# Plant-based milk alternatives in the diets of 1–4 year-olds

## Key points

- Plant-based milk alternatives are marketed as a substitute for animal milks for those who avoid animal-based foods and drinks or for those who avoid dairy products. Commonly used plant bases include soya, oat, pea and different nuts.

- Global and UK dietary guidelines recommend that children who are not being breastfed after the age of 1 year drink animal milk as the main milk drink; most commonly recommending cows' milk. Animal milks contain high quality protein, are complete with all essential amino acids and are a good source of highly bioavailable calcium, vitamin A, B vitamins, zinc and iodine. Plant-based milk alternatives have very variable composition and many have limited nutritional equivalence to animal milk.

- Whilst plant-based milks have a 'healthy halo' related to their plant-based nature it is important to note that there may be some issues with respect to their macro- and micro-nutrient content and the bioavailability of fortificants added.

- Reviews of the safety of plant-based milk alternatives based on soya, almond and oat have been conducted, and while these are regarded as safe in the diets of young children, care is needed if high volumes of these products are consumed or where diets may contain other foods based on the same plant-base.

- In the UK, public health guidance suggests that unsweetened, fortified milk alternatives can be included as the main milk drinks from the age of 1 year (with the exception of rice-based milk alternative). Some plant-based milk alternatives are low in energy and nutrients and there remains a lack of data on how families manage a plant-based diet for young children to provide context to the nutritional safety of this guidance.

- If families are advised to use an unsweetened and fortified plant-based milk alternative soya-based and pea-based products are the most prudent choice since nut-based and coconut-based products in that category are very low in energy and protein.

- Oat based milk alternatives contain free sugars from the processing of oats and the suitability of these products should be reviewed by the Scientific Advisory Committee on Nutrition (SACN) when considering their use in the diets of 1-4 year-olds in the UK.

- Lack of clear and consistent labelling of plant-based milk alternatives make it difficult for families to choose appropriate products for children. SACN should consider the need for clear and mandatory labelling of plant-based milk alternatives as to their suitability for 1-4 year-olds based on clearly defined nutritional criteria. No health claims should be allowed.

- We also recommend that:

    - Research is funded on how families manage plant-based diets for young children in the UK and the role that plant-based milk alternatives play in these diets to inform guidance.
    - Research is funded to consider the bioavailability of fortificants in plant-based milk alternatives in the diets of young children.
    - Products suitable for young children should have mandatory fortificant levels.

## Introduction

Public health guidance both globally, and in the UK, recommends that all infants are breastfed exclusively for the first 6 months of life, and are breastfed alongside complementary foods in the second 6 months. Global recommendations support continued breastfeeding in the second year of life, with WHO guidance recommending all infants are breastfed for 2 years or more. However, for centuries there has been an emphasis on the importance of milk in the diets of infants and young children in many countries of the world. Milk is highly associated with early childhood and the replacement of breastmilk with an animal milk for infants and young children is established in public health recommendations.

Whilst some plant-based milk alternatives have always been available, there has been an increasing trend towards plant-based diets in recent years and data from the Grocer in 2020 reported that 74% of 18–24-year-olds, 81% of 25–34-year-olds and 69% of 35-44 year-olds had bought a plant-based milk alternative at some point (The Grocer, 2020). It is still common for many of those buying plant-based milk alternatives to also buy animal milks, however, and they may use each for different purposes. The Grocer research reported that whilst almost half of respondents would use a plant-based milk for use on breakfast cereal, a third or less would use it in tea, cooking or baking. Whilst environmental and animal welfare concerns and concerns over allergens has fuelled some dietary changes, milk alternatives are also chosen for their taste (The Grocer, 2020). In 2018, plant-based milk alternatives represented 4% of sales of the total milk market in the UK, though almost a quarter of the population (23%) reported using plant-based milk alternatives in the 3 months to February 2019, a year-on-year increase of 4% (Mintel, 2019). According to Mintel (Mintel, 2019) 26% of under 35-year-olds report dairy avoidance in their household.

In the UK, the prevalence of veganism has grown 400% in the last few years, albeit from a very low base: an estimated 150,000 people in 2015 to an estimated 600,000 people in 2019 (Vegan Society, 2021). While those who choose a completely plant-based or vegan diet may currently represent a fraction of the population, it has been suggested that those choosing vegetarian or vegan diets may account for a quarter of the UK population by 2025 (NFU, 2017). Little data is available on how many families with infants and young children are choosing a plant-based diet in the UK, but it is likely that this number will rise as a younger generation habituated to plant-based foods and drinks enter parenthood, and as environmental concerns increase.

The composition of most plant-based milk alternatives is distinctly different to that of animal milk, with differences in both nutritional composition and bioavailability of nutrients. The plant-based food and drink market is going through a period of rapid evolution, and the number of plant-based milk alternatives on the market has greatly expanded in the past few years. It is likely however that the market will continue to expand rapidly driven by health and environmental concerns, and the data suggests that the plant-based milk alternative market is growing five times faster than its dairy milk counterpart (Kantar, 2020).

In the UK, 127.5 million litres of plant-based drinks were sold in 2019, an increase of 11% from 2018. Soy and almond drinks dominate the vast majority of the revenue, accounting for approximately 40% each (COT, 2021).

There is no standard labelling for these products to allow consumers to choose those that might be suitable for young children, for example distinguishing between fortified products and non-fortified. There are also a number of concerns about components of some plant-based milk alternatives that should be considered.

For those consumers using some plant-based milk alternatives alongside other animal-based foods there are unlikely to be significant dietary consequences. However, should families choose completely plant-based diets for their children aged 1-4 years there are potential nutritional and health implications and it is these we discuss in this paper.

## Overview of plant-based milk alternatives

It is possible to make a liquid that be used as a milk replacement from almost any plant base. Soya has been used most commonly, but other plant bases such as nuts, oats, peas, hemp and rice are commonly used. Most plant-based milk alternatives are largely composed of water with varying amounts of solids from the plant base (soya and oat milks typically contain about 10% solids, and nut milks typically contain around 2-3%) so the nutritional value of a plant-based milk alternative has no equivalence to its original food source (Scholz-Ahrens et al, 2018).

**Rice-based milk alternatives**

Rice-based milk alternatives are not recommended for consumption by children under 5 years of age due to their arsenic content. The Committee on Toxicity's most recent statement outlining the potential risks of arsenic poisoning from the consumption of rice-based milk alternatives in 2016 concluded that the advice that rice-based milk alternatives should be avoided by children aged 1 to 4.5 years should remain, with the proviso that up to 50ml/day in the diet of children aged 1 to 5 years was not an appreciable risk (COT, 2016). The NHS recommendation is that:

*Toddlers and young children under the age of 5 shouldn't have rice drinks because of the levels of arsenic they contain. (NHS, 2020)*

For this reason we do not consider rice-based milk alternatives in this paper.

Plant-based milk alternatives are ultra-processed foods when considered by the globally recognised NOVA classification (FAO, 2019). The NOVA food classification system is an epidemiological tool that classifies all foods and food products into 4 groups, based on the extent to which that food has been processed. The precise definition of each of these groups, superimposed on national dietary consumption data, allows the scientific assessment of the effects of food processing on human health and use of this information to inform public health policy (FAO, 2019). Using this system, evidence suggests that displacement of unprocessed foods by ultra-processed foods is associated with a deterioration in the quality of diets, (increased consumption of ingredients associated with non-communicable diseases, such as added sugars, saturated and trans fats and sodium, as well

as decreased consumption of fibre, protein and some micronutrients) and consequently adverse health outcomes including obesity and obesity-related outcomes (FAO, 2019).

The fourth group in this classification system is 'ultra-processed foods'. This group consists of products 'formulated mostly or entirely from substances extracted from foods or derived from food constituents' (FAO, 2019). Ultra-processed foods rely on additives that enhance the sensory quality of foods to render them convenient and hyperpalatable for consumers and highly profitable for manufacturers (FAO, 2019).

In order to have broad appeal, plant-based milks are designed to replicate the properties of cows' milk. Plant material (cereals, legumes, seeds, nuts) is broken down and extracted in water. Additives are used to enhance stability, quality and nutritional attributes (McClements et al, 2017). Emulsifiers and stabilisers are added to imitate cows' milk in appearance and consistency. Flavourings are added to improve palatability and added sugars are used in some milks to further increase appeal and taste. The liquid can be processed further to create different products and may be fortified with vitamins and minerals to imitate the nutritional composition of animal milk.

There is an increasing proliferation of plant-based milk alternatives available in the UK. Unlike cows' milk which conforms to a set of specific nutritional standards, plant-based milk alternatives are not regulated and have no standard composition. Consequently, energy density and nutritional content vary extensively between plant-based milk types and between brands depending on the raw material, processing operations and additives. Under these circumstances, clear nutritional guidance on the packaging is essential so that parents and caregivers can choose an appropriate product. Products with free sugars are not consistently indicated in the labelling, especially in the case of flavoured products. Current packaging does not explicitly distinguish between products that have been fortified and those that haven't, which poses nutritional risk if these products exclusively replace cows' milk in the diets of young children 1-4 years.

The majority of plant-based milk alternatives cannot use the term 'milk' in the product name. In 2007, The European Union ruled in 2007 that the use of the term 'milk' refers only to products of animal origin, with exceptions made for almond milk and coconut milk (EU 1308/2013). Manufacturers use a variety of names for their products, many attempting to suggest an equivalence in some way to animal milk e.g.mylks, M.LK, drinks. They are primarily marketed in cartons and positioned both alongside animal milks in supermarket chiller cabinets and on the shelves often alongside ambient ranges of other foods designed for consumers with special dietary needs.

There are a wide range of plant-based milk alternatives currently available in UK supermarkets. In this paper we do not discuss Alpro 1+ Growing Up Milk as this is included in information on drinks marketed as growing up and toddler milks which can be accessed at Milks marketed for children — First Steps Nutrition Trust. In Table 1 we give some examples of commonly available plant-based milk alternatives which are sweetened or unsweetened and fortified or unfortified. We have not included flavoured plant-based milk alternatives as these should clearly be avoided by young children (e.g. chocolate, strawberry flavoured milk alternatives).

**Table 1: Examples of soya-based, nut-based, pea-based, coconut-based and hemp-based milk alternatives commonly sold in UK supermarkets.**

| Unsweetened and fortified plant-based milk alternatives | Unsweetened and unfortified plant-based milk alternatives | Sweetened and fortified plant-based milk alternatives | Sweetened and unfortified plant-based milk alternatives |
|---|---|---|---|
| **Soya-based milk alternatives** | | | |
| • Tesco Soya Unsweetened<br>• Chilled Alpro Soya No sugars<br>• Chilled Alpro Soya light<br>• M&S Unsweetened Soya Drink | • Tesco Organic Soya Unsweetened<br>• Plenish Organic Soya Unsweetened<br>• Provamel Organic Soya No Sugars<br>• Sojade So Soya! | • Tesco Soya Drink Sweetened<br>• Alpro Soya<br>• Alpro Soya chilled<br>• Alpro Barista Soya<br>• Alpro Soya Vanilla Drink<br>• M&S Sweetened Soya Drink | • Tesco Organic Soya Sweetened<br>• Alpro My Cuppa Soya<br>• Rude Health Soya drink Organic<br>• Provamel Organic Bio Soya Calcium |
| **Almond-based milk alternatives** | | | |
| • Chilled Alpro Almond No Sugars<br>• Tesco Almond Unsweetened<br>• Alpro Almond No Sugars Unroasted<br>• M&S Unsweetened Almond | • Innocent Almond<br>• Plenish Organic Almond Unsweetened<br>• Rude Health Ultimate Almond Organic<br>• Provamel Organic Almond No Sugars<br>• Alpro Organic Almond Unsweetened | • Alpro Almond Roasted<br>• Tesco Almond Sweetened<br>• M&S Sweetened Almond | • Rude Health Almond Drink Organic |
| **Hazelnut-based milk alternatives** | | | |
| | • Plenish Organic Hazelnut | • Alpro Hazelnut original<br>• Alpro Hazelnut chilled | • Innocent Hazelnut*<br>• Rude Health Unsweetened Hazelnut* |
| **Cashew-based milk alternatives** | | | |
| | • Alpro Cashew original<br>• Alpro Cashew chilled<br>• Plenish Cashew<br>• Rude Health Unsweetened Cashew | | |

**Table 1: Examples of soya-based, nut-based, pea-based, coconut-based and hemp-based milk alternatives commonly found in UK supermarkets.**

| Unsweetened and fortified plant-based milk alternatives | Unsweetened and unfortified plant-based milk alternatives | Sweetened and fortified plant-based milk alternatives | Sweetened and unfortified plant-based milk alternatives |
|---|---|---|---|
| **Pea based milk alternatives** | | | |
| • Unsweetened Mighty Pea M.LK<br>• Sproud Unsweetened Powered by Peas<br>• Qwrkee Plant-based Pea Ml'k Unsweetened[2] | | • Mighty Pea M.LK<br>• Sproud Barista Powered by Peas<br>• Qwrkee Plant-based Pea M'lk Sweetened | |
| **Coconut-based milk alternatives** | | | |
| • Alpro Coconut no sugars | • Innocent Coconut[1]<br>• Rude Health Coconut Drink Organic<br>• Alpro Organic Coconut with rice<br>• Provamel Organic rice coconut | • Alpro Coconut*<br>• M&S Coconut<br>• Tesco Coconut drink | • Alpro Barista Coconut |
| **Hemp based milk alternatives** | | | |
| | • Good Hemp Creamy Seed<br>• Good Hemp Original Seed<br>• Sojade Hemp | | • Good Hemp Barista Seed |
| **Mixed plant-based milk alternatives** | | | |
| | • Alpro Coconut and Almond<br>• Alpro Coconut and Almond chilled | | |

[1] Innocent coconut milk has seaweed added as a natural source of calcium but not other fortificants.
[2] Contains 0.3g added sugar (maltodextrin & inulin) per 100mls.

Sweetened and unsweetened products were categorised according to product labelling and the presence of added sugars listed in the nutrition information. Those marked with an asterisk (*) contain sugars that are derived from the breakdown of starch in rice but do not have other added sugar mentioned on the label. Some of these milks may be marketed as containing "no added sugar" but they will contain simple sugars from the breakdown of rice starch in processing.

**It is recommended that children aged 1-4 years have unsweetened and fortified plant-based milk alternatives, those shown in the first column of the table**. It is obviously extremely difficult to distinguish products based on the name of the product and there is an urgent need for clarity in labelling to support families in making appropriate decisions on a suitable product. One manufacturer provides information on the packaging related to suitability of use by young children, but this manufacturer also produces a plant-based 'growing-up milk' which they market for children aged 1-3 years, and their assessments of suitability are their own.

### Oat-based milk alternatives

Oat-based milk alternatives do not have added sweeteners but they contain sugars that are created from the breakdown of starch in oats during processing. The enzymatic breakdown of oats during processing will lead to starch reduced to simple sugars such as maltose and glucose (Nutraingredients, 2019). Some "unsweetened" oat-based milk alternatives contain more sugar per 100mls than some sweetened soya, almond and pea-based milk alternatives. For this reason we have categorised these differently simply as fortified or unfortified products (see Table 2). There are currently no recommendations that families with young children should avoid oat-based milk alternatives, but this should be considered in the on-going review of dietary recommendations for 1-4 year olds by the Scientific Advisory Committee on Nutrition.

**Table 2. Fortified and unfortified oat-based milk alternatives commonly sold in UK supermarkets**

| Fortified oat-based milk alternatives | Unfortified oat-based milk alternatives |
|---|---|
| • Oatly Oat Drink Whole<br>• Oatly Oat Drink Barista Edition<br>• Oatly Oat Drink<br>• Oatly Oat Drink Semi<br>• Oatly Oat Drink Skinny<br>• Alpro Oat<br>• Chilled Alpro Oat No Sugars<br>• Tesco Oat Drink<br>• M&S Oat<br>• Mighty Pea Protein Oat | • Oatly Organic Oat<br>• Plenish Organic Oat Unsweetened<br>• Rude Health Oat Organic<br>• Rude Health Chilled Oat Drink Organic<br>• Rude Health Barista Oat Organic<br>• Provamel Organic Oat |

## The nutritional composition of plant-based milk alternatives

Plant-based milk alternatives have a highly variable nutritional composition depending on plant type, processing procedures, added ingredients such as sugar and sweeteners, and fortification. Some products may naturally contain some micronutrients, but as the amount of base material used is often low and water is the main ingredient, fortification is likely to be the main source. The base ingredients show a very small proportion of the plant base is typically used (2-10%), with the main ingredient being water. In addition ingredients are added to act as flavourings, preservatives, stabilsiers, emulsifiers and thickening agents as well as fortificants.

**Table 3: Examples of the ingredients in some plant-based milk alternatives.**

| | Base | Added Sugar | Preservative | Flavouring and flavour enhancers | Stabilisers, emulsifiers, thickening agents | Added vitamins and minerals |
|---|---|---|---|---|---|---|
| **Alpro Soya chilled** | Water, Hulled Soya Beans (8%) | Sugar | Potassium Phosphates | Flavouring, Sea Salt | Gellan Gum | Calcium Carbonate, Potassium Iodide, Vitamins B2 (riboflavin), B12, D2 |
| **Alpro Almond chilled** | Water, Almond (2.3 %) | Sugar | | Sea salt, Natural flavouring | Locust bean gum, Gellan Gum Lecithins (Sunflower) | Tri-calcium phosphate, Vitamins (B2 (riboflavin), B12, E, D2). |
| **Innocent Hazelnut** | Spring Water, Rice (11%), Hazelnut (4.7%) | | | Sea Salt | | Seaweed Lithothamnium Calcareum (natural source of calcium) |
| **Original Oatly Oat Drink** | Water, Oats (10%) | | Dipotassium Phosphate | Salt | Rapeseed Oil | Calcium Carbonate, Potassium Iodide, Vitamins D2, riboflavin, B12 |
| **Mighty Pea M.LK** | Water, Pea Protein Isolate (4%) | Grape Juice Concentrate | Potassium Carbonate | Natural Flavourings, Sea Salt | Guar Gum, Gellan Gum, Sunflower Oil, | Calcium Carbonate, Iodine, Vitamins (B12, D) |
| **Alpro Coconut chilled** | Water, Coconut Milk (5.3%) (Coconut Cream, Water), Rice (3.3%), | | | Sea Salt | Guar Gum, Gellan Gum, Xanthan Gum | Tri-Calcium Phosphate, Vitamins (B12, D2) |
| **Good Hemp Seed Milk** | Water, Hemp Seed Base (4%) | | Dipotassium Phosphate | Sea Salt | Sunflower Lecithin, Gellan Gum | |

The nutritional composition of a selection of unsweetened fortified plant-based milk alternatives is compared with that of cows' milk in Table 4. Legume-based milk alternatives (pea, soya) are higher in protein than other plant-based milk alternatives. Fortificants are usually added to mimic the amount found in cows' milk, however their lower bioavailability should be considered. As shown earlier there are a variety of products with similar names, some with added sugars, some with added fortificants. Here we show a selection of those that are unsweetened and fortified but also an oat milk, which as explained earlier, due to the breakdown of oat starch in processing will be a source of free sugars despite having no added sugars on the label.

**Table 4: A comparison of the nutritional composition of some commonly available fortified plant milks, with cows' milk.**

| Per 100mls | **Whole cows' milk[1]** | **Unsweetened fortified oat milk alternative[2]** | **Unsweetened fortified soya milk alternative[3]** | **Unsweetened fortified pea milk alternative[4]** | **Unsweetened fortified coconut milk alternative[5]** | **Unsweetened fortified almond milk alternative[6]** |
|---|---|---|---|---|---|---|
| Energy (kcal) | 63 | 46 | 33 | 32 | 14 | 13 |
| Protein (g) | 3.4 | 1.0 | 3.3 | 3.3 | 0.1 | 0.4 |
| Fat (g) | 3.6 | 1.5 | 1.8 | 2.0 | 1.2 | 1.1 |
| Carbohydrate (g) | 4.6 | 6.7 | 1.0 | 0.1 | 0 | 0 |
| of which lactose (g) | 4.6 | 0 | 0 | 0 | 0 | 0 |
| of which sugars other than lactose (g) | 0 | 4.1 | 0.3 | 0.1 | 0 | 0 |
| Salt | 0.1 | 0.1 | 0.1 | 0.26 | 0.13 | 0.13 |
| ***Vitamins*** | | | | | | |
| Riboflavin (mg) | 0.23 | 0.21 | 0.21 | Not added | Not Added | 0.21 |
| Vitamin B12 (µg) | 0.9 | 0.38 | 0.38 | 0.94 | 0.38 | 0.38 |
| Vitamin D (µg) | Trace | 1.1 | 0.75 | 0.78 | 0.75 | 0.75 |
| ***Minerals*** | | | | | | |
| Calcium (mg) | 120 | 120 | 120 | 186 | 120 | 120 |
| Iodine (µg) | 31 | 22.5 | 13 | 31 | 8 | 6 |
| ***Price*** | | | | | | |
| per 100ml | 7p | 15p | 10p | 20p | 18p | 18p |

1. Nutritional composition data from Finglas et al (2015); cost data based on Tesco whole cows' milk 2 pint (1.13l), Tesco 2021, 71p/litre
2. Oatly Oat Drink, Tesco 2021, £1.50/litre
3. Tesco Soya Unsweetened, Tesco 2021, 95p/litre
4. Mighty Pea Unsweetened M.LK, Tesco 2021, £2.00/litre
5. Alpro Coconut No Sugars, Tesco 2021, £1.80/litre
6. Alpro Almond No Sugars, Tesco 2021, £1.80/litre
7. Where data not available on product taken from Bath et al, 2016.

## Potential health benefits from consumption of plant-based milk alternatives

Much of the research considering the nutritional profile of plant-based milk alternatives suggests their increasing popularity is driven by health issues, including concern over energy and the fat/cholesterol intake associated with cows' milk (Mäkinen et al, 2015; Sethi et al, 2016; Vanga and Raghavan, 2018; Verduci et al, 2019;). While there is a lack of data comparing the motives of UK consumers for choosing plant-based alternatives over animal milk, one study looking at product attributes that drove purchasing decisions in the US, reported that plant-based milk alternatives appeal to health-conscious consumers because of their perceived [relative to cows' milk] lower calorie, fat and carbohydrate content (McCarthy et al, 2017). Current global and UK dietary guidelines encourage diets high in fruits and vegetables, whole grains, legumes and nuts, moderate in low-fat dairy and seafood and low in processed meats, sugar-sweetened beverages, refined grains and sodium (PHE, 2016a). These messages suggest that plant-based milk alternatives fit well into a healthy diet.

Some of the perceived health benefits of plant-based milk alternatives have a basis in scientific evidence as some plants used to create milk alternatives contain components that are associated with health benefits. For example, the phytosterols in soya have been associated with lowering cholesterol (Fukui et al, 2002; Biswas et al, 2011) and beta-glucan found in oats has been associated with a cholesterol lowering effect. The soluble fibre in oats increases solution viscosity and delays gastric emptying which increases gastric transit time and acts to reduce blood glucose and thereby total and LDL cholesterol (Deswal et al, 2014; Verduci et al, 2019). Isoflavones in soya and antioxidants in many plant materials (such as vitamin E in almonds and coconut) are associated with protection against oxidative damage, anti-carcinogenic effects, cardiovascular disease and osteoporosis (Omoni and Aluko, 2005; Sethi et al, 2016).

Whether plant-based milk alternatives can be related to similar health outcomes is unlikely since they are largely composed of water and contain only very small amounts of the raw plant material (Sethi et al, 2016; Sholz-Ahrens et al, 2019; Verduci et al, 2019). The 'healthy halo' that these plant-based ingredients have may confuse consumers, and despite a lack of evidence of health benefits associated specifically with consuming plant-based milk alternatives, the advertising and market positioning of these products supports and appeals to health themes; for example, naming conventions such as "Mighty Pea M.LK", "Rude Health" and marketing messages such as "*100% plant-based*", "*naturally occurring sugars*" "*low in sugars*". A marketing campaign for Oatly oat-based milk alternative used the strapline *'It's like milk but made for humans'* suggesting some benefit to human well-being. Alpro milk advertising used the phrase *'Good for you'* in their marketing, and Alpro television adverts have focused on images related to sport and health.

Whilst products are not currently marketed for children it is likely that families perceive these products as healthy for the whole family. It is important that families are aware that young children require an energy and nutrient dense diet, and that perceived health benefits of a plant-based diet may not be relevant or health promoting for young children.

## Potential health risks from consumption of plant-based milk alternatives

As the main milk drink cows' milk typically provides a significant proportion of a number of important nutrients to the diets of 1–4-year-olds in the UK, including energy, protein, vitamin A, calcium, iodine, riboflavin and zinc. There is very little available data on the consumption of plant-based milk alternatives by young children. However inadequate substitution of cows' milk (after the first year of life) with plant-based milk alternatives has been related to nutritional gaps in the diets of young children, especially if the plant-based milk alternative is the only, or predominant drink in the child's diet (Scholz-Ahrens et al, 2019; Verduci et al, 2019). Currently dietary modelling is the only way of considering the potential impact of substituting animal milk for plant-based milk alternatives in the diets of young children as we currently have no data on the actual choices made by families using these in their children's diet.

**Low energy intake**

Unsweetened plant-based milk alternatives are typically lower in fat and many are lower in protein and carbohydrate than cows' milk. However, there is a wide variation in individual energy intake, and this makes messages about which products to choose difficult. Advice to avoid plant-based milk alternatives that contain added sugars may result in consumers choosing one of the many of the unsweetened and fortified products that may be lower in energy than other alternatives. As a result, energy density per 100mls for many products is also significantly lower than cows' milk. Young children have high energy requirements to fuel rapid growth, yet their capacity for food intake is physiologically limited. If plant-based milk alternatives are used as a main milk drink in the diets of young children, there is a risk of both low calorie and nutrient intake, as plant-based milk alternatives may displace other more energy and nutrient dense sources of food. Care is therefore needed to ensure that the whole diet is energy and nutrient-dense and that important nutrients are included from other food sources. Large volumes of plant-based milk alternatives should be avoided. If families are advised to only choose unsweetened and fortified products, then it may be prudent to avoid nut based and coconut-based products. Oat-based milk alternatives contain simple sugars from the breakdown of oats in processing but have no added sugar shown on the label. These products need review.

**At the present time unsweetened and fortified soya-based and pea-based milk alternatives are in our opinion the best choices for 1-4 year-olds where neither breastmilk nor animal milk are consumed.**

**Low fat intake**

Substituting plant-based milk alternatives for cows' milk may impact fat (and therefore energy) intake in the diets of young children. Plant-based milk alternatives are significantly lower in total fat than cows' milk. Liquid cows' milk represents 20% of the total dietary fat intake in the diets of young children 1.5-3yrs in the UK (PHE, 2020).

There are no UK dietary recommendations in relation to fat intakes in children below the age of 2 years. This is because young children have a high requirement for dietary fat to support energy expenditure, fat deposition and oxidation (Koletzko, 1999) and brain function and cognitive development (Agostoni and Coroli, 2012) during a period of rapid growth. Dietary fats are also

required to deliver fat soluble vitamins and essential omega-6 and omega-3 polyunsaturated fatty acids, although these needs can be met with small intakes of fat (Koletzko, 1999). Consequently, fats should not be restricted in the diets of children younger than 2 years. While evidence on the health outcomes of dietary fat intake in early childhood is limited (Agostoni and Coroli, 2012; Fewtrell et al, 2017; SACN, 2019) and further research is needed, there is no evidence available for a health benefit of a low-fat intake in early childhood (Koletzko, 1999) and total fat or quality of fat in young children has not been associated with later health outcomes (Agostoni and Coroli, 2012).

**Low protein intake and poor protein quality**

Young children have a high requirement for dietary protein to fuel rapid body growth. Protein is essential for growth and maintaining and repairing body tissue as well as the synthesis of enzymes that are involved in control and regulation of biological functions. Plant-based milk alternatives based on pulses (soya, pea) have a similar total protein content to animal milk. Most other plant-based milk alternatives are significantly lower in total protein compared to animal milks.

The quality of plant protein, which includes the profile of amino acids, digestibility and bioavailability, is considered of lower nutritional quality than cows' milk (FAO, 2013; Scholz-Ahrens et al, 2019). Unlike animal proteins, plant-based proteins, with the exception of soya, pea, brown rice, corn and potato do not contain all or enough of the essential amino acids to be considered a complete source of protein (WHO/FAO/ UNU, 2007; Gorissen et al, 2018). As such, milk alternatives derived from many of the available plant bases do not contain all of the essential amino acids necessary for protein synthesis.

Additionally, although soya and pea proteins offer all essential amino acids, the content of leucine, which has been shown to stimulate human muscle protein synthesis is almost 30% lower in soya protein per 100g and almost 20% lower in pea proteins per 100g than cows' milk (Gorissen et al, 2018). The digestibility of plant proteins and the bioavailability of their amino acids for skeletal muscle synthesis is also significantly lower (Scholz-Ahrens et al, 2019). Accordingly, whereas the FAO categorize cows' milk as an excellent source of protein, soya is classified as a good source of protein (Scholz-Ahrens et al, 2019). Most other plant-based milk alternatives would be considered low in protein (cereal-based milk alternatives) or very low in protein (nut and rice-based milk alternatives) (FAO, 2013; Scholz-Ahrens et al, 2019).

Table 5 compares the total amount of protein derived from a daily serving of whole cows' milk (400mls) or plant-based milk alternatives with the reference nutrient intake for protein for children 1-3 years. A daily total serving of 400mls of cows' milk provides all the essential amino acids and protein equivalent to 94% of the daily reference nutrient intake for a 1-3 year-old. Only milk alternatives derived from legumes provide good quality protein and meet a significant proportion of the daily protein reference nutrient intake (RNI). In contrast, plant-based milk alternatives derived from cereals and nuts provide limited amounts of protein and would need to be balanced with other sources of protein to ensure all essential amino acids are received. Offering milk alternatives based on cereals and nuts may pose a nutritional risk by displacing other higher quality sources of protein.

**Table 5: Protein content of plant-based milk alternatives compared to cows' milk.**

| | Whole cows' milk[1] | Unsweetened fortified oat milk alternative[2] | Unsweetened fortified soya milk alternative[3] | Unsweetened fortified pea milk alternative[4] | Unsweetened fortified coconut milk alternative[5] | Unsweetened fortified almond milk alternative[6] |
|---|---|---|---|---|---|---|
| Protein g/100mls | 3.4 | 1.0 | 3.3 | 3.3 | 0.1 | 0.4 |
| Protein (g) in 400mls | 13.6 | 4.0 | 13.2 | 13.2 | 0.4 | 1.6 |
| Protein intake from 400mls as % of daily protein RNI for a child 1-2 years (RNI = 14.5g.day) | 94% | 28% | 91% | 91% | 3% | 11% |
| Protein intake from 400mls as % of daily protein RNI for a child 3-4 years (RNI= 17.1g/day) | 80% | 23% | 77% | 77% | 2% | 9% |

Reference Nutrient Intake (RNI) derived from Department of Health (1991)

1. Nutritional composition data from Finglas et al (2015)
2. Oatly Oat Drink, Tesco 2021
3. Tesco Soya Unsweetened, Tesco 2021
4. Mighty Pea Unsweetened M.LK, Tesco 2021
5. Alpro Coconut No Sugar, Tesco 2021
6. Alpro Almond No Sugars, Tesco 2021

A lower intake of protein from the main milk drink in a young child's diet may not be a concern if a child is consuming an adequate volume and variety of other sources of quality protein. Indeed, data from the National Diet and Nutrition Survey 2016/17-2018/19 suggests there is no risk of low protein intakes across the general population of young children. Current protein intakes in young children exceed government recommendations at almost 3 times the reference nutrient intake: for 1.5-3 year-olds the mean intake is 41g/day compared to a reference nutrient intake of 14.5g (PHE, 2016a) and for 4-10 year-olds, the mean intake is over 50g compared to a reference nutrient intake of 19.7g (PHE, 2020). Where children are following strict vegetarian or totally plant-based diets, there is a greater risk of low protein intake, and so using a plant-based milk alternative with a low protein content as the main milk drink in these diets may increase the risk of low protein intake. However, the survey also shows that on average children 1-4 years are consuming enough protein from non-animal sources to exceed the daily reference nutrient intake for total protein intake. Children on a plant-based diet can get enough protein as long as they eat a good variety of different foods each day. Children on plant-based diets will obtain protein from nuts, seeds, peas, beans and pulses, soya products (including tofu and soya milk alternative and yoghurt), vegetables, and cereal foods such as bread, rice, pasta and potatoes. For more information on eating well for infants and young children on a vegan diet see Eating well early years — First Steps Nutrition Trust

It is recommended that research is undertaken with families who use plant-based milk alternatives in a plant-based diet for children under five years of age to review the quantity and quality of protein consumed so that clearer guidance can be given.

**High free sugars intake**

Many plant-based milk alternatives contain free sugars to enhance the palatability of the product. Public Health England (PHE) has set a definition for free sugars in the UK (Swan et al, 2018) and defines these as:
"*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.*

This definition also specifically includes:
"*all sugars naturally present in dairy-alternative drinks such as soya, rice, oat and nut-based drinks."*

This means that the sugars that are either added to plant-based milk alternatives as listed on the packaging, or those that are "naturally occurring" (which may be from processing or other natural ingredients) are defined as free sugars. Sugars appear on food labels as 'sugars' which is the sum of all sugars present in a food, and can include both sugars present in milk, dairy products, fruit and vegetables as well as added sugars such as sucrose or sugars from fruit and vegetable juices and purées. It is important to know where sugars originate from as it is the free sugars, as opposed to those enclosed in the cell structure of foods such as fruit, that have a detrimental effect on long-term health (SACN, 2015). Lactose in cows' milk is not a free sugar. As the major carbohydrate of human milk and cows' milk, lactose provides about 40% of the energy. It has beneficial effects on gut physiology including prebiotic effects, softening of stools, and effective absorption of water, calcium and sodium (Koletzko et al, 2005).

The Scientific Advisory Committee on Nutrition recommends that the free sugars intake in children aged from 2 years does not exceed 5% of energy intake (SACN, 2015). Whilst there is no specific recommendation for children aged 1-2 years, advice is to minimise free sugars intake and it would seem logical that intakes not exceeding 5% of energy would be prudent in all children under the age of five years.

**Table 6: Free sugars in some sweetened fortified plant-based milk alternatives compared to recommended intakes of free sugars in 1-4 year-olds.**

| | Whole cow's milk[1] | Oat milk alternative[4] | Sweetened almond milk alternative[3] | Sweetened soya milk alternative[2] | Sweetened pea milk alternative[5] | Coconut milk alternative[6] |
|---|---|---|---|---|---|---|
| Energy kcal/100mls | 66 | 46 | 27 | 40 | 39 | 20 |
| Carbohydrate g/100mls | 4.7 | 6.7 | 2.9 | 2.6 | 2.0 | 2.7 |
| Lactose g/100mls | 4.7 | 0 | 0 | 0 | 0 | 0 |
| Other sugars g/100mls | 0 | 4.1 | 2.8 | 2.4 | 2.0 | 1.9 |
| Listed sugars | Lactose | Natural sugars from oats | Sugar | Sugar | Grape juice concentrate | Naturally occurring sugars from rice |
| Total sugars (g) in 400mls | 18.8 | 16.4 | 11.2 | 9.6 | 8 | 7.6 |
| Energy from free sugars as % of recommended amount for 1-2 year old (11.4g/day) | 0 | 144% | 98% | 84% | 70% | 67% |
| Energy from free sugars as % of recommended amount for 3-4 year old (16.4g/day) | 0 | 100% | 89% | 59% | 49% | 46% |

1. Nutritional composition data from Finglas et al (2015)
2. Alpro Soya.
3. Tesco Almond Sweetened.
4. The Original Oatly Oat Drink,
5. Mighty Pea M.LK.
6. Alpro Coconut.

All of the plant-based milk alternatives above contain free sugars and a daily serving of 400mls of most of these sweetened milks would make a substantial contribution to total daily free sugar intake. If a child aged 1-2 years drank 400ml/day of Oatly Oat Drink they would exceed the daily recommended intake of free sugars. Nutritional information on that product includes an asterisk to indicate that the high sugar content comes from 'natural sugars' but these would be classified as

free sugars. Maltose and glucose are the sugars primarily derived from the breakdown of starch in oats during the production process. Mighty Pea M.LK packaging compares its free sugar content, derived from added 'grape juice concentrate' (glucose and fructose) to the intrinsic lactose content of cows' milk with the misleading statement: "*50% Less Sugar than Cows' Milk."*

The American Heart Association has recommended that no added sugars should be given to infants under two years of age (Vos et al, 2016). While introducing complementary foods, sugar intake should be limited, as it can encourage an acceptance of and preference for sweet foods, and cause tooth decay when the first teeth start coming through (Department of Health, 1994). A high sugar intake at the age of three years increases the risk of developing caries at the age of six (Karjalainen et al, 2001). In addition, intake of sweet foods in childhood can impact a child's weight and health throughout life and is linked with obesity and diabetes (Drewnowski et al, 2012). Even relatively small amounts of added sugars in foods can make a significant contribution to the overall intake of an infant.

The childhood obesity plan for action (PHE, 2016b) recommended clearer labelling to enable families to make healthy choices. It was noted that families needed to understand which sugars they need to eliminate or reduce in their diets. Current labelling does not identify free sugars and therefore does not adequately allow families to make choices in line with public health guidance. A review of food labelling should make the addition of free sugar content information mandatory on nutrition labelling required by law.

**Low micronutrient intakes and poor bioavailability**

Plant-based milk alternatives are not naturally rich sources of vitamins and minerals, but many are fortified to offer some equivalence to animal milk. Typically, fortified milks have calcium, vitamin D and vitamin B12 and some also have riboflavin and iodine added. However, there is a difference in bioavailability between some micronutrients intrinsically within a food and those added as a supplement. The physical state of nutrients in plant-based milk alternatives and the interaction with the food matrix are important determinants of absorbability (Heaney et al, 2005).

In contrast liquid cows' milk is the primary source of riboflavin, calcium and iodine and an important source of vitamin A, potassium and zinc. Populations with low intakes of animal milks may be at risk for low intake of these nutrients (Scholz-Ahrens, 2019; Sakkas et al, 2020). Table 7 shows the importance of liquid cows' milk as a contributor of micronutrients in the diets of young children. Liquid cows' milk as whole or semi-skimmed milk provides on average 38% of the total riboflavin intake, 36% of the total calcium intake, 20% of the total zinc intake and 47% of the total iodine intake. Liquid milk therefore currently makes a significant contribution to the intake of some important micronutrients in the diet.

**Table 7: Milk and milk products as a source of micronutrients compared with other food groups in the diets of children aged 1½ to 3 years[1].**

| % contribution from this food group to total micronutrient intake | Vitamin A | Riboflavin | Calcium | Magnesium | Potassium | Zinc | Iodine |
|---|---|---|---|---|---|---|---|
| **Total milk and milk products** | 35 | 54 | 59 | 25 | 30 | 35 | 64 |
| **of which whole milk** | **16** | **28** | **27** | **13** | **16** | **15** | **34** |
| **of which semi-skimmed milk** | **3** | **10** | **9** | **4** | **5** | **5** | **13** |
| Cereal and cereal products | 11 | 22 | 24 | 29 | 16 | 26 | 10 |
| Eggs, egg dishes and fat spreads | 12 | 3 | 1 | 1 | 1 | 3 | 5 |
| Meat, meat products, fish and fish products | 7 | 8 | 5 | 11 | 12 | 21 | 11 |
| Vegetables and potatoes | 22 | 3 | 3 | 12 | 16 | 7 | 2 |
| Other foods and drinks | 4 | 3 | 3 | 5 | 5 | 1 | 2 |

[1] National Diet and Nutrition Survey data from years 9-11 (PHE, 2020)

### Calcium

Animal milk is one of the richest sources of calcium and the calcium from dairy products is well absorbed (Barlowska et al, 2011; Singhal et al, 2017; Scholz-Ahrens et al, 2019). In contrast, the bioavailability of calcium varies significantly when used as a fortificant and can be influenced by numerous factors, including the presence of inhibitors such as oxalate in almonds or phytates in grains (Scholz-Ahrens et al, 2019). Although plant-based milk alternatives may be fortified with calcium in quantities that appear to be equivalent to those found in cows' milk, the amount that can be absorbed from these milk alternatives is difficult to determine. One study conducted among healthy adult males, that compared the absorption of calcium from cows' milk with a soya-based milk alternative fortified with tri-calcium phosphate, found that the fortified soya milk was 25% less bioavailable (Heaney et al, 2000) but no difference in bioavailability was found when calcium carbonate was used (Zhao et al, 2005; Mäkinen et al, 2015). In some cases, the level of fortification, particularly regarding calcium, is used in marketing messages to suggest equivalence with cows' milk. Mighty Pea M.LK includes a statement on its packaging: "*50% More Calcium than Cow's Milk*". Families should be aware that absolute amounts of calcium cannot be compared when there are differences in bioavailability.

There is currently no data to show how children on plant-based diets obtain their calcium and how this compares to dietary reference values. Calcium absorption also depends on an adequate vitamin D status, and whilst in the UK vitamin drops containing Vitamin D are recommended for all under 5's, and the majority of vitamin D should be made by the action of sunlight on skin, milk and milk products currently provide about 30% of total dietary vitamin D intakes. Rickets, associated with calcium and vitamin D deficiency, has been reported in young children on a lower calcium diet, particularly where animal milks are not consumed (Thandrayen and Pettifor, 2018) and where non-fortified soya-based milk alternatives are consumed (Van Winckel, 2017). One prospective cohort study, conducted over the course of 20 years among 30,000 participants found that compared with consumers of animal products, vegans were found to have statistically significant higher risks of total, hip, leg, and vertebral fractures, while vegetarians had higher risk of hip fractures. These increased risks were partly attributed to lower intake of calcium and protein (Tong et al, 2020) but may also be related to overall increased fracture rate in a population who may cycle and be more active as part of a lifestyle that includes a plant-based diet. More information is needed on the impact of calcium intakes from plant-based diets on the health of young children.

**Zinc**

Milk and milk products are the principal supplier of dietary zinc in the diets of young children in the UK, accounting for 35% of total intake. Liquid cows' milk provides 20% of dietary zinc in the diets of children 1.5-3yrs (PHE, 2020). Zinc from plant sources is less well absorbed than zinc from animal sources due to the presence of phytates, so it is important to make sure that children consuming plant-based diets have other foods rich in zinc on a daily basis.

**Iodine**

Young children in the UK obtain almost two thirds of their iodine intake from milk and milk products and liquid milk contributes 47% to the dietary intake of children 1.5-3yrs (PHE, 2020), which is enough to satisfy 85% of the reference nutrient intake (PHE 2016a). Substituting cows' milk with plant-based alternatives may not negatively impact children who include animal products in their diet as mean intake of iodine is 80% greater than the reference nutrient intake. However, the risk of poor iodine status is increased among those who follow an exclusively plant-based diet (Eveleigh et al, 2020; Sakkas, 2020). Only a few of the plant-based milks available in UK supermarkets currently are fortified with iodine, and a recommendation for mandatory fortification with iodine for products suitable for young children should be considered.

**Riboflavin**

Most children aged 1.5-3 years in the UK obtain more than half of their riboflavin from dairy products, and liquid cows' milks account for 38% of this (PHE, 2020). Not all plant-based milk alternatives are fortified with riboflavin so care should be taken when selecting a product. Riboflavin is typically included in most unsweetened calcium-fortified soya milk alternatives and 300ml a day of an unsweetened fortified soya milk alternative will provide around 80% of the daily riboflavin needs for a 1–4-year-old.

**Vitamin B12**

Vitamin B12 is found almost exclusively in animal products and the only good sources for children following a plant-based diet are foods that are fortified with vitamin B12. Most unsweetened fortified milk alternatives are fortified with vitamin B12 although they typically contain less than half of the comparable amount in cows' milk. The Mighty Pea M.LK is fortified with 0.94 micrograms/100ml.

Recommendations for the amount of vitamin B12 needed in fortified foods or as a supplement vary as the bioavailability of vitamin B12 varies by dietary source (Watanabe, 2007). As a prudent measure, The Vegan Society recommends that young children aged 1-4 years have about 1.5 micrograms a day from fortified foods or a supplement of 3 micrograms a day. 300-400ml of fortified unsweetened milk alternatives will generally provide adequate vitamin B12 (about 1.5 micrograms a day).

**Other potentially risks components**

The Committee on Toxicity (COT) have recently issued an overarching statement summarizing previous position statements on the safety of consumption of soya, almond and oat-based milk alternatives for young children aged 6 months to 5 years (COT, 2021). The overarching statement refers to the evidence outlined in previous discussion papers (COT, 2019; COT, 2020a; COT 2020b) and resulting position statements regarding the consumption of soya, almond and oat-based milk alternatives for young children.

**Soya-based milk alternatives contain phytoestrogens**

The principal concern related to the consumption of soya-based products in the diets of young children relates to the phytoestrogens present, and the potential irreversible impact these might have on the developing reproductive system. Milk alternatives derived from soya contain phytoestrogens, which have a similar chemical structure to oestrogen, a sex hormone responsible for the regulation and development of the female reproductive system and some secondary sex characteristics in both males and females (COT, 2003). The safety of phytoestrogens in infant formula and complementary foods was considered by COT in 2003 and 2013, and in 2021, the committee considered soya-based milk alternative consumption in children aged 6 months to 5 years (COT, 2021).

Phytoestrogens found in plant foods have been shown to produce oestrogenic activity since the 1940s when sheep grazing on phytoestrogen-rich clover experienced adverse effects on their fertility. Adverse effects in animal models are “well established” (COT, 2013) at exposure levels of 1.6-500 mg/kg bw/day (COT, 2003). The concentration of phytoestrogens, particularly in soy raised concerns that the adverse effects observed in animals could also occur in children who were fed soy-based infant formulae (phytoestrogens present in soya-based infant formula have been measured to range from 18-46.7 mg/L), especially given their relative exposure on a body weight basis, (approximately 4 mg/kg bw/day) (COT, 2003).

Since then, many invitro studies have examined the effects of different phytoestrogens on the biology of animals. Several studies identified by COT in their evidence review found evidence for the effect of phytoestrogens on sexual development and reproductive function in animals such as rats, rabbits and monkeys (COT, 2003). However, extrapolating this data from animal studies to clinical end points in humans, based on human dietary exposure, is problematic for many reasons. In addition, the pharmacokinetics of phytoestrogens have been shown to be affected by factors such as species, age, gender, diet, dose, route of administration and metabolism (COT, 2003; COT,2013). Many studies did not include details of dose related to body weight, which makes comparison to human dosing difficult. Additionally, many doses were administered subcutaneously,

bi-passing hepatic first metabolism and gastrointestinal metabolism, which have also been shown to have a major effect on the strength of biological phytoestrogen interactions.

In the initial review in 2003, COT noted that there have been no reports of adverse effects in human populations that have traditionally consumed soya and there remains limited data on children.

*"The main challenge in the assessment of the safety of these drinks is the lack of information regarding dietary intakes for children following dairy-free or plant-based diets"* **(**COT, 2021).

COT conducted dietary exposure modelling in infants related to soya-based formula (COT, 2013) and in complementary foods including soya-based milk alternatives in children up to 5 years (COT, 2019) based on consumption data from the UK Diet and Nutrition Survey of Infants and Young Children (DNSIYC) (Lennox et al, 2013) and from the NDNS rolling survey (PHE, 2020). It was assumed that all milk, yoghurt and cheese in the diets of children 18 months- 5 years were replaced by soya-based alternatives. However, it was noted that the phytoestrogen content of foods is also highly variable and exposure estimates for the purposes of toxicity evaluation are therefore subject to a high degree of uncertainty.

In 2021, COT reviewed exposure to isoflavones from soya-based milk alternatives. Using the same "uncertain" assumptions from the previous toxicity review in 2013 with additional assumptions to model chronic exposure, the committee found that exposure to phytoestrogens from the consumption of soya-based milk alternatives in children aged 6 months to 5 years was less than the exposure previously attributed to infants aged 0-6 months (9.5mg/kg bw per day), who were exclusively fed soya-based formula. On this basis, there was less concern, albeit that when all dietary sources of phytoestrogens were combined, exposures in children aged 6 months to 5 years were much closer to the level of 9.5mg/kg bw/day.

When considering potential toxicity of the phytoestrogens in soya-based milk alternatives COT have pointed to a fundamental lack of information regarding the dietary intakes of children following plant-based diets. Advice on soya consumption remains unchanged however, so soya-based milk alternatives for children above the age of 1 year are considered safe (COT, 2021).

**Almond-based milk alternatives may contain contaminants**

Most almond-based milk alternatives contain a small percentage of almonds (typically 2.5%) but there is evidence of contaminants in almonds such as aflatoxins, cyanide and cyanogenic glycosides. Animal studies have shown aflatoxins to be both genotoxic and carcinogenic and for this reason levels in the food supply are regulated and must be below maximum permitted levels. Potential risks associated with the consumption of almond-based milk alternatives in the diets of infants and young children was considered in a discussion paper by the Committee on Toxicity in 2020 (COT, 2020[a]) and a statement issued in 2021 (COT, 2021).

Aflatoxins may result from the fungal contamination of almonds under some storage and processing conditions. In the review of evidence, COT found no evidence of occurrence of aflatoxins in almond-based milk-alternatives and limited occurrence data for aflatoxins in nut samples.

An exposure assessment was conducted using aflatoxin concentrations that had been measured in nut samples and equated to1 litre of almond-based milk alternative containing 6% almond content in the base. There is scarce data in UK nutritional surveys on the consumption of almond drinks in children under five 5 years of age. Available consumption data for cows' milk was used as a proxy and it was assumed that all cows' milk would be replaced by almond-based milk alternative.

The Committee on Toxicity concluded that there was little available data on contaminants in almond-based milk alternatives and that daily intakes of contaminants were likely to be within safe levels. COT advise that almond-based milk alternatives may be safely consumed by children over the age of 1 year (COT, 2021).

**Oat-based milk alternatives may contain mycotoxins**

The Committee on Toxicity prepared a discussion paper on the health risk of potential mycotoxin contamination in oat-based milk alternatives for children below the age of 5 years (COT, 2020b). Mycotoxins are regularly found in oats and there is some concern that chronic exposure to mycotoxins from the consumption of oat-based milk alternatives may pose a health risk.

Under specific storage and processing conditions, oats are potentially vulnerable to fungal colonisation, which leads to the production of the T-2 mycotoxin. Mycotoxins are cytotoxic, can cause skin and mucosa erosions and the reduction of immune cells. Levels of contamination in the food supply are monitored against a set of standards within biological tolerance (based on kg/bw) of appreciable health risks, to ensure that exposures are at a safe level.

Using occurrence data from European harvested oats an exposure assessment for infants and young children was conducted for oat-based milk alternative. Assumptions on intake were based on animal milk intakes by young children in the Diet and Nutrition Survey of Infants and Young Children (Lennox et al, 2013) and data from the National Diet and Nutrition Survey (PHE, 2020). All estimates of acute exposure were below the acute reference dose and were not of toxicological concern. Estimates of high chronic exposure (97.5$^{th}$ percentile) however exceeded the tolerable daily intake in toddlers (aged 6 to 18 months) and young children (aged 18 months to5 years).

COT concluded that the risk of chronic exposure in children aged 6 months to 5 years was low and therefore oat-based milk alternatives may be safely consumed by children over the age of 1 year (COT, 2021).

**Paper prepared by Rachael Wall and Dr Helen Crawley. April 2021.**

# References


Agostoni, C., and Caroli, M. (2012). Role of fats in the first two years of life as related to later development of NCDs. *Nutrition, Metabolism and Cardiovascular Diseases*, 22(10), pp.775-780.

Barłowska, J., Szwajkowska, M., Litwińczuk, Z., and Król, J. (2011). Nutritional Value and Technological Suitability of Milk from Various Animal Species Used for Dairy Production. *Comprehensive Reviews in Food Science and Food Safety*, 10(6), pp.291-302.

Bath S et al, (2016). Iodine concentration of milk-alternative drinks available in the UK. *Proceedings of the Nutrition Society*; **75** (OCE3), E119

Biswas, S., Sircar, D., Mitra, A., and De, B. (2011). Phenolic constituents and antioxidant properties of some varieties of Indian rice. *Nutrition & Food Science*, 41(2), pp.123-135.

COT (2003) *Phytoestrogens and Health*. Available at: https://cot.food.gov.uk/sites/default/files/cot/phytoreport0503.pdf (Accessed 23 April 2021).

COT (2013) *Statement on the potential risks from high levels of soya phytoestrogens in the infant diet*. Available at: https://cot.food.gov.uk/sites/default/files/cot/cotstaphytos.pdf (Accessed 23 April 2021).

COT (2016) *Statement on potential risks from arsenic in the diet of infants aged 0 to 12 months and children aged 1 to 5 years*. Available at: https://cot.food.gov.uk/sites/default/files/finalstatementonarsenic_0.pdf (Accessed 23 April 2021).

Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (2019) *Discussion Paper on soya drink Consumption in children aged 6 months to 5 years of age.* (TOX2019/65) Available at: https://cot.food.gov.uk/sites/default/files/tox201965discussionpaperonsoyadrink_0.pdf (Accessed 23 April 2021).

Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (2020[a]) *Discussion Paper on the potential risks from almond drink Consumption in children aged 6 months to 5 years of age*. (TOX/2020/17) Available at: https://cot.food.gov.uk/sites/default/files/2020-08/TOX-2020-16%20Almond%20drinks%20first%20draft.doc_accesibleinadobepro_tobeuploaded.pdf (Accessed 23 April 2021).

Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (2020[b]) *Discussion Paper on the health risk of mycotoxin contamination in oat drinks for children aged 6 months to 5 years of age*. (TOX2020/03) Available at: https://cot.food.gov.uk/sites/default/files/tox202003oatdrinks.pdf (Accessed 23 April 2021).

Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (2021) *Overarching statement on consumption of plant-based drinks in children aged 6 months to 5 years of age.* (COT2021/01) Available at: https://cot.food.gov.uk/sites/default/files/2021-02/Overarching%20statement%20on%20consumption%20of%20plant-based%20drinks%20in%20children%20aged%206%20months%20to%205%20years%20of%20age_2.pdf (Accessed 23 April 2021).

Department of Health (1991) *Dietary Reference Values for Food Energy and Nutrients for the United Kingdom*. Report on Health and Social Subjects No. 41. London HMSO.

Department of Health (1994). *Weaning and the Weaning Diet*. Report on Health and Social Subjects No. 45. London: HMSO

Department of Health (2004). Chief Medical Officer's Update: Advice issued on soya-based infant formulas. CMO Update 37. 2004. Available at: http://www.second-opinions.co.uk/soy-online-service/04070176.pdf (Accessed 23 April 2021).

Deswal, A., Deora, N., and Mishra, H. (2014). Optimization of Enzymatic Production Process of Oat Milk Using Response Surface Methodology. *Food and Bioprocess Technology*, 7(2), pp.610-618.

Drewnowski, A., Mennella, J.A., Johnson, S.L., Bellisle, F. (2012). Sweetness and food preference. *Journal of Nutrition*, 142, 6, 1142-1148.

Eveleigh, E., Coneyworth, L., Avery, A., and Welham, S. (2020). Vegans, Vegetarians, and Omnivores: How Does Dietary Choice Influence Iodine Intake? A Systematic Review. *Nutrients*, 12(6), p.1606.

Fewtrell, M., Bronsky, J., Campoy, C., Domellöf, M., Embleton, N., Fidler, M. N., Hojsak, I., Hulst, J., Indrio, F., Lapillonne, A., and Molgaard, C. (2017). Complementary Feeding: A Position Paper by the European Society for Paediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN) Committee on Nutrition. *Journal of Pediatric Gastroenterology & Nutrition*, 64(1), pp.119-132.

Finglas, P.M., Roe, M.A., Pinchen, H.M., Berry,R., Church, S.M., Dodhia, S.K., Farron-Wilson, M. and Swan, G. (2015). *McCance and Widdowson's The Composition of Foods: Seventh Summary Edition*. Cambridge: Royal Society of Chemistry.

Food and Agriculture Organization of the United Nations (2013) *Report of an FAO Expert Consultation. Dietary protein quality evaluation in human nutrition*. Available at: http://www.fao.org/ag/humannutrition/35978-02317b979a686a57aa4593304ffc17f06.pdf (Accessed 23 April 2021).

Food and Agriculture Organization of the United Nations (2019) *Ultra-processed foods, diet quality, and health using the NOVA classification system*. Rome, FAO. (Accessed 23 April 2021)

Fukui, K., Tachibana, N., Wanezak,i S., Tsuzaki, S., Takamatsu, K., Yamamoto, T., Hashimoto, Y. and Shimoda, T. (2002). Isoflavone-Free Soy Protein Prepared by Column Chromatography Reduces Plasma Cholesterol in Rats. *Journal of Agricultural and Food Chemistry*, 50(20), pp.5717-5721.

Gorissen, S., Crombag, J., Senden, J., Waterval, W, Bierau J, Verdijk L and van Loon L (2018). Protein content and amino acid composition of commercially available plant-based protein isolates. *Amino Acids*, 50(12), pp.1685-1695.

Heaney, R., Dowell, M., Rafferty, K., and Bierman, J. (2000). Bioavailability of the calcium in fortified soy imitation milk, with some observations on method. *The American Journal of Clinical Nutrition*, 71(5), pp.1166-1169.

Heaney, R., Rafferty, K., Dowell, M., and Bierman, J. (2005). Calcium Fortification Systems Differ in Bioavailability. *Journal of the American Dietetic Association*, 105(5), pp.807-809.

Kantar (2020) *Veganism, flexitarianism, and the power of influencers. Available at:* https://www.kantar.com/uki/inspiration/consumer/veganism-flexitarianism-and-the-power-of-influencers/. (Accessed 23 April 2021).

Karjalainen, S., Soderling, E., Sewon, L., et al (2001). A prospective study on sucrose consumption, visible plaque and caries in children from 3 to 6 years of age. *Community Dentistry and Oral Epidemiology*, 29, 136-142.

Koletzko, B. (1999). Response to and range of acceptable fat intakes in infants and children. *European Journal of Clinical Nutrition*, 53(S1), pp.s78-s83.

Koletzko, B., Baker, S., Cleghorn, G., et al (2005). Global standard for the composition of infant formula: Recommendations of an ESPGHAN coordinated International Expert Group. *Journal of Pediatric Gastroenterology*, 41, 584-599.

Lennox, A., Sommerville, J., Ong, K., et al (eds) (2013). *Diet and Nutrition Survey of Infants and Young Children, 2011*. https:// www.gov.uk/government/publications/diet-and-nutritionsurvey- of-infants-and-young-children-2011

Mäkinen, O., Wanhalinna, V., Zannini, E., and Arendt, E. (2015). Foods for Special Dietary Needs: Non-dairy Plant-based Milk Substitutes and Fermented Dairy-type Products. *Critical Reviews in Food Science and Nutrition*, 56(3), pp.339-349.

McCarthy, K., Parker, M., Ameerally, A., Drake, S., and Drake, M. (2017). Drivers of choice for fluid milk versus plant-based alternatives: What are consumer perceptions of fluid milk? *Journal of Dairy Science*, 100(8), pp.6125-6138.

McClements, D J., Bai, L., & Chung, C. (2017) Recent advances in the utilization of natural emulsifiers to form and stabilize emulsions. *Annual Review of Food Science and Technology*, 8, 205–236.

Mintel (2019) *Milking The VeganTrend: A Quarter (23%) Of Brits Use Plant-Based Milk*. Available at: https://www.mintel.com/press-centre/food-and-drink/milking-the-vegan-trend-a-quarter-23-of-brits-use-plant-based-milk. (Accessed 23 April 2021).

NFU (2017) *The Future of Food*. Available at: https://www.nfuonline.com/nfu-online/news/the-future-of-food-2040/ (Accessed 23 April 2021).

NHS (2020) *What To Feed Young Children*. Available at: https://www.nhs.uk/conditions/baby/weaning-and-feeding/what-to-feed-young-children/ (Accessed 23 April 2021).

Nutraingredients (2019) Oatly challenged over 'no added sugars' claims on unsweetened oatmilk (foodnavigator-usa.com)

Omoni. A., and Aluko, R. (2005). Soybean Foods and Their Benefits: Potential Mechanisms of Action. *Nutrition Reviews*, 63(8), pp.272-283.

Public Health England (2016a) *Government Dietary Recommendations. Government Recommendations for Energy and Nutrients for males and females aged 1-18 years and 19+.* Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/618167/government_dietary_recommendations.pdf (Accessed 23 April 2021).

Public Health England (2016b). *Childhood Obesity. A Plan for Action*. Available at: https://www.gov.uk/government/publications/childhood-obesity-a-plan-for-action (Accessed 23 April 2021).

Public Health England (2020) National Diet and Nutrition Survey Rolling Programme years 9-11 Combined. Data Tables. Available at: https://www.gov.uk/government/statistics/ndns-results-from-years-9-to-11-2016-to-2017-and-2018-to-2019. (Accessed 23 April 2021).

SACN (2019) *Saturated Fats and Health*. Available at: https://www.gov.uk/government/publications/saturated-fats-and-health-sacn-report (Accessed 23 April 2021).

SACN (2015) *Carbohydrates and Health*. Available at: https://www.gov.uk/government/publications/sacn-carbohydrates-and-health-report (Accessed 23 April 2021).

Sakkas, H., Bozidis, P., Touzios, C., Kolios, D., Athanasiou, G., Athanasopoulou, E., Gerou, I., and Gartzonika, C. (2020). Nutritional Status and the Influence of the Vegan Diet on the Gut Microbiota and Human Health. *Medicina*, 56(2), p.88.

Scholz-Ahrens, K., Ahrens, F., and Barth, C. (2019) Nutritional and health attributes of milk and milk imitations. *European Journal of Nutrition*, 59(1), pp.19-34.

Sethi, S., Tyagi, S., and Anurag, R. (2016). Plant-based milk alternatives an emerging segment of functional beverages: a review. *Journal of Food Science and Technology*, 53(9), pp.3408-3423.

Singhal, S., Baker, R., and Baker, S. (2017). A Comparison of the Nutritional Value of Cow's Milk and Nondairy Beverages. *Journal of Pediatric Gastroenterology & Nutrition*, 64(5), pp.799-805.

Swan, G., Powell, N., Knowles, B., Bush, M., and Levy, L. (2018). A definition of free sugars for the UK. *Public Health Nutrition*, 21(9), pp.1636-1638.

Thandrayen, K. and Pettifor, J. (2018). The roles of vitamin D and dietary calcium in nutritional rickets. *Bone Reports*, 8, pp.81-89.

Tong, T., Appleby, P., Perez-Cornago, A ., and Key, T. (2020). Vegetarian diets and risks of total and site-specific fractures: results from the prospective EPIC-Oxford study. Proceedings of the Nutrition Society, 79(OCE2).

The Grocer (2020) *Online purchases, sales spikes and dairy alternatives: 10 charts explaining UK attitudes to dairy*. Available at: https://www.thegrocer.co.uk/trend-reports/online-purchases-sales-spikes-and-dairy-alternatives-10-charts-explaining-uk-attitudes-to-dairy/650157.article. (Accessed 23 April 2021).

The Vegan Society (2021) *Worldwide*:*Veganism in the UK*. Available at: https://www.vegansociety.com/news/media/statistics/worldwide. Accessed 23 April 2021

Vanga S and Raghavan V (2017). How well do plant based alternatives fare nutritionally compared to cow's milk? *Journal of Food Science and Technology*, 55(1), pp.10-20.

Van Winckel, M. (2017) *Vegetarian and vegan diets; pros and cons in infants, children and adolescents.* Presented at the Annual Meeting of the European Society for Paediatric Gastroenterology, Hepatology and Nutrition. Prague, Czech Republic, 11 May, 2017.

Verduci, E., D'Elios, S., Cerrato, L., Comberiati, P., Calvani, M., Palazzo, S., Martelli, A., Landi, M., Trikamjee, T. and Peroni,T. (2019). Cow's Milk Substitutes for Children: Nutritional Aspects of Milk from Different Mammalian Species, Special Formula and Plant-Based Beverages. *Nutrients*, 11(8), p.1739.

Vos, M.B., Kaar, J.L., Welsh, J.A., et al (2016). Added sugars and cardiovascular disease risk in children. A scientific statement from the American Heart Association. *Circulation*; **134**: 1-13.

Watanabe, F. (2007). Vitamin B12 sources and bioavailability. *Exp Biol Med*, **232**(10):1266-74.

WHO/FAO/UNU Expert Consultation (2007) *Protein and amino acid requirements in human nutrition.* WHO Tech Rep Ser 935:1–265.

Zhao, Y., Martin, B., and Weaver, C. (2005). Calcium Bioavailability of Calcium Carbonate Fortified Soymilk Is Equivalent to Cow's Milk in Young Women. *The Journal of Nutrition*, 135(10), pp.2379-2382.