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Potential intakes of total polyols based on UK usage survey data

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Polyols are approved for use as sweeteners in specific foods but they may be used for other technological purposes in a wider range of foods, all on a *quantum satis* basis. The European Polyols Association (EPA) has identified 24 categories of food where polyols are used and it has been able to establish the levels at which the polyols are used in each type of food and whether for sweetening or non-sweetening purposes. The UK National Dietary and Nutrition survey database was used to estimate potential exposures to total polyols based on reported use levels. It was possible to express potential polyol intake on the basis of exposure relating to a single eating occasion, a meal period, 1 day and the average over 4 days of the survey. Potential intakes of polyols were approximately twice that found on a per-item or a meal-period basis when estimated on a daily basis. Apparent intakes were lower when averaged over the 4 days of the survey. It was felt that intake expressed on a per-meal occasion basis was most relevant to the development of digestive discomfort. On the basis of maximum use levels of polyols in all food categories, adults had the highest intake of total polyols up to 5.6 g per meal period at the 95th percentile. However, when expressed on a bodyweight basis, children had higher intakes, up to 0.15 g kg^{-1} bw per meal period. Distributions of potential polyol exposures were highly skewed towards lower values with higher levels of exposure relating to sweetener uses occurring relatively infrequently.

Keywords: polyols; exposure; intake; sweeteners; sorbitol (E 420); mannitol (E 421); isomalt (E 953); maltitol (E 965); lactitol (E 966); xylitol (E 967)

Introduction

Polyols are carbohydrates regulated in the European Union as food additives with a long history of use all over the world for more than 30 years. They are chemically considered polyhydric alcohols and are derived from carbohydrates, mainly from corn, wheat and sugar beet. The most commonly used polyols are sorbitol (E 420), mannitol (E 421), isomalt (E 953), maltitol (E 965), lactitol (E 966), xylitol (E 967) and erythritol (E 968). Their safety has been assessed at international level by JECFA (World Health Organisation 1982, 1983a, 1983b, 1986, 1987, 1993, 1999, 2000) and by the Scientific Committee on Food (SCF) (European Commission 1985, 1989, 2003) and they have been assigned an ADI of "not specified". Polyols are used for their sweetening properties and/or to fulfil other technological functions, including acting as bulking agents, emulsifiers, stabilisers, humectants, thickeners, texturisers, glazing agents or anti-caking agents. They are commonly used for "bulk" sweetening because, unlike intense sweeteners, they replace sugar at a 1:1 ratio whilst having a lower gram-for-gram caloric value than sugar. They provide alternatives to sugars and their benefits have been established for improved dental health, improved glycaemic control (EFSA 2011b) and calorie reduction since their caloric value is less than the caloric value of fully available carbohydrates (Regulation (EU) No 1169/2011).

The food uses of polyols are regulated in the European Union by Regulation (EC) 1333/2008 on food additives, which provides in Annex II A (EU Commission 2011) a single comprehensive list of food categories according to a new food categorisation system, with permitted food additives listed for each food category. Polyols are authorised in a range of foods at *quantum satis* level for both sweetening and non-sweetening purposes. The study aims at estimating the potential intake of total polyols based on their actual usage levels in foods.

The European Association of Polyol Producers (EPA) has identified 24 categories of food (of which eight are types of confectionery) and established actual use levels for polyols in each type of food and whether they are for sweetening or for non-sweetening purposes. This information has been collated and made available to estimate potential exposures of consumers to polyols from their approved uses in food.

The methods used to estimate exposures to polyols are intended to be consistent with the EFSA approach for food additives described in the Guidance for Submission for Food Additive Evaluations of the European Food Safety Authority (EFSA) Panel on Food Additives and Nutrient

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Sources Added to Food (ANS) (EFSA 2012a). However, the EFSA Food Additive Intake Method (FAIM) is designed to estimate chronic exposure to food additives covering periods of 2 days or more (EFSA 2012b), whereas for polyols, shorter exposure periods are more relevant to the effect of concern – digestive discomfort. For example, in an opinion on erythritol in 2010, the ANS Panel considered acute intake from diet soft drinks drinking occasions within a maximum duration of 15 min when reaching its conclusion (EFSA 2010). In an opinion on polyglycitol syrup the panel considered only chronic intakes averaged over 7 days (EFSA 2009).

In this paper the effect of using different exposure periods for the assessment of potential exposures to total polyols is considered. Exposure estimates based on identical total polyol usage data are presented for exposure periods ranging from an acute event (a single eating occasion) to the chronic or "usual" intake (the average over 4 days). Single eating occasions generally relate to consumption of one food type. However, as the exposure period is extended, other food types may be included. The study aims to identify the critical exposure period and to then consider other sources of variation such as the age of consumer and the effect of considering typical in place of maximum usage levels.

Materials and methods

Polyol usage data

UK market survey data for new product launches in the period 2002–06 were used to identify products in which polyols were identified on the labels. This period was chosen because there was significant growth in the polyols market during this time and the survey was expected capture the majority of applications. A total of 594 products falling into 19 application categories were identified and these were subdivided into sweetener and non-sweetener uses. For several food categories polyols could have either sweetening or non-sweetening uses.

The EPA has consulted industry experts on technologically relevant use levels for polyols in each of the categories identified in the usage survey (Table 1). Data were originally reported for all authorised polyols (isomalt, lactitol, maltitol, mannitol, sorbitol, xylitol and erythritol). Certain foods could contain different polyols and some could contain more than one and so a typical and highest value for total polyol concentration was identified for each food category. Because use levels for sweetener applications are higher than for miscellaneous uses, these were separated in Table 1.

Table 1. Polyol use levels as a sweetener or a miscellaneous additive in the UK.

	Use level (%)	
Use category	Typical	Maximum
Sweeteners		
Milk and milk-derivative-based preparations, energy-reduced or with no added sugar	5	5
Edible ices, energy-reduced or with no added sugar	5	10
Jellies, marshmallows with no added sugar	65	80
Hard candy with no added sugar	95	98
Gums with no added sugar	65	80
Chewy candy with no added sugar	65	80
Tablets with no added sugar	97	99
Cocoa-based products, energy-reduced or with no added sugar	35	45
Chewing gum with no added sugar	65	75
Cereal and energy bars	20	30
Sweet biscuits/cookies	15	35
Miscellaneous additives		
Milk and milk-derivative-based preparations	1	2.5
Fruit- and vegetable-based desserts	0.3	2
Edible ices	1	2
Jellies, marshmallows	2	10
Gums	2	10
Chewy candy	1	2
Cocoa-based products	2	4
Dessert sauces	5	5
Savoury sauces/dressings	3	3
Cakes – pastries and sweet goods	1.5	3
Cereal and energy bars	1.5	5
Savoury biscuits/crackers	2	2
Sweet biscuits/cookies	1	2
Snacks	1	5
Meat/fish-based products	1.5	8
Composite and miscellaneous foods	1	2.5
Spirits and liqueurs	2	4

Food consumption data

The UK National Diet and Nutrition Survey (NDNS) data collected in the years 2008–09 were selected for this study because they are relatively recent and therefore more likely to include food categories relevant to current polyol usage (NDNS 2012). The data are particularly suited to this type of assessment because they are available in their individual form so that the detailed food consumption records for each individual in the survey and his/her age and bodyweight are provided. The food consumption data cover individuals aged from 1 to over 65 years and for each participant the database holds data on age, sex, bodyweight and a food consumption diary gathered over 4 days. The UK 2008/9 data are provided for more than 2000 individuals aged between 1 and 91 years. Of these, 99% consumed a food that might contain polyols. For certain food categories the number of consumption events recorded is very small and there are not sufficient consumers to make reliable estimates of upper percentile exposures. However, there are sufficient data to estimate reliable overall upper percentile exposures for all foods

Table 2. Mealtime intervals reported in NDNS 2008–9 food consumption survey.

Meal period	Duration (hours)
6 am to 8:59 am	3
9 am to 11:59 am	3
12 noon to 1:59 pm	2
2 pm to 4:59 pm	3
5 pm to 7:59 pm	3
8 pm to 9:59 pm	2
10 pm to 5:59 am	8

combined. The EFSA Guidelines for the European Union comprehensive food consumption database have examined the reliability of upper percentile estimates and recommended that percentiles calculated over a number of subjects/days lower than 60 (for the 95th percentile) and lower than 300 (for the 99th percentile) may not be statistically robust and should be interpreted with caution (EFSA 2011a). Such values have been italicised in all result tables.

The NDNS food consumption diary records data for each eating occasion over the 4 days including survey day, meal period, time of consumption, food description and the amount consumed. The description of "meal period" is unique to this survey and is divided over seven intervals (Table 2).

Data analysis

All the foods in the NDNS database were categorised according to use categories identified for polyols in Table 1, where relevant. This represents a conservative approach because it assumes that all foods in categories where polyols may be used actually contain polyols whereas many foods will contain other sweeteners or miscellaneous agents or may contain no additives at all.

The amount of each food item consumed at each eating occasion was then multiplied by the maximum concentration of polyols provided in Table 1 to estimate the maximum polyol intake for each food item. The total polyol intake associated with each food item was divided by each individual's bodyweight to derive their intake for each food item on a bodyweight basis. Intake statistics (mean, median, 90th and 95th percentiles) were then calculated from the distribution of all values from all individuals. Each individual's intake was then recalculated over either a meal period (Table 2), 1 day or averaged over 4 days. Intakes are expressed on the basis of consumers only. This means that individuals who did not consume foods containing polyols were excluded from the calculations. Because of the small number of food descriptions corresponding to "Hard candy with no added sugar" and "Tablets with no added sugar", these two categories were combined.

Results

Polyol intakes per eating occasion (food item)

Eating occasion exposure estimates correspond to the consumption of individual food items and do not include other items eaten at the same time. Intakes can be expressed as g per serving or g kg^{-1} bodyweight per serving. There were a total of 14,093 occasions when a potentially polyol-containing food was consumed during the survey. Average total polyol intakes per eating occasion from all sources combined were 1.5 g (0.04 g kg^{-1} bw) and rose to 4.8 g (0.13 g kg^{-1} bw) at the 95th percentile.

It was possible to break down intakes per eating occasion on the basis of food category (Table 3). The foods most frequently associated with polyol intake were "Sweet biscuits/cookies", "Milk-and milk-derivative-based preparations" (desserts) and "Cocoa-based products" (confectionery). However, the highest intakes were associated with some less frequently consumed products containing polyols such as certain confectionery products, fish/meat product and miscellaneous foods. The relatively low frequency of consumption of these foods meant they did not have a significant effect on total intakes from all sources.

Polyol intakes per meal period

Intakes calculated per meal period (Table 2) include all polyol-containing foods consumed within each specified time period. The number of meal periods where polyol-containing foods were consumed was 11 548, suggesting that each meal period included on average 1.22 food items that could contain polyols. Average total polyols intakes per meal period from all sources combined were 1.9 g (0.05 g kg^{-1} bw) and rose to 5.6 g (0.15 g kg^{-1} bw) at the 95th percentile, reflecting the consumption of more than one polyol-containing food in some meal periods (Table 4).

When total polyol intake was divided between the seven meal periods, consumption of polyol-containing foods occurred most frequently during daytime hours and in particular between 12.00 noon and 8.00 p.m. (Table 5). However, intakes of polyols within each meal period for those who consumed were more consistent between periods. Again the consumption of foods associated with higher intakes was relatively infrequent and so they did not have a significant effect on total intakes from all sources.

Polyol intakes per day

Intakes calculated per day include all polyol-containing food consumed within 1 survey day. Different recording days for each individual are treated as if they were from different individuals and the total number of survey days on which subjects consumed any polyol-containing foods

Table 3. Intakes of total polyols associated with individual eating occasions.

Food category	*N*	%	Total polyol intake (g per item)				Total polyol intake (g kg^{-1} bw per item)			
			Average	Median	90th %ile	95th %ile	Average	Median	90th %ile	95th %ile
Milk and milk-derivative-based preps	2473	17.5	2.5	2.4	4.5	5.0	0.07	0.05	0.15	0.21
Edible ices	820	5.8	1.6	1.2	2.4	3.6	0.04	0.03	0.09	0.10
Jellies, marshmallows and gums	145	1.0	3.6	2.1	9.7	10.2	0.10	0.06	0.25	0.34
Chewy candy	154	1.1	0.6	0.4	1.2	1.7	0.02	0.01	0.04	0.06
Tablets and hard candy	11	0.1	6.0	3.0	*11.9*	*11.9*	0.15	0.07	*0.18*	*0.46*
Cocoa-based products	2195	15.6	1.7	1.1	2.7	5.0	0.04	0.02	0.07	0.10
Chewing gum	82	0.6	2.2	1.5	*3.0*	*3.0*	0.05	0.03	*0.08*	*0.11*
Cereal and energy bars	124	0.9	1.6	1.6	1.9	*1.9*	0.04	0.03	0.07	*0.10*
Sweet biscuits/cookies	2997	21.3	0.6	0.4	1.0	1.3	0.01	0.01	0.03	0.04
Fruit- and vegetable-based desserts	3	0.0	2.1	1.8	*3.2*	*3.4*	0.05	0.06	*0.06*	*0.06*
Dessert sauces	49	0.3	0.9	0.8	*1.0*	*1.3*	0.03	0.02	*0.04*	*0.06*
Savoury sauces/dressings	1717	12.2	0.6	0.5	1.0	1.8	0.01	0.01	0.02	0.04
Cakes – pastries and sweet goods	1477	10.5	1.8	1.7	3.0	3.6	0.04	0.03	0.08	0.11
Savoury biscuits/crackers	298	2.1	0.5	0.4	0.8	*0.8*	0.01	0.01	0.02	*0.03*
Snacks	746	5.3	1.3	1.3	2.0	2.5	0.03	0.03	0.06	0.08
Meat/fish-based products	31	0.2	5.3	5.3	*8.2*	*10.2*	0.10	0.08	*0.19*	*0.25*
Composite, miscellaneous foods	261	1.9	6.9	7.0	10.5	11.4	0.15	0.13	0.28	0.36
Spirits and liqueurs	510	3.6	2.2	1.8	4.0	5.5	0.03	0.02	0.06	0.08
All the above foods	14,093	100.0	1.5	1.0	3.4	4.8	0.04	0.02	0.09	0.13

Notes: *N*, number of eating occasions for individual food items.
Figures in italics = insufficient consumers to provide a reliable estimate of percentiles.

Table 4. Intakes of total polyols associated with mealtimes.

Food category	*N*	%	Total polyol intake (g per period)				Total polyol intake (g kg^{-1} bw per period)			
			Average	Median	90th %ile	95th %ile	Average	Median	90th %ile	95th %ile
Milk and milk-derivative-based preps	2414	20.9	2.5	2.5	4.8	5.0	0.07	0.05	0.16	0.21
Edible ices	810	7.0	1.6	1.2	2.4	3.6	0.05	0.03	0.09	0.11
Jellies, marshmallows and gums	142	1.2	3.7	2.3	9.7	10.2	0.10	0.07	0.26	0.34
Chewy candy	148	1.3	0.6	0.4	1.2	1.8	0.02	0.01	0.04	0.06
Tablets and hard candy	11	0.1	6.0	3.0	*11.9*	*11.9*	0.15	0.07	*0.18*	*0.46*
Cocoa-based products	2090	18.1	1.7	1.2	2.8	6.0	0.04	0.03	0.08	0.10
Chewing gum	82	0.7	2.2	1.5	*3.0*	*3.0*	0.05	0.03	*0.08*	*0.11*
Cereal and energy bars	123	1.1	1.6	1.6	1.9	*1.9*	0.04	0.03	0.07	*0.11*
Sweet biscuits/cookies	2836	24.6	0.6	0.5	1.0	1.3	0.01	0.01	0.03	0.04
Fruit- and vegetable-based desserts	3	0.0	2.1	1.8	*3.2*	*3.4*	0.05	0.06	*0.06*	*0.06*
Dessert sauces	49	0.4	0.9	0.8	*1.0*	*1.3*	0.03	0.02	*0.04*	*0.06*
Savoury sauces/dressings	1655	14.3	0.6	0.5	1.1	1.8	0.01	0.01	0.03	0.04
Cakes – pastries and sweet goods	1439	12.5	1.9	1.7	3.2	3.9	0.04	0.03	0.09	0.11
Savoury biscuits/crackers	296	2.6	0.5	0.4	0.8	*1.0*	0.01	0.01	0.02	*0.03*
Snacks	735	6.4	1.4	1.3	2.0	2.5	0.03	0.03	0.07	0.08
Meat/fish-based products	31	0.3	5.3	5.3	*8.2*	*10.2*	0.10	0.08	*0.19*	*0.25*
Composite, miscellaneous foods	261	2.3	6.9	7.0	10.5	*11.4*	0.15	0.13	0.28	*0.36*
Spirits and liqueurs	402	3.5	2.8	1.8	5.5	7.4	0.04	0.02	0.08	0.10
All the above foods	11,548	100.0	1.9	1.3	4.0	5.6	0.05	0.03	0.11	0.15

Notes: *N*, number of eating periods where food consumed.
Figures in italics = insufficient consumers to provide a reliable estimate of percentiles.

Table 5. Intakes of total polyols categorised by mealtimes.

			Total polyol intake (g per period)				Total polyol intake (g kg^{-1} bw per period)			
Time period	*N*	%	Average	Median	90th %ile	95th %ile	Average	Median	90th %ile	95th %ile
6 am to 8:59 am	658	6	1.9	1.5	4.3	5.0	0.05	0.03	0.11	0.15
9 am to 11:59 am	1546	13	1.6	1.0	3.6	4.8	0.04	0.02	0.09	0.13
12 noon to 1:59 pm	2482	21	1.8	1.2	3.9	5.2	0.05	0.03	0.11	0.16
2 pm to 4:59 pm	2273	20	1.7	1.2	3.6	5.0	0.04	0.03	0.10	0.14
5pm to 7:59 pm	2563	22	2.2	1.5	4.8	6.8	0.06	0.03	0.14	0.20
8 pm to 9:59 pm	1479	13	1.9	1.2	4.0	6.0	0.04	0.02	0.08	0.12
10 pm to 5:59 am	547	5	2.2	1.2	5.3	7.6	0.03	0.02	0.07	0.10
All periods	11,548	100	1.9	1.3	4.0	5.6	0.05	0.03	0.11	0.15

Note: *N*, number of eating periods where food consumed.

was 6202 days. This suggests that each day included on average 2.27 food items that could contain polyols. Average total polyols intakes per day were 3.5 g (0.09 g kg^{-1} bw) and rose to 10.4 g (0.27 g kg^{-1} bw) at the 95th percentile, reflecting the consumption of more than one polyol-containing food during most days (Table 6). Once again, the consumption of foods associated with higher intakes did not have a significant effect on total intakes from all sources.

Polyol intakes over 4 days (expressed as an average daily amount)

Intakes calculated over 4 days include all polyol-containing foods consumed during the period of the survey divided by the number of days of the survey. The number of subjects who reported consumption during the survey was 1933, indicating that not all subjects consumed polyol-containing foods on every day. Average total polyols intakes per day average over the survey were 2.7 g (0.07 g kg^{-1} bw) and rose to 7.2 g (0.20 g kg^{-1} bw) at the 95th percentile, reflecting the tendency for some individuals to not consume polyol-containing foods every day (Table 7).

Discussion

The foods most frequently associated with polyol intake in all exposure scenarios were "Sweet biscuits/cookies", "Milk- and milk-derivative-based preparations" (desserts) and "Cocoa-based products" (confectionery). However, the highest intakes were associated with some less frequently consumed products containing polyols such as certain confectionery products, fish/meat product and miscellaneous foods. The consumption of these foods was relatively infrequent and so they did not have a significant effect on total intakes from all sources at the average or 95th percentile.

Consumption statistics for the four different exposure periods can be compared to identify trends (Table 8). Intake estimates are lowest when assessed on a per-item level since each food item consumed is considered separately. Intakes appear to increase when meal periods are considered because foods eaten concurrently are taken into account. However, the increase is only marginal suggesting that concurrent consumption of polyol-containing food is relatively infrequent. Typically each meal period includes only 1.2 polyol-containing food items. When intakes are estimated on a daily basis they are approximately twice that found on a per-item or meal-period basis. This is because total daily consumption is summed whether consumption is concurrent or not. Apparent intakes fall again when they are averaged over the 4 days of the survey, reflecting the fact that not all individuals consume polyol-containing food every day. For the effect of concern, digestive discomfort, intake estimates based on a meal period (2–3 h) probably provide the best estimate of relevant exposure since they are long enough to include a certain amount of concurrent exposure from different foods that might contain polyols but not so long as to include exposure episodes that are too far apart in time to be considered additive or clinically relevant to the endpoint. More detailed data analyses have therefore been based on this exposure scenario.

Estimates of total polyol exposure based on meal periods were investigated for differences between different age bands. The food consumption data were subdivided by principal age bands employed in the EFSA Comprehensive Food Consumption Database: 1–2, 3–9, 10–17 and 18+ years (there were no data on children less than 1 year; and the elderly were grouped with adults). When expressed on a g per meal-period basis children had lower intakes of polyols than adolescents and adults (Table 9). However, after bodyweight correction, children tended to have higher intakes because of their higher energy demands in relation to bodyweight. In reality children may not be exposed to such intake levels because many foods that contain polyols, particularly for sweetening purposes, are weight-loss or calorie-reduced products that are normally aimed at adult consumers. Children are more likely to be offered the regular variants of such foods.

Table 6. Intakes of total polyols associated with 1 day.

Food category	*N*	%	Total polyol intake (g day^{-1})				Total polyol intake (g kg^{-1} bw day^{-1})			
			Average	Median	90th %ile	95th %ile	Average	Median	90th %ile	95th %ile
Milk and milk-derivative-based preps	1996	32.2	3.1	2.9	5.6	7.5	0.09	0.06	0.19	0.26
Edible ices	791	12.8	1.7	1.3	2.4	3.6	0.05	0.03	0.09	0.11
Jellies, marshmallows and gums	139	2.2	3.8	2.4	9.6	11.0	0.11	0.07	0.26	0.40
Chewy candy	136	2.2	0.6	0.4	1.4	2.1	0.02	0.01	0.04	0.06
Tablets and hard candy	11	0.2	6.0	3.0	*11.9*	*11.9*	0.15	0.07	*0.18*	*0.46*
Cocoa-based products	1810	29.2	2.0	1.4	3.6	7.1	0.04	0.03	0.09	0.13
Chewing gum	64	1.0	2.8	1.6	*4.5*	*8.8*	0.06	0.04	*0.11*	*0.15*
Cereal and energy bars	117	1.9	1.7	1.6	1.9	*2.6*	0.04	0.03	0.09	*0.12*
Sweet biscuits/cookies	2312	37.3	0.7	0.5	1.3	1.8	0.02	0.01	0.04	0.05
Fruit- and vegetable-based desserts	3	0.0	2.1	1.8	*3.2*	*3.4*	0.05	0.06	*0.06*	*0.06*
Dessert sauces	49	0.8	0.9	0.8	*1.0*	*1.3*	0.03	0.02	*0.04*	*0.06*
Savoury sauces/dressings	1522	24.5	0.7	0.5	1.4	2.0	0.01	0.01	0.03	0.04
Cakes – pastries and sweet goods	1278	20.6	2.1	1.8	3.8	4.7	0.05	0.04	0.10	0.13
Savoury biscuits/crackers	277	4.5	0.5	0.5	0.8	*1.0*	0.01	0.01	0.02	*0.03*
Snacks	687	11.1	1.4	1.3	2.5	3.0	0.04	0.03	0.07	0.08
Meat/fish-based products	31	0.5	5.3	5.3	*8.2*	*10.2*	0.10	0.08	*0.19*	*0.25*
Composite, miscellaneous foods	258	4.2	6.9	7.0	10.5	*12.5*	0.16	0.13	0.29	*0.39*
Spirits and liqueurs	304	4.9	3.7	2.8	7.4	10.9	0.05	0.03	0.10	0.16
All the above foods	6202	100.0	3.5	2.5	7.6	10.4	0.09	0.05	0.20	0.27

Notes: *N*, number of days on which food consumed.
Figures in italics = insufficient consumers to provide a reliable estimate of percentiles.

Table 7. Intakes of total polyols averaged over 4 days.

Food category	*N*	%	Total polyol intake (g day^{-1})				Total polyol intake (g kg^{-1} bw day^{-1})			
			Average	Median	90th %ile	95th %ile	Average	Median	90th %ile	95th %ile
Milk and milk-derivative-based preps	997	51.6	1.5	1.1	3.1	4.0	0.04	0.02	0.10	0.14
Edible ices	557	28.8	0.6	0.5	1.1	1.4	0.02	0.01	0.03	0.04
Jellies, marshmallows and gums	114	5.9	1.2	0.8	2.6	3.3	0.03	0.02	0.09	0.11
Chewy candy	117	6.1	0.2	0.1	0.4	0.6	0.01	0.00	0.01	0.02
Tablets and hard candy	11	0.6	1.7	0.7	*3.3*	*4.6*	0.04	0.02	*0.10*	*0.14*
Cocoa-based products	1011	52.3	0.9	0.5	1.8	2.5	0.02	0.01	0.04	0.05
Chewing gum	45	2.3	1.0	0.6	*2.2*	*3.5*	0.02	0.01	*0.05*	*0.06*
Cereal and energy bars	74	3.8	0.7	0.6	1.1	*1.3*	0.02	0.01	0.03	*0.04*
Sweet biscuits/cookies	1177	60.9	0.4	0.3	0.7	0.9	0.01	0.01	0.02	0.03
Fruit- and vegetable-based desserts	4	0.2	0.5	0.4	*0.8*	*0.9*	0.01	0.01	*0.01*	*0.01*
Dessert sauces	47	2.4	0.2	0.2	*0.4*	*0.4*	0.01	0.00	*0.01*	*0.02*
Savoury sauces/dressings	960	49.7	0.3	0.2	0.6	0.7	0.01	0.00	0.01	0.02
Cakes – pastries and sweet goods	838	43.4	0.8	0.6	1.6	2.0	0.02	0.01	0.04	0.05
Savoury biscuits/crackers	187	9.7	0.2	0.1	0.4	*0.5*	0.00	0.00	0.01	*0.01*
Snacks	450	23.3	0.6	0.4	1.1	1.3	0.01	0.01	0.03	0.04
Meat/fish-based products	27	1.4	1.6	1.3	*2.4*	*2.9*	0.03	0.02	*0.07*	*0.09*
Composite, miscellaneous foods	220	11.4	2.0	1.9	3.8	*5.0*	0.05	0.04	0.08	*0.10*
Spirits and liqueurs	175	9.1	1.6	1.0	3.2	4.5	0.02	0.01	0.04	0.06
All the above foods	1933	100.0	2.8	2.3	5.7	7.2	0.07	0.04	0.16	0.20

Notes: *N*, number of days on which food consumed.
Figures in italics = insufficient consumers to provide a reliable estimate of percentiles.

Table 8. Comparison of intake statistics from varying exposure periods.

	N	Average	Median	90th %ile	95th %ile		Average	Median	90th %ile	95th %ile	
Food item	14,093	1.5	1	3.4	4.8	g per item	0.04	0.02	0.09	0.13	g kg^{-1} bw per item
Meal period	11,548	1.89	1.25	4.02	5.63	g per period	0.05	0.03	0.11	0.15	g kg^{-1} bw per period
One day	6202	3.5	2.5	7.6	10.4	g day^{-1}	0.09	0.05	0.2	0.27	g kg^{-1} bw day^{-1}
Four-day average	1933	2.82	2.28	5.67	7.18	g day^{-1}	0.07	0.04	0.16	0.2	g kg^{-1} bw day^{-1}

Table 9. Intakes of total polyols associated with mealtimes broken out by age (g per period).

		Total polyol intake (g day^{-1})				Total polyol intake (g kg^{-1} bw day^{-1})			
Age band	*N*	Average	Median	90th %ile	95th %ile	Average	Median	90th %ile	95th %ile
1–2	705	1.3	1.0	3.0	3.6	0.10	0.08	0.22	0.28
3–9	2881	1.6	1.2	3.6	4.7	0.07	0.05	0.16	0.22
10–17	2552	2.2	1.5	4.9	7.1	0.04	0.03	0.09	0.13
18+	5410	2.0	1.2	4.4	6.0	0.03	0.02	0.06	0.08
All ages	11,548	1.9	1.3	4.0	5.6	0.05	0.03	0.11	0.15

Note: *N*, number of eating periods where food consumed.

Use applications for polyols as sweeteners are restricted by food additive regulations to specific categories of foods whereas use in non-sweetening miscellaneous applications is less restricted. However, use levels required for sweetening purposes can be expected to be higher than those required for humectant or other non-sweetening applications. As a consequence some differences in patterns of exposure might be expected. Total polyol exposures have been assessed after separating sweetener from non-sweetener (miscellaneous) applications (Table 10). For sweetener applications the number of meal periods where consumption occurred was 226, or representing 1.9% of all eating meal periods where polyols were consumed. Average total polyols intakes associated with sweetener applications were 5.9 g (0.11 mg kg^{-1} bw) and rose to 11.8 g (0.26 g kg^{-1} bw) at the 95th percentile. In contrast, the majority of meal periods where there was polyol exposure were relate to non-sweetener applications where average total polyols intakes per day were 1.8 g (0.04 g kg^{-1} bw) and rose to 5.0 g (0.15 g kg^{-1} bw) at the 95th percentile.

The EPA survey of polyol applications identified typical use levels in addition to the maximum use levels applied so far in this assessment (Table 1). If typical use levels are substituted for maximum use levels in the assessment, then estimates of exposure can be revised to take normal use into consideration. When using typical polyol levels average total polyol intakes per meal period were reduced to 0.9 g (0.02 g kg^{-1} bw) and rose to 2.6 g (0.07 g kg^{-1} bw) at the 95th percentile (Table 11). Since actual polyol use levels can lie anywhere between the typical and maximum use levels, real exposures will lie between these two sets of values. However, the probability that a consumer is exposed to any of these levels is lower than indicated by these estimates because not all foods that could contain polyols actually do so. Other sweeteners and other additives are available that provide the non-sweetener applications provided by polyols. Polyol exposure estimates presented in this paper are likely to be very conservative because maximum or typical use levels have been used throughout. However, in the real market only a proportion of the foods that could contain polyols actually do so because other food additives are available and some foods will contain no additives at all. This means that the possibility that an individual might be exposed to polyols is considerably lower, so that estimates of exposure at 90th and 95th percentiles would be correspondingly reduced.

The polyol-use levels and food consumption data used in these assessments relate to patterns of usage and consumption current in the UK. Other countries may have different patterns of usage, particularly for non-sweetener applications. The results cannot be directly extrapolated to other European countries although it is expected that they will be of a similar order of magnitude.

Conclusions

Estimates of exposure to polyols are dependent on the scenario adopted for exposure modelling. It is possible to base estimates of exposure on periods ranging from a single eating occasion to the averaged cumulative

Table 10. Intakes of total polyols associated with mealtimes subdivided by sweetener and non-sweetener application.

Food category	*N*	%	Total polyol intake (g per period)				Total polyol intake (g kg^{-1} bw per period)			
			Average	Median	90th %ile	95th %ile	Average	Median	90th %ile	95th %ile
Sweetener applications										
Milk and milk-derivative-based preps	7	0.1	8.1	10.6	*10.6*	*10.6*	0.13	0.15	*0.17*	*0.17*
Edible ices	13	0.1	7.8	6.0	*12.0*	*14.4*	0.19	0.15	*0.24*	*0.45*
Tablets and hard candy	11	0.1	6.0	3.0	*11.9*	*11.9*	0.15	0.07	*0.18*	*0.46*
Cocoa-based products	107	0.9	8.0	8.1	10.4	10.8	0.13	0.12	0.21	0.29
Chewing gum	82	0.7	2.2	1.5	3.0	3.0	0.05	0.03	0.08	0.11
Sweet biscuits/cookies	6	0.1	12.3	10.5	*15.8*	*18.4*	0.25	0.24	*0.36*	*0.41*
Total sweetener	226	1.9	5.9	6.0	10.5	11.8	0.11	0.09	0.21	0.26
Miscellaneous applications										
Milk and milk-derivative-based preps	2407	20.7	2.5	2.5	4.8	5.0	0.07	0.05	0.16	0.21
Edible ices	797	6.9	1.5	1.2	2.4	3.5	0.04	0.03	0.08	0.10
Jellies, marshmallows and gums	142	1.2	3.7	2.3	9.7	10.2	0.10	0.07	0.26	0.34
Chewy candy	148	1.3	0.6	0.4	1.2	1.8	0.02	0.01	0.04	0.06
Cocoa-based products	1987	17.1	1.4	1.1	2.3	2.9	0.03	0.02	0.07	0.08
Cereal and energy bars	123	1.1	1.6	1.6	1.9	1.9	0.04	0.03	0.07	0.11
Sweet biscuits/cookies	2830	24.4	0.6	0.5	1.0	1.3	0.01	0.01	0.03	0.04
Fruit- and vegetable-based desserts	3	0.0	2.1	1.8	*3.2*	*3.4*	0.05	0.06	*0.06*	*0.06*
Dessert sauces	49	0.4	0.9	0.8	*1.0*	*1.3*	0.03	0.02	*0.04*	*0.06*
Savoury sauces/dressings	1655	14.3	0.6	0.5	1.1	1.8	0.01	0.01	0.03	0.04
Cakes – pastries and sweet goods	1439	12.4	1.9	1.7	3.2	3.9	0.04	0.03	0.09	0.11
Savoury biscuits/crackers	296	2.6	0.5	0.4	0.8	1.0	0.01	0.01	0.02	0.03
Snacks	735	6.3	1.4	1.3	2.0	2.5	0.03	0.03	0.07	0.08
Meat/fish-based products	31	0.3	5.3	5.3	*8.2*	*10.2*	0.10	0.08	*0.19*	*0.25*
Composite, miscellaneous foods	261	2.2	6.9	7.0	10.5	11.4	0.15	0.13	0.28	0.36
Spirits and liqueurs	402	3.5	2.8	1.8	5.5	7.4	0.04	0.02	0.08	0.10
Total miscellaneous	11,381	98.1	1.8	1.2	3.8	5.0	0.04	0.03	0.10	0.15

Notes: *N*, number of periods on which food consumed.
Figures in italics = insufficient consumers to provide a reliable estimate of percentiles.

Table 11. Intakes of total polyols associated with mealtimes using typical use levels.

Food category	*N*	%	Total polyol intake (g per period)				Total polyol intake (g kg^{-1} bw per period)			
			Average	Median	90th %ile	95th %ile	Average	Median	90th %ile	95th %ile
Milk and milk-derivative-based preps	2414	20.9	1.0	1.0	1.9	2.0	0.03	0.02	0.06	0.09
Edible ices	810	7.0	0.8	0.6	1.2	1.8	0.02	0.02	0.04	0.05
Jellies, marshmallows and gums	142	1.2	0.7	0.5	1.9	2.0	0.02	0.01	0.05	0.07
Chewy candy	148	1.3	0.3	0.2	0.6	0.9	0.01	0.01	0.02	0.03
Tablets and hard candy	11	0.1	5.9	2.9	*11.6*	*11.6*	0.15	0.07	*0.18*	*0.45*
Cocoa-based products	2090	18.1	1.0	0.6	1.4	3.9	0.02	0.01	0.04	0.07
Chewing gum	82	0.7	1.9	1.3	*2.6*	*2.6*	0.04	0.03	*0.07*	*0.09*
Cereal and energy bars	123	1.1	0.5	0.5	0.6	*0.6*	0.01	0.01	0.02	*0.03*
Sweet biscuits/cookies	2836	24.6	0.3	0.2	0.5	0.7	0.01	0.00	0.01	0.02
Fruit- and vegetable-based desserts	3	0.0	0.3	0.3	*0.5*	*0.5*	0.01	0.01	*0.01*	*0.01*
Dessert sauces	49	0.4	0.9	0.8	*1.0*	*1.3*	0.03	0.02	*0.04*	*0.06*
Savoury sauces/dressings	1655	14.3	0.6	0.5	1.1	1.8	0.01	0.01	0.03	0.04
Cakes – pastries and sweet goods	1439	12.5	0.9	0.8	1.6	2.0	0.02	0.02	0.04	0.06
Savoury biscuits/crackers	296	2.6	0.5	0.4	0.8	*1.0*	0.01	0.01	0.02	*0.03*
Snacks	735	6.4	0.3	0.3	0.4	0.5	0.01	0.01	0.01	0.02
Meat/fish-based products	31	0.3	1.0	1.0	*1.5*	*1.9*	0.02	0.01	*0.04*	*0.05*
Composite, miscellaneous foods	261	2.3	2.7	2.8	4.2	*4.5*	0.06	0.05	0.11	*0.14*
Spirits and liqueurs	402	3.5	1.4	0.9	2.8	3.7	0.02	0.01	0.04	0.05
All the above foods	11,548	100.0	0.9	0.6	1.9	2.6	0.02	0.01	0.05	0.07

Notes: *N*, number of meal periods on which food consumed.
Figures in italics = insufficient consumers to provide a reliable estimate of percentiles.

consumption over a period of several days. In the case of polyols the effect of concern is digestive discomfort and this is related to the consumption of polyols in the short-term. The amount consumed in any 1 day is of limited relevance if the consumption is evenly spaced across the day so that a large amount is not consumed at any one time. However, consumption of different food items containing polyols can be additive if the time interval between consumption results in a combined effective dose.

The UK NDNS food consumption survey provides a unique opportunity to assess total polyol exposure using different time intervals. Within the survey, foods that are eaten within the same 2–3-h period are grouped together so that it is possible to base an exposure estimate on this scenario as well as per eating occasion or per day. It was proposed that this approach would give the best approximation to real exposures to polyols that are relevant to the effect of concern.

It was found that exposure estimates based on this meal period were higher by a factor of approximately 20% than estimates based on a single eating occasion showing that the method took concurrent consumption into account. However, estimates based on 1 day's total exposure were approximately twice the values observed on a meal-period basis. This indicates that exposure estimates based on a meal-period basis have the potential to provide considerably more realistic representation of the real situation than the alternative scenarios. In the majority of cases polyol intakes from all sources associated with a meal period were less than 5.6 g or 0.15 g kg^{-1} bw. Intakes associated with particular foods may be higher but the probability associated with such events was very low. In many cases the frequency of consumption of such foods was too small to allow reliable estimates of high percentile intakes (EFSA 2011a).

Distributions of potential polyol exposures were highly skewed towards lower values with higher levels of exposure occurring relatively infrequently. The highest probabilities of exposure to polyols were associated with miscellaneous uses of polyols that require lower use levels. Higher potential exposures were associated with less frequently consumed products where polyols were used for sweetening purposes, some of which could be consumed over an extended period of time, although consumption was reported only once. For example a packet of breath-freshening lozenges might be reported on one occasion but was probably consumed over a longer period of time.

The period over which an intake estimate is based can have a significant effect on the results. It is therefore critical to ensure that the time period is relevant to the endpoint of concern. In the case of polyols it is total consumption over a period of a few hours that is of interest and this study has demonstrated that it is possible to produce intake estimates on this basis that avoid overestimation by summing consumption over a period of 1 day or more or underestimating by focussing on a single eating occasion.

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