Assessing the health benefits and risks of consuming plant-based drinks

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1. Background

1.1 Introduction

1.1 ‘Plant-based drinks’ describes the group of beverage products manufactured from plants including legumes, cereals, nuts or seeds, which are widely used as alternatives to animal milks.

1.2 The plant-based drinks market has grown considerably in the UK over recent years. Almond, oat and soya drinks make up most of the market, with oat drinks showing the largest growth and being the most commonly consumed (Medici and others, 2023; Mintel, 2023; Smart Protein, 2021). The variety of plant bases used to produce plant-based drinks has also grown, with ingredients including pea protein, cashew, hazelnut and hemp, as well as more longstanding bases such as coconut and rice. There has also been an increase in the number of products marketed specifically to young children.

1.3 The increasing popularity and consumption of these products is due to a variety of factors (Clegg and others, 2021). These include:

- cultural, environmental and ethical beliefs and values
- perceived health benefits
- personal preference
- being an alternative to cows’ milk for people with cows’ milk protein allergy or those who are lactose intolerant

1.4 The nutrient content of plant-based drinks varies across different plant types and brands (Medici and others, 2023). There are no specific regulations relating to plant-based drinks in the UK over and above existing legislation that all food business operators must comply with if they are selling, manufacturing or importing plant-based drinks in the UK, including providing nutrition information. There is also specific legislation for fortified foods and drinks. Plant-based drinks tend to:

- contain some free sugars (sugars added as an ingredient or present as a result of the manufacturing process)
- vary in the type and amount of micronutrient fortification (some are not fortified; some are only fortified with calcium; others are also fortified with riboflavin, vitamin B12 and/or vitamin D, and increasingly iodine)

1.5 Plant-based drinks in the UK are not allowed to be fortified with any nutrients if they are labelled as ‘organic’. Most plant-based drinks would be classified as ‘ultra-processed’ according to the NOVA classification system (Monteiro and others, 2018) because of the additives they contain.

1.6 Cows’ milk is an important contributor to intakes of calcium and other minerals and vitamins (‘micronutrients’). For children aged 1 to 5 years, it is also a major contributor to energy, protein and saturated fat intake. While it is not an essential component of diets of children aged 1 to 5 years (or other age groups), if it is not consumed, other foods and drinks need to replace the nutrients it provides.

1.7 Both cows’ milk and plant-based drinks may contain chemical contaminants or naturally occurring components. Chemical contaminants can be harmful if they are present at high levels. Chemical contaminants include organic chemicals, heavy metals and mycotoxins. Naturally occurring components include glycosides, isoflavones and naturally occurring oestrogens. Some of these components may have positive or negative health effects.

1.8 The Scientific Advisory Committee on Nutrition (SACN) and the Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) have considered plant-based drinks as part of previous risk assessments, but have not undertaken a joint, integrated benefit-risk assessment on plant-based drinks before.

1.9 In England and Wales, the Nursery Milk Scheme allows childcare settings to reclaim the cost of providing one-third of a pint of milk per day to children in their care. And the Healthy Start scheme provides its recipients with a weekly payment that can be spent on healthy foods, including cows’ milk. The Day Care Foods Scheme in Northern Ireland allows childcare settings to claim reimbursement for one-third of a pint of milk per day provided to children who attend these settings. The legislation governing these schemes covers only cows’ milk and infant formula based on cows’ milk. It does not allow for providing plant-based drinks which people following a vegan diet, and other consumers, may wish to use instead.

1.10 The Scottish Milk and Healthy Snack Scheme which commenced in August 2021 includes provision of an unsweetened ‘calcium-enriched’ (that is, calcium-fortified) non-dairy alternative drink for those children who do not drink cows’ milk due to medical, ethical or religious reasons. While unsweetened calcium-enriched soya drinks are the preferred non-dairy alternative drink, other unsweetened calcium-enriched non-dairy alternative drinks can be provided.

1.11 To inform considerations on the provision of plant-based drinks through these statutory government schemes, and guidance more generally, SACN and COT agreed to undertake an assessment of the nutritional and toxicological issues associated with consumption of almond, oat and soya drinks, with a particular focus on children aged 1 to 5 years (see SACN meeting minutes June 2021 and COT meeting minutes July 2021 (PDF, 488KB)).

1.12 A joint working group was established in December 2021, with an independent chair and members from both SACN and COT. The working group was tasked with carrying out a benefit-risk assessment considering both the nutritional and toxicological aspects associated with the consumption of plant-based drinks by the UK population. The work was supported by a joint SACN and COT secretariat.

1.2 Terms of reference

1.13 The terms of reference for this assessment are:

- to conduct a benefit-risk assessment considering both nutritional and toxicological aspects associated with the consumption of plant-based drinks (almond, oat and soya) by the UK population

- based on this benefit-risk assessment, to provide integrated advice to the UK health departments

1.3 Approach

1.14 The benefit-risk assessment had a specific focus on children aged 1 to 5 years. In this report, 1 to 5 years should be understood to mean 12 months up to their fifth birthday. However, given the increasing availability and consumption of plant-based drinks in the UK by the general population, the assessment was expanded to also cover all adults and children aged 5 years and over. It was recognised that the benefits and risks identified in children aged 1 to 5 years might also be applicable to older children and adults. Conversely, there may also be benefits and risks that are applicable only to specific population groups.

1.15 The benefit-risk assessment was restricted to consideration of the nutritional and toxicological issues associated with the almond, oat and soya drinks, which together were the most popular plant-based drinks in the UK at the time the joint SACN and COT working group commenced its assessment (2021). Other plant-based drink types, such as pea or hemp drinks are not covered. Rice drinks were excluded because:

- existing advice recommends that they should not be consumed by young children aged 5 years and under due to their inorganic arsenic content

- they are not a commonly consumed drink in the UK adult population

1.16 Unless otherwise stated, references to ‘plant-based drinks’ in this report cover only the drink types considered in the joint SACN and COT benefit-risk assessment, that is, almond, oat and soya drinks.

1.17 As the most commonly consumed animal milk, cows’ milk was the main reference scenario against which plant-based drinks consumption was compared in this report. Other animal milks, such as goats’ and sheep milk were not considered. The impact on nutrient intakes of removing cows’ milk from the diet and replacing this with water was also considered. In this situation it was assumed that water meets relevant drinking water legislation: there were no toxicological concerns associated with this substitution and that any impact would be restricted to nutrient intakes.

1.18 Continued breastfeeding is recommended into the second year of life and beyond. However, SACN and COT agreed that breast milk should not be included as a comparator for children aged 1 to 5 years. The reasons for this were:

- to avoid any inadvertent inference that comparisons to breast milk are restricted to nutrition (because breastfeeding and breast milk have many other benefits besides nutrition)

- to avoid implying that it would be appropriate to replace breast milk with a plant-based drink in the second year of life rather than continuing to breastfeed

- that there was unlikely to be good national reference data for breastmilk composition in this age group to allow such assessment, given the low proportion of women in the UK who breastfeed into the second year of life (see SACN subgroup on maternal and child nutrition meeting minutes from February 2021)

1.19 This assessment assumed that cows’ milk was replaced with a plant-based drink. It is recognised that not all individuals who choose not to consume cows’ milk will consume plant-based drinks. It is also recognised that nutrient requirements can be met through a variety of dietary patterns that do and do not contain animal products. Consideration of different dietary patterns and/or consumption scenarios of varying combinations of plant-based drinks and foods was outside the scope of this report.

1.20 The assessment did not cover individuals or groups with specific dietary or nutrient requirements, with the exception of those following a vegan diet (or a diet that is mostly free from animal products). A vegan diet contains no food of animal origin (such as meat, poultry, fish, dairy, eggs or honey). It is based on plants such as vegetables, grains, beans, nuts, seeds and fruits, and can also include other non-animal foods such as yeast and fungi.

1.21 Throughout this report, when considering the nutritional composition of cows' milk and the 3 plant-based drinks, nutrients are listed in the order they appear in the UK Government Dietary Recommendations document (Public Health England, 2016).

1.22 A number of issues were outside the scope of this report, including:

- sustainability and the environment
- cultural practices
- ethical beliefs
- consumer perceptions about the relative health benefits of different drinks
- product costs
- other factors driving consumer choices to consume these products
- individual food additives

1.23 Plant-based drinks may contain a number of food additives which fulfil a technical purpose in the product. All food additives are subject to robust risk assessment by regulatory authorities before they are authorised for use and are subject to re-evaluation if the totality of scientific evidence suggests a safety concern. Food additives are authorised for use in specific food categories and the additive provisions detail the maximum use level along with any specific restrictions. This ensures that safe levels of use are not exceeded.

1.24 Cows' milk and the 3 plant-based drinks considered in this assessment are potentially allergenic for a minority of consumers. Cows' milk protein allergy (CMPA) is a reproducible immune-mediated allergic response to one or more proteins in cows' milk. Although CMPA has a 1% incidence rate in children aged under 2 years, it may be over diagnosed in the UK and elsewhere (Allen, 2025; Mehta and others, 2022). The proteins in goats' and sheep milk are similar to those found in cows' milk and therefore likely to elicit an allergic response in sensitised individuals.

1.25 Consumers may choose plant-based drinks for a variety of reasons, one of which may be confirmed or unconfirmed allergy to cows' milk. However, almond and soya drinks have the potential for allergenicity among a minority of consumers, while consumers who are sensitive to gluten may choose to avoid oat drinks. Soya and tree nuts (such as almonds) are well established food allergens, while low levels of gluten may occur in oats through contamination during harvesting and processing.

1.26 The allergenic potential of cows' milk and almond, oat and soya drinks is an important consideration for consumers of these products, however allergenicity issues were outside the scope of this assessment.

1.27 The evaluation of the evidence was conducted in line with the SACN Framework for the Evaluation of Evidence (SACN, 2023b) and COT Risk analysis framework and Food Standards Agency Good Practice Agreement for Scientific Advisory Committees (PDF, 112KB). The benefit-risk assessment was conducted using the Benefit-Risk Assessment for Foods (BRAFO) methodology (Hoekstra and others, 2012). As stated in the codes of practice for SACN and COT, the committees do not have a remit for risk management (that is, how the recommendations made are translated into policy and advice) which is the responsibility of government. This report was developed using usual SACN process and was signed off by both SACN and COT.

1.28 With the support of the Knowledge and Library Services team at the UK Health Security Agency (UKHSA), a scoping literature search was conducted in November 2021 to identify key scientific papers on plant-based drinks and nutrition-related outcomes. Details of the scoping literature search are provided in Annex 2. Following consideration of the findings from the scoping search, it was agreed that conducting a full literature search was not necessary (see SACN and COT working group minutes from May 2022).

1.29 A call for evidence was published on the SACN website (from 11 March to 10 April 2022) inviting interested parties to highlight relevant research and information on plant-based drinks, in particular on the amounts and bioavailability of micronutrients added to these products, that had not been identified through the literature search. Details on the call for evidence are provided in Annex 3.

1.30 The draft report was made available for peer review from 23 July to 19 September 2024 on the SACN website. Comments received from interested parties were taken into consideration before the report was finalised. Peer review comments and the SACN and COT responses to these are published alongside the draft report.

1.4 Previous assessments of relevance

1.31 Government dietary advice is based on recommendations from SACN and its predecessor the Committee on Medical Aspects of Food and Nutrition Policy (COMA), and from COT.

1.41 SACN

1.32 The assessments undertaken by SACN and COMA that are particularly relevant to this report are:

- SACN statement on the WHO guideline on non-sugar sweeteners in 2025 (SACN, 2025b)
- Statement on processed foods and health in 2023 (SACN, 2023c) and Rapid evidence update in 2025 (SACN, 2025a)
- Feeding young children aged 1 to 5 years in 2023 (SACN, 2023a)
- Nutrition and older adults in 2021 (SACN, 2021)
- Saturated fats and health in 2019 (SACN, 2019)
- Feeding in the first year of life in 2018 (SACN, 2018)
- Vitamin D and health in 2016 (SACN, 2016)
- Carbohydrates and health in 2015 (SACN, 2015)
- Iodine and health in 2014 (SACN, 2014)
- Dietary reference values for energy in 2011 (SACN, 2011a)
- Salt and health in 2003 (SACN, 2003)
- Nutritional aspects of cardiovascular disease in 1994 (Department of Health, 1994)
- Dietary reference values for food energy and nutrients for the United Kingdom in 1991 (Department of Health, 1991)

1.4.2 COT

1.33 Toxicological considerations drew on evidence provided in published COT statements and opinions. The information in this chapter and the supporting tables is largely taken from:

- COT's risk assessment of cows' milk (COT, 2023b)

- COT’s overarching statement on consumption of plant-based drinks in children aged 6 months to 5 years of age which reviewed a number of potential contaminants in almond, oat and soya drinks (COT, 2021b)

- the scientific reviews prepared as part of the COT and SACN programme of work reviewing the diet of infants and young children, the Overarching statement on contaminants in the diet of children and Addendum to the overarching statement on contaminants in the diet of children (COT, 2019b; COT, 2020a)

1.5 Existing UK guidance on drinks

1.34 This benefit-risk assessment was undertaken in the context of existing UK government recommendations on drinks which were informed by previous SACN, COMA and COT assessments. Existing recommendations, communicated through the NHS website, are summarised below.

1.5.1 Babies aged under 12 months

1.35 Guidance for babies aged under 12 months (1 year) includes the following:

- it is recommended that babies are breastfed exclusively (breast milk only) for around the first 6 months of their life and, alongside solid foods, continue to be breastfed into the second year of life or beyond

- infant formula (based on either cows’ or goats’ milk) is the only suitable alternative to breast milk for babies who are under 12 months of age - the use of soya-based formula should only be on medical advice

- follow-on formula is not suitable for babies under 6 months and does not need to be introduced after 6 months

- cows’ milk should not be given as a main drink until children are 1 year old

- goats’ and sheep milk are not suitable as a main drink until children are 1 year old

- plant-based drinks should not be given as a main drink to babies under 12 months of age

- babies under 12 months of age do not need fruit juice or smoothies

- fizzy drinks should not be given to babies or young children

- diet or reduced-sugar drinks are not recommended for babies and young children
- ‘baby’ and herbal drinks are not recommended
- tea and coffee are not suitable for babies under 12 months of age
- slush ice drinks are not suitable for children under 7 years of age due to the glycerol content

1.5.2 Children aged 1 to 5 years

1.36 Guidance for children aged 1 to 5 years includes the following:

- continued breastfeeding into the second year of life
- milk and/or water, in addition to breast milk, should constitute the majority of drinks given to children aged 1 to 5 years
- pasteurised whole and semi-skimmed cows’ milk can be given as a main drink from the age of 1 year, as can pasteurised goats’ and sheep milks
- pasteurised skimmed and 1% cows’ milk should not be given as a main drink until 5 years of age - these lower fat milks can be used in cooking
- unsweetened calcium-fortified plant-based drinks, such as soya, oat or almond drinks, can be given to children from the age of 1 year
- children aged 1 to 5 years should not be given rice drinks as they may contain too much arsenic
- formula milks (including infant formula, follow-on formula, ‘growing-up’ or other ‘toddler’ milks) are not required by children aged 1 to 5 years
- specialised formula, including low-allergy formula, are also usually not required after the first year of life
- children aged 1 to 5 years should not be given sugar-sweetened beverages (including sweetened plant-based drinks)
- tea and coffee are not suitable for young children
- slush ice drinks are not suitable for children under 7 years of age due to the glycerol content

1.5.3 All children

1.37 Guidance for all children includes the following:

- high caffeine energy drinks are not recommended for children under 16 years

- the consumption of 100% fruit and vegetable juices and/or smoothies should be limited to a combined total of 150 millilitres (ml) (one portion) per day and consumed with meals to reduce the risk of tooth decay

1.5.4 Adults

1.38 Guidance for adults includes the following:

- the Eatwell Guide recommends that people should aim to drink 6 to 8 cups or glasses of fluid a day - water, lower-fat milk and sugar-free drinks, including tea and coffee all count

- the consumption of 100% fruit and vegetable juices and/or smoothies should be limited to a combined total of 150 millilitres (ml) (one portion) per day and consumed with meals to reduce the risk of tooth decay

- when buying dairy alternatives, go for unsweetened, calcium-fortified versions

2. Drinks under consideration

2.1 The main drinks being considered in this assessment are the plant-based drinks, almond, oat and soya drinks, as well as the comparator drinks cows' milk and water.

2.1 Cows' milk

2.1.1 Nutritional considerations

2.2 'Milk' is a protected term under the Codex Alimentarius General Standard for the Use of Dairy Terms, as well as EU and UK legislation (EU Regulation 1308/2013, which is assimilated law in Great Britain). Under the General Standard, 'milk' is defined as "the normal mammary secretion of milking animals obtained from one or more milkings", and cows' milk is the most common type.

2.3 Cows' milk contains energy, protein (with all the essential amino acids), fat (mainly saturated fatty acids and, to a lesser extent, monounsaturated fatty acids) and carbohydrates. The minimum protein and fat content of whole, semi-skimmed and skimmed cows' milk is controlled by legislation. Cows' milk also contains micronutrients, including vitamin A, riboflavin, vitamin B6, vitamin B12, folate, calcium, magnesium, potassium, zinc and iodine. Composition differs between the different types of cows' milk (that is, whole, semi-skimmed or skimmed), particularly with regards to energy, saturated fat and vitamin A content. The vitamin A that is present in cows' milk is mostly in the form of pre-formed vitamin A (retinol and retinyl esters), with smaller amounts present as provitamin A carotenoids (for example, beta-carotene) (see Glossary for more details on the different forms of vitamin A).

2.4 Cows' milk also contains lactose, a sugar that is naturally present in milk and dairy products (see Glossary for more details). This sugar, when naturally present in milk and milk products, is excluded from the definition of 'free sugars' (Swan and others, 2018) (see Glossary for more details) as it has reduced cariogenicity compared with other sugars, such as glucose, sucrose and fructose. A number of protective factors (casein, calcium and phosphate) that aid remineralisation of tooth enamel is also present in cows' milk.

2.5 A number of bioactives (milk peptides, immunoglobulins, lactoferrin, growth factors and milk oligosaccharides) which may confer health benefits are also present in cows' milk (Lin and others, 2021).

2.6 The exact nutrient composition is dependent on the type of milk, geographical location, season, diet of the animals, and farming practices (Dougkas and others, 2019; Haug and others, 2007).

2.7 Table 2.1 presents the nutrient composition of whole, semi-skimmed and skimmed milk. The data is from Composition of Foods Integrated Dataset (CoFID). The data presented is for pasteurised cows' milk (average of summer and winter values) and is based on laboratory analysis carried out in 1996.

Table 2.1: nutrient composition of whole, semi-skimmed and skimmed cows' milk

Energy or nutrient	Whole cows' milk	Semi-skimmed cows' milk	Skimmed cows' milk
Energy (kcal/100g)	63	46	34
Energy (kJ/100g)	265	195	144
Protein (g/100g)	3.4	3.5	3.5
Fat (g/100g)	3.6	1.7	0.3
Saturated fat (g/100g)	2.3	1.1	0.1
Carbohydrate (g/100g) (note 1)	4.6	4.7	4.8

Energy or nutrient	Whole cows' milk	Semi-skimmed cows' milk	Skimmed cows' milk
Free sugars (g/100g)	0	0	0
Fibre (g/100g)	0	0	0
Vitamin A (µg/100g) (note 2)	38	20	1
Riboflavin (mg/100g)	0.23	0.24	0.22
Vitamin B6 (mg/100g)	0.06	0.06	0.06
Folate (µg/100g)	8	9	9
Vitamin B12 (µg/100g)	0.9	0.9	0.8
Vitamin D (µg/100g)	Trace	Trace	Trace
Iron (mg/100g)	0.02	0.02	0.03
Calcium (mg/100g)	120	120	125
Magnesium (mg/100g)	11	11	11
Potassium (mg/100g)	157	156	162
Zinc (mg/100g)	0.5	0.4	0.5
Iodine (µg/100g)	31	30	30
Sodium (mg/100g)	42	43	44

Note 1: carbohydrates in cows' milk are predominantly lactose.

Note 2: vitamin A (retinol equivalents) calculated as:

retinol µg/100g + (beta-carotene equivalents µg/100g ÷ 6)

2.8 In 2025, updated values were published for the riboflavin, vitamin B12 and iodine content of cows' milk based on laboratory analysis in 2022 to 2023 (OHID, 2025b). The new values for pasteurised milk were all lower than the previous published values (based on analysis in 1996) with the exception of iodine in pasteurised skimmed milk. For riboflavin, the new values were 0.19, 0.18 and 0.15 milligram (mg) per 100 grams (g) for whole, semi-skimmed and skimmed milk, respectively. For vitamin B12, the new values were 0.4, 0.4 and 0.3 micrograms (µg) per 100g for whole, semi-skimmed and skimmed milk, respectively. For iodine, the new values were 23, 26 and 31µg per 100g for whole, semi-skimmed and skimmed milk, respectively. These differences from the 1996 analysis may reflect alterations in feeds, grazing practices, supplementation strategies, genetics, environmental conditions and dairy processing techniques (Barkema and others, 2015; March and others, 2014; Medeiros and others, 2022). They may also be a result of improvements in analytical methods in the 30 years since the last analysis.

2.1.2 Contribution of cows' milk to nutrient intakes

2.9 Cows' milk is an important contributor to intakes of calcium and other micronutrients (notably, riboflavin, vitamin B12 and iodine in all age groups, and vitamin A in children aged 1 to 5 years). For these children, cows' milk is also a major contributor to energy, protein and saturated fat intakes. If cows' milk is not consumed, other dietary components are needed to replace the micronutrients it provides.

2.10 Data on cows' milk consumption and its contribution to energy and macronutrient intakes and to micronutrient intakes by age group based on NDNS 2016 to 2019 data, are presented in Table 2.2 and Table 2.3, respectively.

2.11 Data is taken from the National Diet and Nutrition Survey (NDNS) (data collected 2016 to 2019) and the Diet and Nutrition Survey of Infants and Young Children (DNSIYC) (data collected in 2011). Milk consumption includes whole, semi-skimmed and skimmed cows' milk consumed as a drink, on breakfast cereal or in homemade recipe dishes.

2.12 Given that the fieldwork for DNSIYC was carried out in 2011, the data might not accurately reflect current cows' milk consumption by young children at the time of publication of this report. Moreover, contributions of cows' milk to intakes of riboflavin, vitamin B12 and iodine (in Table 2.3) are based on cows' milk composition data from analysis undertaken in 1996 and not on the new values based on analysis undertaken in 2022 to 2023.

Table 2.2: cows' milk consumption and contribution to energy and macronutrient intakes from cows' milk by age group

Consumption or contribution to intakes	12 to 18 months	1.5 to 5 years	5 to 10 years	11 to 18 years	19 to 49 years	50 to 64 years	65 to 74 years	75+ years
Cows' milk consumption (g/day) (note 1)	286	246	174	136	118	170	156	220
Contribution to energy intake (MJ/day)	0.77	0.6	0.39	0.28	0.26	0.34	0.31	0.45
Contribution to energy intake (kcals/day)	182	144	91	66	60	81	73	106
% contribution to energy intake	19	13	6	4	3	5	4	7
Contribution to protein intake (g/day)	8.9	8	5.8	4.5	4.3	6.1	5.4	7.6
% contribution to protein intake	23	19	11	7	6	8	8	12
Contribution to total fat intake (g/day)	9.9	7.5	4.4	3.0	2.7	3.3	2.9	4.5
% contribution to total fat intake	27	18	8	5	4	5	5	7
Contribution to saturated fat intake (g/day)	6	4.4	2.7	1.9	1.7	2	1.8	2.8
% contribution to saturated fat intake	34	25	13	8	6	8	8	11
Contribution to free sugars intake (g/day)	0	0	0	0	0	0	0	0

Consumption or contribution to intakes	12 to 18 months	1.5 to 5 years	5 to 10 years	11 to 18 years	19 to 49 years	50 to 64 years	65 to 74 years	75+ years
Contribution to fibre intake (g/day) (note 2)	0	0	0	0	0	0	0	0
Contribution to sodium intake (mg/day)	91	114	75	58	51	73	67	95
% contribution to sodium intake	14	10	5	4	3	4	4	6

Data source: NDNS 2016 to 2019

Note 1: cows' milk consumption includes whole, semi-skimmed and skimmed cows' milk consumed as a drink, on breakfast cereal or in homemade recipe dishes.

Note 2: fibre intakes for children aged 12 to 18 months are presented as non-starch polysaccharides as DNSIYC pre-dated the SACN 2015 broader definition of dietary fibre (SACN, 2015).

Table 2.3: percentage contribution to micronutrient intakes from cows' milk by age group

Micronutrient	12 to 18 months (% of total intake)	1.5 to 5 years (% of total intake)	5 to 10 years (% of total intake)	11 to 18 years (% of total intake)	19 to 49 years (% of total intake)	50 to 64 years (% of total intake)	65 to 74 years (% of total intake)	75+ years (% of total intake)
Vitamin A	16	16	9	7	5	5	4	6
Riboflavin	40	37	26	19	16	21	20	27
Vitamin B6	24	20	12	8	7	9	9	14
Vitamin B12	47	43	31	22	18	25	24	31
Folate	20	13	7	5	4	5	5	7
Vitamin D (note 1)	0	11	0	0	0	0	0	0
Iron	0	<1	0	0	0	0	0	<1
Calcium	38	37	26	19	17	23	22	30
Magnesium	20	16	9	6	5	7	6	10
Potassium	26	21	12	9	7	9	9	13
Iodine	50	47	35	27	20	26	24	33
Zinc	23	19	11	7	6	9	8	12

Data source: NDNS 2016 to 2019

Note 1: a few brands of cows' milk are fortified with vitamin D.

2.13 Mandatory nutrition labelling applies to the majority of prepackaged food, including cows' milk. The mandatory nutrition declaration must include the energy value and the amounts (in grams (g)) of fat, saturates, carbohydrate, sugars, protein and salt, and can be voluntarily supplemented with an indication of the amounts of a number of other nutrients, such as fibre and micronutrients. If a nutrition or health claim is made in relation to any of the supplementary nutrients, these must be declared as part of the nutrition declaration. Cows' milk packaging tends to adhere to mandatory requirements and does not include supplementary information.

2.1.3 Toxicological considerations

2.14 As part of the supporting work for this benefit-risk assessment, COT undertook a risk assessment of cows' milk, reviewing numerous chemicals that could occur naturally or contaminate cows' milk (COT, 2023b). This risk assessment focussed specifically on children aged 6 months to 5 years of age.

2.15 Cows' milk may contain chemical contaminants that have passed into milk via the feed and feeding stuffs consumed by the cows or that have been introduced as a result of subsequent processing of the milk. The contaminants present could include organic compounds such as dioxins and polychlorinated biphenyls (PCBs), inorganic contaminants such as heavy metals, toxins produced by fungal infestation of feed (mycotoxins) and veterinary medicines (including antibiotics) or pesticide residues. Endogenously produced compounds such as oestrogen or insulin-like growth factor 1 (IGF-1) may also be present in cows' milk, albeit at very low levels.

2.16 COT concluded that most of these potential contaminants of cows' milk presented no risk of adverse health effects in children aged 6 months to 5 years at the levels observed in cows' milk. This would also apply to adults. The exceptions were:

- iodine – small exceedances of the relevant health-based guidance values (HBGV) as a result of high-level consumption (at the 97.5th percentile)

- the polycyclic aromatic hydrocarbon (PAH) compound benzo[a]pyrene (BaP) and PAH4 (a group of PAH indicator compounds) - although consumers were exposed to these compounds, the margins of exposure were at a level which indicated a low level of risk, and overall, the risk posed by these potential contaminants was considered low

- the mycotoxin, aflatoxin M1 (AFM1), individually as well as total aflatoxins due to the contribution of AFM1 – the risk to health in children aged 6 months to 5 years was considered unlikely but could not be completely excluded

2.17 Isoflavones are a type of phytoestrogen which can mimic natural oestrogenic activity. They may occur in cows' milk via animal feed. However, the possible risks to health for children in all these age groups from exposure to isoflavones in cows' milk were considered unknown. No HBGV have been established for these compounds in young children and hence there is a lack of knowledge on the toxicological significance of the levels that might be found in cows' milk. Data on occurrence is also limited. However, the levels of isoflavones present in cows' milk are significantly lower than those in soya drinks.

2.18 The COT statement on cows' milk details the assumptions on consumption of cows' milk used in the toxicological review for children. Chronic exposure assessments were undertaken in children aged 6 months to 5 years using data from the NDNS and from DNSIYC (Lennox and others, 2013; PHE, 2014; PHE, 2018). The exposures were estimated for both cows' milk consumed solely as a drink and cows' milk consumed as a drink and used in recipes.

2.1.4 Monitoring of cows' milk

2.19 Control measures and regular testing along the supply chain are in place to ensure that contamination of milk is kept to a minimum and within legal limits.

2.2 Plant-based drinks

2.2.1 Nutritional considerations

2.20 The plant-based drinks market is rapidly evolving with evidence of product diversification and reformulation.

2.21 Plant-based drinks are not nutritionally equivalent to cows' milk. Cows' milk is a single food with some natural variation in the nutrient content and regulations controlling the minimum fat and protein content of different milk types. Plant-based drinks are manufactured products and nutrient profiles vary across the different plant types and brands (Medici and others, 2023). This is in part due to the extent to which products are fortified with micronutrients.

2.22 Analysis of changes in plant-based drinks sold in UK supermarkets between 2020 and 2023 found that, compared with 2020, the composition of products on the market in 2023 tended to be lower in free sugars and fortified with a greater number of micronutrients (including iodine) (Wall and others, 2023). Values for micronutrient fortificants (from product labels) were also found to be at levels closer to those found in cows' milk. Products with differing amounts of total and saturated fat have also become more common to reflect the range of fat content in cows' milk. However, the composition of products remained variable and 22% were unfortified (Wall and others, 2023).

Protein

2.23 Of the 3 plant-based drink types that were considered, soya drink is most similar to cows' milk in terms of protein quantity and quality (which refers to the profile of essential amino acids and their biodigestibility). Both oat and almond drinks are much lower in protein than cows' milk. While the proteins in almond, oat and soya drinks contain all the essential amino acids, these are present in lower amounts than found in cows' milk, and are particularly low in almond and oat drinks (which is partly because the level of protein in these drinks is lower) (FAO, 2013; Scholz-Ahrens and others, 2020).

Dietary fat

2.24 Almond, oat and soya drinks tend to be lower in saturated fatty acids (saturated fat) compared with whole and semi-skimmed cows' milk. There was a lack of data on the unsaturated (monounsaturated and polyunsaturated) fatty acid content of these drinks at the time this assessment was conducted.

Free sugars and other sweeteners

2.25 Sugars that are present in plant-based drinks are 'free sugars' by definition (Swan and others, 2018). Free sugars are present in plant-based drinks either as sugars added as an ingredient or as a result of processing of the plant base. For example, in the case of oat drinks, free sugars can be liberated through the enzymatic breakdown of starch within the oats during processing. Consequently, plant-based drinks that are labelled as 'unsweetened' or as containing 'no added sugars' may still contain free sugars as a result of processing.

2.26 Over the course of this assessment, 'no sugars' versions of almond, oat and soya drinks became more widely available. In the case of 'no sugars' soya and almond drinks, sugars are not added at the formulation stage. 'No sugars' oat drinks may be produced by controlling the enzymatic breakdown of starches to minimise production of free sugars.

2.27 Irrespective of the free sugars content, plant-based drinks may not have the same protective effects against dental caries offered by casein, calcium and phosphate that is present in cows' milk (Vitiello and others, 2024).

2.28 Plant-based drinks (along with cows' milk-based drinks) specifically marketed for young children (also known as 'growing up' drinks) often contain free sugars. These drinks may also contain maltodextrins (FSNT, 2024), which are oligosaccharides that principally occur from the hydrolysis of starch (from maize or potatoes) and are widely used in the food industry to modify the texture of food products (SACN, 2015). Maltodextrins can be hydrolysed by salivary amylase in the mouth, releasing the free sugars maltose and glucose, which may contribute to tooth decay (Al-Khatib and others, 2001; Rezende and Hashizume, 2018).

Micronutrients

2.29 With the exception of organic plant-based drinks, which cannot be fortified with micronutrients according to the organic standards for Great Britain, the majority of plant-based drinks are fortified with micronutrients to varying degrees. It should be noted that both fortified and unfortified products contain naturally occurring micronutrients, such as folate and zinc.

2.30 When work began on this assessment in 2021, all fortified plant-based drinks contained calcium and were also often fortified with riboflavin and vitamin B12. The majority of products were not fortified with iodine and only one oat drink, specifically marketed for children aged 1 to 3 years, was fortified with vitamin A (in the form of retinyl acetate, see Glossary under 'vitamin A' for details).

2.31 In 2020, 4% of plant-based drinks sold in the UK were fortified with iodine (Clegg and others, 2021). By 2023, 31% of these drinks were fortified with iodine (Wall and others, 2023); it remained the case that no plant-based drinks marketed for the general population were fortified with vitamin A.

2.32 Plant-based drinks are often fortified with vitamin D (whereas cows' milk contains only trace amounts of vitamin D, see Table 2.1). There are 2 forms of vitamin D, which are:

- vitamin D2, which is derived from fungi and UVB-irradiated yeast
- vitamin D3, which is usually obtained from animal sources although vegan vitamin D3 can be obtained from lichen

2.33 Both forms of vitamin D have been shown to be effective in raising serum 25(OH)D concentrations, and therefore can reduce the risk of vitamin D deficiency. There is some evidence to suggest that vitamin D3 may be more efficacious than vitamin D2 in raising serum 25(OH)D concentrations (SACN, 2024).

2.34 Bioavailability may differ between micronutrients that are naturally present within the food matrix and those that are added as fortificants (Heaney and others, 2005). Some micronutrient fortificants, notably calcium, have uncertain physical stability and bioavailability in the final matrix (Merritt, 2023). As the evidence base is not well established, it is not yet possible to predict the relative bioavailability of calcium added to plant-based drinks compared with calcium found in animal milks. It has been reported that:

- calcium absorption from plant foods may be influenced by several factors, including the presences of phytates (in cereals, legumes and seeds), which may bind calcium and reduce absorption
- where calcium is added as a fortificant, the solubility of the calcium compound used may have a role in determining calcium bioavailability (Muleya and others, 2024)

Other considerations

2.35 The precise composition of plant-based drinks is uncertain. There are few, if any, analytical data available for products currently on the market. The composition as stated on the label is subject to analytical measurement uncertainty. It may also be affected by overage, a practice whereby nutrients are added at higher than declared levels at the manufacturing stage to account for losses during processing and storage. This practice ensures that the amount of a nutrient declared on the label is correct at the end of the product's shelf life. Overage can be as high as 30% for fat soluble vitamins used in supplements (EVM, 2003). The exact level of overage will depend on when, during the product's shelf life, it is consumed. The level of overage in plant-based drinks, if any, is unknown. Overage means that consumers may be consuming more of a fortificant than has been predicted from the values declared on the label.

2.36 The nutrient content of plant-based drinks at the point of consumption is dependent on whether the product has been shaken, since the added nutrients are not part of a food matrix (Smith and others, 2022).

2.37 Plant-based drinks also contain non-nutritive bioactive compounds, such as phytochemicals. These are present in smaller amounts in plant-based drinks compared with what is present in the nuts and seeds from which they are derived due to the manufacturing process (Aydar and others, 2020).

2.38 Most plant-based drinks would be classified as 'ultra-processed' according to the NOVA classification system of foods according to levels of processing (Monteiro and others, 2018). Their production requires extensive processing of the plant base (including soaking, grinding, blanching, separation procedures, homogenisation, thermal processing) and addition of nutrients and other ingredients (including emulsifiers, stabilisers and flavourings) to achieve an appearance, taste and mouthfeel that more closely resemble cows' milk (Merritt, 2023). SACN has concluded that observed associations between ultra-processed foods and health are concerning, but it is unclear whether these foods are inherently unhealthy due to processing or due to their nutritional content (SACN, 2025a).

2.2.2 Toxicological considerations

2.39 COT considered the toxicological implications of the presence of both natural constituents, such as isoflavones in soya and cyanogenic glycosides in almonds, as well as potential contaminants, such as mycotoxins, in plant-based drinks. COT's overarching statement on consumption of plant-based drinks in children aged 6 months to 5 years of age (COT, 2021b) includes a statement on the potential risks from:

- soya drink consumption in children aged 6 months to 5 years of age
- oat drink consumption for children aged 6 months to 5 years of age
- almond drink consumption in children aged 6 months to 5 years of age

Previous COT risk assessments

2.40 The main toxicological concerns identified with respect to plant-based drinks were the potential presence of mycotoxins in all 3 drink types and the isoflavone content of soya drinks.

2.41 Mycotoxins are a group of naturally occurring chemicals produced by certain moulds. Chronic exposure to mycotoxins is associated with a range of chronic adverse effects, including cancer and kidney damage, while acute exposure is associated with vomiting. While the majority of mycotoxins assessed were not of concern, the risk of ochratoxin A (OTA) in oat drinks was potentially of concern for some age groups. The risks posed by aflatoxins in almond drinks could not be determined, with significant uncertainties in the extent to which exposure was estimated being noted. However, not all of the mycotoxins were assessed in all 3 drinks, since for some drinks their occurrence would be very unlikely.

2.42 Isoflavones are a type of phytoestrogen. These are naturally occurring compounds found in plants that can mimic the effects of natural oestrogens and potentially lead to adverse effects on reproduction and development. Most isoflavones in the diet come from soya and soya products along with legumes (lentils, beans and peas). COT had previously endorsed existing SACN advice that, due to its isoflavone content, soya-based infant formula should be used only if it has been recommended or prescribed by a health visitor or GP and is only suitable from 6 months of age.

2.43 COT highlighted the lack of data on consumption of plant-based drinks in infants and young children and consequently the high degree of uncertainty regarding the risks of exposure to either chemical contaminants or naturally occurring substances. Data on the concentrations of natural constituents and on the presence of chemical contaminants are also limited.

2.44 Overall, COT concluded that neither the safety of the plant-based drinks reviewed, nor the suitability of the current UK government guidance (see chapter 1), could be confirmed from a toxicological perspective. However, any risk would likely be small.

Soya drink

2.45 Soya drinks are made from soaking the beans and then grinding with water, prior to boiling. Alternatively, grits, full-fat flakes or flour can be added to water to make a slurry prior to boiling (Odo, 2003). These drinks have been estimated to contain approximately 8% soya.

2.46 Soya drinks may contain contaminants such as heavy metals due to soil geology or mycotoxins due to fungal contamination of the raw commodity, as well as pesticide residues (COT, 2021b).

2.47 Soya-based infant formula has been reported to contain high levels of aluminium as soybeans can naturally accumulate aluminium, and aluminium impurities may occur in other basic components of the soya-based infant formula. In addition, aluminium may also be present due to contamination during processing in aluminium vessels; this is potentially relevant to soya drinks (EFSA, 2008c; Navarro-Blasco and Alvarez-Galindo, 2003). Aluminium exposure from soya-based infant formula has been estimated to be an order of magnitude higher than exposure from non-soya formula, although still within the relevant HBGV (COT, 2016a).

2.48 Soya contains isoflavones which can mimic natural oestrogenic activity. These may have either beneficial or adverse effects depending on the context and population group concerned. The levels of isoflavones present in soya drinks are substantially higher than in cows' milk.

2.49 Due to small sample sizes and low numbers of consumers, there is currently limited information on the consumption of soya-based foods and drinks from DNSIYC and NDNS.

2.50 The chronic exposure estimates for isoflavones (from the whole diet) in children between 6 months and 5 years of age were calculated using several sources including:

- the British Nutrition Foundation (2019) 'Healthy eating for toddlers'
- the First Steps Nutrition Trust (2021) 'Eating Well: vegan infants and under 5s
- The Vegan Society (2016) 'Food tips for vegan children'
- the Public Health England (2017) guidance 'Example menus for early years settings in England' (COT, 2020c)

2.51 These publications provided guidance on the frequency of consumption and on portion sizes for children under age 5 years. Considering the lack of specific consumption information for the groups of interest, these publications were deemed to cover the most representative consumption scenarios for children following dairy-free or vegan diets.

2.52 Table 2.4 below sets out the estimated consumption of soya drink by children of different age groups based on the above sources.

Table 2.4: estimated consumption of soya drink in children following a plant-based diet (COT, 2020c)

Age	Intake
6 to 12 months	200 millilitres (ml) per day
12 to 24 months	300 to 500ml per day
24 to 48 months	300 to 500ml per day
48 to 60 months	300 to 500ml per day

Oat drink

2.53 Oat drinks can be made from oat flour and/or syrup, which is then mixed with water, or from whole oat kernels. Oat drinks contain 8% to 10% oats. COT (2020b) estimated that there is approximately 10.8g of oats per 100 ml of oat drink.

2.54 Oat drinks may contain contaminants such as heavy metals due to soil geology or mycotoxins due to fungal contamination of the raw commodity, as well as pesticide residues (COT, 2021b).

2.55 As for soya drinks, there is limited data on the consumption of oat drinks by children aged 1 to 5 years, thus the estimated exposures are as estimated for soya drinks and are based on the same assumptions.

Almond drink

2.56 Almond drinks are made from almonds which are roasted, blanched and the skins removed; they are then made into a paste which is mixed with water. The drinks have been estimated to contain approximately 5% almond.

2.57 Almond drinks may contain contaminants such as heavy metals due to soil geology or mycotoxins due to fungal contamination of the raw commodity, as well as pesticide residues (COT, 2021b).

2.58 Almonds contain cyanogenic glycosides. These are compounds that contain cyanide which can be released if they are broken down by enzyme activity. Symptoms of cyanide toxicity include headache, dizziness, mental confusion, stupor, cyanosis with twitching and convulsions, terminal coma. Cyanogenic glycosides have a bitter taste and are present at significantly lower levels in sweet almonds compared to bitter almonds; commercial cultivars of almonds are all sweet almonds (COT, 2021b).

2.59 As is the case for soya and oat drinks, there is few data on the consumption of almond drinks by children aged 1 to 5 years. Therefore, the estimated exposures are as estimated for soya drinks and are based on the same assumptions.

Monitoring of plant-based drinks

2.60 Manufacturers monitor both raw materials and the final product with the focus on the former, with suppliers being required to provide raw materials meeting the manufacturers' specification. A wide range of potential contaminants, including heavy metals, mycotoxins and pesticide residues, is tested regularly with the frequency of testing varying with the manufacturer. Testing takes place "at least annually" but may be more frequent (every few weeks).

2.2.3 Consumption and purchasing data

Consumption data

2.61 NDNS data was analysed to understand consumption of almond, oat and soya drinks in the UK population. The latest NDNS data available at the time of analysis was collected from 2016 to 2019. In this data set the total number of consumers of plant-based drinks was low (7%; 184 consumers in a sample of 3,558, 64 children (aged 1.5 to 18 years) and 120 adults). There were insufficient child consumers in the data set for analysis. Plant-based drinks were consumed in all age groups, with soya and almond drinks consumed most often. For adult consumers (19 to 49 years) of plant-based drinks, 58% were exclusive consumers (did not consume cows' milks over the survey period). Most adult consumers were consuming less than one serving (200ml) of plant-based drinks per day. High consumers of plant-based drinks (97.5th percentile) were consuming more than 2 servings per day, suggesting that these consumers were substituting plant-based drinks for cows' milk for a range of uses.

2.62 In the NDNS 2019 to 2023 data published in June 2025, plant-based drinks were consumed by 10% of the sample (328 consumers - 98 children and 230 adults) over the 4 survey days (OHID, 2025a). Due to changes in the methods for collecting dietary data in NDNS these figures should not be directly compared with the 2016 to 2019 figures.

2.63 DNSIYC data was not interrogated for plant-based drink consumption because the fieldwork was carried out in 2011 when plant-based drinks were not well established on the market. The data is therefore unlikely to accurately reflect plant-based drink consumption by young children living in the UK in 2025.

Purchasing data on almond, oat and soya drinks

2.64 Kantar Worldpanel data and the Department for Environment, Food and Rural Affairs' (Defra) Family Food survey were used to examine purchasing behaviours. Kantar purchasing data was used as a proxy measure of consumption.

2.65 Kantar Worldpanel is a commercially produced data set providing volume sales and nutrition data for foods and drinks purchased by a consumer panel of 30,000 regionally and demographically representative households in Great Britain.

2.66 The most recent Kantar data set of purchasing behaviours of unflavoured almond, oat and soya drinks that was available at the time this report was published, covers 52 weeks from 3 September 2023 to week ending 1 September 2024 (see PHE (2020a) for information on methodology).

2.67 Kantar data indicated that over the 52 weeks ending 1 September 2024, sales of almond, oat and soya drinks equated to around 6% of the total sales of cows' milk (whole, semi-skimmed and skimmed). Oat drinks were the most popular plant-based drink across all household life stages. Pre-family households (under 45 years no children), 'empty nesters' (1 to 2 adults between 45 and 65 and no children) and retired households purchased more plant-based drinks than other household life stages. Data also indicated that propensity to purchase plant-based drinks was correlated to socioeconomic status, with households in the 2 highest social grades (AB and C) most likely to buy plant-based drinks. For more information on socioeconomic status, see Office for National Statistics guidance Approximated social grade data.

2.68 The Defra Family Food dataset records household food and drink purchases. Data is collected for a sample of households in the UK using self-reported diaries supported by till receipts of all purchases over a 2-week period. Time trend data on household food purchases from this survey, from 2004 to 2022 to 2023, were considered to help understand changes in consumer purchasing behaviours (and inferred consumption) over time and to estimate the average volume (ml) of plant-based drinks purchased per person per week.

2.69 Data from this survey showed an increase in average household purchases of plant-based drinks since 2004, with a 65% increase between 2019 to 2020 and 2020 to 2021 and little change since. Data from 2022 to 2023 showed mean household purchases equivalent to a population average of 110g per person per week, which is higher than indicated by NDNS consumption data from 2019 to 2023 (88g/week). Analysis by household income decile shows generally higher purchases in higher income deciles but no consistent pattern is seen across the deciles.

2.3 Water

2.70 To compare plant-based drinks with water, it was assumed that drinking water would meet the relevant drinking water standards and regulations, and thus would not pose any toxicological risks.

2.71 The regulations set standards for the following chemical parameters in drinking water:

- acrylamide
- antimony
- arsenic
- benzene
- benzo(a)pyrene
- boron
- bromate
- cadmium

- chromium
- copper
- cyanide
- 1, 2 dichloroethane
- epichlorohydrin
- fluoride
- lead
- mercury
- nickel
- nitrate
- nitrite
- pesticides (aldrin, dieldrin, heptachlor, heptachlor epoxide, other pesticides)
- polycyclic aromatic hydrocarbons
- selenium
- tetrachloroethene and trichloroethene
- trihalomethanes
- vinyl chloride

2.72 In England and Wales, limits are also set for aluminium, iron, manganese, sodium and tetrachloromethane, with equivalent legislation existing for Scotland and Northern Ireland.

2.4 Nutritional substitution analysis

2.4.1 Approach

2.73 A substitution analysis was undertaken to examine the impact on total dietary intakes when total volumes of all types of cows' milk (whole, semi-skimmed and skimmed) consumed by participants in UK dietary surveys were substituted with the equivalent volumes of almond, oat and soya drink, separately, for different age groups. The substitution analysis did not consider the impact of separately replacing whole, semi-skimmed, skimmed cows' milk with almond, oat or soya drinks.

2.74 The approach, methods and findings from the substitution analysis are described below with further information provided in Annex 1.

2.75 While cows' milk was the main reference against which plant-based drink consumption was compared, the potential impact on nutrient intakes of not consuming an alternative to cows' milk (replacing consumption of cows' milk with water rather than almond, oat or soya drink) was also considered.

2.76 The impact of replacing cows' milk with plant-based drinks or water on nutrient intakes is broadly governed by the absolute volume of cows' milk within the whole diet and its relative importance in the contribution of nutrients. The youngest children (1 to 5 years) and the oldest adults (75 years and over) consume the largest volumes of cows' milk but the contribution of cows' milk to nutrient intake is largest in the diets of children aged 1 to 5 years. While current government dietary advice on drinks for babies and young children is that pasteurised whole and semi-skimmed cows' milk can be given as a main drink from age 1 year, children aged 1 to 5 years typically consume more whole milk than semi skimmed milk. Cows' milk consumption in all other age groups is dominated by semi-skimmed milk, with low consumption of skimmed milk.

2.77 The substitution analysis assumed that there were no changes to the wider diet and that there were no dietary changes to compensate for the lower energy content of some plant-based drinks (or water) compared with cows' milk. It also assumed no substitution was made of other dairy products with their plant-based equivalents. Incorporating different dietary patterns or consumption scenarios of varying combinations of plant-based drinks (and foods) would have added complexity to the model.

2.78 Nutrients included in the substitution analysis primarily reflect compositional differences between cows' milk and plant-based drinks, particularly where cows' milk is an important contributor to dietary intakes.

2.79 The nutrients included were:

- energy
- protein

- saturated fat
- total carbohydrate
- free sugars
- fibre
- vitamin A
- riboflavin
- folate
- vitamin B12
- vitamin D
- calcium
- magnesium
- potassium
- iodine
- zinc

2.80 Salt was also considered.

2.81 It was not possible to consider amino acid or unsaturated fatty acid composition in the substitution analysis. This was because the evidence base was not sufficient. This included a lack of data on the amino acid and unsaturated fatty acid content of almond, oat and soya drinks sold in the UK at the time of the assessment.

2.4.2 Volume and nutrient contribution of cows' milk

2.82 The volume and nutrient contribution of all types of cows' milk (whole, semi-skimmed and skimmed) to be replaced with plant-based drinks and water in the substitution analysis were derived from consumption data from UK dietary surveys:

- secondary analysis of DNSIYC provided the volume and nutrient intake data for children aged 12 to 18 months

- secondary analysis of NDNS (years 2016 to 2019) provided the volume and nutrient intake data for all age groups from 1.5 years to 75 years and over

2.83 The volumes of cows' milk for different age groups were based on total cows' milk consumption by individuals over the 4 consecutive days of the survey (see Table 2.2). This includes whole, semi-skimmed and skimmed cows' milk consumed as a drink on breakfast cereal or in home-made recipe dishes. It does not include cows' milk in 'ready-made' manufactured products and other milk products.

2.84 The nutrient contribution from cows' milk was based on established typical macro and micronutrient composition values published in CoFID for whole, semi skimmed and skimmed cows' milk (see Table 2.1). The values used take account of seasonal differences in composition. Updated values for riboflavin, vitamin B12 and iodine content of cows' milk were not used as these were not available at the time the substitution analysis was carried out. The updated values are provided in section 2.1.1.

2.4.3 Nutrient profiles for plant-based drinks

2.85 Due to the limited data on the consumption of plant-based drinks at the time of the benefit-risk assessment, it was necessary to model the potential impact on the nutrient intakes of different population groups when cows' milk is replaced with plant-based drinks.

2.86 SACN and COT derived a range of nutrient profiles for each plant-based drink type (almond, oat and soya). The nutrient profiles were based on purchasing data for products that were sold in the UK in 2019 to 2020 and nutritional composition data on these products that were obtained from manufacturer product descriptions on supermarket websites in January 2022. The impact on nutrient intakes for different population groups of replacing cows' milk consumption (based on data from UK dietary surveys) with equivalent volumes of plant-based drinks across the different nutrient profiles was then determined.

2.87 Given the number and variety of plant-based drinks available and the lack of 'standard' nutrient profiles, 3 nutrient profiles were derived for each plant base for comparison against cows' milk. That is, a 'typical', an 'enhanced' and an 'unfortified and/or sweetened' nutrient profile was established for each of almond, oat and soya drinks. The nutrient profiles and the methodology used to derive these are described in the section 'Nutrient profiles used in the substitution analysis' below and summarised in Table 2.5 and Table A1.1.

Purchasing data

2.88 As a first step, Kantar Worldpanel data (for 52 weeks from 6 September 2019 to week ending 6 September 2020) was interrogated in December 2021 to identify purchases, sales volumes and nutrient data of unflavoured almond, oat and soya drinks. In January 2022, nutrient data (per 100ml) for each product was updated using information provided in manufacturer product descriptions published on supermarket websites (see below).

2.89 Drinks belonging to each plant base were grouped and ordered by highest volume sales regardless of nutrient profile (see Table A1.1).

Sources of nutrient composition data

2.90 To assess the impact of replacing cows' milk with plant-based drinks it was necessary to assign values for all nutrients under consideration in all 3 drink types. The sources of information used to derive composition data for almond, oat and soya plant-based drinks, in order of preference, were:

- manufacturer product descriptions from supermarket websites (data obtained in January 2022), which provided nutrient values used to derive modelling profiles (energy, macronutrients and fortified micronutrients)
- the UK CoFID, which provided analytical values for naturally occurring levels of micronutrients not added as fortificants in soya drinks - CoFID does not currently include almond or oat drinks
- United States Department of Agriculture (USDA), which provided estimated values for naturally occurring levels of micronutrients not added as fortificants in plant-based drinks (where no data found in CoFID)
- NDNS nutrient data bank, which provided estimated values for naturally occurring levels of micronutrients not added as fortificants in plant-based drinks where analytical values are not available

2.91 Energy content in kcals per 100g was calculated for each profile in each plant base based on energy conversion factors for the derived values for protein (4kcals/g), carbohydrate (3.75kcals/g) and fat (9kcals/g) (FAO, 2003). In line with the definition of 'free sugars' (Swan and others, 2018), all sugars in drinks (other than dairy milk), including plant-based drinks, are classified as free sugars. Many plant-based drinks contain free sugars either as sugars added as an ingredient or as sugars present through processing of the plant base, for example in oat drinks (see section 2.2.1 for more information on free sugars and other sweeteners).

Nutrient profiles used in the substitution analysis

2.92 Table 2.5 provides details of the resulting nutrient profiles for ‘typical’, ‘enhanced’ and ‘unfortified and/or sweetened’ plant-based drinks, as well as for cows’ milk, used in the assessment.

Table 2.5: nutrient profiles used in the substitution analysis

Nutrient profile	Description
Typical	Based on the most frequently purchased products (top 5 by volume sales and a sales weighted average for each nutrient in these products) at the time the data was collected (from 6 September 2019 to 6 September 2020).
Enhanced (the most favourable nutrient profile)	Unsweetened (no sugars added as an ingredient and no free sugars as a result of processing) and fortified with micronutrients (at levels found in existing products) to more closely align with the nutrient content of cows’ milk.
Unfortified and/or sweetened (the least favourable nutrient profile)	No micronutrient fortification and/or contained sugars added as an ingredient.

‘Typical’ nutrient profile

2.93 The ‘typical’ nutrient profile reflects the nutrient profiles of the top 5 almond, oat and soya drinks based on volume sales data from the Kantar data set (2019 to 2020). As such, the ‘typical’ nutrient profile was aligned to the top selling products, regardless of their nutrient profile. As mentioned above, the nutritional composition information for each of these products was updated using manufacturer product descriptions published on supermarket websites in January 2022. The amount of each nutrient for this nutrient profile was then calculated as the sales weighted average of that nutrient in the top 5 products. Therefore, products that had higher sales volumes had a greater influence on the resulting nutrient profile. The ‘typical’ products were all fortified (but to a lesser extent than the ‘enhanced’ profile) and contained some free sugars (less than the ‘unfortified and/or sweetened’ profile but more than ‘enhanced’). The selected values are noted in Table 2.6 below.

‘Enhanced’ nutrient profile

2.94 The ‘enhanced’ nutrient profiles for each plant-based drink type were derived by selecting the most nutritionally beneficial values (either the upper or lower end of the range of values) for relevant nutrients in products that cumulatively contributed 90% of sales in 2019 to 2020 when listed by descending sales volume (using nutritional composition information on these products from January 2022) (see

Annex 1, Table A1.1 for details). For example, for the ‘enhanced’ soya drink profile, the highest values found for protein, fibre and micronutrients were used, and the lowest values found for saturated fat and free sugars were used from the products included. Micronutrient levels were taken from micronutrient fortification levels found in the included products on the basis that these were realistic and achievable. The selected values are noted in Table 2.6 below.

2.95 The resulting 'enhanced’ nutrient profiles for almond, oat and soya drinks were unsweetened (did not contain sugars added as an ingredient or free sugars as a result of processing) and were fortified with vitamin A, riboflavin, vitamin B12, vitamin D, calcium and iodine.

2.96 At the time of the assessment (January 2022), no single plant-based drink product on the market fully met the ‘enhanced’ nutrient profile. Plant-based drinks were typically fortified with riboflavin, vitamin B12 and calcium at comparable levels with cows’ milk, and most were also fortified with vitamin D. Only a few products were fortified with iodine at similar levels to cows’ milk and an oat drink that became available in early 2022 did not contain free sugars.

2.97 Vitamin A (retinyl acetate) was added to one oat drink marketed specifically for young children aged 1 to 3 years. Given the rapidly evolving plant-based drinks market with new products explicitly aimed at achieving a nutrient profile as close to cows’ milk as possible, it was considered that the inclusion of vitamin A in the 'enhanced' nutrient profiles for almond, oat and soya drinks (at the level found in semi-skimmed cows' milk, that is, 21ug/100ml) was justified.

‘Unfortified and/or sweetened’ nutrient profile

2.98 The ‘unfortified and/or sweetened’ nutrient profiles were based on the least nutritionally beneficial values for relevant nutrients in almond, oat and soya drinks sold in the UK in January 2022. These profiles are unfortified (which would include many ‘organic’ products) and/or contained sugars added as an ingredient. Added sugars are included in the definition of 'free sugars'. As with the ‘typical’ nutrient profile, the ‘unfortified and/or sweetened’ nutrient profile was based on sales weighted averages of products sold in 2019 to 2020 (with nutritional values based on products sold in the UK in January 2022). Therefore, products that had higher sales had a greater influence on the resulting profile. As there were only a small number of products that met these criteria, all products were included (see Annex 1, Table A1.1). For soya drinks, 3 products were included and for almond drinks, 4 products were included. Any oat drinks that were unfortified were also included in this profile. Oat drinks do not typically contain sugars added as an ingredient but they can vary in free sugars content as a result of processing of the oats. The selected values are noted in Table 2.6 below.

Table 2.6: nutrient profiles for cows' milk and typical, enhanced and unfortified and/or sweetened plant-based drinks used in modelling

Drink	Nutrient profile	Energy (kcal/100g)	Protein (g/100g)	Saturated fat (g/100g)	Carbohydrate (g/100g)	Free sugars (g/100g)	Dietary fibre (g/100g)
Cows' milk	Whole cows' milk (note 1)	63	3.4	2.3	4.6	0	0
Cows' milk	Semi- skimmed cows' milk (note 1)	46	3.5	1.1	4.7	0	0
Cows' milk	Skimmed cows' milk (note 1)	34	3.5	0.1	4.8	0	0
Soya	Enhanced	24 (note 2)	3.5	0.2	0.12 (note 3)	0	1.2
Soya	Typical	35	3.1	0.5	1.5	1.3	0.5
Soya	Unfortified and/or sweetened	43	3.6 (note 4)	0.4	2.4	2.4	0.6
Almond	Enhanced	13 (note 2)	0.8	0.1	0.13	0	0.5
Almond	Typical	15	0.4	0.1	0.4	0.3	0.3
Almond	Unfortified and/or sweetened	37	0.9	0.2	4.9	3.9	0.2
Oat	Enhanced	40 (note 2)	1.8	0.1	5.9	0	1.4
Oat	Typical	46	0.6	0.2	6.6	3.5	1.1
Oat	Unfortified and/or sweetened	40	0.8	0.1	6.6	3.7	0.7

Table 2.6 (continued): nutrient profiles for cows' milk and typical, enhanced and unfortified and/or sweetened plant-based drinks used in modelling

Drink	Nutrient profile	Vitamin A (µg/100g)	Riboflavin (mg/100g)	Folate (µg/100g)	Vitamin B12 (µg/100g)	Vitamin D (µg/100g)
Cows' milk	Whole cows' milk (note 1)	38	0.2	8	0.9	0
Cows' milk	Semi- skimmed cows' milk (note 1)	21	0.2	9	0.9	0
Cows' milk	Skimmed cows' milk (note 1)	1	0.2	9	0.8	0
Soya	Enhanced	21 (note 5)	0.21	9 (note 6)	0.38	0.75
Soya	Typical	0	0.18	9 (note 6)	0.32	0.63
Soya	Unfortified and/or sweetened	0	0.05 (note 6)	14 (note 6)	0	0
Almond	Enhanced	21 (note 5)	0.21	1 (note 6)	0.38	0.75
Almond	Typical	0	0.19	1 (note 6)	0.38	0.75
Almond	Unfortified and/or sweetened	0	0	1 (note 6)	0	0
Oat	Enhanced	21 (note 5)	0.21	15	0.69	1.5
Oat	Typical	0	0.20	20 (note 6)	0.40	0.86
Oat	Unfortified and/or sweetened	0	0	3 (note 6)	0	0

Table 2.6 (continued): nutrient profiles for cows' milk and typical, enhanced and unfortified and/or sweetened plant-based drinks used in modelling

Drink	Nutrient profile	Calcium (mg/100g)	Iodine (µg/100g)	Zinc (mg/100g)	Potassium (mg/100g)	Magnesium (mg/100g)
Cows' milk	Whole cows' milk (note 1)	120	31	0.5	157	11
Cows' milk	Semi- skimmed cows' milk (note 1)	120	30	0.4	156	11
Cows' milk	Skimmed cows' milk (note 1)	125	30	0.5	162	11
Soya	Enhanced	120	35	0.3 (note 6)	119 (note 6)	18 (note 6)
Soya	Typical	120	5	0.3 (note 6)	119 (note 6)	18 (note 6)
Soya	Unfortified and/or sweetened	13 (note 7)	1	0.3 (note 6)	74 (note 6)	15 (note 6)
Almond	Enhanced	120	35	0.1 (note 6)	16 (note 6)	6 (note 6)
Almond	Typical	120	0	0.1 (note 6)	16 (note 6)	6 (note 6)
Almond	Unfortified and/or sweetened	7 (note 6)	0.3 (note 7)	0.1 (note 6)	16 (note 6)	6 (note 6)
Oat	Enhanced	120	35	0.9	37 (note 6)	12 (note 6)
Oat	Typical	120	9	0.3 (note 6)	37 (note 6)	12 (note 6)
Oat	Unfortified and/or sweetened	5 (note 6)	0	0.3 (note 6)	37 (note 6)	12 (note 6)

Note 1: values for cows' milk based on those published in CoFID. New analytical values for riboflavin, vitamin B12 and iodine were not available at the time of the substitution analysis.

Note 2: kcals/g calculation based on energy conversion factors for protein (4kcals/g), carbohydrate (3.75kcals/g) and fat (9kcals/g).

Note 3: carbohydrate values are based on the percentage of soya beans used in the recipe. Carbohydrate and protein values are correlated as soya beans are the source of protein. Higher carbohydrate values generally also indicate higher protein. As ‘enhanced’ nutrient profile maximises protein, the upper range of carbohydrate is also used in this scenario.

Note 4: ‘unfortified and/or sweetened’ nutrient profile is based on a sales weighted average nutrient content of 3 products in this category. In this case, the protein value was influenced by a product with a particularly high protein content that contributed 59% of sales. This protein content was not typical, and so the value was lower in both the ‘typical’ and ‘enhanced’ nutrient profiles.

Note 5: vitamin A values for ‘enhanced’ plant-based drinks were set at 21ug/100ml in line with semi-skimmed cows’ milk.

Note 6: micronutrients not listed on product packaging (that is, those that are naturally present and have not been added through fortification) have been estimated based on those published in CoFID or if there was no published value in CoFID, to values used in the years 9 to 11 NDNS nutrient data bank (NDB).

Note 7: iodine value for ‘unfortified and/or sweetened’ nutrient profile for almond drink were taken from USDA Food Data Central for shelf stable almond drink (no iodine values were found in CoFID or NDB).

2.99 The volume and nutrient contribution of cows' milk used in the substitution analysis reflects estimated total consumption based on UK dietary survey data. The majority of cows' milk consumed is either whole or semi-skimmed and therefore findings from the substitution analysis largely reflect the impact of these milk types (and not skimmed milk) being replaced with almond, oat and soya drinks.

2.100 The proportion of the population whose intake of a particular micronutrient was below the lower reference nutrient intake (LRNI) was used as an indicator of the potential impact of replacing cows' milk with the different plant-based drink nutrient profiles and whether this was of public health concern.

2.5 Replacing cows' milk with almond, oat or soya drinks

2.101 Data tables detailing the impact on nutrient intakes of replacing cows' milk with plant-based drinks or water by age group and plant-based drink type can be found in Annex 1, Table A1.2 to Table A1.25.

2.5.1 'Typical' nutrient profile

2.102 The substitution analysis suggests that replacing cows' milk with 'typical' nutrient profile almond, oat and soya drinks would lead to lower intakes of energy and saturated fat and to higher intakes of fibre and vitamin D. More detailed information covering the impact on intakes of other nutrients if cows' milk is replaced with the 'typical' nutrient profiles is provided below.

Protein

2.103 Of the 3 plant-based drink types that were considered, soya drink is most similar to cows' milk in terms of protein content and quality (which refers to the profile of essential amino acids (EAA) and their biodigestibility). Both almond and oat drink are much lower in protein than cows' milk. Whilst the proteins in almond, oat and soya drinks provide all the essential amino acids, these are present in lower amounts than in cows' milk and are particularly low in almond and oat drinks. This is partly because the level of protein in these drinks is lower (FAO, 2013; Scholz-Ahrens and others, 2020).

2.104 UK dietary recommendations for protein are based on egg and milk protein and assume complete digestibility (COMA, 1991).

2.105 It was not possible to consider protein quality in the substitution analysis (or the BRAFO assessment in chapter 3). There are uncertainties in determining the sufficiency of essential amino acid (EAA) intakes at the population level given that there are no dietary reference values (DRVs) for EAAs. In addition, there was a lack of data on the amino acid content of almond, oat and soya drinks sold in the UK at the time of the assessment.

2.106 The substitution analysis indicated that replacing cows' milk with plant-based drinks that are lower in protein would not pose a risk to protein intakes for the general population; according to UK dietary survey data, mean intakes of protein exceed the reference nutrient intake (RNI) in all age groups.

2.107 Evidence identified through a rapid scoping search (see Annex 4) indicated that protein intakes of children aged 1 to 5 years following a vegetarian or vegan diet met or exceeded the RNI (although intakes were still lower than for those children consuming an omnivorous diet). However, there was some limited evidence suggesting that the overall protein quality of their diet was different. This was a pattern of overall lower concentrations of circulating EAA in children following a vegan diet, compared with children consuming an omnivorous diet.

Free sugars

2.108 Cows' milk does not contain free sugars while all sugars in plant-based drinks are free sugars. Therefore, replacing cows' milk with 'typical' soya or almond drinks would contribute additional (and potentially excess) free sugars to diets.

2.109 The oat drinks used to derive the 'typical' nutrient profile did not contain sugars added as an ingredient but nevertheless would have contained higher amounts of free sugars than 'typical' soya and almond drinks because free sugars are released from the processing of oats.

2.110 Free sugars might also be present in small amounts of unsweetened versions of soya and almond drinks also as the result of processing.

Micronutrients

2.111 Cows' milk is an important source of iodine for all population groups and vitamin A in children aged 1 to 5 years. Neither of these micronutrients are included in 'typical' nutrient profile almond, oat and soya drinks. Replacing cows' milk with 'typical' nutrient profile almond, oat and soya drinks would be associated with lower intakes of these micronutrients and higher risks of inadequate nutrient intakes especially in children aged 1 to 5 years.

2.112 At the time the substitution analysis was conducted (January 2022), most plant-based drink products were fortified with calcium and riboflavin at equivalent or similar levels to cows' milk and vitamin B12 at slightly lower levels. Therefore, replacing cows' milk with 'typical' nutrient profiles of almond, oat and soya drinks would be expected to have a negligible impact on intakes of these nutrients. This is especially so if bioavailability is assumed to be comparable. However, there is some limited evidence that micronutrient fortificants may be less bioavailable than micronutrients that are naturally present in foods and drinks.

2.5.2 'Enhanced' nutrient profile

2.113 In comparison to 'typical' nutrient profile almond, oat and soya drinks, the 'enhanced' nutrient profile almond, oat and soya drinks did not include free sugars. In addition to commonly used fortificants, they also included vitamin A and iodine at comparable levels to those found in cows' milk.

2.5.3 'Unfortified and/or sweetened' profile

2.114 Replacing cows' milk with almond, oat and soya drinks containing sugars added as an ingredient would increase the risk of higher intakes of free sugars.

2.115 Where cows' milk makes an important contribution to intakes of micronutrients, the substitution analysis indicated that there may be a risk of inadequate micronutrient intakes if cows' milk is replaced with unfortified versions of almond, oat and soya drinks (or versions fortified at lower levels than cows' milk). For calcium and riboflavin this might be associated with overall inadequate intakes relative to requirements. Vitamin B12 intakes are adequate in the general population. However, people following a vegan diet are at risk of inadequate vitamin B12 intakes and consuming unfortified plant-based drinks might exacerbate this risk.

2.6 Replacing cows' milk with water

2.116 The impact of consuming water instead of cows' milk is governed by the volume and type of milk consumed, and relative importance of milk as a contributor to specific nutrients for different age groups. As with plant-based drinks, replacement of cows' milk with water would result in lower intakes of energy and saturated fats.

2.117 Replacing cows' milk with water would have a detrimental impact on intakes of a range of micronutrients including vitamin A, riboflavin, folate, vitamin B12, calcium, iodine, zinc, magnesium and potassium in some age groups, and could lead to an increase in prevalence of inadequate intakes.

2.118 Replacing cows' milk with water would have a greater impact on micronutrient intakes and the prevalence of inadequate intakes in the population than replacing cows' milk with 'typical' nutrient profile almond, oat and soya drinks.

2.119 Key issues include:

- an increased prevalence of inadequate vitamin A intakes, most noticeably in children aged 1 to 5 years who consume the most whole milk
- inadequate calcium intakes and increased prevalence of low intakes in children aged 11 to 18 years and adults aged 50 to 64 years, 65 to 74 years, 75 years and over
- inadequate intakes of iodine and increased prevalence of low intakes, most significantly in children aged 1 to 18 years

2.7 Updates following peer review

2.120 The draft SACN and COT report was issued for peer review in July 2024. In line with SACN's process for conducting risk assessments, only new evidence or data that had the potential to change the report's conclusions or recommendations were considered following peer review.

2.121 The draft SACN and COT report (2024) noted that ahead of publication of the final report, it might be necessary to repeat the substitution analysis using updated data (see limitations section in chapter 4). However, SACN and COT agreed that updating the substitution analysis would be unlikely to change the report's conclusions or recommendations.

2.122 SACN and COT recognised that the plant-based drinks market was continuing to evolve. Throughout the period of the SACN and COT assessment, there have been changes to the nutrient composition of plant-based drinks in the UK. This has resulted in more products being fortified with micronutrients and being lower in sugar (Wall and others, 2023). SACN and COT noted that modelling the impact of replacing cows' milk with the 'enhanced' nutrient profiles future proofs the substitution analysis.

2.123 In addition, SACN and COT noted that the updated values for the content of selected micronutrients in cows' milk were unlikely to change the report's conclusions or recommendations.

3. Benefit-Risk Analysis for Foods

3.1 Background

3.1 Benefit-risk assessment aims to simultaneously compare the beneficial and adverse health outcomes associated with consumption of food or drinks to arrive at an overall view on the net benefit or risk associated with a particular consumption scenario. Benefit-risk assessment of plant-based drinks in comparison to cows' milk is particularly complex. This is because there are potentially both nutritional and toxicological risks and benefits (or reduced risks) associated with cows' milk and with plant-based drinks, with these differing to some extent between the types of plant-based drinks. Various approaches can be taken to this type of assessment.

3.2 To compare the benefits and risks of replacing cows' milk with plant-based drinks, it was agreed that the Benefit-Risk Analysis for Foods (BRAFO) methodology should be used (Hoekstra and others, 2012). BRAFO takes a tiered approach starting with pre-assessment and formulation of the problem to determine the scope of the assessment, defining 2 scenarios, which are:

- a reference scenario (usually the current scenario)
- an alternative scenario

3.3 The stages of BRAFO are:

- Tier 1, which identifies and assesses individual risks and benefits (this may be sufficient if there is no benefit or no risk identified of one scenario over the other)
- Tier 2, which qualitatively integrates the risks and benefits (this may be sufficient if there is a clear advantage or disadvantage of one scenario)
- Tier 3 and Tier 4, which involve quantitative integration of the risks and benefits

3.2 Pre-assessment and problem formulation

3.4 The BRAFO conducted for this report considered both nutritional and toxicological aspects associated with replacing consumption of cows' milk with plant-based drinks in children (aged 1 year and over) and adults in the UK. A particular focus was on children aged 1 to 5 years (from 12 months up to their fifth birthday, that is 60 months).

3.5 The reference scenario was cows' milk consumption (total volumes of all types of cows' milk consumed by participants in UK dietary surveys) while there were 3 alternative scenarios: the complete replacement of cows' milk with almond, oat or soya drinks.

3.6 Three nutrient profiles were modelled for each plant-based drink type (see nutritional substitution analysis in chapter 2). In total, 9 different plant-based drink nutrient profiles were modelled. Combinations of plant-based drinks were not considered.

3.7 The problem formulation was as follows:

- does complete replacement of cows' milk with almond drinks lead to overall beneficial or adverse outcomes in children aged 1 year and over and in all adult ages?
- does complete replacement of cows' milk with oat drinks lead to overall beneficial or adverse outcomes in children aged 1 year and over and in all adult ages?
- does complete replacement of cows' milk with soya drinks lead to overall beneficial or adverse outcomes in children aged 1 year and over and in all adult ages?

3.8 The BRAFO considered 2 main areas, which were:

- nutritional considerations comparing the differing energy, macronutrient and micronutrient content
- toxicological considerations comparing the levels of both natural constituents and chemical contaminants that could be present in plant-based drinks and cows' milk

3.3 Triage stage and Tier 1 BRAFO

3.9 The main nutrients and chemical contaminants and naturally occurring components present or potentially present in cows' milk and in almond, oat and soya drinks were preliminarily assessed in the triage stage to determine which of these should be included in Tier 1 BRAFO.

3.10 Nutritional and toxicological considerations were analysed separately to reflect differences in the available evidence bases and how the certainty of the evidence is assessed.

3.3.1 Nutritional considerations

3.11 Decisions regarding which nutrients should be considered in the initial triage stage were informed by:

- the functions of each nutrient and current UK dietary recommendations on requirements for that nutrient by age group
- findings from DNSIYC (2011) and NDNS 2016 to 2019 (see chapter 2), including intakes of each nutrient by age group compared with dietary recommendations, and the prevalence of intakes below the lower reference nutrient intake (LRNI) or above the reference nutrient intake (RNI)
- whether intakes of each nutrient are a public health concern
- average cows' milk consumption and its contribution to intakes of each nutrient by age group (see chapter 2)
- the nutritional substitution analysis showing the potential impact on intakes of each nutrient if cows' milk is replaced with plant-based drinks (see chapter 2)
- the approach to micronutrient fortification of plant-based drinks at the time the substitution analysis was conducted (January 2022)
- evidence on each nutrient and related health outcome as assessed in SACN or COMA evidence evaluations, including an assessment of the quality or certainty of the evidence if available (see SACN's 'Framework and methods for the evaluation of evidence that relates food and nutrients to health' on the SACN webpage for details)
- a rapid scoping review on protein intakes in children aged 1 to 5 years (see Annex 4)
- whether the modelled changes in intake of the nutrient arising from replacing cows' milk with each of the 3 nutrient profiles for each plant-based drink type are of sufficient magnitude to be associated with potential health benefits or risks of public health significance for different age groups (it should be noted that the extent of the benefits and risks is dependent on which nutrient profile is used for each plant-based drink)

3.12 Evidence on the bioavailability of the micronutrient fortificants commonly added to plant-based drinks compared with that of micronutrients naturally present in cows' milk is limited and therefore was not considered (see chapter 2).

3.13 Some of the nutrients considered in the triage stage:

- were considered by SACN before 2015 (before evidence was formally assessed for its certainty or strength for any relationship between a nutrient and health outcome)
- have not been subject to a SACN risk assessment but are on SACN's work programme at the time of publication of this report (2025)
- have not been subject to a SACN risk assessment and are not on SACN's work programme

3.14 The following nutrients were identified for consideration at the triage stage:

- energy
- macronutrients: protein, saturated fat, free sugars, dietary fibre
- vitamins: vitamin A, riboflavin, folate, vitamin B12, vitamin D
- minerals: calcium, magnesium, potassium, zinc, iodine

3.15 Each nutrient was considered individually, and a decision was made as to whether to take the nutrient forward to Tier 1 analysis. Details of these considerations are provided below.

Energy

3.16 Findings from DNSIYC (2011) and NDNS (2016 to 2019) indicated that mean energy intakes were below the Estimated Average Requirement (EAR) in all age groups except for children aged 1.5 to 3 years. However, this is likely to be due to underreporting of energy intakes, a common issue in dietary surveys (Mirmiran and others, 2006). Other evidence indicates that energy intakes are above the EAR (OHID, 2024).

3.17 Contribution of cows' milk to energy intakes were:

- around 20% for children aged 12 to 18 months
- 13% for children under 5 years
- 6% for children aged 5 to 10 years
- 4% for children aged 11 to 18 years

- 3 to 4% for adults aged 19 to 74 years
- 7% for older adults aged 75 years and over

3.18 Findings from the substitution analysis indicated that replacing cows' milk with almond, oat and soya drinks would reduce energy intakes in all age groups because these plant-based drinks have a lower energy content than cows' milk. The substitution analysis did not look at the impact of replacing different types of cows' milk (whole, semi-skimmed and skimmed) with different plant-based drinks. Semi-skimmed cows' milk is the most commonly consumed milk in the UK. It has a higher energy content than unsweetened almond or soya drinks but a similar energy content to unsweetened oat drinks.

3.19 The largest reduction in energy intakes would be seen in children aged 1 to 5 years who obtain the highest proportion of energy intake from (mostly whole) cows' milk compared with other age groups.

3.20 Evidence from previous SACN reports suggests that:

- energy intakes that consistently exceed requirements lead to weight gain and obesity in the long term (SACN, 2011a)
- overweight and obesity increases the risk of other health outcomes such as type 2 diabetes (T2D), insulin resistance, hypertension, dyslipidaemia, some cancers (SACN, 2011a)
- higher child BMI or weight status at age 1 to 5 years is associated with higher adult BMI or risk of adult overweight or obesity (SACN, 2023a)

Protein

3.21 Findings from DNSIYC (2011) and NDNS (2016 to 2019) indicated that mean protein intakes were high and exceeded the RNI in all age groups. There was also some evidence identified from primary studies (see Annex 4) indicating that mean protein intakes in children aged 1 to 5 years following a vegan or vegetarian diet met or exceeded the RNI, although intakes were lower than those in children consuming an omnivorous diet.

3.22 Contribution of cows' milk to protein intakes were:

- 23% for children aged 12 to 18 months
- 19% for children aged 1.5 to 5 years

- 6% to 11% for older children (up to age 18 years) and adults (aged up to 74 years)
- 12% for older adults (aged 75 years and over)

3.23 Replacing cows' milk with:

- soya drink would have no impact on protein intakes because soya drink has comparable protein content to cows' milk
- almond and oat drinks would reduce protein intakes because these are lower in protein content than cows' milk

3.24 Evidence from previous SACN reports indicates that:

- insufficient protein intake is associated with growth restriction (SACN, 2018)
- higher total protein intake in children aged 1 to 5 years is associated with higher BMI in childhood (SACN, 2023a)
- low risk of impact on growth from lower protein content in almond and oat drinks due to high mean intakes of protein across all age groups – children aged 1 to 5 years following a vegan diet may be an exception to this (see Annex 4)

3.25 It should be noted that protein is on SACN's future work programme.

Saturated fat

3.26 Findings from DNSIYC (2011) and NDNS (2016 to 2019) indicated that mean saturated fat intakes in all age groups exceeded the UK government recommendation that intakes should be no more than 10% of energy excluding ethanol (hereafter shortened to 10% energy).

3.27 Contribution of cows' milk to saturated fat intakes were:

- 34% for children aged 12 to 18 months
- 25% for children aged 1.5 to 5 years
- 6 to 11% for older children (up to age 18 years), adults (up to age 74 years) and older adults (aged 75 years and over)

3.28 Replacing whole or semi-skimmed cows' milk with almond, oat and soya drinks would result in reduced saturated fat intakes in all age groups because almond, oat and soya drinks are lower in saturated fat than these types of cows' milk. It would also increase the proportion of the population with saturated fat intakes of no more than 10% energy intake.

3.29 A reduction in saturated fat intake would also contribute to lower population energy intakes.

3.30 Evidence from a previous SACN report (SACN, 2019) suggests that reducing saturated fat intake reduces the risk of cardiovascular disease (CVD) and coronary heart disease (CHD) events, lowers total LDL and HDL cholesterol and improves indicators of glycaemic control (T2D).

Free sugars

3.31 Findings from DNSIYC (2011) and NDNS (2016 to 2019) indicated that intakes of free sugars in:

- all age groups exceeded the UK government recommendation that the population average intake should be no more than 5% of energy intake, excluding ethanol
- children aged 4 to 18 years were more than double the maximum recommended intake
- adults and children aged under 5 years were about double the maximum recommended intake

3.32 Cows' milk contains lactose, a sugar that is naturally present in milk and is excluded from the definition of 'free sugars'. Sugars present in almond, oat and soya drinks (either added as an ingredient or present due to the manufacturing process) are free sugars by definition (Swan and others, 2018). For the purposes of this report, 'sweetened' nutrient profiles of almond, oat and soya drinks are based on products which contain sugars added as an ingredient (see chapter 2).

3.33 Replacing cows' milk with:

- 'sweetened' almond, oat and soya drinks would result in increased intakes of free sugars and would increase the proportion of the population with intakes of free sugars above the maximum level recommended by the UK government
- the 'typical' nutrient profiles of almond, oat and soya drinks, especially oat drinks where free sugars are released during the manufacturing process, would result in a small increase in free sugars intake

3.34 Evidence from previous SACN reports suggests that:

- higher intakes of free sugars in children aged 1 to 5 years is associated with increased dental caries (increment, incidence or prevalence) in childhood and adolescence (SACN, 2023a)

- in the general population, the direction of the association indicates that greater consumption of sugars is detrimental to oral health (SACN, 2015)

- studies in adults indicate that higher intakes of free sugars are associated with increased energy intake (SACN, 2015)

Sugar-sweetened beverages (SSBs)

3.35 For the purposes of this report, ‘sweetened’ almond, oat and soya drinks (containing sugars added as an ingredient) are considered to be sugar-sweetened beverages (SSBs). The UK government advises that children aged 1 to 5 years should not be given SSBs (including sweetened plant-based drinks), while older children and adults are advised to reduce consumption of SSBs. With respect to plant-based drinks, the advice is to choose unsweetened versions.

3.36 Replacing cows’ milk with ‘sweetened’ almond, oat or soya drinks would increase SSB consumption in all age groups.

3.37 Evidence from a previous SACN report (SACN, 2015) indicates that:

- in children aged under 18 years, greater consumption of SSBs is detrimental to oral health and is linked to weight gain and higher BMI

- in adults, greater consumption of SSBs increases the risk of T2D

Dietary fibre

3.38 Findings from DNSIYC (2011) and NDNS (2016 to 2019) indicated that mean dietary fibre intakes are below UK dietary recommendations in all age groups.

3.39 Replacing cows’ milk with almond, oat and soya drinks would result in increased fibre intakes in all age groups (cows’ milk does not contain fibre, whereas almond, oat and soya drinks do); however, mean intakes would still be below UK government recommendations.

3.40 Evidence from a previous SACN report (SACN, 2015) indicates that higher consumption of dietary fibre is associated with reduced incidence of CVD, coronary events, haemorrhagic plus ischemic stroke, T2D, colorectal cancer, colon cancer and constipation.

Vitamin A

3.41 Findings from DNSIYC (2011) and NDNS (2016 to 2019) indicated that mean vitamin A intakes in all age groups were adequate (above the RNI). However, 9% of children aged 1.5 to 3 years, 10 to 11% of children aged 4 to 10 years, and 18% of children aged 11 to 18 years had vitamin A intakes (from diet only) below the LRNI. Data on vitamin A intake should be interpreted with caution as there are a number of uncertainties around assessing vitamin A intakes (SACN, 2023a).

3.42 Vitamin A status data from NDNS (2008 to 2019) indicated that 7% of children aged 1.5 to 3 years had blood retinol concentrations below 0.70μmol per litre (SACN, 2023a). This is considered to be indicative of inadequate vitamin A status in young children (EFSA, 2015b; Tanumihardjo and others, 2016; WHO, 2011).

3.43 Data from DNSIYC and NDNS indicated that between 2% and 4% of children aged up to 5 years may have had intakes above the tolerable upper limit (TUL) when taking into account both diet and supplements (the TUL only applies to retinol, not to other forms of vitamin A such as carotenoids) (SACN, 2023a).

3.44 Contribution of cows' milk to vitamin A intakes were:

- 16% for children aged 1 to 5 years – secondary analysis of data from NDNS (2008 to 2019) indicated that children in this age group with vitamin A intakes below the LRNI obtained a higher proportion of their vitamin A intake from milk (and other dairy products) compared with children with intakes at or above the LRNI (SACN, 2023a)

- 7 to 9% for older children (up to age 18 years)

- 5 to 6% for adults (all age groups)

3.45 Vitamin A is not naturally present in almond, oat and soya drinks. Replacing cows' milk with 'unfortified and/or sweetened' or 'typical' nutrient profile almond, oat or soya drinks would result in reduced vitamin A intakes and an increase in the proportion of the population with intakes below the LRNI, most markedly in children aged 12 to 18 months and 1.5 to 5 years.

3.46 The 'enhanced' nutrient profiles of almond, oat and soya drinks include fortification with vitamin A at levels comparable with semi-skimmed cows' milk.

3.47 Evidence from previous SACN reports (SACN, 2005; SACN, 2023a) suggests that vitamin A deficiency can adversely affect several physiological functions, such as vision, immunity, and worsening of low iron status.

Riboflavin

3.48 Findings from DNSIYC (2011) and NDNS (2016 to 2019) indicated that mean riboflavin intakes across the population were adequate (above the RNI) but a substantial proportion of the 11 to 18 year age group and adult women (over 10%) had intakes below the LRNI.

3.49 Contribution of cows' milk to riboflavin intakes were:

- 37% to 40% for children aged 1 to 5 years
- 25% for children aged 5 to 10 years
- 16% to 21% for older children (aged 11 to 18 years) and adults (aged up to 74 years)
- 27% for older adults (aged 75 years and over)

3.50 Riboflavin is not naturally present in almond, oat and soya drinks. 'Typical' and 'enhanced' nutrient profile plant-based drinks include fortification with riboflavin at levels comparable with cows' milk.

3.51 There would likely be no impact on riboflavin intakes if cows' milk is replaced with fortified almond, oat or soya drinks. If cows' milk was replaced with unfortified drinks, this would reduce riboflavin intakes and increase the proportion of children aged 11 to 18 years and adult women with intakes below the LRNI.

3.52 Riboflavin has not been subject to a SACN risk assessment. Not meeting UK dietary recommendations for riboflavin could increase the risk of impaired growth, cheilosis (angular stomatitis) and dermatitis (WHO, 2004).

Folate

3.53 Findings from DNSIYC (2011) and NDNS (2016 to 2019) indicated that mean folate intakes were adequate (meet the RNI) in all age groups. However, 9% of children aged 11 to 18 years had intakes below the LRNI.

3.54 Contribution of cows' milk to folate intakes were:

- 20% for children aged 12 to 18 months
- 13% for children aged 1.5 to 5 years
- 4 to 7% for older children (up to age 18 years) and adults (all age groups)

3.55 Folate is naturally present in soya drinks at similar levels to cows' milk, whereas oat and almond drinks naturally contain higher and lower amounts, respectively. At the time of the assessment, only a few products were fortified with folic acid (the synthetic form of folate).

3.56 Replacing cows' milk with almond, oat or soya drinks would have a negligible impact on folate intakes and mean intakes would remain above the RNI.

3.57 Replacing cows' milk with soya and oat drinks would marginally decrease the proportion of the population aged 11 to 18 years who have intakes below the LRNI (from 10% with cows' milk in the diet to 9% with soya drink and 8% with oat drink in the diet).

3.58 Replacing cows' milk with almond drink would marginally increase the proportion of the population aged 11 to 18 years with intakes below the LRNI from 10% to 11%.

3.59 Evidence from previous SACN reports (SACN, 2006; SACN, 2017) indicates that:

- shortage of folate compromises the formation and maturation of red blood cells in the bone marrow and leads to anaemia
- maternal folate deficiency is one of the main risk factors for neural tube defect affected pregnancies (SACN, 2006; SACN, 2017)

Vitamin B12

3.60 Findings from DNSIYC (2011) and NDNS (2016 to 2019) indicated that mean vitamin B12 intakes were adequate (well above the RNI) and the proportions of the population with intakes below the LRNI were very low.

3.61 Contribution of cows' milk to vitamin B12 intakes were:

- over 40% for children under 5 years
- 30% for children aged 5 to 10 years
- 22% for children aged 11 to 18 years and
- 18 to 25% for adults (aged 19 to 74 years); and 31% for older adults (aged 75 and over)

3.62 Vitamin B12 is not naturally present in almond, oat and soya drinks.

3.63 'Typical' and 'enhanced' nutrient profile plant-based drinks include fortification with vitamin B12. Vitamin B12 levels in cows' milk used for this analysis (based on laboratory analysis in 1996) were higher than the levels in vitamin B12 fortified plant-based drinks. Updated analysis of vitamin B12 in cows' milk (OHID, 2025b) indicates that levels are lower than the previous analysis and are similar to the levels added to B12-fortified plant-based drinks.

3.64 Replacing cows' milk with almond, oat or soya drinks would have little impact at a population level if drinks were fortified with vitamin B12. Even if cows' milk was replaced with unfortified products, mean intakes of vitamin B12 would still be above the RNI in all age groups and the risk of inadequate intakes would be very low.

3.65 Not meeting UK government recommendations for vitamin B12 could increase the risk of pernicious anaemia and impaired neurological development in young children (WHO, 2004).

Vitamin D

3.66 Findings from DNSIYC (2011) and NDNS (2016 to 2019) indicated that mean vitamin D intakes from the diet were well below the RNI in all age groups.

3.67 Cows' milk, which contains trace amounts of vitamin D, is not usually fortified with vitamin D.

3.68 'Typical' and 'enhanced' nutrient profile plant-based drinks include fortification with vitamin D. Therefore, replacing cows' milk with vitamin D-fortified plant-based drinks may increase vitamin D intakes at a population level.

3.69 Evidence from a previous SACN report (SACN, 2016) indicated that the risk of poor musculoskeletal health is increased at serum vitamin D (25-hydroxyvitamin D) concentrations of less than 25 nanomole per litre. SACN based its recommendation on a review of the evidence on rickets, osteomalacia, falls and muscle strength and function. Vitamin D may also reduce the risk of acute respiratory tract infection (SACN, 2020).

Calcium

3.70 Findings from DNSIYC (2011) and NDNS (2016 to 2019) indicated that mean calcium intakes in the UK were:

- below the RNI for children aged 11 to 18 years, with a substantial proportion of this age group (above 10%) below the LRNI
- below the LRNI in 9% of women aged 19 to 64 and 64 to 75 years
- adequate (relative to the LRNI) in other age groups

3.71 Contribution of cows' milk to calcium intakes were:

- 37% to 38% for children aged 1 to 5 years
- 26% for children aged 5 to 10 years
- 17% to 23% for children aged 11 to 18 years, and for adults
- 30% for older adults (aged 75 years and over)

3.72 'Typical' and 'enhanced' nutrient profile almond, oat and soya drinks include fortification with calcium at levels comparable to cows' milk.

3.73 Replacing cows' milk with unfortified almond, oat and soya drinks would increase the proportion of the population in all age groups with calcium intakes below the LRNI, especially children aged 11 to 18 years.

3.74 Not meeting UK government recommendations for calcium could increase the risk of musculoskeletal health outcomes, such as rickets, osteomalacia, osteoporosis, and fractures (IOM, 2011; SACN, 2012; WHO, 2004).

3.75 Calcium is on SACN's watching brief.

Potassium

3.76 Findings from DNSIYC (2011) and NDNS (2016 to 2019) indicated that mean potassium intakes in the UK were above the RNI for children aged up to 10 years but were well below the RNI for children aged 11 to 18 years and adults. A substantial proportion (over 10%) of these age groups had potassium intakes below the LRNI.

3.77 Contribution of cows' milk to potassium intakes were:

- 25% for children aged 12 to 18 months
- 20% for children aged 1.5 to 5 years
- 7% to 9% for older children (up to 18 years) and adults (aged up to 74 years)
- 13% for older adults (aged 75 years and older)

3.78 Potassium is naturally present in almond, oat and soya drinks but at lower levels than in cows' milk, particularly in the case of almond and oat drinks. Almond, oat and soya drinks are not usually fortified with potassium.

3.79 Replacing cows' milk with almond, oat or soya drinks would result in a small reduction in mean intakes and a small increase in the percentage of children aged 11 to 18 years and adults with potassium intakes below the LRNI, particularly when replaced with almond or oat drinks.

3.80 Evidence from a previous SACN and COT risk assessment (SACN and COT, 2017) indicates that:

- increasing potassium intakes through supplements, diet, or both, and decreasing dietary sodium intakes, have been associated with a number of positive health effects; these could apply to the whole population or specific 'at risk' population groups

- potential benefits of increased potassium intakes include reduced systolic and diastolic blood pressure, reduced risk of stroke and improved bone health

Iodine

3.81 Findings from DNSIYC (2011) and NDNS (2016 to 2019) indicated that mean iodine intakes in the UK were below the RNI for girls aged 11 to 18 years and a substantial proportion (over 10%) had intakes below the LRNI.

3.82 Contribution of cows' milk to iodine intakes were:

- around 50% for children aged 1 to 5 years; high level (97.5th percentile) consumption of cows' milk can result in small exceedances of the relevant health-based guidance values (HBGV), but this is not thought to be of concern for this age group (COT, 2023b)

- 35% for children aged 5 to 10 years

- 27% for children aged 11 to 18 years

- 20 to 26% for adults aged up to 74 years

- 33% for older adults (aged 75 years and over)

3.83 Almond, oat and soya drinks have negligible amounts of naturally occurring iodine. Most almond, oat and soya drinks sold in the UK were not fortified with iodine at the time the assessment was conducted in 2022. However, fortification with iodine has since become more common.

3.84 Iodine levels in cows' milk used for this analysis (based on laboratory analysis in 1996) were higher than those indicated in updated analysis of iodine in cows' milk

(OHID, 2025b). However, the updated values remain higher than the values for iodine used in the 'typical' nutrient profiles for almond, oat and soya drinks.

3.85 Replacing cows' milk with 'typical' almond, oat or soya drinks would result in reduced iodine intakes and a substantial increase in the proportion of the population (all age groups) with intakes below the LRNI. The impact would be greatest for children aged 1 to 5 years because they consume the largest volume of cows' milk.

3.86 Not meeting UK government recommendations for iodine could increase the risk of impaired thyroid function and potential defective reproduction, growth impairments and neurodevelopmental damage to the fetus in deficient pregnant or lactating women. Iodine is on SACN's future work programme.

Zinc

3.87 Findings from DNSIYC (2011) and NDNS (2016 to 2019) indicated that mean zinc intakes in the UK were below the RNI in children aged 1.5 to 18 years and a substantial proportion of children aged 1.5 to 4 years and 11 to 18 years (over 10%) had intakes below the LRNI.

3.88 It should be noted that there is uncertainty in the estimates of the proportion of children at risk of zinc inadequacy. This is because there is no suitable biomarker of mild-to-moderate zinc deficiency (SACN, 2023a). A reliable means of assessing status would help to determine physiological requirements and consequently the required dietary intakes needed to meet these (COMA, 1991).

3.89 Contribution of cows' milk to zinc intakes are:

- 19% to 23% for children under 5 years
- 8% to 11% for older children (up to 18 years) and adults (up to 74 years)
- 12% for older adults (75 years and over)

3.90 Zinc is naturally present in almond, oat and soya drinks but at lower levels than cows' milk. Almond drinks contain less zinc than soya or oat drinks.

3.91 Replacing cows' milk with almond drinks (but not oat or soya drinks) would increase the proportion of children aged 1 to 18 years with intakes below the LRNI.

3.92 Zinc is present in all tissues and is an essential component of a number of enzymes with structural, regulatory or catalytic roles. It plays a role in immune function, protein and DNA synthesis, wound healing and cell signalling and division; it also supports growth.

3.93 Zinc has not been subject to a SACN risk assessment.

Magnesium

3.94 Findings from DNSIYC (2011) and NDNS (2016 to 2019) indicated that mean magnesium intakes in the UK were above the RNI for children aged under 11 years but below the RNI for children aged 11 to 18 years and for adults.

3.95 Contribution of cows' milk to magnesium intakes were:

- 20% for children aged 12 to 18 months
- 16% for children under 5 years
- 5 to 9% for older children (up to age 18 years) and adults (up to age 74 years)
- 10% for older adults (aged 75 years and over)

3.96 Compared with cows' milk, soya drinks naturally contain higher amounts of magnesium, while oat drinks contain similar amounts, and almond drinks contain lower amounts. Almond, oat and soya drinks are not usually fortified with magnesium. There would be a negligible impact of replacing cows' milk with almond, oat or soya drinks.

3.97 Magnesium is a cofactor in a large number of enzyme systems that regulate diverse biochemical reactions in the body, including protein synthesis, muscle and nerve function, blood glucose control and blood pressure regulation. It plays a role in skeletal development and is also required for energy production. Magnesium is on SACN's watching brief.

Salt (sodium)

3.98 Findings from DNSIYC (2011) and NDNS (2016 to 2019) indicated that mean salt (sodium) intakes in the UK were above recommendations for all age groups.

3.99 Contribution of cows' milk to sodium intakes were:

- 14% for children aged 12 to 18 months
- 10% for children under 5 years
- 3% to 6% for older children (up to 18 years) and adults

3.100 Compared with cows’ milk, almond, oat and soya drinks contain similar amounts of salt. There would be a negligible impact of replacing cows’ milk with almond, oat or soya drinks.

3.101 A previous risk assessment by SACN (2003) concluded that reducing the average population salt intake would proportionally lower population average blood pressure levels and confer significant public health benefits by contributing to a reduction in the burden of cardiovascular disease.

3.3.2 Tier 1 analysis: nutritional considerations

Background

3.102 Based on the nutritional considerations detailed above, the following nutrients were included in the Tier 1 analysis for:

- soya drinks: energy, protein, saturated fat, free sugars, fibre, vitamin A, riboflavin, vitamin B12, vitamin D, calcium, iodine
- oat drinks: energy, protein, saturated fat, free sugars, fibre, vitamin A, riboflavin, vitamin B12, vitamin D, calcium, potassium, iodine
- almond drinks: energy, protein, saturated fat, free sugars, fibre, vitamin A, riboflavin, vitamin B12, vitamin D, calcium, potassium, iodine, zinc

3.103 Nutrients not included in the Tier 1 analysis were:

- folate
- magnesium
- potassium (soya drinks only)

3.104 Folate was not included in Tier 1 analysis on the basis that cows' milk and the 3 plant-based drinks under consideration all contain low levels of folate. Therefore, replacing cows' milk with almond, oat or soya drinks would minimally impact folate intakes in all age groups.

3.105 Magnesium was not included in Tier 1 analysis on the basis that replacing cows’ milk with almond, oat or soya drinks would minimally impact magnesium intakes in all age groups.

3.106 Potassium was not included in Tier 1 analysis for soya drinks on the basis that replacing cows’ milk with soya drinks would minimally impact potassium intakes in all age groups. Although mean potassium intakes in children aged 11 to 18 years and adults were below the RNI, the contribution of cows’ milk to potassium intakes in these age groups is also relatively low.

3.107 Salt was also not included in the Tier 1 analysis on the basis that replacing cows' milk with almond, oat or soya drinks would minimally impact salt intakes in all age groups.

3.108 Each nutrient was assessed to establish whether the alternative scenario, in which cows’ milk (the 'reference' scenario) is replaced with ‘typical’ nutrient profiles for almond, oat and soya drinks, was associated with benefits or risks. Replacement of cow's milk with 'enhanced' and 'unfortified and/or sweetened' nutrient profiles was also considered.

3.109 ‘Typical’ nutrient profiles (that is, those based on the top selling products, regardless of their nutrient profile) for each plant-based drink type were used in this assessment to ensure a more realistic benefit-risk assessment.

3.110 At the time the substitution analysis was conducted (January 2022), plant-based drinks were typically fortified with riboflavin, vitamin B12 and calcium at comparable levels to cows’ milk (but not iodine or vitamin A). These products were also typically fortified with vitamin D. The ‘typical’ nutrient profiles for each drink type, including the levels of micronutrient fortificants used in the nutritional substitution analysis, are provided in Annex 1.

3.111 The nutrient profile for cows’ milk (the 'reference' scenario against which the alternative scenarios were compared) was established using total volumes of all types (whole, semi-skimmed and skimmed) of cows’ milk consumed by survey participants in the NDNS (2016 to 2019) and the DNSIYC.

3.112 The outcomes of the Tier 1 analysis for the nutrients under consideration are detailed below.

Energy

3.113 The impact of the alternative scenario (replacing cows’ milk with ‘typical’ nutrient profile plant-based drinks) was that it:

- would be beneficial at a population level as 'typical' nutrient profile plant-based drinks are lower in energy than cows’ milk and energy intakes exceed requirements in all age groups
- could result in an undesirable reduction in energy intakes for people, especially children aged 1 to 5 years, living with underweight

3.114 The largest reduction in energy intakes would be seen in children aged 1 to 5 years who obtain the highest proportion of energy intake from (mostly whole) cows' milk compared with other age groups.

3.115 The Tier 1 conclusion was that the alternative scenario (for all plant-based drink types) could be beneficial for all population groups except for people, especially children, living with underweight.

Protein

3.116 The impact of the alternative scenario (replacing cows' milk with 'typical' nutrient profile plant-based drinks) was that it:

- would have no impact for the general population
- could result in lower protein intakes for children aged 1 to 5 years following a vegan diet if they consume almond or oat drinks rather than soya drinks

3.117 The Tier 1 conclusion was that there is no clear difference between scenarios, except for children aged 1 to 5 years following a vegan diet where the alternative scenario of oat or almond drink could be potentially detrimental.

Saturated fat

3.118 The impact of the alternative scenario (replacing cows' milk with 'typical' nutrient profile plant-based drinks) was that it could be beneficial at a population level as 'typical' nutrient profile plant-based drinks are lower in saturated fat than whole and semi-skimmed cows' milk and mean saturated fat intakes exceed dietary reference values (DRVs) in all age groups.

3.119 The Tier 1 conclusion was that the alternative scenario (for all plant-based drink types) could be beneficial for all age groups.

Free sugars

3.120 The impact of the alternative scenario (replacing cows' milk with 'typical' nutrient profile plant-based drinks) was that it could be detrimental at a population level as sugars in plant-based drinks are free sugars by definition and mean intakes of free sugars exceed maximum recommendations in all age groups. The largest increase in intakes of free sugars would be in children aged 1 to 5 years who consume the largest volumes of cows' milk.

3.121 The Tier 1 conclusion was that the alternative scenario (for all plant-based drink types) could be detrimental for all population groups, especially children aged 1 to 5 years.

Dietary fibre

3.122 The impact of the alternative scenario (replacing cows' milk with 'typical' nutrient profile plant-based drinks) was that it would be beneficial at a population level as all plant-based drinks contain fibre whereas cows' milk contains no fibre and fibre intakes do not meet recommendations in all age groups.

3.123 Tier 1 conclusion was that the alternative scenario (for all plant-based drink types) could be beneficial for all age groups.

Vitamin A

3.124 The impact of the alternative scenario (replacing cows' milk with 'typical' nutrient profile plant-based drinks) was that it could be detrimental at a population level because naturally occurring levels of vitamin A in plant-based drinks are negligible and 'typical' nutrient profile plant-based drinks do not include vitamin A as a fortificant.

3.125 Children aged 1 to 5 years could be most impacted as cows' milk makes a substantial contribution to vitamin A intakes in this age group.

3.126 The Tier 1 conclusion was that the alternative scenario (for all plant-based drink types) could be detrimental for children aged 1 to 5 years.

Riboflavin

3.127 The alternative scenario (replacing cows' milk with 'typical' nutrient profile plant-based drinks) was that it:

- would have no impact as 'typical' nutrient profile plant-based drinks include riboflavin as a fortificant
- could result in lower riboflavin intakes if the alternative scenario is unfortified almond, oat or soya drinks

3.128 The Tier 1 conclusion was that:

- there is no clear difference between scenarios for all age groups
- replacing cows' milk with unfortified plant-based drinks could be detrimental for all age groups

Vitamin B12

3.129 The impact of the alternative scenario (replacing cows' milk with 'typical' nutrient profile plant-based drinks) was that it would have no impact as 'typical' nutrient profile drinks include vitamin B12 as a fortificant and intakes are well above the RNI for vitamin B12.

3.130 If the alternative scenario is unfortified almond, oat or soya drinks, it could be detrimental for people who are at risk of inadequate vitamin B12 intakes, such as those following a vegan diet.

3.131 The Tier 1 conclusion was that there:

- is no clear difference between scenarios for all age groups
- consuming unfortified plant-based drinks could be detrimental for people who follow a vegan diet who are at greater at risk of inadequate vitamin B12 intakes than individuals who consume animal products

Vitamin D

3.132 The impact of the alternative scenario (replacing cows' milk with 'typical' nutrient profile plant-based drinks) was that:

- it could be beneficial as 'typical' nutrient profile plant-based drinks include vitamin D as a fortificant (and there is very little vitamin D that is naturally present in cows' milk)
- vitamin D intakes are below the RNI in all age groups

3.133 The Tier 1 conclusion was that the alternative scenario (for all plant-based drink types) could be beneficial for all age groups.

Calcium

3.134 The impact of the alternative scenario (replacing cows' milk with 'typical' nutrient profile plant-based drinks) was that it would:

- have no impact, as 'typical' nutrient profile plant-based drinks include calcium as a fortificant
- result in lower calcium intakes if unfortified plant-based drinks replaced cows' milk, which could be detrimental for all age groups, especially children aged 11 to 18 years

3.135 The Tier 1 conclusion was that:

- there is no clear difference between scenarios

- replacing cows' milk with unfortified plant-based drinks could be detrimental for all age groups, especially children aged 11 to 18 years

Iodine

3.136 The impact of the alternative scenario (replacing cows' milk with 'typical' nutrient profile plant-based drinks) was that it could be detrimental at a population level as naturally occurring levels of iodine in plant-based drinks are negligible and 'typical' nutrient profile plant-based drinks do not include iodine as a fortificant.

3.137 The Tier 1 conclusion was that the alternative scenario (for all plant-based drink types) could be detrimental for all age groups.

Zinc

3.138 The impact of the alternative scenario (replacing cows' milk with 'typical' nutrient profile almond drinks) was that it could be detrimental at a population level as 'typical' nutrient profile almond drinks do not include zinc as a fortificant and intrinsic levels of zinc are lower than in cows' milk.

3.139 The Tier 1 conclusion was that the alternative scenario (for almond drinks) could be detrimental, especially for children aged 1 to 18 years.

Potassium

3.140 The impact of the alternative scenario (replacing cows' milk with 'typical' nutrient profile almond and oat drinks only) was that it could be detrimental at a population level as 'typical' nutrient profile almond and oat do not include potassium as a fortificant and naturally occurring levels of potassium are lower than in cows' milk.

3.141 The Tier 1 conclusion was that the alternative scenario (for almond and oat drinks) could be detrimental at a population level. However, the contribution of cows' milk to potassium intakes in age groups most at risk of inadequate potassium intakes (that is, children aged 11 to 18 years, and adults) is relatively low.

Summary of Tier 1 analysis (nutrition)

3.142 For the following nutrients considered in the Tier 1 analysis, replacing cows' milk (reference scenario) with 'typical' nutrient profile plant-based drinks (alternative scenarios) could be:

- beneficial for energy (except for people, especially children, living with underweight), saturated fat, dietary fibre and vitamin D for all age groups

- detrimental for free sugars, iodine, potassium (almond and oat drinks only) for all age groups; vitamin A particularly in children aged 1 to 5 years; and zinc (almond drinks only), particularly for children aged 1 to 18 years

- detrimental for protein in children aged 1 to 5 years following a vegan diet where the alternative scenario is oat and almond drink

3.143 There is no clear difference between scenarios for:

- protein (except for children aged 1 to 5 years following a vegan diet where the alternative scenario of almond or oat drink might be detrimental)

- riboflavin, vitamin B12 and calcium

3.144 Where the alternative scenario is an unfortified plant-based drink, the alternative scenario could also be detrimental for:

- riboflavin and calcium for all population groups

- vitamin B12 for people following a vegan diet

3.145 The impact of using the ‘enhanced’ nutrient profiles was also considered to help inform potential guidance on the nutritional composition of plant-based drinks going forward and may support risk management considerations.

3.146 If water was used as the 'alternative scenario', this would have a detrimental impact on intakes of a range of micronutrients and could lead to an increase in prevalence of inadequate intakes. It would have a greater impact on micronutrient intakes and the prevalence of inadequate intakes in the population than replacing cows’ milk with 'typical' nutrient profile almond, oat and soya drinks.

3.3.3 Toxicological considerations

3.147 Toxicological considerations drew on evidence provided in published COT statements and opinions. The information in this chapter and the supporting tables is largely taken from the:

- COT risk assessment of cows’ milk (COT, 2023b)

- 2021 review of plant-based drinks which reviewed a number of potential contaminants in almond, oat and soya drinks (COT, 2021b)

- scientific reviews prepared as part of the COT and SACN programme of work reviewing the diet of infants and children aged 1 to 5 years (COT, 2019b; COT, 2020a)

3.148 To assess the toxicological implications of the ‘alternative’ scenarios (almond, oat and soya drinks), SACN and COT considered the following points.

3.149 Whether the level or certainty of evidence was convincing, limited or uncertain, taking into account factors such as:

- whether there are established HBGVs
- how these HBGVs were established
- the nature of the available database where there are no HBGVs

3.150 Whether the magnitude of effect was small, moderate or large, dependent on the change in the relevant endpoint if known or using expert judgement if not. The magnitude of effect was considered small where the magnitude of the change seen was small, even though the endpoint may be considered severe. It is also noted for endpoints such as cancer that the magnitude of effect in an individual may be small, but this may be more significant at a population level.

3.151 While the assessment was largely based on the published literature, the working group also considered the available monitoring data on contaminant levels supplied by manufacturers, these largely consisted of values below the limits of detection and were stated to be within specified guidelines.

3.152 The following chemical contaminants and naturally occurring components were considered at the triage stage for possible inclusion in Tier 1 BRAFO:

- isoflavones
- cyanogenic glycosides
- insulin-like growth factor 1 (IGF-1)
- pesticides and veterinary medicine residues (including antibiotics)
- heavy metals - lead, cadmium, mercury, aluminium
- organic contaminants - per- and polyfluoroalkyl substances (PFAS)

- brominated flame retardants - hexabromocyclododecanes (HBCDDs), polybrominated biphenyls (PBBs), tetrabromobisphenol A (TBBPA), polybrominated diphenyl ethers (PBDEs), bisphenol A (BPA), phthalates, dioxins and dioxin-like polychlorinated biphenyls (PCBs), non-dioxin-like PCBs, polycyclic aromatic hydrocarbons (PAHs)

- mycotoxins - aflatoxin, ochratoxin A (OTA), deoxynivalenol (DON), T2 and HT2 toxins

- microplastics

- perchlorate

- chlorate

- nitrate and nitrite

3.153 Each chemical contaminant or component was considered individually, and a decision was made as to whether to take it forward to Tier 1 analysis. Details of these considerations are provided below.

Naturally occurring components

Isoflavones

3.154 Phytoestrogens are naturally occurring plant constituents which can mimic natural oestrogenic activity. The largest group of phytoestrogens are flavonoids, which can be divided into 3 subclasses: coumestans, prenylated flavonoids and isoflavones. The most prevalent flavonoids are isoflavones. Although soya and soya products along with legumes (lentils, beans and peas) are considered to be the highest source, isoflavones are also found at lower levels in cereals, fruit and vegetables, beer, meat and milk (Gacek, 2014). These have been shown to influence biological processes mainly through their structural similarities to oestrogens and their ability to bind to oestrogen receptors. Phytoestrogens in the form of isoflavones have been shown to produce some reproductive and developmental changes in animal studies although such effects have not been reported in human epidemiological studies or clinical trials (COT, 2013c).

3.155 Soya in particular contains a significant quantity of isoflavones. Low levels of isoflavones are also present in plants, grains and beans. Isoflavones can transfer to cows’ milk via feed. Levels of isoflavones are potentially higher in organic milk where red clover is used in feed, although this will depend on the feeding systems used.

3.156 Soya and/or isoflavones have been reported to have both beneficial and adverse effects in a variety of human studies. However, the findings have yet to be included in formal recommendations made by regulatory authorities. As such, any potential beneficial or adverse effects in certain populations have been noted but not considered further.

3.157 For isoflavones, endocrine effects related to reproduction and development have been observed in some animal studies. It is unclear if these effects would also occur in humans, but they are reported to occur in animals at exposure levels close to those from soya infant formula. Soya provides the greatest contribution to dietary phytoestrogens. Soya may occur as a minor ingredient in processed foods or in higher quantities as a specific substitute for animal protein. Although infant formula based on soya is available, SACN has stated that there is no substantive medical need for, nor health benefit arising from, the use of soya-based infant formula and it should only be used in exceptional circumstances to ensure adequate nutrition (COT, 2003). Therefore, soya formula should only be used if it has been recommended or prescribed by a health visitor or GP and is only suitable from 6 months of age. This is reiterated in current government advice as communicated through NHS advice on types of formula.

3.158 Diets high in soya may precipitate a transition to overt hypothyroidism in people with subclinical, compensated hypothyroidism, and may also affect the dose of thyroxine that is needed for treatment of hypothyroidism. The magnitude of the effect is small, and COT considered that it did not have "major clinical implications" (COT, 2015c). However, a potential risk to some individuals cannot be excluded. This has not been considered further.

3.159 High soy diets might be associated with reduced cancer risk (WCRF, 2017). The World Cancer Research Fund (WCRF) found that intake of isoflavones through soy foods may be associated with lower risk of all-cause mortality, mortality from breast cancer and breast cancer recurrence after a breast cancer diagnosis (Tsilidis and others, 2023). Intake of isoflavones may also protect against lung cancer in 'never' smokers. There is no evidence of increased risk of cancer from soya foods or drinks. This has not been considered further.

3.160 It has been claimed that the endocrine activity of isoflavone supplements may help alleviate menopausal symptoms. The National Institute for Health and Care Excellence (NICE) states that for complementary therapies, there is some evidence that isoflavones may relieve vasomotor symptoms, but the magnitude of any effect is likely to be small. Furthermore, the quality, purity, constituents and safety of these products may be unknown, and different preparations may vary. This has not been considered further.

Previous assessments of soya and isoflavones

3.161 The safety of phytoestrogens was considered by COT in 2003 and 2013 (COT, 2003; COT, 2013c). In 2003, in its report on phytoestrogens and health, COT noted that animal studies indicated that intake of isoflavones in early life can produce oestrogenic effects, affect thyroid function, alter protein concentrations and structures in the brain, and alter some parameters of immune function, as well as sexual development in older animals. Overall, the results of animal studies were inconsistent, but the findings of some of the studies indicated possible risks to humans. The COT 2003 report noted that the available human data was limited, and that most of the relevant scientific information was derived from experimental studies in animals, mainly rodents. The extrapolation of such studies to humans was difficult because of inter-species differences in absorption, distribution, metabolism, and excretion; sexual development and reproductive function, and the use of relatively high doses or non-oral routes of administration. The adverse effects of soya phytoestrogens in the form of isoflavones on reproductive endpoints in animal studies was reported at levels varying from 1.6 to 500 milligram (mg) per kilogram (kg) of body weight (bw) per day.

3.162 In 2013, COT concluded that, based on the evidence of some developmental and reproductive effects observed in animal studies along with evidence from human studies raising the possibility of subtle effects of uncertain clinical significance, there was some uncertainty about the safety of soya-based infant formula. They therefore concluded, consistent with the outcomes of the 2003 evaluation, that SACN advice still stood.

3.163 COT also concluded that it was not possible to propose HBGVs for isoflavones due to limitations in the available data.

3.164 More recent data was evaluated in 2019 (COT, 2019a). COT concluded that the new animal studies it reviewed did not add significantly to the overall database. As with previous evaluations, although there was some indication of possible adverse effects being reported in human studies, it was not possible to determine, based on the limited data available, whether sensitivity to phytoestrogens in the young varied among different age groups.

3.165 The evaluation of the effects of isoflavones by COT and other bodies has focused on children since their exposure would be higher on a per kilogram body weight (per kg bw) basis but also as the effects of isoflavones in mimicking endogenous hormones would be particularly relevant to children and their developing reproductive systems.

3.166 Isoflavones were only considered in soya drinks as the levels of phytoestrogens in oat and almond drinks would be significantly lower than in soya (Gacek, 2014). The

COT review of soya drinks built on earlier work specifically conducted on soya isoflavones and the potentially adverse endocrine-modifying effects in children (COT, 2003; COT, 2013c). The COT review of soya drinks (COT, 2021b) further considered the implications of soya drink consumption in combination with other soya containing foods on total isoflavone exposure.

Dietary exposure to isoflavones

Isoflavones in soya drinks

3.167 Exposure to isoflavones from exclusive consumption of soya-based infant formula has been estimated to be up to 9.5mg per kg bw per day (COT, 2013c). This was compared to isoflavone exposures from soya-based drinks in infants and children aged 1 to 5 years as given in Table 3.1. The exposure is representative of that of a child following a vegan diet; the assumptions on exposure are set out in section 2.2.2. It was assumed that the soya dink would contain 603mg per kg isoflavones, though the concentrations are known to be variable (Kuhnle and others, 2009).

Table 3.1: isoflavone exposure from soya drinks in children aged 6 months to 60 months

Age (months)	Exposure from soya drinks (mg/kg bw/day)
6 to 12	1.3
12 to 18	1.7 to 2.8
18 to 24	1.5 to 2.5
24 to 48	1.2 to 2
48 to 60	0.98 to 1.6

3.168 COT concluded that the intake of phytoestrogens from consumption of soya drinks in children aged 6 months to 5 years ranged from 0.98 to 2.8mg per kg bw per day. This was less than the previously estimated maximum intake of 9.5mg per kg bw per day from soya-based infant formula, and hence there was less potential concern. However, it was noted that when considering all foods and drinks containing soya in the diet combined, the exposures were much closer to the level of 9.5mg per kg bw per day achieved through consumption of soya-based infant formula.

Isoflavones in cows’ milk

3.169 Isoflavones are known to be transferred to cows’ milk after digestion of plant-based feed stuffs (Bláhová and others, 2016). The occurrence of isoflavones in cows’ milk is dependent on the feed, with milk phytoestrogen concentration being strongly influenced by silage plant composition. For example, feed with either deliberate addition of, or inadvertently contaminated with, red clover will have greatly increased concentrations of isoflavones (Höjer and others, 2012). Isoflavone levels may be significantly higher in organic milk, compared with milk from free range or conventionally farmed cows. However, this may be dependent on the feeding system used.

3.170 Assuming consumption of cows' milk as set out in Table 3.2 below, isoflavone exposures in children of different age groups can be estimated as follows. These estimates assume isoflavone concentrations of 67.7microgram (µg) per kg and 417µg per kg in conventionally farmed and organically farmed milk respectively. This indicative assessment uses data from Nørskov and others (2019).

Table 3.2: exposure to isoflavones from cows' milk for children aged 6 months to 5 years

Age (months)	Mean µg per kg body weight exposure to sum of isoflavones if 67.7µg/kg milk	Mean µg per kg body weight exposure to sum of isoflavones if 417µg/kg milk	97.5th percentile µg per kg body weight exposure to sum of isoflavones if 67.7µg/kg milk	97.5th percentile µg per kg body weight percentile to sum of isoflavones if 417µg/kg milk
6 to 12	0.9	5.4	3.2	20.0
12 to 18	2.2	13.3	5.1	31.3
18 to 24	2.0	12.1	5.3	12.1
24 to 48	1.6	9.6	4.0	24.6
48 to 60	1.2	6.7	3.1	19.2

3.171 Exposures to isoflavones from cows' milk in children aged up to 5 years are estimated to range from 0.9 to 5.3µg per kg bw from conventional milk to 5.4 to 31.3µg per kg bw from organic milk containing 417µg per kg.

3.172 Exposure to isoflavones from soya drinks on a per kg body weight basis is 30 to 3,000 times higher than from cows' milk depending on the age of the child and the type of cows' milk. When taken together with isoflavones from other soya products, intakes in vegan children approach the levels associated with endocrine effects in animal studies. However, as noted above, there are numerous uncertainties in the database.

3.173 Isoflavones were taken forward to Tier 1 BRAFO (soya drinks only).

Cyanogenic glycosides

3.174 Cyanogenic glycosides are compounds which are naturally present in the kernels of some plant species including bitter almonds. Cyanogenic glycosides break down to release cyanide. Ingestion of cyanide can lead to convulsions, dizziness, mental confusion, heart failure and death.

3.175 Cyanogenic glycosides were only assessed in almond drinks.

3.176 There is a COT acute reference dose (ARfD) of 5µg per kg bw (COT, 2006) and an EFSA ARfD of 20µg per kg bw (EFSA, 2016; EFSA, 2019a). No data was available to assess exposure from almond drinks.

3.177 Bitter almonds are not produced as commercial almond cultivars, which are grown in commercial orchards minimising the potential for cross contamination.

3.178 Cyanogenic glycosides were not taken forward to Tier 1 BRAFO.

Insulin-like growth factor 1 (IGF-1)

3.179 IGF-1 is a growth factor that can be found at low levels in cows' milk. High serum IGF-1 levels may be associated with an increased risk of various types of cancer. Levels in cows' milk are very low and any IGF-1 ingested via food would be digested. In addition, tumours produce their own growth factors making interpretation of the data difficult. The Committee on the Carcinogenicity of Chemicals in Food, Consumer Products and the Environment (COC) concluded that dietary exposure to IGF-1 was not of concern to health (COC, 2019).

Naturally occurring oestrogens

3.180 Oestrogens are a category of sex hormones responsible for the development and regulation of the female reproductive system. They are naturally present in cows' milk and are also be found in human breast milk. This is covered in more detail in COT's cows' milk risk assessment (COT, 2023b).

3.181 The potential risks of exposure to oestrogens for children include developmental effects in the urogenital, hormonal and central nervous systems and mammary glands. Excess exposure to oestrogen is known to be associated with an increased risk of cancers such as breast, ovarian and uterine cancer. There have been differences in the conclusions of risk assessment bodies on the genotoxicity of 17β-oestradiol, the primary oestrogenic hormone in women, and the role of genotoxicity in its carcinogenic effects.

3.182 The contribution of oestrogens ingested from cows' milk to circulating levels of oestrogens is expected to be minimal, due to:

- the low levels present in cows' milk relative to circulating hormone levels
- the low bioavailability of orally ingested bioactive oestrogens as a result of metabolism in the intestinal mucosa and first pass metabolism in the liver

3.183 The Joint Expert Committee of Food Additives (JECFA) established an acceptable daily intake (ADI) of 0.05µg per kg bw per day based on a no observed effect level for multiple hormone dependent parameters in postmenopausal women (FAO and WHO, 2000). This ADI was set in the context of the risk assessment of hormonal growth promoters which are not permitted in the UK.

3.184 Mean exposure to oestrogens from cows' milk (lower bound to upper bound) in µg per kg bw per day is: 0.00348 to 0.00355, 0.00856 to 0.00875, 0.00775 to 0.00793, 0.00615 to 0.00629, 0.00455 to 0.00465 in children aged 6 to 12, 12 to 18, 18 to 24, 24 to 48 and 48 to 60 months, respectively. The highest mean exposure level is 0.00875µg per kg bw per day.

3.185 High (97.5th percentile) exposure (lower bound to upper bound) µg per kg bw per day is: 0.0128 to 0.0131, 0.0201 to 0.0205, 0.0211 to 0.0216, 0.0158 to 0.0161 and 0.0123 to 0.0126 in children aged 6 to 12, 12 to 18, 18 to 24, 24 to 48 and 48 to 60 months, respectively. The highest high exposure level is 0.0216µg per kg bw per day.

3.186 All exposures are within the ADI.

3.187 Naturally occurring oestrogens were taken forward to Tier 1 BRAFO.

Pesticide and veterinary medicine residues

Pesticides

3.188 Maximum Residue Levels (MRLs) are set for pesticide residues based on good agricultural practice and safe use by regulatory bodies such as EFSA, JECFA and the WHO/FAO Joint Meeting on Pesticide Residues (JMPR).

3.189 Exposure from cows' milk is negligible as there are few MRL failures, so the risk is also negligible. Manufacturers' monitoring data for a suite of pesticide residues in plant-based drinks indicated that, where detected, the levels of pesticide residues measured were within permitted levels. Pesticides were therefore not taken forward to Tier 1 BRAFO.

Veterinary medicines residues (including antibiotics)

3.190 MRLs are set for veterinary residues based on identified adverse effects by regulatory bodies such as EFSA and JECFA.

3.191 Exposure from cows' milk is negligible as there are few MRL failures, so the risk is also negligible. Veterinary medicines residues are not relevant to plant-based drinks and were therefore not taken forward to Tier 1 BRAFO.

Heavy metals

Lead

3.192 Lead may enter the dairy chain through bovine ingestion of flaking lead paint, fragments from vehicle and electric fence batteries, soils containing high levels of geological lead, ash from fires containing lead residues and spent lead shot from shooting. Lead may enter plant-based drinks via soil geology or environmental contamination, where lead is present due to historic emissions from leaded petrol.

3.193 Chronic lead exposure can lead to numerous adverse effects including neurological, neurodevelopmental, cardiovascular and renal toxicity and potential allergenicity.

3.194 Neurodevelopmental toxicity is the most sensitive end point for lead and there is currently no defined threshold. It is assessed using a margin of exposure (MOE) approach with a given exposure being compared to an intake of lead associated with a 1-point decrease in the intelligence quotient (IQ) established via benchmark dose modelling.

3.195 EFSA (2010a) concluded that "a margin of exposure of 10 or greater should be sufficient to ensure that there was no appreciable risk of a clinically significant effect on IQ. At lower MOEs, but greater than 1.0, the risk is likely to be low, but not such that it could be dismissed as of no potential concern".

3.196 COT (2016b) agreed with the EFSA approach but noted that due to uncertainties in the data, an MOE of less than 1 was not necessarily of concern.

3.197 Examples of mean lead exposures (lower bound to upper bound) from food in children in the UK are: 0.049 to 0.064, 0.077 to 0.049, 0.082 to 0.11, 0.067 to 0.10, 0.061 to 0.084µg per kg bw per day in children aged 4 to 6, 6 to 9, 9 to 12, 12 to 15 and 15 to 18 months of age, respectively (COT, 2016b).

3.198 Examples of high lead exposures (lower bound to upper bound) from food in children in the UK are: 0.19 to 0.23, 0.18 to 0.25, 0.19 to 0.25, 0.15 to 0.22, 0.13 to 0.17µg per kg bw per day in children aged 4 to 6, 6 to 9, 9 to 12, 12 to 15 and 15 to 18 months of age, respectively (COT, 2016b).

3.199 A lead exposure of approximately 0.5µg per kg bw is a reference point established by EFSA which would be equivalent to a blood lead level that could result in a 1-point decrease in IQ. The exposures above would all result in MOEs greater than 1. Aggregate exposure assessments for lead in the diet resulted in MOEs less than 1 but these are driven by environmental contributions from soil and dust, with dietary lead exposures contributing little to the total.

3.200 Industry monitoring data did not detect lead in plant-based drinks at levels above the limit of detection (LOD) of 0.2mg per kg.

3.201 Lead was taken forward to Tier 1 BRAFO.

Cadmium

3.202 Cadmium is a renal toxin, which may enter the food chain via soil geology or environmental contamination.

3.203 JECFA set a provisional tolerable monthly intake of 25µg per kg bw (equivalent to 5.8µg per week) for cadmium (FAO and WHO, 2010) while EFSA set a tolerable weekly intake (TWI) of 2.5µg per kg bw (EFSA, 2012a). Exposure to cadmium from cows' milk was well below the TWI.

3.204 Manufacturers’ monitoring data reports that cadmium levels in plant-based drinks are within regulatory limits, where detected.

3.205 Cadmium was not taken forward to Tier 1 BRAFO.

Mercury

3.206 Mercury causes a range of adverse effects depending on its chemical form. The effects include neurotoxicity, immunotoxicity and adverse effects on the liver and kidneys. Methyl mercury is a highly toxic form of mercury which can accumulate in the food chain, notably in fish and seafood. The developing fetus, infants and children are most vulnerable to the neurotoxic effects of mercury.

3.207 A TWI for inorganic mercury of 4µg per kg bw was established by EFSA based on adverse effects on the kidney (EFSA, 2012b).

3.208 Methyl mercury is not thought to occur in cows’ milk and the TWI for inorganic mercury is not exceeded in cows’ milk.

3.209 Manufacturers’ monitoring data reports that mercury is not detected in plant-based drinks.

3.210 Mercury was not taken forward to Tier 1 BRAFO.

Aluminium

3.211 Aluminium may have adverse effects on the kidney and on the nervous and reproductive systems.

3.212 Aluminium was assessed in soya drinks only because aluminium levels in soya products are thought to be high due to the aluminium tanks used in processing.

3.213 A TWI of 1mg per kg bw per week set by EFSA (EFSA, 2008c) and a provisional TWI of 2mg per kg per bw per week was set by JECFA (FAO and WHO, 2012).

3.214 Dietary exposures to aluminium in infants and children aged 1 to 5 years are within the JECFA provisional TWI. This includes soya formula and drinks (COT, 2013a).

3.215 Aluminium was not taken forward to Tier 1 BRAFO.

Organic chemicals

Perfluoroalkyl and polyfluoroalkyl substances (PFAS)

3.216 PFAS are a large group of synthetic chemicals used in consumer products and other applications which occur as environmental contaminants. Most of the information on the fate of PFAS and Perfluoroalkyl Carboxylic Acids (PFCAs) is based on 2 individual PFAS compounds: perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS).

3.217 PFAS could theoretically enter plant-based drinks or cows' milk via packaging.

3.218 PFAS are associated with a variety of adverse effects on the liver, kidney, thyroid hormones and the immune system. A TWI of the sum of 4 PFAS chemicals (perfluorohexane sulfonic acid (PFHxS), PFOS, PFOA and perfluorononanoic acid (PFNA)) of 4.4ng per kg bw per day was derived by the EFSA Panel on Contaminants in the Food Chain (2020b), based on reduced antibody levels against diphtheria vaccine. COT (2022) expressed a number of reservations about the endpoint and the modelling used to derive the TWI and further work is under way to consider the available database and risk assessment.

3.219 PFAS have not been detected in cows' milk at current levels of quantification (COT, 2022; EFSA, 2020b) and there are no data available on plant-based drinks.

3.220 PFAS were taken forward to Tier 1 BRAFO.

Brominated flame retardants

3.221 Brominated flame retardants are environmental contaminants which may enter the food chain.

Hexabromocyclododecanes (HBCDDs)

3.222 Effects of HBCDDs on the liver, thyroid, nervous system and reproductive system have been observed in animal studies.

3.223 COT used a reference point of 3µg per kg bw (COT, 2015a) based on a study by Eriksson and others (2006) which reported neurodevelopmental effects in laboratory animals. However, a lot of uncertainties were noted.

3.224 Exposure from cows' milk is low and within HBGVs. No data is available on plant-based drinks.

3.225 HBCDDs were not taken forward to Tier 1 BRAFO.

Polybrominated biphenyls (PBBs)

3.226 Liver, nervous system, reproductive effects, and liver cancer (by a non-genotoxic mechanism) by PBBs have been reported in laboratory animal studies. The adverse effects produced vary depending on the specific PBB compound.

3.227 A no observed effect level of 0.15mg per kg bw was identified based on non-genotoxic carcinogenic effects (EFSA, 2010b). COT considered that meaningful risk assessment in infants was not possible (COT, 2015b).

3.228 Exposure from cows' milk is low and within HBGVs. No data is available on plant-based drinks.

3.229 PBBs were not taken forward to Tier 1 BRAFO.

Tetrabromobisphenol A (TBBPA)

3.230 Neurodevelopmental and possible thyroid effects from TBBPA have been noted in studies in laboratory animals (COT, 2019b).

3.231 A benchmark dose lower confidence limit with a benchmark response of 10% (BMDL10) of 16mg per kg bw per day was established by EFSA based on changes in thyroid hormone levels but a lot of uncertainties were noted (EFSA, 2011b).

3.232 Exposure from cows' milk is low and within HBGVs. No data is available on plant-based drinks.

3.233 TBBPA was not taken forward to Tier 1 BRAFO.

Polybrominated diphenyl ethers (PBDEs)

3.234 Effects on the reproductive system, immune system, thyroid hormone homeostasis and liver function from PBDEs have been reported in animal studies. Also, there is potential for DNA damaging effects via the induction of reactive oxygen species.

3.235 The HBGVs established by EFSA (EFSA, 2011a) and COT (COT, 2015d; COT, 2017b) for the different PBDEs are based on neurodevelopmental effects but a range of uncertainties were noted.

3.236 Exposure from cows' milk is low and within HBGVs. No data is available on plant-based drinks.

3.237 PBDEs were not taken forward to Tier 1 BRAFO.

Bisphenol A (BPA)

3.238 BPA is a compound used in the production of some hard plastics.

3.239 Numerous adverse effects have been reported, including on the mammary gland, and on the reproductive, neuro-behavioural, immune and metabolic systems.

3.240 A tolerable daily intake (TDI) of 4μg per kg bw per day was established by EFSA in 2015 (EFSA, 2015c). This was revised to 0.2ng BPA per kg bw per day in 2023. COT had a number of concerns with respect to the approach taken by EFSA and the study used to establish the TDI. COT has since adopted a TDI established by the German Federal Institute for Risk Assessment of 0.2μg per kg bw per day (COT, 2024).

3.241 BPA was not taken forward to Tier 1 BRAFO because the levels of BPA in cows' milk are not of concern (COT, 2023a) and BPA are not relevant to plant-based drinks.

Phthalates

3.242 Phthalates are a group of chemicals which have been used in the manufacturing of plastics. They are associated with endocrine disruption and adverse effects on the liver.

3.243 A TDI of 0.05mg per kg bw per day was established by EFSA in 2019 for all phthalates (EFSA, 2019b) with the exception of diisodecylphthalate (DIDP) which has a separate TDI of 0.15mg per kg bw per day.

3.244 Phthalates were not taken forward to Tier 1 BRAFO because the levels of phthalates in cows' milk are not of concern (COT, 2023a) and phthalates are not relevant to plant-based drinks.

Dioxins and dioxin-like polychlorinated biphenyls (PCBs)

3.245 Dioxins and dioxin-like PCBs are organic pollutants which persist in the environment and enter the food chain. They enter the environment largely as byproducts of industrial processes and combustion. They are fat soluble and occur at higher levels in fatty foods. Dioxins have a range of toxic effects on cells and in laboratory animal studies. 2,3,7,8- tetrachlorodibenzyl dioxin (TCDD) is regarded as the most toxic of the group. The toxicities of other congeners are related to that of TCDD by toxic equivalency factors (TEFs). The toxicity of mixtures of dioxins and dioxin-like PCBs is quantified by the product of the concentration of each congener in the mixture and a TEF to yield a toxic equivalent (TEQ) value.

3.246 COT (2001) recommended a TDI of 2 picogram (pg) World Health Organization toxic equivalents (WHO-TEQ) per kg bw per day based upon effects on the developing male reproductive system mediated via the maternal body burden. This was also considered to protect against other possible effects, such as non-genotoxic mechanism and cardiovascular effects. The most recent EFSA opinion (EFSA, 2018) recommended a TWI of 2pg TEQ per kg bw per week, a 7-fold reduction in the previous TWI. However, COT have expressed reservations about this recommendation and their existing advice currently stands (COT, 2021a).

3.247 Mean exposure using the upper bound mean value for cows' milk (pg WHO-TEQ per kg bw day) is 0.416, 1.02, 0.928, 0.736, 0.544 in children aged 6 to 12, 12 to 18, 18 to 24, 24 to 48 and 48 to 60 months, respectively.

3.248 High exposure using upper bound mean value for cows' milk (pg WHO-TEQ per kg bw day is 1.54 2.40, 2.53, 1.89, 1.47 in children aged 6 to 12, 12 to 18, 18 to 24, 24 to 48 and 48 to 60 months, respectively.

3.249 Mean exposure using the upper bound high level value for cows' milk (pg WHO-TEQ per kg bw per day) is 0.91, 2.24, 2.03, 1.61, 1.19 children aged 6 to 12, 12 to 18, 18 to 24, 24 to 48 and 48 to 60 months, respectively.

3.250 High exposure using the upper bound high level value for cows' milk (pg WHO-TEQ per kg bw per day) is 3.35, 5.25, 5.53, 4.13, 3.22 in children aged 6 to 12, 12 to 18, 18 to 24, 24 to 48 and 48 to 60 months, respectively.

3.251 Therefore, the TDI of 2pg WHO-TEQ per kg bw per day could be exceeded depending on the combination of consumption level and/or dioxin concentration assumed (COT, 2023a). However, it should be noted that the risk assessment is very conservative.

3.252 Monitoring data from industry did not report the presence of dioxins or dioxin-like PCBs in plant-based drinks. No other occurrence data is available.

3.253 Dioxins and dioxin-like PCBs were taken forward to Tier 1 BRAFO.

Non-dioxin-like PCBs

3.254 Non-dioxin-like PCBs are organic pollutants which persist in the environment and enter the food chain. PCBs entered the environment through historic use in industrial processes and consumer products. They are fat soluble and occur at higher levels in fatty foods. Reported adverse effects include reproductive effects, immunotoxicity, cancer (non-genotoxic mechanism) and endocrine disruption. Liver and thyroid effects are the most sensitive.

3.255 An HBGV was not established by EFSA (2005) but the no observed adverse effect level (NOAEL) from animal studies was considered to be 10µg per kg bw per day. Similarly, JEFCA (FAO and WHO, 2016) did not establish a HBGV but the NOAEL was considered to be 10µg per kg bw per day. These NOAELs are used to assess the implications of PCB exposure using an MOE approach.

3.256 Survey data from EFSA of 5,640 samples from 23 EU countries, including the UK, reported upper bound mean and 95th percentile occurrence concentrations of 0.32 and 0.56µg per kg respectively assuming a 3.5% whole milk sample basis (COT, 2023a).

3.257 The data reported by EFSA were less than the regulatory value of 1µg per kg for foods intended for young children.

3.258 Manufacturers' data reports that PCBs were not detected in plant-based drinks.

3.259 Non-dioxin-like PCBs were not taken forward to Tier 1 BRAFO.

Polycyclic aromatic hydrocarbons (PAHs)

3.260 PAHs are persistent organic pollutants formed through incomplete combustion or pyrolysis. They are genotoxic carcinogens and have adverse effects on the liver and on thyroid hormones.

3.261 A HBGV was not established by EFSA (EFSA, 2008b). However, BMDL10 values for Benz(a)pyrene (BaP) and the sum of PAH4 of 0.070mg per kg bw per day and 0.340mg per kg bw per day, respectively, were derived.

3.262 MOEs for cows' milk based on the EFSA BMDL10 values are high and are unlikely to be of concern (COT, 2020a; COT, 2023a). No data is available on PAHs in plant-based drinks.

3.263 PAHs were not taken forward to Tier 1 BRAFO.

Mycotoxins

Aflatoxin

3.264 Aflatoxins (AFs) are produced as a result of fungal contamination. There are 4 main types based on their chemical structure: B1, B2, G1 and G2. AFs are most commonly associated with groundnuts, tree nuts, dried fruit, spices, figs, crude vegetable oils, cocoa beans, maize, rice, cottonseed and copra (the flesh from coconut).

3.265 AFM1 is the hydroxylated metabolite of AFB1 and is found in milk and dairy products obtained from livestock that have ingested contaminated feed.

3.266 AFs cause immunotoxic effects due to impaired DNA duplication in the bone marrow resulting in low leukocyte levels and immunodeficiency, mutagenic and carcinogenic effects. The liver is the primary target.

3.267 Since AFB1 is both genotoxic and carcinogenic, it is assessed using an MOE approach (EFSA, 2020b). In this instance, an MOE below 10,000 is considered to be of health concern.

3.268 The EFSA (2020b) risk assessment reported that “milk and dairy products contributed < [less than] 1% of total AFB1 exposure in all surveys”.

3.269 In the absence of suitable occurrence data, potential exposures from plant-based drinks were estimated based on maximum permitted levels as follows (COT, 2021b):

- almond – assuming 0.48μg per kg in ready to eat almonds, chronic consumption would be 0.01, 0.013 to 0.022, 0.012 to 0.02, 0.0095 to 0.016 and 0.0078 to 0.013μg per kg bw in children aged 6 to 12, 12 to 18, 18 to 24, 24 to 48 and 48 to 60 months, respectively

- almond – assuming 0.72μg per kg in almonds needing further processing, chronic consumption would result in exposures of 0.016, 0.02 to 0.033, 0.018 to 0.03, 0.014 to 0.024 and 0.012 to 0.020μg per kg bw in children aged 6 to 12, 12 to 18, 18 to 24, 24 to 48 and 48 to 60 months, respectively

3.270 A full exposure assessment was not conducted for oat or soya drinks. However, exposure would be comparable to or less than the exposure from almond drinks. MOEs of less than 10,000 were estimated, however, there were significant uncertainties and while these will have overestimated exposure, it is unclear by how much.

3.271 Monitoring data supplied by industry do not report AFs above regulatory limits.

3.272 AFs were taken forward to Tier 1 BRAFO.

Ochratoxin A (OTA)

3.273 OTA is a mycotoxin produced as a result of the fungal contamination of a range of food commodities. OTA is associated with adverse effects on the kidneys. It is carcinogenic but whether the mechanism is genotoxic is unclear.

3.274 An MOE approach is taken to the risk assessment of OTA by EFSA (2020a).

3.275 OTA is not thought to transfer to milk of ruminants; therefore, exposure, if any, would be low.

3.276 An estimated concentration of 6.11µg OTA per kg oat drink from occurrence data in European-harvested oats was used for the COT assessment (COT, 2021b). OTA was assessed in oat drinks only. Contamination of the other drinks would be less.

3.277 Exposures were 130, 170 to 280, 150 to 250, 120 to 200, and 100 to 170ng per kg bw per day in children aged 6 to 12, 12 to 18, 18 to 24, 24 to 48 and 48 to 60 months of age, respectively.

3.278 Monitoring data supplied by industry do not report on OTA.

3.279 OTA was taken forward to Tier 1 BRAFO.

Deoxynivalenol (DON)

3.280 DON is a trichothecene mycotoxin found predominantly in grain species such as wheat, barley, oats or rye. It is also known as vomitoxin. Adverse effects include acute nausea, vomiting, diarrhoea, abdominal pain, headache, dizziness, and fever.

3.281 A group TDI was established by EFSA (2013) for the sum of DON, 3-Ac-DON, 15-Ac-DON and DON3-glucoside of 1µg per kg bw. EFSA also established an ARfD of 8µg per kg bw per eating occasion.

3.282 Trichothecene mycotoxins are not thought to transfer to the milk of ruminants. Therefore, exposure, if any, would be expected to be low. It is unknown if any DON metabolites could transfer into cows' milk, but this seems unlikely, given their physicochemical properties.

3.283 Subsequently, data from a Food Standards Scotland survey reported DON in several non-dairy alternative drinks. Where detected, levels ranged from 0.13 to

8.78μg per kg, including a sample of oat drink which contained 1.56μg per kg (FSS, 2022). However, monitoring data supplied by industry do not report DON.

3.284 DON is less likely to occur in soya or almond drinks than in oat drinks. A full exposure assessment was not conducted but exposure would be lower or comparable to that from oat drinks.

3.285 DON was taken forward to Tier 1 BRAFO.

T2 and HT2 toxins

3.286 T2 and HT2 are trichothecene mycotoxins. Acute adverse effects include gastrointestinal irritation and vomiting, while longer term effects include haematoxicity and immunotoxicity.

3.287 For T2 and HT2 a TDI of 0.02μg per kg bw and for ArfD a TDI of 0.3μg per kg bw were established by EFSA (EFSA, 2017b). T2 and HT2 are unlikely to transfer to cows' milk (COT, 2023b).

3.288 COT concluded that the risk from T2 and HT2 in oat drinks was low (COT, 2021b).

3.289 Manufacturers' monitoring data did not report on T2 or HT2. According to FSS survey data, although T2 and HT2 were generally not detected, T2 and HT2 were detected at low levels in some oat drink samples (FSS, 2022).

3.290 T2 and HT2 were not taken forward to Tier 1 BRAFO.

Microplastics

3.291 Microplastics are widespread environmental contaminants. COT stated that at present there is no clear evidence of adverse effects (COT, 2021c).

3.292 Limited analytical information is available for cows' milk and no information on plant-based drinks has been identified.

3.293 Microplastics were not taken forward to Tier 1 BRAFO.

Perchlorate

3.294 The ion perchlorate (ClO4-) occurs in the environment due to the use of fertilisers leading to accumulation in plants, and through industrial emissions. It is also formed from degradation of chlorine-based cleaning products. The use of plant protection products and water disinfection could slightly increase exposure to perchlorate. Perchlorate acts on the thyroid, inhibiting iodine uptake via the sodium-iodide symporter protein. This leads to depletion in the levels of thyroid hormones leading to hypothyroid effects in individuals with a moderate iodine deficiency.

3.295 A TDI of 0.3µg per kg bw per day was established by EFSA (2017a).

3.296 Using the upper bound mean concentration of perchlorate in liquid milk, consumption of cows' milk does not lead to the TDI being exceeded (COT, 2023b). However, where the upper bound high-level concentration of perchlorate is used in the assessment, mean level consumers aged 12 to 18 months consumed 107% of the TDI, with high level consumers being exposed to 153% to 263% of the TDI.

3.297 Perchlorate may enter plant-based drinks through addition of water and/or other manufacturing processes. No data is available on soya drinks, but perchlorate is measured at low levels in soya beans. No data is available on almond drinks and for oat drinks. Monitoring data from manufacturers reported that perchlorate was below the limit of detection of 0.01 or 0.05mg per kg (FSS, 2022).

3.298 Perchlorate was taken forward to Tier 1 BRAFO.

Chlorate

3.299 Chlorates are chemical contaminants arising from the use of chlorine-based disinfectants. They have adverse effects on the thyroid due to competitive inhibition of iodine binding, potentially leading to goitre.

3.300 A TDI of 3µg per kg per bw was established by EFSA (2015a). This was based on read across from perchlorate but was multiplied by a factor of 10 to account for the lower potency of chlorate. In COTs review of the diet of infants and children aged 1 to 5 years, the TDI for chlorate was not exceeded (COT, 2019b).

3.301 Manufacturers' monitoring data reports that chlorate was not detected in plant-based drinks.

3.302 Chlorate was not taken forward to Tier 1 BRAFO.

Nitrate and nitrite

3.303 Nitrates can occur naturally in foods or be used as food additives. Nitrites can be formed from nitrates but are also used as food additives. Exposure to nitrates can result in methemoglobinemia due to the oxidising activity of nitrate. Consumption of red and processed meat is associated with increased risk of cancer. The mechanism for this association is unclear but it could be via nitrosamine formation, though other mechanisms have been proposed (SACN, 2011b).

3.304 An ADI of 3.7mg per kg bw was established by EFSA based on methemoglobinemia formation (EFSA, 2008a).

3.305 Cows' milk provides less than 1% of the ADI for nitrate. Soybeans do not contain a high quantity of nitrates.

3.306 Nitrate and nitrite were not taken forward to Tier 1 BRAFO.

3.3.4 Tier 1 analysis: toxicological considerations

Background

3.307 The outcome of the Tier 1 analysis for the chemical contaminants or naturally occurring components under consideration are summarised below.

3.308 After considering the likely occurrence, data availability and whether exposure was close to the relevant HBGV, and level of uncertainty, it was agreed that the following substances should be considered as part of Tier 1 analysis:

- for soya drinks: isoflavones (in relation to thyroid status, endocrine disruption, menopausal symptoms), lead, dioxins (and dioxin-like compounds), per- and polyfluoroalkyl substances (PFAS); perchlorate, aflatoxins, ochratoxin A (OTA), deoxynivalenol (DON, oestradiol

- for oat drinks: lead, dioxins (and dioxin-like compounds), per- and polyfluoroalkyl substances (PFAS), perchlorate, aflatoxins, ochratoxin A (OTA), deoxynivalenol (DON), oestradiol

- for almond drinks: lead, dioxins (and dioxin-like compounds), per- and polyfluoroalkyl substances (PFAS), perchlorate, aflatoxins, ochratoxin A (OTA), deoxynivalenol (DON), oestradiol

3.309 The Tier 1 assessment of the 8 toxicological components is detailed above (see section 3.3.3) and summarised below.

Isoflavones (soya only)

3.310 Impact of the alternative scenario (replacing cows' milk with plant-based drinks) was that:

- the alternative scenario in which cows' milk is replaced with soya drink could be detrimental to children due to the potential for adverse endocrine effects arising from soya isoflavones

- any possible benefits of increased isoflavone exposure would be relevant to adults rather than children and are difficult to quantify

3.311 Tier 1 conclusion: risk of alternative scenario. See 'Naturally occurring components' in section 3.3.3 for more details.

Lead

3.312 Impact of the alternative scenario (replacing cows' milk with plant-based drinks) was that the drink with the lowest lead concentrations (whether the reference or alternative scenario) poses the lowest risk. However, lead levels are likely to be low in both plant-based drinks and cows' milk.

3.313 Tier 1 conclusion: no clear difference in scenario identified.

Dioxins and dioxin-like PCBs

3.314 Impact of the alternative scenario (replacing cows' milk with plant-based drinks) was that:

- the conclusion on whether the reference or alternative scenario is the lower risk would depend on the concentrations involved with the product, with the lowest levels resulting in reduced exposure, hence being potentially beneficial

- levels of dioxins and dioxin-like PCBs are likely to be lower in plant-based drinks than in cows' milk, although the levels in cows' milk are not of concern and the 2 scenarios do not differ meaningfully in risk

3.315 Tier 1 conclusion: no clear difference in scenario identified.

Per- and polyfluoroalkyl substances (PFAS)

3.316 Impact of the alternative scenario (replacing cows' milk with plant-based drinks) was whether the reference or alternative scenario is the most beneficial would depend on the PFAS concentrations involved, with the drink with the lowest PFAS levels resulting in reduced exposure. However, as levels are likely to be low in both plant-based drinks and cows' milk, neither would pose a significant risk.

3.317 Tier 1 conclusion: no clear difference in scenario identified.

Aflatoxin

3.318 Impact of the alternative scenario (replacing cows' milk with plant-based drinks) was that:

- while the aflatoxin metabolite AFM1 is likely to be lower in plant-drinks than cows' milk, the parent aflatoxin AFB1 could be higher in plant-based drinks

- the effect of processing on aflatoxins is unknown but it could reduce the potential aflatoxin concentration through washing and processing where any fungal contamination would occur

- the risks of the alternative scenario would be higher as exposure to aflatoxin has the potential to be higher in almond drinks

3.319 However, in the absence of detailed occurrence data it is not possible to draw conclusions. Exposure is likely to have been appreciably overestimated.

3.320 Tier 1 conclusion: no clear difference in scenario identified.

Ochratoxin A (OTA)

3.321 Impact of the alternative scenario (replacing cows' milk with plant-based drinks) was that:

- OTA levels are potentially higher in plant-based drinks than in cows' milk since OTA is not thought to transfer into the milk of ruminants and as fungal contamination of the bulk plant commodity can occur

- the effect of processing is unknown, but it could reduce OTA concentrations

- there are uncertainties with respect to the potential carcinogenic effect of OTA and the mechanism by which it proceeds, and therefore it was not possible to conclude whether exposures to OTA were a potential health concern

3.322 Tier 1 conclusion: no clear difference in scenario identified.

Deoxynivalenol (DON)

3.323 Impact of the alternative scenario (replacing cows' milk with plant-based drinks) was that DON levels are potentially higher in plant-based drinks than in cows' milk since DON is not thought to transfer into the milk of ruminants and as fungal contamination of the bulk plant commodity can occur. However, the levels would not be of concern in either cows' milk or plant-based drinks.

3.324 Tier 1 conclusion: no clear difference in scenario identified.

Perchlorate

3.325 Impact of the alternative scenario (replacing cows' milk with plant-based drinks) was that:

- plant-based drinks are likely to contain lower levels of perchlorate, and therefore consumption in place of cows' milk would reduce overall dietary perchlorate exposure
- however, consuming neither cows' milk nor plant-based drinks would lead to the TDI for perchlorate being exceeded

3.326 Tier 1 conclusion: no clear difference in scenario identified.

Oestrogens or oestrodiol

3.327 Impact of the alternative scenario (replacing cows' milk with plant-based drinks) was that although consumption of soya drinks results in potentially lower exposure compared to cows' milk due to the lower levels of oestrogen, the levels in cows' milk would not be of concern, thus the risks from the reference and the alternative scenarios do not differ.

3.328 Tier 1 conclusion: no clear difference in scenario identified.

Summary of Tier 1 analysis (toxicological)

3.329 No specific benefits were identified if cows' milk (reference scenario) is replaced with plant-based drinks (alternative scenario) but exposures to certain components such as aflatoxins or perchlorate were potentially reduced in either the reference or alternative scenarios. Since the majority of these components (aflatoxins, lead, DON, OTA, oestradiol, perchlorate, PFAS, and dioxins and dioxin-like PCBs) would be unlikely to give rise to concern from consumption of either cows' milk or plant-based drinks, there is no practical difference between the reference and alternative scenarios in most instances. However, it should be noted that little occurrence data is available, which limited the conclusions that could be drawn.

3.330 For the majority of chemicals considered in the Tier 1 analysis there was no difference between the reference and alternative scenarios. This was because either the chemicals were not present or were present at levels where they were within relevant HBGVs and no risk was posed by either scenario and so there was no difference between the 2. These chemicals were not considered further in Tier 2 analysis.

3.331 Tier 1 analysis indicated that the most significant concern arising from the alternative scenario (cows' milk being replaced with a plant-based drink) was with respect to isoflavones in soya drinks, where the risk of the alternative scenario for this component may outweigh the benefit. This is discussed in detail below.

3.332 With the exception of isoflavones in soya drinks (described in 'Naturally occurring components' in section 3.3.3), the conclusions apply to both children and adults.

3.4 Summary of Tier 1 BRAFO by plant-based drink type

3.333 The sections below summarise the outcomes of the Tier 1 analysis of nutritional and toxicological considerations by plant-based drink type. For each plant-based drink type (almond, oat or soya drink), toxicological considerations were the same regardless of which nutrient profile (that is, ‘typical’, ‘enhanced’ or ‘unfortified and/or sweetened’) was being assessed.

3.4.1 ‘Typical’ nutrient profile almond drinks

Nutritional considerations

3.334 The alternative scenario in which cows’ milk is replaced with ‘typical’ nutrient profile almond drinks indicates that there could be:

- benefits associated with lower intakes of energy (except among individuals living with underweight, particularly children), protein (except for children aged 1 to 5 years following a vegan diet) and saturated fat and higher intakes of fibre and vitamin D
- risks associated with additional (and potentially excess) free sugars and inadequate intakes of vitamin A, iodine, zinc and potassium, and lower protein intakes which may be a risk for children aged 1 to 5 years following a vegan diet

Toxicological considerations

3.335 With respect to toxicological concerns, there may be differences in the scenarios depending on the levels of contaminants potentially present in the different drink types, however, on the basis of the available information, there are no clear differences between the scenarios.

3.4.2 ‘Typical’ nutrient profile oat drinks

Nutritional considerations

3.336 The alternative scenario in which cows’ milk is replaced with ‘typical’ nutrient profile oat drinks indicates that there could be:

- benefits associated with lower intakes of energy (except among individuals living with underweight, particularly children), protein (except for children aged 1 to 5 years following a vegan diet) and saturated fat and higher intakes of fibre and vitamin D

- risks associated with additional (and potentially excess) free sugars and inadequate intakes of vitamin A, iodine, zinc and potassium, and lower protein intakes which may be a risk for children aged 1 to 5 years following a vegan diet

Toxicological considerations

3.337 With respect to toxicological concerns, there may be differences in the scenarios depending on the levels of contaminants potentially present in the different drink types, however, on the basis of the available information, there are no clear differences between the scenarios.

3.4.3 ‘Typical’ nutrient profile soya drinks

Nutritional considerations

3.338 The alternative scenario in which cows’ milk is replaced with ‘typical’ nutrient profile soya drinks indicates that there could be:

- benefits associated with lower intakes of energy (except among individuals living with underweight, particularly children) and saturated fat and higher intakes of fibre and vitamin D

- risks associated with additional (and potentially excess) free sugars, and lower intakes of vitamin A, iodine and zinc and higher risks of inadequate intakes of these micronutrients, especially in children aged 1 to 5 years

- no impact on protein intakes because soya drinks provide a comparable quantity of protein to cows’ milk

3.339 Although protein quality was not assessed, of the 3 plant-based drinks under consideration, soya drink is the most similar to cows’ milk in terms of protein quality.

Toxicological considerations

3.340 With respect to toxicological concerns, there may be differences in the reference and alternative scenarios depending on the levels of contaminants potentially present in drinks in both scenarios. Based on the evidence available, there are no clear differences between the scenarios with respect to the majority of chemicals considered. However, for soya drinks there is a potential risk related to the endocrine-modifying effects of isoflavones in highly exposed population groups, notably children aged 1 to 5 years following a vegan diet who may be more exposed to isoflavones per kg bodyweight.

3.4.4 ‘Enhanced’ nutrient profile almond, oat and soya drinks

3.341 The potential benefits associated with the consumption of ‘typical’ nutrient profile plant-based drinks would also apply to ‘enhanced’ nutrient profile plant-based drinks.

3.342 The ‘enhanced’ nutrient profile includes fortification with vitamin A and iodine at levels comparable to that found in semi-skimmed cows’ milk. The potential risks of higher intakes of free sugars associated with the consumption of ‘typical’ nutrient profile plant-based drinks would be mitigated by ‘enhanced’ nutrient profile plant-based drinks which assumes no free sugars are present.

3.4.5 ‘Unfortified and/or sweetened’ almond, oat and soya drinks

3.343 Some potential benefits associated with the consumption of ‘typical’ nutrient profile plant-based drinks also apply to ‘unfortified and/or sweetened’ plant-based drinks, which are also lower in energy and saturated fat and higher in fibre than cows’ milk. However, these drinks contain added sugars ('free sugars') and/or are not fortified with micronutrients. Therefore, replacing cows’ milk with these drinks would be associated with increased risks of higher intakes of free sugars and/or lower intakes of some micronutrients.

3.5 Tier 2 BRAFO

3.344 The results of the Tier 1 BRAFO indicated that both beneficial and adverse changes in health outcomes might occur with a change from the reference to the alternative scenarios.

3.345 Tier 2 BRAFO qualitatively integrates the potential benefits and risks of the different scenarios (reference and alternative) to establish whether the:

- risks of the alternative scenario compared with the reference scenario clearly dominate the benefits, in which case the reference scenario should be advised

- benefits of the alternative scenario compared with the reference scenario clearly dominate the risks, in which case the alternative scenario should be advised

3.346 The potential benefits and risks of the alternative scenario (almond, oat and soya drinks) compared with the reference scenario (cows' milk) differ according to the plant-based drink type being considered and its nutrient profile, as well as the population subgroup (based on age and dietary pattern).

3.347 Energy, protein, saturated fat, free sugars, dietary fibre, vitamin A, riboflavin, vitamin B12, vitamin D, calcium and iodine were included in the Tier 2 BRAFO analysis. Based on the findings of the Tier 1 BRAFO analysis (section 3.3.2), potassium was not progressed to Tier 2. Given the uncertainties in relation to zinc, it was also not progressed to Tier 2.

3.5.1 Alternative scenario: 'unfortified and/or sweetened' plant-based drinks

3.348 Compared with the reference scenario of cows' milk, 'unfortified and/or sweetened' plant-based drinks were associated with the following potential benefits:

- lower energy (reduced risk of obesity); it should be noted that this would not be a benefit among individuals living with underweight, particularly children

- lower saturated fat (reduced risk of CVD)

- higher fibre (reduced risk of CVD, T2D, colorectal cancer)

- lower protein with almond and oat drinks (excess protein intakes associated with higher BMI); with the exception of children aged 1 to 5 years following a vegan diet who may be at risk from lower protein intakes (inadequate protein intake is associated with impaired growth in children)

3.349 Compared with the reference scenario of cows' milk, 'unfortified and/or sweetened' plant-based drinks were associated with the following potential risks:

- higher free sugars (dental caries)

- higher consumption of SSBs (dental caries)

- inadequate vitamin A (impaired immune function, impaired vitamin D function, visual disorders, worsening of low iron status)

- inadequate riboflavin (impaired growth and other health outcomes)

- inadequate calcium (musculoskeletal health outcomes)
- inadequate iodine (impaired thyroid function, reproductive and neurodevelopmental impacts)
- inadequate vitamin B12 in those people following a vegan diet (pernicious anaemia and impaired neurological development among young children)
- lower protein with almond and oat drinks in children aged 1 to 5 years following a vegan diet for whom lower protein intakes may be a risk (inadequate protein intake is associated with impaired growth in children)
- higher isoflavones with soya drinks (endocrine-modifying effects), most notably in children aged 1 to 5 years following a vegan diet who might be more exposed to isoflavones per kg bodyweight

3.350 Evidence is not available to quantitatively assess the potential benefits compared with the potential risks of replacing cows' milk with unfortified and/or sweetened plant-based drinks. However, based on a qualitative assessment of the available evidence, the potential risks of replacing cows' milk with unfortified and/or sweetened plant-based drinks outweigh the potential benefits, and it is therefore recommended that current advice is retained for all age groups.

3.5.2 Alternative scenario: 'typical' profile plant-based drinks

3.351 Compared with the reference scenario of cows' milk, 'typical' nutrient profile plant-based drinks were associated with the following potential benefits:

- lower energy (reduced risk of obesity); it should be noted that this would not be a benefit among individuals living with underweight, particularly children
- lower saturated fat (reduced risk of CVD)
- higher fibre (reduced risk of CVD, T2D, colorectal cancer)
- lower protein with almond and oat drinks (excess protein intakes associated with higher BMI); with the exception of children aged 1 to 5 years following a vegan diet who may be at risk from lower protein intakes (inadequate protein intake is associated with impaired growth in children)
- higher vitamin D (bone health, reduced risk of acute respiratory tract infection)

3.352 Compared with the reference scenario of cows' milk, 'typical' nutrient profile plant-based drinks were associated with the following potential risks:

- higher free sugars (dental caries)
- inadequate vitamin A (impaired immune function, impaired vitamin D function, visual disorders, worsening of low iron status)
- inadequate iodine (impaired thyroid function, reproductive and neurodevelopmental impacts)
- lower protein with almond and oat drinks in children aged 1 to 5 years following a vegan diet for whom lower protein intakes may be a risk (inadequate protein intake is associated with impaired growth in children)
- higher isoflavones in soya drinks (endocrine-modifying effects), most notably in children aged 1 to 5 years following a vegan diet who may be more exposed to isoflavones per kg bodyweight

3.353 Evidence is not available to quantitatively assess the potential benefits compared with the potential risks of replacing cows' milk with 'typical' nutrient profile plant-based drinks.

3.354 However, based on a qualitative assessment of the available evidence, it is considered that for children aged 1 to 5 years:

- any potential benefits of consuming 'typical' nutrient profile plant-based drinks are outweighed by the potential risks
- the reference scenario of cows' milk is therefore preferable for children aged 1 to 5 years

3.355 For adults and children aged 5 years and over, the relative benefits and risks of the alternative compared with the reference scenario will vary according to the population group under consideration and the dietary pattern followed, and the most appropriate product will depend on a variety of individual factors.

3.5.3 Alternative scenario: ‘enhanced’ profile plant-based drinks

3.356 Compared with the reference scenario of cows’ milk, ‘enhanced’ nutrient profile plant-based drinks would be associated with the following potential benefits:

- lower energy (reduced risk of obesity); it should be noted that this would not be a benefit among individuals living with underweight, particularly children
- lower saturated fat (reduced risk of CVD)
- higher fibre (reduced risk of CVD, T2D, colorectal cancer)
- lower protein with almond and oat drinks (excess protein intakes associated with higher BMI); with the exception of children aged 1 to 5 years following a vegan diet who may be a risk from lower protein intakes (inadequate protein intake is associated with impaired growth in children)
- higher vitamin D (musculoskeletal health, reduced risk of ARTI)

3.357 Compared with the reference scenario of cows’ milk, ‘enhanced’ nutrient profile plant-based drinks would be associated with the following potential risks:

- lower protein with almond and oat drinks for children aged 1 to 5 years following a vegan diet for whom lower protein intakes may be a risk (inadequate protein intake is associated with impaired growth in children)
- higher isoflavones exposure in soya drinks (endocrine-modifying effects), most notably in children aged 1 to 5 years following a vegan diet

3.358 Some of the potential risks associated with the ‘typical’ nutrient profile plant-based drinks would be mitigated if the ‘enhanced’ profile plant-based drinks were to be the alternative scenario. Therefore, based on a qualitative assessment of the available evidence, it was considered that plant-based drinks that met the ‘enhanced’ nutrient profile would be an acceptable drink choice for all age groups over 1 year of age.

3.359 If cows' milk was replaced with water, this would have a greater impact on micronutrient intakes and the prevalence of inadequate intakes in the population than replacing cows’ milk with 'typical' (and 'enhanced') nutrient profile almond, oat and soya drinks.

3.360 It is important to note that, according to the latest available data (Wall and others, 2023) at the time of publication of this report (2025), there was no product available on the UK market that met the ‘enhanced’ profile. In 2023, only around 31% of products were fortified with iodine and only one plant-based drink (marketed for children aged 1 to 5 years) was fortified with vitamin A at the time the substitution analysis was conducted.

3.361 It is also important to note the uncertainties in the data used for this benefit-risk assessment, most notably:

- whether the bioavailability of micronutrients added to plant-based drinks is equivalent to the bioavailability of micronutrients that are naturally present in cows' milk

- the protein quality, with regards to the amino acid composition and the digestibility of the protein found in drinks, is also unclear for almond, oat and soya drinks

3.362 Furthermore, all soya drinks, regardless of nutrient profile, will contain isoflavones.

3.363 With all 3 alternative scenarios ('unfortified and/or sweetened', 'typical' and 'enhanced' nutrient profiles), the potential benefits of lower energy and saturated fat intakes compared with the reference scenario of cows' milk would be removed if skimmed cows' milk was used as the comparator in place of the current profile of cows' milk consumption. The latter is based on consumption data from NDNS and DNSIYC which is dominated by semi-skimmed milk in all age groups other than children aged 1 to 5 years (for whom it is whole milk), with low consumption of skimmed milk. If cows' milk consumption moved from predominantly whole or semi-skimmed to predominantly skimmed milk, the resulting reduction in saturated fat intakes would also be associated with a reduction in vitamin A intake (a fat-soluble vitamin), which would not be beneficial. For this reason, skimmed milk is not recommended as a main drink for young children aged under 5 years.

3.364 There was insufficient data to allow the balance of benefits and risks to be assessed quantitatively. It was therefore not possible for the assessment to proceed to Tier 3.

3.6 Conclusions

3.365 Results of the Tier 2 BRAFO qualitative integration indicate that the overall potential benefits associated with the alternative scenario (that is, almond, oat and soya drinks) would outweigh the potential risks if a number of mitigations are made to reduce these risks. These mitigations are:

- fortification of all plant-based drinks with the following micronutrients at levels comparable to those found in semi-skimmed cows' milk: vitamin A, riboflavin, vitamin B12, calcium and iodine, as well as with vitamin D
- restricting consumption to unsweetened drinks (that is, drinks that do not contain sugar added as an ingredient or free sugars as a result of processing)
- for those following a vegan diet, particularly children aged 1 to 5 years, consuming a variety of protein sources across the diet to counter the potential lower intake of protein associated with consuming oat and almond drinks

3.366 Based on their qualitative assessment of the available evidence, SACN and COT considered that:

- the reference scenario of cows' milk would be preferable for children aged 1 to 5 years
- plant-based drinks that met the 'enhanced' nutrient profile would be an acceptable drink choice for all age groups over 1 year of age

3.367 For adults and children aged 5 years and over, the relative benefits and risks of the alternative compared with the reference scenario will vary according to the population group under consideration and the dietary pattern followed, and the most appropriate product will depend on a variety of individual factors.

3.368 It should be noted that in their overall Conclusions (chapter 4) and Recommendations (chapter 5), SACN and COT also took into consideration findings from the SACN statement on the WHO guideline on non-sugar sweeteners SACN statement on the WHO guideline on non-sugar sweeteners (SACN, 2025b).

3.369 The BRAFO indicated that there are no clear toxicological concerns associated with the consumption of almond, oat and soya drinks, except for the higher isoflavones content of soya drinks. Isoflavones have known endocrine-modifying effects. In contrast, soya drinks may provide nutritional benefits for some population groups, especially children aged 1 to 5 years following a vegan diet. This is because soya drinks typically contain a comparable quantity of protein to cows' milk, and of the 3 plant-based drinks under consideration, are most similar to cows' milk in terms of protein quality. Protein is required to support appropriate growth and development in children.

3.370 Balancing the potential risks and benefits of soya drink consumption in place of cows' milk is complex. There are insufficient data to conduct a direct comparison of the net benefit on different health endpoints (that is, endocrine-modifying effects compared with appropriate growth). However, the alternative scenario (soya drink) is of potential concern for those children consuming both soya drinks and other soya-based products as the predominant source of protein in their diet due to exposure to isoflavones. The risks of higher isoflavone exposure associated with consumption of soya drinks could be mitigated by choosing a variety of protein sources (including plant-based alternatives) in the rest of the diet and not restricting the protein source to soya-based products (that is, in both drinks and foods).

3.371 For children consuming protein from a wide range of sources, exposure to isoflavones would unlikely be of significant concern and all unsweetened and fortified drinks, including soya drink, would be acceptable. This is on the assumption that soya consumption (and thus, isoflavone exposure) will be lower as protein is not predominantly from soya-based products.

4. Summary and conclusions

4.1 Background

4.1 This report compared the benefits and risks (nutritional and toxicological) of consuming plant-based drinks in the UK compared with consuming cows' milk. The assessment had a specific focus on children aged 1 to 5 years. This was due to cows' milk being a large contributor to nutrient intakes in this age group. Furthermore, in terms of toxicological risks, children aged 1 to 5 years may be more sensitive to certain adverse effects and may be more highly exposed on a body weight basis. However, given the increasing availability and consumption of plant-based drinks more widely, the assessment was expanded to also cover all adults and children aged 5 years and over.

4.2 The benefit-risk assessment focused on comparing the consumption of cows' milk (that is, total volumes of all types of cows' milk consumed by age group in UK dietary surveys) with the consumption of the most popular plant-based drinks in the UK (almond, oat and soya drinks) on nutritional intakes, toxicological exposures and related health outcomes. Other types of plant-based drinks, such as pea and coconut, were not included in the assessment. Rice drinks were also not considered because existing UK dietary guidance states that rice drinks should not be consumed by children under age 5 years as they may contain too much arsenic (SACN (2023a) endorses COT (2016c)). Rice drinks are also not commonly consumed by older children and adults in the UK.

4.3 The impact on nutrient intakes of removing cows' milk from the diet and not replacing this with almond, oat or soya drink, was also considered. It was assumed that in this situation, cows' milk would be replaced with water.

4.4 A Benefit-Risk Analysis for Foods (BRAFO) was conducted to compare both nutritional and toxicological outcomes on health. Cows' milk consumption was the 'reference scenario' and almond, oat and soya drinks were the 'alternative scenarios'.

4.5 The assessment was mainly informed by:

- previous evaluations undertaken by SACN on nutrition and by COT on toxicology and health outcomes
- nutritional intake data from UK dietary survey and Kantar purchasing data (for Great Britain) for information on total volume of cows' milk consumed and the types of plant-based drinks available
- a nutritional substitution analysis to determine the potential impact on nutrient intakes of replacing cows' milk with plant-based drinks or water - nutrients considered in the substitution analysis reflected differences between cows' milk and plant-based drinks and health outcomes of greatest public health concern

4.6 The assessment was based on mean nutrient intakes and assumed a healthy population. The assessment did not cover individuals or groups with specific dietary or nutrient requirements, except for those following a vegan diet (or a diet that is mostly free from animal products). The risk of allergenicity from consumption of cows' milk and almond, oat and soya drinks was outside the scope of this assessment, as was consideration of:

- sustainability and environmental issues
- cultural practices
- ethical beliefs
- product costs
- other factors driving consumer choices to consume these products

4.7 The BRAFO and nutritional substitution analysis were not updated following peer review. SACN and COT agreed that updating these analyses would be unlikely to change the report's conclusions or recommendations. SACN and COT noted that, as part of SACN's process for conducting risk assessments, only evidence that had the potential to change the report's conclusions or recommendations would be considered following peer review.

4.2 Nutritional considerations and approach

4.8 Cows' milk is a major component of the diets of most children (particularly those aged 1 to 5 years), providing energy and protein (it contains all the essential amino acids) and saturated fat. It is also an important contributor to intakes of calcium and other micronutrients (notably, riboflavin, vitamin B12 and iodine in all age groups and vitamin A in children aged 1 to 5 years). Cows' milk is not an essential component in the diets of children aged 1 to 5 years (or the diets of other age groups). But if it is not part of their diet, other foods and drinks are needed to replace the nutrients that it provides.

4.9 Whole, semi-skimmed and skimmed cows' milk vary in the amount of energy, saturated fat and vitamin A they contain. The nutrient content of plant-based drinks also varies considerably (there are no specific legal or minimum standards governing nutrient composition of these products). As a result, plant-based drinks tend to:

- contain free sugars (sugars added as an ingredient or present as a result of the manufacturing process)
- vary in the type and amount of micronutrient fortification, with some only fortified with calcium, others fortified with calcium, riboflavin, vitamin B12, vitamin D and increasingly iodine, and others not fortified with any micronutrients - only one product was identified that was fortified with vitamin A at the time the assessment was conducted in 2022

4.10 Organic products are not permitted to be fortified with any nutrients under current legislation.

4.11 Given the small number of consumers of plant-based drinks in UK dietary surveys at the start of this assessment (2022), it was necessary to model the potential nutritional impact of replacing cows' milk consumption with different plant-based drinks. A nutritional substitution analysis was therefore conducted to determine the impact on total dietary intakes when the total volumes of all types of cows' milk consumed by participants in UK dietary surveys were replaced with equivalent volumes of almond, oat or soya drinks, or water. For different age groups, the proportion of the population whose intake of a particular nutrient was below the LRNI was used as an indicator of the potential impact of replacing cows' milk with the different plant-based drinks, and whether this was of public health concern. The nutritional substitution analysis assumed that there were no changes to the wider diet and no substitution was made of other dairy products with their plant-based equivalents.

4.12 Due to the variety of plant-based drink products available in the UK, the assessment was based on 3 theoretical nutrient profiles for each type of plant-based drink, which provided a sliding scale of nutritional impacts.

4.13 The 'typical' nutrient profiles were based on the nutritional composition of the most popular almond, oat and soya drinks sold in the UK in January 2022. These drink profiles:

- tended to contain free sugars (sugars added as an ingredient or present as a result of the manufacturing process)
- were fortified with riboflavin, vitamin B12 and calcium (but not vitamin A or iodine) at comparable levels to cows' milk
- were also fortified with vitamin D

4.14 The 'enhanced' nutrient profiles were based on the most nutritionally beneficial values for relevant nutrients in almond, oat and soya drinks. This profile was based on the nutrient composition of drinks sold in the UK in January 2022. These drink profiles were:

- unsweetened (without free sugars)
- fortified with vitamin A, riboflavin, vitamin B12, calcium and iodine at comparable levels to cows' milk
- also fortified with vitamin D

4.15 The 'unfortified and/or sweetened' nutrient profiles were based on the least nutritionally beneficial values for relevant nutrients in almond, oat and soya drinks sold in the UK in January 2022. These drink profiles were not fortified with any vitamins or minerals and/or contained sugars added as an ingredient.

4.3 Toxicological considerations and approach

4.16 Both cows' milk and plant-based dinks may contain naturally occurring components such as isoflavones that could have beneficial or adverse health effects, as well as contaminants that could be present at potentially harmful levels. These contaminants could be organic chemicals, heavy metals or mycotoxins. The range of compounds potentially present was assessed, taking into account factors such as exposure, the proximity of the estimated exposures to health-based guidance values (HBGV) and the availability of suitable data.

4.3 Benefit-risk assessment on plant-based drinks

4.17 SACN and COT conducted a Benefit-Risk Analysis for Foods (BRAFO) to assess the benefits and risks of changing from the reference scenario (in the case of this report 'cows' milk') to an alternative scenario (almond, oat and soya drinks), resulting in a statement about which scenario is preferred in terms of health.

4.18 The main nutrients and toxicological components that are present or potentially present in cows' milk and in almond, oat and soya drinks were preliminarily assessed ('triaged') to determine which of these should be included in BRAFO.

4.19 Nutritional and toxicological considerations were first analysed separately to reflect differences in the available evidence bases and how the certainty of the evidence is assessed.

4.4.1 BRAFO: nutritional considerations

4.20 The BRAFO focused on:

- the impact of consuming plant-based drinks in place of cows' milk (informed by the findings of the nutritional substitution analysis)
- the contribution cows' milk makes to nutrient intakes for different UK population groups and the nutrients of greatest public health concern

4.21 Each nutrient identified at the triage stage was considered separately based on:

- its function
- current dietary recommendations on requirements
- current nutrient intakes compared with requirements for different population groups, based on data from UK dietary surveys

- findings from the nutritional substitution analysis
- evidence on the nutrient in relation to health outcomes and whether changes in nutrient intakes resulting from replacement of cows' milk with almond, oat or soya drink would be of likely public health concern

4.22 The following nutrients were considered in the BRAFO assessment:

- energy
- protein
- saturated fat
- free sugars
- dietary fibre
- vitamin A
- riboflavin
- vitamin B12
- vitamin D
- calcium
- potassium
- iodine
- zinc

4.4.2 BRAFO: toxicological considerations

4.23 The BRAFO focused on:

- the level or certainty of evidence, such as whether there are established HBGVs and how these were established
- the magnitude of effect

- available data, which was largely based on the published literature but also included consideration of monitoring data on contaminant levels supplied by manufacturers

4.24 Each chemical contaminant and naturally occurring component identified at the triage stage was considered separately based on:

- their likely occurrence in cows' milk and plant-based drinks
- whether exposure was close to the relevant HBGV
- evidence on health outcomes and whether changes in exposure to chemical contaminants or naturally occurring components would likely be a public health concern

4.25 The following chemical contaminants and naturally occurring components were considered in the BRAFO assessment:

- isoflavones
- lead
- dioxins and dioxin-like polychlorinated biphenyls (PCBs)
- non-dioxin-like PCBs
- per- and polyfluoroalkyl substances (PFAS)
- aflatoxin
- deoxynivalenol (DON)
- ochratoxin A (OTA)
- perchlorate
- oestradiol

4.4.3 Results of the benefit-risk assessment

4.26 Replacing cows' milk with 'typical' nutrient profile plant-based drinks may have some nutritional benefits.

4.27 ‘Typical’ almond, oat and soya drinks may contribute to:

- lower intakes of energy and saturated fat - this would be beneficial for all age groups, except for people living with underweight, particularly children, for whom lower energy intakes would not be beneficial

- higher intakes of dietary fibre and vitamin D in all age groups

4.28 ‘Typical’ almond and oat drinks may contribute to lower intakes of protein (soya drinks are the most similar to cows’ milk in terms of protein quantity and quality). This would be beneficial because mean protein intakes are above requirements in all age groups in the UK. In addition, evidence suggests that excess protein intakes in children aged 1 to 5 years may be associated with increased BMI in later childhood. However, lower protein intakes from consuming ‘typical’ almond and oat drinks may not benefit children aged 1 to 5 years following a vegan diet, who may be at risk from lower protein intakes.

4.29 Replacing cows’ milk with ‘typical’ nutrient profile plant-based drinks may have potential nutritional risks by contributing to:

- higher intakes of free sugars in all age groups

- inadequate intakes of some micronutrients, especially in children aged 1 to 5 years who get a higher proportion of their micronutrient intake from cows’ milk

4.30 Nutritional concerns may be lessened if almond, oat and soya drinks met the 'enhanced' nutrient profile. That is, if they were unsweetened (without free sugars) and were fortified with vitamin A, riboflavin, vitamin B12, calcium and iodine at similar levels to those in cows’ milk and also vitamin D. However, it is uncertain whether micronutrient fortificants are as ‘bioavailable’ (as easily digested and absorbed) as micronutrients that are naturally present in cows’ milk.

4.31 Replacing cows’ milk with the ‘unfortified and/or sweetened’ nutrient profile drinks has nutritional risks for all population groups. It may contribute to higher intakes of free sugars and inadequate intakes of some micronutrients.

4.32 For children, particularly children aged 1 to 5 years following a vegan diet, consuming water in meals and snacks where other children would usually consume cows’ milk may contribute to lower protein intakes and increase the risk of inadequate micronutrient intakes.

4.33 For most toxicological chemical contaminants and naturally occurring components considered in the assessment, there was no clear risks or benefits associated with replacing cows’ milk with almond, oat or soya drinks. This was because either the contaminants or components were not present or were present at levels that posed little or no risk. SACN and COT noted a number of uncertainties, particularly with respect to exposure and occurrence data.

4.34 The only potential toxicological concern clearly identified relates to isoflavones from soya drinks in highly exposed populations, such as children aged 1 to 5 years following a vegan diet whose exposure to isoflavones per kg of bodyweight may be high. For these groups, the endocrine-modifying effects of these phytoestrogens is a potential risk. A qualitative assessment indicated that the potential risks of isoflavone exposure in soya drinks may outweigh the potential benefits associated with their higher protein content compared with almond and oat drinks. This risk could be partially mitigated by ensuring that these children consume a variety of (non-animal) protein sources rather than relying solely on soya products.

4.35 The ingredients used to make plant-based drinks may be at risk of fungal contamination which can result in the presence of mycotoxins (naturally occurring toxins produced by fungi that can contaminate food and cause health problems), such as aflatoxin in soya and ochratoxin A in oats. The limited data available suggests that this may not be a major concern in practice in the UK, but the possible presence of such contaminants should be carefully monitored.

4.36 While there was insufficient data to allow quantitative integration of risks and benefits, the qualitative integration was considered sufficient to make judgements on the balance of benefits and risks relating to the alternative scenarios compared with the reference scenario.

4.4 Limitations

4.37 The assessment was restricted to consideration of the nutritional and toxicological issues associated with the most commonly consumed plant-based drinks (almond, oat and soya drinks), based on data available at the time the joint SACN and COT working group commenced its assessment (2022). Other plant-based drink types, such as pea or hemp drinks are not covered.

4.38 The assessment was based on the nutrient composition of almond, oat and soya products available in January 2022. The nutrient composition of plant-based drinks is highly variable, and the market is evolving rapidly. At the time of publication of this report (2025), more products were fortified with micronutrients and contained lower levels of free sugars than was the case when this assessment was initiated. However, SACN and COT noted that such compositional changes to plant-based drinks were captured in the 'enhanced' nutrient profile and these changes were unlikely to change the report's conclusions or recommendations.

4.39 The information on nutrient composition of these products was primarily informed by manufacturer product descriptions (rather than independent laboratory analyses). Therefore, it was not possible to consider the full nutrient profile of products (including any ‘overage’).

4.40 There is limited direct evidence on population intakes of plant-based drinks and the impact of their consumption on nutrient intakes and toxicological exposures and health outcomes. There is also an absence of evidence on total consumption of plant-based products (particularly soya), and how this may impact toxicity. While plant-based drinks have increased in popularity in the UK in recent years, the number of consumers remains low compared with cows’ milk. This means that the numbers of consumers in dietary surveys such as the NDNS are currently too low for detailed analysis. The impact of more recent changes to the plant-based drinks market are particularly unclear for children aged 12 to 18 months, for whom the most recent UK dietary survey was carried out in 2011. SACN and COT were also aware that dietary surveys data only represent a snapshot of participants’ intakes usual dietary habits.

4.41 Changes in dietary patterns since data was collected are unlikely to be restricted to plant-based drinks consumption. Consumers may also have changed the balance of their diets to include more plant-based alternatives to meat and dairy products, which could affect estimation of risk, particularly around protein and protein quality. More up-to-date data collection, and in the longer term, the increased sample size in NDNS and its extension to include children from 12 rather than 18 months, will help address this evidence gap and allow modelling to determine the impact on nutrient intakes of consuming plant-based drinks and more broadly, plant-based diets.

4.42 There also remains limited dietary data on the consumption of plant-based drinks by individuals following a vegan or vegetarian diet, or who have limited consumption of animal products. The NDNS data set will include some individuals who are following a vegan diet or a dairy-product-free diet. Given that these individuals would not be consuming cows’ milk, the modelled substitution would have no impact on their usual nutrient intakes. No analysis has been carried out specifically on the subgroup following a vegan diet as numbers in the NDNS data set are very low.

4.43 SACN and COT were also aware of the limitations in the wider evidence base on the dietary intakes and nutritional status of children adhering to a vegan diet, or a diet mostly free from animal products.

4.44 The assessment was based on the total volumes of all types of cows’ milk consumed by age group, based on data from UK dietary surveys, rather than considering the impact of separately replacing whole, semi-skimmed, skimmed cows' milk with soya, almond or oat drink. While using the nutrient composition of semi-skimmed or skimmed milk as individual comparators would have aligned with UK government dietary advice, it would not have reflected population consumption in the UK.

4.45 The substitution of the total volume of all types of cows' milk with plant-based drinks results in lower energy intakes. For the purposes of this analysis, it was assumed that this energy deficit was not compensated for through consumption of other foods and drinks as there is no available data on the dietary modifications made by people swapping to plant-based drinks to use as a basis for modelling any replacement.

4.46 Since the assessment was conducted, the nutrient composition of cows' milk (whole, semi and skimmed milk) has also been reanalysed for certain micronutrients. The updated figures for riboflavin, vitamin B12 and iodine are lower than the previous figures used in the substitution analysis. However, SACN and COT agreed that these changes were unlikely to change their conclusions and recommendations.

4.47 Kantar data reports food and drink purchases by household but this does not provide information on which household members are consumers. The Kantar data set used for this analysis (the 52 weeks from 6 September 2019 to week ending 6 September 2020) also covers the time period when the UK was in the first national lockdown due to the COVID-19 pandemic and the data collected may not be representative of 'normal' purchasing habits.

4.48 It was not possible to consider protein quality (amino acid composition and biodigestibility) or unsaturated fats in the substitution analysis or BRAFO due to uncertainties in the evidence base on these topics.

4.49 No adjustments were made to the data resulting from this analysis to take account of potential differences in the bioavailability of fortificants included in plant-based drinks.

4.50 Although there was only limited information on exposures to chemicals of potential toxicological concern from plant-based drinks consumption, it was still possible to reach conclusions on the potential risks for most of these chemicals.

4.51 A call for evidence was issued to plant-based drink manufacturers and trade bodies during this assessment. Responses provided insights into the plant-based drinks market. However, information provided was variable in content and quality and details could not be published due to commercial sensitivities.

4.5 Conclusions

4.52 Replacing cows’ milk with soya, almond or oat drinks results in potential benefits and risks from both a nutritional and a toxicological perspective.

4.53 Based on the data available at the time of publication of the report, SACN and COT noted that no almond, oat or soya drink sold in the UK is nutritionally equivalent to cows’ milk.

4.54 Replacing cows’ milk with ‘typical’ nutrient profile drinks may have some nutritional benefits, as follows.

4.55 For almond, oat and soya drinks, ‘typical’ drinks may contribute to lower intakes of energy and saturated fat - this would be beneficial in all age groups except for individuals living with underweight, particularly children, for whom lower energy intakes would not be beneficial.

4.56 For almond, oat and soya drinks, ‘typical’ drinks may contribute to higher intakes of dietary fibre and vitamin D in all age groups.

4.57 For almond and oat drinks, ‘typical’ drinks may contribute to lower intakes of protein (soya drink is the most similar to cows’ milk in terms of protein quantity and quality). This would be beneficial because mean protein intakes are above requirements in all age groups in the UK; and evidence in children aged 1 to 5 years suggests that excess protein intakes may be associated with increased BMI in later childhood. However, lower protein intakes as a result of consuming ‘typical’ almond and oat drinks may not benefit children aged 1 to 5 years following a vegan diet for whom lower protein intakes may be a risk. It was not possible to consider protein quality in the substitution analysis or BRAFO due to uncertainties in the evidence base for these topics.

4.58 Replacing cows’ milk with ‘typical’ nutrient profile plant-based drinks may have potential nutritional risks by contributing to higher intakes of free sugars and insufficient intakes of key micronutrients (vitamins A and iodine), especially in children aged 1 to 5 years for whom the relative contribution of cows’ milk to nutrient intakes is largest.

4.59 The nutritional concerns related to plant-based drinks when consumed in place of cows’ milk, especially in children aged 1 to 5 years, would be lessened if unsweetened (without free sugars) almond, oat and soya drinks were fortified with vitamin A, riboflavin, vitamin B12, calcium and iodine at comparable levels to those in cows’ milk, as proposed in the ‘enhanced’ nutrient profile. However, it is unclear whether the bioavailability of micronutrient fortificants in plant-based drinks is equivalent to the bioavailability of micronutrients naturally present in cows' milk. It was therefore not possible to consider the relative bioavailability of micronutrients from the different drink types as part of this benefit-risk assessment.

4.60 As with plant-based drinks, and assuming no other dietary changes, replacement of cows' milk with water would result in lower intakes of energy and saturated fats, with potential benefits to health given that mean intakes of these in the general population are above recommendations. For most population groups, the resulting decrease in protein intakes would not pose a nutritional risk as mean protein intakes exceed requirements in all age groups. However, replacing consumption of cows' milk with water would contribute to insufficient intakes of micronutrients to a greater extent than replacing cows' milk with unsweetened, fortified plant-based drinks.

4.61 The nutrition substitution analysis was based on total volumes of all types of cows' milk consumed by participants in UK dietary surveys. It did not consider the impact of separately replacing whole, semi-skimmed or skimmed cows' milk with the different plant-based drinks. However, there are significant health advantages for most adults and children of consuming lower fat cows' milk compared with whole cows' milk. The most commonly consumed cows' milk in the UK is semi-skimmed cows' milk. Current UK dietary guidance advises that whole and semi-skimmed cows' milk can be given as a main drink from age one year. However, the lowest fat cows' milks (skimmed and 1%) should not be given as a main drink until 5 years of age because of the low vitamin A content.

4.62 For older children and adults, the BRAFO recognises that if cows' milk consumption moved from predominantly whole or semi-skimmed to predominantly skimmed cows' milk, this would reduce intakes of energy and saturated fat, and the potential health benefits of replacing cows' milk with soya, almond or oat drinks would be reduced. However, reducing saturated fat intakes would also be associated with a reduction in vitamin A intake (a fat-soluble vitamin) which would not be beneficial. For this reason, skimmed milk is not recommended as a main drink for young children under age 5 years.

4.63 SACN and COT have been mindful of the existing advice on cows' milk consumption for different age groups. As such, when making recommendations on the fortification of plant-based drinks, they recommended that comparison is made to semi-skimmed or whole cows' milk as the most appropriate cows' milk for the most vulnerable group (that is, children aged 1 to 5 years).

4.64 For children, particularly children aged 1 to 5 years following a vegan diet, the consumption of water in meals and snacks where other children would usually consume cows' milk might contribute to insufficient protein intakes and exacerbate the risk of inadequate micronutrient intakes.

4.65 The only potential toxicological concern clearly identified relates to isoflavones from soya drinks in highly exposed populations, such as children aged 1 to 5 years following a vegan diet. This risk could be partially mitigated by ensuring that these children consume a variety of protein sources in the rest of the diet and not restricting the protein source to soya-based products (that is, in both drinks and foods).

4.66 Additionally, the bulk commodities used to make plant-based drinks may be subject to fungal contamination, which can result in the possible presence of mycotoxins, such as aflatoxin in soya and ochratoxin A in oats, which would be of potential health concern. The limited occurrence data available suggests that this is unlikely to be a major concern in practice, but the possible presence of such contaminants should be carefully monitored.

4.67 Overall, the assessment has identified that, almond, oat and soya drinks available in the UK are not nutritionally equivalent to cows' milk. The most appropriate current alternative to cows' milk varies by age group and wider dietary intakes and concerns. The greatest concerns in replacing cows' milk with almond, oat and soya drinks relate to children aged 1 to 5 years, particularly those following a vegan diet.

4.68 While this assessment focused on almond, oat and soya drinks, SACN and COT noted that many of their conclusions, and as a result their recommendations, would apply to all plant-based drinks.

4.69 In drawing their overall conclusions (chapter 4) and Recommendations (chapter 5), SACN and COT also considered findings from the SACN statement on the WHO guideline on non-sugar sweeteners (SACN, 2025b).

4.70 Although it was beyond the scope of this assessment, SACN and COT noted that there are no minimum nutritional composition requirements for these products. Also, to meet organic standards, organic plant-based drinks are not fortified with calcium or any other micronutrients.

5. Recommendations

5.1 The following recommendations are for adults and children aged 1 year and over. They are made in the context of existing UK population advice. This includes existing recommendations on:

- non-sugar sweeteners (SACN, 2025b)
- processed foods (SACN, 2025a)
- feeding young children aged 1 to 5 (SACN, 2023a)
- rice drinks, in the Food Standard Agency Arsenic in rice advice (2018)

5.2 In the recommendations, the term ‘vegan diets’ extends to diets that are mostly free from animal products. ‘Children aged 1 to 5 years’ covers children up to their fifth birthday. Where recommendations state ‘plant-based drinks’ this refers to all types, not just almond, oat and soya.

5.1 Fortification of plant-based drinks

5.3 Plant-based drinks should be fortified with vitamin A, riboflavin, vitamin B12, calcium and iodine at levels comparable with those found in semi-skimmed cows’ milk.

5.4 Plant-based drinks should also be fortified with vitamin D, which is already common practice and should be encouraged.

5.2 Recommendations for the general population

5.2.1 All children aged 1 to 5 years

5.5 For children aged 1 to 5 years, SACN and COT recommend that:

- whole or semi-skimmed cows’ milk are preferable to plant-based drinks for children aged 1 to 5 years who consume animal products
- fortified and unsweetened (without free sugars or non-sugar sweeteners) almond, oat and soya drinks are an acceptable alternative to cows’ milk
- unfortified or sweetened (with free sugars or non-sugar sweeteners) plant-based drinks are not an acceptable alternative to cows’ milk

- there is no need for drinks specifically marketed for children aged 1 to 3 years, including plant-based follow-on formula, 'growing up' and other 'toddler' drinks

- they are ideally breastfed into the second year of life or beyond

5.2.2 Children aged 1 to 5 years following a vegan diet

5.6 For children aged 1 to 5 years following a vegan diet, SACN and COT recommend that:

- fortified and unsweetened (without free sugars or non-sugar sweeteners) versions of almond, oat and soya drinks are preferable to water in meals and snacks where other children would usually consume cows' milk

- fortified and unsweetened (without free sugars or non-sugar sweeteners) soya drink is preferable as their main alternative to cows' milk, because it usually contains higher amounts of protein than either almond or oat drink

- they are offered a variety of suitable alternatives to animal-based food and drinks, rather than mainly consuming soya products, to avoid high intakes of isoflavones

5.2.3 All children aged 5 years and over and all adults

5.7 For the general population of children aged 5 years and over and all adults, SACN and COT recommend that:

- fortified and unsweetened (without free sugars or non-sugar sweeteners) almond, oat and soya drinks are an acceptable alternative to cows' milk

- unfortified or sweetened (with free sugars or non-sugar sweeteners) plant-based drinks are not an acceptable alternative to cows' milk

5.3 Recommendations for the government to consider

5.8 SACN and COT recommend that government considers

- collecting detailed, nationally representative dietary data with a sufficient sample size to monitor the consumption of plant-based drinks and enable assessment by population subgroups including:

    - racially and ethnically diverse groups

    - socially disadvantaged groups

    - individuals, particularly children, who follow a vegan or vegetarian diet

- monitoring the nutritional impact of a possible population shift towards greater adoption of vegetarian, vegan and diets that are mostly free from animal products, particularly in children
- collecting data on the nutritional composition of plant-based drinks
- monitoring industry data on the nutritional composition and the levels of contaminants of toxicological concern in plant-based drinks
- establishing minimum requirements for the vitamin A, riboflavin, vitamin B12, calcium and iodine content of plant-based drinks at a comparable level to (and assuming equivalent bioavailability from) semi-skimmed cows' milk
- encouraging industry to continue to fortify plant-based drinks with vitamin D
- establishing minimum toxicological standards for chemical contaminants in plant-based drinks, particularly those marketed to young children
- options to help consumers make informed choices about the suitability of plant-based drinks compared with cows' milk

5.4 Recommendations for industry

5.9 SACN and COT recommend that industry:

- reduces the free sugars content of plant-based drinks (whether these are added as an ingredient or are present due to manufacturing processes)
- aims for plant-based drinks to be nutritionally equivalent to semi skimmed cows' milk for levels of vitamin A, riboflavin, vitamin B12, calcium and iodine
- fortifies plant-based drinks with vitamin D
- avoids adding non-sugar sweeteners to plant-based drinks
- minimises the toxicological risks associated with plant-based drinks, including minimising the presence of chemical contaminants and undesirable naturally occurring components (such as isoflavones and mycotoxins)
- makes data on the nutritional composition of plant-based drinks and the levels of substances of toxicological concern publicly available

6. Research recommendations

6.1 SACN and COT identified a number of gaps in the evidence during the development of this report. Areas recommended for future research are summarised below.

6.2 SACN and COT recommend that research in children aged 1 to 5 years follows overarching principles outlined in the SACN report 'Feeding young children aged 1 to 5 years' (SACN, 2023a). Particular consideration should be given to vulnerable groups including those experiencing multiple disadvantages. In the following recommendations, the term ‘vegan diets’ extends to diets that are mostly free from animal products.

6.3 SACN and COT recommend that researchers:

- examine the variations in different analytical methods used to detect and measure chemical contaminants in plant-based drinks

- examine the bioavailability of micronutrient fortificants in plant-based drinks (particularly compared with the bioavailability of micronutrients from cows’ milk), the plant-based food matrix, and other plant-based products, using appropriate nutrient-specific methodologies

- consider individual milk comparators (whole, semi-skimmed and skimmed milk) in any future nutritional substitution analysis

- consider protein quality (including amino acid composition and biodigestibility) and micronutrient content of vegan diets consumed by the UK population and the potential health implications, particularly among children aged 1 to 5 years

- monitor population intakes of all plant-based substitutes for meat and dairy products, particularly soya, and the effect this may have on exposure to chemicals of toxicological concern, particularly among children aged 1 to 5 years

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8. Glossary and abbreviations

8.1 Glossary

Acceptable daily intake (ADI)

ADI is an estimate of the amount of a substance in food or drink, expressed on a bodyweight basis (for example mg per kg bodyweight), that can be ingested daily over a lifetime by humans without appreciable health risk. The term ADI is used for substances such as food additives which are deliberately added to food. The term Tolerable Daily Intake is comparable but applies to contaminants.

Acute reference dose (ARfD)

ARfD is an estimate of the amount of a substance in food or drink, expressed on a body weight basis that can be ingested in a period of 24 hours or less without appreciable health risk.

Benchmark dose modelling (BMD and BMDL 10)

Benchmark dose modelling (BMD and BMDL 10) is an alternative quantitative approach to dose-response assessment using more of the data than the NOAEL process. This approach uses mathematical models to fit all available data points and uses the best fitting model to interpolate an estimate of the dose (benchmark dose) that corresponds to a particular level of response (a benchmark response). A measure of uncertainty is also calculated, and the lower confidence limit on the benchmark dose is called the BMDL. For example, a BMDL10 represents the lower 95% confidence limit of the benchmark dose (BMD) associated with a 10% increase in response. This value can them be used to establish a HBGV.

Bioavailability

Bioavailability is defined the proportion of the nutrient that is digested, absorbed and metabolized through normal pathways.

Body mass index (BMI)

BMI is an individual's weight in kilograms divided by the square of height in metres (kg/m2). For more information see NICE guideline NG246 on Overweight and obesity management.

Committee on Carcinogenicity of Chemicals in Food, Consumer Products and the Environment (COC)

COC advises the government and government agencies on whether substances are likely to cause cancer.

Cyanogenic glycosides

Cyanogenic glycosides are naturally occurring plant compounds that can release hydrogen cyanide, upon enzymatic breakdown. They are found in almonds, but with higher levels occurring in bitter almond varieties. Commercial cultivars of almonds are all sweet almonds. The levels present in sweet almonds, including those use to make almond drinks, are not of concern.

DEFRA Family Food

The DEFRA Family Food data set records household and out of home food and drink purchases separately. Data is collected for a sample of households in the UK using self-reported diaries supported by till receipts of all purchases over a 2 week period. Where possible quantities are recorded in the diaries but are otherwise estimated.

Diet and Nutrition Survey of Infants and Young Children (DNSIYC)

DNSIYC is a standalone survey providing detailed information on the food consumption, nutrient intakes and nutritional status of infants and young children aged 4 up to 18 months living in private households in the UK. Fieldwork was carried out between January and August 2011 (Lennox and others, 2013). The survey was carried out in all 4 countries of the UK and was designed to be representative of the UK population. Dietary assessment was similar to methodology used in NDNS and was carried out using a food diary and completed over 4 consecutive days (Lennox and others, 2013).

Dietary reference values (DRVs)

DRVs provide benchmark levels of nutrient requirements which can be used to compare mean values for population intakes. Although information is usually inadequate to calculate precisely and accurately the range of requirements for a nutrient in a group of individuals, it has been assumed to be normally distributed. This gives a notional mean requirement or Estimated Average Requirement (EAR) with the RNI defined as 2 notional standard deviations above the EAR. Intakes above the RNI will almost certainly be adequate to meet the needs of 97.5% of the population. The LRNI, which is 2 notional standard deviations below the EAR, represents the lowest intakes which will meet the needs of approximately 2.5% of individuals in the group. Intakes below this level are almost certainly inadequate for most individuals.

Estimated average requirement (EAR)

This is the estimated average requirement of a group of people for energy or protein or a vitamin or mineral. About half of a defined population will usually need more than the EAR, and half less.

Free sugars

Free sugars are defined as (Swan and others, 2018):

- all added sugars in whatever form in including honey, nectars and syrups, whether added during manufacture or by the consumer

- all sugars naturally present in fruit and vegetable:

    - juices
    - concentrates
    - smoothies
    - purées and pastes
    - powders
- extruded fruit and vegetable products and similar products in which the structure has been broken down all sugars in drinks (except for dairy-based drinks)
- lactose and galactose added as ingredients

Health based guidance value (HBGV)

HBGV is a value indicating the amount of chemical in food that a person can consume on a regular basis usually over a lifetime without any significant risk to health.

Healthy Start

Healthy Start is a UK-wide government scheme that offers a nutritional safety net for pregnant women, new mothers and children under 4 years of age in very low income families, and encourages them to eat a healthier diet. The scheme provides vouchers to put towards the cost of milk, fruit and vegetables or infant formula, and coupons for free Healthy Start vitamin supplements.

JECFA

The Joint FAO/WHO Expert Committee on Food Additives (JECFA) is an international scientific expert committee, administered jointly by the Food and Agriculture Organization of the United Nations (FAO) and WHO. It evaluates the safety of food additives, contaminants, naturally occurring toxicants and residues of veterinary drugs in food.

Kantar Worldpanel

Kantar Worldpanel is a commercially produced data set providing volume sales and nutrition data for foods and drinks purchased by a consumer panel of 30,000 regionally and demographically representative households in Great Britain. The data set includes products consumed in the home regardless of place of purchase, for example convenience stores or supermarkets, and excludes those purchased and consumed out of the home. The data collected are weighted to provide a representative picture of total food and drink purchasing in Great Britain over the time period for which data is provided.

Kantar take-home food and drink main data set

This data set includes total volume of sales in kilograms/litres/servings and nutrition data for individual food products per 100 grams (g)/100 millilitres (ml)/serving as well as details of pack size (such as number of products included in multipacks). Households are defined by age of main shopper and age of youngest child, as follows:

- pre-family (main shopper aged under 45 years and no children in the household)
- young family (children in the household, with the youngest child aged 0 to 4 years)
- middle family (children in the household, with the youngest child aged 5 to 9 years)
- family 10 years plus (children in the household, with the youngest child aged 10 to15 years)
- older dependents (main shopper aged 45 to 64 years, no children but 3 or more adults in the household)
- empty nesters (main shopper aged 45 to 64 years, no children but 1 to 2 adults in the household)
- retired (main shopper aged 65 years and over, no children but 1 to 2 adults in the household)

Socioeconomic status groups are aligned to the Office for National Statistics national statistics socio-economic classification (ONS NS-SEC) (AB, C1, C2, D, E). Note that as the data is commercially sensitive, volume sales data is not reproduced in this report.

Lactose

Lactose is a disaccharide consisting of galactose and glucose linked by a beta 1-4 glycosidic bond. It is a naturally occurring sugar in milk and dairy products.

Limit of detection (LOD)

LOD is the lowest concentration of a substance that can be reliably detected by an analytical method, but not necessarily quantified.

Lower reference nutrient intake (LRNI)

LRNI is the estimated average daily intake of a nutrient which can be expected to meet the needs of only 2.5% of a healthy population. Values set may vary according to age, gender and physiological state (for example, pregnancy or breastfeeding).

Margin of exposure (MOE) approach

The MOE approach is a methodology that allows the comparison of the risks posed by different genotoxic and carcinogenic substances. It uses a reference point, often taken from an animal study and corresponding to a dose that causes a low but measurable response in animals. This reference point is then compared with various dietary intake estimates in humans, taking into account differences in consumption patterns. The size of the margin of exposure considered of low concern will vary depending on the toxicological endpoint concerned as well as the available data. For a genotoxic carcinogen an MOE of greater than 10,000 would be of low concern, but for other endpoints it could be 100 or lower.

Maximum residue levels or limits (MRLs)

MRLs are the maximum permitted concentrations of pesticide or veterinary medicine residues respectively in a food.

Mycotoxins

Mycotoxins are toxic compounds that are naturally produced by certain types of moulds (fungi). Moulds that can produce mycotoxins grow on numerous foods such as cereals, dried fruits, nuts and spices. Exposure to mycotoxins can result in a range of adverse health effects.

National Diet and Nutrition Survey (NDNS)

NDNS is a continuous cross-sectional survey of food consumption, nutrient intakes and nutritional status in adults and children living in private households in the UK. It is designed to be representative of the UK population and has been running since 2008. Until 2024, the UK sample included 500 adults and 500 children per year. It also excluded children under 18 months, pregnant and breastfeeding women, and people living in institutions. Until 2019, dietary assessment was carried out using a paper diary completed for 4 consecutive days. From 2019, the dietary assessment has been carried out using an automated online tool, Intake24. From 2024, the sample size has increased to 2000 adults and 2000 children per year, the lower participant age range extended to 12 months and pregnant and lactating women are no longer excluded. Details of the rationale, design and methods of the survey have been described elsewhere (Venables and others, 2022).

No observed adverse effect level (NOAEL)

The NOAEL is the highest administered dose at which no adverse effect has been observed in an exposed population (humans or laboratory animals). This value can be used to set HBGVs.

Non-sugar sweeteners

The WHO defines non-sugar sweeteners (NSS) as “all synthetic and naturally occurring or modified non-nutritive sweeteners that are not classified as sugars”. The WHO notes that NSS can also be referred to as: high-intensity sweeteners, low or no-calorie sweeteners, non-caloric sweeteners, sugar substitutes. NSS are also sometimes called ‘artificial sweeteners’. For more information, see Use of non-sugar sweeteners: WHO guideline.

Organic

Organic production is an overall system of farm management and food production that combines best environmental practices, a high level of biodiversity, the preservation of natural resources, the application of high animal welfare standards and a production method in line with the preference of certain consumers for products produced using natural substances and processes. The organic production method thus plays a dual societal role, where it on the one hand provides for a specific market responding to a consumer demand for organic products, and on the other hand delivers public goods contributing to the protection of the environment and animal welfare, as well as to rural development. (see 'Introductory text (1)' of assimilated Council Regulation 834/2007)

PAH and PHA4

Polyaromatic hydrocarbons (PAHs) are a group of chemical contaminants which are formed by incomplete combustion. PAH4 refers to a group of four PAHs that are often analysed together to assess PAH contamination. These four compounds are: benzo[a]pyrene, chrysene, benz[a]anthracene, and benzo[b]fluoranthene.

Protein quality

Protein quality is an index of how well a protein meets the requirements of essential amino acids.

Reference nutrient intake (RNI)

RNI is the average daily intake of a nutrient sufficient to meet the needs of almost all members (97.5%) of a healthy population. Values set may vary according to age, gender and physiological state (for example, pregnancy or breastfeeding).

Sales weighted average

Sales weighted average is where the individual nutrient values for each product are weighted by the product’s total sales volume in unit sales, which was litres in this case.

Sugar-sweetened beverage

In this report, a sugar-sweetened beverage (SSB) is any (non-dairy) beverage (carbonated drinks, fruit-based drinks, squashes, flavoured water) where sugars have been specifically added as a sweetener. Where possible, these are distinguished from 100% fruit juices (with naturally occurring levels of sugars).

Sweetened

In this report, a drink is 'sweetened' if sugars have been added to it as an ingredient.

Tolerable daily intake (TDI)

TDI is an estimate of the amount of contaminant, expressed on a body weight basis (for example mg/kg bodyweight), that can be ingested daily over a lifetime without appreciable health risk. For chemical contaminants which can accumulate within the body over time, a tolerable weekly intake (TWI) or tolerable monthly intake (TMIs) may be set instead.

Tolerable upper level (TUL)

A tolerable upper intake level (TUL) is intended to specify the level above which the risk for harm begins to increase and is defined as the highest average daily intake of a nutrient that is, likely to pose no risk of adverse health effects for nearly all persons in the general population, when the nutrient is consumed over long periods of time, usually a lifetime.

Toxic equivalency (TEQ)

TEQ is a system used to assess the overall toxicity of mixtures of chemicals, particularly dioxins and dioxin-like compounds, by expressing their combined effect as a single value relative to a reference substance. This system relies on toxic equivalency factors (TEFs), which represent the toxicity of each compound compared to the most toxic compound in the group. WHO-TEQ refers to the TEQ system developed by the World Health Organization for dioxins and dioxin-like compounds.

Unsweetened

In this report, 'unsweetened' refers to a drink that does not contain sugars added to it as an ingredient and no free sugars present as a result of processing.

Vegan diet

A vegan diet contains no food of animal origin (meat, poultry, fish, dairy, eggs or honey). It is based on plants such as vegetables, grains, beans, nuts, seeds and fruits, and can also include other non-animal foods such as yeast and fungi. In this report 'vegan diets' extends to diets that are mostly free from animal products.

Veganism

Veganism is a philosophy and way of living which seeks to exclude - as far as is possible and practicable - all forms of exploitation of, and cruelty to, animals for food, clothing or any other purpose; and by extension, promotes the development and use of animal-free alternatives for the benefit of animals, humans and the environment.

Veganism attracts protection under Article 9 of the European Convention on Human Rights and ethical veganism is a protected characteristic for the purposes of the British Equality Act 2010.

Vitamin A

Vitamin A is obtained from the diet either as preformed vitamin A (mainly retinol and retinyl esters) in foods of animal origin or as provitamin A carotenoids, dietary precursors of retinol, in plant-derived foods (these include alpha- and beta-carotene, and beta-cryptoxanthin). Annex II of Regulation (EC) 1925/2006 specifies the permitted forms of vitamin A that can be added to food in the UK. These are retinol; the retinyl esters: retinyl acetate and retinyl palmitate; and beta carotene.

8.2 Abbreviations

ADI: acceptable daily intake

AFB1: aflatoxin B1

AFB2: aflatoxin B2

AFM1: aflatoxin M1

ARfD: acute reference dose

BaP: benzo[a]pyrene

BbF: benzo[b]fluoranthene

BMI: body mass index

BPA: bisphenol A

bw: body weight

CHD: coronary heart disease

ChR: chrysene

CMPA: cows' milk protein allergy

CoFID: Composition of Foods Integrated Dataset

COC: Committee on the Carcinogenicity of Chemicals in Food, Consumer Products and the Environment

COMA: Committee on Medical Aspects of Food and Nutrition Policy

COT: Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment

CS: case study

CSS: cross-sectional study

Defra: Department for Environment, Food and Rural Affairs

DHSC: Department of Health and Social Care

DNSIYC: Diet and Nutrition Survey of Infants and Young Children

DON: deoxynivalenol

DRVs: dietary reference values

EAR: estimated average requirement

EFSA: European Food Safety Authority

EU: European Union

FAO: Food and Agriculture Organization of the United Nations

FSA: Food Standards Agency

g/day: grams per day

GP: general practitioner

HBCD: hexabromocyclodecane

HBGV: health based guidance value

HDL cholesterol: high density lipoprotein cholesterol

HIC: high income country

IGF-1: insulin-like growth factor 1

IU: international units

JECFA: Joint FAO and WHO Expert Committee on Food Additives

JMPR: joint meeting on pesticide residues

kcal: kilocalorie

kg: kilogram

kj: kilojoule

LDL cholesterol: low density lipoprotein cholesterol

LMIC: lower- or middle-income country

LOD: limit of detection

NOAEL: no observed adverse effect level

LRNI: lower reference nutrient intake

MA: meta-analysis

mg: milligram

ml: millilitre

MOE: margin of exposure

NDNS: National Diet and Nutrition Survey

ng: nanogram

NMEs: non-milk extrinsic sugars

NICE: National Institute for Health and Care Excellence

OTA: ochratoxin A

PAH: polycyclic aromatic hydrocarbon

PBB: polybrominated biphenyls

PBD: plant-based drinks

PBDEs: polybrominated diphenyl ethers

PCBs: polychlorinated biphenyls

PCS: prospective cohort study

PFAs: per- and polyfluoroalkyl substances

PFCAs: perfluorocarboxylic acids

pg: picogram

PTMI: provisional tolerable monthly intake

RCT: randomised controlled trial

RS: retrospective cohort

SACN: Scientific Advisory Committee on Nutrition

SMD: standardised mean difference

SR: systematic review

SSB: sugar-sweetened beverage

T2D: type 2 diabetes

TBBPA: tribromobisphenol A

TCDD: 2,3,7,8-tetrachlorodibenzo-p-dioxin

TDI: tolerable daily intake

TEF: toxic equivalency factor

TEQ: toxic equivalent

TMI: tolerable monthly intake

TUL: tolerable upper level

TWI: tolerable weekly intake

µg: microgram

WCRF: World Cancer Research Fund

WHO: World Health Organization

9. Roles, membership and acknowledgments

9.1 SACN's role and membership

The role of SACN is to provide independent scientific advice on and risk assessments of nutrition and related health issues. It advises the 4 UK health departments, and other government departments and agencies.

Membership of SACN and the register of members' interests at the time of publication is provided in the 'SACN annual report 2024'. The SACN annual report and SACN's code of practice is available on the SACN webpage.

9.2 COT's role and membership

The role of the COT is to provide independent expert advice on matters concerning the toxicity of chemicals. It advises the 4 UK health departments, and other government departments and agencies.

Membership of the COT can be found at COT Membership and details of Members' interests at COT Register of interests. The COT's papers, statement and annual reports can be found on the COT website.

9.3 Acknowledgements

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Professor Louis Levy (formerly Head of Nutrition Science, Public Health England).

Professor Joe Millward (Emeritus Professor of Human Nutrition, University of Surrey).

9.4 Suggested citation

Scientific Advisory Committee on Nutrition and Committee on Toxicity. Assessing the health benefits and risks of consuming plant-based drinks. 2025.

Annex 1: nutritional substitution analysis

Methodology to derive plant-based drink nutrient profiles

The nutrient profiles for almond, oat and soya drinks used in the substitution analysis were based on products available in January 2022; these may not accurately reflect the current plant-based drink market.

Table A1.1: methodology to derive plant-based drink nutrient profiles (based on Kantar data for the 52 weeks from 6 September 2019 to week ending 6 September 2020) (note 1)

Nutrient profile	Inclusion criteria	Number of products included in calculation	Proportion of sales represented by products (note 2)	Nutrient profile calculation
Soya enhanced	Unsweetened fortified include products representing ≥90% sales	11 of 19	91%	Upper and lower range
Soya typical	Top 5 products by sales volume	5 of 58	39%	Sales weighted average
Soya unfortified and/or sweetened	Unfortified and/or sweetened no minimum sales threshold	3 of 5 (note 3)	85%	Sales weighted average
Almond enhanced	Unsweetened fortified include products representing ≥90% sales	8 of 14	93%	Upper and lower range
Almond typical	Top 5 products by sales volume	5 of 34	67%	Sales weighted average

Nutrient profile	Inclusion criteria	Number of products included in calculation	Proportion of sales represented by products (note 2)	Nutrient profile calculation
Almond unfortified and/or sweetened	Unfortified and/or sweetened no minimum sales threshold	4 of 4	100%	Sales weighted average
Oat enhanced (note 4)	Unsweetened fortified include products representing ≥90% sales	7 of 17	93%	Upper and lower range
Oat typical	Top 5 products by sales volume	5 of 24	78%	Sales weighted average
Oat unfortified and/or sweetened	Unfortified and/or sweetened no minimum sales threshold	7 of 7	100%	Sales weighted average

Note 1: individual products may appear in more than one category.

Note 2: for enhanced and unfortified and/or sweetened nutrient profiles, the proportion of sales represented by products refers to product sales for those nutrient profiles. For top 5 products, proportion of sales is of total sales.

Note 3: products not available or lacking available nutrient information.

Note 4: oat drinks do not typically contain sugars added as an ingredient (that is, they are ‘unsweetened’) but contain free sugars as a result of the processing of oats.

Results of substitution analysis by age group

Abbreviations and notes used in tables A1.2 to A1.25

Abbreviations
DRV: dietary reference value

g: grams

kcal: kilocalorie

LRNI: lower reference nutrient intake

MJ: megajoule

RNI: reference nutrient intake

TE: total energy including energy from ethanol (alcohol)

Notes
Note 1: this analysis assumes that any reduction in energy intake as a result of replacing cows' milk with an equivalent volume of plant-based drink is not compensated for by increased intake of other foods or drinks.

Note 2: at the time the substitution analysis was carried out, DRVs for fats and carbohydrates were expressed as a percentage of total energy intake including energy from ethanol (alcohol). DRVs are now expressed as a percentage of energy excluding ethanol (SACN, 2025c).

Note 3: 'total sugars' shows total sugars intakes (including free sugars) when consuming cows' milk or plant-based drinks or water. Cows' milk contains on average between 4.6 to4.8g of lactose per100ml (dependent on milk type), compared with the typical and unfortified and/or sweetened plant-based drinks models that contain a smaller amount (up to 3.7g per 100ml) of 'free' sugars. The baseline case (cows' milk) in each age group is therefore higher in 'total sugars' than any plant-based drinks model. However, typical and unfortified and/or sweetened plant-based drinks are higher in free sugars than the baseline model as cows' milk contains no free sugars.

Note 4: likely to be an underestimate of total salt intake as discretionary salt use is not fully captured in NDNS.

Note 5: replacing cows' milk with plant-based drinks reduces overall energy intake, reduces the proportion of energy from protein and fat and increases the proportion of energy from free sugars. The impact depends on the type of cows' milk being replaced.

Note 6: baseline case based on total milk consumption by individual, over / 4 consecutive days (DNSIYC and NDNS), which may include different types of milk (whole milk, semi-skimmed, and skimmed) and milk added to home-made composite dishes.

Note 7: the nutrient profiles for plant-based drinks are based on ingredients and quantities as listed on product packaging. This may exclude vitamins that are naturally present within the drink but have not been added, for example through fortification. Where the values for some vitamins were not listed on packaging, they have been updated to reflect the most recent nutrient values from the McCance and Widdowson's The Composition of Food Integrated Dataset (CoFID) or where unavailable, from the nutrient data bank (NDNS years 9 to 11) or FoodData Central.

Note 8: enhanced nutrient profiles include vitamin A at 21µg per 100ml (in line with semi skimmed milk). Current products (those used as basis for typical and unfortified and/or sweetened) do not include vitamin A fortification.

Note 9: one oat drink specifically marketed at children contains 1.5ug per 100g of vitamin D where the majority of products contain 0.75ug per 100g.

Note 10: the nutrient profiles for plant-based drinks are based on ingredients and quantities as listed on product packaging. This may exclude minerals that are naturally present within the drink but have not been added, for example through fortification. Where the values for some minerals were not listed on packaging, they have been updated to reflect the estimated nutrient values from the nutrient data bank (NDNS years 9 to 11) or CoFID. All values for magnesium and potassium, and all values for zinc and iron were updated with the exception of enhanced oat. Calcium values were also applied in all unfortified and/or sweetened plant-based drinks nutrient profiles.

Note 11: one oat drink is fortified with folate (15µg per100ml), iron(1.4mg per 100ml) and zinc (0.9mg per 100ml).

Note 12: enhanced nutrient profiles include iodine at 35µg per 100ml (in line with maximum fortification on some products). Whole cows' milk contains 31µg per 100ml and Semi-skimmed cows' milk contains 30µg per 100ml so enhanced plant-based drinks can contribute more to meeting DRVs than cows' milk.

Note 13: the definition of free sugars (Swan and others, 2018) includes: all added sugars in any form; all sugars naturally present in fruit and vegetable juices, purées and pastes and similar products in which the structure has been broken down; all sugars in drinks (except for dairy-based drinks); and lactose and galactose added as ingredients. Intakes for children aged 12 to 18 months are presented as non-milk extrinsic sugars (NMES) as DNSIYC pre-dated the definition of free sugars. The definition of NMES is similar to that of free sugars except that for NMES 50% of sugars in canned, stewed dried or preserved fruits was defined as extrinsic and 50% intrinsic.

Note 14: NSP (non-starch polysaccharides) comprise cellulose and non-cellulose polysaccharides (for example pectins, glucans, arabinogalactans, arabinoxylans, gums and mucilages) (Department of Health, 1991; Department of Health, 1994). SACN (2015) recommended a broader definition of dietary fibre to include all carbohydrates that are neither digested nor absorbed in the small intestine and have a degree of polymerisation of 3 or more monomeric units, plus lignin. The broader definition of dietary fibre is measured by AOAC methods and is colloquially known as 'AOAC fibre' AOAC fibre intakes are typically about a third higher than NSP intakes.

Note 154: the SACN report 'Feeding young children aged 1 to 5 years' (2023a) includes the recommendation that “UK dietary recommendations on average intake of free sugars (that free sugars should not exceed 5% of total dietary energy intake) should apply from age 1 year”.

Note 16: the nutrient profile for unfortified/unsweetened soya drink used the CoFID value for folate content of soya drink. This is slightly higher than the fortified value

Tables A1.2 to A1.4: age group 12 to 18 months mean total daily energy and nutrient intakes when all cows' milk in diet is replaced by equivalent volume of plant-based drinks or water

The abbreviations and notes used in these tables are described in the section 'Abbreviations and notes used in tables A1.2 to A1.25' above.

Table A1.2: age group 12 to 18 months - macronutrients (energy, protein and saturated fat)

DRV or intake	Energy (MJ/day) (note 1)	Energy (kcals/day) (note 1)	Protein (g/day)	Protein (%TE)	Saturated fat (g/day)	Saturated fat (%TE) (note2)
DRVs	3.0 to 3.2	717 to 765	14.5	No DRV	No DRV	No DRV
Baseline (note 6)	4.1	967	37.7	15.6	17.5	16.3
Soya enhanced	3.6	850	38.2	18.0	11.5	12.2
Soya typical	3.7	882	37.1	16.8	12.4	12.6
Soya unfortified and/or sweetened	3.8	904	38.6	17.1	12.1	12.0
Almond enhanced	3.4	819	30.5	14.9	11.2	12.3
Almond typical	3.5	824	29.4	14.3	11.2	12.2
Almond unfortified and/or sweetened	3.7	887	30.8	13.9	11.5	11.7
Oat enhanced	3.8	896	33.4	14.9	11.2	11.3
Oat typical	3.8	913	30.0	13.1	11.5	11.3
Oat unfortified and/or sweetened	3.7	896	30.5	13.6	11.2	11.3

DRV or intake	Energy (MJ/day) (note 1)	Energy (kcals/day) (note 1)	Protein (g/day)	Protein (%TE)	Saturated fat (g/day)	Saturated fat (%TE) (note2)
Water	3.3	782	28.2	14.5	10.9	12.6

DRVs are set for children aged 1 year. The DRVs provided here are minimum and maximum values for males and females in this age group.

Table A1.2 (continued): age group 12 to 18 months - macronutrients (total sugars, non-milk extrinsic sugars (NMES), fibre and salt)

DRV or intake	Total sugars (note 3) (g/day)	Total sugars (note 3) (%TE) (note 2)	NMES (g/day) (note 13)	NMES (% TE) (note 5)	NMES (note 13) (% meeting DRV) (note 15)	Fibre (note 14) (g/day)	Salt (note 4) (g/day)
DRVs	DRV relates to free sugars	DRV relates to free sugars	No DRV	No DRV	No DRV	No DRV	<2g/day 1 to 3 years
Baseline (note 5)	65.9	25.6	19.7	7.7	28	7.3	2.3
Soya enhanced	52.2	23.0	19.7	8.7	21	10.8	2.0
Soya typical	56.0	23.8	23.5	10.0	12	8.8	2.2
Soya unfortified and/or sweetened	59.1	24.5	26.6	11.0	10	9.1	2.5
Almond enhanced	52.2	23.9	19.7	9.0	20	8.8	2.3
Almond typical	53.1	24.2	20.6	9.4	16	8.2	2.4
Almond unfortified and/or sweetened	63.4	26.8	30.9	13.1	8	7.9	2.2
Oat enhanced	52.2	21.9	19.7	8.3	24	11.3	2.2

DRV or intake	Total sugars (note 3) (g/day)	Total sugars (note 3) (%TE) (note 2)	NMES (g/day) (note 13)	NMES (% TE) (note 5)	NMES (note 13) (% meeting DRV) (note 15)	Fibre (note 14) (g/day)	Salt (note 4) (g/day)
Oat typical	62.3	25.6	29.8	12.2	9	10.5	2.2
Oat unfortified and/or sweetened	62.8	26.3	30.3	12.7	8	9.3	2.3
Water	52.2	25.1	19.7	9.5	18	7.3	2.0

Table A1.3: age group 12 to 18 months - vitamins

Intake	Vitamin A (mean % RNI)	Vitamin A (% < LRNI)	Riboflavin (mean % RNI)	Riboflavin (% < LRNI)	Vitamin B12 (mean % RNI)	Vitamin B12 (% < LRNI)	Folate (mean % RNI)	Folate (% < LRNI)	Vitamin D (mean % RNI)
Baseline (note 6)	174	2	249	<1	732	<1	206 (note 7)	<1	38
Soya enhanced	169 (note 8)	3	235	<1	537	<1	200 (note 7)	<1	59
Soya typical	154	10	221	<1	503	<1	200 (note 7)	<1	56
Soya unfortified and/or sweetened	154	10	159 (note 7)	<1	319	1	221 (note 7; note 16)	<1	38
Almond enhanced	169 (note 8)	3	235	<1	537	<1	168 (note 7)	<1	59

Intake	Vitamin A (mean % RNI)	Vitamin A (% < LRNI)	Riboflavin (mean % RNI)	Riboflavin (% < LRNI)	Vitamin B12 (mean % RNI)	Vitamin B12 (% < LRNI)	Folate (mean % RNI)	Folate (% < LRNI)	Vitamin D (mean % RNI)
Almond typical	154	10	226	<1	537	<1	168 (note 7)	<1	59
Almond unfortified and/or sweetened	154	10	135	3	319	1	168 (note 7)	<1	38
Oat enhanced	169 (note 8)	3	235	<1	714	<1	225 (note 11)	<1	81
Oat typical	154	10	231	<1	548	<1	245 (note 7)	<1	62
Oat unfortified and/or sweetened	154	10	135	3	319	1	176 (note 7)	<1	38
Water	154	10	135	3	319	1	164	<1	38

Table A1.4: age group 12 to 18 months - minerals

Intake	Calcium (mean % RNI)	Calcium (% < LRNI)	Magnesium (mean % RNI)	Magnesium (% < LRNI)	Potassium (mean % RNI)	Potassium (% < LRNI)	Iodine (mean % RNI)	Iodine (% < LRNI)	Zinc (mean % RNI)	Zinc (% < LRNI)
Baseline (note 6)	226	<1	159	<1	200	<1	248	<1	109	4

Intake	Calcium (mean % RNI)	Calcium (% < LRNI)	Magnesium (mean % RNI)	Magnesium (% < LRNI)	Potassium (mean % RNI)	Potassium (% < LRNI)	Iodine (mean % RNI)	Iodine (% < LRNI)	Zinc (mean % RNI)	Zinc (% < LRNI)
Soya enhanced	228	<1	186 (note 10)	<1	187 (note 10)	<1	240 (note 12)	<1	103 (note 10)	6
Soya typical	228	<1	186 (note 10)	<1	187 (note 10)	<1	118	4	103 (note 10)	6
Soya unfortified and/or sweetened	140 (note 10)	2	176 (note 10)	<1	171 (note 10)	<1	101 (note 10)	15	103 (note 10)	6
Almond enhanced	228	<1	145 (note 10)	<1	150 (note 10)	<1	240 (note 12)	<1	91 (note 10)	17
Almond typical	228	<1	145 (note 10)	<1	150 (note 10)	<1	97	21	91 (note 10)	17
Almond unfortified and/or sweetened	136 (note 10)	3	145 (note 10)	<1	150 (note 10)	<1	98 (note 10)	19	91 (note 10)	17
Oat enhanced	228	<1	165 (note 10)	<1	158 (note 10)	<1	240 (note 12)	<1	137 (note 10)	2
Oat typical	228	<1	165 (note 10)	<1	158 (note 10)	<1	134	1.4	103 (note 10)	6

Intake	Calcium (mean % RNI)	Calcium (% < LRNI)	Magnesium (mean % RNI)	Magnesium (% < LRNI)	Potassium (mean % RNI)	Potassium (% < LRNI)	Iodine (mean % RNI)	Iodine (% < LRNI)	Zinc (mean % RNI)	Zinc (% < LRNI)
Oat unfortified and/or sweetened	134 (note 10)	4	165 (note 10)	<1	158 (note 10)	<1	97 (note 10)	21	103 (note 10)	6
Water	130	7	125	3	145	1.1	97	21	86	26

Tables A1.5 to A1.7: age group 18 to 60 months (1.5 to 5 years) mean total daily energy and nutrient intakes when all cows' milk in diet is replaced by equivalent volume of plant-based drinks or water

The abbreviations and notes used in these tables are described in the section 'Abbreviations and notes used in tables A1.2 to A1.25' above.

Table A1.5: age group 1.5 to 5 years - macronutrients (energy, protein and saturated fat)

DRV or intake	Energy (note 1) (MJ/day)	Energy (note 1) (kcals/day)	Protein (g/day)	Protein (%TE)	Saturated fat (g/day)	Saturated fat (%TE) (note 2)
DRVs	3.0 to 6.2 MJ/day	765 to 1482 kcals	14.5 to 19.7 g/day	14.5 to 19.7 g/day	No DRV	No DRV
Baseline (note 6)	4.7	1106	42.4	15.3	17.8	14.4
Soya enhanced	4.3	1023	42.7	16.7	13.5	11.8
Soya typical	4.4	1050	41.7	15.9	14.2	12.1
Soya unfortified and/or sweetened	4.5	1069	43.0	16.1	14.0	11.7
Almond enhanced	4.2	995	36.0	14.5	13.2	11.9
Almond typical	4.2	1000	35.1	14.0	13.2	11.8
Almond unfortified and/or sweetened	4.4	1055	36.3	13.8	13.5	11.4
Oat enhanced	4.5	1062	38.5	14.5	13.2	11.1
Oat typical	4.5	1077	35.6	13.2	13.5	11.2

DRV or intake	Energy (note 1) (MJ/day)	Energy (note 1) (kcals/day)	Protein (g/day)	Protein (%TE)	Saturated fat (g/day)	Saturated fat (%TE) (note 2)
Oat unfortified and/or sweetened	4.4	1062	36.0	13.6	13.2	11.1
Water	4.1	963	34.1	14.1	13.0	12.0

Table A1.5 (continued): age group 1.5 to 5 years (up to 60 months) - macronutrients (total sugars, free sugars, fibre and salt)

DRV or intake	Total sugars (note 3) (g/day)	Total sugars (note 3) (%TE) (note 2)	Free sugars (g/day)	Free sugars (% TE) (note 5)	Free sugars (% meeting DRV)	Fibre (g/day)	Fibre (% meeting DRV)	Salt (note 4) (g/day)
DRVs	DRV relates to free sugars	DRV relates to free sugars	(1-5 years) Should not exceed 5% TE	(1-5 years) Should not exceed 5% TE	(15 years) Should not exceed 5% TE	15 g/day	15 g/day	<2g/day 1 to 3 years <3g/day 4 years
Baseline (note 6)	66.3	22.5	31.1	10.3	12	11	16	2.8
Soya enhanced	55.6	20.4	31.1	11.1	6	14	36	2.6
Soya typical	58.8	21	34.3	12	3	12.2	20	2.8
Soya unfortified and/or sweetened	61.5	21.6	37	12.7	2	12.5	22	3
Almond enhanced	55.6	20.9	31.1	11.4	5	12.2	20	2.9

DRV or intake	Total sugars (note 3) (g/day)	Total sugars (note 3) (%TE) (note 2)	Free sugars (g/day)	Free sugars (% TE) (note 5)	Free sugars (% meeting DRV)	Fibre (g/day)	Fibre (% meeting DRV)	Salt (note 4) (g/day)
Almond typical	56.3	21.1	31.9	11.6	4	11.7	18	2.9
Almond unfortified and/or sweetened	65.2	23.2	40.7	14.3	1	11.5	18	2.8
Oat enhanced	55.6	19.6	31.1	10.7	9	14.5	39	2.8
Oat typical	64.2	22.4	39.7	13.6	1	13.7	33	2.8
Oat unfortified and/or sweetened	64.7	22.8	40.2	14	1	12.7	25	2.8
Water	55.6	21.6	31.1	11.8	5	11	16	2.6

DRVs are set by age groups (1 year, 2 to 3 years, 4 to 6 years). The DRVs provided here are minimum and maximum values for males and females across these age groups.

Table A1.6: age group 1.5 to 4 years - vitamins

Intake	Vitamin A (mean % RNI)	Vitamin A (% < LRNI)	Riboflavin (mean % RNI)	Riboflavin (% < LRNI)	Vitamin B12 (mean % RNI)	Vitamin B12 (% < LRNI)	Folate (mean % RNI)	Folate (% < LRNI)	Vitamin D (mean % RNI)
Baseline (note 6)	141	8	219	<1	790	0	189	<1	40
Soya enhanced	135 (note 8)	9	211	<1	622	0	194 (note 7)	<1	58

Intake	**Vitamin A (mean % RNI)**	**Vitamin A (% < LRNI)**	**Riboflavin (mean % RNI)**	**Riboflavin (% < LRNI)**	**Vitamin B12 (mean % RNI)**	**Vitamin B12 (% < LRNI)**	**Folate (mean % RNI)**	**Folate (% < LRNI)**	**Vitamin D (mean % RNI)**
Soya typical	123	18	200	<1	595	0	194 (note 6)	<1	55
Soya unfortified and/or sweetened	123	18	150 (note 7)	<1	454	0	210 (note 7; note 16)	<1	40
Almond enhanced	135 (note 8)	9	211	<1	622	0	168 (note 7)	<1	58
Almond typical	123	18	204	<1	622	0	168 (note 7)	<1	58
Almond unfortified and/or sweetened	123	18	131	<1	454	0	168 (note 7)	<1	40
Oat enhanced	135 (note 8)	9	211	<1	759	0	214 (note 11)	<1	77 (note 9)
Oat typical	123	18	207	<1	631	0	230 (note 7)	<1	61
Oat unfortified and/or sweetened	123	18	131	<1	454	0	175 (note 7)	<1	40
Water	123	18	131	<1	454	0	165	<1	40

Table A1.7: age group 1.5 to 4 years - minerals

Intake	Calcium (mean % RNI)	Calcium (% < LRNI)	Magnesium (mean % RNI)	Magnesium (% < LRNI)	Potassium (mean % RNI)	Potassium (% < LRNI)	Iodine (mean % RNI)	Iodine (% < LRNI)	Zinc (mean % RNI)	Zinc (% < LRNI)
Baseline (note 5)	189	<1	164	<1	196	0	167	4	96	12
Soya enhanced	191	<1	185 (note 10)	<1	186 (note 10)	0	189 (note 12)	4	91 (note 10)	15
Soya typical	191	<1	185 (note 11)	<1	186 (note 10)	0	92	18	91 (note 10)	15
Soya unfortified and/or sweetened	120 (note 10)	5	177 (note 10)	<1	173 (note 10)	0	79 (note 10)	31	91 (note 910	15
Almond enhanced	191	<1	153 (note 10)	<1	156 (note 10)	<1	189 (note 12)	4	82 (note 10)	24
Almond typical	191	<1	153 (note 10)	<1	156 (note 10)	<1	76	34	82 (note 10)	24
Almond unfortified and/or sweetened	116 (note 10)	7	153 (note 10)	<1	156 (note 10)	<1	77 (note 10)	33	82 (note 10)	24

Intake	Calcium (mean % RNI)	Calcium (% < LRNI)	Magnesium (mean % RNI)	Magnesium (% < LRNI)	Potassium (mean % RNI)	Potassium (% < LRNI)	Iodine (mean % RNI)	Iodine (% < LRNI)	Zinc (mean % RNI)	Zinc (% < LRNI)
Oat enhanced	191	<1	169 (note 10)	<1	162 (note 10)	<1	189 (note 12)	4	119 (note 11)	6
Oat typical	191	<1	169 (note 10)	<1	162 (note 10)	<1	105	9	91 (note 10)	15
Oat unfortified and/or sweetened	115 (note 10)	7	169 (note 10)	<1	162 (note 10)	<1	76	34	91 (note 10)	15
Water	112	11	137	<1	152	<1	76	34	77	34

Tables A1.8 to A1.10: age group 5 to 10 years mean total daily energy and nutrient intakes when all cows' milk in diet is replaced by equivalent volume of plant-based drinks or water

The abbreviations and notes used in these tables are described in the section 'Abbreviations and notes used in tables A1.2 to A1.25' above.

Table A1.8: age group 5 to 10 years - macronutrients (energy, protein and saturated fat)

DRV or intake	Energy (note 1) (MJ/day)	Energy (note 1) (kcals/day)	Protein (g/day)	Protein (%TE)	Saturated fat (g/day)	Saturated fat (%TE) (note 2)	Saturated fat (% meeting DRV)
DRVs	6.2 to 7.6 MJ/day	1482 to 1817 kcals/day	19.7 to 28.3 g/day	19.7 to 28.3 g/day	Should not exceed 10% TE	Should not exceed 10% TE	Should not exceed 10% TE
Baseline (note 6)	6.2	1,478	54.1	14.6	21.6	13	11
Soya enhanced	6	1,428	54.3	15.2	19.2	11.9	23
Soya typical	6.1	1,447	53.6	14.8	19.7	12.1	21
Soya unfortified and/or sweetened	6.1	1,461	54.5	14.9	19.5	11.9	23
Almond enhanced	5.9	1,409	49.6	14.1	19	12	22
Almond typical	5.9	1,412	48.9	13.8	19	11.9	23
Almond unfortified and/or sweetened	6.1	1,451	49.7	13.7	19.2	11.7	25
Oat enhanced	6.1	1,456	51.3	14.1	19	11.6	28

DRV or intake	Energy (note 1) (MJ/day)	Energy (note 1) (kcals/day)	Protein (g/day)	Protein (%TE)	Saturated fat (g/day)	Saturated fat (%TE) (note 2)	Saturated fat (% meeting DRV)
Oat typical	6.2	1,466	49.2	13.4	19.2	11.6	27
Oat unfortified and/or sweetened	6.1	1,456	49.6	13.6	19	11.6	28
Water	5.8	1,386	48.2	13.9	18.8	12.1	22

Table A1.8 (continued) Age group 5 to 10 years - macronutrients (total sugars, free sugars, fibre and salt)

DRV or intake	Total sugars (note 3) (g/day)	Total sugars (note 3) (%TE)	Free sugars (g/day)	Free sugars (% TE) (note 5; note 2)	Free sugars (% meeting DRV)	Fibre (g/day)	Fibre (% meeting DRV)	Salt (note 4) (g/day)
DRVs	DRV relates to free sugars	DRV relates to free sugars	Should not exceed 5% TE	Should not exceed 5% TE	Should not exceed 5% TE	20 g/day	20 g/day	<3 g/day 5-6 years
Baseline (note 6)	81.5	20.7	48.7	12	2	14.6	11	3.9
Soya enhanced	73.9	19.4	48.7	13	2	16.7	23	3.7
Soya typical	76.2	19.7	51	13	1	15.5	15	3.9
Soya unfortified and/or sweetened	78.1	20	52.9	13	1	15.7	16	4
Almond enhanced	73.9	19.7	48.7	13	2	15.5	15	4

DRV or intake	Total sugars (note 3) (g/day)	Total sugars (note 3) (%TE)	Free sugars (g/day)	Free sugars (% TE) (note 5; note 2)	Free sugars (% meeting DRV)	Fibre (g/day)	Fibre (% meeting DRV)	Salt (note 4) (g/day)
Almond typical	74.4	19.8	49.2	13	1	15.2	14	4
Almond unfortified and/or sweetened	80.7	20.9	55.5	14	1	15	13	3.9
Oat enhanced	73.9	19	48.7	12	2	17.1	27	3.9
Oat typical	80	20.5	54.8	14	1	16.6	22	3.9
Oat unfortified and/or sweetened	80.3	20.7	55.1	14	1	15.9	16	3.9
Water	73.9	20	48.7	13	1	14.6	11	3.7

Table A1.9: age group 5 to 10 years - vitamins

Intake	Vitamin A (mean % RNI)	Vitamin A (% < LRNI)	Riboflavin (mean % RNI)	Riboflavin (% < LRNI)	Vitamin B12 (mean % RNI)	Vitamin B12 (% < LRNI)	Folate (mean % RNI)	Folate (% < LRNI)	Vitamin D (mean % RNI)
Baseline (note 6)	133	11	154	1	433	<1	144	<1	36
Soya enhanced	131 (note 8)	11	150	1	359	<1	146 (note 7)	<1	49
Soya typical	123	16	145	1	347	<1	146 (note 7)	<1	47

Intake	Vitamin A (mean % RNI)	Vitamin A (% < LRNI)	Riboflavin (mean % RNI)	Riboflavin (% < LRNI)	Vitamin B12 (mean % RNI)	Vitamin B12 (% < LRNI)	Folate (mean % RNI)	Folate (% < LRNI)	Vitamin D (mean % RNI)
Soya unfortified and/or sweetened	123	16	120 (note 7)	1	286	<1	153 (note 7)	<1	36
Almond enhanced	131 (note 8)	11	150	1	359	<1	135 (note 7)	1	49
Almond typical	123	16	146	1	359	<1	135 (note 7)	1	49
Almond unfortified and/or sweetened	123	16	110	2	286	<1	135 (note 7)	1	36
Oat enhanced	131 (note 8)	11	150	1	418	<1	154 (note 11)	<1	62 (note 9)
Oat typical	123	16	148	1	362	<1	161 (note 7)	<1	51
Oat unfortified and/or sweetened	123	16	110	2	286	<1	138 (note 7)	1	36
Water	123	16	110	2	286	<1	134	1	36

Table A1.10: age group 5 to 10 years - minerals

Intake	Calcium (mean % RNI)	Calcium (% < LRNI)	Magnesium (mean % RNI)	Magnesium (% < LRNI)	Potassium (mean % RNI)	Potassium (% < LRNI)	Iodine (mean % RNI)	Iodine (% < LRNI)	Zinc (mean % RNI)	Zinc (% < LRNI)
Baseline (note 6)	144	1	113	2	132	1	118	7	92	8
Soya enhanced	144	1	122 (note 10)	2	128 (note 11)	1	129 (note 13)	5	89 (note 11)	10
Soya typical	144	1	122 (note 10)	2	128 (note 11)	1	80	18	89 (note 11)	10
Soya unfortified and/or sweetened	107 (note 10)	4	119 (note 10)	2	123 (note 11)	1	73 (note 11)	25	89 (note 11)	10
Almond enhanced	144	1	109 (note 10)	3	116 (note 10)	1	129 (note 12)	5	84 (note 10)	15
Almond typical	144	1	109 (note 10)	3	116 (note 10)	1	72	28	84 (note 10)	15
Almond unfortified and/or sweetened	105 (note 10)	5	109 (note 10)	3	116 (note 10)	1	72 (note 10)	28	84 (note 10)	15
Oat enhanced	144	1	115 (note 10)	2	118 (note 10)	1	129 (note 12)	5	104 (note 11)	5
Oat typical	144	1	115 (note 10)	2	118 (note 10)	1	86	12	89 (note 10)	10
Oat unfortified and/or sweetened	105 (note 10)	5	115 (note 10)	2	118 (note 10)	1	72	28	89 (note 10)	10

Intake	Calcium (mean % RNI)	Calcium (% < LRNI)	Magnesium (mean % RNI)	Magnesium (% < LRNI)	Potassium (mean % RNI)	Potassium (% < LRNI)	Iodine (mean % RNI)	Iodine (% < LRNI)	Zinc (mean % RNI)	Zinc (% < LRNI)
Water	103	6	102	4	114	1	72	28	81	18

Tables A1.11 to A1.13: age group 11 to 18 years mean total daily energy and nutrient intakes when all cows' milk in diet is replaced by equivalent volume of plant-based drinks or water

The abbreviations and notes used in these tables are described in the section 'Abbreviations and notes used in tables A1.2 to A1.25' above.

Table A1.11: age group 11 to 18 years - macronutrients (energy, protein and saturated fat)

DRV or intake	Energy (note 1) (MJ/day)	Energy (note 1) (kcals/day)	Protein (g/day)	Protein (%TE)	Saturated fat (g/day)	Saturated fat (%TE) (note 2)	Saturated fat (% meeting DRV)
DRVs	8.4 to 10.5	2,000 to 2,500	41.2 to 55.2 g/day	41.2 to 55.2 g/day	Should not exceed 10% TE	Should not exceed 10% TE	Should not exceed 10% TE
Baseline (note 6)	7	1,658	64.5	15.5	23.6	12.6	18
Soya enhanced	6.8	1,623	64.6	15.9	22	12	24
Soya typical	6.9	1,638	64	15.6	22.4	12.1	23
Soya unfortified and/or sweetened	6.9	1,649	64.7	15.7	22.3	11.9	24
Almond enhanced	6.7	1,608	60.9	15.1	21.9	12	23
Almond typical	6.7	1,611	60.3	15	21.9	12	24
Almond unfortified and/or sweetened	6.9	1,641	61	14.9	22	11.8	26
Oat enhanced	6.9	1,645	62.2	15.1	21.9	11.7	26

DRV or intake	Energy (note 1) (MJ/day)	Energy (note 1) (kcals/day)	Protein (g/day)	Protein (%TE)	Saturated fat (g/day)	Saturated fat (%TE) (note 2)	Saturated fat (% meeting DRV)
Oat typical	6.9	1,653	60.6	14.7	22	11.8	26
Oat unfortified and/or sweetened	6.9	1,645	60.9	14.8	21.9	11.7	26
Water	6.9	1,590	59.8	15	21.7	12.1	23

Table A1.11 (continued): age group 11 to 18 years - macronutrients (total sugars, non-milk extrinsic sugars (NMES), fibre and salt)

DRV or intake	Total sugars (note 3) (g/day)	Total sugars (note 3) (%TE)	Free sugars (g/day)	Free sugars (% TE) (note 5; note 2)	Free sugars (% meeting DRV)	Fibre (g/day)	Fibre (% meeting DRV)	Salt (note 4) (g/day)
DRVs	DRV relates to free sugars	DRV relates to free sugars	Should not exceed 5% TE	Should not exceed 5% TE	Should not exceed 5% TE	25g/day for 11 to 16 years 30g/day 16 to 18 years	25g for 11 to 16 years 30g/day 16 to 18 years	<6g/day
Baseline (note 6)	82.5	18.6	54.8	12	7	15.9	4	4.6
Soya enhanced	76.5	17.7	54.8	13	6	17.6	8	4.5
Soya typical	78.3	17.9	56.6	13	4	16.6	6	4.6
Soya unfortified and/or sweetened	79.8	18.1	58.1	13	4	16.8	6	4.7
Almond enhanced	76.5	17.8	54.8	13	6	16.6	6	4.7
Almond typical	76.9	17.9	55.3	13	5	16.4	5	4.7
Almond unfortified and/or sweetened	81.8	18.7	60.2	14	3	16.2	5	4.6
Oat enhanced	76.5	17.4	54.8	12	6	17.9	8	4.6
Oat typical	81.3	18.4	59.6	13	4	17.4	7	4.6
Oat unfortified and/or sweetened	81.6	18.6	59.9	14	4	16.9	6	4.6

DRV or intake	Total sugars (note 3) (g/day)	Total sugars (note 3) (%TE)	Free sugars (g/day)	Free sugars (% TE) (note 5; note 2)	Free sugars (% meeting DRV)	Fibre (g/day)	Fibre (% meeting DRV)	Salt (note 4) (g/day)
Water	76.5	18	54.8	13	5	15.9	4	4.5

Table A1.12: age group 11 to 18 years - vitamins

Intake	Vitamin A (mean % RNI)	Vitamin A (% < LRNI)	Riboflavin (mean % RNI)	Riboflavin (% < LRNI)	Vitamin B12 (mean % RNI)	Vitamin B12 (% < LRNI)	Folate (mean % RNI)	Folate (% < LRNI)	Vitamin D (mean % RNI)
Baseline (note 6)	96	18	127	17	332	<1	99	10	29
Soya enhanced	96 (note 8)	18	125	18	291	1	100 (note 7)	9	39
Soya typical	91	21	121	19	285	1	100 (note 7)	9	38
Soya unfortified and/or sweetened	91	21 (note 7)	106	27	252	3	104 (note 7; note 16)	8	29
Almond enhanced	96 (note 8)	18	125	18	291	1	95 (note 7)	11	39
Almond typical	91	21	122	18	291	1	95 (note 7)	11	39
Almond unfortified and/or sweetened	91	21	101	32	252	3	95 (note 7)	11	29

Intake	Vitamin A (mean % RNI)	Vitamin A (% < LRNI)	Riboflavin (mean % RNI)	Riboflavin (% < LRNI)	Vitamin B12 (mean % RNI)	Vitamin B12 (% < LRNI)	Folate (mean % RNI)	Folate (% < LRNI)	Vitamin D (mean % RNI)
Oat enhanced	96 (note 8)	18	125	18	323	0	104 (note 11)	8	50 (note 9)
Oat typical	91	21	123	18	293	1	108 (note 7)	8	41
Oat unfortified and/or sweetened	91	21	101	32	252	3	96 (note 7)	11	29
Water	91	21	101	32	252	3	94	12	29

Table A1.13: age group 11 to 18 years - minerals

Intake	Calcium (mean % RNI)	Calcium (% < LRNI)	Magnesium (mean % RNI)	Magnesium (% < LRNI)	Potassium (mean % RNI)	Potassium (% < LRNI)	Iodine (mean % RNI)	Iodine (% < LRNI)	Zinc (mean % RNI)	Zinc (% < LRNI)
Baseline (note 6)	83	15	73	40	68 (note 10)	30	89	24	86	18
Soya enhanced	84	14	77 (note 10)	33	67 (note 11)	31	96 (note 12)	19	85 (note 10)	20
Soya typical	84	14	77 (note 10)	33	67 (note 10)	31	65	41	85 (note 10)	20
Soya unfortified and/or sweetened	68 (note 10)	28	76 (note 10)	36	65 (note 10)	33	61 (note 10)	48	85 (note 10)	20

Intake	Calcium (mean % RNI)	Calcium (% < LRNI)	Magnesium (mean % RNI)	Magnesium (% < LRNI)	Potassium (mean % RNI)	Potassium (% < LRNI)	Iodine (mean % RNI)	Iodine (% < LRNI)	Zinc (mean % RNI)	Zinc (% < LRNI)
Almond enhanced	84	14	71 (note 10)	42	62 (note 10)	38	96 (note 12)	19	82 (note 10)	25
Almond typical	84	14	71 (note 10)	42	62 (note 10)	38	60	50	82 (note 10)	25
Almond unfortified and/or sweetened	67 (note 10)	29	71 (note 10)	42	62 (note 10)	38	60 (note 10)	49	82 (note 10)	25
Oat enhanced	84	14	74 (note 10)	38	63 (note 10)	36	96 (note 12)	19	94 (note 11)	15
Oat typical	84	14	74 (note 10)	38	63 (note 10)	36	69	35	85 (note 10)	20
Oat unfortified and/or sweetened	67 (note 10)	29	74 (note 11)	38	63 (note 10)	36	60	50	85 (note 10)	20
Water	66	31	69	47	62	39	60	50	80	26

Tables A1.14 to A1.16: age group 19 to 49 years mean total daily energy and nutrient intakes when all cows' milk in diet is replaced by equivalent volume of plant-based drinks or water

The abbreviations and notes used in these tables are described in the section 'Abbreviations and notes used in tables A1.2 to A1.25' above.

Table A1.14: age group 19 to 49 years - macronutrients (energy, protein and saturated fat)

DRV or intake	Energy (note 1) (MJ/day)	Energy (note 1) (kcals/day)	Protein (g/day)	Protein (%TE)	Saturated fat (g/day)	Saturated fat (%TE) (note 2)	Saturated fat (% meeting DRV)
DRVs	8.4 to 10.5 MJ/day	2,000 to 2,500 kcals/day	45.0 to 55.5g/day	45.0 to 55.5g/day	Should not exceed 10% TE	Should not exceed 10% TE	Should not exceed 10% TE
Baseline (note 6)	7.6	1,875	77.6	16.6	25.7	12.2	26
Soya enhanced	7.5	1,846	77.6	16.8	24.4	11.7	32
Soya typical	7.5	1,858	77.2	16.6	24.7	11.8	30
Soya unfortified and/or sweetened	7.6	1,868	77.8	16.7	24.6	11.7	32
Almond enhanced	7.4	1,833	74.5	16.3	24.3	11.7	32
Almond typical	7.4	1,835	74.0	16.1	24.3	11.7	32
Almond unfortified and/or sweetened	7.5	1,861	74.6	16.0	24.4	11.6	33
Oat enhanced	7.6	1,864	75.6	16.2	24.3	11.5	34

DRV or intake	Energy (note 1) (MJ/day)	Energy (note 1) (kcals/day)	Protein (g/day)	Protein (%TE)	Saturated fat (g/day)	Saturated fat (%TE) (note 2)	Saturated fat (% meeting DRV)
Oat typical	7.6	1,871	74.2	15.9	24.4	11.5	34
Oat unfortified and/or sweetened	7.5	1,864	74.5	16.0	24.3	11.5	34
Water	7.4	1,817	73.5	16.2	24.1	11.7	32

Table A1.14 (continued): age group 19 to 49 years - macronutrients (total sugars, free sugars, fibre and salt)

DRV or intake	Total sugars (note 3) (g/day)	Total sugars (note 3) (%TE)	Free sugars (g/day)	Free sugars (% TE) (note 4)	Free sugars (% meeting DRV)	Fibre (g/day)	Fibre (% meeting DRV)	Salt (note 4) (g/day)
DRVs	DRV relates to free sugars	DRV relates to free sugars	Should not exceed 5% TE	Should not exceed 5% TE	Should not exceed 5% TE	30g/day	30g/day	<6g/day
Baseline (note 6)	87.7	17.5	53.7	10.4	15	19.7	9	5.4
Soya enhanced	82.6	16.8	53.7	10.6	15	21.1	12	5.3
Soya typical	84.1	17.0	55.3	10.8	13	20.3	10	5.3
Soya unfortified and/or sweetened	85.4	17.2	56.6	11.1	12	20.4	11	5.5
Almond enhanced	82.6	16.9	53.7	10.7	15	20.3	10	5.4
Almond typical	83.0	17.0	54.1	10.7	14	20.0	10	5.4
Almond unfortified and/or sweetened	87.2	17.6	58.3	11.5	11	19.9	9	5.3
Oat enhanced	82.6	16.6	53.7	10.5	15	21.3	13	5.4
Oat typical	86.7	17.4	57.9	11.3	11	21.0	12	5.4
Oat unfortified and/or sweetened	87.0	17.5	58.1	11.4	11	20.5	11	5.4

DRV or intake	Total sugars (note 3) (g/day)	Total sugars (note 3) (%TE)	Free sugars (g/day)	Free sugars (% TE) (note 4)	Free sugars (% meeting DRV)	Fibre (g/day)	Fibre (% meeting DRV)	Salt (note 4) (g/day)
Water	82.6	17.0	53.7	10.8	14	19.7	9	5.3

Table A1.15: age group 19 to 49 years - vitamins

Intake	Vitamin A (mean % RNI)	Vitamin A (% < LRNI)	Riboflavin (mean % RNI)	Riboflavin (% < LRNI)	Vitamin B12 (mean % RNI)	Vitamin B12 (% < LRNI)	Folate (mean % RNI)	Folate (% < LRNI)	Vitamin D (mean % RNI)
Baseline (note 6)	144	10	172	9	698	<1	142	5	53
Soya enhanced	144 (note 8)	10	170	9	667	<1	143 (note 7)	5	62
Soya typical	140	13	167	10	662	1	143 (note 7)	5	61
Soya unfortified and/or sweetened	140	13	154 (note 7)	14	637	3	146 (note 7)	4	53
Almond enhanced	144 (note 8)	10	170	9	667	<1	139 (note 7)	6	62
Almond typical	140	13	168	9	667	<1	139 (note 7)	6	62
Almond unfortified and/or sweetened	140	13	149	18	637	3	139 (note 7)	6	53

Intake	Vitamin A (mean % RNI)	Vitamin A (% < LRNI)	Riboflavin (mean % RNI)	Riboflavin (% < LRNI)	Vitamin B12 (mean % RNI)	Vitamin B12 (% < LRNI)	Folate (mean % RNI)	Folate (% < LRNI)	Vitamin D (mean % RNI)
Oat enhanced	144 (note 8)	10	170	9	691	<1	147 (note 11)	4	71 (note 9)
Oat typical	140	13	169	9	669	<1	150 (note 7)	3	63
Oat unfortified and/or sweetened	140	13	149	18	637	3	140 (note 8)	5	53
Water	140	13	149	18	637	3	138	6	53

Table A1.16: age group 19 to 49 years - minerals

Intake	Calcium (mean % RNI)	Calcium (% < LRNI)	Magnesium (mean % RNI)	Magnesium (% < LRNI)	Potassium (mean % RNI)	Potassium (% < LRNI)	Iodine (mean % RNI)	Iodine (% < LRNI)	Zinc (mean % RNI)	Zinc (% < LRNI)
Baseline (note 6)	117	7	97	11	80	19	110	11	117	5
Soya enhanced	117	7	101 (note 10)	10	78 (note 10)	21	117 (note 12)	8	115 (note 10)	6
Soya typical	117	7	101 (note 10)	10	78 (note 10)	21	92	20	115 (note 10)	6
Soya unfortified and/or sweetened	99 (note 10)	14	99 (note 10)	10	77 (note 10)	22	89 (note 10)	23	115 (note 10)	6
Almond enhanced	117	7	96 (note 10)	12	75 (note 10)	24	117 (note 12)	8	112 (note 10)	8
Almond typical	117	7	96 (note 10)	12	75 (note 10)	24	88	24	112 (note 10)	8
Almond unfortified and/or sweetened	98 (note 10)	15	96 (note 10)	12	75 (note 10)	24	88 (note 10)	24	112 (note 10)	8
Oat enhanced	117	7	98 (note 10)	11	76 (note 10)	23	117 (note 12)	8	124 (note 11)	4
Oat typical	117	7	98 (note 10)	11	76 (note 10)	23	95	17	115 (note 10)	6

Intake	Calcium (mean % RNI)	Calcium (% < LRNI)	Magnesium (mean % RNI)	Magnesium (% < LRNI)	Potassium (mean % RNI)	Potassium (% < LRNI)	Iodine (mean % RNI)	Iodine (% < LRNI)	Zinc (mean % RNI)	Zinc (% < LRNI)
Oat unfortified and/or sweetened	98 (note 11)	15	98 (note 10)	11	76 (note 10)	23	88	24	115 (note 10)	6
Water	97	16	93	13	74	25	88	24	111	8

Tables A1.17 to A1.19: age group 50 to 64 years mean total daily energy and nutrient intakes when all cows' milk in diet is replaced by equivalent volume of plant-based drinks or water

The abbreviations and notes used in these tables are described in the section 'Abbreviations and notes used in tables A1.2 to A1.25' above.

Table A1.17: age group 50 to 64 years - macronutrients (energy, protein and saturated fat)

DRV or intake	Energy (note 1) (MJ/day)	Energy (note 1) (kcals/day)	Protein (g/day)	Protein (%TE)	Saturated fat (g/day)	Saturated fat (%TE) (note 2)	Saturated fat (% meeting DRV)
DRVs	8.4 to 10.5	2,000 to 2,500	45.0 to 55.5g/day	45.0 to 55.5g/day	Should not exceed 10% TE	Should not exceed 10% TE	Should not exceed 10% TE
Baseline (note 6)	6.9	1,730	72.5	16.8	24.4	12.6	23
Soya enhanced	6.8	1,693	72.6	17.2	22.8	12.0	32
Soya typical	6.8	1,712	71.9	16.8	23.3	12.1	30
Soya unfortified and/or sweetened	6.9	1,725	72.9	16.9	23.2	11.9	32
Almond enhanced	6.7	1,674	68.0	16.3	22.7	12.0	32
Almond typical	6.7	1,678	67.4	16.1	22.7	12.0	32
Almond unfortified and/or sweetened	6.8	1,715	68.2	15.9	22.8	11.8	34
Oat enhanced	6.9	1,720	69.7	16.2	22.7	11.7	35

DRV or intake	Energy (note 1) (MJ/day)	Energy (note 1) (kcals/day)	Protein (g/day)	Protein (%TE)	Saturated fat (g/day)	Saturated fat (%TE) (note 2)	Saturated fat (% meeting DRV)
Oat typical	6.9	1,730	67.7	15.7	22.8	11.7	35
Oat unfortified and/or sweetened	6.8	1,720	68.0	15.8	22.7	11.7	35
Water	6.6	1,652	66.7	16.1	22.5	12.1	32

Table A1.17 (continued): age group 50 to 64 years - macronutrients (total sugars, free sugars, fibre and salt)

DRV or intake	Total sugars (note 3) (g/day)	Total sugars (note 3) (%TE)	Free sugars (g/day)	Free sugars (% TE) (note 5; note 2)	Free sugars (% meeting DRV)	Fibre (g/day)	Fibre (% meeting DRV)	Salt (note 4) (g/day)
DRVs	DRV relates to free sugars	DRV relates to free sugars	Should not exceed 5% TE	Should not exceed 5% TE	Should not exceed 5% TE	30g/day	30g/day	<6g/day
Baseline (note 6)	83.4	18.1	41.0	8.7	22	19.7	9	4.8
Soya enhanced	76.0	16.8	41.0	8.9	21	21.7	17	4.6
Soya typical	78.2	17.1	43.2	9.3	18	20.5	11	4.7
Soya unfortified and/or sweetened	80.1	17.4	45.1	9.6	14	20.7	12	4.9
Almond enhanced	76.0	17.0	41.0	9.0	21	20.5	11	4.8

DRV or intake	Total sugars (note 3) (g/day)	Total sugars (note 3) (%TE)	Free sugars (g/day)	Free sugars (% TE) (note 5; note 2)	Free sugars (% meeting DRV)	Fibre (g/day)	Fibre (% meeting DRV)	Salt (note 4) (g/day)
Almond typical	76.5	17.1	41.5	9.1	20	20.2	10	4.8
Almond unfortified and/or sweetened	82.7	18.1	47.7	10.3	12	20.0	9	4.7
Oat enhanced	76.0	16.6	41.0	8.7	22	22.1	18	4.7
Oat typical	82.0	17.8	47.0	10.0	12	21.6	16	4.7
Oat unfortified and/or sweetened	82.3	17.9	47.3	10.2	12	20.9	13	4.7
Water	76.0	17.3	41.0	9.1	20	19.7	9	4.6

Table A1.18: age group 50 to 64 years - vitamins

Intake	Vitamin A (mean % RNI)	Vitamin A (% < LRNI)	Riboflavin (mean % RNI)	Riboflavin (% < LRNI)	Vitamin B12 (mean % RNI)	Vitamin B12 (% < LRNI)	Folate (mean % RNI)	Folate (% < LRNI)	Vitamin D (mean % RNI)
Baseline (note 6)	163	7	168	6	583	1	151	4	54
Soya enhanced	163 (note 8)	7	165	6	538	2	152 (note 7)	4	67
Soya typical	158	10	161	6	531	2	152 (note 7)	4	65

Intake	Vitamin A (mean % RNI)	Vitamin A (% < LRNI)	Riboflavin (mean % RNI)	Riboflavin (% < LRNI)	Vitamin B12 (mean % RNI)	Vitamin B12 (% < LRNI)	Folate (mean % RNI)	Folate (% < LRNI)	Vitamin D (mean % RNI)
Soya unfortified and/or sweetened	158	10	143 (note 7)	10	495	5	156 (note 7; note 16)	3	54
Almond enhanced	163 (note 8)	7	165	6	538	2	145 (note 7)	4	67
Almond typical	158	10	162	6	538	2	145 (note 7)	4	67
Almond unfortified and/or sweetened	158	10	135	15	495	5	145 (note 7)	4	54
Oat enhanced	163 (note 8)	7	165	6	573	1	157 (note 11)	3	80 (note 9)
Oat typical	158	10	164	6	541	2	161 (note 7)	2	69
Oat unfortified and/or sweetened	158	10	135	15	495	5	147 (note 7)	4	54
Water	158	10	135	15	495	5	144	5	54

Table A1.19: age group 50 to 64 years - minerals

Intake	Calcium (mean % RNI)	Calcium (% < LRNI)	Magnesium (mean % RNI)	Magnesium (% < LRNI)	Potassium (mean % RNI)	Potassium (% < LRNI)	Iodine (mean % RNI)	Iodine (% < LRNI)	Zinc (mean % RNI)	Zinc (% < LRNI)
Baseline (note 6)	121	6	98	11	84	13	123	7	112	7
Soya enhanced	122	6	103 (note 10)	10	82 (note 10)	13	132 (note 12)	6	110 (note 10)	8
Soya typical	122	6	103 (note 10)	10	82 (note 10)	13	96	14	110 (note 10)	8
Soya unfortified and/or sweetened	96 (note 10)	14	101 (note 10)	10	80 (note 10)	16	91 (note 10)	19	110 (note 10)	8
Almond enhanced	122	6	96 (note 10)	12	77 (note 10)	21	132 (note 12)	6	106 (note 10)	11
Almond typical	122	6	96 (note 10)	12	77 (note 10)	21	90	20	106 (note 10)	11
Almond unfortified and/or sweetened	94 (note 10)	18	96 (note 10)	12	77 (note 10)	21	90 (note 10)	19	106 (note 10)	11
Oat enhanced	122	6	100 (note 10)	11	78 (note 10)	19	132 (note 12)	6	122 (note 11)	4
Oat typical	122	6	100 (note 10)	11	78 (note 10)	19	101	12	110 (note 10)	8
Oat unfortified and/or sweetened	94 (note 10)	18	100 (note 10)	11	78 (note 10)	19	90	20	110 (note 10)	8

Intake	Calcium (mean % RNI)	Calcium (% < LRNI)	Magnesium (mean % RNI)	Magnesium (% < LRNI)	Potassium (mean % RNI)	Potassium (% < LRNI)	Iodine (mean % RNI)	Iodine (% < LRNI)	Zinc (mean % RNI)	Zinc (% < LRNI)
Water	92	19	92	15	76	21	90	20	103	12

Tables A1.20 to A1.22: age group 65 to 74 years mean total daily energy and nutrient intakes when all cows' milk in diet is replaced by equivalent volume of plant-based drinks or water

The abbreviations and notes used in these tables are described in the section 'Abbreviations and notes used in tables A1.2 to A1.25' above.

Table A1.20: age group 65 to 74 years - macronutrients (energy, protein and saturated fat)

DRV or intake	Energy (note 1) (MJ/day)	Energy (note 1) (kcals/day)	Protein (g/day)	Protein (%TE)	Saturated fat (g/day)	Saturated fat (%TE) (note 2)	Saturated fat (% meeting DRV)
DRVs	8.0 to 9.8 MJ/day	1,912 to 2,342 kcals/day	46.5 to 53.3g/day	46.5 to 53.3g/day	Should not exceed 10% TE	Should not exceed 10% TE	Should not exceed 10% TE
Baseline (note 6)	6.7	1,676	69.3	16.5	24.3	12.8	20
Soya enhanced	6.5	1,641	69.4	16.9	22.8	12.3	25
Soya typical	6.6	1,658	68.8	16.6	23.3	12.4	24
Soya unfortified and/or sweetened	6.6	1,670	69.6	16.7	23.1	12.3	26
Almond enhanced	6.5	1,623	65.2	16.1	22.7	12.4	25
Almond typical	6.5	1,627	64.6	15.9	22.7	12.3	25
Almond unfortified and/or sweetened	6.6	1,661	65.4	15.7	22.8	12.2	28
Oat enhanced	6.6	1,666	66.8	16.0	22.7	12.0	30

DRV or intake	Energy (note 1) (MJ/day)	Energy (note 1) (kcals/day)	Protein (g/day)	Protein (%TE)	Saturated fat (g/day)	Saturated fat (%TE) (note 2)	Saturated fat (% meeting DRV)
Oat typical	6.7	1,675	64.9	15.5	22.8	12.1	29
Oat unfortified and/or sweetened	6.6	1,666	65.2	15.7	22.7	12.0	30
Water	6.4	1,603	64.0	16.0	22.5	12.4	24

Table A1.20 (continued): age group 65 to 74 years - macronutrients (total sugars, free sugars, fibre and salt)

DRV or intake	Total sugars (note 3) (g/day)	Total sugars (note 3) (%TE)	Free sugars (g/day)	Free sugars (% TE) (note 5; note 2)	Free sugars (% meeting DRV)	Fibre (g/day)	Fibre (% meeting DRV)	Salt (note 4) (g/day)
DRVs	DRV relates to free sugars	DRV relates to free sugars	Should not exceed 5% TE	Should not exceed 5% TE	Should not exceed 5% TE	30g/day	30g/day	<6g/day
Baseline (note 6)	80.6	18.0	40.8	9.0	17	19.7	9	4.4
Soya enhanced	73.8	16.9	40.8	9.2	17	21.5	11	4.2
Soya typical	75.9	17.2	42.9	9.5	16	20.5	9	4.3
Soya unfortified and/or sweetened	77.6	17.4	44.6	9.9	13	20.6	9	4.5

DRV or intake	Total sugars (note 3) (g/day)	Total sugars (note 3) (%TE)	Free sugars (g/day)	Free sugars (% TE) (note 5; note 2)	Free sugars (% meeting DRV)	Fibre (g/day)	Fibre (% meeting DRV)	Salt (note 4) (g/day)
Almond enhanced	73.8	17.1	40.8	9.3	17	20.5	9	4.4
Almond typical	74.3	17.1	41.3	9.4	17	20.1	9	4.4
Almond unfortified and/or sweetened	79.9	18.0	46.9	10.5	13	20.0	9	4.3
Oat enhanced	73.8	16.6	40.8	9.0	18	21.9	11	4.4
Oat typical	79.3	17.8	46.3	10.2	13	21.4	11	4.4
Oat unfortified and/or sweetened	79.6	17.9	46.6	10.4	13	20.8	9	4.4
Water	73.8	17.3	40.8	9.4	17	19.7	9	4.2

Table A1.21: age group 65 to 74 years - vitamins

Intake	Vitamin A (mean % RNI)	Vitamin A (% < LRNI)	Riboflavin (Mean % RNI)	Riboflavin (% < LRNI)	Vitamin B12 (mean % RNI)	Vitamin B12 (% < LRNI)	Folate (mean % RNI)	Folate (% < LRNI)	Vitamin D (mean % RNI)
Baseline (note 6)	175	9	218	7	1,222	1	148	2	91

Intake	Vitamin A (mean % RNI)	Vitamin A (% < LRNI)	Riboflavin (Mean % RNI)	Riboflavin (% < LRNI)	Vitamin B12 (mean % RNI)	Vitamin B12 (% < LRNI)	Folate (mean % RNI)	Folate (% < LRNI)	Vitamin D (mean % RNI)
Soya enhanced	176 (note 8)	8	216	7	1,180	4	148 (note 7)	2	102
Soya typical	171	9	212	7	1,174	4	148 (note 7)	2	100
Soya unfortified and/or sweetened	171	9	195 (note 7)	12	1,141	4	152 (note 7; note 16)	2	91
Almond enhanced	176 (note 8)	8	216	7	1,180	4	142 (note 7)	3	102
Almond typical	171	9	213	7	1,180	4	142 (note 7)	3	102
Almond unfortified and/or sweetened	171	9	189	16	1,141	4	142 (note 7)	3	91
Oat enhanced	176 (note 8)	8	216	7	1,212	1	153 (note 11)	2	114 (note 9)
Oat typical	171	9	215	7	1,182	4	157 (note 7)	2	104
Oat unfortified and/or sweetened	171	9	189	16	1,141	4	144 (note 7)	3	91
Water	171	9	189	16	1,141	4	141	3	91

Table A1.22: age group 65 to 74 years - minerals

Intake	Calcium (mean % RNI)	Calcium (% < LRNI)	Magnesium (mean % RNI)	Magnesium (% < LRNI)	Potassium (mean % RNI)	Potassium (% < LRNI)	Iodine (mean % RNI)	Iodine (% < LRNI)	Zinc (mean % RNI)	Zinc (% < LRNI)
Baseline (note 5)	120	6	99	10	82	12	130	5	116	6
Soya enhanced	121	6	103 (note 10)	5	80 (note 10)	13	138 (note 12)	3	114 (note 10)	6
Soya typical	121	6	103 (note 12)	5	80 (note 11)	13	104	12	114 (note 10)	6
Soya unfortified and/or sweetened	97 (note 10)	13	102 (note 10)	8	78 (note 10)	15	100 (note 10)]	17	114 (note 10)	6
Almond enhanced	121	6	97 (note 10)	11	76 (note 10)	19	138 (note 12)	3	110 (note 10)	8
Almond typical	121	6	97 (note 10)	11	76 (note 10)	19	99	17	110 (note 10)	8
Almond unfortified and/or sweetened	95 (note 10)	15	97 (note 10)	11	76 (note 10)	19	99 (note 10)	17	110 (note 10)	8
Oat enhanced	121	6	100 (note 10)	9	77 (note 10)	17	138 (note 12)	3	125 (note 11)	5
Oat typical	121	6	100 (note 10)	9	77 (note 10)]	17	109	9	114 (note 10)	6
Oat unfortified and/or sweetened	95 (note 10)	15	100 (note 10)	9	77 (note 10)	17	99	17	114 (note 10)	6

Intake	Calcium (mean % RNI)	Calcium (% < LRNI)	Magnesium (mean % RNI)	Magnesium (% < LRNI)	Potassium (mean % RNI)	Potassium (% < LRNI)	Iodine (mean % RNI)	Iodine (% < LRNI)	Zinc (mean % RNI)	Zinc (% < LRNI)
Water	94	15	93	14	75	20	99	17	108	8

Tables A1.23 to A1.25: age group 75 years and over mean total daily energy and nutrient intakes when all cows' milk in diet is replaced by equivalent volume of plant-based drinks or water

The abbreviations and notes used in these tables are described in the section 'Abbreviations and notes used in tables A1.2 to A1.25' above.

Table A1.23: age group 75 years and over - macronutrients (energy, protein and saturated fat)

DRV or intake	Energy (note 1) (MJ/day)	Energy (note 1) (kcals/day)	Protein (g/day)	Protein (%TE)	Saturated fat (g/day)	Saturated fat (%TE) (note 2)	Saturated fat (% meeting DRV)
DRVs	7.7 to 9.6 MJ/day	1,840 to 2,294 kcals/day	46.5 to 53.3 g/day	46.5 to 53.3 g/day	Should not exceed 10% TE	Should not exceed 10% TE	Should not exceed 10% TE
Baseline (note 6)	6.5	1,591	63.4	15.9	25.3	14.1	12
Soya enhanced	6.3	1,540	63.5	16.5	23.1	13.3	19
Soya typical	6.4	1,564	62.6	16.0	23.8	13.4	17
Soya unfortified and/or sweetened	6.4	1,582	63.8	16.1	23.5	13.2	19
Almond enhanced	6.2	1,516	57.5	15.2	22.9	13.3	19
Almond typical	6.2	1,520	56.7	14.9	22.9	13.3	19
Almond unfortified and/or sweetened	6.4	1,569	57.8	14.7	23.1	13.0	20
Oat enhanced	6.4	1,575	59.7	15.2	22.9	12.8	21

DRV or intake	Energy (note 1) (MJ/day)	Energy (note 1) (kcals/day)	Protein (g/day)	Protein (%TE)	Saturated fat (g/day)	Saturated fat (%TE) (note 2)	Saturated fat (% meeting DRV)
Oat typical	6.4	1,588	57.1	14.4	23.1	12.9	21
Oat unfortified and/or sweetened	6.4	1,575	57.5	14.6	22.9	12.8	21
Water	6.0	1,487	55.8	15.0	22.7	13.5	18

Table A1.23 (continued): age group 75 years and over - macronutrients (total sugars, free sugars, fibre and salt)

DRV or intake	Total sugars (note 3) (g/day)	Total sugars (note 3) (%TE)	Free sugars (g/day)	Free sugars (% TE) (note 5; note 2)	Free sugars (% meeting DRV)	Fibre (g/day)	Fibre (% meeting DRV)	Salt (note 4) (g/day)
DRVs	DRV relates to free sugars	DRV relates to free sugars	Should not exceed 5% TE	Should not exceed 5% TE	Should not exceed 5% TE	30g/day	30g/day	<6g/day
Baseline (note 6)	85.3	20.1	44.1	10.1	15	17.3	3	4.3
Soya enhanced	75.8	18.4	44.1	10.5	14	19.9	8	4.1
Soya typical	78.6	18.9	47.0	11.0	10	18.4	4	4.3
Soya unfortified and/or sweetened	81.1	19.2	49.4	11.5	8	18.6	4	4.5

DRV or intake	Total sugars (note 3) (g/day)	Total sugars (note 3) (%TE)	Free sugars (g/day)	Free sugars (% TE) (note 5; note 2)	Free sugars (% meeting DRV)	Fibre (g/day)	Fibre (% meeting DRV)	Salt (note 4) (g/day)
Almond enhanced	75.8	18.7	44.1	10.7	14	18.4	4	4.4
Almond typical	76.4	18.9	44.8	10.8	13	17.9	4	4.4
Almond unfortified and/or sweetened	84.4	20.2	52.7	12.4	5	17.7	3	4.3
Oat enhanced	75.8	18.0	44.1	10.3	15	20.4	8	4.3
Oat typical	83.5	19.7	51.9	12.0	8	19.7	7	4.3
Oat unfortified and/or sweetened	83.9	20.0	52.3	12.2	6	18.8	4	4.3
Water	75.8	19.1	44.1	10.9	13	17.3	3	4.1

DRVs are set by age groups (75 years and over). The DRVs provided here are minimum and maximum values for males and females across this age group.

Table A1.24: age group 75 years and over - vitamins

Intake	Vitamin A (mean % RNI)	Vitamin A (% < LRNI)	Riboflavin (Mean % RNI)	Riboflavin (% < LRNI)	Vitamin B12 (mean % RNI)	Vitamin B12 (% < LRNI)	Folate (mean % RNI)	Folate (% < LRNI)	Vitamin D (mean % RNI)
Baseline (note 6)	186	5	173	8	670	<1	123	3	60
Soya enhanced	186 (note 8)	6	170	8	613	1	124 (note 7)	4	76
Soya typical	178	8	165	8	604	1	124 (note 7)	4	74
Soya unfortified and/or sweetened	178	8	140 (note 7)	12	557	5	130 (note 7)	3	60
Almond enhanced	186 (note 8)	6	170	8	613	1	115 (note 7)	5	76
Almond typical	178	8	166	8	613	1	115 (note 7)	5	76
Almond unfortified and/or sweetened	178	8	131	19	557	5	115 (note 7)	5	60
Oat enhanced	186 (note 8)	6	170	8	658	0	131 (note 11)	2	93 (note 9)
Oat typical	178	8	168	8	616	1	136 (note 7)	1	79

Intake	Vitamin A (mean % RNI)	Vitamin A (% < LRNI)	Riboflavin (Mean % RNI)	Riboflavin (% < LRNI)	Vitamin B12 (mean % RNI)	Vitamin B12 (% < LRNI)	Folate (mean % RNI)	Folate (% < LRNI)	Vitamin D (mean % RNI)
Oat unfortified and/or sweetened	178	8	131	19	557	5	118 (note 7)	4	60
Water	178	8	131	19	557	5	114	5	60

Table A1.25: age group 75+ years - minerals

Intake	Calcium (mean % RNI)	Calcium (% < LRNI)	Magnesium (mean % RNI)	Magnesium (% < LRNI)	Potassium (mean % RNI)	Potassium (% < LRNI)	Iodine (mean % RNI)	Iodine (% < LRNI)	Zinc (mean % RNI)	Zinc (% < LRNI)
Baseline (note 6)	125	4	84	15	76	19	130	7	110	6
Soya enhanced	125	4	90 (note 10)	12	73 (note 10)	19	143 (note 12)	4	107 (note 10)	8
Soya typical	125	4	90 (note 10)	12	73 (note 10)	19	96	17	107 (note 10)	8
Soya unfortified and/or sweetened	91 (note 10)	16	88 (note 10)	13	70 (note 10)	25	89 (note 10)	22	107 (note 10)	8
Almond enhanced	125	4	81 (note 10)	19	67 (note 10)	32	143 (note 12)	4	101 (note 10)	12

Intake	Calcium (mean % RNI)	Calcium (% < LRNI)	Magnesium (mean % RNI)	Magnesium (% < LRNI)	Potassium (mean % RNI)	Potassium (% < LRNI)	Iodine (mean % RNI)	Iodine (% < LRNI)	Zinc (mean % RNI)	Zinc (% < LRNI)
Almond typical	125	4	81 (note 10)	19	67 (note 10)	32	88	24	101 (note 10)	12
Almond unfortified and/or sweetened	89 (note 10)	19	81 (note 10)	19	67 (note 10)	32	88 (note 10)	23	101 (note 10)	12
Oat enhanced	125	4	86 (note 10)	14	68 (note 10)	30	143 (note 12)	4	124 (note 12)	3
Oat typical	125	4	86 (note 11)	14	68 (note 11)	30	102	14	107 (note 10)	8
Oat unfortified and/or sweetened	89 (note 11)	19	86 (note 11)	14	68 (note 11)	30	88	24	107 (note 10)	8
Water	87	20	76	28	66	34	88	24	98	15

Annex 2: scoping literature search: plant-based drinks and nutrition-related outcomes

Background

A scoping literature search was conducted to identify the available evidence on plant-based drinks in relation to nutrition.

Embase and Medline databases were searched via Ovid from 1 January 2000 to 11 November 2021. The search was restricted to papers published in English. The key search terms used in the search strategy were as follows.

Exposure terms: ‘milk’ or ‘animal milk’ or ‘cows’ milk’ or ‘dairy milk’ or ‘bovine milk’ or ‘milk alternative’ or ‘plant-based drink’ or plant-based milk’ or plant-based alternative’ or ‘non-dairy drink’ or ‘non-dairy milk’ or ‘non-dairy alternative’ or ‘plant-based dairy alternative’ or ‘plant-based milk substitutes’ or ‘milk imitations’ or ‘non-cow milk beverage’ or ‘soya milk’ or ‘soya drink’ or ‘soya alternative’ or ‘oat milk’ or ‘oat drink’ or ‘oat alternative’ or ‘almond milk’ or ‘almond drink’ or ‘almond alternative’

Outcome terms: ‘diet’ or ‘nutrition’ or ‘energy intake’ or ‘macronutrients’ or ‘protein’ or ‘protein quality’ or ‘protein quantity’ or ‘carbohydrates’ or ‘sugars’ or ‘free sugars’ or ‘salt’ or ‘sodium’ or ‘micronutrient’ or ‘mineral’ or ‘vitamin’ or ‘vitamin A’ or ‘vitamin B2’ or ‘ riboflavin’ or ‘vitamin B12’ or ‘cobalamin’ or ‘vitamin D’ or ‘calcium’ or ‘iodine’ or ‘iron’ or ‘zinc’ or ‘selenium’ or ‘nutrition status’ or ‘deficiency’ or ‘rickets’ or ‘hypocalcaemia’ or ‘anaemia’ or ‘hyponatraemia’ or ‘fibre’

Given the exploratory nature of this literature search, no restriction was placed on study type. As a result, some evidence which would normally be excluded from SACN risk assessments was included. Papers were divided and screened by 2 reviewers. Papers were screened by title and abstract and excluded based on the predefined inclusion and exclusion criteria as described in the section ‘Inclusion and exclusion criteria’ below.

Eighty eight articles meeting the inclusion criteria were identified through the scoping search (see below): 80 articles through the search undertaken by UKHSA's Knowledge and Library Services team and a further 8 articles were identified by working group members and through hand searches conducted by the SACN secretariat. Evidence identified through the scoping search is presented in presented in the section ‘Evidence identified through the scoping search’ below.

A call for evidence was issued from 11 March to 10 April 2022 inviting interested parties to highlight any additional evidence meeting the inclusion criteria (see Annex 3). Details of the additional evidence identified through the call for evidence that met the inclusion criteria are provided in Annex 3.

Inclusion and exclusion criteria

Study design

The inclusion criteria were:

- systematic reviews and meta-analyses published in peer-reviewed journals
- primary studies
- metabolic studies relevant in vitro
- narrative reviews
- product comparisons

The exclusion criteria were:

- animal studies
- reviews published in grey literature (such as dissertations, conference proceedings, books or book chapters, opinion pieces, and other non-peer reviewed articles)

Target group

The inclusion criteria were:

- adults and children from 6 months to 18 years old
- healthy or with cows' milk allergy
- product comparison without human participants

The exclusion criteria were:

- children below 6 months old

Countries

The inclusion criteria were:

- UK and high-income countries (HIC)

The exclusion criteria were:

- low or middle-income countries (LMIC)

Language

The inclusion criteria were:

- English

The exclusion criteria were:

- non-English

Exposure

The inclusion criteria were:

- plant-based drinks (focus on soya, almond and oat)

The exclusion criteria were:

- animal milks (not as a main exposure but could be a comparator)
- formula substitutes
- fermented products
- other novelty or treated products that are not standard on the market
- other plant-based alternatives (such as cheese, yoghurt and so on)
- plant-based drinks other than soya, almond and oat

Outcomes

The inclusion criteria were:

- nutrition-related outcomes
- health outcomes
- growth and development outcomes
- bioavailability

The exclusion criteria were:

- allergy treatment
- effects of fortification

Evidence identified through the scoping search

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Literature search on the toxicology of plant-based drinks

For soya drinks, a literature search was conducted to update the 2013 COT report on soya phytoestrogens. Details of the search can be found in the COT Discussion paper on soya drink consumption in children aged 6 months to 5 years of age (PDF, 257KB). Few original studies have been published since the Committee last reviewed the health effects of phytoestrogens in the diets of infants and young children in 2013 – 7 additional studies were identified in humans and 4 in animals.

The details of the literature search conducted to identify any chemical contaminants found in almond drink that may be of toxicological concern are given in Annex A to the COT Discussion paper on the potential risks from almond drink consumption in children aged 6 months to 5 years of age (PDF, 263KB). Based on the literature search, one relevant paper identified cyanide as a contaminant in almond drinks. Another 2 papers identified aflatoxin as a contaminant in almond nuts but not specifically in almond milks or drinks. No other relevant papers were found.

A structured literature search strategy was conducted to investigate the prevalence of mycotoxins, including T-2 and HT-2, ochratoxin A (OTA), and deoxynivalenol (DON), in oats or oat drink.

Several essential keywords and their synonyms were identified. For mycotoxins, these included the terms: "T-2 toxin", "HT-2 toxin", "ochratoxin A", "deoxynivalenol", and "mycotoxin contamination". For oats, several terms were utilised such as "oat", "Avena sativa", "oat grain", "oatmeal", and "oat product". Lastly, for oat drink, several terms were used: "oat-based milk", "oat drink", and "oat beverage". Several keywords were added related to occurrence, such as "prevalence", "contamination", "concentration", "detection" and "levels".

To ensure a comprehensive search, Boolean operators were used to combine synonyms within each category using ‘OR’ and then integrated these categories with ‘AND’. The search strategy therefore took the form of: “(Mycotoxins) AND (oats OR oat milk OR oat drink) AND (occurrence OR contamination OR levels)”.

To focus the search, several criteria were established for inclusion such as peer-reviewed articles and scientific literature published by regulatory authorities. Simultaneously, the criteria for exclusion involved non-English language articles or non-peer reviewed sources. For the systematic search, appropriate databases were selected, including (but not limited to) PubMed and Web of Science to yield a comprehensive data set for analysis. The search strategy was executed within the chosen databases, and after retrieving a list of articles, the inclusion and exclusion criteria were applied to filter the results. The retrieved articles were then reviewed by the secretariat to extract relevant information regarding the occurrence of mycotoxins in oats or oat milk. This information encompassed methodologies, sample sizes, geographic locations, and concentration levels.

Annex 3: call for evidence

Introduction

Following consideration of the findings from the scoping literature search and the toxicology literatures searches (Annex 2), the joint SACN and COT working group agreed that conducting a full literature search was not necessary. It was agreed that a call for evidence should be issued to help identify relevant research and information on plant-based drinks that may not have been identified through the scoping search.

A call for evidence was issued from 11 March to 10 April 2022 inviting interested parties to highlight any additional evidence meeting the inclusion criteria. It noted that the joint SACN and COT working group was particularly interested in identifying information on:

- processing and manufacturing methods
- contaminant occurrence data from monitoring
- product specifications
- nutrient composition and micronutrient fortificants
- suitability of plant-based drink products for different age groups

Manufacturers of plant-based drinks were encouraged to respond to the call for evidence and were contacted directly where possible.

Details of the additional evidence identified through the call for evidence that met the inclusion criteria are provided below.

Summary of responses to the call for evidence and information received from plant-based drinks manufacturers

Seven interested parties responded to the call for evidence. Of these, 5 responses were from plant-based drinks manufacturers and 2 responses were from trade bodies.

Information was supplied in confidence and therefore detail at an individual manufacturer level is not disclosed in this report. It should be noted that the data provided was limited and unlike other sources cited, this data is not in the public domain and therefore cannot be independently verified.

Evidence highlighted through the call for evidence: academic literature

In total, 25 scientific papers or reports were identified through the call for evidence, of which 12 met the inclusion criteria and had not been identified through the scoping search or hand searches. These 12 papers were as follows.

Alae-Carew C, Green R, Stewart C, Cook B, Dangour AD and Scheelbeek PFD. The role of plant-based alternative foods in sustainable and healthy food systems: Consumption trends in the UK. Science of the Total Environment 2022: volume 807, part 3, article number 151,041.

Bonke A, Sieuwerts S and Petersen IL. Amino Acid Composition of Novel Plant Drinks from Oat, Lentil and Pea. Foods 2020: volume 9, issue 4, page 429.

Cifelli CJ, Auestad N and Fulgoni VL. Replacing the nutrients in dairy foods with non-dairy foods will increase cost, energy intake and require large amounts of food: National Health and Nutrition Examination Survey 2011-2014. Public Health Nutrition 2022: volume 25, issue 2, pages 332 to 343.

Drewnowski A. Perspective: Identifying Ultra-Processed Plant-Based Milk Alternatives in the USDA Branded Food Products Database. Advances in Nutrition 2021a: volume 12, issue 6, pages 2,068 to 2,075.

Drewnowski A. Plant-based milk alternatives in the USDA Branded Food Products Database would benefit from nutrient density standards. Nature Food 2021b: volume 2, issue 8, pages 567 to 569.

Geiker NRW, Mølgaard C, Iuliano S, Rizzoli R, Manios Y, van Loon LJC, and others. Impact of whole dairy matrix on musculoskeletal health and aging-current knowledge and research gaps. Osteoporosis International 2020: volume 31, issue 4, pages 601 to 615.

McClements DJ and Grossmann L. A brief review of the science behind the design of healthy and sustainable plant-based foods. NPJ Science of Food 2021: volume 5, issue 1, article number 17.

Munekata PES, Domínguez R, Budaraju S, Roselló-Soto E, Barba FJ, Mallikarjunan K, and others. Effect of Innovative Food Processing Technologies on the Physicochemical and Nutritional Properties and Quality of Non-Dairy Plant-Based Beverages. Foods 2020: volume 9, issue 3, page 288.

Penhaligan J, Poppitt SD and Miles-Chan JL. The Role of Bovine and Non-Bovine Milk in Cardiometabolic Health: Should We Raise the "Baa"? Nutrients 2022: volume 14, issue 2, page 290.

Ratajczak AE, Zawada A, Rychter AM, Dobrowolska A and Krela-Kaźmierczak I. Milk and Dairy Products: Good or Bad for Human Bone? Practical Dietary Recommendations for the Prevention and Management of Osteoporosis. Nutrients 2021: volume 13, issue 4, page 1,329.

Shkembi B and Huppertz T. Calcium Absorption from Food Products: Food Matrix Effects. Nutrients 2021: volume 14, issue 1, page 180.

Singh-Povel CM, van Gool MP, Gual Rojas AP, Bragt MCE, Kleinnijenhuis AJ and Hettinga KA. Nutritional content, protein quantity, protein quality and carbon footprint of plant-based drinks and semi-skimmed milk in the Netherlands and Europe. Public Health Nutrition 2022: volume 25, issue 5, pages 1,416 to 1,426.

Evidence highlighted through the call for evidence: industry specific questions

The following section presents an overview of the responses received on the industry-specific questions.

Manufacturers that responded to the call for evidence shared the composition of some of their products or referred to their website for detail. They also shared their manufacturing methods.

Toxicology related questions

Several of the plant-based drinks manufacturers supplied a limited amount of analytical data on their products which related to toxicology. These included monitoring data on both the raw ingredients, notably soya beans, and to a lesser extent the finished drink product. The data largely consisted of targeted analysis of pesticides, heavy metals and mycotoxins conducted for the purposes of routine monitoring. The monitoring appears to have been conducted on a regular but infrequent basis. In general, the chemicals of concern were either not detected or were below regulatory limits.

Nutrition related questions

Nutrient composition and micronutrient fortificants

In general, manufacturers of plant-based drinks stated that they aim for their products to be nutritionally similar to cows' milk. Most manufacturers fortify with calcium, riboflavin, vitamin B12 and vitamin D. The number of products also fortified with iodine has increased in recent years.

One manufacturer noted that while they aspire to fortify products with several micronutrients, this is technically challenging if adhering to a "clean labelling" approach.

Manufacturers use dietary recommendations from various organisations and authorities in the UK and EU and consider the overall intakes of the target population (for example from NDNS data) to determine the nutrient specification of their products.

While some manufacturers have products specifically marketed for children aged 1 to 3 years and designed to meet the needs of this age group, other manufacturers do not market their plant-based drinks ranges for children.

Manufacturers noted that legislation prevents the fortification of organic foods and drinks.

Vitamin D

Vitamin D2 (ergocalciferol) is typically used as the fortificant in plant-based drinks because it is of non-animal origin, which is important for consumers that are looking for 100% plant-based products. The responses highlighted some evidence indicating that, as well as vitamin D3, vitamin D2 from foods can be effective in increasing 25-hydroxyvitamin D levels and noted that the evidence regarding whether vitamin D2 and D3 are bioequivalent is inconclusive. The references to the evidence highlighted are presented in Annex 2.

Iodine

Manufacturers highlighted challenges in setting a single level for iodine fortification given that while there is mandatory iodisation of salt in most European countries, this is not the case in the UK. Cows' milk is the main source of dietary iodine in the UK due to the fortification of feed for dairy cows with iodine as well as the use of teat dips containing iodine.

Other micronutrients
None of the responses considered vitamin A, despite cows' milk being a substantial contributor to vitamin A intake, especially in young children.

It was noted that plant-based drinks contain other micronutrients in low levels but not in sufficient amounts to include a 'source of' claim on the pack labelling. None of the manufacturers reported plans to fortify with other micronutrients that have not already been discussed.

Energy and macronutrients
The call for evidence included a question on the potential to increase protein content in almond and oat drinks to reflect the levels in cows' milk.

Manufacturers noted that protein intakes are adequate in the UK population suggesting that substituting cows' milk with plant-based drinks, even those that contain very low levels of protein such as almond and oat drinks, would not lead to inadequate protein intakes.

The availability of products with a range of protein contents to ensure that certain population subgroups (for example, people with metabolic conditions such as phenylketonuria), have access to low protein alternatives is also an important consideration.

One manufacturer highlighted that most plant-based drinks contain fibre and "beneficial" fat composition.

Sugars
Interested parties commonly compared the level of total sugars in plant-based drinks and cows' milk. They proposed that there is no need for sugar reduction in plant-based drinks as the levels are already lower than cows' milk and that the sugars in unsweetened products, such as oat drinks, are "naturally" occurring.

The responses highlighted the view that a low level of sugars is important for the taste and acceptability of these products in all age groups and that consumers should have a choice of products with and without sugars.

Other comments
Manufacturers noted that offering a choice and variety of plant-based products to consumers is key. With regards to government schemes (that is, the Nursery Milk Scheme

and Healthy Start), restriction to one type of drink (for example soya) should be avoided because of allergy issues and user preferences, familiarity and acceptability.

Annex 4: rapid scoping review of protein intakes in young children

Protein intakes in young children aged 1 to 5 years

The Reference Nutrient intake (RNI) for protein is 14.5 grams per day for children aged 1 to 3 years and 19.7 grams per day for children aged 4 and 5 years (Department of Health, 1991). Data from the Diet and Nutrition Survey of Infants and Young Children (DNSIYC) and the National Diet Nutrition Survey (NDNS) years 2016 to 2019 indicated that mean protein intake in children aged 12 to 18 months was 37.7 grams per day, more than twice the RNI and 41 grams per day in children aged 18 to 47 months, which is close to 3 times the RNI for this age group. Children aged 4 to 5 years had a mean protein intake of approximately 46 grams per day, more than twice the RNI for this age group.

Milk (24%) followed by meat (including meat products and dishes) (17%) were the largest contributors to protein intake in children aged 12 to 18 months, while for children aged 48 to 60 months, meat (including meat products and dishes) (27%) was the largest contributor to protein intake followed by milk (16%).

Protein intakes in young children (1 to 5 years) following a vegetarian or vegan diet

Although findings from national dietary surveys indicate that mean protein intakes in young children in the UK are adequate, the potential impact of replacing cows' milk with plant-based drinks in the diets of young children following a vegan or vegetarian diet, particularly in relation to protein quantity and quality (that is, amino acid composition), was highlighted as an important consideration for this risk assessment.

Of the 3 plant-based drinks under consideration in this risk assessment, only soya drink provides comparable levels of protein to cows' milk. Soya and soya products also contain isoflavones which have potential adverse endocrine disrupting effects in children. It was therefore necessary to explore the relative nutritional benefits of consuming soya drink (in terms of protein intakes) compared with the potential toxicological risks of consuming soy isoflavones, for young children following a vegan or vegetarian diet.

Following a rapid scoping search, no data was identified that specifically addressed the question of the impact of plant-based drinks consumption on protein intakes in young children. Evidence was therefore sought regarding protein intakes in young children following a vegetarian or vegan diet compared with omnivorous children.

Seven studies were identified (Alexy and others, 2021; Desmond and others, 2021; Gorczyca and others, 2011; Hovinen and others, 2021; Larsson and Johansson, 2002; Nathan and others, 1997; Weder and others, 2019). Of these, 6 were cross-sectional in design while one was a longitudinal observational case-comparison study. All studies included populations from northern Europe. One study included children aged 1 to 3 years and in all other studies, children were aged between 2 and 18 years.

In all cases, protein intakes were lower in those children following a vegan or vegetarian diet compared with those consuming an omnivorous diet, but protein intakes still at least met, if not exceeded, the RNI.

Only one small study (n=40, median age 3.5 years) (Hovinen and others, 2021) reported on protein quality. Untargeted metabolomics indicated a pattern of overall lower concentrations of circulating essential amino acids in vegan children compared with omnivores.

Given the overall lack of evidence, particularly reflecting current dietary patterns, and the heterogeneity and quality of the evidence that is available, it is difficult to draw conclusions on the protein quality of vegan and vegetarian diets consumed by young children in the UK.

Protein intakes and health outcomes

Findings from SACN reports considering infants and young children have highlighted evidence that, in addition to concerns regarding inadequate intakes, intakes of protein above requirements may be associated with increased body fatness in later childhood.

SACN's Feeding in the first year of life report (SACN, 2018) concluded that evidence from randomised controlled trials comparing higher versus lower infant formula protein contents supports observational evidence linking higher intakes of animal protein in infancy to rapid weight gain and later risk of obesity.

SACN's Feeding young children aged 1 to 5 report (SACN, 2023a) identified 'moderate' evidence from systematic reviews that higher vs lower total protein intake in children aged 1 to 5 years is associated with higher BMI in childhood (and noted that the role of total dietary energy intake is uncertain in this relationship). SACN recommended that government consider strategies to reduce consumption of excess protein in children aged 1 to 5 years.