Fruit juices, sugar sweetened beverages and artificially sweetened beverages: consumption patterns and impact on overweight and obesity

Review of Scientific Evidence and Policies on Nutrition and Physical Activity-Objective B2: Consumption, energy intake and impact of fruit juices and of artificially and sugar sweetened beverages

Summary Report

Written by ICF Consulting Services Ltd

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Preface

About this project

Overweight, obesity and their related diseases represent a leading cause of morbidity and mortality, and pose a major challenge for the sustainability of healthcare systems of EU Member States. The growing prevalence of overweight and obesity among all age groups across Europe constitutes a serious concern for policy makers. Tackling this issue requires a comprehensive response that reflects the multifactorial and complex nature of obesity and overweight. One particularly important area of focus has been on the development of preventative strategies which include nutritional and physical activity interventions.

The European Commission Directorate General for Health and Food Safety (DG SANTE) recognises the significant challenges policy makers face in developing effective and efficient policy interventions relating to diet and physical activity. One such challenge includes the complexity and breadth of the evidence base. By providing independent, accurate summaries of recent and relevant information and statistics on determinants of diet and physical activity and their impact on health, this project aims to support policy makers to continue to develop policy instruments which enable people to make healthier lifestyle choices. In particular, this project aims to support the development of healthier behaviours in vulnerable and/or at-risk subpopulations (including children, pregnant and lactating women, and older adults) and low socio-economic status groups (including low income and education).

About this series

This evidence review is one of eight reviews relating to different determinants of diet and physical activity.

Seven of the reviews are of the scientific evidence and policies in the following areas:

- Knowledge, attitudes and behaviours contributing to positive energy balance (objective area A1);
- Dietary and physical activity patterns in Europe (objective area B1);
- Consumption of fruit juices, artificially and sugar-sweetened beverages and its impact on weight status and health (objective area B2);
- Consumption of high-fructose syrup and its impact on weight status and health (objective area B3);
- Relationship between weight status and physical activity with school and work performance outcomes (objective area C);
- Early warning indicators of obesity and physical inactivity trends (objective area D);
- Nutrition and physical activity guidelines for specific population groups (objective area E).

Building on these seven reviews, the final review (objective area A2) examines specifically the evidence for effective and efficient policies and interventions in terms of promoting, supporting and improving nutritional and physical activity behaviours at both individual and population level.

All reviews, and their summaries, are available on the DG SANTE webpage here.

Approach and purpose

The reviews have been designed to provide policymakers with summaries of recent and relevant evidence in these key areas of interest. Given the broad scope of each of the reviews, it should be stressed that they are not intended to be rigorous systematic reviews of all literature published in this field. Rather, they are intended as pragmatic

reviews combining a comprehensive search methodology with expert academic input, facilitated through workshops, to provide a practical and accurate summary of key issues and tackling broad lines of enquiry, with the greater aim of supporting the development and improvement of policies in this area. Each of the project's eight methodologies and analyses was reviewed by DG SANTE and academic experts in these topics.

While the methods to conduct this comprehensive literature review are systematic, it is *not* a systematic review. This review does not systematically analyse literature to identify *all* relevant published data and/or appraise its quality. Methods to conduct the literature review consisted of five steps: (1) refining the research questions, (2) developing a search approach and databases, (3) conducting literature searches, (4) screening articles for inclusion; and (5) abstracting and synthesising relevant data.

To minimise bias, the literature search approach included identification of a priori search parameters (also considered first level inclusion and exclusion criteria), agreed with DG SANTE, to guide searches and inform screening and selection processes for data inclusion. Due to the immense number of literature search results at step 3, the application of quite limiting exclusion criteria at step 4 was deemed necessary. This may however have resulted in not screening all potentially relevant literature. All relevant articles that were found appropriate for inclusion were reviewed for relevance to each objective area, and the scope of the specific research questions. Furthermore, the inclusion of different types of scientific evidence (from systematic reviews and peer-reviewed original articles down to BSc theses) and the presentation of this scientific evidence next to grey literature information presented a challenge in terms of maintaining an understanding of the quality and weight of the evidence. The authors addressed this to some extent by structuring the document in such a way that peer-reviewed and grey literature are clearly identified. The full methodology and steps taken for each review is included in Annex of the full literature review documents.

DG SANTE and the Joint Research Centre (JRC) provided input on all stages of the project and comments on the literature reviews. Expert workshops were organised to discuss findings, highlight additional relevant sources to fill gaps and improve the series of reviews. Experts were carefully selected from academic and policy-making fields, based on expertise of the specific topics addressed.

The methodology used across all eight reviews remained consistent, and within each review a detailed summary of the approach is provided, along with a full bibliography for further reading.

Objective B2: Consumption, energy intake and impact of fruit juices and of artificially and sugar sweetened beverages

This comprehensive review presents the findings from peer literature (peer reviewed research studies and systematic reviews) and grey literature on the consumption, energy intake, and impact of fruit juices and of artificially and sugar sweetened beverages (including sweetened alcoholic beverages) on overweight, obesity, and health (including alcohol-related harm).

1.1 Scope of this review

In general, findings in this review focus on European data and trends although data from other countries are included where available and where useful for comparative purposes. Use, consumption and health impacts of high fructose corn syrup (HFCS) is beyond the scope of this objective and is covered separately under objective B3. A review of policy responses to the issues raised in this objective area is presented in Objective A2 as part of a wider discussion of policy responses to improve dietary behavior and physical activity levels.

1.2 Methodology

The review is mainly based on peer reviewed literature which has been discussed first in all cases. Peer reviewed literature findings are followed by grey literature evidence which has been used to support peer reviewed evidence, fill any evidence gaps and/or further explain data or trends. A detailed explanation of the methodology used for this review is available in the full review report for Objective B2. The review draws on a total of 60 peer review references and 49 grey literature references.

1.3 Research questions

In the review, we focus on the most current literature (peer-reviewed research and systematic reviews, as well as grey literature) to answer the following questions:

- Who consumes SSBs, how much do they consume and what are the drivers behind such choices?
- Who consumes fruit juices, how much do they consume and what are the drivers behind such choices?
- Who consumes LCS beverages, how much do they consume and what are the drivers behind such choices?
- What are the consequences of such consumption on overweight and obesity?
- Who consumes sweetened alcoholic beverages (artificially or sugar-sweetened), namely alcopops and sweetened spirit drinks that are pre-mixed, how much do they consume and what are the drivers behind such choices?
- What are the consequences of such consumption on alcohol-related harm?
- What is the role played by artificial sweeteners in general and by LCS beverages in particular in developing a preference for the sugary taste and what behavioural and health consequences could there be?

Who consumes SSBs, how much do they consume and what are the drivers behind such choices?

Findings on consumption patterns were affected by variations in study design and differences in the way SSB consumption levels were reported (i.e. by volume, frequency, percentage of total beverage intake or of total calorie intake). However, the following general trends were identified:

- SSB consumption is higher among men than women (Singh, 2015; Heuer et al. 2015; Pollard et al. 2016; Malisova et al. 2015). A similar gender divide was identified in studies focussing on SSB consumption in children (Mensink et al. 2007; Cavallo et al. 2016; Dzielska et al. 2015), however the pattern varied by age and MS (Bjelland et al. 2013; Inchley et al. 2016).
- Young adults and adolescents tend to consume more SSBs than older adults (Heuer et al. 2015; Singh et al. 2015; Inchley et al. 2016) and there is some grey literature evidence to suggest that children as young as one year old are consuming SSBs in some MS (Woś et al. 2010).
- The relationship between SES and SSB consumption is complex: educational status appears to be an important dimension of SES in predicting SSB consumption (Fismen et al. 2016; Robertson et al. 2007). Within high income countries, there is evidence that low SES is associated with higher SSB consumption (Heuer et al. 2015; Bjelland et al. 2013; Inchley et al. 2016).

Globally, there is nearly a tenfold difference between highest and lowest regional SSB intake levels (Singh et al. 2015). European regions report relatively low levels of SSB consumption in 2010 compared to the rest of the world: between 0.15 and 0.76 eight ounce servings on average per day depending on European region, age and gender. This compares to 1.9 eight ounce servings in the Caribbean, the region with highest recorded consumption levels (Singh et al. 2015). There is also evidence to suggest a general decline in SSB purchases across Europe since 2010 (ICCR 2016).

However, within Europe, large variations were observed between MS. Western Europe reported the highest levels of overall consumption (Singh et al. 2015) and at MS level, the literature identified the Netherlands (adults and children) and Belgium (adults) as the top SSB consumers (Azais-Braesco et al. 2017; ICCR 2016[1]).

Among children, TV viewing/screen time, snack consumption, living near a fast food/convenience store and various parental factors including parental SES, age, SSB consumption, children attending out-of-home care, formula milk feeding and early introduction of solids were identified as drivers for SSB consumption (Paes et al. 2015; Park et al. 2012; Pawellek et al. 2016). Early childhood SSB consumption was also linked with higher consumption in later childhood (Bjelland et al. 2013). Among adults, consumption of SSBs during childhood, obesity (Pollard et al. 2016), stress (Tryon et al. 2015) and seasonality/cold weather (Malisova et al. 2015) were identified as key drivers of SSB consumption. Grey literature also identified price discounting in the UK (Tedstone et al. 2015) and marketing and advertising (Sjolin 2006) as drivers of SSB consumption.

Who consumes fruit juices, how much do they consume and what are the drivers behind such choices?

Across Europe, average daily fruit juice consumption varies by MS. A peer reviewed secondary analysis of data from the European Food Safety Authority's Concise Food Consumption Database in 19 countries (Elmadfa and Meyer 2015) found that the highest average daily consumption levels of fruit and vegetable juice were reported in Germany, Finland, Austria, Netherlands and Slovenia (between 226ml/day and

[1] This reference used sales data as a proxy for consumption.

128ml/day respectively) while lowest consumption levels were reported in Italy, Slovakia, Poland and Ireland (between 30ml/day and 33ml/day respectively).

More generally, studies reported higher fruit juice consumption in higher income countries (Singh et al. 2015) and among males (compared to females) (Singh et al. 2015; Heuer et al. 2015; Duffey et al. 2012; Vagstrand et al. 2009). No global correlation between fruit juice consumption and age was identified (Singh et al. 2015). However there is some evidence in developed nations of younger age groups consuming more fruit juice than older age groups (Heuer et al. 2015; Francou et al. 2015). In some European countries, babies and very young children were found to be regularly consuming fruit juice (Woś et al. 2010), although evidence is limited to one grey literature study.

Findings on the drivers of fruit juice consumption were limited. Peer reviewed findings suggest a non-significant association between the winter season and higher fruit juice consumption among adults in Greece. High fruit juice consumption among mothers (Vagstrand et al. 2009) and low SES of mothers (Mantziki et al. 2015) were identified as potential drivers for fruit juice consumption among children in some, but not all, MS.

Who consumes LCS beverages, how much do they consume and what are the drivers behind such choices?

There is limited European-level data on LCS consumption patterns and levels: most available data is from the US. Approximately a quarter of adults and a fifth of young people consume LCS beverages in the US. LCS consumption levels in the US have increased over the last 20 years and this trend is expected to continue worldwide (Sylvetsky and Rother 2016).

A small number of studies suggest that females are more likely to consume LCS beverages than males (Sylvetsky and Rother 2016; Paulsen et al. 2016; Pollard et al. 2016) and there is limited evidence to suggest a positive association between LCS consumption and SES (Sylvetsky and Rother 2016). A negative association between age and LCS consumption was also identified in the literature but varying patterns were reported across studies (Sylvetsky and Rother 2016; Paulsen et al. 2016).

Limited information from individual MSs on drivers of LCS consumption suggest that obese individuals may be more likely to consume LCS beverages compared to those with a healthy weight (Paulsen et al. 2016) and that more LCS beverages may be consumed in winter compared to summer (Malisova et al. 2015).

What are the consequences of such consumption on overweight and obesity?

There is strong peer reviewed evidence to support a positive relationship between SSB consumption and weight status, BMI and/or body fat in both children and adults (for example Malik, Schulze, and Hu 2006; Malik, Pan, Willett, and Hu 2013; Vartanian, Schwartz and Brownell 2007; Funtikova et al. 2015). Grey literature also supported the link between SSB consumption and other negative health outcomes including tooth decay (Tedstone et al. 2015; EFSA 2010; Inchley et al. 2016), obesity-related health problems including type 2 diabetes and cardiovascular disease (Walsh 2015; EFSA 2010; Olimpi 2012; Inchley et al. 2016) and nutrient deficiencies (Inchley et al. 2016; EFSA 2010; Jacobson 2005; Woś et al. 2010).

No evidence was found to support a positive association between fruit juice consumption and weight/BMI (Vagstrand et al. 2009; Shefferly, Scharf and DeBoer 2016; Crow-White et al. 2016). There is currently a lack of randomised controlled clinical trials on this topic to support a causal relationship.

There is no conclusive evidence that consumption of LCS beverages is associated with changes in body weight or body fat among adults (Miller and Perez 2014; Rogers

2016; Anderson et al. 2012; Fowler et al. 2015; Ma et al. 2016; Reid et al. 2016; Brown et al. 2010). However there is some evidence from large epidemiological studies reviewed by Brown, de Banate and Rother (2010) of an association between the consumption of artificially-sweetened beverage consumption and weight gain in children. There is also some evidence that replacing SSBs with LCS beverages can reduce existing body fat (Campos et al. 2015; de Ruyter et al. 2012).

Who consumes sweetened alcoholic beverages (artificially or sugar-sweetened), namely alcopops and sweetened spirit drinks that are pre-mixed, how much do they consume and what are the drivers behind such choices?

Alcopop consumption is highest among adolescents and young adults (Heuer et al. 2015; Copeland et al. 2007; Rabinovich et al. 2009; Alcohol Justice and the San Rafael Alcohol & Drug Coalition 2015). However, in European MS, with the exception of Lichtenstein, alcopops were not found to be the most popular alcoholic drink among adolescents (ESPAD 2015; Sierosławski 2015; Anderson, Suhrcke and Brookes 2012; PBS DGA 2007; Hemström, Leifman, and Ramstedt 2001, referenced in Anderson & Baumberg 2006).

Adolescent girls are generally more likely to consume alcopops than boys (Metzner and Kraus 2008; ESPAD 2015; Muller and de Greef 2013). There is limited evidence that alcopop consumption may also be positively associated with SES and parental education (Anderson, Suhrcke and Brookes 2012).

Targeted marketing/advertising (Winpenny et al. 2012; Alcohol Justice, and the San Rafael Alcohol and Drug Coalition 2015) and the sweet taste of alcopops (Alcohol Justice and the San Rafael Alcohol & Drug Coalition 2015) were identified as drivers for consumption among adolescents. However evidence was limited to grey literature.

What are the consequences of such consumption on alcohol-related harm?

At present, there is not enough evidence to support a relationship between alcopop consumption and increased alcohol use, heavy episodic drinking and negative alcohol-related consequences. More studies are required that control for other forms of alcohol consumption.

What is the role played by artificial sweeteners in general and by LCS beverages in particular in developing a preference for the sugary taste and what behavioural and health consequences could there be?

Limited peer-reviewed evidence from the US suggests that individuals prefer consuming SSBs over ASBs due to a perceived sweeter taste (Delogu et al. 2016). However, when consumed, non-caloric sweeteners may lead to subtle changes in eating behaviours which increase calorie consumption over the longer-term (Hill et al. 2014).

Looking at wider health consequences of consuming artificial sweeteners and LCS beverages, there is persuasive evidence that consumption of non-caloric artificial sweeteners can lead to glucose intolerance by altering intestinal microbiota (Suez et al. 2014; Suez et al. 2015) and limited evidence that maternal consumption of ASBs during pregnancy may influence infant BMI (Azad et al. 2016). However studies focussing on links between consumption of artificial sweeteners or LCS beverages and type 2 diabetes (Sylvetsky et al. 2016; Imamura 2015), cancer (Mishra et al. 2015) and coronary heart disease (de Koning 2012) were inconclusive or showed no relationship.

Conclusion

In Europe, **SSB** consumption levels are relatively low compared to the rest of the world although variation exists across Europe, with Western Europe reporting the highest European consumption levels. In general, males and children and adolescents consume the highest quantities of SSBs, and, in high income countries, SSB consumption was found to be negatively associated with SES. Increased SSB consumption has also been linked to other individual, interpersonal and environmental drivers including certain parenting behaviours and characteristics, individual behaviours and traits (e.g. stress, obesity), and retail environment factors such as marketing and advertising exposure. There is strong and consistent evidence to suggest that SSB consumption leads to increased weight status, BMI and/or body fat in both children and adults. These findings support the need to take action to address high consumption levels in certain MS and among certain population sub-groups.

Fruit juice consumption patterns varied across Europe, although more studies are required to support the findings from this review. High country income and being male were associated with higher fruit juice consumption and, in some developed nations, there is evidence that fruit juice consumption is negatively correlated with age. Other drivers for consumption include seasonality, mothers' fruit juice consumption and mothers' SES however more evidence on drivers is required. No evidence was found to support a positive association between fruit juice consumption and weight/BMI: more research, particularly randomised controlled clinical trials, in this area is required.

Most available data on **LCS beverage** consumption comes from the US: there is a need for comparative EU-wide studies on this topic to better identify consumption levels and trends within Europe. In general, females are more likely to consume LCS beverages than males and there was some evidence to support a link between consumption and age, SES, being obese and seasonality, although more information on patterns and drivers of consumption is required. There is no conclusive evidence that consumption of LCS beverages is associated with changes in body weight or body fat. However there is some evidence that *replacing* SSBs with LCS beverages can reduce existing body fat. There is also evidence to suggest a link between consumption of LCS beverages and other negative behavioural and health impacts such as increased glucose intolerance: further research and assessment of the impact of LCS beverages on health is required.

Alcopop consumption was found to be highest among adolescents and young adults, particularly young females. It may also be associated with SES, level of parental education and marketing exposure, although evidence was limited to grey literature findings. There is insufficient evidence to support a relationship between alcopop consumption and increased alcohol use or risk of alcohol-related harm: more studies that control for other forms of alcohol consumption are required.

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Annex 3 Glossary

The following definitions are common definitions that are used across all eight objective areas. Where a study uses a different definition, this is highlighted on an individual basis in the review reports.

Table 1. Definitions of terms used across the reviews

Term	Definition	Source
Adult obesity	An abnormal or excessive fat accumulation that presents a risk to health, with a BMI of 30 or more.	World Health Organisation (WHO) (http://www.who.int/topics/obesity/en/)
Adult overweight	An abnormal or excessive fat accumulation that presents a risk to health, with a BMI equal to or more than 25.	WHO (http://www.who.int/topics/obesity/en/)
Alcopops	Pre-mixed beverages containing a spirit, wine or malt combined with a non-alcoholic drink.	1. Anderson, P., Suhrcke, M. and Brookes, C. (2012) An overview of the market for alcohol beverages of potentially particular appeal to minors. London: HAPI.
Artificially sweetened beverages (ASBs)	Beverages sweetened with low-calorie or zero-calories sweeteners such as sucralose, aspartame, saccharin, stevia or sugar alcohols.	ICF definition based on all literature identified in objective area B2 literature review
Body Mass Index	A person's weight (in kilograms) divided by the square of his or her height (in metres).	WHO (http://apps.who.int/bmi/index.jsp?introPage=intro_3.html)
Child/adolescent obesity	There are different systems available to measure child or adolescent obesity for different ages. Children under 5 obesity is weight-for-height greater than 3 standard deviations above WHO Child Growth Standards median; Children aged 5-19 overweight is BMI-for-age greater than 2 standard	WHO http://www.who.int/mediacentre/factsheets/fs311/en/ (Other definitions are available for different national and international systems).

Term	Definition	Source
	deviation above the WHO Growth Reference median.	
Child/adolescent overweight	There are different systems available to measure child or adolescent overweight for different ages. Children under 5 overweight is weight-for-height greater than 2 standard deviations above WHO Child Growth Standards median; Children aged 5-19 overweight is BMI-for-age greater than 1 standard deviation above the WHO Growth Reference median.	WHO http://www.who.int/mediacentre/factsheets/fs311/en/ (Other definitions are available for different national and international systems).
Exercise	Exercise, is a subcategory of physical activity that is planned, structured, repetitive, and purposeful in the sense that the improvement or maintenance of one or more components of physical fitness is the objective.	WHO (http://www.who.int/dietphysicalactivity/pa/en/)
Insufficient physical activity	Physical activity that does not meet WHO recommended levels of at least 60 minutes a day of moderate-vigorous activity for children and adolescents and at least 150 minutes of moderate-intensity aerobic physical activity throughout the week for adults.	WHO http://www.who.int/mediacentre/factsheets/fs385/en/
Physical activity	Any bodily movement produced by skeletal muscles that requires energy expenditure.	WHO (http://www.who.int/topics/physical_activity/en/)
Physical inactivity	A lack of physical activity	WHO (http://www.who.int/dietphysicalactivity/pa/en/)
Sedentary behaviour	Any waking behaviour	Tremblay, M. S., et al.

Term	Definition	Source
	characterized by an energy expenditure ≤1.5 metabolic equivalents (METs) while in a sitting or reclining posture.	(2017). Sedentary Behavior Research Network (SBRN) – Terminology Consensus Project process and outcome. *The International Journal of Behavioral Nutrition and Physical Activity*, *14*, 75. http://doi.org/10.1186/s12966-017-0525-8
Sugar sweetened beverages (SSBs)	Any beverage with added sugars. This includes soft drinks, soda, fruit drinks, punch, sports drinks, sweetened tea and coffee drinks, energy drinks and sweetened milk. These beverages may be sweetened with added sugars such as sucrose (table sugar) or high fructose corn syrup, which is what distinguishes them from 100% fruit juice and beverages with non-caloric sweeteners (e.g., aspartame, saccharin or sucralose).	US Department of Agriculture. 2010. *US Department of Health and Human Services. Dietary guidelines for Americans, 2010.* 7th edition, Washington (DC): US Government Printing Office

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