PLANT BASED ALTERNATIVES

The environmental sustainability and health implications of plant-based proteins and plant-based meat alternatives

WWF

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GLOSSARY

Amazon Soy Moratorium
An agreement signed by actors across civil society, industry and government in 2006 to ensure that soy production in the Amazon region only occurs on existing converted agricultural land and not through deforestation of native vegetation.

Bioavailability
Bioavailability is the fraction of a nutrient in food that is absorbed and utilised.

CO2e
Carbon dioxide equivalent is a term used to describe the different greenhouse gases (carbon dioxide, methane, nitrous oxide, ozone) in a common unit.

Complete proteins
Complete proteins have all the essential amino acids our bodies need. Animal-based protein such as meat, poultry, fish, eggs, milk and cheese are considered complete proteins.

Conventional production systems (CAPS)
Conventional agriculture production systems (CAPS) can be defined as those cropping systems that are most commonly used for a given area that utilise synthetic agricultural chemicals (fertilisers and pesticides).

Deforestation
Deforestation, clearance, clearcutting or clearing is the removal of a forest or stand of trees from land that is then converted to non-forest use.

Energy loss
When energy is transformed from one form to another, or moved from one place to another, or from one system to another there is energy loss. This means that when energy is converted to a different form, some of the input energy is turned into a highly disordered form of energy, such as heat.

Environmental savings
Environmental savings are defined as savings in negative environmental impact. For the purposes of our research, we have used the following indicators to measure environmental savings: GHG emissions, habitat loss, energy use, land use, water use.

Essential amino acids
An essential amino acid, or indispensable amino acid, is an amino acid that cannot be synthesised from scratch by the organism fast enough to supply its demand and must therefore come from the diet.

Fortification
Fortification involves the addition of nutrients to foods irrespective of whether or not the nutrients were originally present in the food.

GHG
A greenhouse gas (GHG or GhG) is a gas that absorbs and emits radiant energy within the thermal infrared range, causing the greenhouse effect. The primary greenhouse gases in Earth's atmosphere are water vapour, carbon dioxide, methane and nitrous oxide.

GMO
GMO is the shorthand for 'genetically modified'. This refers to the process of altering the genes of a living thing.

Grass-fed
Grass-fed refers to beef that comes from cattle that have primarily grazed on grass throughout the course of their lives. This is unlike the more common 'grain-fed beef' that you find in supermarkets; beef from cows that eat solely grain-based feeds composed of soy or corn.

Habitat loss
Habitat loss is the process by which a natural habitat becomes incapable of supporting its native species.

HFSS
Used for UK advertising to ascertain whether a product is overall 'High in Fat, Salt, Sugar'.

Land use change
The process, whereby a specific area of land is converted from one use to another – including from 'wild' to human-centric uses. This describes the immediate, local, cause of the change (e.g. cropland replacing grassland).

LCA
Life cycle assessment or LCA is a methodology for assessing environmental impacts associated with all the stages of the life cycle of a commercial product, process, or service

Macronutrients
Macronutrients are the nutrients we need in larger quantities that provide us with energy: in other words, fat, protein and carbohydrate.

Mass balance (palm oil)
System where sustainable palm oil from certified sources is mixed with ordinary palm oil throughout supply chain.

Micronutrients
Micronutrients are mostly vitamins and minerals and are equally important but consumed in very small amounts.

Monoculture farming
Monoculture farming is a form of agriculture that is based on growing only one type of a crop at one time on a specific field.

Mycoprotein
Mycoprotein is a protein made from Fusarium venenatum, a naturally occurring fungus.

Nitrogen-fixing crops
Nitrogen-fixing plants are those whose roots are colonised by certain bacteria that extract nitrogen from the air and convert or 'fix' it into a form required for their growth.

NOVA
The NOVA classification assigns a group to food products based on how much processing they have been through:

- Group 1 – Unprocessed or minimally processed foods
- Group 2 – Processed culinary ingredients
- Group 3 – Processed foods
- Group 4 – Ultra-processed food and drink products

Organic livestock system
Organic farming is based on closed agricultural systems and minimal use of non-renewable energy sources (e.g. artificial fertilisers)

Overgrazing
Overgrazing occurs when plants are exposed to intensive grazing for extended periods of time, or without sufficient recovery periods. It can be caused by either livestock in poorly managed agricultural applications, game reserves, or nature reserves.

Phytosterols
Phytosterols are phytosteroids, similar to cholesterol, that serve as structural components of biological membranes of plants.

Plant based alternatives
Meat substitutes in a plant-based diet.

Soil erosion
Soil erosion is the displacement of the upper layer of soil; it is a form of soil degradation.

Soy/pea protein concentrates
Soy/pea protein concentrate is about 70% protein and is defatted soy/pea flour without the water-soluble carbohydrates.

Soy/pea protein isolate
Soy/pea protein isolate is a highly refined or purified form of soy/pea protein with a minimum protein content of 90% on a moisture-free basis. It is made from defatted soy/pea flour which has had most of the non-protein components, fats and carbohydrates removed.

Soy/pea protein textures
Also known as textured soy/pea protein, soy meat, or soya chunks, is a defatted soy/pea flour product.

Sustainability
Sustainability focuses on meeting the needs of the present without compromising the ability of future generations to meet their needs.

Water use
Water use refers to water actually used by end users (e.g. households, services, agriculture, industry) within a territory for a specific purpose such as domestic use, irrigation or industrial processing.

Whole foods
Whole foods are foods that are either not processed at all or processed minimally.

PRODUCT ENVIRONMENTAL IMPACT

SUMMARY

- Highest water, GHG emissions and land savings are gained by substituting beef and pork.
- Overall, habitat loss impacts are much lower and less wide-ranging for plant-based products compared with the equivalent animal-based products.
- Data gaps exist which, in some cases, challenge the direct comparison between plant-based protein alternatives and meat equivalents. This was particularly apparent for chicken substitute products and product energy use.

METHODS

The five best-selling plant-based protein alternative products were selected to compare the environmental impacts against their animal-based protein equivalents. Products were selected to cover a range of commodity ingredients and meat products, which they are designed to mimic, and for availability across major Sodexo markets. This research therefore provides an insight into the basis of these specific five products and ingredients and is not a complete comparison of all the plant-based alternative products and ingredients that are available.

Table 1.
Overview of product categories, primary and secondary ingredients, and key markets

Product categories	Branded product	Primary plant protein ingredient	Secondary ingredient	Major markets with confirmed product availability
Plant-based milk alternative	Alpro	Water	Almond	UK, Ireland, France, Italy
Sausages	Quorn	Mycoprotein	Rapeseed, palm oil	US, UK, Ireland, France, Italy
Burger	Beyond Burger	Pea	Rapeseed, coconut oil	US, Canada, UK, France, Italy
Meatballs	Future Farm	Chickpea	Coconut oil	US, Canada, UK, France, Italy, Brazil
Chicken	Vegetarian Butcher	Soy	n/a	US, Canada, UK, Ireland, France, Italy, Brazil
Minimally processed wholefoods	n/a	Soy, chickpea, pea, lentil, almond	n/a	

Where information was available, direct comparisons were made on a product's GHG emissions, water use, land use, impact on habitat loss, and energy use. Information was collected from a combination of Life Cycle Assessments (LCAs) within academic literature, and information available on company websites.

The environmental impacts of an animal-based protein product can vary significantly, depending on production system and location. For each animal-based protein product where mainstream production systems can vary significantly, such as with chicken and dairy, two contrasting environmental impact figures were given from each production system.

Some data gaps existed which limited the extent to which plant-based protein alternatives can be compared directly with equivalent meat products. Quorn, for example, has analysed the environmental footprint of many of their products, but has not yet released findings for sausages. Therefore, this study looked at data for mycoprotein, the plant-based protein that accounts for 41% of the Quorn recipe and compared this with pork. No studies were found detailing the environmental impact of Future Farm meatball products, or What the Cluck chicken. To counter this, we compared the environmental impacts of a pea-protein based meatballs, and, for chicken, we calculated the GHG emissions for soy protein isolate, which is the majority ingredient in What the Cluck chicken.

RESEARCH FINDINGS

The substitution of European pork with mycoprotein, US conventional beef with Beyond Burgers, and Brazilian meatballs with pea-based meatballs, offered very high levels of GHG savings. These substitutions reduce product GHG emissions by 81%, 89% and 89% respectively. This is an unsurprising finding, given the land use change associated with cattle grazing and soy-feed for cows. Savings from substituting dairy milk for almond drink are more modest but still significant, with savings of 43–47%, depending on the production system. Similarly, substituting chicken with What the Cluck chicken resulted in savings of 48–64% of GHG emissions.

Water use reduction was most dramatic when comparing conventional US beef to Beyond Burgers, where 99% of water use is saved from a substitution – the equivalent of 217 litres per burger. Pork substitution with mycoprotein also offered significant savings, at 87% or 5,219 litres per kg.

Substituting Brazilian beef meatballs with pea-based meatballs offered the highest percentage land saving, at 97%. Substituting conventional US beef substitution with Beyond Burgers also offered large savings on land use, with savings of 85%, or 3.5 m2 per burger. This is unsurprising given that beef production requires very large quantities of land.

Pork substitution with mycoprotein also reduced land use by 85%. Large land savings with mycoprotein are also unsurprising, given that mycoprotein is industrially produced in large containers.

Habitat loss is an issue within all livestock production systems, although some organic livestock systems do mitigate this risk to a large extent. Within plant-based protein alternatives, mycoprotein is the only product with no significant impacts on land use change and, therefore, habitat loss, given it is produced and manufactured within factories. All other plant-based ingredients are likely to have some impact on local habitat loss, whether it be through monocrop farming, fertiliser use or land use change. However, these impacts are much lower and less wide-ranging compared with the equivalent animal-based protein products.

For many plant-based products, information was not available on energy use, leaving significant data gaps. However, for those products where information was available, the picture is mixed. For example, Beyond Burgers offer an energy saving of 46% compared with conventional US burgers; however, for almond drink, energy use is either matched or higher than the animal-based protein equivalent.

Table 2.
Almond drink comparison[1,2]

	Almond drink*	Conventional dairy (FPCM)	Organic dairy (FPCM)	Almond drink savings against conventional dairy	Almond drink savings for organic dairy
GHG emissions	0.8kg CO_2e per kg	1.4kg CO_2e per kg	1.5kg CO_2e per kg	-43%*** (0.6kg CO_2e per kg)	-47% (0.7kg CO_2e per kg)
Water use	200–700 litres per kg	781 litres per kg	935 litres per kg**	-10 to -74% (81–581 litres per kg)	-25 to -79% (235–735 litres per kg)
Land use	0.1–0.9m2 per kg	1.3m2 per kg	1.8m2 per kg	- 31 to -92% (0.4–1.2m2 per kg)	-27 to -94% 0.5–1.7m2 per kg)
Habitat loss	High mortality of imported honey bees for pollination, which also threatens native bee species. Monoculture farming and high fertiliser use threatens local species.	Soy and palm in feed linked to deforestation and land use change. Degradation of local water resources from manure. Overgrazing and soil erosion from hooves.	Similar types of impacts to conventional dairy, but to a much lower extent due to the standard's stipulation of majority grass fed and organic feed diet.	Although habitat losses are incurred from almond drink production, these are less pervasive than conventional dairy.	Difficult to compare directly. There is likely some degree of habitat loss from each.
Energy demand	5MJ per kg	3.1MJ per kg	5MJ per kg	No savings	No savings

* This is an approximation based on the ingredient profile for an almond drink consumed in Sweden.

** Brazilian production system – studies for water use of organic Dutch milk not available for direct comparison. For further comparison, Brazilian conventional milk used 785 litres per kg.

*** Green numbers indicate savings in environmental impact of plant-based products compared to animal-based products. E.g., -10-74% means there was a range of reduction between 10% up to 74%.
Red indicates no savings or savings.

1 Potter, H.K., et al. (2020). Environmental impact of plant-based foods – data collection for the development of a consumer guide for plant-based foods. https://pub.epsilon.slu.se/17699/1/Report112.pdf (accessed 30/6/2021)

2 Thomassen, M.A., et al. (2008). Life cycle assessment of conventional and organic milk production in the Netherlands. http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=877842968193E1B2F0E19583A18DE56D?doi=10.1.1.460.5507&rep=rep1&type=pdf (accessed 30/6/2021)

Table 3.
Vegetarian sausages comparison[3]

	Quorn vegetarian sausages*	European Pork**	Vegetarian sausage savings against pork
GHG emissions	1.6kg CO_2e per kg	8.3kg CO_2e per kg	-81%*** (6.7kg CO_2e per kg)
Water use	776 litres per kg (539 green, 35 blue, 202 grey)	5,995 litres per kg (5,070 green, 416 blue, 509 grey)	87% (-89% green, -92% blue, -60% grey) (5,219 litres per kg: 4,531 green, 381 blue, 307 grey)
Land use	1.8m2 per kg	12m2 per kg	-85% (10.2m2 per kg)
Habitat loss	N/a – mycoprotein is industrially produced	Soy in pork feed is associated with deforestation and land use change in South America. Mismanagement of manure is associated with local water degradation.	Pork production is one of the largest consumers of soy from South America, a hot spot for deforestation. Mycoprotein substitution mitigates this risk.

*Comparison with mycoprotein, key 'pork' ingredient, not whole sausage, for which information was unavailable.

**Comparison is with pork (N.B. not pork sausages) from typical European housed farming.

*** Green numbers indicate savings in environmental impact of plant-based products compared to animal-based products. E.g., -85% means there was a range of reduction of 85%.

3 Hsu, K., et al. (2018). Quorn footprint comparison report. https://www.quorn.co.uk/assets/files/content/Carbon-Trust-Comparison-Report-2018.pdf (accessed 30/6/2021)

Table 4.
Vegan burger comparison[4]

	Beyond Burger	US conventional burger*	Beyond Burger savings against beef burger
GHG emissions	0.4kg CO_2e per burger	3.7kg CO_2e per burger	-89%** (3.3kg CO_2e per burger)
Water use	1.1 litres per burger	218.4 litre per burger	-99% (217.3 litre per burger)
Land use	0.3m2 per burger	3.8m2 per burger	-92% (3.5m2 per burger)
Habitat loss	No direct links found relating habitat loss to the production of ingredients. Small quantities of coconut oil could be associated with deforestation in South East Asia.	Soy and palm in animal feed is linked to deforestation and land use change. Possible degradation of local water resources from manure. Soil erosion from hooves and overgrazing.	Significant savings of habitat loss from plant-based substitution.
Energy demand	6.1MJ per burger	11.4MJ per burger	-46% (5.3MJ per burger)

*Beyond Burgers only publish an LCA that is compared with conventional US beef, the company does not give figures for organic/grass fed comparisons.

** Green numbers indicate savings in environmental impact of plant-based products compared to animal-based products. E.g., -10-74% means there was a range of reduction between 10% up to 74%. Red indicates no savings or savings.

4 Heller, M.C., Keoleian, G.A. (2018). Beyond Meat's Beyond Burger Life Cycle Assessment: A detailed comparison between a plant-based and an animal-based protein source. https://css.umich.edu/sites/default/files/publication/CSS18-10.pdf (accessed 30/6/2021)

Table 5.
Vegan meatball comparison[5]

	Pea protein-based meatball	Brazilian beef meatballs	Irish beef meatballs	Pea-protein meatball savings against Brazilian meatballs	Pea-protein meatball savings against Irish meatballs
GHG emissions	0.5kg CO_2e per 100g	4.6kg CO_2e per 100g	3.3kg CO_2e per 100g	-89%*** (4.1kg CO_2e per 100g)	-84% (2.8kg CO_2e per 100g)-
Water use	270 litres per 100g	430 litres per 100g	1,030 litres per 100g	-59% (160 litres per 100g)	74% (760 litres per 100g)
Land use	38 'points'** per 100g	1186 'points'** per 100g	354 'points'** per 100g	-97% (1,148 'points'** per 100g)	-88% (316 'points'** per 100g)
Habitat loss	Pea production is not associated with significant environmental issues or habitat loss.	Cattle grazing, and soy feed is a major cause of deforestation and land use change. Possible degradation of local water resources from manure. Soil erosion from hooves and overgrazing.	Depends on production methods, but soy and in feed is linked to deforestation and land use change. Possible degradation of local water resources from manure. Soil erosion from hooves and overgrazing.	Very significant reduction in risk to habitat loss.	Reduction in risk to habitat loss
Energy use	8.6MJ per 100g	19.8MJ per 100g	15.4MJ per 100g -	56% (11.2MJ per 100g)	-44% (6.8MJ per 100g)

*No information was found on the environmental impact of Future Farm Meatballs or textured soy protein – their primary protein ingredient. They do contain, however, protein from peas and chickpeas and therefore are the next best option for comparison in the literature with meatballs made from pea protein.

** Authors are not clear on how land use 'points' are calculated, and therefore, we were not able to translate back to a land equivalent.

*** Green numbers indicate savings in environmental impact of plant-based products compared to animal-based products.

5 Saget, C., et al. (2021). Substitution of beef with pea protein reduces the environmental footprint of meat balls while supporting health and climate stabilisation goals. Journal of Cleaner Production, 297:126447. doi: https://reader.elsevier.com/reader/sd/pii/S0959652621006673?token=B279B02FD765BCA370E9FE734BF7CD52345FC801182AE68F97F30D43FBE4AD2B6A0969C75FEA3126130670B751C3A3D6&originRegion=eu-west-1&originCreation=20210610150941 (accessed 30/6/2021)

Table 6.
Vegan chicken pieces comparison[6,7,8,9]

	What the Cluck chicken*	Conventional chicken***	Organic chicken***	Vegan chicken savings against conventional chicken	Vegan chicken savings against organic chicken
GHG emissions	0.99kg CO_2e per kg**	1.89–2.38kg CO_2e per kg	2.86kg CO_2e per kg	-48- 59%*** (0.9-1.4kg CO_2e per kg)	-64% (1.9kg CO_2e per kg)
Water use	Unclear****	96–127 litres per kg	2.34 litres per kg	Unclear	Unclear
Habitat loss	Much lower likelihood that soy for direct human consumption is linked to deforestation and land use change, as it is in livestock feed. See section on soy sustainable sourcing.	Soy in feed linked to deforestation and land use change in South America. Pollution of waterways from manure.	Soy in feed can be linked to deforestation and land use change in South America. Pollution of waterways from manure.	Very significant reduction in risk of deforestation and land use change in South American countries from soy.	Still some reduction in risk since organic chickens can be fed with soy linked to deforestation and land use change in South America.
Energy use	*Data not available for establishing energy use for soy protein concentrate.*	14.7-20.4MJ per kg	12.8MJ per kg	Unclear	Unclear

* Since the commissioning of this report, What the Cluck chicken pieces has reformulated the product to address issues with salt levels https://www.tesco.com/groceries/en-GB/products/303350536 (accessed 06/04/2022)

** Figures cover only soy protein concentrate, which accounts for 88% of What the Cluck chicken ingredients. Assumes soy is sourced from Canada, but company sourcing geographies are not clear. Canadian CO_2e per kg of soybean is higher than other non-South American producing countries, such as the US, Italy, China and Ukraine, and can therefore be considered the upper limit, and figure is likely to present the minimum possible CO2e savings.

*** Figures are whole carcass weight chicken.

*** Green numbers indicate savings in environmental impact of plant-based products compared to animal-based products.

**** Data not available for converting water footprint to soy protein concentrate.

6 Wiedemann, S., et al. (2012). Using life cycle assessment to quantify the environmental impact of chicken meat production. Australian Government Rural Industries Research and Development Corporation. https://www.agrifutures.com.au/wp-content/uploads/publications/12-029.pdf (accessed 30/6/2021)

7 Blonk Consultants. (2020). The environmental footprint of soy: life cycle assessment. https://www.proterrafoundation.org/news/information-sharing-environmental-footprint-of-soy-life-cycle-assessment-lca/ (accessed 30/6/2021)

8 RTRS. 2020. Technical supporting document. https://issuu.com/rtrs/docs/rtrs_calculadora_eng_?fr=sOWUyYjM5MDM2MDc (accessed 15/03/2022)

9 Kroes, H., Kuepper, B. (2015). Mapping the soy supply chain in Europe. http://d2ouvy59p0dg6k.cloudfront.net/downloads/mapping_soy_supply_chain_europe_wwf_2015.pdf (accessed 30/6/2021)

ASSESSMENT OF SUSTAINABLE SOURCING OF INGREDIENTS

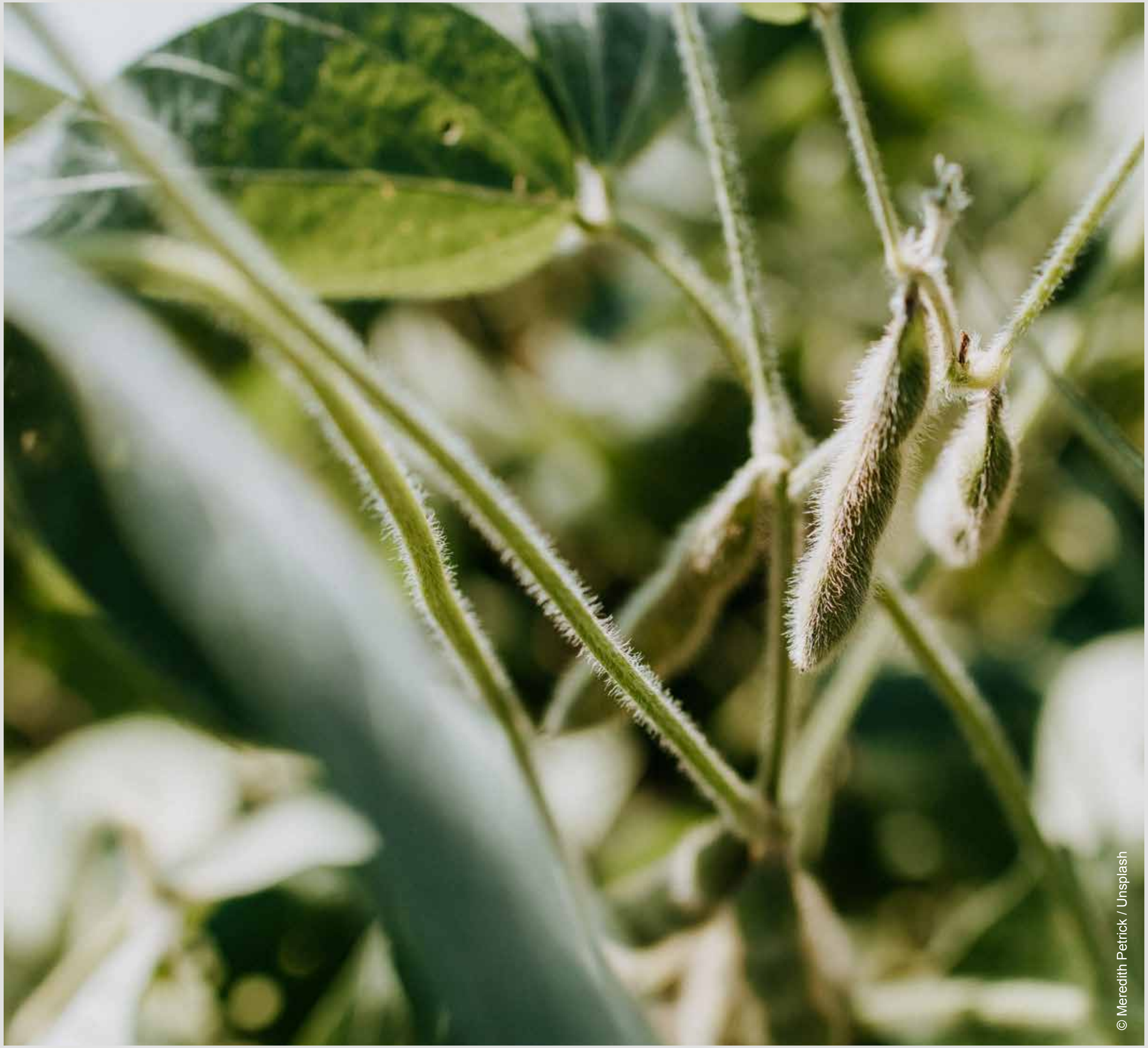
OVERVIEW

Six key ingredients commonly used in plant-based protein alternatives were selected by WWF for further analysis. The research examined the likely provenance for key markets, and key sustainable sourcing issues – such as deforestation. Five of these ingredients – almonds, lentils, chickpeas, soy and peas – are agricultural crops, while mycoprotein, an industrial product, was also included due to its usage in Quorn products. Overall, each of these products is fairly low-risk in terms of environmental and social issues and is available with organic certification in most markets identified for this report, although thereare some potential environmental issues associated with soy and almond production.

Table 7.
Domestic production and key sourcing regions for soy in markets.*

Key market	Domestic production	Key sourcing regions
UK and Ireland	There is no significant production of soybeans in the UK or Ireland.	Argentina (1.51m tonnes), Brazil (0.97m tonnes), North America (0.50m tonnes), Paraguay (0.28m tonnes) and China (0.09m tonnes) are the largest importers of soy into the UK.[10]
North America	The US is the second largest producer in the world, growing 96.8m tonnes of soybeans in 2019.[11]	Most consumption is domestic production. Canada (1.8m tonnes), India (1.6m tonnes) and Argentina (0.4m tonnes) also import some volumes into the USA.
France	France produced 0.43m tonnes of soybeans in 2019.	Brazil (4.98m tonnes), USA (0.38m tonnes), Argentina (0.47m tonnes) and Belgium (0.79m tonnes) are the most significant importers of soybeans into France. It is likely that soy imported from Belgium was grown in another country.
Brazil	Brazil is the largest soybean producer in the world, growing 114.2m tonnes of soybeans in 2019. Most consumption is domestic.	Paraguay (0.24m tonnes) and Argentina (0.76m tonnes) are the only significant importers of soybeans into Brazil.
Australia	0.02m tonnes of soybeans produced in 2019.	Argentina (1.87 million tonnes) is the only significant importer of soybeans into Australia.

10 EFECA. (n.d.) UK RT on sustainable soy. https://www.efeca.com/wp-content/uploads/2020/10/UK-RT-on-Sustainable-Soy-APR-19_20-final.pdf (accessed 30/06/2022)
11 2019 data from FAOSTAT https://www.fao.org/faostat/en/#home (accessed 30/06/022)



SOY

A highly efficient source of protein, soy is commonly used in both animalfeed and as a meat-alternative for human consumption. It can be bought in its basic form as a 'soy mince' or in processed products such as 'Future Meatballs' and 'What the Cluck chicken'. Processed products commonly use soy protein isolate or soy protein concentrate, which are produced by removing the fat and hull from soybean meal. While the use of soy in meat-alternatives has been controversial, due to links between soy production and deforestation, over 75% of the global soy output is used in animal feed, with the remaining 25% including soy used for human consumption (as whole soybeans, soybean oil or soybean meal) and also soy used in biofuels or in other industrial purposes. The soy used for direct human consumption is unlikely to have links to deforestation or conversion, especially if certified soy is used.

KEY SOURCING REGIONS

Data is available for soy imports by country, but this is based on total soy usage (including usage of animal feed) so may not be reflective of usage in plant-based products. While some regions, including Europe, import high volumes of genetically modified soy from South America, this is typically used in animal feed, and usage of GMO soy in food for human consumption is not widespread due to both EU restrictions and consumer reluctance to accept GMO foods.[13] Soy in meat-alternatives is therefore likely to be sourced from regions specialising in non-GMO production, including China, India, Canada and Europe.

KEY SOURCING ISSUES DEFORESTATION AND LAND RIGHTS

Soy is a key driver of deforestation and conversion of other natural ecosystems in South America, where land is converted into pasture for cattle grazing before being replaced by intensive soy plantations, driving cattle production elsewhere and fuelling further land conversion. While the Amazon Soy Moratorium has been effective in preventing further deforestation in the Amazon from 2008, the deforestation frontier has now shifted to parts of the highly biodiverse Cerrado region, as well as valuable areas of Paraguay and Argentina, such as the Atlantic Forest and Chaco. In Brazil, the Bolsonaro administration, elected in 2018, has threatened the ability of the environmental agency to enforce existing Forest Law. As a result, deforestation linked to soy has risen, along with associated displacement of indigenous groups and human rights abuses.[13]

However, the link between soy and deforestation primarily relates to soy used in animal feed. There are three reasons to believe that soy used in protein alternatives for human consumption is unlikely to be linked to deforestation.

1. Soy for human consumption within the EU and UK is likely to be non-GMO. Non-GMO soy is likely to be sourced from regions outside of South America and deforestation/ conversion fronts where soy production is expanding, such as in North America's Great Plains.
2. Soy for human consumption is likely to be certified to a standard that guarantees zero-deforestation, or significantly reduces the risk of deforestation. Some of these standards, such as ProTerra, also guarantee that the soy is non-GMO and so are commonly used in food products. See Certification for further information on certification standards used.
3. Soy in food products is commonly in the form of Soy Protein Concentrate. Three key manufacturers of Soy Protein Concentrate – CJ Selecta, Caramuru and Imcopa – all set a cut-off date of 2020 for deforestation in their supply chains.[14] This means that any products sourced from these companies will not be sourced from land that has been converted after August 2020. Caramuru is particularly active in Brazil and sells soy protein products under the Sinhá brand. It is not, however, clear to what extent these companies are supplying soy protein concentrate to manufacturers of food for human consumption.

BIODIVERSITY AND PESTICIDE USAGE

Soybeans are typically grown in monocultures and cultivation often involves the usage of chemical inputs, many of which can be toxic to fish, bees and other wildlife.[15] These issues apply regardless of the country of origin of soybeans, including the US where drinking water in areas associated with soybean cultivation has been polluted by agricultural run-off chemicals.[16] However, pesticide usage is a particular issue in Brazil, where many pesticides that are banned in other countries are still permitted in Brazil.[17] There has been little action to date addressing the issue of pesticide usage, and no major soy trader has a commitment on pesticide usage, which applies across the whole supply chain (i.e. including non-certified supply).[18]

CERTIFICATION

Soy certification is widely used in soy food products, whether to prove evidence of non-GMO or wider sustainability criteria. Unlike other plant-based protein alternatives, there is a wide range of certification schemes to choose from for certified soy. The table below evaluates different types of certification that are available.

13 European Commission. (n.d.) GMO Legislation. https://ec.europa.eu/food/plants/genetically-modified-organisms/gmo-legislation_en (accessed 15/03/2022
14 Proterra Foundation. (2021). An initiative to achieve deforestation-free supply chains from Brazil. https://www.proterrafoundation.org/news/an-initiative-to-achieve-100-percent-deforestation-free-supply-chains-from-brazil/ (accessed 30/06/2022)
15 Kansas State University. (n.d.) Insecticides commonly used on soybeans. https://entomology.k-state.edu/extension/insect-information/crop-pests/soybeans/insecticides.html (accessed 30/06/2022)
16 EPA (2020)
17 Gonzales, J. (2019). Bolsonaro administration approves 290 new pesticide products for use. https://news.mongabay.com/2019/08/bolsonaro-administration-approves-290-new-pesticide-products-for-use/ (accessed 30/06/2022)
18 Soy Transparency Coalition, 3Keel. (2020) Soy Transparency Coalition 2020 Trader Assessment. https://soytransparency.org/wp-content/uploads/2021/04/STC-2020-report-public-final.pdf (accessed 30/06/2022)

Table 8.
Available soy certifications.

Certification type	Availability in plant-based food products	Effectiveness in addressing deforestation	Effectiveness in addressing other issues (for example, pesticides)	Cost implications
RTRS (Round Table on Responsible Soy) - Credits	E.g. Co-op[19] and Tesco – all soy is covered by RTRS credits.	RTRS certification makes up 1% of global soy production. Cut-off date is 2009. Inherent in this certification type is the presence of non-certified materials, and so it does not guarantee deforestation-free materials. Credits are not a chain of custody model of certification – the end product contains no known certified soy, or an equivalent volume that has been controlled, and there is no physical traceability through the supply chain. Credits do not provide any guarantee that the physical volumes of soy used are free of deforestation/conversion or other environmental/social risks.	RTRS includes some but not all protection against pesticides.[20] It also includes some protections of indigenous community rights including Free, Prior and Informed Consent.	1 credit = 1 tonne of soy. The premium of RTRS soy (around 0.5% of the soy price)
RTRS (Round Table on Responsible Soy) – Mass balance	Information not publicly available.	Cut-off date is 2009. Inherent to this certification type is the presence of non-certified materials, and so, it may not guarantee deforestation-free materials. Under a mass balance system, the physical mixing of certified and non-certified soy is allowed at any stage, provided that the quantities are controlled in documentation. Purchasing a certain volume of mass balance-certified soy does not guarantee that this entire volume is free of deforestation/conversion or other environmental/social risks.	RTRS includes some but not all protection against pesticides. It also includes some protections of indigenous community rights including Free, Prior and Informed Consent.	The premium of RTRS soy (around 0.5% of the soy price)

19 Coop. (n.d.) Our soy commitment. https://www.coop.co.uk/sustainability/responsible-sourcing/soy-commitment (accessed 30/06/2022)

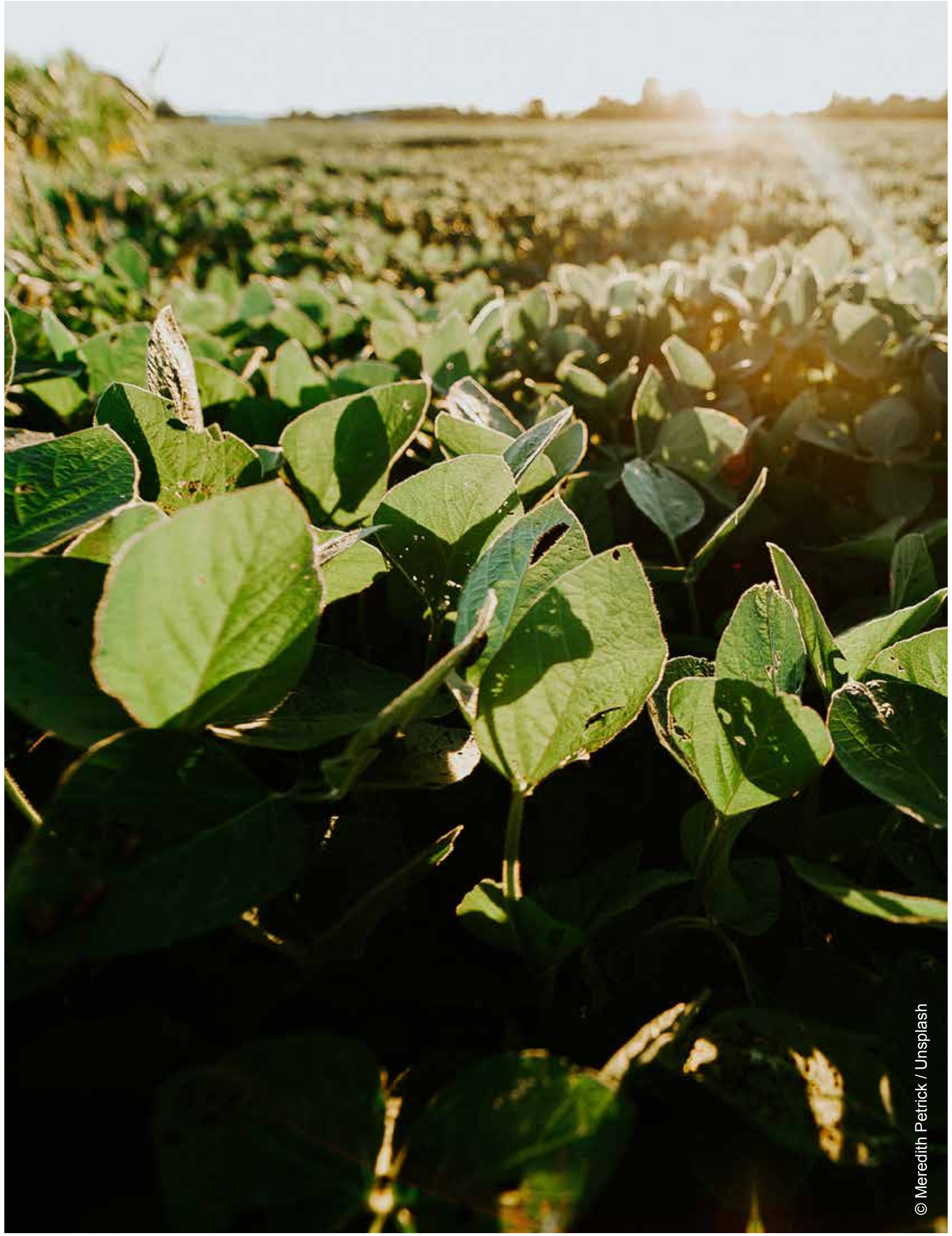
20 RTRS Standards for Responsible Soy. (2017). RTRS Standard for Responsible Soy production version 3.1. https://responsiblesoy.org/wp-content/uploads/2019/08/RTRS%20Standard%20Responsible%20Soy%20production%20V3.1%20ING-LOW.pdf (accessed 30/06/2022)

Certification type	Availability in plant-based food products	Effectiveness in addressing deforestation	Effectiveness in addressing other issues (for example, pesticides)	Cost implications
ProTerra – Segregation or Identity Preservation	All non-GMO soy protein concentrate sold by CJ Selecta, Caramuru or Imcopa is ProTerra certified.	ProTerra meets the minimum level for forests, wetlands and biodiversity protection. Emphasis is on the on-GMO, nature of the certification scheme.	Non-GMO. ProTerra maintains policies on human rights, good agricultural practices, continuous efforts to reduce the use of fertilisers and pesticides and supports high conservation values.	Information not publicly available
Donau Soja	Information not publicly available.	Produced in Europe and therefore, do not contribute directly towards deforestation.	GMO-free	Information not publicly available
Organic	Wide availability	The certification criteria recommended by the International Federation of Organic Agriculture Movements (IFOAM) specify that organic farms should not be established on 'land that has been obtained by clearing of High Conservation Value Areas in the preceding 5 years', but fail to elaborate how these areas should be identified, by whom, and how compliance is audited (Source: Cambridge Conservation Initiative).	The principal guidelines for organic production are to use materials and practices that enhance the ecological balance of natural systems and that integrate the parts of the farming system into an ecological whole (for example, not using GMO, synthetic pesticides, etc).	Information not publicly available

Profundo has created a benchmark for different certification systems, which rate them on level of assurance and forests, wetlands and biodiversity protection. In their analysis, RTRS certification was judged as one of the most effective types of certifications, and ProTerra, Europe/Donau Soja, CRS also meet the minimum level for forests, wetlands and biodiversity protection.

The International Trade Centre's Standards Map identifies seven sustainability standards that can apply to soy and that are aligned with the 2021 FEFAC Sustainable Sourcing Guidelines, including the desired criterion 34 of the FEFAC Guidelines pertaining to no conversion: RTRS, ProTerra, Donau Soy, Europe Soy, Sustainable Farming Assurance Programme, CRS (Cefetra Certified Responsible Soya Standard) and Cargill Triple S. The indicators covered in each of these standards vary, as well as their level of stringency. WWF encourages companies who (in addition to a robust conversion-free strategy) wish to purchase certified materials to consider these carefully. In addition, it is important to note that within each standard, several stringent chain of custody models are available. These models greatly vary in their ability to provide environmental and social guarantees on the physical volumes of soy produced, traded or purchased (book and claim credits and mass balance systems in particular do not provide enough guarantees that the physical volumes of soy used are free of deforestation, conversion or other environmental and social risks).

RTRS or ProTerra segregated or identity-preserved certification standards are the most suitable certification schemes for plant-based products when sourcing from regions at risk of deforestation, based on their availability within typical plant-based products, their commitments against deforestation, and their wider reputation within the industry. For soy sourced from areas at low risk of deforestation (i.e. outside of South America), Organic certification may be preferable as it addresses other environmental issues with soy production. WWF encourages companies sourcing soy to adopt robust Accountability Framework-aligned conversion-free commitments with a clear cut-off date of 2020 at the latest, with a robust monitoring and verification system, and that they require their suppliers to adopt aligned commitments as well.



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PEAS

Peas are increasingly being used as an alternative ingredient for both meat and dairy products, including the Beyond Burger.[21] The adoption of peas by Cargill[22] is testament to its growing popularity across global markets, and it is reasonable to expect a larger number of protein alternative products to use pea protein in the future. Whether used for dairy or meat alternatives, peas are commonly used in the form of pea protein isolate. This can be produced by green peas or yellow split peas, depending on the purpose and region.

21 Beyond Meat. (n.d.) https://www.beyondmeat.com/products/the-beyond-burger/ (accessed 30/06/2022)

22 Food Ingredients. (2020). Cargill scales up European plant-based portfolio with pea protein addition, https://www.foodingredientsfirst.com/news/cargill-scales-up-european-plant-based-portfolio-with-pea-protein-addition.html (accessed 30/06/2022)

KEY SOURCING REGIONS

Peas are commonly grown and consumed domestically, rather than being imported from abroad. Globally, the top five countries producing peas are China, India, USA, France and Egypt.[23] Limited data is available on sourcing countries for peas used as a protein alternative. However, it is known that Cargill sources much of its pea supply from Canada.[24] There appears to be relatively low volumes of peas grown in or imported into Brazil, so other alternative protein types may be more appropriate in this market.

KEY SOURCING ISSUES

There appears to be very few social and environmental issues associated with the growing and sourcing of peas. In a study by Blonk Consultants, yellow peas were found to have the lowest environmental impact of all green proteins assessed.

Table 9.
Domestic production and key sourcing regions for pea in regions.*

Key market	Domestic production	Key sourcing regions
UK and Ireland	UK produced 153,115 tonnes of green peas and 159,900 tonnes of dry peas in 2019	Most peas imported are sourced from Europe – France (37k tonnes), Belgium (18k tonnes), Italy (12k tonnes), Lithuania (15k tonnes) and Latvia (7k tonnes)
North America	USA produced 1.014 million tonnes dry peas and 0.229 million fresh peas in 2019	Most peas are imported from nearby countries – Canada (225k tonnes), Guatemala (23k tonnes) and Mexico (13k tonnes)
France	France produced 709,380 tonnes dry peas and 282,190 green peas produced in 2019	Most peas imported are from Europe – Belgium (17k tonnes), Spain (13k tonnes), Sweden (11k tonnes)
Brazil	Brazil produced 2,715 tonnes peas in 2019	No information on imports is available on UN Comtrade
Australia	Australia produced 218,500 tonnes dry peas and 22,431 green peas in 2019	No information on imports is available on UN Comtrade

* Data on domestic production is sourced from FAOSTAT and data on key sourcing regions is from UN COMTRADE, unless otherwise specified.

23 World Mapper. (n.d.) Green peas production. https://worldmapper.org/maps/green-peas-production/ (accessed 30/06/2022)

24 Food Ingredients. (2020). Cargill scales up European plant-based portfolio with pea protein addition, https://www.foodingredientsfirst.com/news/cargill-scales-up-european-plant-based-portfolio-with-pea-protein-addition.html (accessed 30/06/2022)

25 Blonk, H., et al. (2017). Milieueffecten van vlees en vleesvervangers (in Dutch: Environmental effects of meat and meat substitutes). http://docplayer.nl/66006005-Milieueffecten-van-vlees-en-vleesvervangers.html (accessed 30/6/2021)

26 FERA. (2018). Arable. https://secure.fera.defra.gov.uk/pusstats/surveys/documents/arable2018.pdf (accessed 30/6/2021)

27 Forum for the Future. (n.d.) https://www.unilever.com/Images/2002-in-pursuit-of-the-sustainable-pea_tcm244-409704_en.pdf (accessed 30/6/2021)

PESTICIDE USAGE

Pesticide usage is the only environmental issue widely mentioned in reference to pea production. However, this is not as significant an issue for peas as it is for other crops due to the ability of peas to fix nitrogen into the ground, reducing the need for the addition of chemical forms of nitrogen. The Department for Environment, Food and Rural Affairs (Defra) data shows that 0.4kg of pesticides are applied to each hectare of land use, with dry harvest peas typically receiving three rounds of herbicide, two rounds of insecticide and one round of fungicide. There has been some action by companies, including Unilever, to reduce pesticide usage and it is possible to source peas without synthetic inputs by using organic certification.

CERTIFICATION

The only certification widely available for peas is organic certification. It is not clear exactly what share of pea protein production is organic, but the market for organic pea proteins was valued at US$18 billion in 2021 (including protein isolates, concentrates and textured proteins), showing its significance.[28] Cargill offers organic pea protein options.[29]

28 Markets and Markets. (2016). Organic pea protein market by type, application, & by region – global trends & forecasts to 2021. https://www.marketsandmarkets.com/Market-Reports/organic-pea-protein-market-82420155.html (accessed 30/6/2021)

29 Food Ingredients. (2020). Cargill scales up European plant-based portfolio with pea protein addition, https://www.foodingredientsfirst.com/news/cargill-scales-up-european-plant-based-portfolio-with-pea-protein-addition.html (accessed 30/06/2022)


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CHICKPEAS

Chickpeas are not widely used in processed protein alternatives but may be found as crushed chickpeas or chickpea flour in plant-based burgers or meatballs. There are two main types of chickpea – Desi chickpeas are typically used to make chickpea flour, while cans of chickpeas and cooked chickpeas are usually of the Kabuli variety. Examples of plant-based products containing chickpeas include Asda chickpea burger mix. Chickpeas can also be purchased either canned or dried for use as an ingredient in plant-based dishes, such as curries, falafel, or 'homemade' burgers.

KEY SOURCING REGIONS

Chickpeas are grown across a wide variety of countries and climates, although production in Europe is relatively limited. Certain countries, such as Australia and India, specialise in the production of Desi chickpeas while the Kabuli variety is more common in North America.

KEY SOURCING ISSUES

Very few sourcing issues have been identified with chickpea production. Similar to peas, chickpeas are nitrogen fixing and so require fewer chemical inputs than many other crops. Furthermore, they are insect-pollinated and responsible planting of chickpeas can provide a boost to wildlife and biodiversity in growing areas.

Table 10.
Domestic production and key sourcing regions for chickpeas in regions.*

Key market	Domestic production	Key sourcing regions
UK and Ireland	No significant production currently. It is likely that climate change will make chickpea production more feasible in the UK in the future.[30]	Australia (10k tonnes), India (9k tonnes), Russia (9k tonnes) and Italy (8k tonnes) were the most significant sourcing regions in 2019.[31] Italy specialises in organic production.
North America	The USA was the world's seventh largest producer of chickpeas in 2019, producing 283k tonnes.	The biggest sourcing regions for the USA in 2019 were Canada (20k tonnes), Mexico (12k tonnes), Australia (4k tonnes), Argentina (3k tonnes) and India (2k tonnes). [32]
France	There is limited data available on chickpea growing in France, but local sources suggest a production volume of 50k tonnes in 2019.	The biggest sourcing regions for France in 2019 were Mexico (2k tonnes), India (2k tonnes) and Spain (1k tonnes).
Brazil	No information is available on domestic production, suggesting this is limited.	The biggest sourcing regions in 2019 were Mexico (4k tonnes) and Argentina (3k tonnes).
Australia	Australia was the world's eighth largest producer of chickpeas in 2019, producing 281k tonnes.	The biggest sourcing regions in 2019 were India (200k tonnes) and Iran (14k tonnes). [33]

* Data on domestic production is sourced from FAOSTAT and data on key sourcing regions is from UN COMTRADE, unless otherwise specified.

30 Cambridge Food Hub. (2019). Chickpeas for a changing climate. https://cambridgefoodhub.org/2019/11/28/chickpeas-for-a-changing-climate/ (accessed 30/06/2021)

31 CBI Ministry of Foreign affairs. (2020). The European market potential for chickpeas. https://www.cbi.eu/market-information/grains-pulses-oilseeds/chickpeas/market-potential (accessed 30/06/2021)

32 UN COMTRADE (International trade statistics from the United Nations)

33 UN COMTRADE (International trade statistics from the United Nations)

34 Cambridge food hub. (2019). Chickpeas for a changing climate. https://cambridgefoodhub.org/2019/11/28/chickpeas-for-a-changing-climate/ (accessed 30/06/2021)

35 Henderson, E. (2019). Why veganism isn't as environmentally friendly as you might think. https://www.independent.co.uk/life-style/food-and-drink/veganism-environment-veganuary-friendly-food-diet-damage-hodmedods-protein-crops-jack-monroe-a8177541.html (accessed 30/06/021).

WATER USAGE

Water usage can be an issue for chickpea production in certain areas, including in parts of West Asia and North Africa where rainfall is not sufficient to meet the needs of crops.[36] While water usage is not especially high overall, chickpeas have been found to have a water footprint of 4,177 litres, which is higher than other pulses.[37]

CERTIFICATION

Organic certification is the primary available certification scheme for chickpea production. It is not clear what share of chickpea production globally is certified as organic, but organic chickpeas are widely available as an ingredient. There are also some examples of processed products using organic chickpeas.[38]

36 Zhang, H., et al. (2000). Water use and water use efficiency of chickpea in a Mediterranean environment. Crop and Pasture Science, 51(2):295-304. https://www.researchgate.net/publication/263003608_Water_use_and_water_use_efficiency_of_chickpea_in_a_Mediterranean_environment (accessed 30/06/2021).

37 Healabel. (n.d.). Chickpeas. https://healabel.com/c-ingredients/chickpeas (accessed 30/06/2021)

38 Natural Grocery. (n.d.) Biona Mushroom Burgers Organic. https://www.naturalgrocery.co.uk/product/biona-chickpea-falafel-burger-organic/ (accessed 30/06/2021)


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MYCOPROTEIN

Mycoprotein is widely used in Quorn products,[39] including vegetarian and vegan burgers, sausages, mince, 'chicken style' pieces and ready meals, and which are sold in 19 different countries, including much of Europe and the US, but not South America.[40] As the Quorn EU patent expired in 2010,[41] a number of other mycoprotein products are in the process of being developed and a wider range of products are likely to be available in the future.

39 Quorn. (n.d.) Homepage. https://www.quorn.co.uk/ (accessed 30/06/2021)

40 Filho, P.F.S., et al (2019). Mycoprotein: environmental impact and health aspects. World Journal of Microbiology and Biotechnology, 35, Article number 147. https://link.springer.com/article/10.1007/s11274-019-2723-9 (accessed 30/06/2021)

41 Blythman, J. (2018). The Quorn revolution: the rise of ultra-processed fake meat. The Guardian. https://www.theguardian.com/lifeandstyle/2018/feb/12/quorn-revolution-rise-ultra-processed-fake-meat (accessed 30/06/2021)

KEY SOURCING REGIONS

The production of mycoprotein is limited to a small number of factories, and no information is available on the volume of mycoprotein produced by country. In the past, mycoprotein production has been limited to the Quorn production site in Teesside, UK. However, at least three new companies have recently begun mycoprotein production since the Quorn patent expired. Information on production volumes is limited, but there appears to be significant potential for expansion.

- 3F BIO is expanding mycoprotein production with a facility in Ghent, which is expected to produce 16,000 tonnes of ABUNDA[42] mycoprotein each year.[43]
- Mycorena opened a new factory in Sweden in 2021 as a pilot and is aiming to be Europe's largest mycoprotein supplier by 2025.[44]
- EnyeTech has established a new process for mycoprotein production in Argentina, which it claims is more efficient than Quorn as it optimises the culture medium and incorporates artificial intelligence into the production process.[45]

KEY SOURCING ISSUES

There is a low number of social and environmental issues associated with mycoprotein production. However, as mycoprotein is fed on glucose derived from wheat and corn, with approximately 2kg of wheat needed to produce 1kg mycoprotein.[46] Production of these materials commonly uses chemical inputs such as pesticides, which may cause harm to the natural environment, and it is not clear where in the world or through which production methods these inputs are produced for mycoprotein products. The water footprint of mycoprotein is higher than some other protein alternatives due to the manufacturing processes, but this is still ten times less than the water footprint of both beef and chicken.[47]

The GHG emissions of Quorn mycoprotein are significantly lower than other meat options. Mycoprotein production produces 1.14kg CO2e per kg, and for a finished Quorn product, such as Quorn Mince, this is 1.72kg CO2e per kg. By comparison, the most intensively produced broiler chicken is 2.4kg CO2e per kg, and beef can be anywhere between 12 and 60kg CO2e per kg, depending upon how and where it is produced.[48]

The environmental impact of mycoprotein can be reduced through innovation, which allows for use of agricultural waste or a reduction in processing waste. Innovators in the market include 3F Bio, who are working to reduce wastage by feeding unprocessed sugars back into the biorefinery.[49]

CERTIFICATION

No certification is currently available for mycoprotein products. However, the egg white commonly used as a binder in Quorn production is certified as Free Range for products sold in the UK market.[50]

42 Enough. (n.d.). Abunda Mycoprotein. https://www.enough-food.com/what-is-it (accessed 30/06/2021)

43 Bio Base Europe Pilot Plant. (2019). Successful scale-up of 3FBIO technology paves the way for first integrated bio-based protein biorefinery, to be built in Ghent. http://www.bbeu.org/pilotplant/successful-scale-up-of-3fbio-technology-leads-to-first-integrated-bio-based-protein-biorefinery-to-be-built-in-ghent/ (accessed 30/06/2021)

44 Mycorena. (2021.) Mycorena opens its new production facility. https://mycorena.com/mycotalks/mycorena-opens-its-new-production-facility (accessed 30/06/2021)

45 Michail, N. (2019). 'A Nespresso machine for plant protein': Argentinian scientists optimise mycoprotein production. Food Nativator-latam. https://www.foodnavigator-latam.com/Article/2019/04/01/Scientists-optimize-mycoprotein-production-for-cheaper-Quorn (accessed 30/06/2021)

46 Microbiology Society. (2018). https://microbiologysociety.org/publication/past-issues/microbes-and-food/article/mycoprotein-production-and-food-sustainability.html (accessed 30/06/2021)

47 Ibid.

48 Ibid.

49 Enough Foods. (n.d.) https://www.enough-food.com/news (accessed 30/06/2021)

50 Quorn. (n.d.) https://www.quorn.co.uk/products (accessed 30/06/2021)

LENTILS

Lentils are widely available, either as a dried ingredient or canned, or in processed protein alternatives such as burgers.[51] Lentils have also been used in milk alternative products, although this is still a relatively small market.[52] A number of different lentils are available for different uses, including brown lentils, green lentils and red lentils. Each functions slightly differently but can be used in various protein alternative products.

51 Sainsburys. (n.d.) Sainsburys sweet potato quinoa lentil burger. https://www.sainsburys.co.uk/gol-ui/Product/sainsburys-sweet-potato--quinoa---lentil-burger-x4-350g (accessed 30/06/2021)

52 Vegan life Magazine. (n.d.) Can you make milk from lentils? https://www.veganlifemag.com/ripple-milk-lentils/ (accessed 30/06/2021)

KEY SOURCING REGIONS

Canada is the largest producer of lentils in the world and supplies all key market regions. Turkey is also a significant supplier of lentils to Europe and North America. Lentils are available in all regions, but domestic production is limited in the UK and Ireland, and Brazil.

KEY SOURCING ISSUES

There is a low number of environmental issues associated with lentil production. Lentils mostly do not require irrigation and so are well suited to arid and dry climates without unsustainable water usage.[57] They are also nitrogen-fixing crops, which means a lower volume of fertiliser is required, reducing risk of damaging local biodiversity and greenhouse gas emissions.[58] No significant social or labour issues have been identified, although some countries where lentils are grown (i.e. India and Turkey) are relatively high risk for labour issues. [59]

CERTIFICATION

Organic certification is the primary available certification for lentils and is available for both raw lentils and processed products containing lentils. Fairtrade lentils are also available[60] and may be a suitable option for lentils sourced from countries where labour rights and salaries are an issue.

Table 11.
Domestic production and key sourcing regions for lentils in regions.*

Key market	Domestic production	Key sourcing regions
UK and Ireland	Although FAOSTAT shows no record of lentil production in the UK, there is some small-scale production with an estimated 730 tonnes of lentils grown in the UK.[53]	Key sourcing regions for the UK are Canada (15.4k tonnes), Turkey (6.1k tonnes), France (1.6k tonnes) and India (1.2k tonnes). Sourcing regions for Ireland are similar, but with some additional volumes (1.2k tonnes) from Italy.
North America	Canada is the world's largest producer, producing 2.2m tonnes in 2019. The US was the seventh largest producer in 2019, producing 244k tonnes of lentils.[54]	Largest sourcing regions for the USA are Canada (61.7k tonnes), Turkey (2.4k tonnes) and India (1.9k tonnes) and Mexico (0.6k tonnes). Canada imports lentils from the USA (79.3k tonnes) and small volumes from elsewhere.
France	France produces approximately 22k tonnes of lentils each year, most of which are consumed domestically.[55]	Largest sourcing regions are Canada (12.1k tonnes), China (3.4k tonnes), Turkey (3.0k tonnes) and USA (1.5k tonnes).
Brazil	FAOSTAT does not show any volumes produced in Brazil, suggesting production is limited.	Canada is the only significant sourcing region, importing 14.4k tonnes in 2019.
Australia	Australia is the third largest producer of lentils globally, producing 533.8k tonnes of lentils in 2019.[56]	Canada is the main sourcing region, supplying 923.9k tonnes lentils each year.

* Data on domestic production is sourced from FAOSTAT and data on key sourcing regions is from UN COMTRADE, unless otherwise specified.

53 Naylor, T. (2018). On the pulse: why beans, peas and lentils are making a comeback. https://www.theguardian.com/lifeandstyle/2018/apr/19/on-the-pulse-why-beans-peas-and-lentils-are-making-a-comeback (accessed 30/06/2021)
54 FAOSTAT. (2019). https://www.fao.org/faostat/en/#home (accessed 30/06/2021)
55 CBI Ministry of Foreign Affairs. (2019). Exporting dried lentils grains to Europe. https://www.cbi.eu/market-information/grains-pulses-oilseeds/lentils-grains/europe (accessed 30/06/2021)
56 FAOSTAT. (2019). https://www.fao.org/faostat/en/#home (accessed 30/06/2021)
57 Angadi, S.V., et al. (2008). Adaptation of alternative pulse and oilseed crops to the semiarid Canadian Prairie: Seed yield and water use efficiency. Canadian Journal of plant science. https://cdnsciencepub.com/doi/pdf/10.4141/CJPS07078 (accessed 30/06/2021)
58 Chaudhary, A., Tremorin, D. (2020). Nutritional and environmental sustainability of lentil reformulated beef burger. Sustainability, 12:6712. https://www.mdpi.com/2071-1050/12/17/6712/pdf (accessed 30/06/2021)
59 According to country risk scores on World Bank Rule of Law and ITUC Rights Index.
60 https://www.traidcraftshop.co.uk/fairtrade-and-organic-red-lentils-500g

ALMONDS

Almonds are a tree nut, and almond 'milk' is commonly used as a substitute for dairy milk and is sold by a variety of brands globally, including Alpro and Rude Health. In 2019, almond drink was the second most popular dairy milk alternative after soy and worth US$5.4 million, a figure that is expected to grow by over 100% by 2025 to US$13.25 million.[61] However, it has attracted criticism for its intensive water usage in dry regions.[62]

61 Statista. (n.d.) Market value of almond milk worldwide from 2018 to 2025. https://www.statista.com/statistics/781860/global-almond-milk-market/ (acccessed 30/6/2021).

62 Davies, A. (2019). Tough nut to crack: the almond boom and its drain on the Murray-Darling. https://www.theguardian.com/australia-news/2019/may/26/tough-nut-to-crack-the-almond-boom-and-its-drain-on-the-murray-darling (accessed 30/6/2021).

KEY SOURCING REGIONS

The state of California in the United States is the largest producer of almonds with around 80% of almonds produced there. Spain is another significant domestic producer, with Australia increasing production in recent years.

KEY SOURCING ISSUES

The main issue associated with almond production is high water use, which is an issue, given that water can be scarce in regions in which almonds grow. Most of the world's almonds are grown in California, which dedicates about 8% of its total agricultural water supply to growing almonds, and almond trees need water year-round, even when they're not producing almonds. Water use for almond plantations in Australia has resulted in some tensions within growing regions, with the almond producing region Murray-Darling basin calling for a moratorium on the development of any new almond plantations. It is worth noting that high water use is not specific to just almonds though, with walnuts and pistachios requiring similar quantities of water.

In California, significant progress has been made to address the issues – almond farmers have reduced the amount of water it takes to grow almonds by 33% over 20 years through improved and more efficient irrigation techniques, and the almond community has committed to reduce, by 2025, the amount of water required by an additional 20%. ,

Other issues in almond production include the use of pesticides and damage to bee populations. Large colonies of bees are imported into California annually to pollinate the almond trees. While almond pollen is nutritious and provides all ten of the essential amino acids bees need, imported bees, which are usually non-native European species, can out-compete native bee populations, and those beekeepers who export their bees to California for the pollination season often report high losses from disease.

The harvesting of almonds in California is highly mechanised, with tree shakers being used to dislodge almonds from trees, reducing the need for and risks around migrant labour on farms. This research did not find reports of widespread issues associated with labour production.

Table 12.
Domestic production and key sourcing regions for Almonds in regions.*

Key market	Domestic production	Key sourcing regions
UK and Ireland	No domestic production reported on FAOSTAT. Climate is not suitable for almond production.	Likely to be Spain and California. Spain is an important trade hub for the re-export of Californian almonds within Europe, but also has significant domestic production.
North America	Approximately 80% of world's almonds are produced in California.	California supplies nearly all almonds consumed in the US.
France	No domestic production reported on FAOSTAT. But some southern regions have a climate suitable for almond growing, so likely that there is a small level of domestic production.	Likely to be Spain and California. Spain is an important trade hub for the re-export of Californian almonds within Europe, but also has significant domestic production.
Brazil	No domestic production reported on FAOSTAT.	Likely vast majority from California.
Australia	Australia has significantly increased production in recent years, and now accounts for 7% of global production.	Australian demand is mostly met by domestic production.

* Data on domestic production is sourced from FAOSTAT and data on key sourcing regions is from UN COMTRADE, unless otherwise specified.

CERTIFICATION

Organic certification is the primary available certification scheme for almonds. Certified almonds are widely available in all markets, both as a raw ingredient, and within products. Brands that offer an organic almond drink option are Alpro, Rude Health, Provamel, Plenish, and Silk. However, it is worth bearing in mind that organic standards do not address issues around water use, indeed the USDA organic standard has no mention of water in its standard applied to almond production.


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63 Davies, A. (2019). Tough nut to crack: the almond boom and its drain on the Murray-Darling. https://www.theguardian.com/australia-news/2019/may/26/tough-nut-to-crack-the-almond-boom-and-its-drain-on-the-murray-darling (accessed 30/06/2021)

64 U.S. Sustainability. (n.d.) Fact sheets U.S. Almonds – A Global Leader in Sustainability. https://thesustainabilityalliance.us/u-s-almonds-fact-sheet/ (accessed 30/06/2021)

65 Robbins, P. (2019). Are Almonds sustainable? Food Revolution Network. https://foodrevolution.org/blog/almonds-sustainability/ (accessed 30/06/2021)

PALM OIL

Palm oil is used as a secondary ingredient in many plant-based alternatives, and is cultivated between ten degrees north and south of the equator, with temperature ranges between 24 and 32°C, and rainfall that is evenly distributed throughout the year. Palm oil is both the most-produced and most consumed plant-derived oil, as well as being the most productive vegetable oil crop per hectare. Palm oil, palm kernel oil and their derivatives[66] are estimated to be present in over 50% of packaged supermarket products.[67]

66 Derivatives of palm oil and palm kernel oil are variously labelled as palmitate, palmolein, glyceryl, stearate, stearic acid, palmitic acid, palm stearine, palmitoyl oxostearamide, palmitoyl tetrapeptide-3, sodium laureth sulfate, sodium lauryl sulfate, sodium kernelate, sodium palm kernelate, sodium lauryl lactylate/sulphate, hydrated palm glycerides, etyl palmitate, octyl palmitate, palmityl alcohol.

67 Rianto, B., et al. (2012). Overview of palm oil industry landscape in Indonesia. PWC. https://www.pwc.com/id/en/publications/assets/palm-oil-plantation-2012.pdf (accessed 30/06/2021)

KEY SOURCING REGIONS

None of the key market regions has domestic production except Brazil; however, this only accounts for a small amount of global yield. Production is concentrated in Indonesia and Malaysia.

KEY SOURCING ISSUES

The expansion of palm oil cultivation has resulted in deforestation, particularly in Indonesia and Malaysia. Remote sensing studies of a subset of plantations in 20 countries suggests that around 45% of oil palm plantations in Southeast Asia came from areas that were forested in 1989. In other regions, the planting on forested areas appears to have been lower: 31% in South America, 7% in Africa and 2% in Central America.[68]

A specific concern with deforestation is the conversion of peat land. Peat swamp forest is a critically endangered habitat characterised by deep layers of peat soil and highly acidic water. Malaysia, Indonesia and Papua New Guinea support some of the most extensive tropical peatlands in the world, covering around 27.1 million hectares. The development of peat land can have a disproportionate impact on greenhouse gas emissions: peat soil contains large quantities of carbon and plays a major role in carbon sequestration. Draining peat land results in carbon dioxide emissions, and drained peat is highly flammable, releasing further carbon dioxide if burnt.[69] Reliable estimates of peat land conversion suggest that 3.1 million hectares of former peat land in Malaysia, Borneo and Sumatra were covered by palm oil plantations by 2015, equivalent to 21% of the original area of peat land in these areas.[70]

The use of fire to clear forests for agriculture expansion, in particular in Kalimantan and Sumatra, is a major source of greenhouse gas emissions and air pollution, including haze. Burning is particularly severe during the droughts associated with El Niño, and drained peat land represents a particular fire hazard. The 2015 fires in Indonesia caused emissions of between 1.62 and 1.75 billion tonnes of CO2 equivalent,[71,72] and effectively tripled Indonesia's greenhouse gas emissions for that year.

Table 13.
Domestic production and key sourcing regions for Almonds in regions.*

Key market	Domestic production	Key sourcing regions
UK and Ireland	No domestic production due to unsuitable climate.	Unlike most other commodities, palm production is very geographically concentrated in just two countries. Around two-thirds of global palm oil is grown in Indonesia and Malaysia, so all markets will have these countries as their main sourcing regions. Much smaller quantities may come from countries such as Papua New Guinea, Thailand and the Philippines
North America	No domestic production due to unsuitable climate.	
France	No domestic production due to unsuitable climate.	
Brazil	Small amount of domestic production – accounts for 0.005% of global palm yield.	
Australia	No domestic production due to unsuitable climate.	

* Data on domestic production is sourced from FAOSTAT and data on key sourcing regions is from UN COMTRADE, unless otherwise specified.

68 Vijay V., Pimm S.L., Jenkins C.N., Smith S.J. (2017). The impacts of oil palm on recent deforestation and biodiversity loss. PLoS ONE 11(7), 1–19.

69 Hooijer, A., Silvius, M., Wösten, H., and Page, S. (2016). PEAT-CO2, assessment of CO2 emissions from drained peatlands in SE Asia. Delft Hydraulics report Q3943, Delft, Netherlands.

70 Miettinen, J., Shi, C., and Liew, S.C. (2016). Land cover distribution in the peatlands of Peninsular Malaysia, Sumatra and Borneo in 2015 with changes since 1990. Global Ecology and Conservation, 6, pp. 67–78

71 Chamorro, A., Minnemeyer, S., and Sargent, S. (2017). Exploring Indonesia's long and complicated history of forest fires. World Resources Institute. http://www.wri.org/blog/2017/02/exploring-indonesias-long-and-complicated-history-forest-fires (accessed 30/06/2021)

72 World Bank (2016). The cost of fire. An economic analysis of Indonesia's 2015 fire crisis. Indonesia Sustainable Landscapes Knowledge Note, 1. The World Bank Group, Jakarta

Oil palm cultivation and harvesting is very labour intensive. To deal with the high labour requirements, plantations often rely on large amounts of migrant labour, with an estimated 2.5 million international or internal migrant labourers – legal and illegal – in Southeast Asia alone. These migrant workers are largely Indonesian, but also include Bangladeshis, Filipinos, Thai, and other nationalities.[73] While palm oil has significantly contributed to rural development in producer countries, it has also been associated with social concerns, the most important of which are land use rights (particularly in Indonesia,[74,75] but also in other producer countries), forced and child labour (especially Indonesia and Malaysia[77,78]), and issues relating to the terms and conditions of labour (such as wages, health and safety and gender discrimination[79]).

CERTIFICATION

The two major certification schemes for palm oil are the Roundtable on Sustainable Palm Oil (RSPO), which is used principally in consumer goods, and the International Sustainability and Carbon Certification (ISCC), which predominates in the biofuel sector. In studies comparing the various schemes against a range of criteria, the RSPO was found to have the strongest set of requirements.[80]

RSPO has been successful in achieving scale compared with other sustainability certification schemes in most other commodities. The RSPO currently has more than 4,000 members and RSPO certified growers accounted for 19% of global production in 2014.[81]

While RSPO is still considered the best certifications system, there have been significant and recurrent doubts as to whether the RSPO's Principles and Criteria are sufficiently robust, the quality and transparency of the auditing system, and its ability to include smallholder producers. A major drawback in the RSPO system is the lack of controls on the uncertified portion of mass balance certified palm oil. This is likely to be the major source of deforestation-associated palm oil in many European markets, where certification levels are high, but are in large part mass balance. Mass balance and book and claim are two methods where not enough sustainability guarantees can be provided on the physical volumes of palm oil used in the company's supply chains.

Given its large market share, RSPO certified palm oil is widely available in all markets identified for this report. Many major brands of plant-based foods also ensure palm oil ingredients are certified. For example, Quorn and What the Cluck only used RSPO certified palm oil.

73 Cramb, R, and McCarthy, J.F. (2016) Characterising oil palm production in Indonesia and Malaysia. In Cramb, R, and McCarthy, J.F., eds., The Oil Palm Complex (Singapore) pp. 27–77.

74 Siscawati, M. (2011). The case of Indonesia: Under Soeharto's shadow. In The Bitter Fruit of Oil Palm: Dispossession and Deforestation. World Rainforest Movement (2001), UK.

75 Colchester, M. and Jiwan, N. (2006). Ghosts on our own land: Indonesian oil palm smallholders and the Roundtable on Sustainable Palm Oil. Forest People's Programme & Sawit Watch. Moreton-in-Marsh, UK and Bogor, Indonesia.

76 Colchester, Marcus and Sophie Chao (Eds.) (2013) Conflict or consent? The oil palm sector at a crossroads. Forest Peoples Programme, Moreton-in-Marsh

77 World Vision (2013). Forced, Child and Trafficked Labour in the Palm Oil Industry. World Vision Australia.

78 Skinner, E.B. (2013).Indonesia's palm oil industry rife with human-rights abuses: The hidden human toll of the palm oil boom. Bloomberg Business Week. https://www.bloomberg.com/news/articles/2013-07-18/indonesias-palm-oil-industry-rife-with-human-rights-abuses (accessed 30/06/2021)

79 Amnesty International. (2016). The Great Palm Oil Scandal: Labour Abuses Behind Big Brand Names. London: Amnesty International. https://www.amnesty.org/en/documents/asa21/5184/2016/en/ (accessed 30/06/2021)

80 Forest People's Programme. (2017). A comparison of leading palm oil certification standards. https://www.forestpeoples.org/en/responsible-finance-palm-oil-rspo/report/2017/comparison-leading-palm-oil-certification-standards. (accessed 30/06/2021)

81 RSPO. (n.d.) http://www.rspo.org/about (accessed 30/06/2021)


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COCONUT

Coconut fat or oil is used as a secondary ingredient in many plant-based meat alternatives, while coconut milk is used as a dairy milk replacement. Coconut trees grow in warm weather with plenty of sun and rain, and prefer sandy soils. Coconut flesh can be eaten or processed into oil or drinks, the inner liquid is used as coconut water, and the shell and husk can be used to produce homeware products. Indonesia, the Philippines and India are the main producers of coconuts.

KEY SOURCING REGIONS

Brazil is the only region out of the five key regions that domestically produces any coconut commodities. Indonesia, the Philippines and India are the main producers of coconuts and are the main exporters to the key regions.

KEY SOURCING ISSUES

Coconuts are mostly still produced by smallholders using traditional techniques, rather than large scale plantations. Since coconut trees grow best on sandy and coastal soils, their production has a minimal impact on deforestation. Coconut tree cultivation has, however, been associated with biodiversity loss. Tropical islands are often home to unique species whose habitats can be threatened by increasing numbers of coconut trees. Coconut production has been linked to the extinction of species such as the Marianne white-eye and the Ontong Java flying fox.[82]

While coconut production contributes significantly to economic growth in production countries, farmers and coconut pickers are often below the poverty line. Coconut farmers receive only small incomes for selling coconuts, and most value is instead added later on in the value chain, for example at the processing stage.[83] Within the Philippines, 3.5 million coconut farmers and pickers live below the national poverty line, and the average coconut farmer earns less than a dollar a day.[84]

A recent PETA campaign also drew attention to the issue of monkey labour in Thai coconut production, which often uses inhumane techniques such as removal of canine teeth and cramped cages.[85] Many major European brands have since made commitments to not source from suppliers using monkey labour, with Walgreen Boots Alliance stopping the sale of coconuts from Thailand altogether.[86]

Table 14.
Domestic production and key sourcing regions for coconuts in regions.*

Key market	Domestic production	Key sourcing regions
UK and Ireland	No domestic production due to unsuitable climate.	Significant imports from Indonesia and the Philippines. The UK and Ireland also import significant volumes of coconuts from several European countries, including Spain and the Netherlands, but these coconuts will be produced in a mix of Southeast Asian and Latin American countries.
North America	No domestic production reported on FAOSTAT. Some areas of the US do have a climate suitable to coconut production though, so there may be a small amount of domestic production unreported.	The US imports two-thirds of its coconuts from the Philippines, with the remaining mostly coming from Indonesia. Canada imports just over a third of its coconuts from the Philippines, with Sri Lanka and Vietnam making up around 10% of imports each. There is a significant trade route of coconuts from the US to Canada.
France	No domestic production due to unsuitable climate.	The Philippines is the largest producer country that France imports from, followed by French Polynesia, Indonesia and Côte d'Ivoire. Significant imports also flow through other European countries to France, such as from the Netherlands and Spain.
Brazil	Fifth largest producer globally, growing over 2 million tonnes of coconut a year.	Indonesia accounts for around half of imports, and the Philippines around a third.
Australia	No domestic production reported on FAOSTAT. Some areas of Australia do have a climate suitable to coconut production though, so there may be a small amount of domestic production unreported.	Around a third of imports are coming from Malaysia, followed by Philippines, Thailand, Sri Lanka, Indonesia and Vietnam.

* Data on domestic production is sourced from FAOSTAT and data on key sourcing regions is from UN COMTRADE, unless otherwise specified.

CERTIFICATION

The global coconut industry still lacks a unified certification process that is widely available to customers in identified markets. Fairtrade USA has launched a coconut certification, and some brands and supermarkets have an organic coconut offering. Neither Beyond Burgers nor Future Farms have certified the coconuts used as ingredients in products. Alpro does offer an organic coconut milk option.

82 Meijaard, E., Abrams, J.F., Juffe-Bignoli, D., Voigt, M., and Sheil, D. (2020) Coconut oil, conservation and the conscientious consumer. https://pubmed.ncbi.nlm.nih.gov/32810444/ (accessed 30/06/2021)

83 National Anti-Poverty Commission. (2020) Integrated Coconut Industry and Poverty Reduction Road Map. http://www.napc.gov.ph/sites/default/files/documents/articles/Issue%20No.%202%20-%20Coconut%20Road%20Map.compressed.pdf (accessed 30/6/2021)

84 Fair Trade Certified. (n.d.). It's time for the world to start caring about coconuts. https://www.fairtradecertified.org/news/power-of-coconut?utm_source=fairtradece (accessed 30/06/2021)

85 PETA. (n.d.). Monkeys chained, abused for coconut milk. https://investigations.peta.org/monkeys-abused-coconut-milk/ (accessed 30/06/2021).

86 ibid.

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RAPESEED OIL

Rapeseed, also known as rape or oilseed rape, is widely used around the world, and is favoured due to its affordability and versatility as a cooking oil.

KEY SOURCING REGIONS

All key markets produce rapeseed oil domestically. Canada is the largest global producer, while Brazil produces modest quantities.

KEY SOURCING ISSUES

Rapeseed oil is not linked to deforestation like other vegetable oils such as palm and soy. It has, however, been associated with other negative environmental impacts. An LCA study suggests that it, in fact, has worse impacts on acidification, eutrophication and smog compared with palm oil.[87] These negative impacts are partly due to the much larger areas of land being required to produce a giv en quantity of rapeseed oil compared with palm oil, but also high levels of nitrogen fertiliser application. The crop is also vulnerable to pests and diseases, so is often also treated with fungicides and insecticides.[88]

The growing, harvesting and processing of rapeseed is highly mechanised, and there were no significant labour issues found to be associated with its production.

CERTIFICATION

Organic certification is the main certification readily available in the markets, and is a good option considering the high use of fertilisers, insecticides, and fungicides in the production of rapeseed oil. However, neither Quorn nor Beyond Burger certify the rapeseed oil used in their products.

Table 15.
Domestic production and key sourcing regions for rapeseed oil in regions.*

Key market	Domestic production	Key sourcing regions
UK and Ireland	The UK has significant global production and is globally the 10th largest producer. Ireland does grow rapeseed oil but is not a significant global producer.	UK imports fairly large quantities of rapeseed oil from a mixture of European countries, including Belgium, Estonia, Germany, Ireland and the Netherlands. Most Irish imports are from the UK.
North America	Canada is the largest global producer, growing nearly 19 million tonnes annually. The US has high production too, being the 11th largest global producer.	Any Canadian rapeseed oil imports are most likely to come from the US. Similarly, any US imports are most likely to come from Canada.
France	France has very significant production of rapeseed oil, being the largest European producer, and the fourth largest producer globally.	Most French imports are from Germany, followed by Belgium.
Brazil	Brazil does grow rapeseed oil, but production is very modest.	Brazil only imports significant quantities from Paraguay. Chile, Uruguay, the US and the UK.
Australia	Australia is a significant producer of rapeseed oil, being the seventh largest producer.	Unclear. The majority of imports are listed from Malaysia on UN Comtrade, but this is not a producing country. USA and New Zealand also account for a small share of imports.

* Data on domestic production is sourced from FAOSTAT and data on key sourcing regions is from UN COMTRADE, unless otherwise specified.

87 Schmidt, J. (2010) Comparative life cycle assessment of rapeseed oil and palm oil. https://link.springer.com/article/10.1007/s11367-009-0142-0 (accessed 30/06/2021)

88 King, L. (2018). The supply chain of fats: Rapeseed oil. Sustainable Food Trust. https://sustainablefoodtrust.org/articles/the-supply-chain-of-fats-rapeseed-oil/ (accessed 30/06/2021)

NUTRITION IMPLICATIONS

SUMMARY

- **Plant-based diets need to be well-planned in order to meet dietary needs.** Some micronutrients such as calcium, iron, zinc, iodine and vitamin B12 can be easily missed when removing or limiting meat and/or dairy from the diet.
- In addition to knowing the nutrient content of plant-based foods, it is important to **consider the varying differences in the bioavailability of nutrients** intrinsically within a food versus those manually added into recipes.
- **Plant-based milk alternatives should at a minimum be fortified with calcium, vitamin D, vitamin B12 and iodine.** Soy-based and pea-based products are the closest nutritionally to dairy milk, with soy milk being the only plant milk containing all of the essential amino acids.
- For sausage-style products, **mycoprotein is a well-balanced option** and is nutritionally superior to standard pork sausages. It has a favourable fatty acid profile (low in saturates and contains no cholesterol), but salt content is a key area to watch out for.
- **For both burger and meatball products were medium in fat and salt and high in saturated fat.** This is largely due to the plant-based products imitating the flavour and texture of meat; however, if formulating recipes, it would be prudent to improve the nutrition where possible.
- The chicken-style products fared much more positively both for meat and non-meat options and were classified as low in saturated fat and sugar. However, consumers should **take note of the salt content within chicken-alternative, plant-based products;** What the Cluck is significantly high, and Quorn chicken-style pieces, moderately high, in comparison with chicken. Managing and reducing salt inclusion within plant-based processed products should be a top priority for product developers.
- **Generally, plant-based meat substitutes contain more fibre** than their meat equivalent due to the presence of added carbohydrates, unlike meat which does not contain fibre in its natural form.
- **Most plant-based proteins are good sources of protein, but soy is a particularly good one.** Although commonly reported, soy does not disrupt hormones, and the phytoesterols in soy have been associated with lowering cholesterol. Protein quality should be a key consideration when formulating plant-based foods, especially for children and older people.
- There is **unlikely to be any real cause of health concern from ingredients such as gums and flavours,** unless excessively and continuously consumed. This concern is more related to consumer acceptance.
- Generally speaking, **whole foods perform better than processed foods in terms of traffic light labelling,** advertising restrictions and possible protein claims. See table 16.

Table 16.
Overview of plant-based products and nutrition profiling models*

	Traffic light labelling				Advertising pre-9pm?	Protein claim?
	Fat	Sat	Sugar	Salt		
Alpro Almond drink	Low	Low	Low	Low		None
Dairy Milk	Medium	Medium	Medium	Low		High in protein
Quorn Sausages	Medium	Low	Low	Medium		High in protein
Pork Sausages	High	High	Low	High		Source of protein
Beyond Burger	High	High	Low	Medium		High in protein
Beef Burger	High	High	Low	Medium		High in protein
Future Farm Meatballs	Medium	High	Low	Medium		High in protein
Beef Meatballs	Medium	High	Low	Medium		High in protein
What the Cluck chicken	Medium	Low	Low	Medium		High in protein
Chicken Breast	Low	Low	Low	Low		High in protein
Quorn chicken pieces	Low	Low	Low	Medium		High in protein
Soy Beans	Medium	Low	Low	Low		High in protein
Chickpea	Low	Low	Low	Low		High in protein
Pea	Low	Low	Low	Low		High in protein
Lentil	Low	Low	Low	Low		High in protein
Almond	High	High	Low	Low		Source of protein

*The data was sourced from publicly available data on retail and manufacturers websites and from McCance & Widdowson in May 2021.

METHODS

This research compares the nutrition and ingredients of the following products and commodities:

Table 17.
Overview of products analysed for nutritional values

Categories	Comparison of plant-based alternative product to animal-based product
Plant-based milk alternative	Alpro Almond drink vs dairy milk
Sausages	Quorn Sausages (mycoprotein) vs Pork Sausages
Burger	Beyond Burger (soy) vs Beef Burger
Meatballs	Future Farm (chickpea) vs Beef Meatballs
Chicken	What the Cluck chicken(soy) and Quorn chicken pieces (mycoprotein) vs Chicken Breast
Unprocessed wholefoods	Soy, Chickpea, Pea, Lentil, Almond

Key nutrients of concern in plant-based diets, and which are therefore focused on in this research, are: protein, essential fats, iron, calcium, zinc, iodine, selenium, vitamin B12, and vitamin D.

The nutritional values are shown 'per 100g' of product which has been sought from either on-pack labelling; manufacturer or retailer websites; or published nutritional datasets. The values have been compared against three well-established nutrition profiling models:

1. **HFSS advertising:** Used for UK advertising to ascertain whether a product is overall 'High in Fat, Salt, Sugar' (HFSS) or 'Not High in Fat, Salt, Sugar' (Non HFSS). Currently this model is used for programmes with a high index of children watching them, and also by Transport for London across their transport network (advertising on tube platforms, buses, etc). By the end 2022, it will be used to ban all HFSS food and drink advertising before 9pm in the UK. A widespread ban on online advertising has also recently been announced. In this report, all products show a clear HFSS/Non HFSS rating. More details can be found in the technical guidance report: https://www.gov.uk/government/publications/the-nutrient-profiling-model
2. **Traffic lights:** This is used for packaging labelling purposes and gives a green (low), amber (medium) or red (high) rating for levels of fat, saturated fat, sugar and salt. This is currently a voluntary scheme for retailers and manufacturers; however, now that nutrition labelling legislation is governed by the UK (due to Brexit), it is likely that this, or a similar labelling system, will become mandatory. More details of the criteria used can be found here: https://www.food.gov.uk/sites/default/files/media/document/fop-guidance_0.pdf
3. **Protein claims:** This is criteria used to establish whether a protein claim is permissible on packaging or other communication materials. High in protein = at least 20% energy from food/drink is protein. Source of energy = at least 12% energy from food/drink is protein.[89]

In addition, products are assessed against the NOVA food classification system, which classifies foods into four groups depending of the level of ingredient processing.

89 European Commission. (n.d.). Nutrition claims. https://ec.europa.eu/food/food/labelling-and-nutrition/nutrition-and-health-claims/nutrition-claims_en (accessed 30/06/2021)

KEY NUTRIENTS IMPORTANT IN PLANT-BASED PRODUCTS COMPARED WITH MEAT/DAIRY

There is general scientific consensus that prioritising plants in the diet can lead to better outcomes for the health of people and the planet; however, plant-based diets need to be well-planned in order to meet dietary needs. There are also a few nutrients which are either not present, present at low quantities, or less bioavailable in plants.

Bioavailability is an important consideration. For example, if a product contains a good source of iron, the absorption of this would be impeded if the recipe also contained a high polyphenol product, such as spinach. Conversely, if it contains vitamin C, this will increase the absorption of iron. In a similar way, the lactose in dairy milk aids the absorption of calcium. This action can be assisted through fortification of vitamin D, alongside calcium, in plant-based milks. The oxalate in almonds may also influence the bioavailability of calcium; however, almond drink has such low quantities that this shouldn't pose a problem (Alpro Almond only contains 2.3% almonds). Interestingly, there is some evidence to suggest that individuals can adapt their ability to absorb nutrients once their plant-based eating habits become established.[90] The context in which plant-based alternatives are eaten is also relevant. For example, if a product such as a plant-based burger is within healthy eating criteria and thresholds on the packet, this may not be the case when it is actually consumed, since consumers may fry it in oil and then add ingredients high in sugar, salt and fat.

This section highlights the main nutrients of focus in plant-based diets.

90 BDA. (2018). Eating patterns for health and environmental sustainability. https://www.bda.uk.com/uploads/assets/539e2268-7991-4d24-b9ee867c1b2808fc/a1283104-a0dd-476b-bda723452ae93870/one%20blue%20dot%20reference%20guide.pdf, page 64 (accessed 30/06/2021)

Table 18.
Summary of key nutrients relevant to plant-based foods, their functions, and their availability in plant-foods compared to animal foods. See Appendix 1 for full details.

Nutrient	Function	Plant/animal comparison	Additional information
Protein	Essential for growth, maintenance, repair of all body cells. Provides energy and essential amino acids.	Animal-based 'complete proteins' contain all nine essential amino acids. Many plant-based contain all EAA but lysine and methionine are often present in lower amounts.	Elderly and those with greater muscle synthesis (athletes) need greater proportion of protein if coming solely from plants. UK consumption exceeds recommendations in all age groups, including vegans.
Fats	Required for a range of bodily processes and to maintain the normal structure of cells in the body. Fat also carries essential fat-soluble vitamins and is important for their absorption.	Essential fats are predominantly found in oily fish. There are some plant-based sources (linseeds, flax seeds, chia seeds, hemp seeds, walnuts, rapeseed oil, soybeans and soybean oil), but the amounts contained are considerably limited.	On average, all age groups consume less than the recommended amount of oily fish, even those not following a vegan or vegetarian diet. In the UK, much of the UK population are exceeding the guideline maximum intakes of total and saturated fats.
Iron	Helps to make red blood cells, which carry oxygen around the body. It also helps the immune system to work as it should; helps the brain to function normally and supports growth and development in childhood.	Good sources of iron include red meat, beans, pulses, nuts and seeds, fish, quinoa, wholemeal bread and dried fruit. Iron from plant sources is often less bioavailable. It is inhibited by phytates, polyphenols and tannins naturally found in some plant foods. There are a number of ways to optimise consumption.	The main sources of iron in UK diets, across all age groups, are cereal foods (41–55% of total iron intake) and meat (12–21% contribution). Men are unlikely to struggle to meet iron requirements from plant sources due to relatively lower iron requirements; however, in more vulnerable groups, such as toddlers, teenage girls and women of childbearing age, low iron intake is a concern.
Vitamin B12	Helps the body to keep the nervous system healthy, makes red blood cells, metabolises folate and helps the body use energy.	Found exclusively in animal-based foods. Many plant-based products are now fortified with vitamin B12, including some breakfast cereals, plant-based drinks and yoghurt alternatives.	Can be a nutrient of concern for vegan diets. Nutritional yeast flakes or yeast extract are good sources of vitamin B12, however can be high in salt. Nutritional yeast flakes or yeast extract are good sources of vitamin B12, however can be high in salt.
Calcium	Helps build strong bones and teeth, is important for muscle contraction and ensures the blood clots properly.	Milk and milk-based products supply much of the UK population's calcium intake, however, it is also found in white and brown flour milled in the UK (which legally must be fortified with calcium) and associated cereal products. Some vegetables also contain small amounts of calcium.	Soya foods such as calcium-set tofu have similar bioavailability to milk and so can be considered good alternatives to dairy.

Nutrient	Function	Plant/animal comparison	Additional information
Zinc	Involved in a multitude of biological processes.	Animal-based foods (meat, milk and milk products) are a significant source of zinc in the UK diet, however, good plant sources of zinc include mycoprotein, fortified breakfast cereals, soaked beans and lentils.	Zinc intakes can be compromised in teenage girls.
Iodine	Important in the production of thyroid hormones and plays a vital role in the cognitive development of a growing foetus and young children.	Data can vary significantly between products as iodine content is highly variable, depending on seasons and farming practices. Iodine in milk is a by-product of iodine added to animal feed. It is advisable that any plant-based drinks are fortified with iodine (in addition to vitamin B12, calcium and vitamin D).	UK is a mildly iodine deficient country. Girls and women of child bearing age, as well as UK vegans, are vulnerable to deficiency. Seaweed is a plant based source but iodine content is highly variable and can reach dangerous levels in kelp particularly.
Vitamin D	Helps regulate calcium and phosphate in the body which keeps teeth, bones and muscle healthy.	Few dietary sources. UK government recommends everyone (regardless of diet) takes a 10 mcg supplement of vitamin D during the autumn and winter months.	
Selenium	Protects the cells in our bodies against damage. It also helps the immune and thyroid systems to work as they should, helps maintain normal nails and hair and normal fertility in males.	Most selenium in UK diets comes from cereals, meat and seafood, and intakes may be compromised if animal-based foods are limited.	
Fibre	Keeps the digestive system healthy.	Plant-based foods contain much higher levels of fibre.	UK diets are well below the recommended daily intake of 30g.
Sodium/salt	Balances the amount and distribution of water in our bodies, a key role in control of blood pressure.	Found naturally in some foods (e.g. dairy), added to others (e.g. cured meats) most commonly used as table salt.	Recommended intake for adults is no more than 2.4g sodium/day (equivalent to 6g salt/day). In the UK, most people consume more than the recommended daily amount.


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PLANT-BASED MILK ALTERNATIVES

RECOMMENDATION

Plant-based milks are not nutritionally comparable with dairy milk. At a minimum, products should be fortified with added vitamins and minerals (such as calcium, vitamin B12, vitamin D and iodine). Soy and pea milk are the closest nutritionally to dairy milk as they contain higher levels of complete protein (soy milk contains all the essential amino acids which our bodies cannot make itself and therefore have to be supplied by food or drink), and would therefore be the most preferable substitute from an overall nutritional perspective.

SUMMARY

Almond drink is unsurprisingly classified as GREEN throughout for the traffic light labelling system. This is because it is essentially water, a small proportion of almonds (2.3%), fortified vitamins and minerals, and other minor ingredients. As the plant material is low, there is no nutritional equivalence to the original food source. There is limited difference between dairy milk and almond milk alternative terms of the advertising score. Both are classified as Non HFSS (not high in fat, salt, sugar) and neither are near the threshold of HFSS.

FURTHER DETAIL

Plant-based milk alternatives are not, in their natural form, nutritionally comparable with dairy milk and, as a result, many companies fortify their products to include some of the main micronutrients lacking in non-fortified versions (regulatory standards mean this is not possible with organic varieties). However, this is variable across the marketplace, and there is currently no standard composition or labelling required for these products. Ideally, they should be fortified with calcium, vitamin D, vitamin B12 and iodine.

It is important to note that there are varying differences in the bioavailability of some micronutrients intrinsically within a food (i.e. a natural component) versus those added in as a supplement (fortification). For example, the presence of inhibitors such as oxalate in almonds may influence the bioavailability of calcium. Sometimes, the presence of fortified micronutrients is used within marketing messages (for example, Mighty Pea M.LK's claim of 50% more calcium than cow's milk), however, the absolute amounts of calcium cannot be compared when there are differences in bioavailability.

Plant-based milk alternatives can often be perceived as healthy alternatives to dairy, however, most are largely composed of water with varying amounts of solids from the plant material (soy and oat milks typically contain about 10% solids and nut milks typically contain around 2–3%) so the nutritional value has limited equivalence to its original food source. Oat-based milk alternatives contain free sugar (the type we should limit) from the processing of the oats; even though it may be labelled as "no added sugar" or "unsweetened".

All plant-based milks are classified as ultra-processed foods (NOVA). Foods in this category rely heavily on added ingredients to enhance the sensory elements and improve their shelf life.

Table 18.
Summary of key nutrients relevant to plant-based foods, their functions, and their availability in plant-foods compared to animal foods. See Appendix 1 for full details.

Overall nutrition	Almond drink is unsurprisingly classified as GREEN throughout for the traffic light labelling system. This is because it is essentially water, a small proportion of almonds (2.3%), fortified vitamins and minerals, and other minor ingredients. As the plant material is low, there is limited nutritional equivalence to the original food source. There is no difference between dairy milk and almond milk alternative terms of the advertising score. Both are classified as Non HFSS (not high in fat, salt, sugar) and neither are near the threshold of HFSS.
Calories	Dairy milk has over double the calories of the almond drink. This is because of the naturally occurring fats, sugar and protein. Dairy milk is a good energy source, particularly for growing children.
Protein	Almond drink is very low in protein in comparison with dairy milk, which contains high quality protein, complete with all essential amino acids.
Fat	Almond drink contains less total fat and less saturated fat than dairy milk. Lower saturated fat is particularly beneficial for population health, however, total fat is important for growing children.
Sugar	Dairy milk contains more sugar; however, the sugars in plant-based milks are free sugars (the type we should limit) and the sugars in dairy milk are lactose (the type we don't need to limit). Nutrition labelling does not distinguish between these two types of sugars; however, the lactose sugars remain intact in their cell structure until digested and therefore absorbed at a much slower rate; they are also not linked to tooth decay in the same way free sugars are.
Salt	Both products are low in salt.
Micronutrients	Dairy milk is a good source of highly bioavailable calcium, vitamins A, B (B12 and B2), zinc, iodine, phosphorus and potassium. Due to the lactose in cow's milk, the calcium is more readily absorbed. Almond drink is distinctly lacking in iodine, potassium, phosphorus, folate and magnesium. Almond milk alternative is however fortified with calcium (equal to dairy milk, although there will be difference with absorbency, but the presence of vitamin D will aid this). It is also fortified with vitamin B12 (less than half the amount) and riboflavin (almost the same amount). Aside from iodine, Alpro generally do a good job with fortification of added vitamins and minerals.

Table 19.
Nutritional comparison of Alpro almond milk alternative and dairy milk

	Alpro almond milk alternative	Dairy milk, semi skimmed	Reference intake per day
Nutrient profiling	Non HFSS	Non HFSS	
Kcal	22kcal	46kcal	2000kcal
Total fat	1.1g	1.7g	70g
Saturated fat	0.1g	1.1g	20g
Monounsaturated fat	0.7g	0.4g	-
Polyunsaturated fat	0.3g	Trace	-
Carbohydrate	2.4g	4.7g	260g
Sugars	2.4g	4.7g	90g
Fibre	0.4g	0g	30g
Protein	0.4g	3.5g	50g
Salt	0.14g	0.1g	6g
Potassium	0mg	156mg	2000mg
Calcium	120mg	120mg	800mg
Magnesium	0mg	11mg	375mg
Phosphorus	0mg	94mg	700mg
Iron	0mg	0.02mg	14mg
Zinc	0mg	0.4mg	10mg
Manganese	0mg	Trace	2mg
Vitamin D	0.7µg	Trace	10µg
Riboflavin	0.21	0.24mg	1.4mg
Vitamin B6	0mg	0.06mg	1.4mg
Folate	0µg	9µg	200µg
Vitamin B12	0.38µg	0.9µg	2.5µg
Vitamin E	1.8mg	0.04mg	12mg
Iodine	0µg	30µg	150µg

Key (see page 42 for definitions and thresholds)

- High in stated nutrient
- Medium in stated nutrient
- Low in stated nutrient
- Not high in fat, salt, sugar
- High in fat, salt, sugar
- High in protein
- Source of protein
- \- Micronutrient values not available in public domain


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MYCOPROTEIN

RECOMMENDATION

Mycoprotein sausage products are a preferable alternative to pork sausages due to high levels of protein and lower levels of saturated fat. Similar to animal-based products, mycoprotein is a complete protein and so contains all the essential amino acids which our bodies cannot make themselves (and therefore have to be provided by food or drink). Although the Quorn sausage is lower in salt than the pork sausage, it is still quite high.

SUMMARY

Overall nutrition	Quorn sausages have a more well-rounded nutritional profile compared with the pork sausage. They are well below the threshold of UK advertising restrictions, whereas the pork sausage exceeds the threshold significantly. If we consider the traffic light labelling, the pork sausage has three nutrients classified **HIGH** (total fat, saturated fat and salt). Conversely, the Quorn sausage has two **LOW** nutrients and two **MEDIUM**. It has a favourable fatty acid profile (low in saturates and contains no cholesterol).
Calories	The higher fat and protein content of the pork sausage makes this a more calorific product compared with the Quorn sausage.
Protein	The pork sausage provides higher protein per 100g, however, the Quorn product is still a very good source of protein. It has a greater percentage of energy coming from protein; in this comparison, the Quorn product could carry the 'high in protein' claim, whereas the pork sausage could not (although very close to being able to; 19.7% energy from protein and the threshold is >20%. Many pork sausages on the market would be able to use the 'high in protein' claim).
Fibre	Quorn sausage is a source of fibre; the pork variant is not.
Fat	The pork sausage is considerably higher in fat (both total and saturated). Saturated fat is the type we need to limit.
Sugar	Both products are low in sugar.
Salt	In this example, the pork sausage is much higher in salt; however, in general, sausage alternatives tend to have fairly similar salt to their meat equivalents.

FURTHER DETAILS

Quorn is made of mycoprotein. The main ingredient is Fusarium venenatum, a type of fungus that naturally occurs in the soil. Fusarium venenatum is fed with human-grade carbohydrate in large air-lift fermenters before the liquid is separated by centrifugation to leave behind the mycoprotein 'dough', closely resembling bread dough.

Fungi are separate to plants and animals, and include mushrooms as well as a huge variety of micro-fungi species such as Fusarium and yeasts.

Table 20.
Nutritional comparison of Quorn sausage and pork sausage per 100g

	Quorn sausage	Pork sausage*	Reference intake per day
Nutrient profiling	Non HFSS	HFSS	
Kcal	198kcal	294kcal	2000kcal
Total fat	11.1g	22.1g	70g
Saturated fat	1.4g	8g	20g
Monounsaturated fat	–	9.6g	–
Polyunsaturated fat	–	3g	–
Carbohydrate	10.6g	9.8g	260g
Sugars	1.5g	1.5g	90g
Fibre	5.5g	2.3g	30g
Protein	11.2g	14.5g*	50g
Salt	1.2g	1.6g	6g
Potassium	–	14.5mg	2000mg
Calcium	–	110mg	800mg
Magnesium	–	15mg	375mg
Phosphorus	–	220mg	700mg
Iron	–	1.1mg	14mg
Zinc	–	1.4mg	10mg
Manganese	–	0.2g	2mg
Vitamin D	–	1.1g	10µg
Riboflavin	–	0.13g	1.4mg
Vitamin B6	–	0.12mg	1.4mg
Folate	–	4µg	200µg
Vitamin B12	–	1µg	2.5µg

* The pork sausage used for this comparison almost meets the 'High in protein' claim (is 19.7% energy from protein and needs to be >20% energy from protein)

Key (see page 42 for definitions and thresholds)

High in stated nutrient	High in fat, salt, sugar
Medium in stated nutrient	High in protein
Low in stated nutrient	Source of protein
Not high in fat, salt, sugar	- Micronutrient values not available in public domain

BURGERS

RECOMMENDATION

From a purely nutritional perspective, the soy-based Beyond Burger is 'healthier' than the standard beef burger. However, it is important to note that both products are **HIGH** in fat and saturated fat, according to UK government's criteria. Therefore, neither could be regarded as a 'healthy product' and neither would be suitable for advertising on UK TV pre 9pm, online, or via the London transport network (and possibly other cities going forward). The nutritional advantages of the Beyond Burger are that it contains fewer calories, and although the fat and saturated fat content is rated HIGH, it is still lower than the beef equivalent.

SUMMARY

Overall nutrition	Both products are classified as **HIGH** in fat, saturated fat and salt.
Calories	Beyond Burger has less calories than the standard beef burger. This is owing to the lower fat and protein content.
Protein	The beef burger has more protein, however the Beyond Burger still contains a decent amount. Both products are a source of complete protein (i.e. contain all the essential amino acids which our bodies cannot make).
Fibre	Beyond Burger has more fibre than the beef burger, but minimal.
Fat	Beyond Burger has less fat than its beef counterpart, however both are HIGH in total fat and saturated fat.
Sugar	Both are **LOW** in sugar.
Salt	Both contain similar levels of salt (Beyond Burger marginally lower).

FURTHER DETAILS

Beyond Burger is a plant-based burger that is designed to look, cook and taste like beef. It helps to introduce more variety to plant-based diets; however, because of their 'health halo', many consumers believe the presence of plant ingredients is a healthier way of eating and this is not always the case.

When comparing the plain products side by side, the Beyond Burger fares better nutritionally, but this does not necessarily make it a healthy option. Beyond burgers are high in salt and fat, which may be heightened by these products likely being cooked using, and served with, oils and sauces with high levels of salt, fat and/or sugar.

Ultimately Beyond Burgers should be regarded as something to eat occasionally, rather than routinely. Very similar in fact to the general guidance for standard burgers.

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Table 21.
Nutritional comparison of Beyond Burger and standard beef burger per 100g

	Beyond Burger	Beef Burger	Reference intake per day
Nutrient profiling	HFSS	HFSS	
Kcal	252kcal	326kcal	2000kcal
Total fat	19.0g	24.4g	70g
Saturated fat	5.6g	10.9g	20g
Monounsaturated fat	–	11.2g	–
Polyunsaturated fat	–	0.7g	–
Carbohydrate	3.5g	0.1g	260g
Sugars	0g	0.1g	90g
Fibre	1.8g	0.7g	30g
Protein	17g	26.5g	50g
Salt	0.75g	1.0g	6g
Potassium	–	380mg	2000mg
Calcium	–	10mg	800mg
Magnesium	–	22mg	375mg
Phosphorus	–	210mg	700mg
Iron	–	2.5g	14mg
Zinc	–	6.1g	10mg
Manganese	–	0.02g	2mg
Vitamin D	–	1.8µg	10µg
Riboflavin	–	0.2mg	1.4mg
Vitamin B6	–	0.31mg	1.4mg
Folate	–	10µg	200µg
Vitamin B12	–	3µg	2.5µg

Key (see page 42 for definitions and thresholds)

- High in stated nutrient
- Medium in stated nutrient
- Low in stated nutrient
- Not high in fat, salt, sugar
- High in fat, salt, sugar
- High in protein
- Source of protein
- \- Micronutrient values not available in public domain

MEATBALLS

RECOMMENDATION

Both of the meatball products are classified as **MEDIUM** in fat and salt and **HIGH** in saturated fat. However, unlike the burgers, neither can be deemed nutritionally better than the other. For example, although the beef meatballs contain higher levels of fat than predominantly chickpea protein-based Future Farm Meatballs, when this is broken into types of fat, levels of saturated fat are actually lower in beef meatballs. The Future Farm Meatballs are lower in salt (also a key public health concern), but this is not at a low level.

SUMMARY

Overall nutrition	Both products are classified as **HIGH** in saturated fat and **MEDIUM** in salt.
Calories	Both have similar calories
Protein	Both are good sources of protein (beef variant being markedly higher).
Fibre	Low fibre content for the Future Farm and almost non-existent for the beef variant (wouldn't expect to find fibre in a meat product like this)
Fat	Future Farm has less total fat but more saturated fat than the beef meatballs. This is likely to be because of the coconut fat as an ingredient. Both are HIGH in saturated fat and both quite high in total fat.
Sugar	Both are **LOW** in sugar.
Salt	Beef meatballs have almost double the amount of salt

FURTHER DETAILS

Future Farm products are based on soy, pea and chickpea, and are becoming increasingly known for their ability to 'bleed' just like standard meat.

Table 22.
Nutritional comparison of Future Farm Meatballs and standard beef meatballs per 100g

	Future Farm Meatballs	Beef Meatballs	Reference intake per day
Nutrient profiling	HFSS	HFSS	
Kcal	198kcal	220kcal	2000kcal
Total Fat	11g	13.3g	70g
Saturated fat	9g	7g	20g
Monounsaturated fat	–	–	–
Polyunsaturated fat	–	–	–
Carbohydrate	13g	4.1g	260g
Sugars	1g	0.1g	90g
Fibre	1g	1.2g	30g
Protein	12g	20.3g	50g
Salt	0.6g	1g	6g

Key (see page 42 for definitions and thresholds)

- High in stated nutrient
- Medium in stated nutrient
- Low in stated nutrient
- Not high in fat, salt, sugar
- High in fat, salt, sugar
- High in protein
- Source of protein
- \- Micronutrient values not available in public domain


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CHICKEN

RECOMMENDATION

This section compares What the Cluck chicken, Quorn chicken style pieces and standard chicken breast. From a nutritional perspective, chicken is a great source of complete protein, **LOW** in fat, sugar and salt. However, the Quorn chicken style pieces are also a good option. They contain far less protein than chicken, but still a good amount, and are also **LOW** in fat, saturated fat and sugar and **MEDIUM** in salt.

SUMMARY

Overall nutrition	All options are **LOW** in saturated fat, sugar and fat with the exception of What the Cluck chicken classified as **MEDIUM** for fat. Both chicken alternatives (What the Cluck and Quorn chicken pieces) had **MEDIUM** salt content. They all have fairly balanced range of nutrients.
Calories	All of these products have fairly similar low level of calories.
Protein Fibre	Unsurprisingly, the chicken breast has far greater protein content, but the others all provide a good source of protein.
	The Quorn option is high in fibre; zero fibre in chicken and a small level of fibre in What the Cluck.
Fat	What the Cluck (based on soy) has a higher total fat content than the other two products; however, this is unsaturated fat. All options are **LOW** in saturated fat (which is the type of fat we should limit).
Sugar	All are really **LOW** in sugar.
Salt	Chicken is naturally **LOW** in salt. Quorn pieces are medium in salt (some of which will be coming from the rehydrated egg white and some from the flavouring), but What the Cluck contains significantly **MEDIUM** levels of salt (likely to be coming from soy concentrate and/or flavouring).

FURTHER DETAILS

Mycoprotein has been covered within the sausage section, however, in relation to a chicken substitute, there have been several studies investigating the effects of mycoprotein in comparison with other protein sources on satiety. It has been suggested that the effects of mycoprotein on satiety are greater than an equivalent amount of chicken.[91] Having greater satiety means that an individual is likely to feel fuller for longer and so minimises over-eating. However, it is unclear what mechanism underlies this.

What the Cluck is mainly based on a soy structure (water and soy protein concentrate), with only a couple of other ingredients. The salt content would be a key concern, especially as this tends to rate as a fairly bland product and therefore additional seasoning would likely be added.

91 Denny, A., et al. (2008). Mycoprotein and health. Nutrition Bulletin, 33(4): 298-310. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1467-3010.2008.00730.x (accessed 30/06/2021)

Table 23.
Nutritional comparison of What the Cluck chicken, Quorn chicken-style Pieces, standard chicken breast per 100g

	What the Cluck[92]	Chicken breast	Quorn chicken style pieces	Reference intake per day
Nutrient profiling	Non HFSS	Non HFSS	Non HFSS	
Kcal	126kcal	148kcal	148kcal	2000kcal
Total fat	4.2g	2.2g	2.6g	70g
Saturated fat	0.5g	0.6g	0.8g	20g
Monounsaturated fat	–	1.0g	-	–
Polyunsaturated fat	–	0.4g	-	–
Carbohydrate	5.2g	0g	1.7g	260g
Sugars	0.5g	0g	0.6g	90g
Fibre	2.5g	0g	7.1g	30g
Protein	16g	32g	13.8g	50g
Salt	1.1g	0.14g	0.8g	6g
Potassium	–	460mg	71mg	2000mg
Calcium	–	6mg	48mg	800mg
Magnesium	–	36mg	49mg	375mg
Phosphorus	–	310mg	290mg	700mg
Iron	–	0.4mg	0.39mg	14mg
Zinc	–	0.8mg	7.6mg	10mg
Manganese	–	0.01mg	4.9mg	2mg
Vitamin D	–	0µg	-	10µg
Riboflavin	–	0.13mg	0.26mg	1.4mg
Vitamin B6	–	0.63mg	0.1mg	1.4mg
Folate	–	6µg	114µg	200µg
Vitamin B12	–	Trace	0.71µg	2.5µg

Key (see page 42 for definitions and thresholds)

- High in stated nutrient
- Medium in stated nutrient
- Low in stated nutrient
- Low in fat, salt, sugar
- High in fat, salt, sugar
- High in protein
- Source of protein
- \- Micronutrient values not available in public domain

92 Following the originally analysis, authors have been made aware that the What the Cluck chicken pieces product has been reformulated to address the issues with salt levels (changed from 1.7 g/100g to 1.1 g/100g). https://www.tesco.com/groceries/en-GB/products/303350536 (accessed 06/04/2022).

COMMODITIES

RECOMMENDATION

All commodities investigated – soy beans, chickpeas, lentils, peas and almonds – are excellent options nutritionally. They provide a range of macro and micronutrients and are good sources of plant-based and fibre, especially soy, which is a ‘complete protein’ since it contains all essential amino acids.


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SUMMARY

Overall nutrition	Aside from almonds, all options are naturally **LOW** in fat, salt and sugar and provide a range of macro and micronutrients.
Calories	All are low in calories, except for almonds.
Protein	All are good sources of plant-based protein.
Fibre	All contain good levels of fibre, especially chickpeas.
Fat	Aside from almonds, all are **LOW** in saturated fat and **LOW** in total fat. Almonds are the exception as they are a highly energy dense ingredient. They contain a large proportion of monounsaturated fat which helps to protect the heart by maintaining levels of HDL (good) cholesterol and reducing levels of LDL (bad) cholesterol. There is also an emerging body of evidence to support regular nut consumption (30g per day) with weight management efforts.
Sugar	All are **LOW** in sugar and MEDIUM for almonds.
Salt	All are **LOW** in salt.

FURTHER DETAILS

This section compares soy beans, chickpeas, lentils, peas and almonds. All of these options are incredibly nutritious and there are many benefits for including more of these ingredients in our diet.

All options are naturally **LOW** in salt and sugar. They provide a range of macro and micronutrients and are good sources of plant-based and fibre, especially soy which is a 'complete protein'.

Generally speaking, whole foods in a diet are more nutritious than processed foods. However, there is definitely a need for the latter in terms of convenience and variety within a diet.

Most plant-based proteins are good sources of protein, but soy is one of the best. In products such as plant-based drinks, it is the closest nutritionally to dairy milk (followed by pea protein). Although commonly reported, soy does not disrupt hormones, and the phytoesterols in soy have been associated with lowering cholesterol.

Almonds are scored **HIGH** for fat; however, this is because the scoring model is based on 'per 100g' of product. The recommended portion size for nuts is 30g, and it's also important to note that a large proportion of this fat is monounsaturated fat, rather than saturated fat (the type we generally need to limit).

Table 24.
Nutritional comparison of soy beans, chickpeas, lentils, peas and almonds per 100g*

	Soy Beans	Chickpeas	Lentils (red)	Peas	Almonds	Ref. intake per day
Nutrient profiling	Non HFSS	Non HFSS	Non HFSS	Non HFSS	Non HFSS	
Kcal	141kcal	129kcal	102kcal	79kcal	554kcal	2000kcal
Total fat	7.3g	3g	0.7g	1.6g	49.9g	70g
Saturated fat	0.9g	0.3g	Trace	0.3g	3.8g	20g
Monounsaturated fat	1.4g	0.6g	0.2g	0.2g	31.6g	–
Polyunsaturated fat	3.5g	1.4g	0.4g	0.8g	12.3g	–
Carbohydrate	5.1g	18.3g	16.9g	10.0g	5.3g	260g
Sugars	2.1g	0.7g	0.4g	1.2g	4.5g	90g
Fibre	6.1g	10.6g	6.3g	5.6g	12.5g	30g
Protein	14g	8.4g	8.1g	6.7g	21.2g	50g
Salt	<0.01	<0.01g	<0.01g	<0.01g	<0.01g	6g
Potassium	510mg	281mg	220mg	230mg	733mg	2000mg
Calcium	83mg	48mg	10mg	19mg	269mg	800mg
Magnesium	63mg	44mg	18mg	29mg	270mg	375mg
Phosphorus	250mg	141mg	107mg	130mg	481mg	700mg
Iron	3mg	1.9mg	2.14mg	1.5mg	3.71mg	14mg
Zinc	0.9mg	1.1mg	1mg	1mg	3.1mg	10mg
Manganese	0.7mg	1.38mg	0.41mg	0.4mg	2.18mg	2mg
Vitamin D	0µg	0µg	0µg	0µg	0µg	10µg
Riboflavin	0.09mg	0.03mg	0.04mg	0.03mg	1.14mg	1.4mg
Vitamin B6	0.23mg	0.38mg	0.07mg	0.09mg	0.14mg	1.4mg
Folate	54µg	35µg	36µg	27µg	44µg	200µg
Vitamin B12	0µg	0µg	0µg	0µg	0µg	2.5µg

*Data sourced from McCance & Widdowson

Key (see page 42 for definitions and thresholds)

- High in stated nutrient
- Medium in stated nutrient
- Low in stated nutrient
- Low in fat, salt, sugar
- High in fat, salt, sugar
- High in protein
- Source of protein
- \- Micronutrient values not available in public domain

PLANT-BASED PRODUCT INGREDIENTS ADDITIVES AND PROCESSING

OVERVIEW

This section details the ingredients contained within all the processed variants. Although many of these options have a number of different ingredients, it should be noted that there should not be any concerns about additives approved by the European Food Safety Authority and Food Standards Agency and that any health implications would only arrive with excessive continued consumption. Concern around additives is more a matter of consumer acceptance, and there is likely to be more focus on additives in the coming years than there is currently.

Many of the processed options assessed as part of this project have fairly similar additive ingredients to their meat counterparts. In a couple of products, the plant-based version contained more ingredients, but there are technical reasons for this, including flavour and texture purposes. The biggest difference is with plant-based milk. Dairy milk has one labelled ingredient (milk) and Alpro almond drink has: water, almond, sugar, calcium (tri-calcium phosphate), sea salt, stabilisers (locust bean gum, gellan gum), emulsifier (lecithins – sunflower), natural flavouring, vitamins (B2, B12, E, D2). This is fairly standard across the plant-based marketplace.

All ingredients on labels must be stated in descending order of weight when present at more than 2% in the product. Some ingredients must be labelled under a specific heading, for example, preservatives and the corresponding ingredient name and/or E number. All food additives are approved for use in food by the European Food Safety Authority (EFSA) in Europe and by the Food Standards Agency (FSA) in the UK. It is interesting to note there is some controversy regarding certain additives (e.g., sodium nitrite and titanium dioxide, though these are not found in the report's products), acknowledgement of limited research on the potential interactions between additives and their affect on the human body[93], as well as examples of certain food additives not being tolerable to some consumers for example causing gastrointestinal reactions .[94]

NOVA PROCESSING CLASSIFICATION

All the processed products investigated in the report can be classified as either Group 3 for 'processed food' or Group 4 for 'ultra-processed food'. NOVA food classification is a system that classifies foods into four groups based on their levels of processing. Group 4 foods are defined as 'ultra-processed', which include snacks, drinks, ready meals and many other products derived from substances that are not used in home kitchens (e.g., protein isolates), and/or cosmetic additives (e.g., emulsifiers). Group 2 represents processed culinary ingredients, such as plant oils (e.g., olive oil, coconut oil), animal fats, sugar, honey, salt, etc. This categorisation is the most widely used in the literature and does provide some benefits in understanding the wide ranges in processed foods. However, care must be taken as the system has received some criticism around the variety of products found in ultra-processed foods (Group 4) while considered nutritious, can be classified as ultra-processed foods (e.g., shop-bought hummus).

93 Sadler, C., et al. (2021). Processed food classification: Conceptualisation and challenges. Trends in Food Science & Technology, 112:149-162. doi: https://doi.org/10.1016/j.tifs.2021.02.059
94 Sadler, C., et al. (2022). "Even we are confused": A thematic analysis of professionals' perceptions of processed foods and challenges for communication. Front. Nutr. 9L826162. doi: https://doi.org/10.3389/fnut.2022.826162

FURTHER DETAIL

The following tables show each of the ingredients contained within each product, along with a description of its likely use. These are listed in order of quantity within the recipe.

Table 25.
Ingredients of Alpro Almond original milk alternative

ALPRO ALMOND ORIGINAL

Ingredient	Common use / Other information
Water	The vast majority of the product is water.
Almond	Only 2.3% almonds in finished product so minimal benefit.
Sugar	Added for flavour but there are also 'no sugar' variants available.
Calcium *(tri-calcium phosphate)*	This is the manual addition of calcium to the recipe (some reports have shown this is less bioavailable than calcium carbonate; however, this is difficult to verify).
Sea salt	Dairy milk has a naturally occurring salty flavour; this mimics it.
Stabilisers *(locust bean gum, gellan gum)*	These help to thicken the liquid and help with texture. Gellan gum is similar to gelatine, but plant based.
Emulsifier *(lecithins – sunflower)*	This helps consistency, especially keeping the water and the oil from the almonds blended together, and also helps extend shelf life.
Natural flavouring	It is not known which one is used, but it is likely to be an almond flavour to enhance the taste perception of the product.
Vitamins *(B2, B12, E, D2)*	These are vitamins which have been manually added to the recipe to imitate the nutritional composition of animal-based milk. The plant-based drink does not contain iodine, which would be optimal.

Table 26.
Ingredients of Quorn sausages

QUORN SAUSAGES

Ingredient	Common use / Other information
Mycoprotein	41% of the recipe.
Rehydrated free range egg white	To bind the ingredients together (Quorn vegan sausages without egg are also available).
Vegetable oils	Rapeseed and palm.
Onion	For flavour.
Rusk	Made from wheat flour, yeast and salt. Helps to control moisture.
Natural flavouring	For flavour.
Casing	Made from sodium alginate (extracted from brown seaweed), cellulose (a fibre) and starch.
Textured wheat protein	This is wheat flour plus a stabiliser (sodium alginate). Can help to stabilise and/or thicken the ingredients.
Firming agents	Help to keep the product together and extend the shelf-life: calcium chloride, calcium acetate.
Seasoning	Herbs for flavouring (sage and parsley) mixed with a little rapeseed oil.
Pea fibre	Used as a bulking agent, but also helps to increase the fibre of the recipe.
Barley malt extract	Used as a flavour enhancer.
Natural caramelised sugar	To balance the recipe.

Table 27.
Ingredients of pork sauages

PORK SAUSAGES (TESCO OWN BRAND)

Ingredient	Common use / Other information
Pork	72% of the recipe.
Water	Helps to get the ingredients through the casing.
Wheat flour	This is wheat flour which is fortified with calcium carbonate, iron, niacin, thiamine (standard fortification of flours in the UK).
Salt	For flavour and preservation.
Parsley	For flavour.
Dextrose *(sulphites)*	This is sugar – acts as a sweetener.
Emulsifiers	These help to bind the meat together. In this recipe, disodium diphosphate and tetrasodium diphosphate are used.
Yeast extract *(sulphites)*	Enhancing the pork flavour.
Raising agent	Ammonium bicarbonate.
Preservative	Helps with shelf life. In this recipe, sodium metabisulphite is used.
White pepper	For flavour.
Black pepper	For flavour.
Antioxidant	To avoid oxidation and off flavours. In this recipe ascorbic acid is used (otherwise known as vitamin C).
Spice extracts	For flavour (nutmeg extract and mace extract).

Table 28.
Ingredients of Beyond Burger

ALPRO ALMOND ORIGINAL

Ingredient	Common use / Other information
Water	To bind the ingredients.
Pea protein	To increase protein content (16% used in the recipe).
Rapeseed oil	To bind the ingredients.
Coconut oil	To bind the ingredients and acts as flavour enhancer.
Rice protein	To increase protein content.
Flavouring	For flavour.
Stabiliser	To bind the ingredients. Methylcellulose is used in this recipe (derived from cellulose).
Potato starch	A carbohydrate to help hold the ingredients together (similar to flour).
Apple extract	For flavour. Possibly also acting as an antioxidant to minimise oxidation and off flavours or to enhance a flavour.
Colour	To mimic the colour of meat. Beetroot Red is used – natural colour from beets (if it was labelled with an E number it would be E162).
Maltodextrin	A carbohydrate to help hold the ingredients together (similar to flour).
Pomegranate extract	Unable to ascertain specific use. Probably acting as an antioxidant to minimise oxidation and off flavours or to enhance a flavour.
Salt	For flavour and preservative.
Potassium chloride	To give a salty note but less than sodium chloride. Also acts as a preservative.
Concentrated lemon juice	To balance the flavour.
Maize vinegar	To balance the flavour.
Carrot powder	This has so many different uses so difficult to ascertain its role within this specific recipe.
Emulsifier	Used to help prevent separation among ingredients and improve texture (in this recipe it is sunflower lecithin).

Table 29.
Ingredients of Beef Burger

BEEF BURGER (TESCO)

Ingredient	Common use / Other information
Beef	94%.
Rice flour	Absorbs the oil and keeps the moisture inside the product.
Dried potato	To bind and thicken the recipe.
Water	To bind the ingredients.
Dried onion	For flavour.
Sea salt	For flavour and as a preservative.
Spices	For flavour.
Sugar	For flavour (sweetness).
Dextrose	For flavour (sweetness).
Preservative	To aid shelf life (sodium metabisulphite used in this recipe).
Salt	For flavour and preservative.
Black pepper	For flavour.

Table 30.
Ingredients of Future Farm Meatballs

FUTURE FARM MEATBALLS

Ingredient	Common use / Other information
Water	To bind the ingredients.
Vegetable protein	16% textured soy protein, 2% isolated soy protein, 0.5% pea protein, 0.5% chickpea flour.
Coconut fat	Used widely in plant-based meat alternatives for juiciness.
Modified food starch	Usually used for thickening the recipe.
Onion	For flavour.
Salt	For flavour and shelf life.
Dextrose	For flavour (to sweeten).
Colour	Colour to replicate meat. This one uses beetroot powder.
Stabiliser	To bind the ingredients. Methylcellulose is used in this recipe (derived from cellulose).
Natural flavouring	For flavour.

Table 31.
Ingredients of Beef Meatballs

BEEF MEATBALLS

Ingredient	Common use / Other information
Beef	86%.
Water	To bind the ingredients.
Rice flour	Absorbs the oil and keeps the moisture inside the product.
Salt	For Flavour and preservative.
Onion powder	For flavour.
Dextrose	For flavour (sweetness).
Sugar	For flavour (sweetness).
Yeast extract	For flavour.
Black pepper	For flavour.
Sunflower oil	To keep the ingredients together and to aid the cooking process.
Paprika	Possibly flavour or use as a colour.
Vegetable fibre	Possibly used for colour, texture or sensory purposes.
Preservative	To aid shelf life (sodium metabisulphite used in this recipe).
White pepper	For flavour.
Bay	For flavour.
Spice extracts	For flavour.
Flavouring	For flavour.

Table 32.
Ingredients of What the Cluck chicken-style pieces

WHAT THE CLUCK

Ingredient	Common use / Other information
Soy structure	88%; made of water and soy protein concentrate.
Spice extracts	For flavour.
Natural flavourings	For flavour.

Table 33.
Ingredients of Quorn chicken-style pieces

QUORN CHICKEN-STYLE PIECES

Ingredient	Common use / Other information
Mycoprotein	95% of the recipe.
Rehydrated free range egg white	To bind the ingredients together (Quorn products without egg are also available).
Natural flavouring	For flavour.
Firming agents	Help to keep the product together and extend the shelf-life: calcium chloride, calcium acetate.

COUNTRY CASE STUDY:

UK CONSUMPTION OF PLANT-BASED PROTEINS

SUMMARY

- In 2019 in the UK, plant-based protein products purchases were just 8% those of animal-based protein products.
- Overall, purchasing of animal-based protein is decreasing in the UK, while purchasing of plant-based protein products is increasing.
- Increases and decreases are not seen universally across all products in each animal and plant-based protein category. For plant-proteins, dairy alternatives are the only product where significant increased purchasing is seen. For animal-based protein products, purchasing of red meat (beef, lamb and pork), fish and dairy is decreasing, but purchasing of processed meat, poultry and eggs is increasing.
- There are no overall demographic trends for plant-based protein purchasing, but trends do exist on a more granular product basis. For example, the young (under 30s) are much more likely to purchase dairy and meat replacements, whereas older generations (65–74 years) are more likely to purchase nuts, legumes and oilseeds.

INTRODUCTION

The UK represents a popular and growing market for the consumption of plant-based proteins, with 39% of UK meat eaters reporting that they reduced the amount of meat they consumed in 2019.[95] The UK government collects detailed annual data on UK dietary trends, including consumption of plant-based food groups, in the Defra Family Food dataset.

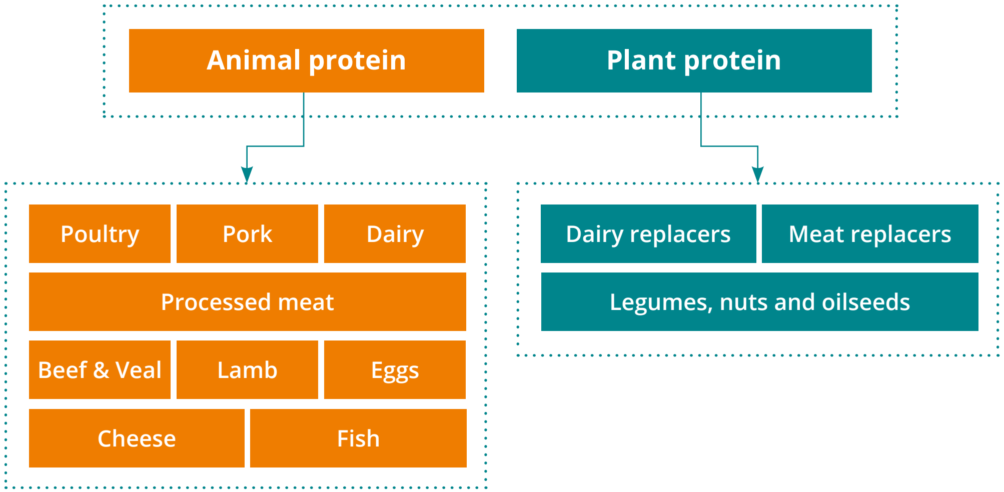
METHOD

The Defra Family Food dataset contains statistics on the average quantity of each food and drink category purchased per average person per week from 1974 to 2019. The dataset is comprehensive, is updated annually, and covers hundreds of different food product categories. Information can be downloaded by age group and by rural or urban population. The dataset is limited though, since it tells us about purchasing of food products rather than actual consumption, as it does not account for household food product waste (for example, purchased salad leaves are more likely to go off and not be consumed than digestive biscuits) or how food products are processed or cooked before consumption.

We selected all food products in the family food survey data that fit into 12 animal and plant-based categories: dairy replacements, meat replacements, legumes, nuts and seeds, poultry, pork, dairy, processed meat, beef and veal, lamb, eggs, cheese and fish. See figure 1 for 12 categories included in study, and table 34 for full list of products from the family food survey data included in each category.

Data was selected from 1990–2019, and a trend line was drawn to show projections to 2030.

Figure 1.
Categories of animal-based and plant-based protein



95 Mintel Press Team. (2020). Plant-based push: UK sales of meat-free foods shoot up 40% between 2014-2019. https://www.mintel.com/press-centre/food-and-drink/plant-based-push-uk-sales-of-meat-free-foods-shoot-up-40-between-2014-19 (accessed 30/06/2021)

Table 34.
Full breakdown of Family Food data included in each of the 12 food categories

	Food category	FF survey data foods
Animal-based protein	Beef and veal	Beef joints, beef steak, minced beef, all other beef and veal, ox liver, corned beef, beef sausages
	Pork	Pork joints, pork chops, pork fillets and steaks, all other pork, pig's liver, bacon and ham joints, bacon and ham rashers, uncooked pork sausages
	Lamb	Mutton, lamb joints, lamb chops, all other lamb, lamb's liver
	Poultry	Chicken and turkey, takeaway chicken, whole chicken or chicken pieces, poultry other than chicken or turkey
	Fish	White fish, blue fish, salmon, shellfish, takeaway fish and fish products, tinned salmon, other tinned or bottled fish, ready meals and other fish products
	Eggs and egg products	Eggs
	Processed meat	Other cooked and canned meat and meat products, meat pies, sausage rolls, burgers, complete meat-based ready meals, other convenience meat products, pâté, delicatessen-type sausages, meat pies, pasties and puddings, meat pastes and spreads, takeaway sausages, saveloys, and miscellaneous meat
Plant protein	Dairy	Evaporated milk, infant milks, instant dried milk, school milk, welfare milk, whole milks, skimmed milks, yoghurt, fromage frais, cream, dried milk products, dairy desserts, milk drinks and other milks
	Cheese	Hard cheese, cottage cheese, soft natural cheese, processed cheese
	Legumes, nuts and oilseeds	Fresh beans, baked beans, other canned beans and pulses, dried pulses other than air-dried, frozen beans, nuts and edible seeds, peanut butter
	Meat replacements *(novel protein foods)*	Soy and novel protein foods
	Dairy replacements *(plant-based milks)*	Non-dairy milk substitutes

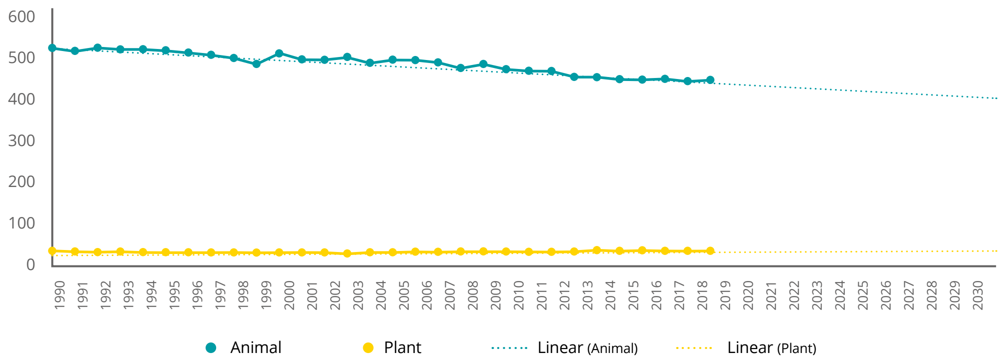
PLANT-BASED PROTEIN CONSUMPTION FINDINGS

The Defra family food survey data showed that plant-based protein consumption still remains significantly below that of meat protein. In 2019, the average UK person purchased 36g of plant-based protein products per day, whereas the total for animal-based protein products was 438g per day. This means the rate of plant-based purchasing is 8% that of animal-based protein (figure 2).

Different trends are observed over time across meat and plant-based protein products. There was a 15% reduction in purchasing of meat protein products from 1990–2019, whereas for plant-based products over the same time period there was a 24% increase. However, given that rates of plant-based consumption are low, this increase only equates to an additional 7g purchased per average person per day since 1990.

Figure 2.
Grams of animal and plant-based consumption per average UK person per day from 1990-2019 and projected to 2030.

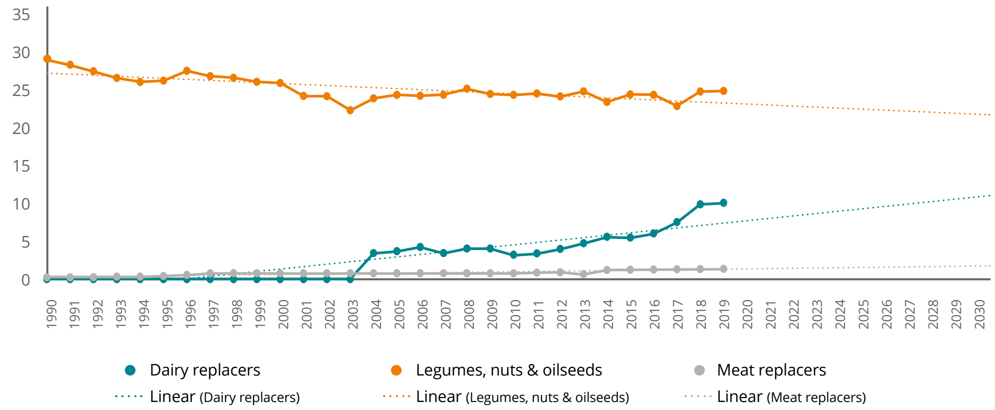
Animal protein consumption linear trends to 2030



When we analyse the trends broken down into plant-based protein products, we see a number of different trends emerging. Over 10 years from 2009–2019, the purchasing of dairy replacements increased significantly (by 150%), but the purchasing of meat replacements and legumes, nuts and oilseeds showed little overall trend up or downwards (figure 3).

Figure 3.
Purchasing of plant-based protein products per average UK person per day, 1990-2019, with trendline continued to 2030.

Plant protein consumption linear trends to 2030



ANIMAL-BASED PROTEIN CONSUMPTION FINDINGS

While the overall purchasing of animal-based protein products decreased from 1990–2019, we see that this downward trend is not true for all types of animal-based protein products. Purchasing of processed meat, poultry and eggs increased from 2009–2019 by 8%, 5% and 22% respectively. On the other hand, the purchasing of red meat declined by 47% for lamb, 16% for beef and veal, and 13% for pork. Fish consumption also decreased by 8%, and dairy by 13% over the same time period (figure 4).

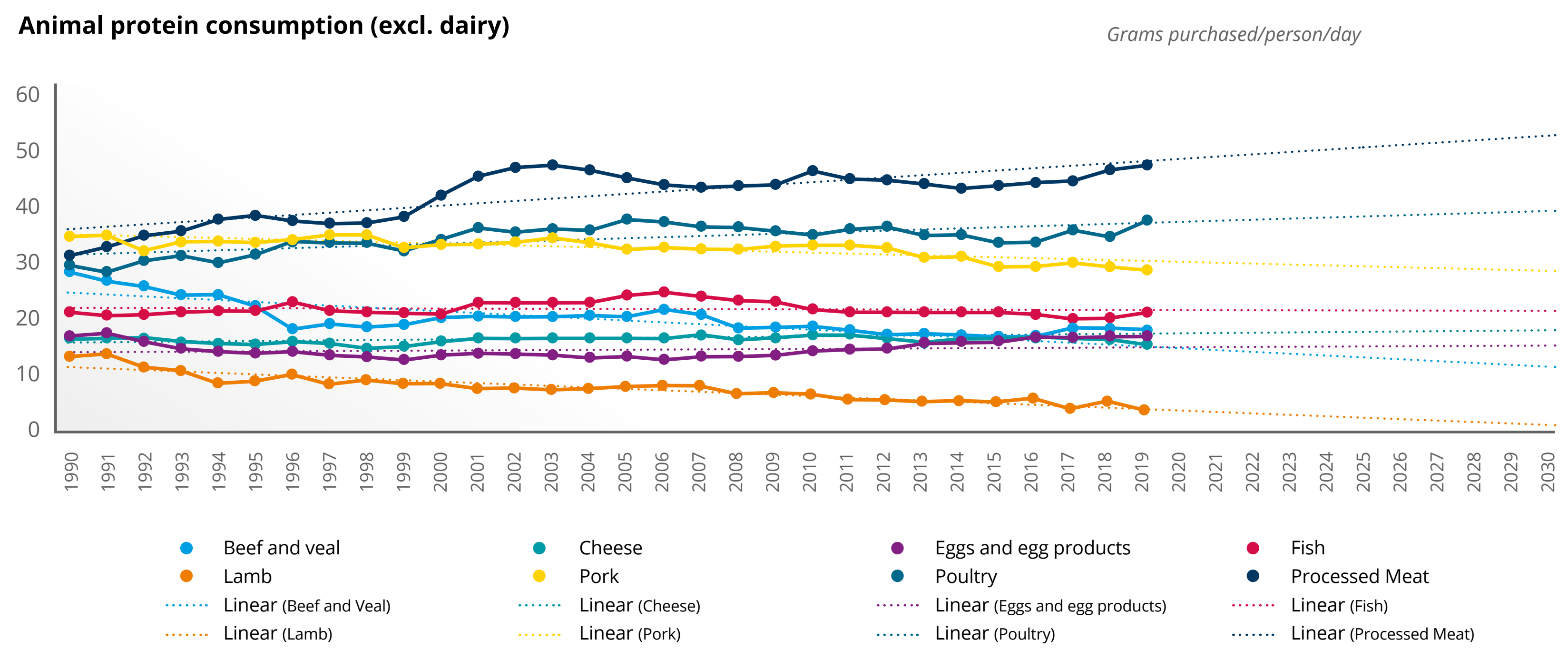
DEMOGRAPHIC TRENDS IN PLANT-BASED PROTEIN CONSUMPTION

We investigated whether purchasing of plant-based proteins differed according to age and location. For dairy replacements, rates of purchasing are higher for the young, and also slightly higher for rural populations. The under 30s age category purchases 53% more dairy replacements than the 65–74 age group, for example, and the rural population purchased 9% more than urban counterparts.

However, the opposite trend is seen for nuts, legumes and oilseeds, where purchasing is skewed towards the older, and slightly more towards urban populations. The under 30s purchased 30% less of this food category than the 65–74 age group, and the urban purchased 5% less than the rural population.

For meat replacements, rural and urban location does not impact purchasing in the UK. However, purchasing is much higher among the young, with the under 30s age group purchasing double the quantity of meat replacements than the 65–74 age group.

Figure 2.
Purchasing of animal-based protein products per average UK person per day, 1990–2019, with trendline continued to 2030.



SAFETY CHARACTERISTICS

OVERVIEW

Plant-based foods can contain allergens and be potential vessels of food-borne diseases. This section assesses how much concern should be given to these issues, with comparisons to allergen levels in animal-based protein equivalents where relevant. It also assesses the measures that are being taken by brands to address allergens and food-borne diseases.

SUMMARY

- Some plant-based proteins can cause allergic reactions. This is most prevalent in nut products.
- However, the overall prevalence of allergies to plant-based proteins, with the exception of nuts, is lower than to eggs and milk.
- Many processed plant-based protein alternatives are produced in settings handling allergens, and feature 'may contain X' labels to warn consumers about the risk of cross-contamination.
- Alpro and Quorn both responded to requests for additional information around handling of allergens and take additional steps to ensure allergens are not present in products.

PREVALENCE OF ALLERGENS

Any food containing protein can, in theory, cause an allergic reaction. Food allergies are much more common in children, but in most cases are outgrown by adulthood. Food allergies increased 18% in the decade between 1997 and 2007. There are a number of competing theories behind this increase, such as increased hygiene, microbiome changes, allergens avoidance in early life, vitamin D insufficiency, reduced antioxidants consumption and obesity.[96] Some people may avoid allergens without a diagnosed allergy, for example if they perceive gluten-free to be healthier.

Overall, allergies to plant-based proteins are lower than to eggs and milk, although it is worth noting that eggs and milk are sometimes used in plant-based branded products, such as egg-whites in Quorn sausages. Almonds and other tree nuts are the most common plant-based allergy, and are thought to affect 1% of the adult population. For this reason, products containing eggs, milk and almonds must be highlighted as allergens on-pack. Soy is the next most common food to be allergic to, and is thought to affect 0.4% of children, and a lower proportion of adults, and must also be highlighted on packaging as an allergen.

Mycoprotein, lentils, chickpeas and peas, on the other hand, are very unlikely to cause allergic reactions. For mycoprotein, Quorn reports that allergy prevalence is less than 1 in 100,000–200,000 people. Nevertheless, there have been some high publicity cases of children with mould spore allergies who have tragically died after eating a Quorn burger. Quorn does therefore include a short description on-pack about allergies, but mycoprotein is not classified as an allergen in any of the 16 countries where it is sold and does not therefore require emboldening on ingredients lists.

96 Mandalari, G. & Mackie, A.R. (2018). Almond allergy: An overview on prevalence, thresholds, regulations and allergen detection. Nutrients, 0(11):1706. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6266711/#:~:text=Data%20from%20the%20literature%20suggests,represents%20a%20potential%20allergenic%20hazard (accessed 30/6/2021)

Table 35.
Allergy prevalence for different ingredients in plant-based food products

Food	Allergy prevalance	Allergen clear on pack?	Other information
Mycoprotein *(Quorn)*	VERY LOW (<0.000001% or 1 in 100,000-200,000)	No Not classified as an allergen in any of the 16 countries where sold. Ingredient not emboldened, but in some countries short description on pack.	Occurs when people are allergic to mould spores. Have been high-profile cases of children who have died not realising they were allergic.
Eggs	MEDIUM (2% of children and 0.006% of adults)	Yes	Normally allergy to egg white, not yolk. Heating disrupts the protein responsible for egg allergy.
Milk	MEDIUM (2.5% of children and 0.006% of adults)	Yes	Heating disrupts the protein responsible for milk allergy – 70% of children with cow milk allergy tolerate baked cow milk.
Soy	LOW (0.4% of children, mostly outgrown by adulthood)	Yes	Sometimes avoided due to reasons other than an allergen, such as worries around GMO farming, or misconception that it affects hormone regulation.
Lentils, chickpeas and peas	VERY LOW (Exact prevalence unknown)	No	Possible to trigger allergic reaction, but prevalence thought to be very low.
Almonds	MEDIUM (1% of general population with tree nut allergies)	Yes	Higher prevalence in children compared with adults.
Wheat	MEDIUM (1% of children, 0.3% adults with wheat allergy, 1% of general population coeliac)	Yes	Only 24% of coeliac are diagnosed in UK.

PREVALENCE OF FOOD-BORNE DISEASES

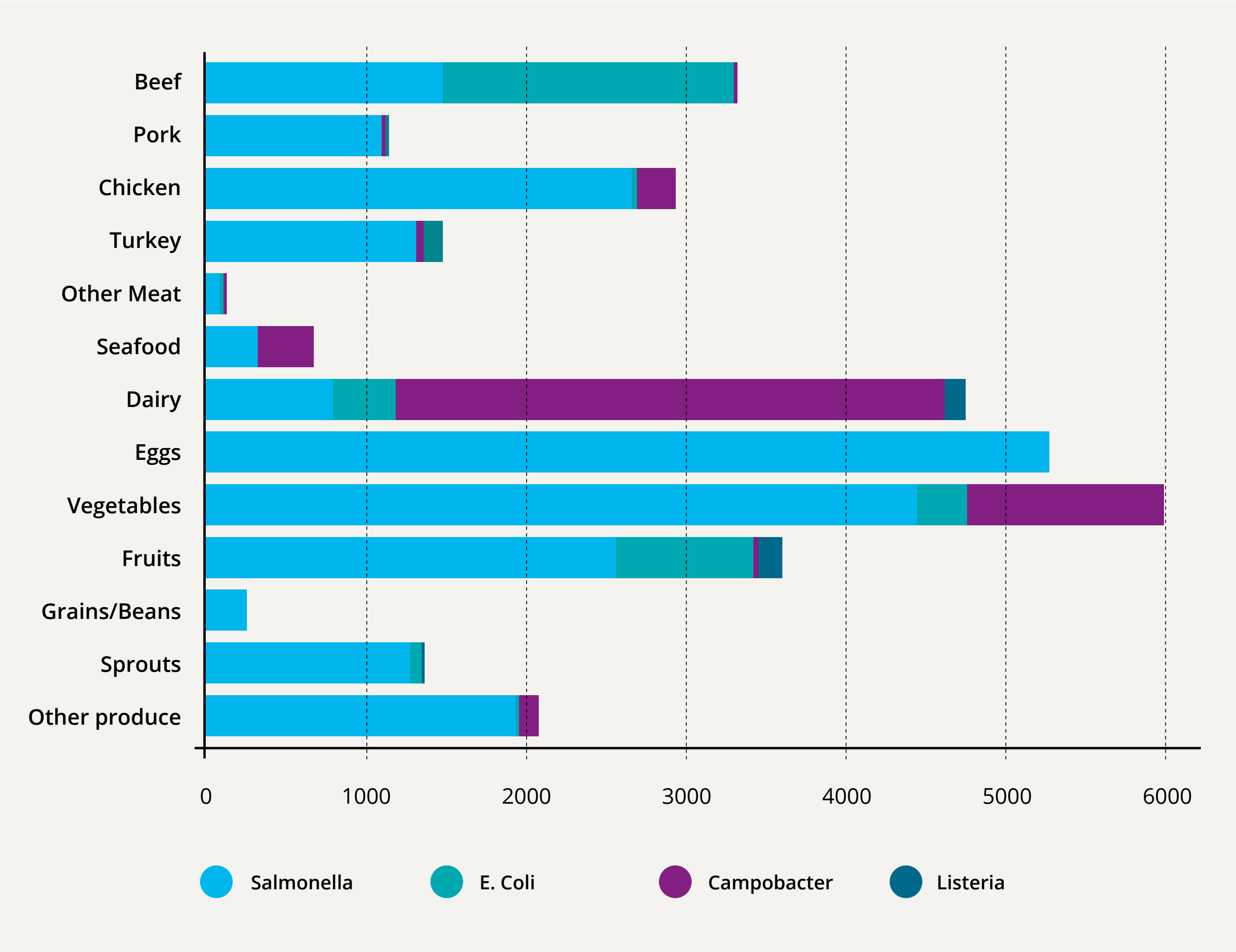
No data was found on the prevalence of food-borne diseases specifically in meat or dairy replacement products, which could be compared directly with meat counterparts. However, data was found in the US that details prevalence of food borne diseases in ingredients commonly used within plant-based protein products.

In the US, outbreaks of food-borne diseases are tracked along with the food source from which they originate[97] (figure 5). Surprisingly, vegetables were responsible for the greatest number of illnesses, most of which were due to Salmonella and E. coli. If the illnesses from fruits were added to those from vegetables, the total outweighed those from meat and poultry. Grains and beans, which are common components in plant-based foods, caused a much lower incidence of food-borne diseases.

It is worth bearing in mind when reading this data that it does not account for the extent to which different foods are consumed within US diets. For example, sprouts are consumed much less often than pork in US diets, so even though they are responsible for a similar number of food-borne illnesses, it would not be correct to interpret that they carry an equal disease risk.

97 Includes estimated total illnesses for only outbreaks that could be attributed to a single pathogen and food category (figure 5).

Figure 5.
Sources of food poisoning in the US between 1998 and 2012



It was unclear in the research if the highly processed forms of foods used in plant-based protein alternatives, such as soy protein isolate, carried the same risk as the unprocessed equivalent, such as cooked soy beans.

MEASURES TAKEN BY BRANDS

Top-selling brands of plant-based food products (Quorn, Alpro, What the Cluck, Beyond Burger and Future Farm) were contacted and asked:

- Are plant-based products manufactured alongside other allergens, with risk of contamination?
- What testing is done on products to understand presence of allergens?
- Do you assess the risks from food-borne diseases in products?

Responses were only received back from Quorn and Alpro, and so the information presented below also draws on publicly available information on company websites.

ALLERGENS: AVOIDING CROSS-CONTAMINATION AND TESTING

Alpro does handle allergens in its manufacturing facilities, such as almonds and hazelnuts, but takes steps to manage these to ensure that there is no risk to other products. If there is a risk of cross-contamination, then this is flagged to consumers on label.

Alpro reported using risk assessments to put in place testing programmes to detect any undeclared allergens, and that this runs through the whole product production cycle, from raw ingredients to processing and the end product.

Alpro guarantees that all products are dairy-free and lactose-free and works with Coeliac UK to ensure that the majority of products are also wheat- and gluten-free. Some Alpro products feature a 'may contain traces of almonds and hazelnuts' claim on label, where hazelnuts and almonds are handled at the same production facilities. Alpro has reported that this label will gradually be removed as Alpro undertakes a major investment programme to arrange its existing production lines to be dedicated to producing soy, rice and oat drinks or almond, hazelnut and coconut drinks.

Quorn informed us that they conduct swabbing of production equipment post cleaning a line to ensure that there are no allergen contaminants, and that all batches are also tested for allergens before sale. If there is any risk of cross-contamination from other allergens handled on the same production line, for example eggs, they would be advised as a 'may also contain' statement on product packaging.

What the Cluck chicken features the label 'may contain milk, egg, gluten, peanuts, and nuts', and no information was provided about allergies publicly by the brand making the product, 'the Vegetarian Butcher'.

Beyond Burger does not have any information on allergens or testing publicly on its website, only some advice in the FAQs section that those with a severe nut allergy should be cautious when introducing pea protein into their diet.

Future Farm provided no information on allergens on their website.

FOOD-BORNE DISEASES

Alpro reports using risk assessments to also test for risks of food-borne diseases, and that this again spans the whole supply chain. The company reported taking actions to avoid contamination, and that it verifies the absence of any food-borne diseases in products.

No brand other than Alpro responded to us on our request for information about testing or processes for food-borne diseases, and information was not found publicly on websites.

RECOMMENDATIONS

- **Prioritise plant-based meat alternative substitutions.** This research has demonstrated clearly that environmental savings can be achieved by substituting meat products with plant-based alternatives. That being said, the potential savings differ depending on the product, the country of origin, and the environmental indicator that is focused upon. Substitutions should be prioritised where the savings are greatest. From the five plant-based alternatives examined in this research, the biggest savings come from beef substitution, and this should therefore be a first step, where feasible and appropriate.
- **Examine and prioritise which environmental savings are most important for which market.** This research shows that for each environmental indicator examined (GHG emissions, land use, habitat loss and water use), each plant-based meat substitution offers a different level of savings. Each market and its supply chain will have a different level of importance attached to each environmental indicator – for example, water use will be much less of a concern for beef sourced from and sold in Ireland, but this would be a significant concern for beef sourced from and sold in Western America. Recommendations around substitutions for plant-based alternatives should be tailored to the environmental context of each market.
- **Incorporate nutrition considerations into decisions around plant-based meat substitutions.** This research, while limited to just five plant-based meat alternatives, shows that caution should be exercised around levels of salt and saturated fat content in products, as well as products such as plant-based milks where fortification is necessary. These considerations should be incorporated into plant-based alternative product development, due diligence work and procurement principles.
- **Contextualise nutrition findings into product serving formats.** Some plantbased alternatives already high in fat, salt or sugar may be normally served with sausages or foods that are also high in fat, salt or sugar, such as burgers with tomato ketchup and chips. This meal format should contextualise and be considered within nutrition decisions.
- **Appreciate the convenience considerations in transitioning to plant-based meal formats.** Plant-based proteins in their raw form can take a while to cook and prepare and require additional kitchen equipment and seasoning ingredients. Plant-based meat substitute products, on the other hand, can be quick and convenient and can add variety to vegetarian, vegan or flexitarian diets. They can also be good transition products for meat-eaters who are otherwise unfamiliar with plant-based foods or meal formats.
- **Minimise processing of plant-based products.** Less processed plant-proteins perform better nutritionally within this research, and so minimising the processing of ingredients should be prioritised when establishing new products and purchasing
- **Understand and manage trade-offs.** This research has shown that trade-offs can exist when making product substitutions between achieving environmental savings, optimising nutrition, and minimising the level of processing of products. A company position should be developed for navigating these trade-offs.

AREAS FOR FURTHER RESEARCH

This report has identified a number of areas for further research, outlined below. Ultimately, this is a topic on which customer attitudes are evolving rapidly, and new and more sophisticated plant-based products are regularly being launched. Staying abreast of these developments is crucial.

- **Define criteria of acceptable nutritional thresholds that plant-based alternatives should meet to be considered a nutritionally viable substitute.** This is important, especially given that some plant-based alternatives contain high levels of saturated fat, sugar and, especially, salt.
- **Explore cultural acceptance and appetite for plant-based alternatives in each priority market.** Some markets may be more receptive than others to the substitution of meat with plant-based alternatives. For example, Germany and the UK are significant European markets for the consumption of plant-based alternatives, but in France these products have faced a backlash, with meat-related terms, such as 'sausage', being prohibited from use on plant-based alternative product labels. Explore whether an increase in plant-based alternatives links to a substitutive effect in animal-based products.
- **Understand health implications.** Further research is required into the health implications of eating highly processed plant-based alternatives, to examine their role in the complexity of healthy sustainable diets beyond their protein, fat, vitamin and mineral content. All additives used in plant-based products are tested to ensure they are safe, but this still leaves questions regarding the health and safety implications of eating a high volume of these products regularly. Additional caution should be taken by vulnerable populations – children, women of childbearing age and the elderly, who may be at risk of suboptimal nutritional status with lower intakes of animal foods and higher intakes of ultra-processed foods.

- **Investigate any unintended consequences of upscaling plant-protein.** This research found no significant sustainable sourcing issues around plant-based protein products. Further research is required to understand how scaling up the production of plant-based alternatives will affect primary and secondary ingredient production and how the level of displacement of animal-based consumption with plant-based alternatives may affect environmental factors, as well as other actors and groups along the supply chain.
- **Understand price implications of plant-based ingredients and products.** Further research should be conducted to understand price implications of substituting meat ingredients or products with plant ingredients or products. It's likely there would be a range of price implications, given that some plant-based ingredients are relatively cheap, such as soy, whereas others, such as nuts, can be very expensive.
- **Stay abreast of developments around plant-based proteins.** Customer attitudes to and market availability of plant-based protein ingredients and products are changing rapidly. A system should be developed to stay on top of these developments.
- **Expand the scope of research.** This research has focused on a limited number of plant-based products and ingredients. While this sample has provided many useful insights, expanding this further to include more products and ingredients would be valuable for confirming current findings, and may offer potential new findings.
- **Look at food waste.** Food waste is an important metric to look at when evaluating the environmental sustainability of products. Further analysis could compare whether citizens are more likely to waste plant-based meat alternatives compared with animal-based products, whether more plant-based meat alternatives are wasted from lack of uptake (e.g., if they aren't sold, or have shorter sell-by dates). It would also be interesting to understand if any side streams come from these products, and if there are any innovative ways of repurposing these.
- **Support regenerative farming techniques.** Look at opportunities in the market for supporting products or raw commodities that are produced using regenerative farming practices.
- **Low cost**, **equitable plant-based alternatives.** In the short term it is important to focus on the immediate needs of those most affected by the cost-of-living crisis. Yet, if we don't get long-term solutions in place, we will continue to go from one crisis to the next, where the most hard-pressed households will time and again pay the price for future shocks. Working with academia and civil society, businesses need to identify affordable and equitable plant-based alternative options and help citizens access these.

CONCLUSION

Plant-based proteins and plant-based protein alternative products can play an important role in driving healthier and more sustainable diets. The environmental benefits of all plant-based protein alternative products investigated (Alpro almond drink, Quorn mycoprotein sausages, Beyond Burgers, Future Farm Meatballs and What the Cluck chicken) are unambiguous and significant, whereas the health comparisons show a slightly more nuanced picture. Some plant-based products, such as mycoprotein sausages, are clearly preferable, nutritionally, to meat equivalents. On the other hand, plant-based milks offer inferior nutrition on a number of indicators, and should at a minimum be fortified.

Wholefood plant-based proteins overall perform well in terms of sustainable sourcing issues in supply chains, and nutrition credentials. One exception to this is almonds, where production uses significant water quantities in drought-prone regions, particularly in California, and fat content means almond nut portion size should be limited to 30 grams. While soy used for livestock feed is strongly linked to deforestation and land use change in South America, this is much less likely to be the case for soy directly consumed by humans, mainly due to legislation in European markets prohibiting direct human consumption of GMO crops. Soy also performs well nutritionally, is low in saturated fat, and is a particularly good source of protein.

The research did not raise any significant concerns around allergens, food-borne diseases, or use of additives or gums in plant-based foods, although it should be noted that exclusively plant-based diets should be carefully planned to ensure all micronutrient needs are met.

This research compares the environmental and health characteristics of five best-selling plant-based meat alternatives, and five unprocessed plant-based proteins. Its aim is to provide an insight into the pertinent issues based on a sample of best-selling options, and is not a complete comparison of all the plant-based alternative products and ingredients that are available, nor an in depth look at all the complex health and environmental issues that could arise from substitution. It identifies several other areas for further research, including understanding the level of cultural acceptance of plant-based alternatives across different markets, as well as greater research into any health implications of excessive consumption of highly processed plant-based food products. Ultimately, this is a topic on which customer attitudes are evolving rapidly, and new and more sophisticated plant-based products are regularly being launched, and a system should be put in place to stay abreast of these developments.

Despite the promising potential of plant-based protein alternatives, particularly for environmental savings, their consumption still lags behind that of meat – purchasing of plant-based products was just 8% of animal-based protein products in the UK in 2019. While in the UK market the purchasing of plant foods is increasing, and that of meat products is decreasing overall, with some exceptions, such as processed meats, the pace of change is not yet fast enough for there even to be comparable consumption levels in the near future for these two sets of products.

IMPORTANT NUTRIENTS

PROTEIN

Why is protein important?

Protein is essential for the growth, maintenance and repair of all body cells. Protein also provides energy and amino acids (some of which we cannot make ourselves and so need to get from our diet).

There is often concern that reducing meat and dairy intake will lead to reduced protein intake; however, studies consistently demonstrate that UK average protein intakes exceed recommendations for all age groups, including vegans.[98]

On a weight-by-weight basis, plant foods compared with animal-based foods contain less protein, but this is due to their more rounded macronutrient content: low in saturated fat, lower energy density, provision of complex carbohydrates and an excellent source of fibre.

Animal-based foods are commonly known as 'complete proteins' because they contain all 20 amino acids (building blocks of protein), including all nine essential amino acids (EAAs). Essential amino acids are those that the body cannot make itself and therefore have to be provided by food or dietary supplementation.

Plants do contain all the EAAs, but two of these (lysine and methionine; found in grains and legumes respectively) are present in lower amounts in plant foods proportionate to amino acid needs, and they therefore should ideally be consumed within the same 24-hour period so their amino acid profiles complement each other.

For the elderly, and those with greater muscle protein synthesis needs (for example, athletes), a greater proportion of protein needs to be consumed if this is coming solely from plants.

FATS

Why is fat important?

Fat provides essential fatty acids (that we can't make ourselves but need in small amounts) as well as energy. Fat is required for a range of bodily processes and to maintain the normal structure of cells in the body. It also carries essential fat-soluble vitamins and is important for their absorption.

Total fat and saturated fat intakes are generally not a concern with plant-based diets; however, as some essential fats are predominantly found in oily fish, consideration should be given to ensuring adequate omega-3 fatty acids when this is limited or absent from the diet.

There are some omega-3 plant-based sources (linseeds, flax seeds, chia seeds, hemp seeds, walnuts, rapeseed oil, soybeans and soybean oil), but the amounts contained are considerably limited. Supplements from microalgae are also available.

On average, all age groups consume less than the recommended amount of oily fish, even those not following a vegan or vegetarian diet.[99]

IRON

Why is iron important?

Iron helps to make red blood cells, which carry oxygen around the body. It also helps the immune system to work as it should; helps the brain to function normally and supports growth and development in childhood.

The main sources of iron in UK diets, across all age groups, is cereal foods (41–55% of total iron intake) and meat (12–21% contribution). The significant iron contribution from cereals is reflective of the UK regulation that white and brown flours milled in the UK have to be fortified with iron.

Good sources of iron include red meat, beans, pulses, nuts and seeds, fish, quinoa, wholemeal bread and dried fruit.

98 BDA. (n.d.). Nutritional considerations for dietitians. https://www.bda.uk.com/uploads/assets/e659bcdb-221d-4490-a21ccbb0aad5ecd0/Practical-guide-nutritional-considerations-re-PROTEIN.pdf (accessed 30/06/2021)

99 BDA. (2018). Eating patterns for health and environmental sustainability. https://www.bda.uk.com/uploads/assets/539e2268-7991-4d24-b9ee867c1b2808fc/a1283104-a0dd-476b-bda723452ae93870/one%20blue%20dot%20reference%20guide.pdf, page 69. (accessed 30/06/2021)

The presence of iron enhancers and inhibitors in the diet can highly influence iron absorption and bioavailability. Iron in plant-based foods takes the form of non-haem iron, which is not as bioavailable as haem iron (such as that from meat).

Iron intakes can be inhibited in plant-based diets by:

- Polyphenols and tannins found in tea, coffee, some vegetables such as spinach and some cereals.
- Foods which are high in phytates, such as grains and legumes.
- Food high in calcium (calcium competes with iron in the gut).

Iron intakes can be enhanced in plant-based diets by:

- Ensuring high polyphenol and tannin foods and drinks are consumed away from iron rich meals and snacks.
- Suitable food preparation techniques such as boiling, soaking, fermentation, germination, milling and heat processes. These can reduce phytate content significantly.
- Including iron-rich plant foods at all meals and including plenty of vitamin C in the diet through fruit and vegetables.
- Consumption of fortified breakfast cereals, nuts and seeds.
- Including fermented soy products such as tempeh and miso, and yeast-leavened bread.
- Inclusion of some meat, poultry or fish (plant-based diets can include a small amount of these).

Men are unlikely to struggle to meet iron requirements from plant sources due to relatively lower iron requirements; however, in more vulnerable groups, such as toddlers, teenage girls and women of childbearing age, low iron intake is a concern.

There is some evidence that the absorption process can adapt over time in vegetarians.[100]

100 BDA. (2018). Eating patterns for health and environmental sustainability. https://www.bda.uk.com/uploads/assets/539e2268-7991-4d24-b9ee867c1b2808fc/a1283104-a0dd-476b-bda723452ae93870/one%20blue%20dot%20reference%20guide.pdf, page 64 (accessed 30/06/2021)

VITAMIN B12

Why is vitamin B12 important?

Vitamin B12 helps the body keep the nervous system healthy, it is needed for the production of red blood cells, metabolises folate and helps the body use energy.

Vitamin B12 is found exclusively in foods of animal origin. Fortified foods, or more preferably a regular supplement, are usually advised for individuals not consuming meat, poultry, seafood, or consuming very little. Vegetarians who consume sufficient milk, yoghurt, cheese and eggs may not need a supplement.

Many plant-based products are now fortified with vitamin B12, including some breakfast cereals, plant-based drinks and yoghurt alternatives. Nutritional yeast flakes or yeast extract are also good sources of vitamin B12, however they can be high in salt.

CALCIUM

Why is calcium important?

Calcium helps build strong bones and teeth, is important for muscle contraction and ensures the blood clots properly. Requirements for calcium are raised during childhood and adolescence as 40% of lifetime bone mass is accumulated.

Milk and milk-based products supply much of the UK population's calcium intake; however, it is also found in white and brown flour milled in the UK (which legally must be fortified with calcium) and associated cereal products. Many vegetables also contain small amounts of calcium and the bioavailability of calcium from green vegetables is generally high, particularly if the oxalate content is low, such as with broccoli, kale and pak choi. Absorption is about 50% (dairy about 30%). Absorption from high-oxalate vegetables, such as spinach and Swiss chard, may be as low as 5%, and so despite their high calcium content, they cannot be considered good sources.

There is a wide range of calcium-fortified plant-based drinks and other products, which can be used in place of dairy products. These are often also fortified with vitamin D to enhance calcium absorption. Organic varieties are not permitted to be fortified.

Soy foods, such as calcium-set tofu and calcium-fortified soy drinks, have similar bioavailability to milk and can be considered good alternatives to dairy.

ZINC

Why is zinc important?

Zinc is involved in a multitude of biological processes and, similar to iron, zinc intakes can be compromised in teenage girls.

Animal-based foods (meat, milk and milk products) are a significant source of zinc in the UK diet; however, good plant sources of zinc include mycoprotein, fortified breakfast cereals, beans and lentils, sunflower seeds, pumpkin seeds and nuts. Some of these contain phytates though, which inhibit zinc absorption. The following can boost absorption:

- Treatment with high temperatures (canned products).
- Toasting.
- Soaking and discarding the water.

IODINE

Why is iodine important?

Iodine is important in the production of thyroid hormones and plays a vital role in the cognitive development of a growing foetus and young children.

Data can vary significantly between products as iodine content is highly variable; it depends on seasons and farming practices. Iodine in milk is a by-product of iodine added to animal feed or used as a disinfectant, and organic farming practices can lead to lower iodine content.

There have been concerns raised about the iodine status of various population subgroups in the UK, with the UK even being classified as a mildly iodine-deficient country. In diets where milk/milk products/fish are limited or excluded, iodine-fortified products or a supplement is usually required.[101]

It is advisable that any plant-based drinks are fortified with iodine (in addition to vitamin B12, calcium and vitamin D).

101 Dineva, M., et al. (2020). Iodine status of consumers of milk-alternative drinks v. cows' milk: data from the UK National Diet and Nutrition Survey. British Journal of Nutrition, 126(1). https://www.cambridge.org/core/journals/british-journal-of-nutrition/article/iodine-status-of-consumers-of-milkalternative-drinks-v-cows-milk-data-from-the-uk-national-diet-and-nutrition-survey/B099FDBEA1A014C4D3273D4F0FFEDB13 (accessed 30/06/2021)

VITAMIN D

Why is vitamin D important?

Vitamin D helps regulate calcium and phosphate in the body, which keeps teeth, bones and muscle healthy. It is made in our bodies when our skin is exposed to appropriate sunlight.

In the Northern hemisphere we can usually obtain vitamin D from the sunshine between April and September. During the winter months, however, we need to get vitamin D from our diet because the sun isn't strong enough for the body to make it.

With the exception of oily fish and cod liver oil, there are few other dietary sources, such as egg yolks, meat and liver, which are sources of vitamin D, albeit still in low quantities. Some foods are fortified, such as margarines, breakfast cereals, plant-based drinks and yoghurt alternatives. Dairy products in the UK are not a source of vitamin D as they are not fortified as standard (unlike in the US and other European countries). Mushrooms can be a good source of vitamin D, but these must be exposed to UV light.

The UK government recommends everyone (regardless of diet) takes a vitamin D supplement during the autumn and winter months. Some vitamin D supplements are not suitable for vegans. vitamin D2 and lichen-derived Vitamin D3 are suitable.

SELENIUM

Why is selenium important?

Selenium helps to protect the cells in our bodies against damage. It also helps the immune and thyroid systems to work as they should, and maintain normal skin and nails and normal fertility in males.

Most selenium in UK diets comes from cereals, meat and seafood, and intakes may be compromised if animal-based foods are limited. This very much depends on the overall dietary pattern, and it's quite easy to get enough selenium in the diet when well-informed.

Brazil nuts are an excellent source of selenium, as well as brown rice, seeded bread, baked beans, green and brown lentils, kidney beans, cashew nuts, pecans, sunflower seeds, chia and flax/linseeds.

Five to six Brazil nuts daily will provide the recommended adult intake of selenium.

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