-Kultanen S. Appetite. 1985 Jun;6(2):115-24.	Gender	Medline Pubmed - MeSH
16	40	Multidimensional evaluation of endogenous and health factors affecting food preferences, taste and smell perception Guido D., Perna S., Carrai M., Barale R., Grassi M., Rondanelli M. [Article in Press] Journal of Nutrition, Health and Aging 2016 (1-11)	Age and BMI	Embase
17	39	Associations between weight status and liking scores for sweet, salt and fat according to the gender in adults (The Nutrinet-Santé study). Deglaire A, Méjean C, Castetbon K, Kesse-Guyot E, Hercberg S, Schlich P. Eur J Clin Nutr. 2015 Jan;69(1):40-6.	Gender and BMI	Medline Pubmed - MeSH
18	81	Taste preference and psychopathology. Aguayo GA, Vaillant MT, Arendt C, Bachim S, Pull CB. Bull Soc Sci Med Grand Duche Luxemb. 2012;(2):7-14.	BMI	Medline Pubmed - MeSH
19	119	Body fat, sweetness sensitivity, and preference: determining the relationship. Ettinger L, Duizer L, Caldwell T. Can J Diet Pract Res. 2012 Spring;73(1):45-8.	BMI	Medline Pubmed - MeSH
20	120	Habituation to the pleasure elicited by sweetness in lean and obese women. Pepino MY, Mennella JA. Appetite. 2012 Jun;58(3):800-5.	BMI	Medline Pubmed - MeSH
21	5	Gustatory responses and eating duration of obese and lean adults. S.A. Witherlya, Rose Marie Pangborn, Judith S. Stern Appetite. Volume 1, Issue 1, March 1980, Pages 53–63	BMI	Embase

22	10	Effects of metabolic state on sweet taste reactivity in humans depend on underlying hedonic response profile. Looy H, Weingarten HP Chem. Senses (1991) 16 (2): 123-130.	BMI	References
23	11	Sensory Discrimination, Intensity Perception, and Affective Judgment of Sucrose-Sweetness in the Overweight. Frijters JE, Rasmussen-Conrad EL J Gen Psychol. 1982 Oct;107(2d Half):233-47.	BMI	References
24	28	Cross-modal interactions for custard desserts differ in obese and normal weight Italian women Proserpio C., Laureati M., Invitti C., Pasqualinotto L., Bergamaschi V., Pagliarini E. Appetite 2016 100 (203-209)	BMI	Embase
25	417	Effects of obesity and set point on taste responsiveness and ingestion in humans. Rodin J. J Comp Physiol Psychol. 1975 Nov;89(9):1003-9.	BMI	Medline Pubmed - MeSH
26	227	The sweet tooth hypothesis: how fruit consumption relates to snack consumption. Wansink B, Bascoul G, Chen GT. Appetite. 2006 Jul;47(1):107-10.	Sweet taste according food products	Medline Pubmed - MeSH
27	276	Taste and food preferences as predictors of dietary practices in young women. Drewnowski A, Henderson SA, Levine A, Hann C. Public Health Nutr. 1999 Dec;2(4):513-9.	Dietary intakes (not sugar consumption)	Medline Pubmed - MeSH
28	360	Sugar and fat: sensory and hedonic evaluation of liquid and solid foods. Drewnowski A, Shrager EE, Lipsky C, Stellar E, Greenwood MR. Physiol Behav. 1989 Jan;45(1):177-83.	Gender	Medline Pubmed - MeSH
29	420	Sugar sweetness and pleasantness: evidence for different psychological laws. Moskowitz HR, Kluter RA, Westerling J, Jacobs HL. Science. 1974 May 3;184(4136):583-5.	Sweet taste according food products	Medline Pubmed - MeSH

30	29	Altered processing of sweet taste in the brain of diet soda drinkers. Green E, Murphy C Physiol Behav. 2012 Nov 5;107(4):560-7.	Association diet beverages and the brain	References
31	25	Sensory preferences and discrimination ability of children in relation to their body weight status Alexy, Ute; Schaefer, Anke; Sailer, Oliver; et al. JOURNAL OF SENSORY STUDIES Volume: 26 Issue: 6 Pages: 409-412 Published: DEC 2011	BMI	Web of Science
32	26	Sweetness intensity perception and pleasantness ratings of sucrose, aspartame solutions and cola among multi-ethnic Malaysian subjects Thai, Pua-Koon; Tan, Eng-Ching; Tan, Wai-Lun; et al. Food quality and preference Volume: 22 Issue: 3 Pages: 281-289 Published: APR 2011	Age, gender and BMI	Web of Science
33	31	Taste and weight: is there a link? Lucy F Donaldson, Lisa Bennett, Sue Baic, and Jan K Melichar Am J Clin Nutr September 2009. (90) no.3 800S-803S	BMI	References
34	32	Psychophysics of sweet and fat perception in obesity: problems, solutions and new perspectives Linda M Bartoshuk, Valerie B Duffy, John E Hayes, Howard R Moskowitz, Derek J Snyder Phil. Trans. R. Soc. B (2006) 361, 1137-1148 Published 29 July 2006.DOI: 10.1098/rstb.2006.1853	BMI	References
35	358	Sensory preferences for fat and sugar in adolescence and adult life. Drewnowski A. Ann N Y Acad Sci. 1989;561:243-50.	Age, gender and BMI	Medline Pubmed - MeSH
36	297	Taste preferences and food intake. Drewnowski A. Annu Rev Nutr. 1997;17:237-53.	Age and BMI	Medline Pubmed - MeSH
37	3	Sensory control of energy density at different life stages. Drewnowski A. Proc Nutr Soc. 2000 May;59(2):239-44.	Age	References

38	19	Predictors and correlates of taste preferences in European children: The IDEFICS study Lanfer, Anne; Bammann, Karin; Knof, Kolja; et al. Food quality and preference Volume: 27 Issue: 2 Special Issue: SI Pages: 128-136	Age	Web of Science
39	413	Effects of body weight and food intake on pleasantness ratings for a sweet stimulus. Thompson DA, Moskowitz HR, Campbell RG. J Appl Physiol. 1976 Jul;41(1):77-83.	BMI	Medline Pubmed - MeSH
40	26	Parents' and children's acceptance of skim chocolate milks sweetened by monk fruit and stevia leaf extracts. Li XE, Lopetcharat K, Drake MA. J Food Sci. 2015 May;80(5):S1083-92.	Age	Medline Pubmed - MeSH
41	362	Sweet tooth demonstrated: individual differences in preference for both sweet foods and foods highly sweetened. Conner MT, Haddon AV, Pickering ES, Booth DA. J Appl Psychol. 1988 May;73(2):275-80.	Sweet taste according food products	Medline Pubmed - MeSH
42	146	Evaluation of the Monell forced-choice, paired-comparison tracking procedure for determining sweet taste preferences across the lifespan. Mennella JA, Lukasewycz LD, Griffith JW, Beauchamp GK. Chem Senses. 2011 May;36(4):345-55.	Age	Medline Pubmed - MeSH
43	110	Sweetness and food preference. Drewnowski A, Mennella JA, Johnson SL, Bellisle F. J Nutr. 2012 Jun;142(6):1142S-8S.	Age, gender and BMI	Medline Pubmed - MeSH

VI. Search of articles on sources other than electronic databases

Institution	Type of searches, results and potential eligible documents	Results
Websites of key government and organization		
Association Suisse des Diététiciens/iennes diplômés/ées http://www.svde-asdd.ch/fr/ http://nutri-point.net/fr/	Search under the tabs : - Edulcorants artificiels / polyols - Santé dentaire - Pédiatrie : obésité chez l'enfant et l'adolescent, alimentation saine chez l'enfant et l'adolescent - Gestion du poids - Additifs	Nothing on sugar
Commission fédérale de l'alimentation COFA https://www.eek.admin.ch/eek/fr/home.html	In « rapport COFA et documentation » Les hydrates de carbone dans l'alimentation (2009)	Nothing on sweet taste preference
	L'alimentation durant les 1000 premiers jours de vie (2015)	The summary and the complete report do not address the question. The report only mentions that infants prefer sweet taste.
Société Suisse de Nutrition Clinique http://ssnc.ch/	Not possible to make a search with key words. In "Brochure et documentation"	Nothing on sugar
Société Suisse de Nutrition http://www.sge-ssn.ch/fr/	Key words: sucre 10 results 03_f_Nutrikid_Equilibre_hydrique_C Dateiname: 03_f_Nutrikid_Equilibre_hydrique_C.pdf | Dateityp: PDF-Dokument | Dateigrösse: 8,45 MB	 Not about sugar taste preference Document on sugar taste preference and age. Presentation on sugar taste preference and age.

(continued) **Société Suisse de Nutrition** http://www.sge-ssn.ch/fr/	Dateiname: Symposium-Prof.-Wolfgang-Langhans-Sweet-genes-2.pdf | Dateityp: PDF-Dokument | Dateigrösse: 1,84 MB Pyramide alimentaire	« Petit à petit, mettez moins de sucre dans vos boissons et aliments. De cette manière, vous vous habituerez lentement à un goût moins sucré. »
	Key words sucre ajouté *03_f_Nutrikid_Equilibre_hydrique_C* Dateiname: 03_f_Nutrikid_Equilibre_hydrique_C.pdf | Dateityp: PDF-Dokument | Dateigrösse: 8,45 MB	
Programme national nutrition santé (PNNS) http://www.mangerbouger.fr/PNNS/Le-PNNS Website for the public	Search with key words sucre Neuf results available (2 informations and 7 Mag): Two informations: Les sujets qui fâchent Lui faire plaisir et veiller à sa santé 7 Mags	Not about sugar taste preference Not about sugar taste preference

(continued) **Programme national nutrition santé** (PNNS) http://www.mangerbouger.fr/pro/ Website for professionals	Onglet "Alimentation" Glucides complexes et glucides simples Guide Produits sucrés Recherche par key words sucre 15 results De l'eau à volonté, moins d'alcool et de boissons sucrées Les recommandations en matière d'alimentation Glucides complexes et glucides simples Les objectifs de santé publique Nutrition et obésité Les objectifs nutritionnels fixés par le Haut conseil de la santé publique L'offre alimentaire en milieu scolaire Un rythme de repas plutôt régulier En Guadeloupe : Tous Centrés sur l'Activité Physique Cuisiner, partager et transmettre avec les ateliers culinaires de Paris Santé Nutrition	 Not about sugar taste preference Not about sugar taste preference « Les produits dits « light » sont effectivement une solution qui permet de consommer moins de sucre. En effet, le sucre y est remplacé par un édulcorant qui confère à l'aliment un goût sucré, sans apporter de calorie. Par contre, les édulcorants ne permettent pas de « se sevrer » du goût sucré et peuvent ainsi contribuer à entretenir, dans votre corps, la prédilection pour le goût sucré. »

Observatoire CNIEL des habitudes alimentaires (OCHA) http://www.lemangeur-ocha.com/	In "Index de A à Z": Search with key words: sucre ajouté 2 results: Manger comme un ogre L'alimentation des populations modestes et défavorisées - Etat des lieux dans un contexte de pouvoir d'achat difficile	Nothing on sugar Not about sugar taste preference
	Search with key words: sucre 44 results	Not about sugar taste preference
European Food Safety Authority https://www.efsa.europa.eu/fr	Publications Search terms: sugar 22 results Publications Search terms: added sugar 0 result	Not about sugar taste preference
	Home page: search with key words: added sugar 10 results: Scientific Opinion on Dietary Reference Values for carbohydrates and dietary fibre Panel on Dietetic Products, Nutrition and Allergies	Nothing about sugar taste preference in the report

American Heart Association http://www.heart.org/HEARTORG/	Home page, search with key words: Sugar: 3250 results, too many results Added sugar: 1610, too many results Sugar preference: 51 results Added sugar preference: 43 results Added sugar taste preference: 10 results Has the World Become Too Sweet? Kids and added sugars: How much is too much? Top Ten Things to Know Added Sugars and Cardiovascular Disease Risk in Children Children should eat less than 25 grams of added sugars daily Statement provides blueprint for healthcare providers to translate nutrition recommendations into practical food choices Busy Parents and Caregivers Must Care for Themselves Sweet & Spicy Mustard Dip with Veggie Dippers What should your toddler eat? Many toddler foods are high in sodium 5 Ways to Navigate Fast Food Menus Like a Pro	**Text on sugar taste preference in children and non-nutritive sweeteners. B** Only mentions the question of the effect of the reduction of added sugar. Nothing on sugar taste preference

Academy of Nutrition and Dietetics http://www.eatright.org/	Home page, search with key words Sugar: 190 articles, too many results Added sugar: 114 articles, too many results	
	Sugar preference: 18 articles	Nothing on sugar taste preference
	The Basics of the Nutrition Facts Label How an RDN Can Help with Diabetes 3 Steps to Help Combat Metabolic Syndrome	
	Children Need Carbohydrates Carbohydrates — Part of a Healthful Diabetes Diet Does TV Influence What Your Child Eats? Essential Nutrients for Women while Cutting Calories Diabetes and Diet 5 Whole Grains to Keep Your Family Healthy 4 Strategies for Smarter Toddler Snacks Is a Low-Carb Diet Safe for Kids? What Is Prediabetes? 5 Snacks for Your Bike Ride 5 Tips for a Healthy Independence Day Party Bite into a Healthy Lifestyle Easy Ways to Lighten Up Your Mexican Fiesta 5 Myths about Building a Healthy Vegetarian Meal	

World Health Organization http://www.who.int/fr/	Home page, search with key words Sucre : 726 results, too many results Sucre ajouté : 252 results, too many results Préférence sucre : 165 results, too many results Goût sucré : 85 results, too many results Accoutumance goût sucré : 2 results, nothing on sugar taste preference Search in the “Sugars intake for adults and children Guideline”	Nothing on sugar taste preference
Recommendations of dietary intakes		
Apports nutritionnels conseillés pour la population française. 3ème édition		Nothing on sugar taste preference
Valeurs de référence pour les apports nutritionnels. 1ère édition. (D-A-CH)		Nothing on sugar taste preference
Dietary Recommeded Intake, US, 2005		Nothing on sugar taste preference
Dietary guidelines for Americans 2015-2020 eighth edition		Nothing on sugar taste preference
General search on Google		
General search on Google	**Key words :** Déshabituer du sucre : No scientific results Accoutumance au sucre : No scientific results Sugar addiction : No scientific results	Article: Age and gender differences in children’s food preferences. Cooke LJ, Wardle J. (2005) Book with interesting references (already included) : Fructose, High Fructose Corn Syrup, Sucrose and Health. Rippe JM. (2014) Potential articles : https://www.scientificamerican.com/article/taste-healthy-foods/

(continued) **General search on Google**	Sugar consumption and taste preferences : 6 articles, already read. 1 book with references **Master thesis**	Sensory taste preferences and taste sensitivity and the association of unhealthy food patterns with overweight and obesity in primary school children in Europe—a synthesis of data from the IDEFICS study. Ahrens W. Flavour. (2015) Thesis Liem : http://edepot.wur.nl/121604 http://www.aappublications.org/news/aapnewsmag/2016/08/23/Sugar082316.full.pdf (Children under 2 years should avoid consuming any added sugar since they need nutrient-rich diets and are developing taste preferences). About habitual sweet food intake and sweet taste preference in adults. Study of category A – included in the review
Google Scholar	**Home page, search with key words:** Consommation, sucre, addiction Diminuer, consommation, sucre Diminution, préférence, goût sucré Sugar, consumption, preference	 1’650 results (too many results) 27’00 results (too many results) 15’000 results (too many results) 198’000 results (too many results) – Many publications were already included in the review

VII. Results on the primary question with statistical values

Author, Year	Sample / Quality	Intervention	Effects of modification of sugar content on sweet taste preference, liking or intake
Wise, 2016[94]	29 adults Positive	Reduction of 40% in calories from simple sugars in diet for 3 months	Sweet taste preference: ↔ P values ranged from 0.17 to 0.79
Yon, 2012[100]	793 children Neutral Industry	Reduction of sugar in flavoured milk in schools	Identical consumption of standard and reformulated lower-sugar flavoured F[1,5]=1.39; p=0.29
Sartor, 2011[96]	12 adults Positive	Supplementation of soft drink during 4 weeks, of about 760 ml energy drink per day	Sweet taste preference: ↔ 50.8 ± 37.5 versus 57.5 ± 30.5, t(11) = 0.85, P = 0.421, h2 partial = .062 - in the initial sucrose-dislikers group: ↑ t(5) = 2.83, p < 0.050, h2 partial = 0.628 - in the initial sucrose-likers group: ↔ t(5) = 1.04, p = 0.348, h2 partial = 0.176
Liem, 2004[99]	59 children and 46 adults Positive	Supplementation of orangeade during 8 days, either sweet or sour, of 200 ml	Sweet taste preference: ↔ in children: ↑ U=120.0, p < 0.05 in adults: ↔ U=88.0, p=0.68
Biguzzi, 2015[95]	219 adults Neutral	Consumption of 16 biscuits / week during 4 weeks: standard biscuit, most reduced sugar variant (28% sugar-reduced biscuit) or stepwise reduction in sugar	Liking of the 28% reduced-sugar biscuits: - Control and stepwise groups: ↔ - Direct group: ↔ Liking of the 9% and 16% reduced-sugar biscuits: - Direct group: ↑ p = 0.0482, p = 0.0812;

Author, Year	Sample / Quality	Intervention	Effects of modification of sugar content on sweet taste preference, liking or intake
Bouhlal, 2011[97]	61 children Positive	Consumption of fruit purée with 3 different sugar concentrations i.e. without sugar, 5% = control and 10% at three snacks times	Fruit puree intake: ↔ F(2,120) = 1·43; p= 0.24
Sullivan, 1990[42]	39 children Negative	15 exposures during 9 weeks with only one of three initially novel foods: added salt, sugar or plain tofu.	Preference in the three groups: ↑ F(3,114) = 3.49, p < 0.05
Brown, 1980[98]	40 infants Negative	Consumption of sweetened or unsweetened food during 3 months since the introduction of solid food. (consumption of unsweetened and sweetened fruits, randomly assigned, during 4 week)	Preference of sweetened and unsweetened food: ↔ Intake of sweetened and unsweetened food: ↔ T =2620; p > 0.05

VIII. Results on the secondary questions with statistical values

Author, Year	Sample / Quality	Exposure	Association between food intake and sweet taste preference in adults
Jayasinghe et al. 2016[101]	45 females Age: median of 29 (IQR: 23-32.5) years Neutral	Sweet foods intake	Association between sweet food intake and sweet taste preference: **Ø** r=.35, p = 0.02
Mennella et al. 2014[41]	76 mothers Age: 36.1 ± 1.0 years0.2 Positive	Daily added sugar intake	Association between daily added sugar intake and sweet taste preference: **Ø** No values provided, only figures
Holt et al. 2000[104]	132 adults Australian: age: 22.8 ± 4.3 years Malaysian: age: 21.5 ± 1.2 years Neutral	Sweet foods and drinks intake and added sugar intake	Association between sweet food and drink intake and sweet taste preference: **+** t = 3.55, p <0.001; t = 3.95, p <0.001 Association between added sugar intake and sweet taste preference: **+** t = 2.47, p <0.05
Stone et al. 1990[105]	100 adults Age: 18-31 (range) years Negative	Sugar intake	Association between sugar intake and sweet taste preference: **Ø** r = 0.098, p > 0.05
Mattes et al. 1986[106]	25 males Age: 17-34 (range) years Neutral	Percent of calories having a predominantly sweet taste	Association between percent calories from sweet foods and sweet taste preference: **+** r = 0.504, p < 0.001
Pangborn et al. 1984[107]	51 adults Age: 18-31 (range) years Neutral	Sweet foods intake	Association between sweet food intake and sweet taste preference: **+** F = 3.96, p > 0.05

Author, Year	Sample / Quality	Exposure	Association between sweet food habits and sweet taste preference in children
Mennella et al. 2014[41]	101 children Age: 7.8 ± 0.2 years Positive	Daily added sugar intake	Association between daily added sugar intake and sweet taste preference: **Ø** No values provided, only figures
Lanfer et al. 2012[87]	1'593 children Age: 6-9 (range) years Positive	Sweet foods intake	Association between sweet food intake and sweet taste preference: **Ø** Statistical values not shown
Pepino et al. 2005[102]	108 children Age: 7.8 ± 0.1 years Neutral	Intake of sugar water during infancy	Association between early exposure to sugar water during infancy and sweet taste preference during childhood: **+** t(106 df) = 2.20; p = 0.03
Liem et al. 2002[103]	83 children Age: 4-7 (range) years Neutral	Formula history: milk versus hydrolysate formulas	Association between formula history and preference for sweetened juices: **Ø** F(1, 79) = .10, p = 0.76 Association between added sugar intake and preference for sweetened juices and cereals: **+** F(1, 78) = 4.68, p < 0.05; F(1, 74) = 6.02, p < 0.05
Beauchamp et al. 1984[109]	63 children Age: 2.0 (SEM: 0.0) years Neutral	Early intake of sugar water during infancy	Association between early exposure to sugar water and sweet taste preference: **+** p < 0.05
Beauchamp et al. 1982[108]	140 children Age: 0.5 year ± 0.0 Neutral	Early exposure to sugar water	Association between early exposure to sugar water and sweet taste preference: **+** F(1, 129) = 7·84, p <0·001
Olson et al. 1981	31 children Age: 4 – 5 (range) years Neutral	Sweet foods intake and food choice and	Association between frequency of sweet food intake and sweet taste preference: **Ø** F= 7.07; df = 1,26; p < 0.05

Author, Year	Sample / Quality	Exposure	Association between artificial sweeteners intake and sweet taste preference
Mahar, 2007[76]	64 females Age : 25 ± 9.2 years Neutral	Sweetened beverages intake	Association between a high intake of sweetened beverages and higher liking of the sweetness level in the juice: **+** F = 60.54 ; df = 4 ; p < 0.0001 Association between liking of sweetness and the 2 sweetener type groups: **Ø** F = 2.97; df = 1 ; p < 0.085