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## Scientific advice related to nutrient profiling for the development of harmonised mandatory front-of-pack nutrition labelling and the setting of nutrient profiles for restricting nutrition and health claims on foods

EFSA Panel on Nutrition, Novel Foods and Food Allergens (NDA),  
Dominique Turck, Torsten Bohn, Jacqueline Castenmiller, Stefaan de Henauw,  
Karen Ildico Hirsch-Ernst, Helle Katrine Knutsen, Alexandre Maciuk, Inge Mangelsdorf,  
Harry J McArdle, Androniki Naska, Carmen Peláez, Kristina Pentieva, Frank Thies,  
Sophia Tsabouri, Marco Vinceti, Jean-Louis Bresson and Alfonso Siani

### Abstract

Following a request from the European Commission, the EFSA Panel on Nutrition, Novel Foods and Food Allergens (NDA) was asked to deliver scientific advice related to nutrient profiling for the development of harmonised mandatory front-of-pack nutrition labelling and the setting of nutrient profiles for restricting nutrition and health claims on foods. This Opinion is based on systematic reviews and meta-analyses of human studies on nutritionally adequate diets, data from the Global Burden of Disease framework, clinical practice guidelines, previous EFSA opinions and the priorities set by EU Member States in the context of their Food-Based Dietary Guidelines and associated nutrient/food intake recommendations. Relevant publications were retrieved through comprehensive searches in PubMed. The nutrients included in the assessment are those likely to be consumed in excess or in inadequate amounts in a majority of European countries. Food groups with important roles in European diets have been considered. The Panel concludes that dietary intakes of saturated fatty acids (SFA), sodium and added/free sugars are above, and intakes of dietary fibre and potassium below, current dietary recommendations in a majority of European populations. As excess intakes of SFAs, sodium and added/free sugars and inadequate intakes of dietary fibre and potassium are associated with adverse health effects, they could be included in nutrient profiling models. Energy could be included because a reduction in energy intake is of public health importance for European populations. In food group/category-based nutrient profiling models, total fat could replace energy in most food groups owing to its high-energy density, while the energy density of food groups with low or no fat content may be well accounted for by the inclusion of (added/free) sugars. Some nutrients may be included in nutrient profiling models for reasons other than their public health importance, e.g. as a proxy for other nutrients of public health importance, or to allow for a better discrimination of foods within the same food category.

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**Correspondence:** [nda@efsa.europa.eu](mailto:nda@efsa.europa.eu)

**Panel members:** Dominique Turck, Torsten Bohn, Jacqueline Castenmiller, Stefaan De Henauw, Karen Ildico Hirsch-Ernst, Helle Katrine Knutsen, Alexandre Maciuk, Inge Mangelsdorf, Harry J McArdle, Androniki Naska, Carmen Peláez, Kristina Pentieva, Alfonso Siani, Frank Thies, Sophia Tsabouri and Marco Vinceti.

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## 1. Introduction

There is evidence from human studies about the relationship between the intake of certain nutrients and non-nutrient components of food and the development of obesity and other diet-related chronic diseases that are of importance for public health in Europe. Cardiovascular diseases (CVD), diabetes mellitus, obesity, osteoporosis, dental caries and cancer, but also iodine and iron deficiency, among others, have been considered by several European countries as public health priorities when setting food-based dietary guidelines (FBDGs) (see Appendix B, results of a questionnaire sent by EFSA to EU/EAA countries).

According to the Global Burden of Disease (GBD) database,<sup>1</sup> in 2019, around 12% of the EU population (~ 60 million people) were affected by CVD, with around 6 million new cases diagnosed per year. Around 10% (~ 49 million people) suffered from type 2 diabetes mellitus (T2DM) (2 million new cases per year). Around 15% of adults were considered obese (BMI > 30 kg/m<sup>2</sup>, data from 2017)<sup>2</sup> and more than 23 million individuals in the EU (i.e. ~ 5% of the population) are at high risk of osteoporotic fractures (Kanis et al., 2021). Dental caries affects 20–90% of 6-year-olds and almost 100% of adults.<sup>3</sup> Also, some types of cancers are related to diet, in particular, cancers of the gastrointestinal tract (WCRF/AICR, 2018).

A diet in line with science-based recommendations for food and nutrient intake is an important determinant of health. Because diets are composed of multiple foods, overall dietary balance may be achieved through complementation of foods with different nutrient profiles so that it is not necessary for individual foods to match the nutrient profile of a nutritionally adequate diet. Nevertheless, individual foods might influence the nutrient profile of the overall diet, depending on the nutrient profile of the particular food and its intake, in terms of frequency and amount (EFSA NDA Panel, 2008).

The term 'nutrient profile' refers to the nutritional composition of a food or diet, whereas 'nutrient profiling' refers to the classification of foods based on their nutritional composition for specific purposes (e.g. nutrition education, product reformulation, product labelling to help consumers make informed dietary choices, regulation of health claims, restriction of advertisement to children) (EFSA NDA Panel, 2008). The World Health Organization (WHO) defines nutrient profiling as 'the science of classifying or ranking foods according to their nutritional composition for reasons related to preventing disease and promoting health' (WHO, 2015b; Storcksdieck genannt Bonsmann et al., 2020a).

Several nutrient-profiling models have been developed worldwide. A systematic review that took into account publications up to 2016 identified 78 published nutrient profiling models (Labonté et al., 2018), of which 56% were newly developed models and 44% were a modification of an existing model. The models have been mainly drawn up for the purpose of establishing food standards for schools (n = 27), front-of-pack labelling (n = 12), restricting marketing of foods to children (n = 10) and regulating health claims made on foods (n = 7).

Nutrient-profiling models may be established by using the same criteria for all foods/food categories (i.e. across the board), or may be specific to certain food groups/categories of food (i.e. category-based models), or a combination of these (e.g. by using the same criteria for all foods with exemptions from the general profile for a limited number of food groups or subgroups thereof) (EFSA, 2008; see also Section 3.2). The models may be based either on thresholds for individual nutrients or on an overall composite score that is the sum of scores attributed to foods according to specific criteria (EFSA NDA Panel, 2008; Santos et al., 2021). The majority of the nutrient-profiling models identified by Labonté et al. (2018) were scoring systems, whereas three were based on thresholds of nutrients and four were hybrid systems. The majority had more than one food category to which different nutritional criteria were applied (ranging up to 99 categories). Only three models applied the same criteria across the board and 12 consisted of two categories. All models included nutrients and non-nutrient components of food that should be limited in the diet. These were mainly sodium, saturated fatty acids (SFAs) and sugars. Eighty-six per cent of the models also included food groups (e.g. fruits, vegetables, nuts, legumes), nutrients (e.g. protein) and non-nutrient food components (e.g. dietary fibre) whose consumption should be increased. A recent systematic review of existing nutrient-profiling models, including, however, fewer models, shows similar results (Santos et al., 2021).

<sup>1</sup> <https://ghdx.healthdata.org/>

<sup>2</sup> [https://ec.europa.eu/eurostat/databrowser/view/sdg\\_02\\_10/default/table?lang=en](https://ec.europa.eu/eurostat/databrowser/view/sdg_02_10/default/table?lang=en)

<sup>3</sup> <https://www.euro.who.int/en/health-topics/disease-prevention/oral-health/data-and-statistics#:~:text=In%20Europe%2C%2020%E2%80%9390%25,have%20experience%20of%20the%20disease>

An important consideration when establishing nutrient-profiling models is the reference quantity to which the nutrient content of a food is related, i.e. per serving size/portion, per weight/volume or per energy content. The advantages and disadvantages of the different options have been reviewed previously in detail by EFSA NDA Panel (2008). Finally, the validation of a nutrient-profiling model is of importance in order to ensure the correct classification of foods for the purpose for which the model has been developed (Santos et al., 2021). Nutrient-profiling models developed for the purpose of restricting nutrition and health claims have been reviewed by EFSA NDA Panel (2008), Labonté et al. (2018) and Santos et al. (2021).

Front-of-pack (FOP) labelling is simplified nutrition information provided on the front of food packages aiming at helping consumers with their food choices<sup>4</sup>. FOP labelling schemes are either 'nutrient-specific' or 'summary indicators'. 'Nutrient-specific' schemes repeat some or all of the numerical information from the mandatory nutrition declaration in a neutral, non-evaluative way (so-called reductive schemes) or evaluate the nutrition information for the consumer by using e.g. traffic-light colours or wording such as 'high', 'medium', 'low' for each nutrient (so-called evaluative systems). 'Summary indicator' schemes are all evaluative schemes and express the overall nutritional value of a food by using some or all the information from the nutrition declaration and/or other nutritional elements. 'Summary indicator' schemes can be subdivided into 'graded' indicators, that provide global and graded information on the overall nutritional value of foods and can be applied on all food products (e.g. Nutri-Score, the Health Star Rating system), and 'positive' indicators (e.g. endorsement logos), that can be applied only on foods complying with certain nutritional criteria. By definition, all evaluative FOP schemes, either 'nutrient-specific' or 'summary indicators', are based on nutrient-profiling models. FOP labelling may take different forms, as reviewed by the Joint Research Centre (JRC) of the European Commission (Storcksdieck genannt Bonsmann et al., 2020a).

### 1.1. Background as provided by the mandate requestor

The Commission adopted on 20 May 2020 the Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system<sup>5</sup>, as part of the European Green Deal. The strategy announces that to promote sustainable food consumption and facilitate the shift to healthy and sustainable diets, the Commission will adopt measures to empower consumers to make informed, healthy and sustainable food choices. In particular, the strategy announces that the Commission will propose harmonised mandatory front-of-pack nutrition labelling. The strategy further announces that to stimulate sustainable food processing and reformulation but also to facilitate the shift to healthier diets, the Commission will set nutrient profiles to restrict the promotion (via nutrition and health claims) of foods high in fat, sugars and salt.

The Farm to Fork Action Plan indicates that a proposal for harmonised mandatory front-of-pack nutrition labelling and for the setting of nutrient profiles to restrict the promotion of foods high in salt, sugars and/or fat will be submitted in Q4 2022.

On 20 May 2020, the Commission also published its Staff Working Document of the Evaluation of the Nutrition and Health Claims Regulation (European Commission, 2020a), accompanying the Farm to Fork Strategy. The evaluation assessed the impact of the non-setting of nutrient profiles and whether nutrient profiles are still fit for their purpose to ensure the objectives of the Claims Regulation. Overall, the evaluation findings show that the specific objective pursued by the setting of nutrient profiles is still pertinent and necessary to meet the objective of the Claims Regulation, which is a high level of consumer protection, and that therefore, the setting of nutrient profiles needs to be further considered. Article 4 of Regulation 1924/2006 on Nutrition and Health Claims on Foods foresees that the European Commission shall establish (by 19 January 2009) specific nutrient profiles that foods or certain groups of foods must respect in order to bear nutrition and health claims. Following the Commission's request of 19 February 2007, EFSA adopted on 31 January 2008 the Scientific Opinion of the Panel on Dietetic Products, Nutrition and Allergies on the setting of nutrient profiles for foods bearing nutrition and health claims. Despite the initial progress, nutrient profiles have not yet been established at EU level given the high controversy of the topic and strong opposition by some Member States in 2009, when the Commission tried to establish them.

<sup>4</sup> [https://ec.europa.eu/food/safety/labelling-and-nutrition/food-information-consumers-legislation/nutrition-labelling\\_en](https://ec.europa.eu/food/safety/labelling-and-nutrition/food-information-consumers-legislation/nutrition-labelling_en)

<sup>5</sup> Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system, COM (2020) 381 final.

On 20 May 2020, the Commission also adopted its report on front-of-pack nutrition labelling (European Commission, 2020b), accompanying the Farm to Fork Strategy. The Report presents the main front-of-pack nutrition labelling schemes currently implemented or being developed at EU level, as well as some of the schemes implemented at international level. The report looks into consumer understanding and impacts of the schemes, including on purchasing behaviour, food reformulation and the internal market. It also addresses the positions of Member States and stakeholders and the question of possible EU harmonisation. The report builds upon literature reviews and data gathered and analysed by the Joint Research Centre (Storcksdieck genannt Bonsmann et al., 2020a). The report concludes that front-of-pack schemes have the potential to help consumers make health-conscious food choices and that evaluative schemes that use colour coding, with or without a graded indicator, appear most promising for improving the healthfulness of consumers' shopping baskets.

Nutrient profiling has various applications, including for health and nutrition claims and for front-of-pack nutrition labelling schemes. There are three main approaches for applying nutrient (profiling) criteria for front-of-pack labelling and the specific approach depends on the front-of-pack nutrition labelling system used (WHO, 2019).

The first typical approach to applying nutrient criteria is to enumerate the nutrient contribution that a food makes to recommended nutrient intakes (e.g. Reference Intakes); information on individual nutrients is kept separate. This approach is used in non-interpretive nutrient-specific front-of-pack schemes.<sup>6</sup>

The second typical approach to applying nutrient profiling criteria<sup>7</sup> is to set threshold amounts (i.e. cut-off points) for individual nutrients, which divide nutrient contributions into categories that are either graded (e.g. high, medium and low in the case of the traffic lights label) or binary (e.g. meet the standard and do not meet the standard in the case of endorsement logos). Information on individual nutrients is kept separate. For endorsement logos, products only display the logo when all relevant cut-off points for individual nutrients are met.<sup>8</sup>

The third typical approach is to apply algorithms to derive a consolidated score representing products' overall nutritional profile. Information on individual nutrients is combined. The approach is used for summary graded indicator schemes.

The second and third approaches differ from the first by interpreting the level of nutrient contribution that a food makes to dietary recommendations, going beyond the provision of numeric information.

Applying nutrient profiling approaches for the purpose of front-of-pack nutrition labelling and for the purpose of restricting nutrition and health claims on foods is an exercise that should take into account dietary recommendations, public health considerations, generally acceptable scientific evidence on the relationship between diet, nutrition and health as well as other considerations of an industrial/commercial, cultural and dietary/culinary nature. Applying nutrient profiling approaches for front-of-pack labelling and for restricting claims should also stimulate product reformulation and should take into account the variability of dietary habits and traditions.

## 1.2. Terms of Reference as provided by the mandate requestor

In accordance with Article 29(1)(a) of Regulation (EC) No 178/2002, the European Commission requests the European Food Safety Authority to provide scientific advice for the development of harmonised mandatory front-of-pack nutrition labelling and the setting of nutrient profiles for restricting nutrition and health claims on foods. In particular, the Authority is requested to provide scientific advice on the following:

- **Nutrients** of public health importance for European populations, **including non-nutrient components** of food (e.g. energy, dietary fibre)
- **Food groups** which have important roles in diets of European populations and subgroups thereof
- **Choice of nutrients and non-nutrient components of food for nutrient profiling**

<sup>6</sup> While such nutrient-specific schemes do provide some assessment of the contribution that a serving of food makes to nutrient intakes, such systems do not provide an evaluative judgement about how numerical values should be interpreted and, consequently, are referred to as a non-interpretive (WHO Health Evidence Network Synthesis Report 61).

<sup>7</sup> For the second and third approach, the terminology 'nutrient profiling' criteria is used; nutrient profiling is the science of classifying or ranking foods according to their nutritional composition for reasons related to preventing disease and promoting health (<https://www.who.int/nutrition/topics/profiling/en/>).

<sup>8</sup> Endorsement logos are therefore also considered as 'summary labels'.

*In providing scientific advice, the Authority is requested to consider the following:*

### **Nutrients of public health importance for European populations, including non-nutrient components of food (e.g. energy, dietary fibre)**

The consideration regarding nutrients as well as non-nutrient food components should be based on evidence of a dietary imbalance in European populations that might influence the development of overweight and obesity or diet-related diseases such as cardiovascular disease, or other disorders; they can include nutrients and non-nutrient food components that might be consumed to excess, as well as those for which intakes might be inadequate.

### **Food groups which have important roles in diets of European populations and subgroups thereof**

Consideration should be given to the food groups/food categories which have important roles in diets of European populations and subgroups.

- due to the quantities of energy, certain macro- and micronutrients, other substances of physiological importance as well as for non-nutrient food components contained in the food group/food category,
- due to the role and importance of the food group/food category in the diet for the population in general or, as appropriate, of certain risk groups including children,
- due to the overall nutritional composition of the food group/food category,
- due to the presence or absence of nutritional elements that have been scientifically recognised as having an effect on health and
- due to effects on health of consuming the food group/food category.

### **Choice of nutrients and non-nutrient components of food for nutrient profiling**

The nutritional criteria and food components for nutrient profiling should aim to inform choice and enable interpretation of food products against risks for diet-related noncommunicable diseases (NCDs) and for promoting healthy diets.

The choice of nutrients of public health importance (e.g. sodium), including non-nutrient components of food (e.g. energy, other substances of physiological importance such as fibre) should be based on scientific evidence that underpins - directly or indirectly - the association of food components/food groups/food categories and related public health outcomes.

## **1.3. Context of the assessment**

Upon a request from the European Commission, in 2008, the NDA Panel provided advice on nutrient profiling with the sole purpose of regulating nutrition and health claims made on foods (EFSA NDA Panel, 2008). The purpose was to avoid that nutrition or health claims could mislead consumers as to the overall nutritional composition of a food when trying to make 'healthy' choices in the context of a nutritionally adequate diet. Nutrient-profiling models aimed at restricting nutrition and health claims on foods were not meant to communicate nutrition information to the consumer. When classifying foods as eligible to bear claims, the potential of the food to adversely affect the overall dietary balance was the main scientific consideration.

In the present mandate, the Commission requests EFSA to provide scientific advice for the development of harmonised mandatory front-of-pack nutrition labelling and the setting of nutrient profiles for restricting nutrition and health claims on foods. This means that the scientific advice provided by the NDA Panel in 2008 should be extended for the purpose of helping consumers make 'healthy' choices through FOP labelling, and thus, the main scientific consideration should also include the potential of foods to beneficially affect the overall dietary balance.

In the general principles for setting nutrient-profiling models for the regulation of nutrition and health claims made on foods (EFSA NDA Panel, 2008) and for setting FBDGs<sup>9</sup> at national level (EFSA NDA Panel, 2010d), the NDA Panel noted that:

- a) The nutrient profile of the overall (habitual) diet is an important determinant of health and the nutrient profile of a nutritionally adequate diet is defined by science-based recommendations for intakes of energy and nutrients (i.e. Dietary Reference Values (DRVs)).

<sup>9</sup> FBDG constitute science-based policy recommendations in the form of guidelines for healthy eating.

- b) Because diets are composed of multiple foods, overall dietary balance may be achieved through complementation of foods with different nutrient profiles, so that it is not necessary for individual foods to match the nutrient profile of a nutritionally adequate diet. Nevertheless, individual foods might influence the nutrient profile of the overall diet, depending on the nutrient profile of the particular food and its intake, in terms of amount and frequency.
- c) For some foods, there is evidence of health benefits that cannot be attributed to their specific content of nutrients (e.g. fruits and vegetables). The level of consumption of foods with established relationships to health that are not nutrient specific should be considered when establishing FBDGs for individual countries.
- d) For a number of nutrients and food groups, a dietary imbalance can increase the risk of obesity and other diet-related diseases (e.g. CVD, some cancers, T2DM, osteoporosis and dental disease) that are of importance for public health in the EU. These include nutrients and foods that might be consumed to excess, as well as those for which intakes might be inadequate.
- e) Nutrient-profiling models should take into account the dietary role and importance of food groups and their contribution of nutrients to the overall diet of the population (or specific population groups), in order to ensure that some food items in food groups with an important dietary role might be eligible to bear claims.
- f) The choice of nutrients to be included in nutrient-profiling models should be driven by their public health importance for EU populations.

The Panel notes that these scientific considerations could underpin both the setting of nutrient-profiling models for restricting claims on foods and the setting of nutrient-profiling models for helping consumers to make 'healthy' food choices.

#### 1.4. Interpretation of the Terms of Reference

The Panel understands that the scientific advice requested relates to the identification of:

- a) **Nutrients and foods, including non-nutrient components of food**, that are of importance for public health in European populations. These include nutrients and foods that might be consumed in excess, as well as those for which intakes might be inadequate, in the context of current Dietary Reference Values (DRVs) for European populations and dietary recommendations on healthy diets either by European countries or independent scientific bodies. Nutrients include macronutrients (protein, carbohydrates and fats), micronutrients (vitamins and minerals) and water. In the context of this opinion, non-nutrient components of food include food components that are not nutrients but for which DRVs for European populations have been established (energy and dietary fibre).
- b) **Food groups** with important dietary roles in European populations and subgroups thereof owing to their nutrient composition and their (habitual) intake, as recognised by Member States in FBDGs. FBDGs also make distinctions between different foods within these food groups based on their potential to influence, beneficially or adversely, the overall dietary balance for certain nutrients. The dietary roles of these food groups might differ across Member States owing to the variability of dietary habits and traditions.
- c) **Criteria that could guide the choice of nutrients and non-nutrient components of food for the nutrient profiling of foods**, with the scope of developing harmonised mandatory FOP nutrition labelling and the setting of nutrient profiles for restricting nutrition and health claims on foods.

The Panel notes that the following aspects related to the nutrient profiling of foods, that have been addressed by EFSA in 2008 in relation to the setting of nutrient profiles for foods bearing nutrition and health claims (EFSA NDA Panel, 2008), are out of the scope of the present mandate:

- a) whether profiles should be set for food in general (across the board) and/or for categories of food
- b) the choice of the reference quantity/basis for profiles (per energy, weight or volume unit of the product vs. per portion)
- c) the approach to the calculation of the profiles (threshold vs. scoring systems)
- d) the feasibility, testing and validation of the profiles

The Panel also understands that this mandate is not a request to develop a nutrient-profiling model or to provide advice on current profiling models already in use for different purposes.

The Panel further understands that the mandate is restricted to providing advice on the relationships between nutrients, non-nutrient components, foods and food groups and diet-related chronic diseases and does not cover any considerations related to the sustainability of the food chain. In addition to scientific considerations, other factors may be taken into account by the European Commission in establishing nutrient-profiling models for the above-mentioned purposes, e.g. feasibility and product innovation.

## 2. Data and methodologies

### 2.1. Data

The data used in the present opinion are review publications, in particular systematic reviews and meta-analyses of human intervention and observational studies on nutritionally adequate diets, data from the Global Burden of Disease framework, clinical practice guidelines, previous EFSA opinions and the priorities set by EU Member States in the context of their FBDGs and associated nutrient/food intake recommendations. Relevant publications have been retrieved through comprehensive searches in PubMed. Priority was given to previous assessments of EFSA, followed by systematic reviews and associated meta-analyses. In few cases, results of individual human studies have been considered, when this was relevant.

### 2.2. Methodologies

For this scientific assessment, a protocol (Appendix A) has been developed in line with existing methodology (EFSA, 2020).

The nutrients and non-nutrient components of food of public health importance for European populations that are consumed in excess or in inadequate<sup>10</sup> amounts have been identified primarily from a questionnaire sent by EFSA to EU/EAA countries through EFSA focal points (see Appendix B). Harmonised nutrient intake data collected in the context of previous EFSA DRV opinions were used to identify the nutrients, among those mentioned by Member States, for which intakes were above or below DRVs/recommendations in a majority of European countries for which dietary surveys were available. Evidence about the relationship between the intake of nutrients and risk of developing diet-related chronic diseases was also considered for the prioritisation of nutrients.

A draft opinion was endorsed by the NDA Panel on 28 October 2021 and was open for public consultation from 15 November 2021 to 9 January 2022. The draft opinion has been amended on the basis of the comments received, which have all been addressed and are published in a technical report (Annex A).

### 2.3. Definitions

In the context of this Opinion, the following definitions apply:

- Nutrients: Macronutrients (protein, carbohydrates, fats), micronutrients (vitamins and minerals) and water.
- Non-nutrient components of foods: Food components that are not nutrients but for which DRVs for European populations have been established (energy and dietary fibre).
- Nutrient profile: Nutritional composition of a food or diet.
- Nutrient profiling: Classification of foods based on their nutritional composition for specific purposes.
- Population Reference Intake (PRI): The level of (nutrient) intake that is adequate for almost all individuals (97.5%) in a population group, given a normal distribution of requirements.
- Average Requirement (AR): The level of (nutrient) intake that is adequate for half of the people in a population group, given a normal distribution of requirements.
- Adequate Intake (AI): This value is estimated when a PRI cannot be established because an AR cannot be determined. It can, for example, be based on the average observed daily level of intake by a population group (or groups) of apparently healthy people that is assumed to be adequate.

<sup>10</sup> In the context of this Opinion, inadequate is to be interpreted as insufficient.

- Reference intake range for macronutrients (RI): The recommended intake range for macronutrients, expressed as % of the energy intake (E%). These apply to ranges of intake that are adequate for maintaining health and are associated with a low risk of selected chronic diseases.
- Tolerable upper intake level (UL): The maximum level of total chronic daily intake of a nutrient (from all sources) judged to be unlikely to pose a risk of adverse health effects to humans.
- Dietary reference values (DRVs): A set of nutrient reference values that include AR, PRI, AI, RI and UL. These values guide professionals on the amount of a nutrient needed to maintain health in an otherwise healthy individual or group of people.
- Cardiovascular disease (CVD): A general term referring to conditions affecting the heart and blood vessels. The most common is coronary heart disease. Stroke, transient ischaemic attack, arrhythmia, peripheral vascular disease and aortic disease are other examples of CVD.<sup>11</sup>
- Coronary heart disease (CHD): The most common form of CVD. A pathological process characterised by atherosclerotic plaque accumulation in the coronary arteries, whether obstructive or non-obstructive (Knuuti et al., 2019).
- Cardiovascular event: Used to denote the composite of a variety of adverse events related to the cardiovascular system.
- Type 2 diabetes mellitus (T2DM): Diabetes is a group of metabolic diseases characterised by hyperglycaemia resulting from defects in insulin secretion, insulin action or both. T2DM encompasses individuals who have insulin resistance and usually have relative insulin deficiency (American Diabetes Association, 2014).
- Dietary fibre: In EFSA's scientific opinion on DRVs for carbohydrates and dietary fibre (EFSA NDA Panel, 2010b), dietary fibre denotes all non-digestible carbohydrates. The definition of dietary fibre for regulatory purposes in the EU is laid down in Regulation (EU) No 1169/2011.<sup>12</sup>
- Saturated fatty acids (SFAs): SFAs are characterised by carbon chains that contain no carbon double bonds, i.e. only single bonds.
- *trans* Fatty acids (TFAs): Unsaturated fatty acids (fatty acids with  $\geq 1$  double bond) that contain at least one double bond in the *trans* configuration (i.e. hydrogen atoms are positioned on the opposite side of the carbon chain at a double bond).
- *cis*-Fatty acids: Unsaturated fatty acids (fatty acids with  $\geq 1$  double bond) in which all double bonds are in the *cis* configuration (i.e. the hydrogen atoms are positioned at the same side of the carbon chain at a double bond).
- Monounsaturated fatty acids (MUFAs): Fatty acids characterised by one double bond in the carbon chain.
- Polyunsaturated fatty acids (PUFAs): Fatty acids characterised by more than one double bond in the carbon chain.
- Long-chain (LC)-PUFAs: PUFAs with a chain length of  $\geq 20$  carbon atoms and  $\geq 3$  double bonds.
- Omega 3 (n-3) fatty acids: PUFAs characterised by the presence of a double bond, three carbon atoms away from the terminal methyl group in their chemical structure.
- Omega 6 (n-6) fatty acids: PUFAs characterised by the presence of a double bond, six carbon atoms away from the terminal methyl group in their chemical structure.
- Linoleic acid (LA): Essential PUFA, precursor of the n-6 family, with 18 carbon atoms and two *cis* double bonds (C18:2, n-6).
- alpha-Linolenic acid (ALA): Essential PUFA, precursor of the n-3 family, with 18 carbon atoms and three *cis* double bonds (C18:3, n-3).
- Arachidonic acid (ARA): PUFA of the n-6 group with 20 carbon atoms and four *cis* double bonds (C20:4, n-6).
- Eicosapentaenoic acid (EPA): LC-PUFA of the n-3 group with 20 carbon atoms and five *cis* double bonds (C20:5, n-3).

<sup>11</sup> <https://www.cancer.gov/publications/dictionaries/cancer-terms/def/cardiovascular-disease>

<sup>12</sup> Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers, amending Regulations (EC) No 1924/2006 and (EC) No 1925/2006 of the European Parliament and of the Council, and repealing Commission Directive 87/250/EEC, Council Directive 90/496/EEC, Commission Directive 1999/10/EC, Directive 2000/13/EC of the European Parliament and of the Council, Commission Directives 2002/67/EC and 2008/5/EC and Commission Regulation (EC) No 608/2004. OJ L 304, 22.11.2011, p. 18–63.

- Docosahexaenoic acid (DHA): LC-PUFA of the n-3 group with 22 carbon atoms and six *cis* double bonds (C22:6, n-3).
- Total sugars: Main types of mono- and disaccharides found in mixed diets (i.e. glucose, fructose, galactose, sucrose, lactose, maltose and trehalose) (EFSA NDA Panel, 2022).<sup>13</sup>
- Added sugars: Mono- and disaccharides added to foods as ingredients during processing or preparation at home, and sugars eaten separately or added to foods at the table.
- Free sugars: Added sugars plus sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates.
- Fruit juices: 100% fruit juices (no added sugars).
- Fruit nectars: fruit juices with added sugars.

### 3. Assessment

#### 3.1. Nutrients and non-nutrient components of foods of public health importance for European populations

Dietary reference values (DRVs) for macronutrients and dietary fibre, micronutrients, energy and water have been established by EFSA for the general healthy population by life stage and sex, with separate recommendations for pregnant and lactating women, where appropriate. DRVs are based on health criteria and consider dietary requirements (e.g. ARs and PRIs relate to nutrient requirements that are defined by specific criteria of nutrient adequacy) and health outcomes, including the risk of developing diet-related chronic metabolic diseases (e.g. upper and lower bounds of RI for macronutrients and some AIs are based on these endpoints). AIs, established when the distribution of nutrient requirements is unknown and ARs and PRIs cannot be set, can also be based on observed (or experimentally derived) nutrient intake estimates in populations for which intakes are deemed to be adequate (EFSA NDA Panel, 2010e).

Harmonised data on food intakes of infants, children, adults, older people, pregnant and lactating women in 21 European Member States plus the UK are available in the EFSA Comprehensive Food Consumption Database.<sup>14</sup> The methods used for estimating dietary intakes varied among countries and even within countries. Nutrient intakes for these population groups have been calculated using the EFSA Nutrient Composition Database<sup>15</sup> (Roe et al., 2013). The database covers ~ 1,750 food entries and additional facet descriptors included in the EFSA food classification system (FoodEx2), and contains data for energy, macro- and micronutrients from national food composition databases up to 2012, provided by 14 national food database compiler organisations. These data have been used by EFSA to provide intake estimates, mostly for micronutrients, in scientific opinions on DRVs for nutrients since 2014. The nutrients for which such intake estimates from the EFSA Comprehensive Food Consumption Database are available are sugars, choline, niacin, riboflavin, thiamine, vitamin A, vitamin B<sub>6</sub>, vitamin B<sub>12</sub>, vitamin E, vitamin K, vitamin D (infants only), calcium, copper, iron, magnesium, phosphorus, potassium, selenium and zinc and these have been used in the present Opinion. For nutrients for which such harmonised intake estimates are not available, the Opinion is mostly based on nutrient intakes derived from national dietary surveys cited in the respective EFSA Opinions on DRVs. Uncertainties related to these intake estimates are acknowledged in the individual EFSA opinions on DRVs.

##### 3.1.1. Nutrients and non-nutrient components of food for which intakes might exceed recommended levels in most population groups and countries in Europe

###### 3.1.1.1. Energy

It is well established that a sustained positive energy balance, i.e. when energy intake exceeds requirements, leads to an accumulation of body fat (Hall et al., 2011). This may ultimately result in the

<sup>13</sup> According to European legislation (Regulation (EU) No 1169/2011), sugar alcohols (polyols) such as sorbitol, xylitol, mannitol and lactitol, which are low-calorie sugar replacers that can be used in foods also for purposes other than sweetening, are 'carbohydrates' not included under the term 'sugars' and will not be considered in this opinion. Alongside polyols, other substances used as sugar replacers and other mono- or disaccharides present in the diet in marginal amounts are not included in the term 'sugars' for the purpose of this assessment (e.g. isomaltulose, D-tagatose).

<sup>14</sup> <https://www.efsa.europa.eu/en/food-consumption/comprehensive-database>

<sup>15</sup> <https://www.efsa.europa.eu/en/microstrategy/food-composition-data>

development of overweight or obesity. Overweight and obesity increase the risk of developing diet-related chronic diseases, such as T2DM or CVD, and some cancers (World Cancer Research Fund and American Institute for Cancer Research, 2018). Overweight and obesity have also been associated with a higher all-cause mortality (Mongraw-Chaffin et al., 2015; Aune et al., 2016b; Global BMI Mortality Collaboration et al., 2016). Evidence from randomised controlled trials (RCTs) shows that weight loss in adults with obesity improves cardiometabolic risk factors in a dose-response manner, namely blood pressure, blood lipid profile and blood glucose control. It has also been shown in RCTs that weight loss, and its maintenance over time, significantly decreases the risk of developing T2DM in individuals with obesity (Jensen et al., 2014) and reduces the risk of all-cause mortality (Ma et al., 2017).

Data on the prevalence of overweight (i.e. body mass index (BMI)  $\geq 25$  kg/m<sup>2</sup>) or obesity (i.e. BMI  $\geq 30$  kg/m<sup>2</sup>) in adults in Europe between 2016 and 2020 are available from Eurostat,<sup>16</sup> the Global Obesity Observatory<sup>17</sup> and WHO.<sup>18</sup> Estimates from the different data providers differ to a certain extent, possibly owing to the different assessment techniques (self-reports vs. measured weights and heights) and populations studied. However, they indicate that the prevalence of overweight or obesity in EU Member States ranges between around 50% and 75% in males and between around 35% and 65% in females. The prevalence of obesity ranges between around 10% and 30% in males and 10% and 35% in females, depending on the country.

Combining data of different age groups from 2007 to 2019 and using different cut-offs for defining overweight and obesity (i.e. WHO, International Obesity Task Force (IOTF), Centers for Disease Control (CDC) or other), the Global Observatory for Obesity reports a prevalence of overweight or obesity in children in EU Member States of around 10–45%.<sup>19</sup> The WHO data in 5- to 19-year-old children from 2016 indicate a prevalence of overweight or obesity (BMI  $> +1$  SD above the median) between 25 and 40% in boys and between 20% and 35% in girls. The prevalence of obesity (BMI  $> +2$  SD above the median) is between 8% and 17% in boys and between 5% and 11% in girls.

ARs for energy were set by EFSA in 2013 (EFSA NDA Panel, 2013) for children and adults, by sex, assuming a normal body weight, based on the calculated resting energy expenditure and considering different physical activity levels. For infants, the AR was based on measurements of total energy expenditure in healthy, full-term and initially breast-fed infants, plus the energy requirement for growth. A PRI was not derived, as this implies an energy intake that is above the requirement for almost all individuals in a group. As the AR still exceeds the energy needs of half of the individuals in the group, it can be used to assess energy intakes in groups of healthy people but is of limited value for individuals (EFSA NDA Panel, 2013).

Lacking information on the physical activity level of the individuals included in dietary surveys in summary publications, and owing to the complex mechanisms regulating energy balance, it is difficult to establish whether energy intakes in a population exceed energy requirements solely based on intake data. However, considering the high prevalence of overweight and obesity in Europe, it can be inferred that energy intakes are higher than required to maintain a normal body weight (BMI of 18.5–24.9 kg/m<sup>2</sup>) in a large proportion of the European population.

While DRVs for protein are set based on physiological requirements (see Section 3.1.2.1), those for fat and digestible carbohydrates are not, but need to reflect the difference between total energy requirement and energy provided by protein. Digestible carbohydrates are not essential and physiological requirements for essential fatty acids cover only part of the energy needs. Therefore, the RIs for digestible carbohydrates (45–60 E%) and total fat (20–35 E%) have been derived by EFSA (EFSA NDA Panel, 2010b,c) based on their effects on the blood lipid profile (i.e. the upper bound for carbohydrates and the lower bound for fat) and the observation that high fat diets may promote excess energy intake and weight gain (i.e. the upper bound for fat and the lower bound for carbohydrates). The NDA Panel noted that total fat intakes  $> 35$  E% may be compatible with both good health and normal body weight depending on dietary patterns and the level of physical activity. Practical considerations (e.g. observed levels of intake, achievable dietary patterns) have also been taken into account. Owing to the positive impact of energy restriction and weight loss on cardiometabolic risk factors and chronic disease risk, the specific effect of individual macronutrients on these endpoints is generally assessed in isocaloric exchange with each other (Willett et al., 1997).

<sup>16</sup> [https://ec.europa.eu/eurostat/databrowser/view/HLTH\\_EHIS\\_BMI1E\\_\\_custom\\_970518/default/table?lang=en](https://ec.europa.eu/eurostat/databrowser/view/HLTH_EHIS_BMI1E__custom_970518/default/table?lang=en)

<sup>17</sup> <https://data.worldobesity.org/>

<sup>18</sup> <https://www.who.int/data/gho/data/themes/topics/topic-details/GHO/ncd-risk-factors>

<sup>19</sup> Data on the prevalence of obesity alone in children are not available from this data source.

Energy-containing food constituents (macronutrients, dietary fibre, alcohol, polyols) have been assigned energy conversion factors for labelling purposes,<sup>20</sup> as shown in Table 1. In some cases (e.g. glycaemic carbohydrates, dietary fibre, polyols), such energy conversion factors are average values that reflect the energy provided by the food constituent as found in mixed diets or are average values set based on practical considerations. They do not necessarily reflect the energy provided by specific components in the group (Elia and Cummings, 2007).

**Table 1:** Energy conversion factors for energy-containing food constituents for labelling purposes

Food constituent	Energy conversion factor
Fat	9 kcal/g (37 kJ/g)
Alcohol	7 kcal/g (29 kJ/g)
Protein	4 kcal/g (17 kJ/g)
Glycaemic carbohydrates	4 kcal/g (17 kJ/g)
Polyols	2.4 kcal/g (10 kJ/g)
Dietary fibre	2 kcal/g (8 kJ/g)

Although energy intake appears more important than the macronutrient composition of diets for weight loss and the prevention of weight gain, there is some evidence that diets with a moderate fat content (< 30–35 E%) favour lower energy intake, weight loss and prevent weight gain as compared to energy dense diets containing > 35 E% as fat (EFSA NDA Panel, 2010c). Guidelines for the prevention and management of uncomplicated obesity<sup>21</sup> (NICE, 2015; Yumuk et al., 2015) recommend limiting energy intake and decreasing the consumption of energy-dense foods, among other interventions, both to prevent excessive weight gain and manage overweight and obesity.

Taking into account the high prevalence of overweight and obesity in Europe, the Panel considers that a reduction in energy intake is of public health importance for European populations.

### 3.1.1.2. Total fat and fatty acid composition of the diet

Fat is an important source of energy and facilitates the absorption of fat-soluble dietary components such as fat-soluble vitamins. Fats and oils are also important sources of essential fatty acids (i.e. LA and ALA).

An RI has been established for total fat between 20 E% and 35 E% for adults, suggesting that wide ranges of total fat intake are compatible with nutritionally adequate diets. The lower bound corresponds to the lowest observed intakes in European countries with no overt signs of deficiencies and no adverse effects on blood lipids. The upper bound is based on evidence that moderate fat intakes may favour lower energy intake, weight loss and prevent weight gain, although it is acknowledged that total fat intakes > 35 E% may be compatible with both good health and normal body weight, depending on dietary patterns and the level of physical activity (EFSA NDA Panel, 2010c).

While the RI for total fat is partly based on practical considerations (e.g. current levels of intake, achievable dietary patterns), the fatty acid composition of the diet is an important determinant that influences blood lipid concentrations and CVD risk. Under isocaloric conditions, the most favourable blood lipoprotein profile for atherosclerosis risk prevention is achieved by replacing mixtures of SFAs and TFAs with *cis*-MUFAs (mostly oleic acid) and/or mixtures of *cis*-PUFAs (mostly the n-6 *cis*-PUFA LA, the n-3 *cis*-PUFA ALA and the n-3 LC-PUFAs EPA and DHA). These effects are dose-dependent (EFSA NDA Panel, 2010c, 2011b,d).

The main dietary determinant of blood low-density lipoprotein (LDL)-cholesterol concentrations is saturated fat. Dietary cholesterol has a similar dose-response effect on blood LDL-cholesterol, but it is consumed in considerably lower daily amounts (in the milligram range). Similarly, the impact of ARA (a n-6 *cis*-PUFA) and of EPA and DHA on the blood lipid profile is expected to be low considering the low daily consumption (in the milligram range) in European diets as compared to SFAs (EFSA NDA Panel, 2010c, 2011b,d).

<sup>20</sup> Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers, amending Regulations (EC) No 1924/2006 and (EC) No 1925/2006 of the European Parliament and of the Council, and repealing Commission Directive 87/250/EEC, Council Directive 90/496/EEC, Commission Directive 1999/10/EC, Directive 2000/13/EC of the European Parliament and of the Council, Commission Directives 2002/67/EC and 2008/5/EC and Commission Regulation (EC) No 608/2004. OJ L 304, 22.11.2011, p. 18–63.

<sup>21</sup> Obesity without other morbidities.

Although the replacement of mixtures of SFAs and TFAs by mixtures of *cis*-MUFAs and/or mixtures of *cis*-PUFAs results in a more favourable blood lipid profile for ischaemic CVD prevention, DRVs for SFAs, TFAs, *cis*-MUFA or *cis*-PUFA could not be set by EFSA based on this endpoint for different reasons that are explained in the following sections.

Mixtures of SFAs and TFAs were shown to increase LDL-cholesterol concentrations in a dose-response manner as compared to carbohydrates, mixtures of *cis*-MUFAs and mixtures of *cis*-PUFAs, and to increase CVD risk compared to *cis*-PUFAs (mainly LA). Owing to the linearity of the dose-response, a UL could not be established. The Panel considered that the intake of SFAs and TFAs should be as low as possible in the context of a nutritionally adequate diet.

No specific role for *cis*-MUFAs in preventing or promoting diet-related diseases has been identified, and hence, no DRV has been set (EFSA NDA Panel, 2010c; Schwingshackl et al., 2021), which is in line with most recent evidence (Schwingshackl et al., 2021).

In view of the different metabolic effects of the various dietary *cis*-PUFAs, no DRVs were established by EFSA for either total *cis*-PUFAs or the n-3/n-6 ratio.

There is an inverse (i.e. beneficial) relationship between the intake of LA and blood LDL-cholesterol concentrations, while this relationship is positive (also beneficial) for HDL-cholesterol concentrations. In addition, LA lowers fasting blood triglyceride concentrations when compared to carbohydrates, and LA, when replacing mixtures of SFAs, decreases cardiovascular events in the population. All these relationships are linear and dose-dependent, with no threshold value. While ALA has similar effects on blood lipids to LA, its relationship with CVD risk when replacing SFAs is less established. In both cases, data on blood lipids and chronic disease risk reduction could not be used to establish a DRV. AIs for these essential fatty acids were derived from the lowest estimated mean intakes of various population groups from a number of European countries where overt deficiency symptoms are not present. For adults, the AI for LA is 4 E% and for ALA 0.5 E% (EFSA NDA Panel, 2010c). Their relative contribution to the blood lipid profile and CVD risk when replacing SFAs and TFAs in the diet could in part depend on the different amounts in which they are consumed.

EPA, and to a lesser degree DHA, are synthesised from ALA through the sequential action of various desaturases and elongases in animal and human tissues. Estimates for the conversion of ALA into EPA are around 8–12%, while the conversion into DHA may be less than 1%. Due to this low conversion rate and the fact that ALA, and EPA and DHA, may have different biological functions, many authorities (including EFSA) established separate recommendations for ALA on the one hand, and for EPA and DHA on the other hand (EFSA NDA Panel, 2010c). An AI of 250 mg/day for EPA and DHA combined was derived based on primary CVD prevention (EFSA NDA Panel, 2010c). At these levels of intake, other mechanisms than their effect on the blood lipid profile (e.g. antiarrhythmic effects) may be more important, as explained in Section 3.1.2.2 on EPA and DHA.

In the context described above, SFAs and TFAs will be considered as nutrients that may be consumed in excess, whereas EPA and DHA will be considered as nutrients for which the intake may be inadequate, in both cases in relation to CVD risk.

### 3.1.1.3. Saturated fatty acids

It is well established that the fatty acid composition of the diet is an important determinant of blood lipid concentrations and CVD risk. Under isocaloric conditions, the most favourable lipoprotein profile for atherosclerosis risk prevention is achieved by replacing SFAs and TFAs in mixed diets with *cis*-MUFAs (mostly oleic acid) and/or mixtures of *cis*-PUFAs (mostly the n-6 LA, the n-3 ALA and the n-3 LC-PUFAs EPA and DHA). These effects are dose dependent (EFSA NDA Panel, 2010c, 2011b,d).

There is a differential effect of different SFAs on blood lipid concentrations. While lauric, myristic and palmitic acids raise blood LDL-cholesterol when replacing carbohydrates, the effect of stearic acid is more neutral (EFSA NDA Panel, 2010c, g). However, fatty acids occur as mixtures in foods and foods rich in stearic acid often contain significant amounts of palmitic acid and other SFAs that increase blood LDL-cholesterol concentrations (EFSA NDA Panel, 2010g). Therefore, the effect of mixtures of SFAs as present in mixed diets is considered below.

It has been consistently demonstrated that there is a positive and causal relationship between blood LDL-cholesterol concentrations and the risk of developing ischaemic CVD, and that the reduction in disease risk is proportional to the reduction of LDL-cholesterol concentrations (EFSA NDA Panel, 2018; Mach et al., 2020). Since there was no evidence for a threshold below which mixtures of SFAs do not raise LDL-cholesterol concentrations at the levels of intake observed in mixed diets, EFSA could not establish a UL for SFAs, but considered that intakes should be as low as possible in the context of a nutritionally adequate diet compatible with current dietary patterns and traditions in European

populations. Several Member States have recommended upper bounds of intake that are mostly in the range of 8–10 E%.<sup>22</sup>

Despite the well-established LDL-cholesterol-raising effects of SFAs, some meta-analyses of observational studies failed to show a positive association between the intake of SFAs in mixed diets and CVD risk in isocaloric exchange with other macronutrients (Siri-Tarino et al., 2010; de Souza et al., 2015; Zhu et al., 2019; Kang et al., 2020). Several possible explanations have been advanced. On the one hand, it has been proposed that the relationship may depend on the food matrices in which SFAs are consumed, and that other nutrient and/or non-nutrient components of SFA-rich foods may modify the risk of developing CVD (Mozaffarian et al., 2010; Mozaffarian, 2016; Astrup et al., 2020). On the other hand, it is possible that, under isocaloric conditions, the health benefits of reducing SFAs in relation to ischaemic CVD risk prevention largely depend on the macronutrient by which they are replaced in the diet. For example, while the CVD risk-lowering effect of *cis*-PUFAs (primarily LA and n-3 LC-PUFA) is sizeable, no benefit is obtained from replacing SFAs with refined carbohydrates (e.g. sugars) (Briggs et al., 2017; Visseren et al., 2021).

The SFA content of fats and oils is variable. The highest percentages of SFAs, expressed as % of total fatty acids, are found in coconut oil (about 90%), palm kernel oil (about 85%), cocoa butter (about 60%), butter, palm oil, lamb fat (all about 50%), beef fat (about 45%) and pork fat (about 40%). The relative proportion of individual SFAs in different food sources also differs. The major SFA in palm oil and butter is palmitic acid, while coconut oil and palm kernel oil contain lauric acid as the predominant fatty acid (EFSA NDA Panel, 2010c; Devi and Khatkar, 2018). The saturated fat component of beef, lamb and pork is characterised by high amounts of palmitic and stearic acid (Wood et al., 2007).

In a review of sources and dietary intakes of fatty acids in Europe, Eilander et al. (2015) reported that the main contributors to SFA intake were dairy (i.e. 17–41%), fats and oils (9–37%), meat and meat products (15–30%), cake and pastry/desserts and sugar/preserve confectionary (reported without percentage contribution to overall SFA intake). Cereals and cereal products were also significant contributors to SFA intake (16–18%) in Finland and the UK. The authors noted that data on the fatty acid composition of some foods listed in national food composition databases are incomplete indicating that the actual SFA, *cis*-MUFA and *cis*-PUFA intakes calculated based on these incomplete composition data may have been underestimated.

In the food consumption surveys considered in the Scientific Opinion on DRVs for fats (EFSA NDA Panel, 2010c), mean intakes of SFAs in most EU Member States were above the recommended upper bounds of intake of 8–10 E%. In adults, average SFA intakes varied between less than 9 and 26 E%. In adults 35 years and older, 35% of the surveys reported mean intakes of SFA to be at 15 E % or higher. This is in agreement with more recent publications (Micha et al. (2014), Eilander et al. (2015) and the European Commission<sup>23</sup>). Intake data on individual SFAs could not be retrieved.

As SFAs increase LDL-cholesterol concentrations, an established risk factor for ischaemic CVD, and the majority of European populations exceed the upper bounds of intake recommended by some Member States, the Panel considers that a reduction in intake of SFAs as present in mixed diets is of public health importance for European populations.

#### 3.1.1.4. *Trans* fatty acids

TFAs increase blood LDL-cholesterol concentrations in a linear dose-dependent manner to a similar extent to SFAs. In addition, and different from SFAs, TFAs reduce blood high-density lipoprotein (HDL)-cholesterol concentrations and increase the total cholesterol to HDL-cholesterol ratio (EFSA NDA Panel, 2010c; Mach et al., 2020). TFAs from ruminant sources have adverse effects on blood lipids and lipoproteins similar to those from industrial sources when consumed in equal amounts (EFSA NDA Panel, 2010c). High intakes of TFAs have also been associated with an increased risk of ischaemic CVD (Bendsen et al., 2011). However, the available evidence was insufficient to establish whether there is a difference between ruminant and industrial TFAs consumed in equivalent amounts on the risk of CHD (EFSA NDA Panel, 2010c). Recent systematic reviews and meta-analyses confirm the positive association between the intake of total and industrial TFA and risk of CHD, whereas the relationship appears to be null for TFA from ruminant sources (Bendsen et al., 2011; de Souza et al., 2015; Schwingshackl et al., 2021). The available evidence, however, remains insufficient to establish whether

<sup>22</sup> [https://knowledge4policy.ec.europa.eu/health-promotion-knowledge-gateway/dietary-fats-table-4\\_en](https://knowledge4policy.ec.europa.eu/health-promotion-knowledge-gateway/dietary-fats-table-4_en)

<sup>23</sup> [https://knowledge4policy.ec.europa.eu/health-promotion-knowledge-gateway/dietary-fats-5b\\_en](https://knowledge4policy.ec.europa.eu/health-promotion-knowledge-gateway/dietary-fats-5b_en)

industrial and ruminant TFA have different effects on CHD risk when consumed in equivalent amounts (Bendsen et al., 2011; de Souza et al., 2015).

Owing to the positive (i.e. unfavourable) and linear dose–response relationship between the intake of TFAs and adverse effects on the blood lipid profile, EFSA could not establish a UL for TFAs. However, several European Member States have recommended upper bounds of intake for TFAs < 1–2 E% by considering what is practically achievable within the context of a nutritionally adequate diet based on known patterns of intake of foods and nutrients in specific populations (EFSA NDA Panel, 2010c).

TFAs are naturally present in dairy products and meat from ruminants, usually at concentrations between 2% and 9% of total fat (Mouratidou et al., 2014). They may also originate from deodorisation of vegetable oils and from heating oils at temperatures > 220°C, such as in deep frying (EFSA NDA Panel, 2010c). Partially hydrogenated oils containing TFAs are used in the manufacturing of margarines and spreads, fine bakery wares and fillings of confectionary, among others.

Intakes of industrially produced TFAs have decreased considerably in Europe owing to reformulation of food products. Already in 2004, mean intakes of TFAs from all sources were close to 1–2 E% in most European countries (EFSA NDA Panel, 2010c). In a report of the JRC of the European Commission published in 2014 (Mouratidou et al., 2014) that considered data from 13 studies published between 2006 and 2013, mean intakes of TFAs were at 1 E% or below in all countries and population groups. TFAs intakes > 1 E% were observed in 25% of the surveyed individuals between the age of 20 and 30 years, the age group with the highest intakes. However, even in this population group, maximum intakes were around 1.2 E%. In addition, as of April 2021, food products that are sold within the European Union may not contain industrially produced TFAs in amounts exceeding 2% of total fat.<sup>24</sup> This is expected to further reduce the consumption of TFAs in the EU.

The Panel notes that the adverse health effects of diets high in TFAs are well documented. The Panel also notes, however, that mean intakes of TFAs from all sources in most European countries and population groups are at or below upper bounds of intakes recommended by some Member States within the context of nutritionally adequate diets. The implementation of current European legislation limiting the use of industrially produced TFAs is expected to further reduce intakes.

### 3.1.1.5. Dietary sugars

There is wide consensus that the intake of dietary sugars is causally related to the development of dental caries at all ages (Jepsen et al., 2017). There is also evidence that high intakes of added and free sugars increase the risk of developing chronic metabolic diseases including obesity, non-alcoholic fatty liver disease, T2DM, dyslipidaemia and hypertension, possibly through excess energy intake leading to positive energy balance and body weight gain, among other mechanisms (WHO, 2015a; EFSA NDA Panel, 2022).

A UL or a safe level of intake for either total, added or free sugars could not be established by EFSA (EFSA NDA Panel, 2022). Whenever dose–response relationships between the intake of dietary sugars and disease risk could be explored, these were positive and linear, and a level of sugars intake at which the risk of disease is not increased over the range of observed intakes could not be established. Uncertainty was high regarding the shape and direction of the relationships between the intake of added and free sugars and chronic metabolic disease risk at levels of intake below 10 E%. Data did not allow comparison of health effects based on the classification of dietary sugars as added or free.

Based on the available body of evidence and related uncertainties, the NDA Panel concluded that the intake of added and free sugars should be as low as possible within the context of a nutritionally adequate diet. The Panel noted that decreasing the intake of added and free sugars would decrease the intake of total sugars to a similar extent.

Several authorities have set recommendations for added or free sugars below 10 E%, or below 5 E%, based on various health endpoints, including chronic metabolic diseases and dental caries. Typically, such recommendations also reflect a judgement of what level of sugars intake is practically achievable within the context of a nutritionally adequate diet based on known patterns of intake of foods and nutrients in specific populations (EFSA NDA Panel, 2022).

<sup>24</sup> Commission Regulation (EU) 2019/649 of 24 April 2019 amending Annex III to Regulation (EC) No 1925/2006 of the European Parliament and of the Council as regards transfat, other than transfat naturally occurring in fat of animal origin. OJ L 110, 25.4.2019, p. 17–20.

The main dietary source of added sugars in Europe is sucrose added at the table and to processed foods, while isoglucose (glucose-fructose and fructose-glucose syrups)<sup>25</sup> is increasingly used as a substitute for sucrose in processed foods and beverages due to its technological characteristics and lower price.

Food groups mostly contributing to the intake of added and free sugars in European countries are 'sugar and confectionery' (i.e. table sugar, honey, syrups, confectionery and water-based sweet desserts), followed by beverages (sugar-sweetened soft and fruit drinks, fruit juices and nectars) and fine bakery wares. The main difference between the intake of added and free sugars is accounted for by fruit juices and nectars. In infants, children and adolescents, sweetened milk and dairy products are also major contributors to mean intakes of added and free sugars (EFSA NDA Panel, 2022).

There is high variability in the intake of added and free sugars across population groups and countries in Europe. Mean intakes of added sugars (mostly between 3 and 17 E%) and mean intakes of free sugars (mostly between 4 and 18 E%) exceed the recommended intakes in about one-third and one half of the available dietary surveys, respectively. In consumers of certain food groups, intakes of added and free sugars exceed the recommended intakes in most European population groups and countries (EFSA NDA Panel, 2022).

Taking into account the well-established positive relationships between (a) the intake of dietary sugars (total/added/free) and dental caries risk and (b) the intake of added and free sugars and the risk of developing chronic metabolic diseases, and that intakes of added and free sugars, particularly in consumers of certain food groups, exceed the recommended intakes in most European countries, the Panel considers that a reduction in the intake of added and free sugars is of public health importance for European populations. The Panel notes that decreasing the intake of added and free sugars would decrease the intake of total sugars to a similar extent.

#### 3.1.1.6. Sodium

The positive (i.e. unfavourable) and causal relationship between the intake of dietary sodium and blood pressure is well established. High sodium intakes increase blood pressure and the risk of hypertension, which is a risk factor for CVD and chronic kidney disease (Williams et al., 2018; Arnett et al., 2019; EFSA NDA Panel, 2019b; Visseren et al., 2021).

In 2019, EFSA established a safe and adequate intake for sodium of 2.0 g/day for adults and children from 11 years of age based on the relationship between sodium intake, blood pressure and risk of CVDs (composite endpoint) including CHD and stroke in adults (EFSA NDA Panel, 2019b). The same year, the National Academy of Sciences in the US (NASEM, 2019) established a Chronic Disease Risk Reduction Intake (CDRR) for sodium based on the beneficial effect of reducing sodium intake on CVD risk, risk of hypertension, systolic blood pressure and diastolic blood pressure. For individuals 14 years of age and older, sodium intakes should be reduced if above 2.3 g/day. Neither body could establish a UL for sodium.

Unprocessed foods and drinking water contain sodium, albeit in low amounts. The sodium content of processed foods, including those prepared at home, can vary substantially across countries, reflecting dietary habits and taste preferences. It may also be influenced by technological considerations and by reformulation of processed foods in response to public health policies. Also, large variations exist in the sodium content of foods belonging to the same group. Sauces (particularly Asian ones), processed meat, cheese, savoury snacks and canned fish are the food groups with the highest sodium content (Webster et al., 2010; Ni Mhurchu et al., 2011; Capuano et al., 2013; Eyles et al., 2013; EFSA NDA Panel, 2019b), while the main contributors to sodium intake in European populations are bread, processed meat and cheese (European Commission, 2012; Kloss et al., 2015; EFSA NDA Panel, 2019b).

Sodium intakes have been estimated from urinary sodium excretion data collected in 18 European countries (EFSA NDA Panel, 2019b). Mean sodium urinary excretion levels across countries ranged between 3.2 and 6.1 g/day (141 and 266 mmol/day) in adult men, and between 2.6 and 4.2 g/day (112 and 182 mmol/day) in adult women. In children, values ranged between 1.7 g/day (72 mmol/day) at 6 years of age and 2.8 and 3.5 g/day (122 and 154 mmol/day) at 13–14 years of age. These data showed that mean sodium intakes in adults and children exceeded the safe and adequate level of intake.

<sup>25</sup> Council Directive 2001/111/EC of 20 December 2001 relating to certain sugars intended for human consumption. OJ L 10, 12.1.2002, p. 53–57.

Taking into account the well-established relationships between sodium intake, blood pressure and CHD risk, and that the majority of European populations exceed the safe and adequate level of intake, the Panel considers that a reduction in the intake of dietary sodium is of public health importance for European populations.

### 3.1.1.7. Conclusions

The Panel notes that mean intakes of SFAs, sodium and added/free sugars exceed the recommended upper bounds of intake in the majority of European populations and subgroups thereof. The Panel considers that excessive consumption of these nutrients is associated with adverse health effects, and that a reduction in the intake of SFAs, sodium and added/free sugars is of public health importance for European populations.

The Panel also notes that, owing to the high prevalence of overweight and obesity in Europe at all ages, energy intake exceeds requirements for the maintenance of a normal body weight in the majority of European populations. The Panel considers that excess energy intake leading to overweight and obesity is associated with adverse health effects, and that a reduction of energy intake is of public health importance for European populations.

Although adverse health effects of diets high in TFAs are well documented, mean intakes of TFAs in most European countries and population groups are at or below recommended limits within the context of a nutritionally adequate diet. Moreover, the public health importance of TFAs has been already addressed through the implementation of current European legislation, limiting the use of industrially produced TFAs in foods, which is expected to further reduce intakes.

## 3.1.2. Nutrients and non-nutrient components of food for which intakes might be inadequate in relation to recommended levels in some population groups and countries in Europe

### 3.1.2.1. Protein

The human body requires dietary protein to support tissue growth and maintenance. The concept of protein requirement includes both total nitrogen and indispensable amino acids. In this context, protein is defined as total nitrogen  $\times$  6.25 and protein requirement is based on nitrogen content. In adults, protein requirement can be measured individually using nitrogen balance, which is the difference between nitrogen intake and the amount lost in urine, faeces, via the skin and other routes. In healthy adults who are in energy balance, the protein requirement (maintenance requirement) is defined as the amount of high-quality dietary protein (i.e. with a Protein Digestibility-Corrected Amino Acid Score of 1) sufficient to achieve nitrogen balance (EFSA NDA Panel, 2012a).

Animals and plants are the main dietary sources of protein. Most animal sources (meat, fish, egg, milk and dairy products) provide high-quality protein, i.e. with high digestibility and optimal indispensable amino acid composition (i.e. high biological value) for human needs. The indispensable amino acid content of plant proteins (grains and grain-based products, legumes and nuts) and/or their digestibility is usually lower. However, the combination of different plant sources of protein (e.g. grains and legumes) may result in an adequate indispensable amino acid intake for humans (EFSA NDA Panel, 2012a).

A meta-analysis of available data on nitrogen balance as a function of nitrogen intake (Rand et al., 2003) was used to estimate the average requirement for protein in adults and children as 105 mg N (or 0.66 g high-quality protein) per kg body weight per day, with the 97.5th percentile being at 133 mg N (or 0.83 g high-quality protein) per kg body weight per day. Thus, an intake of 0.83 g of high-quality protein/kg per day (e.g. 58 g/day for a 70-kg individual) was considered sufficient to cover the protein requirements of 97.5% of the general adult population. This PRI derived by EFSA can be applied to usual mixed diets in Europe, which are likely to contain sufficient amounts of all indispensable amino acids. For older adults, the protein requirement was set to be the same as for adults (EFSA NDA Panel, 2012a).

Protein intakes above the level required to achieve nitrogen balance (i.e. the PRI) have no beneficial effects on muscle mass or function at any age. The scientific evidence for the adverse health effects of high protein intakes reported in the literature (i.e. in relation to body weight control, glucose homeostasis, bone health or kidney function) did not allow to derive a UL for dietary protein (EFSA NDA Panel, 2012a).

Dietary surveys in Europe suggest that average protein intakes in the European adult population, including older adults, are mostly at or above the PRI (i.e. ranging between 67 and 114 g/day in men

and between 59 and 102 g/day in women, corresponding to average intakes between 0.8 and 1.25 g/kg body weight/day). Dietary surveys also indicate that protein intakes are at, or more often above, the PRI in infants > 6 months of age (EFSA NDA Panel, 2017), in children, and during pregnancy and lactation (EFSA NDA Panel, 2012a).

The Panel notes that average protein intakes in Europe are above the PRI in most population groups and countries, and that no beneficial effects on muscle mass or function can be expected from increasing protein intakes further.

### 3.1.2.2. EPA and DHA

EPA and DHA are n-3 LC-PUFAs, i.e. n-3 PUFAs with  $\geq 20$  carbon atoms. EPA can be transformed to eicosanoids. These include prostaglandins, prostacyclins and leukotrienes, which are involved in the regulation of blood pressure, renal function, blood coagulation, inflammatory and immunological reactions and other processes. DHA is a component of structural lipids of membranes. It is mostly found in phospholipids in the nervous tissue and the retina. Large amounts are accumulated in the developing brain, particularly during the first 2 years of life (EFSA NDA Panel, 2010c).

A meta-analysis of RCTs in adults without existing CVD comparing high with low n-3 LC PUFA consumption showed a small but statistically significant reduction in the risk of CVD including CHD mortality and in the risk of CHD events with moderate to low certainty in the evidence (Abdelhamid et al., 2020). Prospective cohort studies also indicate that fish consumption decreases the risk of CVD, and particularly the risk of CHD mortality and sudden cardiac death, in healthy individuals (EFSA NDA Panel, 2010c, 2014c). These associations have also been observed when n-3 LC-PUFAs are used as the exposure variable instead of fish and appear to be dose dependent up to about 250 mg of EPA and DHA per day, i.e. one to two servings of oily fish per week (EFSA NDA Panel, 2010f, 2014c).

There are several mechanisms by which the intake of EPA and DHA from fish and fish oil could reduce CVD risk. EPA and DHA have a well-established antiarrhythmic effect and decrease blood triglycerides, blood pressure, heart rate and platelet aggregation in a dose-response manner. The shape of these dose-response curves and their time course, however, are highly variable, as well as the relative contribution of each of these factors to CVD risk prevention. At the levels of intake observed in European diets (in the milligram/day range), the physiological effects that are most likely to account for clinical cardiovascular benefits, particularly regarding fatal CHD and sudden cardiac death prevention, are (a) the modulation of myocardial sodium and calcium ion channels, reducing susceptibility to ischaemia-induced arrhythmia, and (b) improved myocardial efficiency as a result of reduced heart rate, lower systemic vascular resistance and improved diastolic filling (Mozaffarian and Rimm, 2006; Mozaffarian and Wu, 2011; Rimm et al., 2018).

The AI for adults for the combination of EPA and DHA of 250 mg/day was set by the NDA Panel based on studies on fish consumption and primary prevention of CVD. The same AI was set for children aged 2 years and above. For infants > 6 months and young children up to 2 years, an AI for DHA of 100 mg/day was derived based on the effect of this fatty acid on visual function in the complementary feeding period (EFSA NDA Panel, 2010c).

Sources of EPA and DHA are almost exclusively foods of marine origin, mainly oily fish and derived products.

Representative dietary intake estimates of EPA and DHA in Europe are sparse. In 2012 (EFSA NDA Panel, 2012b), the intake data available (from four or five European countries depending on the fatty acid) came from various publications using different dietary assessment methods, food composition databases and age cut-offs. Mean daily intakes in adults from food only (i.e. excluding food supplements) were between 50 mg/day and 150 mg/day for EPA and between 131 mg/day and 273 mg/day for DHA. In 2014 (EFSA NDA Panel, 2014c), harmonised nutrient intake data from seafood (including EPA and DHA combined) were calculated for the five European countries with the highest percentage of seafood consumed specified at species level in dietary surveys, using the EFSA food composition and consumption databases. Mean daily intakes of EPA and DHA combined in adults ranged from 122 to 585 mg/day, with high variability across countries depending on the percentage of fish consumers. Mozaffarian et al. (2017) reported median intakes of EPA and DHA from fish between 89 mg/day and 563 mg/day in prospective cohort studies conducted in five European countries, with the highest intakes being found mostly in northern European countries.

The Panel notes that harmonised EPA and DHA intake data across European countries and population groups are scarce and that intakes may vary widely across countries depending on the intake of fish/seafood and products thereof.

The average consumption of fish flesh and processed fish and seafood per day in adults and adolescents (consumers and non-consumers) in 21 EU Member States as reported in the EFSA Comprehensive Food Consumption Database ranges from around 7 to 58 g/day, the wide range also reflecting the varying percentages of individuals who consumed fish on the days of the surveys. As the data are mostly based on 24-h recalls and dietary records with two to three replicates<sup>26</sup>, the percentage of individuals never consuming fish in EU Member States cannot be reliably estimated. The recommendations for fish consumption in FBDGs of EU Member States differ and range from 100 to 500 g/week. Even though in the majority of surveys the mean weekly consumption of fish flesh and processed fish and seafood reaches 100 g, comparisons to national recommendations indicate that mean intakes are below those recommendations in all or some subpopulations of adults and adolescents in Austria (pregnant women and adolescents only), the Czech Republic, Denmark, Germany, Greece, Hungary, Ireland (adults, but not in the elderly or very elderly), Italy (very elderly only), Latvia (pregnant women only), Romania and Sweden (adolescents only). The Panel notes that the available data suggest that fish consumption in some EU Member States is below national recommendations.

The Panel considers that intakes of EPA and DHA may be below the AI in European countries with low fish consumption.

The Panel considers that intakes of EPA and DHA may be inadequate for primary CVD risk reduction in Member States with low consumption of fish/seafood and products thereof.

### 3.1.2.3. Dietary fibre

Dietary fibre has been defined in several ways for risk assessment and management purposes. In EFSA's Scientific Opinion on DRVs for carbohydrates and dietary fibre (EFSA NDA Panel, 2010b), dietary fibre denotes all non-digestible carbohydrates. This includes non-starch polysaccharides, resistant starches, resistant oligosaccharides with three or more monomeric units and other non-digestible, but quantitatively minor components that are associated with the dietary fibre polysaccharides, especially lignin. The most recent definitions of dietary fibre proposed at national and international level are quite consistent, but differences exist regarding: (a) whether associated substances (e.g. lignin) are explicitly mentioned, (b) the minimum number of monosaccharide units that are required to be included in the definition and (c) the prerequisite, mainly for extracted, isolated, modified or synthetic carbohydrate polymers, that they have a proven health benefit (Stephen et al., 2017). Most authorities provide non-exhaustive lists of health benefits related to dietary fibre, the most common being in the areas of bowel function, and of lipid and glucose metabolism. The definition of dietary fibre for regulatory purposes in the EU is laid down in Regulation (EU) No 1169/2011<sup>13</sup>.

The main characteristics that may mediate the health effects of dietary fibre include viscosity and the capacity to form gels in the intestinal tract, fermentability in the colon and water-holding capacity.

Whole grain cereals, legumes, fruits and vegetables, and potatoes when eaten with the skin, are the main sources of dietary fibre, but mushrooms, nuts and seeds also contain high amounts. In whole-grain products, the lignified outer layers are the predominant dietary fibre source. Oats and barley contain high concentrations of  $\beta$ -glucan, a water-soluble, viscous type of polysaccharide. Pectins are the main type of dietary fibre in fruits and some vegetables and have properties similar to  $\beta$ -glucan (EFSA NDA Panel, 2010b).

Dietary fibre helps to maintain normal bowel function and alleviates constipation by decreasing colonic transit time and increasing faecal mass (EFSA NDA Panel, 2010b; Portalatin and Winstead, 2012). Dietary fibre increases stool bulk by enhancing the water-holding capacity of stools (Portalatin and Winstead, 2012). Fermentable components of dietary fibre are metabolised by the microbiota, which stimulates microbial growth and increases faecal bulk (Cummings, 2001).

The intake of dietary fibre as found in mixed diets has been inversely associated with the risk of developing CVD and T2DM in prospective cohort studies (EFSA NDA Panel, 2010b). This is supported by the results of recent meta-analyses investigating the relationship between dietary fibre intake and CHD (Threapleton et al., 2013; McRae, 2017), stroke (Zhang et al., 2013; McRae, 2017), cardiovascular mortality (McRae, 2017) and T2DM (Yao et al., 2014). The mechanisms by which dietary fibre could affect CVD and T2DM risk are not fully elucidated but may depend on the characteristics of the different fibre types. The viscosity and gel-forming capacity in the intestinal tract appear to influence glucose and lipid metabolism. Viscous fibres have shown to delay carbohydrate

<sup>26</sup> Only in Ireland and Sweden four replicates were done and in Denmark seven.

absorption and decrease the postprandial glycaemic responses to carbohydrate-rich meals. They could also lower blood total and LDL-cholesterol concentrations (Bazzano, 2008) by increasing the viscosity of the gut content, enhancing bile acid synthesis and excretion of bile acids and cholesterol in faeces (Ellegård and Andersson, 2007; Wolever et al., 2010; Wang et al., 2017). Epidemiological evidence suggests a beneficial effect of total dietary fibre on weight management (Koh-Banerjee et al., 2003; Du et al., 2010).

In 2010, EFSA derived an AI of 25 g per day of dietary fibre from mixed diets (as AOAC fibre or equivalent) that is compatible with an intestinal transit time of about 2–3 days and a defaecation frequency of one per day and a faecal moisture of > 70%, and may be considered adequate for normal laxation in adults (EFSA NDA Panel, 2010b). Dietary fibre intake of 2 g per MJ was considered adequate for normal laxation in children based on the dietary fibre intake that is adequate for normal laxation in adults (25 g, equivalent to 2–3 g per MJ for daily energy intakes of 8–12 MJ) and taking into account that energy intake relative to body size in children is higher than in adults. The effect of dietary fibre on cardiometabolic risk is generally expected to occur at dietary fibre intakes above the AI (EFSA NDA Panel, 2010b).

Average intakes of dietary fibre in national dietary surveys across European adult populations ranged from 15.7 to 29.5 g/day and were, in all surveys but one, below the AI of 25 g/day (EFSA NDA Panel, 2010b). A more recent compilation of national intake data compiled by the European Commission<sup>27</sup> is mostly in line with this observation. In children, the AI of 2 g/MJ was exceeded in around half of the surveys; in the other half, mean intakes ranged from 1.7 to 1.9 g/MJ.

The Panel considers that adequate intake of dietary fibre contributes to maintaining normal bowel function and normal laxation and contributes to reducing the risk of CVD and T2DM. Taking into account that intakes of a majority of European adult populations are below recommendations, and that chronic disease risk reduction could take place at intakes above those recommended for the maintenance of normal bowel function, the Panel considers that an increase in dietary fibre intake is of public health importance for European populations.

#### 3.1.2.4. Potassium

Potassium is an essential mineral and is required for normal cell function. It is the predominant osmotically active intracellular element. It plays a major role in the transfer of water inside and outside cells, assists in the regulation of the acid–base balance and contributes to establishing a membrane potential that supports electrical activity in nerve fibres and muscle cells (EFSA NDA Panel, 2016a).

Potassium intake has been reported to be associated with several health outcomes, particularly cardiovascular endpoints. Adequate dietary potassium intake protects against developing hypertension and improves blood pressure control in patients with hypertension, while inadequate potassium intake may increase blood pressure (Aburto et al., 2013). Furthermore, there is consistent evidence from observational cohort studies that potassium intakes below 3,500 mg (90 mmol)/day are associated with a higher risk of stroke (Vinceti et al., 2016).

In 2016, EFSA established an AI for potassium of 3,500 mg (90 mmol)/day for adult men and women based on the relationship between potassium intake, blood pressure and risk of stroke. For infants and children, the AIs were extrapolated from the AI for adults by isometric scaling and including a growth factor and range between 750 and 3,500 mg/day, depending on the age (EFSA NDA Panel, 2016a). This was in line with WHO recommendations given in 2012 (WHO, 2012).

Potassium is present in all foods, with the highest contents in starchy roots or tubers, vegetables, fruits, whole grains, dairy products and coffee. In Europe, the main food groups contributing to potassium intakes were starchy roots or tubers and products thereof, grains and grain-based products, milk and dairy products and vegetables and vegetable products and fruit and fruit products, including fruit and vegetable juices (EFSA NDA Panel, 2016a). Substantial potassium losses may occur during food processing and cooking (Barciela-Alonso and Bermejo-Barrera, 2015).

Mean dietary intakes of potassium in infants and children up to 10 years of age exceeded the AI, as reviewed in EFSA NDA Panel (2016a) based on data derived from the EFSA Comprehensive Food Consumption Database. In adults, average intakes of females (between 2,5 and 3,4 g/day) were generally below the AI. Average intakes of adult males (between 2,9 and 4,0 g/day) were below the AI in around half of the surveys and age categories (EFSA NDA Panel, 2016a).

Since adequate dietary intakes of potassium contribute to maintain blood pressure levels in the normal range and to reduce the risk of stroke, and dietary intakes of potassium appear to be

<sup>27</sup> [https://knowledge4policy.ec.europa.eu/health-promotion-knowledge-gateway/dietary-fibre-overview-3\\_en](https://knowledge4policy.ec.europa.eu/health-promotion-knowledge-gateway/dietary-fibre-overview-3_en)

inadequate in the majority of European adult populations, the Panel considers that an increase in potassium intakes is of public health importance for European populations.

### 3.1.2.5. Iodine

Iodine is an essential nutrient, required as a structural and functional element of thyroid hormones. Through the effects of these hormones, iodine has an important role in energy-yielding metabolism and the expression of genes that control several physiological functions, including embryogenesis and growth, and the development of neurological and cognitive functions (EFSA NDA Panel, 2014b).

The clinical effects of iodine deficiency are referred to as iodine deficiency disorders. Iodine deficiency can lead to impaired thyroid function, goitre and hypothyroidism, and is associated with a decreased fertility rate and increased infant mortality. Iodine deficiency is also linked to mental development disorders in children, causing poor school performance and reduced work capacity (EFSA NDA Panel, 2014b).

In 2014, EFSA set an AI for iodine for adult men and women of 150 µg/day based on urinary iodine excretion levels that have been associated with the lowest prevalence of goitre. For pregnant women, an AI of 200 µg/day was derived. For infants aged 7–11 months and for children, AIs ranged between 70 µg/day and 130 µg/day (EFSA NDA Panel, 2014b).

Foods are very variable in their content of iodine. Good sources of iodine are marine products (such as fish, crustaceans and bivalves), eggs, milk and their derivatives, and iodised salt. It has to be, however, noted that iodine content of milk and eggs is influenced by feeding practices (EFSA NDA Panel, 2014b). Milk and dairy products are the main sources, contributing to 25–70% of total daily iodine intake in many European populations, depending on the amount of milk and dairy products consumed and their iodine content (van der Reijden et al., 2017). Iodine intake is also related to the content of iodine salts in soils, which is low in mountainous areas and river valleys prone to flooding (WHO, 2004).

Iodine fortification of salt has been implemented in 40 European countries, either as mandatory fortification (13 countries) or voluntary fortification (16 countries), and is not regulated in the other countries. The amount of iodine that is added varies from 10 to 75 mg/kg salt, but is mostly in the range of 15–30 mg/kg (EFSA NDA Panel, 2014b). It is assumed that mandatory salt iodisation at 25 mg/kg salt ensures adequate iodine intake in all population groups, including pregnant and lactating women (Dold et al., 2018).

Iodine intake can be assessed by measuring urinary iodine concentration (UIC), as 90% of iodine consumed is excreted in urine. The following criteria based on urinary iodine concentration in populations have been suggested: median UIC < 20 µg/L, severe iodine deficiency in the population; median UIC 20–49 µg/L, moderate iodine deficiency; median UIC 50–99 µg/L, mild iodine deficiency; median UIC 100–199 µg/L, adequate iodine intake. For pregnant women, a median UIC of < 150 µg/L reflects inadequate intakes in the population, owing to the higher iodine requirements during pregnancy (WHO, 2004).

An UIC of 100 µg/L corresponds to an approximate iodine intake of 150 µg/day in adults.

In a recent study assessing iodine status in Europe based on data from 40 studies from 23 European countries, median standardised<sup>28</sup> UIC was < 100 µg/L in 6.3% (i.e. 1 out of 16) studies in schoolchildren. In adults, 53.8% (i.e. 7 out of 13) studies indicated iodine deficiency in the population with a median standardised UIC < 100 µg/L. Seven out of 11 (63.6%) studies in pregnant women had a median UIC < 150 µg/L (Ittermann et al., 2020).

The Panel considers that adequate dietary intakes of iodine are important for normal thyroid function and prevent the incidence of iodine deficiency disorders. Inadequate iodine intakes that are observed in some European countries and some subpopulations are mainly addressed by national nutrition policies (e.g. supplementation, food fortification) in Member States (see also Appendix B).

### 3.1.2.6. Iron

Iron is required for oxygen transport (as an essential component of haemoglobin), electron transfer, oxidase activities and energy metabolism (EFSA NDA Panel, 2015b).

Often, iron deficiency anaemia (IDA) is used as a surrogate indicator of nutritional iron deficiency. However, IDA may also have non-dietary causes, including conditions that cause blood loss or malabsorption. IDA in infants and young children has been associated with impaired psychomotor development and cognitive performance. However, much of the research performed on this outcome is

<sup>28</sup> Data of the individual studies were harmonised *a posteriori* using conversion formulas established by linear regression models.

confounded by socio-economic factors and by the difficulties in standardising the outcome measurements. In adults, impaired physical performance and an inefficient energy metabolism has been observed (EFSA NDA Panel, 2015b).

In the Panel's Scientific Opinion on DRVs for iron (EFSA NDA Panel, 2015b), the PRI (AR) for iron has been set at 11 (6) mg/day for adult men and post-menopausal women and at 16 (7) mg/day for pre-menopausal, pregnant and lactating women, by using a factorial approach. For children, age-specific values have been set and are stratified by age and sex subgroups, i.e. 11 (6) mg/day for infants 7–11 months, 7 (5) mg/day for 1- to 6-year-olds, 11 (8) mg/day for 7- to 11-year-old children and 12- to 17-year-old boys and 13 (7) mg/day for 12- to 17-year-old females.

Foods that contain relatively high concentrations of iron include meat, fish, cereals, beans, nuts, egg yolks, dark green vegetables, potatoes and fortified food products. The iron content of dairy products and many fruits and vegetables is much lower. Bioavailability of iron from plant foods (non-haem iron) is generally much lower than that from animal (haem-iron) foods (due to a different absorption mechanism for non-haem iron versus haem-iron). The iron status in vegetarians and vegans has been reported to be markedly lower than the omnivorous counterparts in the population. However, absorption of elemental iron from plant sources can be enhanced by reducing agents present in food, most notably by the joint intake of vitamin C – this has also been acknowledged in previous EFSA Opinions (EFSA NDA Panel, 2009, 2015b).

Dietary iron intakes have been estimated by EFSA using the EFSA Comprehensive Food Consumption Database, by selecting data from 13 dietary surveys from nine countries, i.e. Finland, France, Germany, Ireland, Italy, Latvia, the Netherlands, Sweden and the UK (EFSA NDA Panel, 2015b). Except for 7- to 11-month-old infants, median iron intakes exceeded the AR in all population groups and surveys. In 7- to 11-month-old infants, median intakes were below the AR in all four surveys available.

Infants that are at particular risk of iron deficiency are exclusively breastfed infants > 4 months of age born to mothers with a low iron status, with early umbilical cord clamping (< 1 min after birth), born preterm, born small-for-gestational age or those with a high growth velocity. These infants may benefit from the early introduction of complementary foods that are good sources of iron (EFSA NDA Panel, 2019a). The European Society for Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) emphasises the importance of all infants receiving iron-rich complementary foods, owing to the high iron requirements during that life stage (Fewtrell et al., 2017).

The Panel is aware that estimates of the percentage of the population that have inadequate iron intakes vary (Milman, 2019, 2020a,b) and depend on the reference values that are chosen as comparator. Population groups that are commonly considered to have a higher risk of inadequate iron status are women of child-bearing age, pregnant women and children, including certain exclusively breast-fed infants > 4 months of age (see above). Generally, routine iron supplementation (of any population group) is not encouraged in Europe owing to the risk of overconsumption of iron in individuals with sufficient iron stores. Therefore, advice for supplementary intake is limited to individuals with clinically determined impaired iron stores (Brannon and Taylor, 2017).

The Panel considers that low iron intakes are a risk factor for the development of IDA that is associated with adverse health effects. Inadequate iron intakes in infants at risk of iron deficiency are usually addressed by national nutrition policies in Member States by recommending feeding foods that are good sources of iron in the weaning period in line with the recommendations given by ESPGHAN. Inadequate iron intakes in other population subgroups are usually addressed through individual advice.

### 3.1.2.7. Calcium and vitamin D

Insufficient dietary supply of calcium leads to resorption of calcium from bone, causing a loss of bone mass that can result in osteopenia (i.e. lower than normal bone mineral density (BMD) and osteoporosis) (EFSA NDA Panel, 2015a). Inadequate intakes of vitamin D lead to inefficient absorption of dietary calcium and phosphorus, and thus cause an impaired mineralisation of bone (EFSA NDA Panel, 2016b). However, also genotype and environmental and lifestyle factors other than calcium and vitamin D intake play key roles in the maintenance of BMD (EFSA NDA Panel, 2015a).

Combined intakes of calcium and vitamin D from all sources at levels of or above 1,200 mg and 800 IU (20 µg) per day, respectively, have been associated with a reduction of the risk of osteoporotic fractures in postmenopausal women (EFSA, 2009; EFSA NDA Panel, 2010a). Also, there is evidence that intakes of vitamin D and calcium from all sources, as compared to calcium alone, reduce the risk of falling in older adults (EFSA NDA Panel, 2011a). More recent meta-analyses are in line with these findings (Yao et al., 2019; Thanapluetiwong et al., 2020).

There is debate on the amount of calcium that is required to prevent osteoporosis. Willett et al. (2019) and WHO (2003) suggested that calcium intakes in adults of around 500 mg/day may already be sufficient to maintain bone health, based on the notion that in countries with a high fracture incidence, a minimum of 400–500 mg/day of calcium may be sufficient to prevent osteoporosis (WHO, 2003; Willett et al., 2019) and that increasing calcium intakes above this minimum level might not have a beneficial effect on the risk of fractures (Bischoff-Ferrari et al., 2007).

However, DRVs for calcium indicate a PRI that is higher than 500 mg/day (DH, 1991; WHO/FAO, 2004; IoM, 2011; Nordic Council of Ministers, 2014; D-A-CH, 2015; EFSA NDA Panel, 2015a; ANSES, 2016; HCN, 2018).

EFSA has proposed a PRI (AR) for young adults 18–24 years of age of 1,000 (860) mg/day and for adults  $\geq$  25 years of 950 (750) mg/day. For young children aged 1–3 years, the PRI (AR) for calcium has been set at 450 (390) mg/day, for children 4–10 years at 800 (680) mg/day, for adolescents 11–17 years of age at 1,150 (960) mg/day (EFSA NDA Panel, 2015a).

Unlike other vitamins, vitamin D<sub>3</sub> can be synthesised in the body following exposure to sunlight or artificial UV-B irradiation. Dietary intake is, however, essential when the endogenous synthesis is insufficient to cover requirements. Factors affecting the endogenous synthesis of vitamin D<sub>3</sub> include latitude, season, ozone layer and clouds (absorbing UV-B irradiation), surface characteristics (reflecting UV-B irradiation), time spent outdoors, use of sunscreen, clothing, skin colour and age. As these factors may vary considerably, DRVs have been derived based on the assumption that the endogenous vitamin D synthesis is minimal (EFSA NDA Panel, 2016b).

Taking this into account, EFSA has set an AI for vitamin D for adults, including pregnant and lactating women, and children aged 1–17 years of 15  $\mu$ g/day. For infants aged 7–11 months an AI of 10  $\mu$ g/day was derived (EFSA NDA Panel, 2016b). These AIs can, however, mostly not be achieved by dietary intakes alone. Intakes of around 16  $\mu$ g/day from food alone (i.e. somewhat higher than the AI) were only achieved in high consumers (95th percentile), according to published dietary intake data (EFSA NDA Panel, 2016b).

The main contributors to calcium intake, as reviewed by EFSA NDA Panel (2015a), are milk and dairy products that are responsible for between 38% and 85% of the intake, followed by grains and grain-based products (2–35%), water and water-based beverages (1–18%) and vegetables and vegetable products (1–11%). Composite dishes and coffee, cocoa, tea and infusions also contribute up to 12% to the intake.

Dietary sources of vitamin D are mostly fatty fish and eggs, food supplements and fortified foods. Small amounts are also provided by meat (Spiro and Buttriss, 2014).

Calcium intake was estimated in the Panel's Scientific Opinion on DRVs for calcium (EFSA NDA Panel, 2015a) by using data from the EFSA Comprehensive European Food Consumption Database. Data were available from 13 dietary surveys including nine countries (Finland, France, Germany, Ireland, Italy, Latvia (pregnant women), the Netherlands, Sweden and the UK). Comparison of the median calcium intake to the AR showed that adolescents, in particular, are at risk of inadequate intakes. More than 50% of this population (both males and females) in four out of five surveys (i.e. those of France, Germany, Italy and the Netherlands) had calcium intakes below the AR.

The prevalence of inadequate vitamin D status, i.e. serum 25(OH)D concentrations of  $<$  45 or 50 nmol/L, in Europe was reviewed by Spiro and Buttriss (2014). Studies from Austria, France, Germany, the Netherlands, Spain and Northern Europe showed that the prevalence of serum 25(OH)D concentrations of  $<$  45 or 50 nmol/L ranged from about 28–67% in adults. For children, data from Austria showed that around 40% of 7- to 14-year-old children were below this cut-off and that 92% of 13-year-old children from Denmark, Finland, Ireland and Poland did not reach serum 25(OH)D concentrations of 45–50 nmol/L. Being at a higher risk of vitamin D inadequacy, the following population groups are often advised to take vitamin D supplements: infants and young children, pregnant and breast-feeding women, older people, individuals with low or no sun exposure, people with darker skin living in Europe (e.g. NICE, 2014; Rusińska et al., 2018).

The Panel considers that adequate intakes of calcium and vitamin D are required for the maintenance of bone mass. A reduction in the risk of osteoporotic fractures and the risk of falling has only been observed beyond the PRI, at intakes of and above 1,200 mg calcium and 800 IU (20  $\mu$ g) vitamin D per day from all sources. The Panel notes that vitamin D status in European populations is inadequate in a large proportion of children and adults living in Europe and that population groups at particular risk of inadequate status are well known. The Panel also notes that dietary intakes of calcium may be inadequate in adolescents. Even though elderly may have sufficient calcium intakes compared with the DRVs, intakes may not be sufficient to reduce the risk of osteoporotic fractures and

the risk of falling, especially if associated with a suboptimal vitamin D status (EFSA, 2009; EFSA NDA Panel, 2010a).

The Panel considers that whether an increase in calcium intake is beneficial may depend on the population group and that in some cases (e.g. older adults), the recommended intake cannot be achieved through dietary modifications alone. The Panel also considers that vitamin D inadequacy in at-risk populations identified in the national context is ideally addressed by national policies in Member States.

### 3.1.2.8. Folate

Folate is a generic term used for a family of water-soluble organic compounds that belong to the group of B-vitamins. It is an essential micronutrient, required for the synthesis of ribo- and deoxyribonucleic acids (RNA and DNA), and consequently for cell division, and tissue growth, methylation reactions and amino acid metabolism (EFSA NDA Panel, 2014a).

In folate deficiency, DNA replication and thus cell division may be impaired, leading to the production of large and immature macrocytic cells that can result in megaloblastic anaemia. It is well established that periconceptual folate supplementation is associated with a reduced risk of development of neural tube defects, a group of congenital malformations, in the developing fetus. As a consequence, women of childbearing age are advised to consume folic acid supplements in addition to food folate at a dose of 400 µg/day (IoM, 1998; EFSA NDA Panel, 2014a; D-A-CH, 2015; NHMRC, 2017; SACN, 2017).

The EFSA NDA Panel (2014a) established an AI for folate for infants aged 7–11 months of 80 µg DFE<sup>29</sup>/day. For children and adolescents, PRIs were derived by using allometric scaling from the adult AR, and range from 120 to 330 µg DFE/day, respectively. For healthy adults, a PRI of 330 µg DFE/day was set based on the maintenance of adequate folate status. An AI of 600 µg DFE/day was proposed for pregnancy. This value does not include the advice to consume folic acid supplements preconceptionally. For lactating women, a PRI of 500 µg DFE/day was set.

The main sources of naturally occurring food folates are dark green leafy vegetables, legumes and rice. From animal sources, beef liver and crabs are particularly high in folate. Fortified foods, such as breakfast cereals, are the main contributors to the overall dietary intake of folic acid (EFSA NDA Panel, 2014a). Dietary intake of folate was estimated by the Panel in its Opinion on DRVs for folate (EFSA NDA Panel, 2014a), based on national dietary surveys from the Netherlands, Ireland and Germany, the only surveys available at the time expressing intakes as DFEs, even though the way in which DFEs were computed was heterogeneous among them. The Panel notes that data on folate intake in Europe expressed as DFE are insufficient and do not allow conclusions to be drawn on the adequacy of intake in European populations.

The Panel considers that the main public health concern in relation to folate intakes is the preconceptional folate intake of women of childbearing age, that is mainly addressed by national policies in Member States (see also Appendix B).

### 3.1.2.9. Conclusions

The Panel concludes that intakes of dietary fibre and potassium are inadequate in a majority of European adult populations. An increase in the intake of dietary fibre and potassium is of public health importance owing to the adverse health effects that are caused by inadequate intakes. An increase in intake may be achieved through modification of the habitual diet. The Panel also considers that intakes of EPA and DHA may be inadequate for primary CVD risk prevention in Member States with low consumption of fish/seafood and products thereof.

The Panel notes that intakes of calcium, vitamin D, folate, iodine and iron may also be inadequate in certain subgroups of European populations. An increase in the intake of these nutrients is important for such subgroups of the population only, and adequate intakes may not always be achieved through modification of the habitual diet. Inadequate intakes of these nutrients are usually addressed by national nutrition policies (e.g. supplementation, food fortification) in Member States and/or individual advice.

The Panel also notes that, even if dietary protein is required to support tissue growth during childhood and adolescence and maintain muscle mass and function during adulthood and in old age, average protein intakes in Europe are above the PRI in most population groups and countries.

<sup>29</sup> DFE: dietary folate equivalents. For combined intakes of food folate and folic acid, DFEs can be computed as follows: µg DFE = µg food folate + (1.7 × µg folic acid).

## 3.2. Food groups which have important roles in diets of European populations and subgroups thereof

### 3.2.1. Role of food groups in European diets as addressed in food-based dietary guidelines of EU Member States

FBDGs from Member States have been compiled by representatives of the high-level group on nutrition and physical activity. The compilation contains 28 FBDGs from 27 EU Member States (i.e. Belgium has separate FBDGs for Flanders and Wallonia). Recommendations in national FBDGs were presented by Storcksdieck genannt Bonsmann et al. (2020b) by grouping them under the most commonly used food groups/nutrient groups found in national FBDGs, even though it is acknowledged by the authors that food grouping and food group names differ among FBDGs, and that the result is a compromise to provide a meaningful overview. The same classification is used in this opinion. The definition of food groups/categories and/or the classification of specific foods within a certain food category for nutrient profiling purposes is outside EFSA's remit. Term names in the EFSA food classification system (FoodEx 2) are also provided for information.

An overall summary of dietary recommendations and FBDGs by Member States is given below. The role of food groups in European diets is also addressed by identifying the main nutrients (plus dietary fibre) that characterise these food groups. For details on dietary recommendations and FBDGs by individual Member States, the Panel refers to the publication by Storcksdieck genannt Bonsmann et al. (2020b).

**Starchy foods:** Starchy foods provide complex carbohydrates. When consumed in the form of whole grain products, they are also a good source of dietary fibre, B-vitamins, tocopherols and folate. This food group in FBDGs of European countries comprises mainly cereals (including breakfast cereals) and cereal-derived products, such as bread, pasta, rice, couscous or bulgur. Potatoes are included in the category 'starchy foods' in most FBDGs.

Some FBDGs include in these category food products with considerable amounts of sugars, fat, SFAs and/or salt, such as some breakfast cereals, fine bakery wares, fried products, snacks or some breads. A reduction in the intake of these food products is either encouraged directly in FBDGs or indirectly through recommendations to reduce sugar, SFA, fat and salt intakes.

Generally, FBDGs recommend eating starchy foods several times per day (generally between 3 and 11 servings per day, portion sizes vary between FBDGs) with an emphasis on whole grain products.

The FoodEx 2 term names (level 1) in EFSA's Comprehensive Food Consumption Database associated with starchy foods are 'grains and grain-based products' and 'starchy roots and tubers and primary derivatives thereof'.

**Fruits and vegetables, including juices:** Fruits and vegetables are sources of vitamins, minerals and dietary fibre. FBDGs stress the importance of consuming a variety of fresh fruits<sup>30</sup> and vegetables every day, generally between 400 and 650 g/day. However, processing may alter the nutritional properties. For example, juicing leads to a reduction in dietary fibre content and drying to a concentration of the natural sugar content. Also, sugar could be added during processing, such as in canned fruits with syrup, compotes, marmalades or jams. FBDGs are nevertheless not homogeneous in their recommendations regarding the consumption of food products within this group. For example, fruit juices are considered equivalent to a portion of fruit in one country and as sugar-sweetened beverages in another. Most countries, however, recommend restricting the consumption of **fruit juice** to about one serving per day or suggest preferring fresh fruit over juice. A few countries also suggest limiting the intake of **dried fruits** or **canned fruits** or advise the consumption of canned fruits in natural juice rather than syrups. Some processed vegetables may also contain significant amounts of added sodium.

The FoodEx 2 term names (level 1) associated with fruits and vegetables are 'fruit and fruit products' and 'vegetable and vegetable products'. Fruit and vegetable juices and nectars are covered under 'fruit and vegetable juices and nectars (including concentrates)' also at level 1.

**Legumes and pulses:** Legumes and pulses provide carbohydrates, dietary fibre and protein and are also rich in micronutrients. Recommendations in FBDGs to consume legumes span from consumption of one to two times per week to up to three to four times per week (portion sizes vary between FBDGs). The consumption of legumes and pulses is specifically encouraged in seven FBDGs,

<sup>30</sup> In some FBDGs, berries are mentioned separately from fruits.

and in another 10, the partial substitution of meat with legumes and pulses is recommended. Canned legumes and pulses may contain significant amounts of added sodium.

The associated FoodEx 2 term name is 'legumes' at level 2, nested within 'legumes, nuts, oilseeds and spices' (level 1).

**Milk and dairy products:** Milk and dairy products are important contributors to the intake of protein, calcium, riboflavin, vitamin B<sub>12</sub> and iodine. They may, however, also contribute to SFA intake (depending on the fat content), and to added sodium or added sugar intake in their processed forms. FBDGs of EU Member States are consistent in recommending daily consumption of skimmed and semi-skimmed milk, low-fat yoghurt, sour milk products or similar and low-fat cheeses. In some cases, recommendations are made to choose cheeses low in salt and dairy without added sugar.

The associated FoodEx 2 term name (level 1) is 'milk and dairy products'. Plant-based dairy alternatives are not included in this category.

**Meat and meat products (including offal):** Meat and offal are a good source of high-quality protein, iron, zinc, some vitamins (e.g. vitamins A, D and B<sub>12</sub>) and MUFAs. Meat and meat products may, however, contribute significantly to the intake of SFAs and added sodium in case of processed meat. Most FBDGs recommend limiting meat intake typically to around 300–600 g per week, mainly choosing lean meats, and not eating meat every day. Three Member States also address offal and suggest limiting consumption. Some FBDGs specifically suggest reducing consumption of red meat and processed meat. As alternatives to meat, fish, eggs, pulses and products thereof, including tofu, and mycoprotein-based foods as well as seitan are mentioned.

The associated FoodEx 2 term name (level 1) is 'meat and meat products'. Plant-based meat substitutes are not included in this category.

**Fish and shellfish including products thereof:** Fish, depending on the species, is a significant contributor to n-3 LC-PUFAs, iodine and vitamin D intake. Some processed fish products may be high in sodium. Regular fish consumption is recommended in all FBDGs of Member States, ranging from one to four times per week, serving sizes ranging from 30 g to 200 g, but being mostly 100–150 g. Five Member States suggest eating fatty fish, one Member State low-to-medium fat fish and eight Member States indicate that it is important to vary species, also between fatty and lean fish, and fishing locations.

The associated FoodEx 2 term names at level 2 are 'fish (meat)', 'fish offal' and 'fish and seafood processed' nested under 'fish, seafood, amphibians, reptiles and invertebrates' at level 1. 'Fish processed' is found as level 3 under 'Fish and seafood processed'.

**Oils and fats:** Most vegetable oils are rich in MUFAs, PUFAs and vitamin E. Palm oil, palm kernel oil, coconut oil and animal fats are high in SFAs. Red palm oil is also a source of pro-vitamin A carotenoids, while animal fats provide vitamin D. Generally, FBDGs recommend the consumption of vegetable oils high in unsaturated fatty acids and to limit consumption of SFAs.

The FoodEx 2 term name at level 1 is 'animal and vegetable fats and oils and primary derivatives thereof'.

**Nuts and seeds:** Nuts and seeds are good sources of unsaturated fatty acids (including essential fatty acids), protein, dietary fibre, vitamins and minerals (e.g. calcium, magnesium, iron, zinc). Most FBDGs contain recommendations for consumption of unsalted and unsweetened nuts and seeds that range from daily intake to consumption of two to three times per week, serving sizes ranging from 10 to 40 g, mostly being 15–25 g.

The associated FoodEx 2 term names at level 3 are 'treenuts' and 'oilseeds' nested under level 2 'nuts, oilseeds and oilfruits' and level 1 'legumes, nuts, oilseeds and spices'.

**Non-alcoholic beverages (excluding fruit and vegetable juices):** Non-alcoholic beverages are important for fluid intake. FBDGs of Member States recommend drinking daily between 1 and 3 L (mostly 1.5–2 L), preferably water. Advice is given to choose beverages without added sugars, as they can contribute to the intake of added sugars to a significant extent. Some Member States specifically advise moderating the intake of coffee, green and black tea, and other caffeine-containing beverages.

The associated FoodEx 2 term names at level 1 are 'water and water-based beverages' and 'coffee cocoa tea and infusions'.

### 3.2.2. Food groups and health outcomes

Even though the effects of some individual nutrients and non-nutrient components of food on chronic disease risk are well established, as described in Section 3.1, these are usually found in foods and diets as complex mixtures, where synergistic or antagonistic effects may come into play. Food

processing, including the preparation and cooking methods used at home, may also influence the health effects of individual foods.

Diets high in fruits and non-starchy vegetables, whole grains, legumes, nuts and seeds, fish and shellfish, and unsaturated fat-rich vegetable oils, and low in refined starches, red meat and processed foods and beverages with high sodium, added sugars and/or TFA content are associated with a lower risk of developing CVD, T2DM and some types of cancer in Western populations (Mozaffarian, 2016; Willett et al., 2019; USDA, 2020). The Mediterranean-style diet pattern (Davis et al., 2015) and the New Nordic diet-style pattern (Mithril et al., 2012, 2013), also called Baltic Sea diet-style pattern, are good examples of such dietary patterns in Europe. The relationship between the consumption of other foods groups (e.g. dairy, butter, eggs, poultry) in mixed diets and chronic disease risk is less consistent (Mozaffarian, 2016).

## Sources of protein

High-quality protein is needed to ensure the growth of infants and young children, and to maintain lean body mass in the elderly. For people older than 2 years of age, however, a balanced plant-based diet can fulfil protein requirements (USDA, 2020). Meat, dairy, fish, eggs, legumes and nuts are high in protein and often considered as alternatives to each other in dietary recommendations and FBDGs. However, they are also sources of other food constituents that may affect health, so that these protein sources may not be interchangeable as concerns their effect on health.

Several systematic reviews and meta-analyses have investigated the association between red meat and processed meat consumption and the development of chronic metabolic diseases (Aune et al., 2009; Micha et al., 2010; Abete et al., 2014; Wang et al., 2016; Schwingshackl et al., 2017; Tian et al., 2017; Bechthold et al., 2019; Fan et al., 2019; Neuenschwander et al., 2019; Zeraatkar et al., 2019). In some articles, red meat was defined as fresh meat from beef, veal, lamb or pork, including hamburgers and meatballs, and processed meat as any meat preserved by the addition of chemical preservatives, smoking, curing, or salting, such as bacon, salami, sausages, hot dogs, processed deli or luncheon meat (Abete et al. (2014)). These meta-analyses consistently report a positive association between the consumption of processed meat and chronic metabolic disease outcomes, such as CHD, CVD mortality, myocardial infarction, stroke and T2DM as compared to other food sources, and particularly to other protein sources. The association between unprocessed red meat consumption and these endpoints was generally weaker and less consistent, whereas no association was observed for poultry/white meat (Abete et al., 2014; Papier et al., 2021; Iqbal et al., 2021).

Processed meat and red meat were classified by the International Agency for Research on Cancer (IARC) as group 1 and 2A carcinogens to humans, respectively (IARC, 2018). Positive associations were reported between processed meat and colorectum and stomach cancer, and for red meat and colorectum, pancreas and prostate cancer. Most recent systematic reviews of prospective cohort studies tend to confirm the positive associations between red and processed meat consumption and cancer risk (Han et al., 2019; Vernooij et al., 2019; Händel et al., 2020; Farvid et al., 2021; Poorolajal et al., 2021; Ubago-Guisado et al., 2021; Nouri-Majd et al., 2022).

In dose–response meta-analyses conducted in the framework of these systematic reviews, the risk of chronic disease was mostly increased at intakes of 50 and of 100–120 g/day for processed meat and unprocessed red meat, respectively. These levels of intake are above most current recommendations in FBDGs from Member States (see Section 3.2.1).

Plausible mechanisms through which consumption of processed meat, and to a lesser extent of unprocessed red meat, could increase the risk of CVD, T2DM and certain types of cancer, include the intake of high amounts of sodium and other preservatives (for processed meat only), haem iron and heat-induced carcinogens (process contaminants), as well as the unfavourable fatty acid profile (Al-Shaar et al., 2020; Papier et al., 2021).

Consumption of dairy products and moderate consumption of eggs (up to one per day) appears to be unrelated to CVD mortality (Rong et al., 2013; Mozaffarian, 2016; Guo et al., 2017), although some meta-analyses have also reported inverse (i.e. beneficial) associations between total dairy consumption and CVD endpoints other than mortality (Drouin-Chartier et al., 2016; Chen et al., 2021). Fish intake (one to two servings and up to three to four servings per week) significantly decreases CHD mortality in a dose–response manner (Zheng et al., 2012; EFSA NDA Panel, 2014c). It has recently been estimated that the risk of CVD mortality could be decreased by 4% per 20 g/day increment in fish consumption, and an optimal intake of 60 g fish/day for CHD mortality prevention has been suggested (Willett et al., 2019; Zhang et al., 2020).

The intake of moderate amounts of nuts (30–60 g/day) has been shown to beneficially affect cardiometabolic risk factors in RCTs, including blood pressure, blood lipid profile and glucose metabolism, and to decrease the risk of fatal and non-fatal CVD, T2DM and overall mortality in prospective cohort studies in substitution of other food sources (Afshin et al., 2014; Aune et al., 2016a; Mayhew et al., 2016). Similar evidence is available for the consumption of legumes and CHD risk (Afshin et al., 2014), possibly owing to the blood LDL-cholesterol and blood pressure-lowering effects reported in RCTs.

### Sources of digestible carbohydrates and dietary fibre

Carbohydrates are the largest source of energy in European diets. In 2010, the EFSA NDA Panel proposed an RI for digestible carbohydrates between 45 and 60 E% applicable to both adults and children older than 1 year of age (EFSA NDA Panel, 2010b). Major sources of complex carbohydrates in European diets are cereals and potatoes. Whole grain cereals and potatoes, if eaten with the skin, are also good sources of dietary fibre.

Diets high in whole grains have been associated with lower mortality from all causes, CVD and cancer in prospective cohort studies. In a dose response meta-analysis, these associations were monotonic, showing a decrease in risk for total, CVD and cancer mortality of about 7, 9 and 5%, respectively, for each serving (16 g) increase in whole grain intake per day (Zong et al., 2016).

Fruits and vegetables are also good sources of carbohydrates, vitamins, minerals, phytochemicals and dietary fibre. Meta-analyses from prospective cohort studies have consistently reported a lower risk of all-cause mortality, and particularly CVD mortality, associated with the consumption of fruits and vegetables (Wang et al., 2014, 2021; Aune et al., 2017). For each additional serving of fruits or vegetables per day (about 80 g/day), the risk appears to decrease monotonically by about 3–5% (depending on the analysis) up to five servings per day (or two servings of fruits and three of vegetables). The relationship with cancer risk has been less consistent. While Wang et al. (2014) report no association and a prospective analysis of the European Prospective Investigation into Cancer and Nutrition (EPIC) cohort only shows a very small and inconsistent risk reduction at high intakes (Boffetta et al., 2010), more recent meta-analyses including higher number of studies, participants and events, consistently show lower risk of cancer associated with the consumption of fruits and vegetables (or fruits and vegetables separately) up to about five servings per day (Aune et al., 2017; Wang et al., 2021).

Potatoes are starchy vegetables widely consumed in European diets. They contain high amounts of potassium, are a good source of dietary fibre if eaten with the skin, and provide vitamins C and B<sub>6</sub>, among other nutrients. The relationship between the intake of potatoes and chronic disease risk, particularly T2DM, has been systematically investigated because, as is the case with other refined starches, such as white bread or white rice, they contain high amounts of readily available carbohydrates. Recent systematic reviews and meta-analyses show positive (i.e. unfavourable) dose–response relationships between the consumption of potatoes and diabetes risk in Western populations, but the strength of the association differs depending on the way potatoes are prepared. Either no or a mostly modest increase in T2DM risk has been reported for high vs. low consumers of boiled/baked/mashed potatoes (Borch et al., 2016; Zhang et al., 2018; Quan et al., 2020; Guo et al., 2021). Conversely, the association between French fries and diabetes risk is consistent across systematic reviews, possibly because of the strong relationship observed also in relation to weight gain (Borch et al., 2016; Zhang et al., 2018; Quan et al., 2020; Guo et al., 2021).

### Oils and fats

Fats are commonly used for cooking and dressing worldwide. Animal (such as butter and lard) and vegetable (such as oils, margarines and shortenings) fats contain mixtures of SFAs, MUFAs and PUFAs in different proportions, but also other nutrients (e.g.  $\beta$ -carotene, vitamin D, vitamin E) and food components (e.g. polyphenols (EFSA NDA Panel, 2011c)) with potential health effects. While the relative effect of individual fat sources on blood cholesterol concentrations may be predicted by their fatty acid composition, as discussed in Sections 3.1.1.2 and 3.1.2.2, other health effects that may be related to the consumption of the fat source itself could be more difficult to anticipate.

As expected by their fatty acid profile, consumption of vegetable oils high in n-3 and n-6 PUFAs (e.g. sunflower oil, corn oil, soybean oil) in replacement of SFA-rich foods decreases blood LDL-cholesterol concentrations and CHD risk (Mozaffarian et al., 2010). Despite the more neutral effect of MUFAs (such as oleic acid in olive oil and rapeseed oil) compared with PUFAs on the blood lipid profile when replacing SFAs, replacement of dairy fat (butter) by rapeseed oil for cooking may partly explain

the reduction of blood cholesterol concentrations and CHD mortality at national level observed in dietary intervention studies in Northern Europe (Puska and Ståhl, 2010). Plant-based Mediterranean-type diets rich in olive oil have been traditionally associated with low CVD risk in observational and intervention studies (Rosato et al., 2019). The relationship between higher olive oil consumption and lower risk of CHD has also been observed in two large prospective cohort studies (Guasch-Ferré et al., 2020). Some vegetable oils that are high in SFAs, like palm oil or coconut oil, are expected to increase LDL-cholesterol, although long-term studies on chronic disease risk related to the consumption of these oils are lacking.

### 3.2.3. Conclusions

Food groups with important and specific dietary roles in European diets include starchy foods (cereals and potatoes), fruits and vegetables, legumes and pulses, milk and dairy products, meat and meat products, fish and shellfish and products thereof, nuts and seeds and non-alcoholic beverages, as recognised in FBDGs in Member States. However, the dietary roles of these food groups and their relative contribution to the overall diet may vary across individual countries owing to the variability of dietary habits and traditions.

Dietary recommendations made in FBDGs by EU Member States reflect the available evidence on the consumption of certain food groups and their relationship with chronic disease risk, as reviewed in Section 3.2.2. Emphasis is put on increasing the consumption of whole grains, fruits and vegetables (in a wide variety), nuts and seeds, fish and water. Specific food products within some of these food categories that are high in SFAs, sugars and/or sodium owing to food processing are generally discouraged. Most FBDGs recommend limiting meat intake, some suggesting specifically the reduction of unprocessed red and processed meat consumption. FBDGs encourage regular consumption of fat-reduced milk and dairy products, the consumption of legumes and pulses partially replacing meat, and the consumption of vegetable oils rich in *cis*-MUFAs and *cis*-PUFAs instead of fats high in SFAs. The Panel notes that food groups with an important role in the diet of European populations and subgroups thereof have been identified by Member States in FBDGs. The Panel also notes that FBDGs also distinguish between different products within these food groups based on their potential to influence, beneficially or adversely, the overall dietary balance for certain nutrients.

## 3.3. Choice of nutrients and non-nutrient components of foods for nutrient profiling

The choice of nutrients and non-nutrient components of food to set nutrient profiling models, for the purpose of restricting claims on foods and the purpose of FOP labelling, should be driven by their public health importance for EU populations, as discussed in Section 3.1.

Dietary intakes of SFAs, sodium and added/free sugars on the one hand, and dietary fibre on the other, are, respectively, above and below current recommendations in a majority of European populations, and could be considered for inclusion in nutrient profiling models based on their public health importance for European populations.

Total sugars can be used as a proxy for added/free sugars in category-based nutrient-profiling models because added/free sugars are the most variable fraction of total sugars between food products within a given food category. This also applies to food categories containing sugars but not added/free sugars in the unprocessed version (e.g. fruits and vegetables, milk and dairy products). Total sugars may not be equally suitable for nutrient-profiling models to be applied across the board.

In self-selected diets under isocaloric conditions, a reduction in the intake of an energy-providing nutrient is accompanied by the increase in the intake of another. This substitution is of particular importance when it comes to a reduction in the intake of SFAs. As described in Section 3.1.1.3, the health effects of lowering SFA intake depend on the type of energy-providing nutrient by which SFAs are replaced in the diet. The strongest beneficial effect on blood LDL-cholesterol concentrations and CHD risk is observed when mixtures of SFAs are replaced by mixtures of *cis*-PUFAs. The effects of replacing mixtures of SFAs by mixtures of *cis*-MUFAs are less pronounced and are even lower when SFAs are replaced by carbohydrates from whole grains. A replacement of SFAs with refined carbohydrates (e.g. sugars) has not been shown to have an effect (Visseren et al., 2021). The inclusion of SFAs and (added/free) sugars in a nutrient-profiling model could mostly account for the fatty acid profile of foods and for the less favourable replacement of SFAs by refined carbohydrates.

Energy could be included in nutrient-profiling models because a decrease in energy intake is of public health importance for European populations owing to the high prevalence of overweight and

obesity and the positive relationship between energy-dense diets and risk of weight gain. The energy density of foods and of dairy-based beverages is mostly determined by their fat and water content, owing to their extreme energy values, while the energy density of non-alcoholic water-based beverages is mostly driven by their sugar content. In certain food groups (e.g. cereal products), dietary fibre may additionally contribute to the energy density of foods.

Differences in water content may confound energy comparisons across foods and are bigger across food groups (e.g. between solid foods and beverages) than within food groups. This confounding is a great disadvantage when energy is used in nutrient-profiling models intended for application across the board. Still, energy may be a suitable criterion if applied within food groups, where the water content is relatively consistent across products in the group.

In food group/category-based nutrient-profiling models, total fat could replace energy owing to its high-energy density in most food groups, while the energy density of food groups with low or no fat content (e.g. water-based non-alcoholic beverages, jams and marmalades) may be well accounted for by the inclusion of (added/free) sugars in the model. However, total fat does not allow the discrimination of foods based on the nutritional quality of their fat content. Therefore, total fat cannot replace SFAs in nutrient-profiling models, unless food products in a group are relatively homogeneous regarding their fat quality (e.g. milk and dairy products).

Dietary protein is required to support tissue growth during childhood and adolescence and maintain muscle mass and function during adulthood and in old age. Average protein intakes in Europe are above the PRI in most population groups and countries, and no beneficial effects on muscle mass or function can be expected from increasing protein intakes further.

In addition to sodium, for which intakes are above recommendations, other vitamins and minerals of public health importance could be considered, mostly because their intakes in European populations or certain subgroups thereof are lower than recommended. These include potassium, iron, calcium, vitamin D, folate and iodine (see Section 3.1.2). Intakes of potassium appear to be inadequate in a majority of European adult populations, and thus could be considered for inclusion in nutrient-profiling models. For iron, calcium, vitamin D, folate and iodine, inadequate intakes are only observed in very specific subgroups of the population. Whereas dietary modifications alone may not be sufficient (or appropriate) to fulfil the nutrient requirements, some foods/food groups make important contributions to their intake (e.g. milk and dairy products for calcium; meat and meat products for iron; fortified foods such as breakfast cereals for folate). Inadequate intakes of these nutrients are usually addressed by national nutrition policies in Member States and/or individual advice.

Some nutrients may be included in nutrient-profiling models for reasons other than their public health importance, e.g. as a proxy for other nutrients of public health importance, or to allow for a better discrimination of foods within the same food category. For example in relation to the latter, n-3 LC-PUFAs, for which fish and shellfish including products thereof are almost the only dietary source, could be included in nutrient-profiling models owing to the large differences among fish species regarding the content of these fatty acids. This is despite current uncertainties on whether intakes may be below current recommendations in some EU Member States.

Another consideration in the choice of the nutrients and non-nutrient components to be included in a nutrient-profiling model is the feasibility of the model in practice. The larger the number of components included, the more complex the nutrient-profiling model becomes in its application.

## 4. Conclusions

The Panel concludes that:

- food groups with important and specific dietary roles in European diets include starchy foods (cereals and potatoes), fruits and vegetables, legumes and pulses, milk and dairy products, meat and meat products, fish and shellfish and products thereof, nuts and seeds, and non-alcoholic beverages, as recognised in FBDGs in Member States. The dietary roles of these food groups and their relative contribution to the overall diet may vary across individual countries owing to the variability of dietary habits and traditions.
- dietary recommendations made in FBDGs by EU Member States reflect the available evidence on the consumption (frequency and amount) of certain food groups and their relationship with chronic disease risk. Consumption of whole grains, fruits and vegetables, nuts and seeds, fat-reduced milk and dairy products, fish and water is encouraged, whereas food products high in SFAs, sugars and/or sodium owing to food processing are generally discouraged, even within these food categories. FBDGs also encourage regular consumption of legumes and pulses

partially replacing meat (particularly red meat and processed meat), and the consumption of vegetable oils rich in *cis*-MUFAs and *cis*-PUFAs instead of fats high in SFAs.

- dietary intakes of SFAs, sodium and added/free sugars are above current dietary recommendations in a majority of European populations; excess intakes of these nutrients are associated with adverse health effects, and therefore, they could be considered for inclusion in nutrient-profiling models based on their public health importance for European populations;
- energy could be included in nutrient-profiling models because a decrease in energy intake is of public health importance for European populations; in food group/category-based nutrient profiling models, total fat could replace energy owing to its high-energy density in most food groups, while the energy density of food groups with low or no fat content (e.g. water-based non-alcoholic beverages, jams and marmalades) may be well accounted for by the inclusion of (added/free) sugars in the model.
- dietary protein is required to support tissue growth during childhood and adolescence and maintain muscle mass and function during adulthood and in old age. Average protein intakes in Europe are above the PRI in most population groups and countries, and no beneficial effects on muscle mass or function can be expected from increasing protein intakes further.
- intakes of dietary fibre and potassium are below current dietary recommendations in a majority of European adult populations; inadequate intakes of dietary fibre and potassium are associated with adverse health effects, and therefore, dietary fibre and potassium could be considered for inclusion in nutrient-profiling models based on their public health importance for European populations;
- dietary intakes of iron, calcium, vitamin D, folate and iodine are below current dietary recommendations in specific subgroups of European populations only. Whereas dietary modifications alone may not be sufficient (or appropriate) to fulfil the nutrient requirements, some foods/food groups make important contributions to their intake (e.g. milk and dairy products for calcium, meat and meat products for iron; fortified foods such as breakfast cereals for folate). Inadequate intakes of these nutrients are usually addressed by national nutrition policies in Member States and/or individual advice;
- some nutrients may be included in nutrient-profiling models for reasons other than their public health importance, e.g. as a proxy for other nutrients of public health importance, or to allow for a better discrimination of foods within the same food category.

## References

- Abdelhamid AS, Brown TJ, Brainard JS, Biswas P, Thorpe GC, Moore HJ, Deane KH, Summerbell CD, Worthington HV, Song F and Hooper L, 2020. Omega-3 fatty acids for the primary and secondary prevention of cardiovascular disease. *Cochrane Database Systematic Review*, 3. <https://doi.org/10.1002/14651858.CD003177.pub5>
- Abete I, Romaguera D, Vieira AR, Lopez de Munain A and Norat T, 2014. Association between total, processed, red and white meat consumption and all-cause, CVD and IHD mortality: a meta-analysis of cohort studies. *British Journal of Nutrition*, 112, 762–775. <https://doi.org/10.1017/S000711451400124X>
- Aburto NJ, Hanson S, Gutierrez H, Hooper L, Elliott P and Cappuccio FP, 2013. Effect of increased potassium intake on cardiovascular risk factors and disease: systematic review and meta-analyses. *BMJ*, 346, f1378. <https://doi.org/10.1136/bmj.f1378>
- Afshin A, Micha R, Khatibzadeh S and Mozaffarian D, 2014. Consumption of nuts and legumes and risk of incident ischemic heart disease, stroke, and diabetes: a systematic review and meta-analysis. *American Journal of Clinical Nutrition*, 100, 278–288. <https://doi.org/10.3945/ajcn.113.076901>
- Al-Shaar L, Satija A, Wang DD, Rimm EB, Smith-Warner SA, Stampfer MJ, Hu FB and Willett WC, 2020. Red meat intake and risk of coronary heart disease among US men: prospective cohort study. *BMJ*, 371, m4141. <https://doi.org/10.1136/bmj.m4141>
- American Diabetes Association, 2014. Diagnosis and classification of diabetes mellitus. *Diabetes Care*, 37, S81–S90. <https://doi.org/10.2337/dc14-S081>
- ANSES (Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail), 2016. Actualisation des repères du PNNS: élaboration des références nutritionnelles. 196 pp.
- Arnett DK, Blumenthal RS, Albert MA, Buroker AB, Goldberger ZD, Hahn EJ, Himmelfarb CD, Khera A, Lloyd-Jones D, McEvoy JW, Michos ED, Miedema MD, Munoz D, Smith Jr SC, Virani SS, Williams Sr KA, Yeboah J and Ziaieian B, 2019. 2019 ACC/AHA Guideline on the primary prevention of cardiovascular disease: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Circulation*, 140, e596–e646. <https://doi.org/10.1161/CIR.0000000000000678>

- Astrup A, Magkos F, Bier DM, Brenna JT, de Oliveira Otto MC, Hill JO, King JC, Mente A, Ordovas JM, Volek JS, Yusuf S and Krauss RM, 2020. Saturated fats and health: a reassessment and proposal for food-based recommendations: JACC state-of-the-art review. *Journal of the American College of Cardiology*, 76, 844–857. <https://doi.org/10.1016/j.jacc.2020.05.077>
- Aune D, Giovannucci E, Boffetta P, Fadnes LT, Keum N, Norat T, Greenwood DC, Riboli E, Vatten LJ and Tonstad S, 2017. Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality—a systematic review and dose-response meta-analysis of prospective studies. *International Journal of Epidemiology*, 46, 1029–1056. <https://doi.org/10.1093/ije/dyw319>
- Aune D, Keum N, Giovannucci E, Fadnes LT, Boffetta P, Greenwood DC, Tonstad S, Vatten LJ, Riboli E and Norat T, 2016a. Nut consumption and risk of cardiovascular disease, total cancer, all-cause and cause-specific mortality: a systematic review and dose-response meta-analysis of prospective studies. *BMC Medical*, 14, 207. <https://doi.org/10.1186/s12916-016-073>
- Aune D, Sen A, Prasad M, Norat T, Janszky I, Tonstad S, Romundstad P and Vatten LJ, 2016b. BMI and all cause mortality: systematic review and non-linear dose-response meta-analysis of 230 cohort studies with 3.74 million deaths among 30.3 million participants. *BMJ*, 353. <https://doi.org/10.1136/bmj.i2156>
- Aune D, Ursin G and Veierød MB, 2009. Meat consumption and the risk of type 2 diabetes: a systematic review and meta-analysis of cohort studies. *Diabetologia*, 52, 2277–2287. <https://doi.org/10.1007/s00125-009-1481-x>
- Barciela-Alonso MC and Bermejo-Barrera P, 2015. Variation of food mineral content during industrial and culinary processing. *Handbook of Mineral Elements in Food*, 163–176. <https://doi.org/10.1002/9781118654316.ch8>
- Bazzano LA, 2008. Effects of soluble dietary fiber on low-density lipoprotein cholesterol and coronary heart disease risk. *Current Atherosclerosis Reports*, 10, 473–477. <https://doi.org/10.1007/s11883-008-0074-3>
- Bechthold A, Boeing H, Schwedhelm C, Hoffmann G, Knüppel S, Iqbal K, De Henauw S, Michels N, Devleesschauwer B, Schlesinger S and Schwingshackl L, 2019. Food groups and risk of coronary heart disease, stroke and heart failure: a systematic review and dose-response meta-analysis of prospective studies. *Critical Reviews in Food Science and Nutrition*, 59, 1071–1090. <https://doi.org/10.1080/10408398.2017.1392288>
- Bendsen NT, Christensen R, Bartels EM and Astrup A, 2011. Consumption of industrial and ruminant trans fatty acids and risk of coronary heart disease: a systematic review and meta-analysis of cohort studies. *European Journal of Clinical Nutrition*, 65, 773–783. <https://doi.org/10.1038/ejcn.2011.34>
- Bischoff-Ferrari HA, Dawson-Hughes B, Baron JA, Burckhardt P, Li R, Spiegelman D, Specker B, Orav JE, Wong JB, Staehelin HB, O'Reilly E, Kiel DP and Willett WC, 2007. Calcium intake and hip fracture risk in men and women: a meta-analysis of prospective cohort studies and randomized controlled trials. *American Journal of Clinical Nutrition*, 86, 1780–1790. <https://doi.org/10.1093/ajcn/86.5.1780>
- Boffetta P, Couto E, Wichmann J, Ferrari P, Trichopoulos D, Bueno-de-Mesquita HB, van Duijnhoven FJ, Büchner FL, Key T, Boeing H, Nöthlings U, Linseisen J, Gonzalez CA, Overvad K, Nielsen MR, Tjønneland A, Olsen A, Clavel-Chapelon F, Boutron-Ruault MC, Morois S, Laggiou P, Naska A, Benetou V, Kaaks R, Rohrmann S, Panico S, Sieri S, Vineis P, Palli D, van Gils CH, Peeters PH, Lund E, Brustad M, Engeset D, Huerta JM, Rodríguez L, Sánchez MJ, Dorronsoro M, Barricarte A, Hallmans G, Johansson I, Manjer J, Sonestedt E, Allen NE, Bingham S, Khaw KT, Slimani N, Jenab M, Mouw T, Norat T, Riboli E and Trichopoulou A, 2010. Fruit and vegetable intake and overall cancer risk in the European Prospective Investigation into Cancer and Nutrition (EPIC). *Journal of the National Cancer Institute*, 102, 529–537. <https://doi.org/10.1093/jnci/djq072>
- Borch D, Juul-Hindsgaul N, Veller M, Astrup A, Jaskolowski J and Raben A, 2016. Potatoes and risk of obesity, type 2 diabetes, and cardiovascular disease in apparently healthy adults: a systematic review of clinical intervention and observational studies. *American Journal of Clinical Nutrition*, 104, 489–498. <https://doi.org/10.3945/ajcn.116.132332>
- Brannon PM and Taylor CL, 2017. Iron supplementation during pregnancy and infancy: uncertainties and implications for research and policy. *Nutrients*, 9. <https://doi.org/10.3390/nu9121327>
- Briggs MA, Petersen KS and Kris-Etherton PM, 2017. Saturated fatty acids and cardiovascular disease: replacements for saturated fat to reduce cardiovascular risk. *Healthcare (Basel)*, 5. <https://doi.org/10.3390/healthcare5020029>
- Capuano E, van der Veer G, Verheijen PJJ, Heenan SP, van de Laak LFJ, Koopmans HBM and van Ruth SM, 2013. Comparison of a sodium-based and a chloride-based approach for the determination of sodium chloride content of processed foods in the Netherlands. *Journal of Food Composition and Analysis*, 31, 129–136. <https://doi.org/10.1016/j.jfca.2013.04.004>
- Chen Z, Ahmed M, Ha V, Jefferson K, Malik V, Ribeiro PAB, Zuchinali P and Drouin-Chartier J-P, 2021. Dairy product consumption and cardiovascular health: a systematic review and meta-analysis of prospective cohort studies. *Advances in Nutrition*, <https://doi.org/10.1093/advances/nmab118>
- Cummings J, 2001. The effect of dietary fiber on fecal weight and composition. In: Spiller G (ed.). *CRC Handbook of Dietary Fiber in Human Nutrition*, CRC Press, Boca Raton, Florida, USA. pp. 183–252.
- D-A-CH (Deutsche Gesellschaft für Ernährung, Österreichische Gesellschaft für Ernährung, Schweizerische Gesellschaft für Ernährung), 2015. Referenzwerte für die Nährstoffzufuhr, DGE, Bonn, Germany.
- Davis C, Bryan J, Hodgson J and Murphy K, 2015. Definition of the Mediterranean Diet; a literature review. *Nutrients*, 7, 9139–9153. <https://doi.org/10.3390/nu7115459>

- Devi A and Khatkar BS, 2018. Effects of fatty acids composition and microstructure properties of fats and oils on textural properties of dough and cookie quality. *Journal of Food Science and Technology*, 55, 321–330. <https://doi.org/10.1007/s13197-017-2942-8>
- DH (Department of Health), 1991. Dietary reference values for food energy and nutrients for the United Kingdom. Report of the Panel on Dietary Reference Values of the Committee on Medical Aspects of Food Policy, HMSO, London, UK. 212 pp.
- Dold S, Zimmermann MB, Jukic T, Kusic Z, Jia Q, Sang Z, Quirino A, San Luis TOL, Fingerhut R, Kupka R, Timmer A, Garrett GS and Andersson M, 2018. Universal salt iodization provides sufficient dietary iodine to achieve adequate iodine nutrition during the first 1000 days: A cross-sectional multicenter study. *Journal of Nutrition*, 148, 587–598. <https://doi.org/10.1093/jn/nxy015>
- Drouin-Chartier JP, Brassard D, Tessier-Grenier M, Côté JA, Labonté M, Desroches S, Couture P and Lamarche B, 2016. Systematic review of the association between dairy product consumption and risk of cardiovascular-related clinical outcomes. *Advances in Nutrition*, 7, 1026–1040. <https://doi.org/10.3945/an.115.011403>
- Du H, van der AD, Boshuizen HC, Forouhi NG, Wareham NJ, Halkjaer J, Tjønneland A, Overvad K, Jakobsen MU, Boeing H, Buijsse B, Masala G, Palli D, Sørensen TI, Saris WH and Feskens EJ, 2010. Dietary fiber and subsequent changes in body weight and waist circumference in European men and women. *American Journal of Clinical Nutrition*, 91, 329–336. <https://doi.org/10.3945/ajcn.2009.28191>
- EFSA (European Food Safety Authority), 2009. Scientific substantiation of a health claim related to Calcium plus Vitamin D3 chewing tablets and reduction of the risk of osteoporotic fractures by reducing bone loss pursuant to Article 14 of Regulation (EC) No 1924/2006. *EFSA Journal* 2009;7(8):1180, 13 pp. <https://doi.org/10.2903/j.efsa.2009.1180>
- EFSA (European Food Safety Authority), 2020. Draft framework for protocol development for EFSA's scientific assessments. EFSA supporting publication 2020;EN-1843, 46 pp. <https://doi.org/10.2903/sp.efsa.2020.EN-1843>
- EFSA NDA Panel (EFSA Panel on Dietetic Products Nutrition and Allergies), 2009. Scientific Opinion on the substantiation of health claims related to vitamin C and protection of DNA, proteins and lipids from oxidative damage (ID 129, 138, 143, 148), antioxidant function of lutein (ID 146), maintenance of vision (ID 141, 142), collagen formation (ID 130, 131, 136, 137, 149), function of the nervous system (ID 133), function of the immune system (ID 134), function of the immune system during and after extreme physical exercise (ID 144), non-haem iron absorption (ID 132, 147), energy-yielding metabolism (ID 135), and relief in case of irritation in the upper respiratory tract (ID 1714, 1715) pursuant to Article 13(1) of Regulation (EC) No 1924/2006 on request from the European Commission. *EFSA Journal* 2009;7(9):1226, 28 pp. <https://doi.org/10.2903/j.efsa.2009.1226>
- EFSA NDA Panel (EFSA Panel on Dietetic Products Nutrition and Allergies), 2017. Scientific Opinion on the safety and suitability for use by infants of follow-on formulae with a protein content of at least 1.6 g/100 kcal. *EFSA Journal* 2017;15(5):4781, 29 pp. <https://doi.org/10.2903/j.efsa.2017.4781>
- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies), 2008. The setting of nutrient profiles for foods bearing nutrition and health claims pursuant to Article 4 of the Regulation (EC) No 1924/2006 - Scientific Opinion of the Panel on Dietetic Products, Nutrition and Allergies. *EFSA Journal* 2008;6(2):644, 45 pp. <https://doi.org/10.2903/j.efsa.2008.644>
- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies), 2010a. Scientific Opinion in relation to the authorisation procedure for health claims on calcium and vitamin D and the reduction of the risk of osteoporotic fractures by reducing bone loss pursuant to Article 14 of Regulation (EC) No 1924/2006. *EFSA Journal* 2010;8(5):1609, 10 pp. <https://doi.org/10.2903/j.efsa.2010.1609>
- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition, and Allergies), 2010b. Scientific Opinion on Dietary Reference Values for carbohydrates and dietary fibre. *EFSA Journal* 2010;8(3):1462, 77 pp. <https://doi.org/10.2903/j.efsa.2010.1462>
- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition, and Allergies), 2010c. Scientific Opinion on Dietary Reference Values for fats, including saturated fatty acids, polyunsaturated fatty acids, monounsaturated fatty acids, trans fatty acids, and cholesterol. *EFSA Journal* 2010;8(3):1461, 107 pp. <https://doi.org/10.2903/j.efsa.2010.1461>
- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition, Allergies), 2010d. Scientific Opinion on establishing Food-Based Dietary Guidelines. *EFSA Journal* 2010;8(3):1460, 42 pp. <https://doi.org/10.2903/j.efsa.2010.1460>
- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition, and Allergies), 2010e. Scientific Opinion on principles for deriving and applying Dietary Reference Values. *EFSA Journal* 2010;8(3):1458, 45 pp. <https://doi.org/10.2903/j.efsa.2010.1458>

- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies), 2010f. Scientific Opinion on the substantiation of health claims related to eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), docosapentaenoic acid (DPA) and maintenance of normal cardiac function (ID 504, 506, 516, 527, 538, 703, 1128, 1317, 1324, 1325), maintenance of normal blood glucose concentrations (ID 566), maintenance of normal blood pressure (ID 506, 516, 703, 1317, 1324), maintenance of normal blood HDL-cholesterol concentrations (ID 506), maintenance of normal (fasting) blood concentrations of triglycerides (ID 506, 527, 538, 1317, 1324, 1325), maintenance of normal blood LDL-cholesterol concentrations (ID 527, 538, 1317, 1325, 4689), protection of the skin from photo-oxidative (UV-induced) damage (ID 530), improved absorption of EPA and DHA (ID 522, 523), contribution to the normal function of the immune system by decreasing the levels of eicosanoids, arachidonic acid-derived mediators and pro-inflammatory cytokines (ID 520, 2914), and "immunomodulating agent" (4690) pursuant to Article 13(1) of Regulation (EC) No 1924/2006. EFSA Journal 2010;8(10):1796, 32 pp. <https://doi.org/10.2903/j.efsa.2010.1796>
- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies), 2010g. Scientific Opinion on the substantiation of health claims related to stearic acid and maintenance of normal blood cholesterol concentrations (ID 716, 1657) pursuant to Article 13(1) of Regulation (EC) No 1924/2006. EFSA Journal 2010;8(2):1476, 14 pp. <https://doi.org/10.2903/j.efsa.2010.1476>
- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies), 2011a. Scientific Opinion on the substantiation of a health claim related to vitamin D and risk of falling pursuant to Article 14 of Regulation (EC) No 1924/2006. EFSA Journal 2011;9(9):2382, 18 pp. <https://doi.org/10.2903/j.efsa.2011.2382>
- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies), 2011b. Scientific Opinion on the substantiation of health claims related to foods with reduced amounts of saturated fatty acids (SFAs) and maintenance of normal blood LDL-cholesterol concentrations. (ID 620, 671, 4332) pursuant to Article 13(1) of Regulation (EC) No 1924/2006. EFSA Journal 2011;9(4):2062, 14 pp. <https://doi.org/10.2903/j.efsa.2011.2062>
- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies), 2011c. Scientific Opinion on the substantiation of health claims related to polyphenols in olive and protection of LDL particles from oxidative damage (ID 1333, 1638, 1639, 1696, 2865), maintenance of normal blood HDL-cholesterol concentrations (ID 1639), maintenance of normal blood pressure (ID 3781), "anti-inflammatory properties" (ID 1882), "contributes to the upper respiratory tract health" (ID 3468), "can help to maintain a normal function of gastrointestinal tract" (3779), and "contributes to body defences against external agents" (ID 3467) pursuant to Article 13(1) of Regulation (EC) No 1924/2006. EFSA Journal 2011;9(4):2033, 25 pp. <https://doi.org/10.2903/j.efsa.2011.2033>
- EFSA Nda Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies), 2011d. Scientific Opinion on the substantiation of health claims related to the replacement of mixtures of saturated fatty acids (SFAs) as present in foods or diets with mixtures of monounsaturated fatty acids (MUFAs) and/or mixtures of polyunsaturated fatty acids (PUFAs), and maintenance of normal blood LDL-cholesterol concentrations (ID 621, 1190, 1203, 2906, 2910, 3065) pursuant to Article 13(1) of Regulation (EC) No 1924/2006. EFSA Journal 2011;9(4):2069, 18 pp. <https://doi.org/10.2903/j.efsa.2011.2069>
- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies), 2012a. Scientific Opinion on Dietary Reference Values for protein. EFSA Journal 2012;10(2):2557, 66 pp. <https://doi.org/10.2903/j.efsa.2012.2557>
- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies), 2012b. Scientific Opinion related to the Tolerable Upper Intake Level of eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA) and docosapentaenoic acid (DPA). EFSA Journal 2012;10(7):2815, 48 pp. <https://doi.org/10.2903/j.efsa.2012.2815>
- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies), 2013. Scientific Opinion on Dietary Reference Values for energy. EFSA Journal 2013;11(1):3005, 112 pp. <https://doi.org/10.2903/j.efsa.2013.3005>
- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies), 2014a. Scientific Opinion on Dietary Reference Values for folate. EFSA Journal 2014;12(11):3893, 59 pp. <https://doi.org/10.2903/j.efsa.2014.3893>
- EFSA NDA Panel (EFSA Panel on Panel on Dietetic Products, Nutrition and Allergies), 2014b. Scientific Opinion on Dietary Reference Values for iodine. EFSA Journal 2014;12(5):3660, 57 pp. <https://doi.org/10.2903/j.efsa.2014.3660>
- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies), 2014c. Scientific Opinion on health benefits of seafood (fish and shellfish) consumption in relation to health risks associated with exposure to methylmercury. EFSA Journal 2014;12(7):3761, 80 pp. <https://doi.org/10.2903/j.efsa.2014.3761>
- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies), 2015a. Scientific Opinion on Dietary Reference Values for calcium. EFSA Journal 2015;13(5):4101, 82 pp. <https://doi.org/10.2903/j.efsa.2015.4101>
- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies), 2015b. Scientific Opinion on Dietary Reference Values for iron. EFSA Journal 2015;13(10):4254, 115 pp. <https://doi.org/10.2903/j.efsa.2015.4254>
- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies), 2016a. Scientific opinion on Dietary Reference Values for potassium. EFSA Journal 2016;14(10):4592, 56 pp. <https://doi.org/10.2903/j.efsa.2016.4592>
- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies), 2016b. Scientific opinion on Dietary Reference Values for vitamin D. EFSA Journal 2016;14(10):4547, 145 pp. <https://doi.org/10.2903/j.efsa.2016.4547>

- EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies), 2018. Guidance for the scientific requirements for health claims related to antioxidants, oxidative damage and cardiovascular health (Revision 1). *EFSA Journal* 2018;16(1):5136, 21 pp. <https://doi.org/10.2903/j.efsa.2018.5136>
- EFSA NDA Panel (EFSA Panel on Nutrition, Novel Foods and Food Allergens), 2019a. Scientific Opinion on the appropriate age range for introduction of complementary feeding into an infant's diet. *EFSA Journal* 2019;17(9):5780, 241 pp. <https://doi.org/10.2903/j.efsa.2019.5780>
- EFSA NDA Panel (EFSA Panel on Nutrition, Novel Foods and Food Allergens), 2019b. Scientific Opinion on the Dietary Reference Values for sodium. *EFSA Journal* 2019;17(9):5778, 191 pp. <https://doi.org/10.2903/j.efsa.2019.5778>
- EFSA NDA Panel (EFSA Panel on Nutrition, Novel Foods and Food Allergens), 2022. Scientific Opinion on the Tolerable upper intake level for dietary sugars. *EFSA Journal* 2022;20(2):7074, 337 pp. <https://doi.org/10.2903/j.efsa.2021.7074>
- Eilander A, Harika RK and Zock PL, 2015. Intake and sources of dietary fatty acids in Europe: are current population intakes of fats aligned with dietary recommendations? *European Journal of Lipid Science and Technology*, 117, 1370–1377. <https://doi.org/10.1002/ejlt.201400513>
- Elia M and Cummings JH, 2007. Physiological aspects of energy metabolism and gastrointestinal effects of carbohydrates. *European Journal of Clinical Nutrition*, 61, S40–S74. <https://doi.org/10.1038/sj.ejcn.1602938>
- Ellegård L and Andersson H, 2007. Oat bran rapidly increases bile acid excretion and bile acid synthesis: an ileostomy study. *European Journal of Clinical Nutrition*, 61, 938–945. <https://doi.org/10.1038/sj.ejcn.1602607>
- European Commission, 2012. Survey on Members States' implementation of the EU salt reduction framework. 26 pp. Available online: [https://ec.europa.eu/health/sites/health/files/nutrition\\_physical\\_activity/docs/salt\\_report1\\_en.pdf](https://ec.europa.eu/health/sites/health/files/nutrition_physical_activity/docs/salt_report1_en.pdf)
- European Commission, 2020a. COMMISSION STAFF WORKING DOCUMENT EVALUATION of the Regulation (EC) No 1924/2006 on nutrition and health claims made on foods with regard to nutrient profiles and health claims made on plants and their preparations and of the general regulatory framework for their use in foods. SWD (2020) 95 final Available online: [https://ec.europa.eu/food/system/files/2020-05/labelling\\_nutrition-claims\\_swd\\_2020-95\\_part-1.pdf](https://ec.europa.eu/food/system/files/2020-05/labelling_nutrition-claims_swd_2020-95_part-1.pdf)
- European Commission, 2020b. Report from the Commission to the European Parliament and the Council regarding the use of additional forms of expression and presentation of the nutrition declaration. COM(2020) 207 final, 25 pp.
- Eyles H, Webster J, Jebb S, Capelin C, Neal B and Ni Mhurchu C, 2013. Impact of the UK voluntary sodium reduction targets on the sodium content of processed foods from 2006 to 2011: analysis of household consumer panel data. *Preventive Medicine*, 57, 555–560. <https://doi.org/10.1016/j.ypmed.2013.07.024>
- Fan M, Li Y, Wang C, Mao Z, Zhou W, Zhang L, Yang X, Cui S and Li L, 2019. Dietary protein consumption and the risk of type 2 diabetes: a dose-response meta-analysis of prospective studies. *Nutrients*, 11. <https://doi.org/10.3390/nu11112783>
- Farvid MS, Sidahmed E, Spence ND, Mante Angua K, Rosner BA and Barnett JB, 2021. Consumption of red meat and processed meat and cancer incidence: a systematic review and meta-analysis of prospective studies. *European Journal of Epidemiology*, 36, 937–951. <https://doi.org/10.1007/s10654-021-00741-9>
- Fewtrell M, Bronsky J, Campoy C, Domellof M, Embleton N, Fidler Mis N, Hojsak I, Hulst JM, Indrio F, Lapillonne A and Molgaard C, 2017. Complementary feeding: A position paper by the European Society for Paediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN) Committee on Nutrition. *Journal of Pediatric Gastroenterology and Nutrition*, 64, 119–132. <https://doi.org/10.1097/MPG.0000000000001454>
- Global BMI Mortality Collaboration, Di Angelantonio E, Bhupathiraju Sh N, Wormser D, Gao P, Kaptoge S, Berrington de Gonzalez A, Cairns BJ, Huxley R, Jackson Ch L, Joshy G, Lewington S, Manson JE, Murphy N, Patel AV, Samet JM, Woodward M, Zheng W, Zhou M, Bansal N, Barricarte A, Carter B, Cerhan JR, Smith GD, Fang X, Franco OH, Green J, Halsey J, Hildebrand JS, Jung KJ, Korda RJ, McLerran DF, Moore SC, O'Keefe LM, Paige E, Ramond A, Reeves GK, Rolland B, Sacerdote C, Sattar N, Sofianopoulou E, Stevens J, Thun M, Ueshima H, Yang L, Yun YD, Willeit P, Banks E, Beral V, Chen Z, Gapstur SM, Gunter MJ, Hartge P, Jee SH, Lam TH, Peto R, Potter JD, Willett WC, Thompson SG, Danesh J and Hu FB, 2016. Body-mass index and all-cause mortality: individual-participant-data meta-analysis of 239 prospective studies in four continents. *Lancet*, 388, 776–786. [https://doi.org/10.1016/S0140-6736\(16\)30175-1](https://doi.org/10.1016/S0140-6736(16)30175-1)
- Guasch-Ferré M, Liu G, Li Y, Sampson L, Manson JE, Salas-Salvadó J, Martínez-González MA, Stampfer MJ, Willett WC, Sun Q and Hu FB, 2020. Olive Oil Consumption and Cardiovascular Risk in U.S. Adults. *Journal of the American College of Cardiology*, 75, 1729–1739. <https://doi.org/10.1016/j.jacc.2020.02.036>
- Guo J, Astrup A, Lovegrove JA, Gijbbers L, Givens DI and Soedamah-Muthu SS, 2017. Milk and dairy consumption and risk of cardiovascular diseases and all-cause mortality: dose-response meta-analysis of prospective cohort studies. *European Journal of Epidemiology*, 32, 269–287. <https://doi.org/10.1007/s10654-017-0243-1>
- Guo F, Zhang Q, Jiang H, He Y, Li M, Ran J, Lin J, Tian L and Ma L, 2021. Dietary potato intake and risks of type 2 diabetes and gestational diabetes mellitus. *Clinical Nutrition*, 40, 3754–3764. <https://doi.org/10.1016/j.clnu.2021.04.039>

- Hall KD, Sacks G, Chandramohan D, Chow CC, Wang YC, Gortmaker SL and Swinburn BA, 2011. Quantification of the effect of energy imbalance on bodyweight. *Lancet*, 378, 826–837. [https://doi.org/10.1016/S0140-6736\(11\)60812-X](https://doi.org/10.1016/S0140-6736(11)60812-X)
- Han MA, Zeraatkar D, Guyatt GH, Vernooij RWM, El Dib R, Zhang Y, Algarni A, Leung G, Storman D, Valli C, Rabassa M, Rehman N, Parvizian MK, Zworth M, Bartoszko JJ, Lopes LC, Sit D, Bala MM, Alonso-Coello P and Johnston BC, 2019. Reduction of red and processed meat intake and cancer mortality and incidence: a systematic review and meta-analysis of cohort studies. *Annals of Internal Medicine*, 171, 711–720. <https://doi.org/10.7326/m19-0699>
- Händel MN, Rohde JF, Jacobsen R, Nielsen SM, Christensen R, Alexander DD, Frederiksen P and Heitmann BL, 2020. Processed meat intake and incidence of colorectal cancer: a systematic review and meta-analysis of prospective observational studies. *European Journal of Clinical Nutrition*, 74, 1132–1148. <https://doi.org/10.1038/s41430-020-0576-9>
- HCN (Health Council of the Netherlands), 2018. Dietary Reference Values for vitamins and minerals for adults. No. 2018/19e, 34 pp.
- IARC (International Agency for Research on Cancer), 2018. IARC Monographs on the evaluation of carcinogenic risks to humans: red meat and processed meat. Available online: <https://monographs.iarc.who.int/wp-content/uploads/2018/06/mono114.pdf>
- IoM (Institute of Medicine), 1998. Dietary Reference Intakes for thiamin, riboflavin, niacin, vitamin B6, folate, vitamin B12, pantothenic acid, biotin, and choline, National Academy Press, Washington, DC, USA, Food and Nutrition Board. 591 pp.
- IoM (Institute of Medicine), 2011. Dietary Reference Intakes for calcium and vitamin D, National Academies Press, Washington, DC, USA. 1133 pp.
- Ittermann T, Albrecht D, Arohonka P, Bilek R, de Castro JJ, Dahl L, Filipsson Nystrom H, Gaberscek S, Garcia-Fuentes E, Gheorghiu ML, Hubalewska-Dydejczyk A, Hunziker S, Jukic T, Karanfiski B, Koskinen S, Kusic Z, Majstorov V, Makris KC, Markou KB, Meisinger C, Milevska Kostova N, Mullen KR, Nagy EV, Pirags V, Rojo-Martinez G, Samardzic M, Saranac L, Strele I, Thamm M, Top I, Trofimiuk-Müldner M, Ünal B, Koskinen S, Vila L, Vitti P, Winter B, Woodside JV, Zaletel K, Zamrazil V, Zimmermann M, Erlund I and Völzke H, 2020. Standardized map of iodine status in Europe. *Thyroid*, 30, 1346–1354. <https://doi.org/10.1089/thy.2019.0353>
- Jensen MD, Ryan DH, Apovian CM, Ard JD, Comuzzie AG, Donato KA, Hu FB, Hubbard VS, Jakicic JM, Kushner RF, Loria CM, Millen BE, Nonas CA, Pi-Sunyer FX, Stevens J, Stevens VJ, Wadden TA, Wolfe BM and Yanovski SZ, 2014. 2013 AHA/ACC/TOS Guideline for the management of overweight and obesity in adults. *Circulation*, 129, S102–S138. <https://doi.org/10.1161/01.cir.0000437739.71477.ee>
- Jepsen S, Blanco J, Buchalla W, Carvalho JC, Dietrich T, Dörfer C, Eaton KA, Figuero E, Frencken JE, Graziani F, Higham SM, Kocher T, Maltz M, Ortiz-Vigon A, Schmoeckel J, Sculean A, Tenuta LM, van der Veen MH and Machiulskiene V, 2017. Prevention and control of dental caries and periodontal diseases at individual and population level: consensus report of group 3 of joint EFP/ORCA workshop on the boundaries between caries and periodontal diseases. *Journal of Clinical Periodontology*, 44, S85–s93. <https://doi.org/10.1111/jcpe.12687>
- Kang ZQ, Yang Y and Xiao B, 2020. Dietary saturated fat intake and risk of stroke: systematic review and dose-response meta-analysis of prospective cohort studies. *Nutrition, Metabolism, and Cardiovascular Diseases*, 30, 179–189. <https://doi.org/10.1016/j.numecd.2019.09.028>
- Kanis JA, Norton N, Harvey NC, Jacobson T, Johansson H, Lorentzon M, McCloskey EV, Willers C and Borgstrom F, 2021. SCOPE 2021: a new scorecard for osteoporosis in Europe. *Archives of Osteoporosis*, 16, 82. <https://doi.org/10.1007/s11657-020-00871-9>
- Kloss L, Meyer JD, Graeve L and Vetter W, 2015. Sodium intake and its reduction by food reformulation in the European Union — A review. *NFS Journal*, 1, 9–19. <https://doi.org/10.1016/j.nfs.2015.03.001>
- Knuuti J, Wijns W, Saraste A, Capodanno D, Barbato E, Funck-Brentano C, Prescott E, Storey RF, Deaton C, Cuisset T, Agewall S, Dickstein K, Edvardsen T, Escaned J, Gersh BJ, Svtil P, Gilard M, Hasdai D, Hatala R, Mahfoud F, Masip J, Muneretto C, Valgimigli M, Achenbach S, Bax JJ and the ESC Scientific Document Group, 2019. 2019 ESC Guidelines for the diagnosis and management of chronic coronary syndromes: the Task Force for the diagnosis and management of chronic coronary syndromes of the European Society of Cardiology (ESC). *European Heart Journal*, 41, 407–477. <https://doi.org/10.1093/eurheartj/ehz425>
- Koh-Banerjee P, Chu NF, Spiegelman D, Rosner B, Colditz G, Willett W and Rimm E, 2003. Prospective study of the association of changes in dietary intake, physical activity, alcohol consumption, and smoking with 9-y gain in waist circumference among 16 587 US men. *American Journal of Clinical Nutrition*, 78, 719–727. <https://doi.org/10.1093/ajcn/78.4.719>
- Labonté M, Poon T, Gladanac B, Ahmed M, Franco-Arellano B, Rayner M and L'Abbé MR, 2018. Nutrient profile models with applications in government-led nutrition policies aimed at health promotion and noncommunicable disease prevention: a systematic review. *Advances in Nutrition*, 9, 741–788. <https://doi.org/10.1093/advances/nmy045>

- Iqbal R, Dehghan M, Mente A, Rangarajan S, Wielgosz A, Avezum A, Seron P, AlHabib KF, Lopez-Jaramillo P, Swaminathan S, Mohammadifard N, Zatońska K, Bo H, Varma RP, Rahman O, Yusufali A, Lu Y, Ismail N, Rosengren A, Imeryuz N, Yeates K, Chifamba J, Dans A, Kumar R, Xiaoyun L, Tsolekile L, Khatib R, Diaz R, Teo K and Yusuf S, 2021. Associations of unprocessed and processed meat intake with mortality and cardiovascular disease in 21 countries [Prospective Urban Rural Epidemiology (PURE) Study]: a prospective cohort study. *American Journal of Clinical Nutrition*, 114, 1049–1058. <https://doi.org/10.1093/ajcn/nqaa448>
- Ma C, Avenell A, Bolland M, Hudson J, Stewart F, Robertson C, Sharma P, Fraser C and MacLennan G, 2017. Effects of weight loss interventions for adults who are obese on mortality, cardiovascular disease, and cancer: systematic review and meta-analysis. *BMJ*, 359. <https://doi.org/10.1136/bmj.j4849>
- Mach F, Baigent C, Catapano AL, Koskinas KC, Casula M, Badimon L, Chapman MJ, De Backer GG, Delgado V, Ference BA, Graham IM, Halliday A, Landmesser U, Mihaylova B, Pedersen TR, Riccardi G, Richter DJ, Sabatine MS, Taskinen MR, Tokgozoglu L, Wiklund O and Group ESCSD, 2020. 2019 ESC/EAS Guidelines for the management of dyslipidaemias: lipid modification to reduce cardiovascular risk. *European Heart Journal*, 41, 111–188. <https://doi.org/10.1093/eurheartj/ehz455>
- Mayhew AJ, de Souza RJ, Meyre D, Anand SS and Mente A, 2016. A systematic review and meta-analysis of nut consumption and incident risk of CVD and all-cause mortality. *British Journal of Nutrition*, 115, 212–225. <https://doi.org/10.1017/S0007114515004316>
- McRae MP, 2017. Dietary fiber is beneficial for the prevention of cardiovascular disease: an umbrella review of meta-analyses. *Journal of Chiropractic Medicine*, 16, 289–299. <https://doi.org/10.1016/j.jcm.2017.05.005>
- Micha R, Khatibzadeh S, Shi P, Fahimi S, Lim S, Andrews KG, Engell RE, Powles J, Ezzati M, Mozaffarian D and the Global Burden of Diseases Nutrition and Chronic Diseases Expert Group, 2014. Global, regional, and national consumption levels of dietary fats and oils in 1990 and 2010: a systematic analysis including 266 country-specific nutrition surveys. *BMJ*, 348. <https://doi.org/10.1136/bmj.g2272>
- Micha R, Wallace SK and Mozaffarian D, 2010. Red and processed meat consumption and risk of incident coronary heart disease, stroke, and diabetes mellitus: a systematic review and meta-analysis. *Circulation*, 121, 2271–2283. <https://doi.org/10.1161/circulationaha.109.924977>
- Milman NT, 2019. Dietary iron intake in women of reproductive age in Europe: a review of 49 studies from 29 countries in the period 1993–2015. *Journal of Nutrition and Metabolism*, 2019, 7631306. <https://doi.org/10.1155/2019/7631306>
- Milman NT, 2020a. Dietary iron intake in pregnant women in Europe: a review of 24 studies from 14 countries in the period 1991–2014. *Journal of Nutrition and Metabolism*, 2020, 7102190. <https://doi.org/10.1155/2020/7102190>
- Milman NT, 2020b. Dietary iron intakes in men in Europe are distinctly above the recommendations: a review of 39 national studies from 20 countries in the period 1995–2016. *Gastroenterology Research*, 13, 233–245. <https://doi.org/10.14740/gr1344>
- Mithril C, Dragsted LO, Meyer C, Blauert E, Holt MK and Astrup A, 2012. Guidelines for the new nordic diet. *Public Health Nutrition*, 15, 1941–1947. <https://doi.org/10.1017/S136898001100351X>
- Mithril C, Dragsted LO, Meyer C, Tetens I, Biloft-Jensen A and Astrup A, 2013. Dietary composition and nutrient content of the New Nordic Diet. *Public Health Nutrition*, 16, 777–785. <https://doi.org/10.1017/s1368980012004521>
- Mongraw-Chaffin ML, Peters SAE, Huxley RR and Woodward M, 2015. The sex-specific association between BMI and coronary heart disease: a systematic review and meta-analysis of 95 cohorts with 1.2 million participants. *The Lancet Diabetes & Endocrinology*, 3, 437–449. [https://doi.org/10.1016/S2213-8587\(15\)00086-8](https://doi.org/10.1016/S2213-8587(15)00086-8)
- Mouratidou T, Livanou A, Martín Saborido C, Wollgast J and Caldeira S, 2014. Trans fatty acids in Europe: where do we stand? *JRC Science and Policy Reports*, 68 pp.
- Mozaffarian D, 2016. Dietary and policy priorities for cardiovascular disease, diabetes, and obesity: a comprehensive review. *Circulation*, 133, 187–225. <https://doi.org/10.1161/circulationaha.115.018585>
- Mozaffarian D, Dashti HS, Wojczynski MK, Chu AY, Nettleton JA, Männistö S, Kristiansson K, Reedik M, Lahti J, Houston DK, Cornelis MC, van Rooij FJA, Dimitriou M, Kanoni S, Mikkilä V, Steffen LM, de Oliveira Otto MC, Qi L, Psaty B, Djousse L, Rotter JJ, Harald K, Perola M, Rissanen H, Jula A, Krista F, Mihailov E, Feitosa MF, Ngwa JS, Xue L, Jacques PF, Perälä MM, Palotie A, Liu Y, Nalls NA, Ferrucci L, Hernandez D, Manichaikul A, Tsai MY, Kieft-de Jong JC, Hofman A, Uitterlinden AG, Rallidis L, Ridker PM, Rose LM, Buring JE, Lehtimäki T, Kähönen M, Viikari J, Lemaitre R, Salomaa V, Knekt P, Metspalu A, Borecki IB, Cupples LA, Eriksson JG, Kritchevsky SB, Bandinelli S, Siscovick D, Franco OH, Deloukas P, Dedoussis G, Chasman DI, Raitakari O and Tanaka T, 2017. Genome-wide association meta-analysis of fish and EPA+DHA consumption in 17 US and European cohorts. *PLoS One*, 12, e0186456. <https://doi.org/10.1371/journal.pone.0186456>
- Mozaffarian D, Micha R and Wallace S, 2010. Effects on coronary heart disease of increasing polyunsaturated fat in place of saturated fat: a systematic review and meta-analysis of randomized controlled trials. *PLoS Med*, 7, e1000252. <https://doi.org/10.1371/journal.pmed.1000252>
- Mozaffarian D and Rimm EB, 2006. Fish intake, contaminants, and human health: evaluating the risks and the benefits. *JAMA*, 296, 1885–1899. <https://doi.org/10.1001/jama.296.15.1885>
- Mozaffarian D and Wu JH, 2011. Omega-3 fatty acids and cardiovascular disease: effects on risk factors, molecular pathways, and clinical events. *Journal of the American College of Cardiology*, 58, 2047–2067. <https://doi.org/10.1016/j.jacc.2011.06.063>

- NASEM (National Academies of Sciences, Engineering, and Medicine), 2019. Dietary Reference Intakes for sodium and potassium, The National Academies Press, Washington, DC, USA. 498 pp. Available online: <https://www.nap.edu/read/25353/chapter/1>
- NCM (Nordic Council of Ministers), 2014. Nordic Nutrition Recommendations 2012. Integrating nutrition and physical activity, 5th Edition. 627 pp.
- Neuenschwander M, Ballon A, Weber KS, Norat T, Aune D, Schwingshackl L and Schlesinger S, 2019. Role of diet in type 2 diabetes incidence: umbrella review of meta-analyses of prospective observational studies. *BMJ*, 366. <https://doi.org/10.1136/bmj.l2368>
- NHMRC (National Health and Medical Research Council), 2017. Nutrient Reference Values for Australia and New Zealand including Recommended Dietary Intake, 320 pp.
- Ni Mhurchu C, Capelin C, Dunford EK, Webster JL, Neal BC and Jebb SA< 2011. Sodium content of processed foods in the United Kingdom: analysis of 44,000 foods purchased by 21,000 households. *American Journal of Clinical Nutrition*, 93, 594–600. <https://doi.org/10.3945/ajcn.110.004481>
- NICE (National Institute for Health and Care Excellence), 2014. Vitamin D: supplement use in specific population groups. Public health guideline PH56, 55 pp.
- NICE (National Institute for Health and Care Excellence), 2015. Preventing excess weight gain. NICE. Guideline NG7, 55 pp.
- Nouri-Majid S, Salari-Moghaddam A, Aminianfar A, Larijani B and Esmailzadeh A, 2022. Association between red and processed meat consumption and risk of prostate cancer: a systematic review and meta-analysis. *Frontiers in Nutrition*, 9. <https://doi.org/10.3389/fnut.2022.801722>
- Papier K, Knuppel A, Syam N, Jebb SA and Key TJ, 2021. Meat consumption and risk of ischemic heart disease: A systematic review and meta-analysis. *Critical Reviews in Food Science and Nutrition*, 1–12. <https://doi.org/10.1080/10408398.2021.1949575>
- Poorolajal J, Heidarimoghis F, Karami M, Cheraghi Z, Gohari-Ensaf F, Shahbazi F, Zareie B, Ameri P and Sahraee F, 2021. Factors for the primary prevention of breast cancer: a meta-analysis of prospective cohort studies. *Journal of Research Health Science*, 21, e00520. <https://doi.org/10.34172/jrhs.2021.57>
- Portalatin M and Winstead N, 2012. Medical management of constipation. *Clinics in Colon and Rectal Surgery*, 25, 12–19. <https://doi.org/10.1055/s-0032-1301754>
- Puska P and Ståhl T, 2010. Health in all policies-the Finnish initiative: background, principles, and current issues. *Annual Review of Public Health*, 31, 315–328. <https://doi.org/10.1146/annurev.publhealth.012809.103658>
- Quan W, Jiao Y, Xue C, Li Y, Wang Z, Zeng M, Qin F, He Z and Chen J, 2020. Processed potatoes intake and risk of type 2 diabetes: a systematic review and meta-analysis of nine prospective cohort studies. *Critical Reviews in Food Science and Nutrition*, 1–9. <https://doi.org/10.1080/10408398.2020.1843395>
- Rand WM, Pellett PL and Young VR, 2003. Meta-analysis of nitrogen balance studies for estimating protein requirements in healthy adults. *American Journal of Clinical Nutrition*, 77, 109–127. <https://doi.org/10.1093/ajcn/77.1.109>
- van der Reijden OL, Zimmermann MB and Galetti V, 2017. Iodine in dairy milk: sources, concentrations and importance to human health. *Best Practice & Research Clinical Endocrinology & Metabolism*, 31, 385–395. <https://doi.org/10.1016/j.beem.2017.10.004>
- Rimm EB, Appel LJ, Chiuve SE, Djoussé L, Engler MB, Kris-Etherton PM, Mozaffarian D, Siscovick DS, Lichtenstein AH, the American Heart Association Nutrition Committee of the Council on Lifestyle and Cardiometabolic Health, the Council on Epidemiology and Prevention, the Council on Cardiovascular Disease in the Young, the Council on Cardiovascular and Stroke Nursing and the Council on Clinical Cardiology, 2018. Seafood long-chain n-3 polyunsaturated fatty acids and cardiovascular disease: a science advisory from the American Heart Association. *Circulation*, 138, e35–e47. <https://doi.org/10.1161/CIR.0000000000000574>
- Roe MA, Bell S, Oseredczuk M, Christensen T, Westenbrink S, Pakkala H, Presser K and Finglas PM, 2013. Updated food composition database for nutrient intake. EFSA supporting publication 2013;EN-355, 21 pp.
- Rong Y, Chen L, Zhu T, Song Y, Yu M, Shan Z, Sands A, Hu FB and Liu L, 2013. Egg consumption and risk of coronary heart disease and stroke: dose-response meta-analysis of prospective cohort studies. *BMJ*, 346, e8539. <https://doi.org/10.1136/bmj.e8539>
- Rosato V, Temple NJ, La Vecchia C, Castellan G, Tavani A and Guercio V, 2019. Mediterranean diet and cardiovascular disease: a systematic review and meta-analysis of observational studies. *European Journal of Nutrition*, 58, 173–191. <https://doi.org/10.1007/s00394-017-1582-0>
- Rusińska A, Płudowski P, Walczak M, Borszewska-Kornacka MK, Bossowski A, Chlebna-Sokół D, Czech-Kowalska J, Dobrzańska A, Franek E, Helwich E, Jackowska T, Kalina MA, Konstantynowicz J, Książyk J, Lewiński A, Łukaszewicz J, Marcinowska-Suchowierska E, Mazur A, Michałus I, Peregud-Pogorzelski J, Romanowska H, Ruchała M, Socha P, Szalecki M, Wielgoś M, Zwolińska D and Zygmunt A, 2018. Vitamin D supplementation guidelines for general population and groups at risk of vitamin D deficiency in Poland-Recommendations of the Polish Society of Pediatric Endocrinology and Diabetes and the Expert Panel with participation of national specialist consultants and representatives of scientific societies-2018 update. *Frontiers in Endocrinology*, 9, 246. <https://doi.org/10.3389/fendo.2018.00246>
- SACN (Scientific Advisory Committee on Nutrition), 2017. Update on Folic Acid. 82 pp.

- Santos M, Rito AI, Matias FN, Assunção R, Castanheira I and Loureiro I, 2021. Nutrient profile models a useful tool to facilitate healthier food choices: a comprehensive review. *Trends in Food Science & Technology*, 110, 120–131. <https://doi.org/10.1016/j.tifs.2021.01.082>
- Schwingshackl L, Hoffmann G, Lampousi AM, Knüppel S, Iqbal K, Schwedhelm C, Bechthold A, Schlesinger S and Boeing H, 2017. Food groups and risk of type 2 diabetes mellitus: a systematic review and meta-analysis of prospective studies. *European Journal of Epidemiology*, 32, 363–375. <https://doi.org/10.1007/s10654-017-0246-y>
- Schwingshackl L, Zähringer J, Beyerbach J, Werner SW, Hesecker H, Koletzko B and Meerpohl JJ, 2021. Total dietary fat intake, fat quality, and health outcomes: a scoping review of systematic reviews of prospective studies. *Annals of Nutrition and Metabolism*, 77, 4–15. <https://doi.org/10.1159/000515058>
- Siri-Tarino PW, Sun Q, Hu FB and Krauss RM, 2010. Meta-analysis of prospective cohort studies evaluating the association of saturated fat with cardiovascular disease. *American Journal of Clinical Nutrition*, 91, 535–546. <https://doi.org/10.3945/ajcn.2009.27725>
- de Souza RJ, Mente A, Maroleanu A, Cozma AI, Ha V, Kishibe T, Uleryk E, Budyłowski P, Schönemann H, Beyene J and Anand SS, 2015. Intake of saturated and trans unsaturated fatty acids and risk of all cause mortality, cardiovascular disease, and type 2 diabetes: systematic review and meta-analysis of observational studies. *BMJ*, 351. <https://doi.org/10.1136/bmj.h3978>
- Spiro A and Buttriss JL, 2014. Vitamin D: an overview of vitamin D status and intake in Europe. *Nutrition Bulletin*, 39, 322–350. <https://doi.org/10.1111/nbu.12108>
- Stephen AM, Champ MM, Cloran SJ, Fleith M, van Lieshout L, Mejborn H and Burley VJ, 2017. Dietary fibre in Europe: current state of knowledge on definitions, sources, recommendations, intakes and relationships to health. *Nutrition Research Reviews*, 30, 149–190. <https://doi.org/10.1017/S095442241700004X>
- Storcksdieck genannt Bonsmann S, Marandola G, Ciriolo E, Bavel R and Wollgast J, 2020a. Front-of-pack nutrition labelling schemes: a comprehensive review. EUR 29811 EN, Luxembourg, Publications Office of the European Union 2020, ISBN 978-92-76-08970-4. <https://doi.org/10.2760/180167>
- Storcksdieck genannt Bonsmann S, Meusel V, Grammatikaki E, Bakogianni I, Tan M, Wollgast J and Louro Caldeira S, 2020b. Food-Based Dietary Guidelines database. European Commission, 2020, JRC118752.
- Thanapluetiwong S, Chewcharat A, Takkavatakarn K, Praditpornsilpa K, Eiam-Ong S and Susantitaphong P, 2020. Vitamin D supplement on prevention of fall and fracture: a meta-analysis of randomized controlled trials. *Medicine*, 99, e21506. <https://doi.org/10.1097/md.00000000000021506>
- Threapleton DE, Greenwood DC, Evans CE, Cleghorn CL, Nykjaer C, Woodhead C, Cade JE, Gale CP and Burley VJ, 2013. Dietary fibre intake and risk of cardiovascular disease: systematic review and meta-analysis. *BMJ*, 347. <https://doi.org/10.1136/bmj.f6879>
- Tian S, Xu Q, Jiang R, Han T, Sun C and Na L, 2017. Dietary protein consumption and the risk of type 2 diabetes: a systematic review and meta-analysis of cohort studies. *Nutrients*, 9. <https://doi.org/10.3390/nu9090982>
- Ubago-Guisado E, Rodríguez-Barranco M, Ching-López A, Petrova D, Molina-Montes E, Amiano P, Barricarte-Gurrea A, Chirlaque M-D, Agudo A and Sánchez M-J, 2021. Evidence Update on the Relationship between Diet and the Most Common Cancers from the European Prospective Investigation into Cancer and Nutrition (EPIC) Study: a Systematic Review. *Nutrients*, 13, 3582.
- USDA (United States Department of Agriculture), 2020. Dietary Guidelines for Americans 2020–2025. 164 pp.
- Vernooij RWM, Zeraatkar D, Han MA, El Dib R, Zworth M, Milio K, Sit D, Lee Y, Gomaa H, Valli C, Swierz MJ, Chang Y, Hanna SE, Brauer PM, Sievenpiper J, de Souza R, Alonso-Coello P, Bala MM, Guyatt GH and Johnston BC, 2019. Patterns of red and processed meat consumption and risk for cardiometabolic and cancer outcomes: a systematic review and meta-analysis of cohort studies. *Annals of Internal Medicine*, 171, 732–741. <https://doi.org/10.7326/m19-1583>
- Vinceti M, Filippini T, Crippa A, de Sesmaisons A, Wise LA and Orsini N, 2016. Meta-analysis of potassium intake and the risk of stroke. *Journal of the American Heart Association*, 5. <https://doi.org/10.1161/JAHA.116.004210>
- Visseren FLJ, Mach F, Smulders YM, Carballo D, Koskinas KC, Böck M, Benetos A, Biffi A, Boavida J-M, Capodanno D, Cosyns B, Crawford C, Davos CH, Desormais I, Di Angelantonio E, Franco OH, Halvorsen S, Hobbs FDR, Hollander M, Jankowska EA, Michal M, Sacco S, Sattar N, Tokgozoglul L, Tonstad S, Tsioufis KP, van Dis I, van Gelder IC, Wannier C, Williams B and the E. S. C. Scientific Document Group, 2021. 2021 ESC Guidelines on cardiovascular disease prevention in clinical practice: developed by the Task Force for cardiovascular disease prevention in clinical practice with representatives of the European Society of Cardiology and 12 medical societies; with the special contribution of the European Association of Preventive Cardiology (EAPC). *European Heart Journal*, <https://doi.org/10.1093/eurheartj/ehab484>
- Wang X, Ouyang Y, Liu J, Zhu M, Zhao G, Bao W and Hu FB, 2014. Fruit and vegetable consumption and mortality from all causes, cardiovascular disease, and cancer: systematic review and dose-response meta-analysis of prospective cohort studies. *BMJ*, 349. <https://doi.org/10.1136/bmj.g4490>
- Wang X, Lin X, Ouyang YY, Liu J, Zhao G, Pan A and Hu FB, 2016. Red and processed meat consumption and mortality: dose-response meta-analysis of prospective cohort studies. *Public Health Nutrition*, 19, 893–905. <https://doi.org/10.1017/s1368980015002062>
- Wang Y, Harding SV, Thandapilly SJ, Tosh SM, Jones PJH and Ames NP, 2017. Barley  $\beta$ -glucan reduces blood cholesterol levels via interrupting bile acid metabolism. *British Journal of Nutrition*, 118, 822–829. <https://doi.org/10.1017/s0007114517002835>

- Wang DD, Li Y, Bhupathiraju SN, Rosner BA, Sun Q, Giovannucci EL, Rimm EB, Manson JE, Willett WC, Stampfer MJ and Hu FB, 2021. Fruit and vegetable intake and mortality: results from 2 prospective cohort studies of US men and women and a meta-analysis of 26 cohort studies. *Circulation*, 143, 1642–1654. <https://doi.org/10.1161/circulationaha.120.048996>
- WCRF/AICR (World Cancer Research Fund/American Institute for Cancer Research), 2018. Diet, nutrition and physical activity and cancer: a global perspective. 116 pp. Available online: <https://www.wcrf.org/diet-and-cancer/>
- Webster JL, Dunford EK and Neal BC, 2010. A systematic survey of the sodium contents of processed foods. *American Journal of Clinical Nutrition*, 91, 413–420. <https://doi.org/10.3945/ajcn.2009.28688>
- WHO (World Health Organization), 2003. Diet, nutrition and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation. WHO Technical Report Series, 916, 160.
- WHO (World Health Organization), 2004. Iodine Status Worldwide - WHO Global Database on Iodine Deficiency. 58 pp.
- WHO (World Health Organization), 2012. Guideline: Potassium Intake for Adults and Children. 52 pp.
- WHO (World Health Organization), 2015a. Guideline: Sugars Intake for Adults and Children. 59 pp.
- WHO (World Health Organization), 2015b. WHO Regional Office for Europe nutrient profile model. 11 pp.
- WHO (World Health Organization), 2019. Guiding Principles and Framework Manual for front-of-pack Labelling for Promoting Healthy Diet. 46 pp.
- WHO/FAO (World Health Organization/Food and Agriculture Organization of the United Nations), 2004. Vitamin and mineral requirements in human nutrition: report of a Joint FAO/WHO Expert Consultation, Bangkok, Thailand, 21–30 September 1998. 341 pp.
- Willett WC, Howe GR and Kushi LH, 1997. Adjustment for total energy intake in epidemiologic studies. *American Journal of Clinical Nutrition*, 65, 1220S–1228S. <https://doi.org/10.1093/ajcn/65.4.1220S>
- Willett W, Rockstrom J, Loken B, Springmann M, Lang T, Vermeulen S, Garnett T, Tilman D, DeClerck F, Wood A, Jonell M, Clark M, Gordon LJ, Fanzo J, Hawkes C, Zurayk R, Rivera JA, De Vries W, Majele Sibanda L, Afshin A, Chaudhary A, Herrero M, Agustina R, Branca F, Lartey A, Fan S, Crona B, Fox E, Bignet V, Troell M, Lindahl T, Singh S, Cornell SE, Srinath Reddy K, Narain S, Nishtar S and Murray CJL, 2019. Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems. *Lancet*, 393, 447–492. [https://doi.org/10.1016/S0140-6736\(18\)31788-4](https://doi.org/10.1016/S0140-6736(18)31788-4)
- Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, Clement DL, Coca A, de Simone G, Dominiczak A, Kahan A, Mahfoud F, Redon J, Ruilope L, Zanchetti A, Kerins M, Kjeldsen SE, Kreutz R, Laurent S, Lip GYH, McManus R, Narkiewicz K, Ruschitzka F, Schmieder RE, Shlyakhto E, Tsioufis C, Aboyans V, Desormais I and the E. S. C. Scientific Document Group, 2018. 2018 ESC/ESH Guidelines for the management of arterial hypertension. *European Heart Journal*, 39, 3021–3104. <https://doi.org/10.1093/eurheartj/ehy339>
- Wolever TM, Tosh SM, Gibbs AL, Brand-Miller J, Duncan AM, Hart V, Lamarche B, Thomson BA, Duss R and Wood PJ, 2010. Physicochemical properties of oat  $\beta$ -glucan influence its ability to reduce serum LDL cholesterol in humans: a randomized clinical trial. *American Journal of Clinical Nutrition*, 92, 723–732. <https://doi.org/10.3945/ajcn.2010.29174>
- Wood JD, Enser M, Richardson RI and Whittington FM, 2007. Fatty acids in meat and meat products. In: Chow CK (ed.). *Fatty acids in foods and their health implications*, FL, USA, CRC Press, Boca Raton. pp. 87–107.
- World Cancer Research Fund and American Institute for Cancer Research, 2018. Body fatness and weight gain and the risk of cancer. Continuous Project Update Report 2018. 142 pp, available online: <https://www.wcrf.org/diet-and-cancer/>
- Yao B, Fang H, Xu W, Yan Y, Xu H, Liu Y, Mo M, Zhang H and Zhao Y, 2014. Dietary fiber intake and risk of type 2 diabetes: a dose-response analysis of prospective studies. *European Journal of Epidemiology*, 29, 79–88. <https://doi.org/10.1007/s10654-013-9876-x>
- Yao P, Bennett D, Mafham M, Lin X, Chen Z, Armitage J and Clarke R, 2019. Vitamin D and calcium for the prevention of fracture: a systematic review and meta-analysis. *JAMA Network Open*, 2, e1917789. <https://doi.org/10.1001/jamanetworkopen.2019.17789>
- Yumuk V, Tsigos C, Fried M, Schindler K, Busetto L, Micic D, Toplak H and the Obesity Management Task Force of the European Association for the Study of Obesity, 2015. European Guidelines for obesity management in adults. *Obesity Facts*, 8, 402–424. <https://doi.org/10.1159/000442721>
- Zeraatkar D, Han MA, Guyatt GH, Vernooij RWM, El Dib R, Cheung K, Milio K, Zworth M, Bartoszko JJ, Valli C, Rabassa M, Lee Y, Zajac J, Prokop-Dorner A, Lo C, Bala MM, Alonso-Coello P, Hanna SE and Johnston BC, 2019. Red and processed meat consumption and risk for all-cause mortality and cardiometabolic outcomes: a systematic review and meta-analysis of cohort studies. *Annals of Internal Medicine*, 171, 703–710. <https://doi.org/10.7326/m19-0655>
- Zheng J, Huang T, Yu Y, Hu X, Yang B and Li D, 2012. Fish consumption and CHD mortality: an updated meta-analysis of seventeen cohort studies. *Public Health Nutrition*, 15, 725–737. <https://doi.org/10.1017/S1368980011002254>
- Zhang Z, Xu G, Liu D, Zhu W, Fan X and Liu X, 2013. Dietary fiber consumption and risk of stroke. *European Journal of Epidemiology*, 28, 119–130. <https://doi.org/10.1007/s10654-013-9783-1>
- Zhang Y, You D, Lu N, Duan D, Feng X, Astell-Burt T, Zhu P, Han L, Duan S and Zou Z, 2018. Potatoes consumption and risk of type 2 diabetes: a meta-analysis. *Iranian Journal of Public Health*, 47, 1627–1635.

- Zhang B, Xiong K, Cai J and Ma A, 2020. Fish consumption and coronary heart disease: a meta-analysis. *Nutrients*, 12. <https://doi.org/10.3390/nu12082278>
- Zhu Y, Bo Y and Liu Y, 2019. Dietary total fat, fatty acids intake, and risk of cardiovascular disease: a dose-response meta-analysis of cohort studies. *Lipids in Health and Disease*, 18. <https://doi.org/10.1186/s12944-019-1035-2>
- Zong G, Gao A, Hu FB and Sun Q, 2016. Whole grain intake and mortality from all causes, cardiovascular disease, and cancer: a meta-analysis of prospective cohort studies. *Circulation*, 133, 2370–2380. <https://doi.org/10.1161/circulationaha.115.021101>

## Abbreviations

AI	Adequate Intake
AICR	American Institute for Cancer research
ALA	$\alpha$ -linolenic acid
AR	Average Requirement
ARA	arachidonic acid
BMD	bone mineral density
BMI	body mass index
CDC	Centers for Disease Control
CDRR	Chronic Disease Risk Reduction Intake
CHD	coronary heart disease
CVD	cardiovascular diseases
DHA	docosahexaenoic acid
DNA	deoxyribonucleic acid
DRV	Dietary Reference Value
E%	percentage of total energy intake
EEA	European Economic Area
EPA	eicosapentaenoic acid
EPIC	European Prospective Investigation into Cancer and Nutrition
ESPGHAN	European Society for Paediatric Gastroenterology, Hepatology, and Nutrition
EU	European Union
FBDG	food based dietary guideline
FOP	front-of-pack
GBD	Global Burden of Disease
HDL	high-density lipoprotein
IARC	International Agency for Research on Cancer
IDA	iron deficiency anaemia
IOTF	International Obesity Task Force
JRC	Joint Research Centre
LA	linoleic acid
LC	long-chain
LDL	low-density lipoprotein
MUFA	monounsaturated fatty acid
n-3	omega 3
n-6	omega 6
NCD	non-communicable disease
NDA	Panel on Nutrition, Novel Foods and Food Allergens
PRI	Population Reference Intake
PUFA	polyunsaturated fatty acid
RCT	randomised controlled trial
RI	Reference Intake range for macronutrients
RNA	ribonucleic acid
SFA	saturated fatty acid
T2DM	type 2 diabetes mellitus
TFA	<i>trans</i> fatty acid
UIC	urinary iodine concentration
UL	Tolerable Upper Intake Level
WCRF	World Cancer Research Fund
WHO	World Health Organization

## **Appendix A – Protocol for the provision of scientific advice on the development of harmonised mandatory front-of-pack nutrition labelling and the setting of nutrient profiles for restricting nutrition and health claims on foods (endorsed by the NDA Panel on 8 April 2021)<sup>31</sup>**

### **1. Problem formulation (assessment questions and subquestions)**

The mandate can be broken down in the following questions:

- 1) Which nutrients and/or foods, including non-nutrient components of food (e.g. energy, dietary fibre), are of public health importance for European populations? These include:
  - a) Nutrients and/or foods that might be consumed in excess, and
  - b) Nutrients and/or foods for which intakes might be inadequate

in the context of dietary recommendations for healthy diets of European countries or of independent scientific bodies.

- 2) Which food groups (and specific food products thereof) have important dietary roles in European populations (and subgroups thereof) owing to their nutrient composition and frequency of intake?
- 3) Which criteria should be considered when selecting the nutrient and non-nutrient components of food for nutrient profiling?

### **2. Definition of evidence needs based on the subquestion formulation**

To address question 1:

- a) Identification of diet-related chronic diseases which were considered in the setting of FBDGs by Member States;
- b) Evidence on the relationship between nutrients, non-nutrient components (e.g. energy, dietary fibre), foods and food groups, and the diet-related chronic diseases identified under point (a);
- c) Selection of nutrients, non-nutrient components, foods and food groups, identified under point (b), which are considered of public health importance by one or more Member States.

To address question 2:

- a) Information on main food groups and specific food products thereof with important dietary roles in European populations (and subgroups thereof) as recognised by Member States in FBDGs.

To address question 3:

- a) Information on existing nutrient-profiling models;
- b) Evidence from questions 1 and 2 above.

### **3. Identification of the adequate sources of information/data**

Owing to the wide scope of this mandate and the stringent deadline, the Panel will consider review publications and EFSA Scientific Opinions as the main sources of information and data. In particular, the Panel will consider:

- a) Responses to a questionnaire sent to EU/EEA countries through EFSA focal points with the aim of gathering information on the diet-related chronic diseases which formed the basis of setting of FBDGs and on the nutrients, non-nutrient components, foods and food groups considered of public health importance;
- b) Review publications on nutritionally adequate diets based on evidence from intervention and observational studies in humans (e.g. WHO (2003), Willett et al. (2019));
- c) Data from the Global Burden of Disease framework<sup>32</sup>;
- d) Clinical practice guidelines;

<sup>31</sup> The title of the scientific opinion has changed based on the comments received from the public consultation.

<sup>32</sup> <https://www.healthdata.org/diet>; <https://www.thelancet.com/gbd>; <https://vizhub.healthdata.org/gbd-compare/#>

- e) FBDGs in Europe<sup>33</sup>;
- f) EFSA Scientific Opinions on Dietary Reference Values for energy, water, macro- and micronutrients;
- g) EFSA Scientific Opinions on health claims made on food;
- h) Other EFSA Scientific Opinions on the relationship between nutrients and/or foods/food groups and human health, e.g. health benefits of seafood (fish and shellfish) consumption (EFSA NDA Panel, 2014c);
- i) EFSA Scientific Opinions on nutrient profiles to limit health claims on foods (EFSA NDA Panel, 2008) and on the development of FBDGs (EFSA NDA Panel, 2010d);
- j) Comprehensive review on front-of-pack labelling schemes provided by the European Commission.<sup>34</sup>

#### **4. Method for data extraction from included studies**

No data extraction is foreseen.

#### **5. Method for appraising evidence**

Appraisal of included studies is not foreseen.

#### **6. Preliminary identification of sources of uncertainty**

- The assessment will be based on review publications and not on primary studies;
- The classification of foods into food groups may not be well defined and/or differ across sources of information and data;
- Information on the relationship between the intake of nutrients, non-nutrient components of food, foods and food groups and diet-related disease endpoints may only be available from human observational studies;

#### **7. Methods for analysing uncertainties individually and combined**

Uncertainties will be identified and documented at each step of the assessment, but no formal uncertainty assessment is foreseen.

#### **8. Methods for synthesising evidence**

The method for synthesising the evidence will be appropriate to the evidence retrieved.

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<sup>33</sup> [https://ec.europa.eu/jrc/en/health-knowledge-gateway/promotion-prevention/nutrition/food-based-dietary-guidelines#:~:text=Food%2DBased%20Dietary%20Guidelines%20\(FBDGs,acceptable%20and%20practical%20to%20implement](https://ec.europa.eu/jrc/en/health-knowledge-gateway/promotion-prevention/nutrition/food-based-dietary-guidelines#:~:text=Food%2DBased%20Dietary%20Guidelines%20(FBDGs,acceptable%20and%20practical%20to%20implement)

<sup>34</sup> <https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/front-pack-nutrition-labelling-schemes-comprehensive-review>

## Appendix B – Survey in EU/EEA Member States on diet-related chronic diseases considered in national Food-Based Dietary Guidelines (FBDGs)

The survey had the following contents:

- NAME\*:
- COUNTRY\*:
- AFFILIATION\*:
- EMAIL\*:
- DATE:

We kindly ask you to fill the survey. Please answer to the questions by ticking the relevant boxes and specify where relevant.

### 1. Does your country have FBDG?

No

Yes

If yes, please specify the year in which your national FBDGs were last updated (or developed, if only one version exist): \_\_\_\_\_

### 2. Was the risk of diet-related chronic diseases considered when developing/updating your FBDGs?

No

Yes

If yes, please specify the diet-related chronic diseases that were considered when developing/updating your national FBDGs: \_\_\_\_\_

- a. Cardiovascular diseases:
- b. Dyslipidaemia:
- c. Hypertension:
- d. Type 2 diabetes:
- e. Overweight/obesity:
- f. Osteoporosis/bone fractures:
- g. Iron deficiency anaemia:
- h. Iodine deficiency disorders:
- i. Dental caries:
- j. Others: Please specify \_\_\_\_\_

### 3. Have you identified at national level nutrients for which intakes may be inadequate for the whole population or subgroups thereof?

No

Yes

If yes, please specify the nutrients and population groups to which this applies: \_\_\_\_\_

### 4. Do you have a national programme of vitamin/mineral supplementation or fortification in place in your country? (e.g. iodine in salt, vitamin D supplements for specific population groups, folate for women willing to become pregnant, etc.)

No

Yes

If yes, please specify: \_\_\_\_\_

Twenty-four European countries replied to the surveys with the following results:

Q		NO	YES	Specify
1.	Does your country have FBDGs?	2x	22x	2002–2021
2.	Was the risk of diet-related chronic diseases considered		22x	

Q		NO	YES	Specify
	<b>when developing/updating your FBDGs?</b>			
a.	Cardiovascular diseases:		21x	
b.	Dyslipidaemia:		20x	
c.	Hypertension:		19x	
d.	Type 2 diabetes:		21x	
e.	Overweight/obesity:		20x	
f.	Osteoporosis/bone fractures:		18x	
g.	Iron deficiency anaemia:		15x	
h.	Iodine deficiency disorders:		16x	
i.	Dental caries:		15x	
j.	Others: Please specify			
		<ul style="list-style-type: none"> <li>▪ Cancer (14x),</li> <li>▪ Mental health/Neurodegenerative/Neurocognitive disorders (e.g. Alzheimer's disease, dementia, depression and anxiety disorder) (5x)</li> <li>▪ Chronic obstructive pulmonary disease (2x),</li> <li>▪ Musculoskeletal diseases (the mediators of which are overweight and obesity) (1x)</li> <li>▪ Arthrosis (1x)</li> <li>▪ Liver cirrhosis (1x)</li> <li>▪ Chronic kidney disease (1x)</li> <li>▪ Digestive tract diseases (1x)</li> <li>▪ Protein deficiency (1x)</li> <li>▪ Gallbladder and biliary tract diseases (1x)</li> <li>▪ Immune disorders (1x)</li> <li>▪ Risk of infectious diseases (1x)</li> <li>▪ Other conditions (e.g. constipation, dehydration) (1x)</li> <li>▪ Prevent of birth defects (NTDs) through folic acid in women of child-bearing age (1x)</li> <li>▪ Other diseases and early total mortality (1)</li> </ul>		
<b>3.</b>	<b>Have you identified at national level nutrients for which intakes may be inadequate for the whole population or subgroups thereof?</b>	2x	22x	
		<ul style="list-style-type: none"> <li>▪ Vitamin D (17 countries<sup>(a)</sup>: 13x general population<sup>(b)</sup>, 6x children, 1x pregnant women, 4x elderly)</li> <li>▪ Iodine (13 countries: 6x general population, 3x women, 2x pregnant women, 1x lactating women)</li> <li>▪ Folate (12 countries: 3x general population, 2x adults, 2x children, 3x women, 3x pregnant women, 1x adolescents, 1x elderly)</li> <li>▪ Calcium (8 countries: 5x general population, 1x girls, 1x elderly, 1x women, 1x adults)</li> <li>▪ Iron (8 countries: 1x general population, 6x children, 1x women, 3x pregnant women, 1x elderly)</li> <li>▪ Dietary fibre (7 countries: 5x general population, 1x children, 2x adults)</li> <li>▪ Zinc (4 countries: 1x general population, 2x children, 1x pregnant women, 1x women, 2x elderly)</li> </ul>		

Q	NO	YES	Specify
		<ul style="list-style-type: none"> <li>▪ Selenium (4 countries: 2x general population, 2x elderly, 1x women)</li> <li>▪ Vitamin C (4 countries: 2x general population, 2x elderly)</li> <li>▪ Potassium (4 countries: 2x general population, 1x elderly and older women, 1x children)</li> <li>▪ Vitamin B6 (3 countries: 1x general population, 2x elderly)</li> <li>▪ Magnesium (3 countries: 3x general population)</li> <li>▪ Omega 3 fatty acids/ DHA / EPA (3 countries; 2x general population, 1x children, 1x adults)</li> <li>▪ Vitamin B12 (3 countries: 1x general population, 1x elderly, 1x vegans)</li> <li>▪ Vitamin A (2 countries: 1x general population, 1x children, 1x pregnant women, 1x elderly)</li> <li>▪ Copper (2 countries: 2x general population)</li> <li>▪ Protein (2 countries: 1x general population, 1x elderly)</li> <li>▪ Riboflavin (2 countries: 1x general population, 1x elderly)</li> <li>▪ Phosphorus (1 country: 1x general population)</li> <li>▪ Thiamin (1 country: 1x general population)</li> <li>▪ Chromium (1 country: 1x general population)</li> <li>▪ Niacin (1 country: 1x general population)</li> <li>▪ Vitamin K (1 country: 1x general population)</li> <li>▪ Carbohydrates (1 country: pregnant women and adults, in particular elderly)</li> </ul>	
<p>4.</p> <p><b>Do you have a national programme of vitamin/ mineral supplementation or fortification in place in your country? (e.g. iodine in salt, vitamin D supplements for specific population groups, folate for women willing to become pregnant, etc.)</b></p>	<p>3 x</p>	<p>21 x</p>	
		<ul style="list-style-type: none"> <li>▪ Iodine (16 countries: salt, supplements for pregnant women, fortification of cattle)</li> <li>▪ Vitamin D (15 countries: supplements for infants and young children, pregnant women, older adults, elderly, fortification of margarines, cooking oils, dairy)</li> <li>▪ Folate (13 countries: supplements for women of childbearing age, pregnant women)</li> <li>▪ Vitamin B12 (3 countries: supplements for vegans and the elderly)</li> <li>▪ Vitamin A (2 countries fortification of margarines and cooking oils)</li> <li>▪ Selenium (1 country: addition to agricultural fertilisers)</li> <li>▪ Fluoride (1 country: salt, supplements for infants)</li> <li>▪ Iron (1 country: supplements for pregnant women)</li> <li>▪ DHA (1 country: supplements for pregnant women)</li> <li>▪ Vitamin E (1 country: fortification of margarines and cooking oils)</li> </ul>	

(a): Multiple answers possible with respect to subpopulations at risk of inadequacy.

(b): Responses in which no subpopulation was specified have been considered under the category 'general population'.

**Annex A – Technical report: outcome of the public consultation on the draft scientific opinion related to nutrient profiling for the development of harmonised mandatory front-of-pack nutrition labelling and the setting of nutrient profiles for restricting nutrition and health claims on foods**

The Annex can be found in the online version of this output, under the section 'Supporting information', at: <https://doi.org/10.2903/j.efsa.2022.7259>