Consumption and impact of High Fructose syrups

Review of Scientific Evidence and Policies on Nutrition and Physical Activity – Objective Area B3: A comprehensive review of the scientific evidence and policies on the consumption, energy intake and impact of High Fructose syrups on overweight and obesity and health

Summary Report

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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 Area B3: Consumption, energy intake and impact of High Fructose syrups on overweight and obesity and health

High fructose syrups are liquid fructose-glucose sweeteners, commonly derived via the hydrolisation of starch, alternative to common table sugar (sucrose). High fructose syrups are commonly known as either High Fructose Corn Syrup (HFCS), in the United States (US), or Isoglucose, in the European Union (EU)[1]. HFCS is a sweetener that has been widely used since the 1970s (Bray, Neilsen and Popkin, 2004), predominantly in soft drinks, fresh dairy products, and breakfast cereals (DG AGRI, 2015). HFCS gained popularity as a sugar replacement because of its price, intense sweet flavour, longer shelf-life, and, stability in solution when compared with sucrose (White, 2008).

The abolition of the sugar quota in the EU in September 2017, which removes the production quota on HFCS, has led to uncertainty regarding the uptake of HFCS across the EU (JRC, 2014). Health concerns have been raised around what, if any, public health impact will occur from an increase in the consumption of HFCS, and, whether there needs to be an effective monitoring system in place to measure this.

From the literature reviewed, there appears to be no common definition of what percentage of fructose constitutes the syrup being 'high fructose'; different formulations of fructose concentration exist depending on the country regulation and the product that is being made. The lack of a defined composition of fructose in the term HFCS across industry and countries makes it difficult to assess the health impact of HFCS, as the health impact may vary with different molecule compositions.

1.1 Scope of this review

To ensure the most relevant sources were reviewed, we focused on evidence in relation to the consumption, health impacts and monitoring of HFCS only, as evidence on programme and policies concerning HFCS is covered in Objective A2, and other evidence regarding sugar sweetened beverages is analysed in Objective B2.

Furthermore, the intention of this review is not to investigate whether HFCS is safe or other issues addressed within the remit of European Food Safety Authority. Rather, this review examines the scientific evidence and polices on the consumption, energy intake and impact of high fructose syrups on overweight, obesity, and, health.

1.2 Methodology

The review is based primarily on peer reviewed literature (which is prioritised), with grey literature used to supplement any gaps (but treated with caution and the strength of the evidence assessed). A full description of the methodology used for all literature reviews can be found in the original literature review report. The review draws on 19 peer review and 4 grey literature sources selected as relevant.

1.3 Research questions

In this 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** foods containing HFCS and how much?
- How much can that **market** be expected to change in the near future?
- What **consequences** related to overweight and obesity can be anticipated, if any?
- What feasible, effective and efficient **monitoring mechanisms** should be put in place to keep track of this issue?

[1] This document uses 'HFCS' unless Isoglucose is the term presented in the literature reviewed. It must be noted that Isoglucose does not necessarily come from corn, yet acts in the same way as HFCS.

Who consumes foods containing HFCS and how much?

This section summarises the consumption of HFCS in Europe. Currently there is no direct way to measure total HFCS consumption (Duffey and Popkin 2008; Bray, Neilsen and Popkin, 2004) as studies and dietary surveys do not make a clear distinction between HFCS and other added sugars, for examples in food labels. Formulations vary in their fructose-glucose ratio and overall sugar content, so with no clear definition of what HFCS is, there is currently no accurate way of calculating consumption patterns.

An ecological study into the global use of HFCS in 43 countries based on food availability data from the Food and Agriculture Organisation (Goran et al., 2013) found:

- HFCS use is highest in the US (24.78 kg/year per capita), whilst Europeans consume on average at least a third less of HFCS (kg/year per capita);
- Twelve countries within the EU do not use HFCS at all; and
- Of European countries that did consume HFCS, the five countries with the highest use were Hungary, Slovakia, Bulgaria, Belgium, and Turkey. This aligns to increased production in these countries since 2005/2006 (EEIG Agrosynergie, 2011).

Following the abolition of the EU sugar quota (explored further below), consumption of HFCS is likely to increase in all European countries, mirroring higher consumption levels of HFCS in unrestricted markets such as the US[2].

How much can the market for HFCS be expected to change in the near future?

There was no peer review literature on market changes for HFCS in Europe. Findings from grey literature show:

- Following the abolition of the EU sugar quota, the Department of Agriculture and Rural Development in the European Commission estimated that the production of Isoglucose will increase from less than 4% to just below 10% of the sweetener market in 2026 across the EU (DG AGRI, 2016). This estimate assumes an increase in Isoglucose production and consumption, and in the overall use of sugar in Europe.
- The extent to which this increase occurs is likely to vary by Member State, and is likely to be driven by a number of factors, including: manufacturers' willingness to switch to using Isoglucose; consumer acceptance and taste preference; relative price; health concerns; and the influence of policies (EEIG Agrosynergie, 2011).
- DG AGRI (2016) suggests that demand is likely to be highest in EU countries such as Romania, Bulgaria and Hungary, where current sugar prices and sugar consumption are high in spite of a deficit of sugar; Isoglucose could be seen as an attractive competitive alternative.

What consequences related to overweight and obesity can be anticipated, if any?

There was strong evidence that the general consumption of added sugars is linked to changes in metabolism, and increased risk of obesity, heart disease and diabetes. However, due to limited evidence about the health impact of HFCS, it is currently

[2] Bray, Neilsen and Popkin (2004) note HFCS is the sole caloric sweetener in soft drinks in the US, contributing to an increase of over 1000% in its consumption between 1970 and 1990.

inconclusive whether HFCS has health consequences related to overweight and obesity beyond those attributed to added/free sugars.

Based on the handful of international scientific studies in this area, it is possible that:

- Increased levels of HFCS and added sugar consumption (in beverages) is associated with an increased risk of CVD mortality (Stanhope et al., 2015);
- Consumption of HFCS in sugar-sweetened beverages could be linked to increased insulin resistance and slower metabolism (Lin et al., 2016); and
- Increased obesity and diabetes prevalence in the general US population might be partly attributable to the increased consumption and availability of HFCS (Bray, Neilsen and Popkin, 2004; Goran et al., 2013).

Notably, only tentative statements can be made about the health consequences of HFCS as its fructose content is not always accurately known. Studies also often use SSBs as a proxy for HFCS, and difficulties remain in measuring HFCS in diets. Consequently, non-systematic reviews of peer-reviewed research indicate inconsistent findings regarding association and relationship between HFCS consumption with weight gain and obesity (e.g. Stanhope, 2006; Tappy and Le, 2010). Further research needs to be conducted before the health consequences of HFCS consumption can be determined with accuracy. This also leads to the overall conclusion that unless new evidence appears, efforts should be targeted at decreasing total (added) sugar/sweetener consumption rather than specific types of sugar.

What feasible, effective and efficient monitoring mechanisms should be put in place to keep track of this issue?

Literature focusing on monitoring industry use of HFCS or effective monitoring of HFCS consumption was not available. Instead, this section highlights the types of monitoring mechanisms that could be considered.

HFCS intakes may be measured using food composition surveys (Bray, Neilsen and Popkin, 2004) and using nationwide Nutrient Database Systems (Duffey and Popkin, 2008). The transferability and accuracy of these methods remain limited by assumptions about the types and amount of added sugar used. For example, Duffey and Popkin's primary assumption is that HFCS is 100% of the added sugar for soda and fruit drinks, however, HFCS are not routinely used as the sole sweetener in beverages in all countries or in all SSBs.

Other methods of monitoring consumption, intake and impact that have been used in the food and beverage industry include:

- A protocol for monitoring the nutritional makeup of fast food products across countries (The Food Monitoring Group, 2012). This relies on annual surveys obtaining nutritional information directly from fast food companies, product information available online and on packaging, and direct chemical analysis where nutritional information is unavailable. Currently, there is no data for specific food items.
- Linking market-research data on consumer purchasing behaviour and nutritional values listed on products to identify changes in the nutritional composition of items (and their consumption) over time. Examples of regression analysis on such data already exist (e.g. Mathias et al., 2015).

All the methods listed so far are dependent on the availability of data. In the US, there is little publicly available data on HFCS use by food and beverage manufacturers – linked to a lack of overall nutritional information available to consumers and the difficulty in measuring the chemical composition of products to determine the presence of HFCS. This has led to the use of inaccurate proxy measures or

conservative estimates (Bray et al., 2004) for monitoring HFCS consumption. However, since 2016, it is mandatory for manufacturers in all MSs to follow Regulation EU 1169/2011 on food information to consumers, and provide information (in a descending order of quantity) on the use of sucrose, fructose-glucose syrup, and glucose-fructose syrup in the ingredient list. This suggests it will be possible to more accurately monitor HFCS availability and consumption by Europeans in the future.

There is also the possibility of using biomarker-based methods to monitor molecule consumption. A clear advantage of such a method is that it can overcome the limitations of using self-reported data of dietary behaviour, such as social desirability bias. Examples of measurement methods have already been explored in a number of scientific studies on carbon isotype testing and urinary sugar excretion (e.g. Jahren et al., 2006; Tasevka et al., 2014; and Davy and Jahren, 2016). However, the applicability of these studies varies and in general biomarker-based methods for measuring the intake of HFCS or other forms of sugar are not yet feasible for use in public health research. More robust studies are needed in order to model the relationship between measurements of sugar biomarkers and actual sugar intake.

Conclusion

Overall, more precise information on the formula for HFCS used in various foods and beverages, and available data on production of products containing HFCS, is needed before progress is made in monitoring its production and consumption, and the subsequent consequences, if any, on overweight, obesity and health.

Whilst we know that production of HFCS in the EU is lower than the US, there is no recent or detailed data about HFCS use or consumption in European countries. Earlier studies have highlighted variation in the production and use of HFCS among MSs as a result of factors such as price, consumer acceptance and policy changes. Thus, there is no firm evidence on which to base projections of how EU markets may respond to an increased supply of HFCS following the abolition of the EU sugar quota in 2017.

Studies so far have mostly been carried out in the US, where use and consumption of HFCS is substantially higher than in Europe – but poorly recorded. Though there is some limited research into the negative health impacts associated with HFCS consumption (i.e. on CVD mortality, obesity and diabetes), this is inconclusive and difficult to generalise. This has an implication for monitoring the use and consumption of HFCS; if it is not possible to accurately identify or record the use of HFCS in food and beverage production, it is not possible to keep track of how this is changing.

Positively, the EU RFIC regulation 1169/2011 has made it possible to inform the consumer whether fructose-glucose/glucose-fructose syrups or sucrose are used. In turn, this makes providers a better opportunity to monitor which ingredients contribute to the sugars in a food product, and to overcome the many difficulties of measuring consumption of HFCS (e.g. changing formulations of food and beverages or the use of other sugars in combination).

Annex 1 Peer reviewed literature bibliography

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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 deviation above the WHO	WHO http://www.who.int/mediacentre/factsheets/fs311/en/ (Other definitions are available for different national and international systems).

Term	Definition	Source
	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 characterized by an	Tremblay, M. S., et al. (2017). Sedentary

Term	Definition	Source
	energy expenditure ≤1.5 metabolic equivalents (METs) while in a sitting or reclining posture.	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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