SCIENTIFIC OPINION

Scientific Opinion on nutrient requirements and dietary intakes of infants and young children in the European Union[1]

EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA)[2, 3]

European Food Safety Authority (EFSA), Parma, Italy

ABSTRACT

Following a request from the European Commission, the EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA) was asked to deliver a Scientific Opinion on the nutrient requirements and dietary intakes of infants and young children in the European Union. This Opinion describes the dietary requirements of infants and young children, compares dietary intakes and requirements in infants and young children in Europe and, based on these findings, concludes on the potential role of young-child formulae in the diets of infants and young children, including whether they have any nutritional benefits when compared with other foods that may be included in the normal diet of infants and young children. The Panel concluded on the levels of nutrient and energy intakes that are considered adequate for the majority of infants and young children, and evaluated the risk of inadequate nutrient intakes in infants and young children in living Europe. Dietary intakes of alpha-linolenic acid (ALA), docosahexaenoic acid (DHA), iron, vitamin D and iodine (in some European countries) are low in infants and young children living in Europe, and particular attention should be paid to ensuring an appropriate supply of ALA, DHA, iron, vitamin D and iodine in infants and young children with inadequate or at risk of inadequate status of these nutrients. No unique role of young-child formulae with respect to the provision of critical nutrients in the diet of infants and young children living in Europe can be identified, so that they cannot be considered as a necessity to satisfy the nutritional requirements of young children when compared with other foods that may be included in the normal diet of young children (such as breast milk, infant formulae, follow-on formulae and cow's milk).

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KEY WORDS

nutrient requirements, dietary intakes, infants, young children, young-child formula

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SUMMARY

Following a request from the European Commission, the EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA) was asked to deliver a Scientific Opinion on the nutrient requirements and dietary intakes of infants and young children in the European Union. This Opinion describes the dietary requirements of infants and young children, compares dietary intakes and requirements in infants and young children living in Europe and, based on the findings, concludes on the potential role of young-child formulae in the diets of infants and young children, including whether they have any nutritional benefits when compared with other foods that may be included in the normal diet of infants and young children.

In this Opinion, the Panel provides advice on the levels of nutrients which it considers adequate for healthy, term, normal-weight infants and young children, but does not derive any Dietary Reference Values (DRVs). This will be done in the framework of setting DRVs for individual micronutrients.

For infants up to the age of six months, the nutrient content of breast milk from healthy, well-nourished, unsupplemented mothers was used for most nutrients as a basis to provide advice on intake levels of nutrients considered adequate for the majority of infants in the first half-year of life.

For levels of nutrient intakes considered adequate for the majority of infants in the second half-year of life and in young children, the Panel reviewed reference values set by the Scientific Committee for Food in 1993 in the light of more recent recommendations given by other scientific or authoritative bodies, i.e. the French Food Safety Agency (Afssa) and the Health Council of the Netherlands (Gezondheidsraad) as well as the recommendations given by Nordic Council of Ministers, the German-speaking countries (D-A-CH), the US Institute of Medicine (IoM), the National Health and Medical Research Council of the Commonwealth (NHMRC) of Australia and the Ministry of Health of New Zealand and the World Health Organization (WHO), unless the Panel has already given an Opinion or endorsed an Opinion for public consultation on a DRV for a specific nutrient, in which case the previous advice given by the Panel was taken as a basis of the current Opinion (i.e. for energy, protein, fat, carbohydrates and dietary fibre, water, molybdenum, fluoride, manganese, pantothenic acid, biotin and vitamin C).

Based on the available publications reporting on nutrient intakes in infants and young children living in Europe, the Panel evaluated the risk of inadequate nutrient intakes in infants and young children in Europe by comparing the habitual nutrient intakes with the Average Requirement (AR) or with the Adequate Intake (AI). The Panel also reviewed available evidence with respect to studies in infants and young children living in Europe reporting on status markers of nutrient adequacy to complement information provided by nutrient intake studies.

Dietary intakes of linoleic acid (LA), calcium, phosphorus, magnesium, copper, selenium, chromium, molybdenum, manganese, fluoride, vitamin A, vitamin E, vitamin K, thiamin, riboflavin, niacin, pantothenic acid, pyridoxine, biotin, folate, cobalamin, vitamin C and choline in infants and young children living in Europe do not give rise to concern over the risk of inadequate intakes.

Dietary intakes of energy, protein, salt and potassium in infants and young children living in Europe are generally high while intakes of dietary fibre in young children are low. Intakes of protein, salt and potassium are not at levels which are of concern, whereas energy intakes above requirements will lead to an unfavourable gain in body mass.

In the case of n-3 polyunsaturated fatty acids (PUFAs) and zinc, the risk of inadequate intakes in infants and young children living in Europe cannot be quantified. However, as zinc intakes are mainly above the AR and no overt deficiency in this population group in Europe has been reported, it is considered that current zinc intakes in infants and young children living in Europe are not of particular concern.

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Dietary intakes of alpha-linolenic acid (ALA), docosahexaenoic acid (DHA), iron, vitamin D and iodine (in some European countries) are low in infants and young children living in Europe and particular attention should be paid to ensuring an appropriate supply of ALA, DHA, iron, vitamin D and iodine in infants and young children with inadequate or at risk of inadequate status of these nutrients, in particular in the view of the poor iron, vitamin D and iodine status of some sub-groups of infants and young children living in Europe.

Several European countries have translated nutrient intake recommendations for infants and young children into food-based dietary guidelines (FBDG) to help caregivers in the choice of age-appropriate foods to meet dietary needs. It has been shown in one European country that a specific modular dietary schedule for the first year of life and an optimised mixed diet for children aged 1 to 18 years are able to provide an adequate energy and nutrient supply for these age groups, with the exception of vitamin D.

Although dietary habits markedly differ within Member States, these diets can be taken as an example of dietary patterns which can ensure a sufficient energy and nutrient supply in infants and young children.

Fortified formulae, including young-child formula, are one of several means to increase n-3 PUFA, iron, vitamin D and iodine intakes in infants and young children living in Europe with inadequate or at risk of inadequate status of these nutrients. However, other means, such as fortified cow's milk, fortified cereals and cereal-based foods, supplements or the early introduction of meat and fish into complementary feeding and their continued regular consumption, are efficient alternatives to increase intakes of these nutrients. The selection of the appropriate form and vehicle through which these nutrients are provided in the diet will depend on national dietary habits, health authorities, the regulatory context and caregivers' preference. However, it is recommended that guidelines for vitamin D supplementation of infants and children established at national level be followed.

In comparison with cow's milk, currently marketed young-child formulae contain more ALA, DHA (if added), iron and vitamin D but similar amounts of iodine.

The mean content of these nutrients in young-child formulae is within the range of permitted concentrations in follow-on formulae and, except for iron, also in infant formulae.

No unique role of young-child formulae with respect to the provision of critical nutrients in the diet of infants and young children living in Europe can be identified, so that they cannot be considered as a necessity to satisfy the nutritional requirements of young children when compared with other foods that may be included in the normal diet of young children (such as breast milk, infant formulae, follow-on formulae and cow's milk).

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BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION

Directive 2009/39/EC on foodstuffs intended for particular nutritional uses lays down general rules[4] on the composition of such foods that are specially designed to meet the particular nutritional requirements of the persons to whom they are intended, including infants and young children in good health.

One of the measures adopted under that framework legislation is Commission Directive 2006/141/EC on infant formulae and follow-on formulae[5]. That Directive was adopted originally in 1991 and revised globally in 2006.

The Directive defines 'infants' as "children under the age of 12 months" and 'young children' as "children aged between one and three years".

The Directive also defines 'infant formulae' as "foodstuffs for particular nutritional use by infants during the first months of life and satisfying by themselves the nutritional requirements of such infants until the introduction of appropriate complementary feeding" and 'follow-on formulae' as "foodstuffs intended for particular nutritional use by infants when appropriate complementary feeding is introduced and constituting the principal liquid element in a progressively diversified diet of such infants".

The Directive sets essential requirements for the composition of infant formula and follow-on formula, which are based on a number of opinions of the Scientific Committee on Food, the latest one being the "Report of the Scientific Committee on Food on the Revision of Essential Requirements of Infant Formulae and Follow-on Formulae", adopted on 4 April 2003[6]. In the last ten years, scientific and technological developments on the essential composition of these products have progressed and there are increasing calls for a review of the legislation to reflect such developments.

The Commission's proposal for a Regulation of the European Parliament and the Council on foods intended for infants and young children and on food for special medical purposes[7] aims at revising the legal framework applicable to food for particular nutritional uses and, among others, at repealing Directive 2009/39/EC. Negotiations on the proposal are reaching their conclusion and it is expected that such Regulation will be adopted in the next months.

Once the new Regulation is adopted, the Commission will need to adopt delegated acts setting specific rules for the categories of food covered by the Regulation, including infant formulae and follow-on formulae.

In the last years, increasing numbers of milk-based drinks and similar products are marketed in different Member States with the denomination of 'growing-up milks' or 'toddlers' milks' or with similar terminology. The composition of these products varies with respect to the protein origin (they can be derived from protein of animal or vegetable origin such as cows' milk, goats' milk, soy or rice) and other ingredients. They are promoted as being particularly suitable for young children and, as such, under the current rules, may be considered as foodstuffs for particular nutritional uses. However, no composition requirements for these products are set in EU legislation.

Different views exist in the scientific community and among stakeholders on whether these products are necessary to satisfy the nutritional requirements of young children or have any nutritional benefits when compared to other foods that can constitute the normal diet of young children. In this context,

[4] Directive 2009/39/EC of the European Parliament and of the Council of 6 May 2009 on foodstuffs intended for particular nutritional uses, OJ L 124, 20.5.2009, p. 21.

[5] Commission Directive 2006/141/EC of 22 December 2006 on infant formulae and follow-on formulae and amending Directive 1999/21/EC, OJ L 401, 30.12.2006, p. 1.

[6] Report of the Scientific Committee on Food on the Revision of Essential Requirements of Infant Formulae and Follow-on Formulae, adopted on 4 April 2003, SCF/CS/NUT/IF/65 Final, 18 May 2003.

[7] COM (2011) 353.

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some would argue that, given the potential variability of weaning diets that may result in different nutrient intakes for this group of the population, these products are convenient, as a liquid element in the diet of young children, in contributing to meeting their nutritional requirements. Taking all these elements into account, the European Parliament and the Council agreed that these products should be subject of a specific reflection. Therefore, in the abovementioned revision of the legal framework, the Commission will be requested, after consulting the European Food Safety Authority, to draft a report on the necessity, if any, of special provisions for milk-based drinks and similar products intended for young children (hereinafter 'growing-up milks').

In the meantime, at international level, the Codex Committee on Nutrition and Food for Special Dietary Uses (CCNFSDU) agreed at its 34th session in December 2012 to revise their existing standard for follow-up formulae[8], which dates back to 1987 and applies to food intended for use as a liquid part of the weaning diet for the infant from the 6th month on and for young children up to three years of age. Such review will cover all aspects of the existing standard and will include consideration of issues such as technological and scientific developments in follow-up formula production and composition over the past 25 years, the age range of the intended population, product definition and the role of such products in the diet of infants and young children. Furthermore, following comments by WHO and some Codex Member Countries and observers, the review may also consider whether this standard is still necessary at all. The first discussion on this subject will take place at the next session of the CCNFSDU to be held on 4-8 November 2013.

Taking into account the developments described above, it is considered necessary to request the EFSA to provide a scientific opinion on all milk-based drinks and similar products intended for infants and young children.

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

In accordance with Article 29(1) (a) of Regulation (EC) No 178/2002[9], the European Commission asks EFSA to:

- Provide advice on the nutritional requirements of infants and young children and, in particular, on those requirements that may be satisfied by breast milk, milk-based drinks and similar products. In this context it will also be important to provide advice to the Commission on how these nutritional requirements evolve during the age period 0-3 years.

- Provide advice on the essential composition requirements of infant formulae and follow-on formulae by updating the relevant opinions of SCF on the matter.

- Provide advice on the importance of the role that 'growing-up milks' may have as a liquid element in the diet of young children, with respect to elements such as the pattern of consumption, the nutritional intake and any other relevant aspect related to exposure to substances that may be present in their diet. In this context it would be useful to take into account that different products are on the market which may have a considerably varied composition.

- Provide advice on whether 'growing-up milks' are necessary to satisfy the nutritional requirements of young children or have any nutritional benefits when compared to other foods that may be included in the normal diet of young children (such as breast milk, infant formulae, follow-on formulae, cow's milk and other similar products).

- If considered appropriate, advise the Commission with respect to the appropriate age range and the essential composition of 'growing-up milks'.

[8] CODEX STAN 156-1987.
[9] OJ. L 31, 01.02.2002. p. 1.

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ASSESSMENT

1. Introduction

The period of infancy and young childhood is characterised by special needs in nutrition, with respect to requirements for energy and for nutrient amounts per kilogram body mass, which must not only maintain the body but also support a rapid rate of growth and the appropriate synthesis and deposition of body tissue. This growth leads to a doubling of body weight between birth and the age of three to four months and to a tripling by the age of 12 months and consumes about 27 %, 11 % and 5 % of total energy expenditure (TEE) of formula-fed infants from birth to four months, from four to six months and from six to 12 months, respectively (Fomon, 1993). This additional energy requirement for growth includes both the energy deposited in the form of new tissue and the energy required for deposition (i.e. 10.8 kcal per gram of deposited fat and 13.4 kcal/g deposited protein (Roberts and Young, 1988)). Moreover, the metabolically active organs, brain, liver, heart and kidneys, are, relative to body weight, larger than in adults (20 % vs. 5 % of body weight), in spite of the fact that they do not attain 50 % of their adult size until the end of the second year of life (Prentice et al., 2013). These four organs account for a higher percentage of the resting energy expenditure (REE) than in adults (e.g. the brain accounts for 65 % of REE in the newborn compared with about 20 % in adults), whereas muscle contributes only about 8 %, compared with 25 % in adults. Another peculiarity of young infants is that the synthetic capacity for some metabolic intermediates may be limited, making such substances conditionally indispensable in the diet. Homeostatic mechanisms which could compensate for dietary imbalances in adults may be immature with respect to both absorption and to elimination of substances and, owing to the small body size, stores of nutrients (e.g. glycogen) are too low to compensate for insufficient intakes. Moreover, the quantity and quality of nutrient supply during infancy and young childhood has been found to be related to long-term health effects, cognitive development and diseases some of which are the consequence of "programming" metabolism in a negative way (e.g. Barker, 1994; Lucas, 1998).

A special feature of young infancy is that, as a rule, one liquid food is the sole source of nutrition and must supply appropriate amounts of energy, water and nutrients. Breast milk is the preferred food for all healthy infants and provides an adequate supply of all nutrients to support healthy growth and development (with the exception of vitamin K during the first weeks of life and of vitamin D), besides providing protection against infection and immunostimulatory components. Comparative studies in affluent countries have indicated important advantages of breast-feeding over formula-feeding for the recipient infants, such as lower incidence rates of gastrointestinal and respiratory infections (Ip et al., 2007; Agostoni et al., 2009) and a lower risk of obesity (von Kries et al., 1999; Toschke et al., 2002; Owen et al., 2005). Breast milk is, therefore, the model for the composition of infant formula, taking into account that a breast milk substitute should not only imitate the composition of breast milk but also aim at achieving similar health effects (Koletzko et al., 2005).

Infant and follow-on formulae have, therefore, been regulated as foods for particular nutritional uses under Directive 2009/39/EC[10] and its implementing Directive 2006/141/EC[11] based upon a series of reports from the Scientific Committee for Food (SCF, 1983, 1989, 1991, 1993a, 1995, 2003c). No revision of the SCF reports in the light of new available evidence has been undertaken since then, and such review in the context of the revision of the implementation of Regulation (EU) No 609/2013[12] is part of the present Terms of Reference (ToR).

[10] Directive 2009/39/EC of the European Parliament and of the Council of 6 May 2009 on foodstuffs intended for particular nutritional uses, OJ L 124, 20.5.2009, pp. 21–29.

[11] Commission Directive 2006/141/EC of 22 December 2006 on infant formulae and follow-on formulae and amending Directive 1999/21/EC, OJ L 401, 30.12.2006, pp. 1–33.

[12] Regulation (EU) No 609/2013 of the European Parliament and of the Council of 12 June 2013 on food intended for infants and young children, food for special medical purposes, and total diet replacement for weight control and repealing Council Directive 92/52/EEC, Commission Directives 96/8/EC, 1999/21/EC, 2006/125/EC and 2006/141/EC, Directive 2009/39/EC of the European Parliament and of the Council and Commission Regulations (EC) No 41/2009 and (EC) No 953/2009, OJ L 181, 29.6.2013, pp. 35–56.

Other milk-based formulae intended for young children that are available on the market in many Member States are not regulated as yet. Article 12 of Regulation (EU) No 609/2013 requires the European Commission to present a report to the European Parliament and the Council on the necessity, if any, of special provisions for these products.

Owing to the limited time frame given, the Panel has decided, in agreement with the European Commission, to produce two separate Opinions. Of the five parts of the ToR:

- nutritional requirements of infants and young children and their coverage by human milk and milk-based products,
- advice on the necessity of a revision of the essential composition of infant and follow-on formulae as laid down in Directive 2006/141/EC,
- the potential role of milk-based drinks designed, manufactured and advertised to be used in the diets of infants and young children other than infant and follow-on formulae,
- a comparison of the nutritional role of such other milk-based drinks in the diet of young children with other formulae, human milk or cow's milk,
- eventually advice on the essential composition of such other milk-based drinks and their target groups,

the Panel will provide advice in this first Opinion on

1) the dietary requirements of infants and young children,
2) the dietary intakes of infants and young children living in Europe in comparison with the requirements, and
3) based on the findings, the potential role of milk-based drinks designed, manufactured and advertised to be used in the diets of infants and young children, including whether they have any nutritional benefits when compared with other foods that may be included in the normal diet of infants and young children (such as breast milk, infant formulae, follow-on formulae and cow's milk).

The Panel will not discuss safety aspects of ingredients nor of pesticide residues and contaminants but notes that the current maximum residue levels (MRLs) of pesticides[13] and contaminants[14] have been set at the lowest achievable level with a view to protecting vulnerable groups such as children. Foods complying with this framework will, therefore, not pose a health risk to infants and young children. The Panel supports the extension of the relevant rules for infant and follow-on formulae given in Article 4 of Directive 2006/141/EC to milk-based drinks for young children, should these be regulated.

This Opinion will also not address the dietary needs of pre-term infants, very low or low birth weight infants or infants and children with particular nutritional requirements.

[13] Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin and amending Council Directive 91/414/EEC. OJ L 70, 16.3.2005, pp. 1–16.

[14] Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs.OJ L 364, 20.12.2006, pp. 5–24.

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2. Definitions

For this Opinion the following definitions apply:

- Infants means children under the age of 12 months (Article 2(2)(a) of Regulation (EU) No 609/2013).

- Young children means children aged between one and three years (36 months) (Article 2(2)(b) of Regulation (EU) No 609/2013).

- Infant formula means food intended for use by infants during the first months of life and satisfying by itself the nutritional requirements of such infants until the introduction of appropriate complementary feeding (Article 2(2)(c) of Regulation (EU) No 609/2013 and Codex Stan 72-1981[15]).

- Follow-on formula means food intended use by infants when appropriate complementary feeding is introduced and which constitutes the principal liquid element in a progressively diversified diet of such infants (Article 2(2)(d) of Regulation (EU) No 609/2013).

In the definition of the Codex Alimentarius (Codex-Stan 156-1987[16]) "follow-up" formula is "a food intended for use as a liquid part of the weaning diet for the infant from the sixth month on and for young children" and "is prepared from the milk of cows or other animals and/or other constituents of animal and/or plant origin, which have been proved to be suitable for infants from the sixth month on and for young children". This definition can theoretically cover other (milk-based) formulae intended for young children.

- **"**Growing-up milk" or "toddlers' milk" are formulae intended specifically for young children. No compositional criteria have been laid down in EU legislation. They may or may not be based on milk. In the latter case they would have to contain other animal or plant protein. The Panel proposes not to use the term "growing-up milk" because this would imply a particular effect on growth. The Panel will also not use the term "toddlers' milk" because it considers that a "young child" is better defined by age. Young-child formula is the term proposed by the Panel for formulae intended for young children. This includes also formulae based on protein sources other than cow's milk. Such formulae could be considered to be included in the scope of Codex Standard on follow-up formula (Codex-Stan 156-1987).

- Complementary feeding, as defined by WHO in 2002, is "the process starting when breast milk alone is no longer sufficient to meet the nutritional requirements of infants" so that "other foods and liquids are needed, along with breast milk" (WHO, 2002). In the Panel's Opinion on the appropriate age for the introduction of complementary food (EFSA NDA Panel, 2009) "complementary feeding" means the period, when complementary foods are given together with either human milk or a breast milk substitute. The Panel notes that this definition differs from the definition of "complementary feeding" provided by WHO.

- Complementary food in this Opinion comprises, therefore, all liquid, semisolid and solid foods other than breast milk and breast milk substitutes that are fed to infants who are being weaned from the breast. Complementary food can be beverages, spoon-fed foods or finger food (EFSA NDA Panel, 2009). The Codex Alimentarius has separate standards for two types of complementary foods, cereal-based foods and baby foods (Codex-Stan 074-1981, Rev.—

[15] Codex-Stan 72-1981 (Codex Alimentarius), 2011. Standard for infant formula and formulas for special medical purposes intended for infants. Adopted 1981, amended 1983, 1985, 1987, revised 2007, amended 2011.

[16] Codex-Stan 156-1987 (Codex Alimentarius), 2011. Codex Standard for follow-up formula. Adopted 1987, amended 1989, 2011.

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1[17]2006; Codex-Stan 73-1981[18]) whereas, in the EU, these two types are regulated in one Directive 2006/125/EC.[19]

3. Methodological considerations

The dietary requirement of a nutrient has been identified as that amount of a nutrient which must be consumed on a regular basis to maintain health in an otherwise healthy individual, on the assumption that the requirements for energy and all other nutrients have already been satisfied. Nutrient requirements can be deduced from physiological needs and metabolic demand and are given either as Average Requirements (ARs) or Adequate Intakes (AIs). Reference Intake ranges for macronutrients (RI) or Population Reference Intakes (PRIs) are the level of (nutrient) intake that is enough for virtually all healthy people in a group. Nutrient requirements and references should be differentiated from recommended intakes because of differences in the methodology for their derivation and their intention. Considering amongst other nutrient goals for a given population, reference values are translated into recommendations for managing nutritional risks (EFSA NDA Panel, 2010g).

In 2005, the European Commission asked EFSA for advice on Dietary Reference Values (DRVs) for macro- and micronutrients. Since then, the Panel has published Opinions on DRVs for water, energy, carbohydrates and dietary fibre, fats, protein, molybdenum, fluoride, vitamin C and manganese (EFSA NDA Panel, 2010f, 2010d, 2010a, 2012a, 2013b, 2013c, 2013d, 2013e, 2013f) and endorsed opinions on DRVs for biotin and pantothenic acid for public consultation (EFSA NDA Panel, 2013g, 2013a).

3.1. Nutrient requirements

Owing to the limited timeframe given to the Panel for this Opinion, the Panel will provide advice on the levels of nutrients which it considers adequate for the majority of healthy, term, normal-weight infants and young children, but will not derive any ARs or AIs. This will be done in the framework of setting DRVs for individual micronutrients.

For this Opinion, the Panel will review reference values set by the SCF (1993b) in the light of more recent recommendations given by other scientific or authoritative bodies, i.e. the French Food Safety Agency (Afssa) and the Health Council of the Netherlands (Gezondheidsraad) as well as the recommendations given by Nordic Council of Ministers, the German-speaking countries (D-A-CH), the US Institute of Medicine (IoM), the National Health and Medical Research Council of the Commonwealth (NHMRC) of Australia and the Ministry of Health of New Zealand and the World Health Organization (WHO), unless the Panel has already given an Opinion or endorsed an Opinion for public consultation on a DRV for a specific nutrient, in which case the advice given previously by the Panel will be taken as the basis of the current Opinion.

Substances, such as inositol or nucleotides, which are added to infant or follow-on formulae and for which no reference values exist from any of these bodies will not be addressed in the present Opinion.

Neither the SCF nor the Panel has set DRVs for infants up to the age of six months as it is considered that exclusive breast-feeding by well-nourished mothers is nutritionally adequate for most healthy infants born at term (at or after 37 completed weeks of gestation) (EFSA NDA Panel, 2009).

The nutrient content of breast milk from healthy, well-nourished unsupplemented mothers could therefore be used as a basis when providing advice on levels of nutrient intakes considered adequate for the majority of infants in the first half-year of life. However, both the volume and nutrient composition of human milk vary widely over the duration of lactation, between and within meals, depending on maternal factors, particularly the diet, as well as sex and size of the infant and the region

[17] Codex-Stan 074-1981, 2006. Codex Standard for processed cereal-based foods for infants and young children. Adopted in 1981, revised 2006.
[18] Codex-Stan 73-1981, 1989. Codex Standard for canned baby foods. Adopted 1981. Amended 1983, 1985, 1987, 1989.
[19] Commission Directive 2006/125/EC of 5 December 2006 on processed cereal-based foods and baby foods for infants and young children (Codified version). OJ L 339, 6.12.2006, pp. 16–35.

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of the world, with the greatest variations reported for fat and fatty acids (Stam et al., 2013). Therefore, intake via breast milk of certain nutrients cannot be considered to be equivalent to the infant's requirement for that nutrient.

The mean human milk intakes of exclusively breast-fed infants in developed countries at the age of one, two, three, four, five and six months were found to be 699, 731, 751, 780, 796 and 854 mL/day respectively (Butte et al., 2002). This means that, after the age of one month, the intake increases only slowly to about 800 mL/day (range 710–936 mL) at six months (Neville et al., 1988). These data were confirmed in trend by a compilation of breast milk intake data derived using isotope tracer methods (dose-to-the-mother-deuterium-method) from 737 infants and young children (mean age 5.2 months, range 0.4–23 months) from 12 countries around the world (Bangladesh, Brazil, Chile, Kenya, Malawi, Mexico, Papua New Guinea, Senegal, Gambia, the USA, the UK, Zambia): the mean ranged from 0.6 kg/day (95 % confidence interval (CI) 0.51–0.7 kg/day) during the first month to 0.82 kg/day (95 % CI 0.74–0.91 kg/day) at three to four months of life, with little decrease until around eight to nine months (da Costa et al., 2010). In a more recent longitudinal study (The First-Feed study), milk intake and energy intake were measured (using the doubly labelled water method) at two time points around 15 and 25 weeks of age in 50 healthy exclusively breast-fed infants in Scotland. Forty-one were exclusively breast-fed to 25 weeks of age. Mean (± SD) milk intake was (923 ± 122 g/day (n = 36) and 999 ± 146 g/day (n = 33) at 15 and 25 weeks of age, respectively (Nielsen et al., 2011).

The Panel considers the average volume of breast milk to be 800 mL/day with an upper bound of 1 200 mL/day, which will be taken as the basis for calculation of nutrient intakes via breast milk.

3.2. Risk of inadequate nutrient intakes

The proportion of the population with an inadequate intake may be estimated using the AR cut-point method, originally proposed by Beaton (1994) and adopted by IoM (2000a). This method requires knowledge of the AR and the distribution of habitual nutrient intakes and has been shown to be effective in obtaining a realistic estimate of the prevalence of dietary inadequacy (Carriquiry, 1999) when the distribution of nutrient intakes is normal and requirements and intakes are independent. The percentage of the population with a habitual daily nutrient intake that is lower than the AR is taken as an estimate of the percentage of the population with probable inadequate intakes.

The prevalence of inadequacy of intake of a nutrient in a population cannot be estimated using as comparator a less precise estimates of recommended intake, such as an AI, because the relationship of such a reference value to the requirement for the nutrient is not known. Groups with mean intakes at or above the AI can be assumed to have a low prevalence of inadequate intakes for the defined criterion of nutritional status (EFSA NDA Panel, 2010g). If, however, intake falls below the AI, no quantitative (or qualitative) estimate can be made of the probability of nutrient inadequacy. Professional judgement, based on additional types of information, need to be exercised when interpreting intakes below the AI (IoM, 2000a).

In the absence of an AI or an AR set by the Panel for a particular nutrient, the Panel will take as a surrogate the AI or AR set by another scientific or authoritative body.

The Panel will also review available evidence with respect to studies in infants and young children living in Europe reporting on status markers of nutrient adequacy in order to complement information provided by nutrient intake studies.

It should be noted that for most nutrients sufficient data to define the risk of inadequate nutrient intakes in infants and young children living in Europe are not available and the Panel's assessment has to be based on the limited data available.

The Panel notes the underlying limitations and uncertainties of this approach considering that information on precise intake distributions is not available to the Panel, that studies reporting on a sufficient number of percentiles to apply the AR cut-point method with sufficient certainty are rare,

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that the ARs which form the basis of this assessment are mainly extrapolated from other population groups rather than having been based on relevant health outcomes in the population of infants and young children and that data on nutrient deficiencies based on the assessment of status markers in infants and young children living in Europe are limited to certain nutrients of high concern, such as vitamin D and iron, and to some countries.

3.3. Compositional information

The information on the composition of young-child formulae currently available on the EU market and used in this Opinion is derived from data provided to EFSA by AINIA (Asociación de Investigación de la Industria Agroalimentaria) following a procurement procedure (AINIA, 2013). In this procurement procedure, compositional data of 244 young-child formulae from 62 food business operators currently available in the market in at least one of 16 EU Member States (Austria (n = 18), Belgium (n = 17), Czech Republic (n = 14), Finland (n = 3), France (n = 34), Germany (n = 25), Greece (n = 11), Hungary (n = 5), Ireland (n = 10), Italy (n = 24), Netherlands (n = 16), Poland (n = 13), Portugal (n = 8), Spain (n = 32), Sweden (n = 2) and United Kingdom (n = 12) were collected. The majority of these formulae (n = 234) was based on cow's milk. Goat milk and soy were the basis of three and seven formulae, respectively. Around half of the formulae were in liquid form (n = 109) and the remaining are marketed in the form of powder to be reconstituted. The content of energy and nutrients reported by AINIA was generally in the range reported by SNE (Specialised Nutrition Europe) and in the review by Crawley and Westland (2013).

The minimum and maximum permitted amounts of nutrients in infant and follow-on formulae were taken from Directive 2006/141/EC.

The compositional information used in this Opinion with respect to cow's milk is based on information collected by EFSA's Data Collection and Monitoring Unit from 14 EU Member States.

An overview of the nutrient composition and energy content of young-child formulae currently on the market, the essential composition of infant and follow-on formulae according to Directive 2006/141/EC and the nutrient composition and energy content of cow's milk is given in Appendix A.

4. Nutrient requirements and recommendations

4.1. Energy

Humans need energy to perform and regulate all biochemical processes that maintain body structures and functions, and to perform physical activities. Energy requirement is the amount of food energy needed to balance energy expenditure in order to maintain body mass, body composition and a level of physical activity consistent with long-term good health. This includes the energy needed for the optimal growth and development of children (FAO/WHO/UNU, 1985; SCF, 1993b; FAO/WHO/UNU, 2004; IoM, 2005a). Whereas DRVs for protein and various micronutrients are given as a set of values including ARs, PRIs and Tolerable Upper Intake Levels (ULs), DRVs for energy are provided as ARs.

<u>0 to < 12 months</u>

The Panel decided to extend the methodology chosen in its previous Opinion for deriving ARs for energy for older infants (EFSA NDA Panel, 2013b) to infants from birth to six months. The Panel had based the ARs for older infants on the equation for TEE established by Butte (2005) derived from data from infants exclusively breast-fed for four months and adding energy requirements for growth based on the values proposed by Butte et al. (2000) and Butte (2005) and using median body masses from the WHO Growth Standard (WHO Multicentre Growth Reference Study Group, 2006). A detailed description of the methodology is found in the Panel's previous Opinion (EFSA NDA Panel, 2013b).

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12 to < 36 months

In its Opinion of 2013, the Panel decided to use the equations of Henry (2005) for the estimation of REE to calculate ARs for energy for children after the age of one year. For the calculations, median body masses and heights from the WHO Growth Standards (WHO Multicentre Growth Reference Study Group, 2006) were used for children aged 12 to 35 months. A single value was chosen for the physical activity level (PAL) of 12- to 35-month-old children; this PAL value was increased by 1 % per year as a way to take into account the energy expenditure required for growth.

Table 1 gives an overview on energy intakes considered adequate for infants and young children from birth to age 36 months.

Table 1: Intakes of energy considered adequate for infants and young children

Age (months)	AR (MJ (kcal)/day)		AR (MJ (kcal)/kg body weight per day)	
	Boys	Girls	Boys	Girls
0 to < 1	1.5 (359)	1.4 (329)	0.45 (109)	0.43 (103)
1 to < 2	2.1 (505)	1.9 (449)	0.47 (112)	0.45 (107)
2 to < 3	2.2 (531)	2.0 (472)	0.40 (95)	0.39 (92)
3 to < 4	2.1 (499)	1.9 (459)	0.33 (78)	0.33 (79)
4 to < 5	2.3 (546)	2.1 (503)	0.33 (78)	0.33 (79)
5 to < 6	2.4 (583)	2.3 (538)	0.33 (78)	0.33 (78)
6 to < 7	2.5 (599)	2.3 (546)	0.32 (76)	0.31 (75)
7 to < 8	2.7 (634)	2.4 (572)	0.32 (76)	0.32 (76)
8 to < 9	2.8 (661)	2.5 (597)	0.32 (77)	0.32 (76)
9 to < 10	2.9 (698)	2.6 (628)	0.32 (77)	0.32 (76)
10 to < 11	3.0 (724)	2.7 (655)	0.33 (79)	0.32 (77)
11 to < 12	3.1 (742)	2.8 (674)	0.33 (79)	0.32 (77)
12 [(a)]	3.3 (777)	3.0 (712)	n.a.	n.a.
24 [(a)]	4.3 (1028)	4.0 (946)	n.a.	n.a.
36 [(a)]	4.9 (1174)	4.6 (1096)	n.a.	n.a.

(a): PAL value 1.4.
n.a., not available.

4.2. Protein

Dietary protein is an essential component of the diet, supplying the body with nitrogen (N) and amino acids as well as other non-protein metabolically active nitrogenous substances. The protein requirement of infants and young children comprises two components, the maintenance requirement and the growth requirement. The protein requirement can be defined as the minimum intake that will lead to a positive nitrogen balance to allow for growth in normally growing subjects who have an appropriate body composition, are in energy balance and are moderately physically active.

Estimating true protein intakes from breast milk is considered difficult because the non-protein nitrogen fraction accounts for about 25 % of total nitrogen; this is made up of urea (up to 50 % of non-protein nitrogen), amino acids and other nitrogenous compounds, and its utilisation is not entirely understood (WHO/FAO/UNU, 2007).

Therefore, in its previous Opinion (EFSA NDA Panel, 2012a) the Panel decided to derive an AR for protein for infants in the second half-year of life and children based on a factorial approach as the sum of the requirement for maintenance and the requirement for growth adjusted for efficiency of dietary protein utilisation.

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0 to < 6 months

Following the approach taken by the Panel in its earlier Opinion (EFSA NDA Panel, 2012a) and in line with FAO/WHO/UNU (1985), the Panel considered the average maintenance requirement for infants in the first half-year of life to be 0.58 g protein/kg body weight per day (93 mg N/kg body weight per day), which was derived from nitrogen balance studies in infants. The additional requirement for growth was estimated from average daily rates of protein deposition adjusted by an efficiency of utilisation of dietary protein for growth of 66 %.

6 to < 36 months

An average maintenance requirement of 0.66 g protein/kg body weight per day (105 mg N/kg body weight per day) was defined for infants and young children aged from 6 to < 36 months by the Panel in its earlier Opinion (EFSA NDA Panel, 2012a), which was derived from nitrogen balance studies in adults. The average protein requirement for growth was estimated from average daily rates of protein deposition, calculated from studies on whole-body potassium deposition, and adjusted by an efficiency of utilisation of dietary protein for growth of 58 %. This constitutes an AR, to which 1.96 standard deviations were added to derive a PRI.

For the present Opinion, the Panel used the 50th percentile of the WHO Growth Standards (WHO Multicentre Growth Reference Study Group, 2006) as reference body weights rather than the reference body weights derived by van Buuren et al. (2012), which were used in the Panel's previous Opinion (EFSA NDA Panel, 2012a). This is in line with more recent Opinions on DRVs of the Panel. Therefore, minor deviations between these values and the PRIs published in the Panel's earlier Opinion may occur. Intakes of protein considered adequate for the majority of infants and young children are given in Table 2.

Table 2: Intakes of protein considered adequate for the majority of infants and young children

Age (months)	PRI (g per kg body weight per day)	Body weight (kg) [(a)]		PRI (g/day)	
		Boys	Girls	Boys	Girls
0 to < 1	–	–	–	–	–
1 to < 2	1.77	4.5	4.2	8	7
2 to < 3	1.50	5.6	5.1	8	8
3 to < 4	1.36	6.4	5.8	9	8
4 to < 5	1.27	7.0	6.4	9	8
5 to < 6	1.21	7.5	6.9	9	8
6 to < 7	1.15	7.9	7.3	9	8
7 to < 8	1.27	8.3	7.6	11	10
8 to < 9	1.23	8.6	7.9	11	10
9 to < 10	1.19	8.9	8.2	11	10
10 to < 11	1.16	9.2	8.5	11	10
11 to < 12	1.14	9.4	8.7	11	10
12	1.14	9.6	8.9	11	10
18	1.03	10.9	10.2	11	11
24	0.97	12.2	11.5	12	11
36	0.90	14.3	13.9	13	13

(a): 50th percentile of WHO Growth Standards.

4.2.1. Protein intake and health consequences

It has been proposed that the difference in growth observed worldwide between formula-fed and breast-fed infants may be related to differences in protein intake, which 15 years ago was estimated to be 55 to 80 % higher in formula-fed infants than in breast-fed infants (Alexy et al., 1999). In addition, it has been suggested that a higher protein intake may contribute to an enhanced insulin secretion and release of insulin-like growth factor (IGF)-1 and IGF-binding protein (IGFBP)-1, which was observed

in prospective feeding studies with infant formulae of different protein content (13, 15 or 18 g protein/L) and a breast-fed control group (Axelsson, 2006).

Small differences in weight-for-length (adjusted *z*-score for weight-for-length: 0.20 (95% CI 0.06 to 0.34; p = 0.005)) at two years of age were observed in one intervention study comparing infants fed formula with lower or higher protein content (Koletzko et al., 2009; Grote et al., 2010). A lower prevalence of obesity at six years of age was reported in a cohort that in infancy had been fed formula with a lower protein content than in the cohort fed formula with a higher protein content (Thorisdottir et al., 2013b). One systematic literature review reported an association between higher protein intake in infancy and early childhood and increased growth and higher body mass index (BMI) in childhood (Hörnell et al., 2013).

Whether such small differences in growth observed in infants fed higher-protein formula persists beyond early childhood and are related to risk of overweight and obesity in later life is the subject of on-going investigations.

4.3. Fat

Fat is an important dense source of energy, it facilitates the absorption of fat-soluble dietary components such as vitamins and supplies essential fatty acids (α-linolenic acid (ALA) and linoleic acid (LA)) to the body. However it is not possible to define a quantitative requirement for total fat (EFSA NDA Panel, 2010f), except for the lower level of essential polyunsaturated fatty acids (PUFAs).

4.3.1. Total fat

<u>0 to < 6 months</u>

Fat intakes that are adequate for infants aged from 0 to < 6 months can be derived from observed fat intakes in fully breast-fed infants. The fat content of human milk as a percentage of the energy content is highly variable and depends on many factors, of which the most important are method of sampling, duration of nursing, maternal diet and the nutritional status and BMI of the mother. The fat content has been observed to vary between the extremes of 0.4 and 9.0 g/100 mL in mature human milk (Stam et al., 2013). A mean value of 3.22 ± 1.00 g/100 mL has been reported in banked donor milk in the USA (Wojcik et al., 2009) and a median concentration of 3.92 g/100 mL (10th and 90th percentile (P) 2.38 and 5.87 g/100 mL, respectively) was found in 661 longitudinally collected samples from 91 healthy term infants in Denmark (Michaelsen et al., 1994). Assuming an energy content of breast milk of 67 kcal/100 mL (Butte et al., 2002) a fat content of 3.9 g/100 mL would correspond to 52 % of the total energy content. This is in line with the Panel's previous Opinion on the DRV for fat and fatty acids, in which the Panel considered the mean observed fat intake of breast-fed infants aged from 0 to < 6 months of age to be 50 to 55 % of total energy (E%) (EFSA NDA Panel, 2010f).

Since measurement of the volume consumed by individual nursing infants is difficult, the Panel related the average total fat content of human milk expressed as E% to the energy needs of infants aged from 0 to < 6 months as outlined in Table 1 to derive estimations of intakes of total fat which it considered adequate for the majority of infants aged from 0 to < 6 months (see Table 3).

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Table 3: Intakes of total fat (g/day) considered adequate for the majority of infants aged from 0 to < 6 months

Age (months)	Boys		Girls	
	AR energy (kcal/day)	Total fat [(a)] (g/day)	AR energy (kcal/day)	Total fat (g/day)
0 to < 1	359	21	329	19
1 to < 2	505	30	449	26
2 to < 3	531	31	472	27
3to < 4	499	29	459	27
4 to < 5	546	32	503	29
5 to < 6	583	34	538	32

(a): Assuming a fat content of the diet corresponding to 52 E% and an energy intake corresponding to the AR of energy.

6 to < 12 months

The average fat intake of European infants in the second half of the first year of life, when infants receive progressively more complementary foods, varied from 26 to 29 E% (P5) to 38 to 46 E% (P90/P97.5)) (EFSA NDA Panel, 2010f). Most of the nutritional authorities recommend fat intakes of between 30 and 40 E% for infants in the second half of the first year of life, although there is evidence that a fat intake as low as 25 E% can be adequate for healthy growth, provided the energy intake and the micronutrient supply are appropriate (EFSA NDA Panel, 2010f).

In its previous Opinion, the Panel concluded that only an RI for total fat intake can be defined based on practical considerations (e.g. current levels of intake, achievable dietary patterns in healthy infants 6 to < 12 month of age) and set the RI at 40 E% (EFSA NDA Panel, 2010f).

12 to < 36 months

Observed average total fat intake of young children in the EU varied between 26 and 36 E% (EFSA NDA Panel, 2010f).

In its previous opinion, the Panel concluded that , an RI of 35 to 40 E% is appropriate for the second and third years of life based on practical considerations (e.g. current levels of intake, achievable dietary patterns in young children) (EFSA NDA Panel, 2010f).

4.3.2. Essential fatty acids and long-chain (LC)-PUFAs

Two PUFAs, LA (C18:2 n-6) and ALA (C18:3 n-3), are essential in human nutrition and must be provided in the diet. One of their main functions is the regulation of cell membrane fluidity and acting as precursors for the LC-PUFAs arachidonic acid (ARA), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) from which eicosanoids and docosanoids can be formed. In particular, DHA is needed for the normal development of the nervous system and the retina and accumulates in fetal brain and retina during pregnancy and in early childhood (Koletzko et al., 2008). Dietary LA and ALA can be converted by elongation of the carbon chain and the introduction of double bonds into LC-PUFAs; however, the rate of conversion of ALA to DHA in humans is low (less than 1 %) (Burdge, 2006).

The Panel decided previously not to set a DRV for n-6 PUFAs or n-3 PUFAs in general, but set an AI for LA of 4 E% and an AI for ALA of 0.5 E% for all age groups based on the lowest estimated mean intakes of LA and ALA, respectively, in different population groups in various European countries, that were not accompanied by LA or ALA deficiency symptoms (EFSA NDA Panel, 2010f). No AI for ARA was set by the Panel. DHA can be considered a conditionally essential fatty acid for infants, and an AI of 100 mg per day was set for 7- to 24-month-old infants and young children in the Panel's previous Opinion (EFSA NDA Panel, 2010f).

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0 < 6 months

Human milk supplies between 10 and 18 % of total fatty acids as *cis* n-6 PUFA depending on the maternal diet, most of which is LA, which can account for as much as 5 to 8 E% in the diet of a breast-fed infant.

In addition to LA, pregnant women provide their unborn child, and lactating women their breast-feeding infant, with ARA. The content of ARA in human milk varies throughout the world (0.31 to 1.00 weight% of total fatty acids (EFSA NDA Panel, 2010f)) but to a lesser extent than DHA. The average ARA content of human milk has been reported to be 0.47 ± 0.13 weight% of total fatty acids (Brenna et al., 2007). An intake of 800 mL human milk with an assumed fat content of 3.9 g/100 mL, corresponding to a fat intake of 31 g per day and containing about 29.5 g fatty acids, would provide 139 mg of ARA per day assuming an average ARA content of 0.47 weight% (or between 91 and 295 mg of ARA based on the extremes of observed ARA content in breast milk of 0.31–1.00 weight%) (Stam et al., 2013)).

Human milk supplies, on average, 0.5 to 1.0 % of total fatty acids as *cis* n-3 PUFAs. The ALA content of human milk varies between 0.6 and 1.6 % of total fatty acids or between 0.3 and 0.85 E% (IoM, 2005a). DHA is the most important n-3 LC-PUFA in human milk. Depending on the region of the world and habitual dietary habits, DHA contents varying from 0.15 to 1.4 weight% of total fatty acids have been observed (Brenna et al., 2007; Stam et al., 2013). Breast-fed infants accumulate more DHA in brain than infants fed formula containing ALA only and no DHA (Farquharson et al., 1992; Makrides et al., 1994; Cunnane et al., 2000). An intake of 800 mL human milk with an assumed fat content of 3.9 g/100 mL, corresponding to a fat intake of 31 g per day containing about 29.5 g fatty acids would provide 94 mg of DHA per day assuming an average DHA content of 0.32 weight% (Brenna et al., 2007) (or between 44 to 413 mg of DHA based on the extremes of observed DHA content in breast milk of 0.15 and 1.4 weight% (Stam et al., 2013)).

The levels of ARA and DHA in breast milk are mainly derived from maternal stores. They are, moreover, influenced by the maternal diet, in particular by its fatty acid composition and its content of *trans* fatty acids, and by smoking (negative for DHA) (Stam et al., 2013), but they are also under the influence of common polymorphisms (single-nucleotide polymorphisms, SNPs) in the fatty acid desaturase (FADS) gene cluster that codes for the delta-5-desaturase and the delta-6-desaturase, considered to be rate-limiting in the formation of LC-PUFAs from LA and ALA, respectively. Several minor alleles in the FADS cluster appear to determine (mostly negatively) the concentrations of ARA and DHA in human milk but may also affect the consequences of different feeding patterns on the development of infants (Glaser et al., 2011; Lattka et al., 2012).

Taking into account the Panel's previous advice on AIs for LA, ALA and DHA and observed average intakes from breast milk of these fatty acids and ARA, the Panel considers that intakes of total fat, essential fatty acids and n-3 PUFAs as depicted in Table 4 are adequate for the majority of infants aged from 0 to < 6 months.

6 to < 36 months

LA intake in breast-fed infants decreases to 3 to 6 E% after starting complementary feeding. No signs of LA deficiency have been observed at LA intakes above 1 E% in infants (EFSA NDA Panel, 2010f).

Mean intakes of ALA during the second half of the first year of life in EU countries were reported in two studies from Finland and France to be around 0.5 E% (Lagström et al., 1997; Fantino and Gourmet, 2008).

The AIs for LA and ALA of 4 E% and 0.5 E%, respectively, derived previously by the Panel were based on lowest estimated mean intakes of various population groups from a number of European countries where overt deficiency of these fatty acids is not present.

The AI of 100 mg DHA per day for infants older than six months of age and young children below the age of 24 months derived previously by the Panel was based on intervention studies with DHA-enriched formula or complementary foods from age 1.5 to 12 months in formerly and continuing breast-fed infants and which was found to be effective for visual function (Birch et al., 2002; Hoffman et al., 2003; Hoffman et al., 2004).

Intake data on different types of fatty acids for the age group 12 to < 36 months are scarce in the EU. The observed average intake of PUFAs is between 3.8 and 5 E%. The mean intake of LA was in one country 4 E% (P5–P95: 3.2 to 4.7 E%), whilst the intake of ALA was around 0.7 to 0.9 g per day (0.5 E%) and that of DHA 0.04 per day (0.03 E%) (EFSA NDA Panel, 2010f).

For the age period 2 to 18 years, the Panel proposed no AI for DHA. However, the Panel considered that dietary advice for children should be consistent with advice for the adult population, for which an AI of 250 mg per day of DHA and EPA combined has been derived (EFSA NDA Panel, 2010f).

The Panel considers that intakes of total fat, essential fatty acids and n-3 PUFA as depicted in Table 4 are adequate for the majority of infants and young children from 0 to < 36 months.

Table 4: Intakes of fat, essential fatty acids and LC-PUFAs considered adequate for the majority of infants and young children

Age (months)	Total fat (E%)	LA (E%)	ALA (E%)	DHA (mg/day)	DHA + EPA (mg/day)	ARA (mg/day)
0 to < 6	50–55	4	0.5	100	–	140
6 to < 12	40	4	0.5	100	–	–
12 to < 24	35–40	4	0.5	100	–	–
24 to < 36	35–40	4	0.5	–	250	–

4.4. Glycaemic carbohydrates

Glycaemic carbohydrates provide carbohydrates to body cells, mainly in the form of glucose. The main glycaemic carbohydrates are glucose and fructose (monosaccharides), sucrose and lactose (disaccharides), malto-oligosaccharides and starch (polysaccharide).

The first source of glycaemic carbohydrates in infants is human milk, in which lactose, a disaccharide of glucose and galactose, is the primary sugar. Lactose occurs exclusively in milk and milk products. Human milk has the highest lactose content of all milks, 7 g per 100 g, while the lactose content in cow's milk is around 5 g per 100 g.

With the introduction of solids, virtually all types of carbohydrates may be introduced into the infant's diet, mainly through fruits and vegetables.

Even if nutritionally not essential, the avoidance as far as possible of galactose, including human milk, is indicated only in all types of galactosaemia, a rare metabolic disorder with an incidence of about 1 in 60 000 births in Europe caused by three different genetic enzyme defects in the metabolism of galactose (EFSA NDA Panel, 2010c).

<u>0 to < 6 months</u>

In its previous Opinion (EFSA NDA Panel, 2010d), the Panel did not set any DRVs for carbohydrates for infants. Given an energy content of 272 to 280 kJ/100 mL (65 to 67/100 mL) of human milk, an RI of around 40 to 45 % E% as carbohydrates can be derived and considered adequate for the majority of infants in the first six months of life (Jensen, 1995).

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6 to < 12 months

Assuming fat intake as 40 E% in this period, and protein intakes ranging between 5 E% (EFSA NDA Panel, 2010f, 2012a, 2013b) and 15 E% as the maximum acceptable limit (Agostoni et al., 2005), an intake of carbohydrates between 45 E% and 55 E% can be considered adequate for the majority of infants in the second half of the first year of life.

12 to < 36 months

In its previous Opinion (EFSA NDA Panel, 2010d), the Panel based the RI for carbohydrates of 45 to 60 E% for adults on the effect of carbohydrates (and fat) intakes on body weight and blood lipids, while taking into account practical considerations (e.g. current levels of intake, achievable dietary patterns). The Panel proposed that this RI apply also to children aged one year and above.

Table 5 gives an overview on the intakes of glycaemic carbohydrates which are considered adequate for the majority of infants and young children.

4.5. Dietary fibre

The components included in dietary fibre are by definition resistant to hydrolysis and absorption in the small intestine. They pass through the upper gastrointestinal tract and enter the colon substantially unmodified. Inhibitory effects on mineral absorption, i.e. of iron, zinc and calcium, have been attributed to fibre-associated complexing compounds, notably phytic acid in cereals and leguminous seeds (EFSA NDA Panel, 2010d).

Human milk provides oligosaccharides in variable amounts (10 to 20 g/L). Oligosaccharides are highly diverse glycans, comprising about 200 molecular species which differ in size, charge, sequence and abundance. Approximately 75 to 85 % are neutral and 15 to 25 % are acidic. The major part of human milk oligosaccharides is minimally hydrolysed by human enzymes and reaches the large intestine, constituting the main substrate for the gut microbiota and, particularly, for bifidobacteria. The fermentation of non-digestible oligosaccharides leads to the generation of organic acids (lactic acid) and short-chain fatty acids (SCFAs) such as acetic, propionic and butyric acid. While butyrate is a main source of energy for the colonic mucosa and has effects on cell differentiation, acetate and propionate are absorbed from the colon and thus provide energy to the host (Aggett et al., 2003). The absorption of fermentation products, i.e. SCFAs, means that they may contribute to the energy content of the diet, but less than glycaemic carbohydrates (around 8 kJ or 2 kcal per g) (EFSA NDA Panel, 2010d).

Oligosaccharides (e.g. galacto-oligosaccharides (GOS), inulin-type fructans or their combination or with mixtures of polydextrose (PDX) and acidic-oligosaccharides (AOS)) have been produced to be added to infant and follow-on formulae and have been studied for number of health outcomes, such as bowel function (Knol et al., 2005; Scholtens et al., 2006; Rao et al., 2009; Ashley et al., 2012), gastrointestinal and respiratory tract infections (Duggan et al., 2003; Brunser et al., 2006; EFSA NDA Panel, 2010e), atopic dermatitis, eczema, urticaria and asthma (Osborn and Sinn, 2007; EFSA NDA Panel, 2010e).

They have also been studied in relation to any potential untowards effects, such as delayed growth, diarrhoea and an increased risk of inadequate water balance (SCF, 2003c; Ben et al., 2004; Decsi et al., 2005; Fanaro et al., 2005; Bettler and Euler, 2006; Moro et al., 2006; Ziegler et al., 2007; Costalos et al., 2008; Rao et al., 2009; Piemontese et al., 2011; Ashley et al., 2012).

On the basis of the data available, the Panel considers that there is insufficient evidence for any beneficial or adverse effects on infant health of non-digestible oligosaccharides added to infant and follow-on formulae.

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0 to < 12 months

Fibre intakes are not considered in recommendations up to one year of life, even if non-digestible oligosaccharides with human milk and some fibres with vegetables and fruits have already been introduced in the diet of infants. Therefore, the Panel did not quantify adequate fibre intakes in the first year of life.

12 to < 36 months

In its previous Opinion (EFSA NDA Panel, 2010d), the Panel considered the role of dietary fibre in bowel function as the most suitable criterion for establishing an AI. A fibre intake of 2 g per MJ was considered adequate for normal laxation in children aged from the age of one year. Therefore, the Panel proposed an AI of 10 g/day for children aged 12 to 48 months.

Results from the Finnish STRIP (Special Turku Coronary Risk Factor Intervention Project) study indicate that a fibre intake corresponding to 2 to 2.5 g per MJ is compatible with normal growth and development (from 6.7 g per day at 8 months to 9 g per day at 13 months) (Lapinleimu et al., 1995). Children from 13 months of age with low sucrose intake or with high dietary fibre intake consumed foods that were more nutrient dense and had better dietary quality than children with high or average sucrose or fibre consumption (Niinikoski and Ruottinen, 2012).

Table 5 gives an overview of the intakes of dietary fibre which are considered adequate for the majority of young children.

Table 5: Intakes of carbohydrates and dietary fibre considered adequate for the majority of infants and young children

Age (months)	Total carbohydrates	Fibre
0 to < 6	40–45 E%	–
6 to < 12	45–55 E% [(a)]	–
12 to <36	45–60 E%	10 g/day

(a): With fat 40 E%.

4.6. Water

Water is involved in practically all functions of the human body and is its main constituent (up to 75 % of total body weight in newborns, around 60 % in infants in the second half of the first year of life and young children (Fomon et al., 1982; Butte et al., 2000; Fomon and Nelson, 2002)). Total body water, hydration of the intracellular and extracellular compartment and the balance between in- and output of water are homeostatically controlled, predominantly by mechanisms which modify excretion and, less importantly, by stimulation of intake.

Total dietary water intake comprises the water content of foods and of beverages, including drinking water (both tap and bottled water). Water produced through oxidation of food in the body (theoretically 0.41 mL per gram protein oxidised plus 0.6 mL per gram carbohydrate oxidised plus 1.07 mL per gram fat oxidised (Lusk, 1928)) is not included.

0 to < 6 months

Exclusively breast-fed infants do not need additional water; therefore, milk volumes consumed can be considered as the basis to estimate adequate water intakes when corrected for the water content of human milk (87 %) during the first six months of life (EFSA NDA Panel, 2010a).

In its previous Opinion (EFSA NDA Panel, 2010a), the Panel derived an AI for total dietary water of 100 to 190 mL per kg body weight per day based on an average daily volume of milk of 800 mL,

equivalent to 696 mL of water and an upper bound of human milk intake of 1 200 mL per day, corresponding to 1 044 mL of water.

The Panel considers an average volume of total dietary water of 700 to 1 000 mL per day to be adequate for the majority of infants from 0 to < 6 months.

6 to < 12 months

For the second half of the first year of life, the Panel based the AI set in its previous Opinion (EFSA NDA Panel, 2010a) on estimates of total dietary water intake from both human milk (or breast milk substitutes) and complementary food and beverages, although reported values from EU countries are few and differ in assessment methodology. Median total daily water intakes in healthy male infants at the age of 9 and 12 months were 834 mL (P90: 1 070 mL) and 907 mL (P90: 1 063 mL) or 93 and 87 mL per kg body weight per day. For female infants, total daily water intake at 9 and 12 months of age was 839 mL (P90: 1 114 mL) and 780 mL (P90: 1 085 mL) or 99 and 88 mL per kg body weight per day, respectively (Alexy and Kersting, 1999).

This led to an AI of 800 to 1 000 mL for total dietary water per day which the Panel considers adequate for the majority of infants in the second half of the first year of life.

12 to < 36 months

In the Panel's previous Opinion (EFSA NDA Panel, 2010a), an AI of 1 300 mL of total dietary water per day for the age group two to three years was derived based on observed mean intakes, which ranged from 1 100 to 1 200 mL per day, and correcting for a desirable water–energy relationship and for inter-individual variation. The AI of 1 100 to 1 200 mL of total dietary water for children aged one to two years was set by interpolation.

The Panel considers an average volume of total dietary water of 1 100 to 1 300 mL per day to be adequate for the majority of young children aged from 12 to < 36 months.

4.7. Calcium

Calcium is an integral component of the skeleton; approximately 99 % of total body calcium is found in bones and teeth, where it is mainly present as calcium hydroxyapatite. It has a structural role, and is needed for bone rigidity, strength and elasticity (Bonewald, 2011). If the dietary supply of calcium is insufficient to meet physiological requirements, calcium is resorbed from the skeleton so as to maintain blood concentrations within the range required for normal cellular and tissue functions. This leads to skeletal disorders (Abrams, 2010).

No UL for calcium was set for infants and young children owing to insufficient data. A UL for adults has been set at 2 500 mg per day (EFSA NDA Panel, 2012b).

0 to < 6 months

Calcium in breast milk was found to be in the range of 200 to 300 mg/L (Rodriguez Rodriguez et al., 2002; Hicks et al., 2012; Olausson et al., 2012).

The Panel considers that observed mean calcium intakes from breast milk of 200 mg per day (i.e. 250 mg/L × 0.8 L) are adequate for the majority of infants in the first half-year of life.

6 to < 12 months

The SCF (1993b) set an AI of 400 mg calcium per day for infants aged 6 to < 12 months; in the absence of reliable information, the same value was taken as the value for young children aged 12 to < 36 months.

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This value is consistent with more recent reference values from other scientific or authoritative bodies, which range from 260 to 540 mg per day (i.e. 260 mg (IoM, 1997), 270 mg (NHMRC, 2006), 330 mg (D-A-CH, 2013), 400 mg (WHO/FAO, 2004), 450 mg (Gezondheidsraad, 2000), 500 mg (Afssa, 2001), 540 mg (Nordic Council of Ministers, 2013) per day). These DRVs were derived by extrapolation from observed mean intakes from breast milk in younger infants and/or by a factorial approach.

Taking the AI of the SCF (1993b) as a basis, the Panel considers that a calcium intake of 400 mg per day is adequate for the majority of infants aged from 6 to < 12 months.

12 to < 36 months

The SCF (1993b) set a PRI of 400 mg calcium per day for young children, which was based on a factorial approach.

More recent reference values from other scientific or authoritative bodies range from 500 to 700 mg (i.e. 500 mg (Gezondheidsraad, 2000; Afssa, 2001; WHO/FAO, 2004; NHMRC, 2006), 600 mg (D-A-CH, 2013; Nordic Council of Ministers, 2013), 700 mg (IoM, 1997)). These PRIs were generally derived by a factorial approach.

The factorial approach taken by D-A-CH (2013) was based on the calcium intake needed to supply for a calcium retention of 142 mg per day with urinary losses of 37 mg per day, faecal losses of 37 mg per day, i.e. 216 mg per day (Lynch et al., 2007), and assuming an absorption efficiency of 45.6 %.

Taking the PRI of D-A-CH (2013) as a basis, the Panel considers that a calcium intake of 600 mg per day is adequate for the majority of young children.

4.8. Phosphorus

Although phosphorus in the form of phosphate ions is essential for numerous body functions, its metabolism is intricately linked to that of calcium because of the actions of calcium-regulating hormones. Adequate phosphorus and calcium intakes are needed not only for skeletal growth and maintenance, but also for many cellular roles, such as energy production (i.e. adenosine triphosphate (ATP)). Too much phosphorus, in relation to too little dietary calcium, may contribute to bone loss, and too little phosphorus along with too little dietary calcium may not adequately maintain bone mass (Anderson, 2005).

Net phosphorus absorption is a linear function of phosphorus intake. For infants, absorption is highest from human milk (about 90 %), followed by cow's milk and protein hydrolysates (about 70 %) and soy formulae (about 60 %).

No UL for phosphorus has been established due to insufficient data (EFSA, 2004a).

While adults can tolerate varying Ca/P ratios in their diet, infants are more prone to disturbances in their calcium metabolism. A Ca/P molar ratio of 0.9 to 1.7 is usually considered safe (SCF, 1993b).

0 to < 6 months

The average concentration of phosphorus in breast milk in 10 studies reviewed by Atkinson et al. (1995) was reported to be 120 mg/L.

The Panel considers that observed mean intakes of phosphorus from breast milk of 100 mg per day (i.e. 120 mg/L × 0.8 L) are adequate for the majority of infants for the first half-year of life.

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6 to < 12 months

The SCF (1993b) concluded on a PRI of 300 mg phosphorus per day for infants in the second half of the first year of life based on an equimolar relationship between calcium and phosphorus.

This value is in line with more recent reference values from other scientific or authoritative authorities that are in the range of 275 to 420 mg per day (i.e. 275 mg (IoM, 1997; Afssa, 2001; NHMRC, 2006), 300 mg (D-A-CH, 2013) and 420 mg (Nordic Council of Ministers, 2013) per day). These were mainly based on observed mean intakes from breast milk and complementary foods.

Taking the PRI of the SCF (1993b) as a basis, the Panel considers that a phosphorus intake of 300 mg per day is adequate for the majority of infants aged from 6 to < 12 months.

12 to < 36 months

The SCF (1993b) concluded on a PRI of 300 mg phosphorus per day for young children based on an equimolar relationship between calcium and phosphorus.

More recent reference values from other scientific or authoritative authorities are in the range of 360 to 500 mg per day (i.e. 360 mg (Afssa, 2001), 460 mg (IoM, 1997; NHMRC, 2006), based on factorial approaches, 470 mg (Nordic Council of Ministers, 2013), based on an equimolar basis to calcium requirements, and 500 mg (D-A-CH, 2013) per day).

The Panel decided not to use the PRI set by the SCF (1993b). The PRI established by IoM (1997) was based on an estimation of body accretion of phosphorus assuming an efficiency of phosphorus absorption of 70 %.

Taking the PRI of the IoM (1998) as a basis, the Panel considers that a phosphorus intake of 460 mg per day is adequate for the majority of young children.

4.9. Magnesium

Magnesium is the second most abundant intracellular cation after sodium and is a critical cofactor in several enzymatic reactions. Severe magnesium deficiency is very rare and causes neuromuscular manifestations (Feillet-Coudray and Rayssiguier, 2005).

No UL for magnesium normally present in foods could be established by the SCF. A UL related to readily dissociable forms of magnesium was set at 250 mg per day for children aged from four years upwards and adults (SCF, 2001b).

0 to < 6 months

Reported concentrations of magnesium in breast milk vary over a wide range (15 to 64 mg/L), with a median value of 31 mg/L and 75 % of reported mean concentrations below 35 mg/L (Dorea, 2000).

The Panel considers that observed mean intakes of magnesium from breast milk of 25 mg per day (i.e. 31 mg/L × 0.8 L) are adequate for the majority of infants for the first half-year of life.

6 to < 12 months

No DRV was set by the SCF (1993b) for infants in the second half of the first year of life, but a guidance value of 80 mg magnesium per day was given.

This value is in line with more recent reference values from other scientific or authoritative bodies, which are in the range between 54 and 80 mg per day (i.e. 54 mg (WHO/FAO, 2004), 60 mg (D-A-CH, 2013), 75 mg (IoM, 1997; NHMRC, 2006) and 80 mg (Nordic Council of Ministers, 2013) per day).

Taking the guidance value of the SCF (1993b) as a basis, the Panel considers that a magnesium intake of 80 mg per day is adequate for the majority of infants aged from 6 to < 12 months.

12 to < 36 months

The SCF (1993b) derived a guidance value of 85 mg magnesium per day for young children.

This value is consistent with more recent reference values from other scientific or authoritative bodies, which are in the range of 60 to 120 mg per day (i.e. 60 mg (WHO/FAO, 2004), 80 mg (IoM, 1997; Afssa, 2001; NHMRC, 2006; D-A-CH, 2013) and 85–120 mg (Nordic Council of Ministers, 2013) per day).

Taking the guidance value of the SCF (1993b) as a basis, the Panel considers that a magnesium intake of 85 mg per day is adequate for the majority of young children.

4.10. Sodium, chloride and potassium

Cell membrane potentials in cells throughout the body are controlled by the concentrations of sodium and potassium. Their concentration gradients are tightly regulated as they provide the potential for neural transmission, muscle contraction and vascular tone as well as the drive for active transport of nutrients (e.g. glucose). Potassium is the major intracellular and sodium the major extracellular cation in the body. Chloride is the most abundant anion in the extracellular fluid and counterbalances the intracellular negative charges provided by proteins. Chloride also plays a major role as a constituent of hydrochloric acid excreted in the gastric juice.

Sodium, chloride and potassium deficiency arising from inadequate dietary intakes are unlikely because of the ubiquity of these elements (SCF, 1993b).

Published reference values generally agree that the basal losses of these ions in children have not been well defined and that there is a lack of evidence to set specific DRVs for these minerals in young children (DoH, 1991; SCF, 1993b; NHMRC, 2006). No ULs for sodium, potassium and chloride were derived by the Panel owing to insufficient data (EFSA, 2005a, 2005d, 2005c). The major adverse effect of increased sodium chloride intake is elevated blood pressure, a risk factor for cardiovascular and renal diseases, and high levels of blood potassium may affect cardiac function. In addition, it has been suggested that taste preferences later in life are influenced by salt intakes in early life (Stein et al., 2012).

4.10.1. Sodium

0 to < 6 months

The average content of sodium in human milk is reported to be in the range of 6-7 mM (0.14-0.16 g/L) (IoM, 2005b).

The Panel considers that observed mean sodium intakes from breast milk of 120 mg per day (i.e. 150 mg/L × 0.8 L) are adequate for the majority of infants in the first half-year of life.

6 to < 12 months

No DRVs for sodium have been set by the SCF (1993b) for infants in the second half of the first year of life.

More recent reference values for sodium intakes for infants aged from 6 to < 12 months from other scientific or authoritative bodies range from 170 to 370 mg per day (i.e. 170 mg (NHMRC, 2006), 180 mg (D-A-CH, 2013) and 370 mg (IoM, 2005b) per day). These were derived from observed mean intakes from human milk and complementary foods (IoM, 2005b), by extrapolation from younger

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infants (NHMRC, 2006) and by a factorial approach based on growth-related increments in intra- and extracellular fluid plus allowances for renal and extrarenal losses (D-A-CH, 2013).

Taking into account the uncertainties underlying the derivation of reference values for sodium, the Panel considers that a sodium intake in the range of 170 to 370 mg per day is adequate for the majority of infants aged from 6 to < 12 months.

12 to < 36 months

No DRVs for sodium have been set by the SCF (1993b) for young children either

More recent reference values for sodium intakes for infants from 12 to < 36 months from other scientific or authoritative bodies range from 200 to 1 000 mg (i.e. 200-400 mg (NHMRC, 2006), 300 mg (D-A-CH, 2013), 1 000 mg (IoM, 2005b)). These AIs were mainly extrapolated (based on relative energy intake) from the AI of adults.

The Panel decided to carry forward the value set for infants in the second half of the first year of life, and considers that a sodium intake of 170 to 370 mg sodium per day is adequate for the majority of young children.

4.10.2. Chloride

0 to < 6 months

The average chloride content of breast milk has been reported to be 11 mM (0.4 g/L) (IoM, 2005b).

The Panel considers that observed mean chloride intakes from breast milk of 300 mg per day (i.e. 0.4 g/L × 0.8 L) are adequate for the majority of infants in the first half-year of life.

6 to < 12 months

No DRVs for chloride have been set by the SCF (1993b) for infants in the second half-year of life.

More recent reference values from other scientific or authoritative bodies amount to 270 mg (D-A-CH, 2013) and 570 mg (IoM, 2005b) per day, which were derived from requirements for sodium using a molar ratio of 1.

Following the same approach as for sodium, the Panel considers that a chloride intake of 270 to 570 mg per day is adequate for the majority of infants aged from 6 to < 12 months.

12 to < 36 months

No DRVs for chloride have been set by the SCF (1993b) for young children either.

More recent reference values from other scientific or authoritative bodies amount to 450 mg (D-A-CH, 2013) and 1.5 g (IoM, 2005b) per day. These were derived from requirements for sodium using a molar ratio of 1 (D-A-CH, 2013) and by extrapolation from the adult AI (IoM, 2005b).

As for sodium, the Panel decided to carry forward the value set for infants in the second half of the first year of life, and considers that a chloride intake of 270 to 570 mg per day is adequate for the majority of young children.

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4.10.3. Potassium

0 to < 6 months

The average content of potassium in human milk is reported to be around 0.5 g/L (IoM, 2005b).

The Panel considers that observed mean potassium intakes from breast milk of 400 mg per day (i.e. 0.5 g/L × 0.8 L) are adequate for the majority of infants in the first half-year of life.

6 to < 12 months

The SCF (1993b) derived a PRI for potassium of 800 mg per day for infants aged from 6 to < 12 months, which was based on a factorial approach.

This is consistent with more recent reference values from other scientific or authoritative bodies that range from 650 to 1 100 mg per day (i.e. 650 mg (D-A-CH, 2013), 700 mg (IoM, 2005b; NHMRC, 2006) and 1 100 mg (Nordic Council of Ministers, 2013) per day).

Taking the PRI of the SCF (1993b) as a basis, the Panel considers that a potassium intake of 800 mg per day is adequate for the majority of infants aged from 6 to < 12 months.

12 to < 36 months

A PRI of 800 mg per day was set by the SCF (1993b) also for children aged from 12 to < 36 months based on a factorial approach.

More recent reference values from other scientific or authoritative bodies range from 1 to 3 g per day (i.e. 1 g (D-A-CH, 2013), 1.4 g (Nordic Council of Ministers, 2013), 2 g (NHMRC, 2006) and 3 g (IoM, 2005b) per day).

Even though the PRI derived by the SCF is at the lower end of these reference values, the Panel decided to use it and considers that a potassium intake of 800 mg per day is adequate for the majority of young children.

4.11. Iron

Iron is an essential trace element that has important metabolic functions, including oxygen transport, and is involved in many redox reactions. Insufficient intake results in the deficiency condition anaemia, impaired psychomotor development and cognitive performance and reduced immune function (EFSA, 2004a).

Absorption of iron from breast milk is somewhat higher than absorption from infant formula and iron-fortified complementary foods (Domellöf, 2007; Nordic Council of Ministers, 2013). It has been shown that infants have the ability to up-regulate iron absorption when iron stores decrease (Domellöf et al., 2002a; Hicks et al., 2006). This ability of each individual to adapt iron absorption to iron status is likely to make infants more resistant to iron deficiency than the factorial approach would predict.

No UL for iron from all sources has been set by the Panel owing to insufficient data (EFSA, 2004a).

0 to < 6 months

The average iron concentration in breast milk is low and considered to be around 0.35 mg/L (IoM, 2001).

Dietary iron requirements in infants are considered to be negligible in the first four to six months of life (SCF, 1993b). The newborn healthy infant has an iron content of about 250 to 300 mg (75 mg per kg body weight). This iron will cover the needs of the infant during the first four to six months of

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life, and this explains why iron requirements during this period can be provided by human milk (WHO/FAO, 2004).

The Panel considers that observed mean iron intakes from breast milk of 0.3 mg per day (i.e. 0.35 mg/L × 0.8 L) are generally sufficient to ensure that iron status in the first half year of life remains within the normal range for most healthy term infants in industrialised countries (Jonsdottir et al., 2012). It should, however, be noted that for formula-fed infants and some breast-fed infants after 4 to 6 months of age an intake equivalent to this value is not sufficient to maintain iron status within the normal range.

6 to < 12 months.

The SCF (1993b) derived a PRI for iron for infants from 6 to < 12 months of 6.2 mg per day when assuming an absorption efficiency of 15 % and of 9 mg per day when a 10 % absorption efficiency was assumed. This PRI was based on the factorial approach.

Although this value is in line with more recent reference values from other scientific or authoritative bodies, which range from 6 to 11 mg per day (i.e. 6 mg (WHO/FAO, 2004), 7 mg (Afssa, 2001), 8 mg (D-A-CH, 2013; Nordic Council of Ministers, 2013) and 11 mg (IoM, 2001; NHMRC, 2006) per day), the Panel decided not to use the PRI of the SCF (1993b), as it considered basic iron requirements of infants in the second half-year of life to be similar to those of young children whereas the PRIs of the SCF (1993b) differed for these two age groups.

The Panel proposes to take the reference values of the Nordic Council of Ministers (2013) and the D-A-CH (2013) as a basis. These were based on observed iron intakes of infants at the end of the first year of life who did not develop iron deficiency (Nordic Council of Ministers, 2013) and on a factorial approach (D-A-CH, 2013).

Taking the AI of Nordic Council of Ministers (2013) and the PRI of D-A-CH (2013) as a basis, the Panel considers that an iron intake of 8 mg per day is adequate for the majority of infants from 6 to < 12 months.

12 to < 36 months

The SCF (1993b) set a PRI for iron for young children of 3.9 mg per day based on the factorial approach.

More recent reference values from other scientific or authoritative bodies range from 3.9 to 9 mg per day (i.e. 3.9 mg (WHO/FAO, 2004), 7 mg (Afssa, 2001; IoM, 2001), 8 mg (D-A-CH, 2013; Nordic Council of Ministers, 2013) and 9 mg (NHMRC, 2006) per day).

As for infants in the second half of the first year of life, the Panel took the AI of Nordic Council of Ministers (2013) and the PRI of D-A-CH (2013) as a basis and considers that an iron intake of 8 mg per day is adequate for the majority of children aged from 12 to < 36 months.

4.12. Zinc

Zinc is involved in many aspects of cell metabolism, with several enzymes depending on zinc for catalytic activity. It plays a role in immune function, protein synthesis, wound healing, deoxyribonucleic acid (DNA) synthesis and cell division (IoM, 2001). Because of the involvement of zinc in many core areas of metabolism, the features of zinc deficiency are frequently quite unspecific and include impaired growth velocity as one of the primary clinical signs of mild zinc deficiency (IoM, 2001).

A UL for zinc of 7 mg per day for one to three-year-old children was derived by the SCF (2002a).

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0 to < 6 months

Zinc concentrations in human milk sharply decline over the early months post partum and cannot be influenced by maternal intakes. The average content of human milk is approximately 4 mg/L at two weeks, 3 mg/L at one month, 2 mg/L at two months, 1.5 mg/L at three months and 1.2 mg/L at six months post partum (Krebs et al., 1995).

For the first four to six months of life, breast milk provides sufficient zinc for infants (Prasad, 2003). No report exists describing zinc deficiency in full-term breast-fed infants up to six months of age.

In the early months of life, daily zinc intakes from breast milk amount to around 2 mg (i.e. 2.5 mg/L × 0.8 L/day) and the Panel considers these intakes to be adequate for the majority of healthy term breast-fed infants up to six months of life.

Evidence supports the concept that zinc in formula can be up to four times less available than from human milk (Casey et al., 1981; Han et al., 2011). Zinc absorption from soy-based formula is lower than from cow's milk-based formula because of its high phytate content (Lönnerdal et al., 1984). Infant formulae are usually fortified with zinc to levels higher than in human milk (0.5-1.5 mg/100 kcal[20]) to compensate for lower absorption. This leads to daily zinc intakes of around 3 to 5 mg. Such levels of intake were not found to be associated with zinc deficiency in a study in Korean infants who received daily around 4 to 4.5 mg zinc from cow's milk-based formulae or around 5.5 to 7 mg zinc from soy-based formulae (Han et al., 2011).

6 to < 12 months

Breast milk does not provide sufficient amounts of zinc for infants older than six months (Prasad, 2003). In addition to breast milk, age-appropriate foods should be consumed in order to meet requirements (Krebs et al., 2012).

For infants in the second half of the first year of life, the SCF (1993b) had derived a PRI of 4 mg zinc per day following a factorial approach. The absorption rate was taken as 30 %.

This is consistent with the approach taken by WHO/FAO (2004) and in line with more recent reference values of other scientific or authoritative bodies, which range from 2 mg (D-A-CH, 2013) through 3 mg (IoM, 2001; NHMRC, 2006) to 5 mg (Afssa, 2001; Nordic Council of Ministers, 2013) per day.

Taking the PRI of the SCF (1993b) as a basis, the Panel considers that a zinc intake of 4 mg per day is adequate for the majority of infants from 6 to < 12 months.

12 to < 36 months

For young children, the SCF (1993b) used a similar approach to the one for infants, but interpolated values for basal losses between the ones for adults and infants and derived a PRI of 4 mg zinc per day.

This is in line with more recent reference values of other scientific or authoritative bodies which are in the range of 2.4 to 8.3 mg per day (i.e. 2.4–8.3 mg (WHO/FAO, 2004), 3 mg (IoM, 2001; NHMRC, 2006; D-A-CH, 2013), 5–6 mg (Nordic Council of Ministers, 2013) and 6 mg (Afssa, 2001) per day).

Taking the PRI of the SCF (1993b) as a basis, the Panel considers that a zinc intake of 4 mg per day is adequate for the majority of young children.

[20] Commission Directive 2006/141/EC of 22 December 2006 on infant formulae and follow-on formulae and amending Directive 1999/21/EC, OJ L 401, 30.12.2006, p. 1

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4.13. Copper

Copper is an essential nutrient and an indispensable cofactor of many proteins including important enzymes involved in oxidative reactions, in the production of collagen and of pigment, in iron metabolism and in the function of heart, brain and the immune system. Copper absorption in the gut decreases with increasing intake and varies between 35 and 70 %. Copper deficiency is rare in humans and occurs predominantly in premature and small-for-gestational-age infants fed cow's milk formulae, patients with malnutrition, patients receiving total parenteral nutrition devoid of copper or subjects consuming high-zinc supplements. Deficiency symptoms are anaemia, leucopenia, osteoporosis, neurological disturbances and fragility of blood vessels that can result in spontaneous ruptures of vessels (SCF, 1993b).

Copper excess results acutely in gastrointestinal symptoms and chronically in liver and kidney dysfunction. A UL for copper of 1 mg per day was derived by the SCF (2003d) for children aged one to three years.

<u>0 to < 6 months</u>

Breast milk concentrations of copper observed in Europe ranged between 97 and 1 400 µg/L, with medians between 368 and 400 µg/L and mean values of 329 to 390 µg/L (Krachler et al., 1998; Rodriguez Rodriguez et al., 2002; Leotsinidis et al., 2005). Copper concentrations in human milk progressively decline over the months postpartum (IoM, 2001).

Exclusively breast-fed infants do not show signs of copper deficiency, presumably due to copper stores acquired during intrauterine life.

Therefore, the Panel considers that observed mean copper intakes from breast milk of 0.3 mg per day (i.e. 350 µg/L × 0.8 L) are adequate for the majority of infants in the first half-year of life.

<u>6 to < 12 months</u>

The SCF (1993b) set a PRI for copper for infants in the second half of the first year of life of 36 µg per kg body weight per day (0.3 mg per day) based on a factorial approach assuming an absorption efficiency of 50 %.

This value is consistent with more recent reference values from other scientific or authoritative bodies, which range from 0.22 to 0.7 mg per day (i.e. 0.22 mg (IoM, 2001; NHMRC, 2006), 0.3 mg (Nordic Council of Ministers, 2013), 0.6 mg (Afssa, 2001) and 0.6–0.7 mg (D-A-CH, 2013) per day). WHO (1996) recommended 40 µg/kg body weight per day.

Taking the PRI of the SCF (1993b) as a basis, the Panel considers that a copper intake of 0.3 mg per day is adequate for the majority of infants from 6 to < 12 months.

<u>12 to < 36 months</u>

The SCF (1993b) set the PRI for copper for young children at 0.4 mg per day by interpolation.

This value is in line with more recent reference values from other scientific or authoritative bodies, which range from 0.34 to 0.75 mg per day (i.e. 0.34 mg (IoM, 2001), 0.3–0.4 mg (Nordic Council of Ministers, 2013), 0.5-1 mg (D-A-CH, 2013), 0.7 mg (NHMRC, 2006) and 0.75 mg (Afssa, 2001) per day). WHO (1996) recommended 28 µg per kg body weight per day.

Taking the PRI of the SCF (1993b) as a basis, the Panel considers that a copper intake of 0.4 mg per day is adequate for the majority of young children.

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4.14. Selenium

Selenocysteine is an indispensable constituent of 25 different selenoproteins. Most selenoproteins are involved in redox reactions and three deiodinases convert thyroxine to triiodothyronine, but the function of some selenoproteins is as yet unknown. Dietary selenium absorption is not under homeostatic control and varies from 50 to 90 % (Fairweather-Tait et al., 2010; Fairweather-Tait et al., 2011). Selenium deficiency, e.g. following long-term parenteral nutrition, malabsorption syndromes or use of special diets containing insufficient selenium, leads to impaired muscle function and loss of pigment in hair and skin. In selenium-deficient regions, Keshan disease, a cardiomyopathy, and Kaschin–Beck disease, a degenerative osteoarthropathy, have been observed. The aetiology of both is probably not only due to selenium deficiency (SCF, 1993b).

Chronic selenium excess is characterised by hair loss and nail dystrophy, breath smelling of garlic, dermatitis and neurological and endocrinological symptoms (selenosis). The SCF (2000f) has set a UL for selenium of 60 µg per day for children aged one to three years.

<u>0 to < 6 months</u>

A wide range of selenium concentrations in human milk have been observed, depending on the amount of selenium consumed by the mother from natural foods. In general, selenium concentrations are highest in colostrum (zero to five days, median 26 µg/L). Breast milk concentrations of selenium in Europe range from 3 to 84 µg/L, with a mean value of 16.3 ± 4.7 µg/L (Krachler et al., 1998; Zachara and Pilecki, 2000; Navarro-Blasco and Alvarez-Galindo, 2003; Özdemir et al., 2008).

The Panel considers that observed mean selenium intakes from breast milk of 12.5 µg per day (i.e. 16 µg/L × 0.8 L) are adequate for the majority of infants in the first half-year of life.

<u>6 to < 12 months</u>

The SCF (1993b) defined a PRI for selenium for infants in the second half of the first year of life of 10 µg per day, which was extrapolated from the adult value.

Although this is in line with more recent reference values of other scientific or authoritative bodies, which range from 7 to 30 µg per day (i.e. 7–30 µg (D-A-CH, 2013), 10 µg (WHO/FAO, 2004), 15 µg (NHMRC, 2006; Nordic Council of Ministers, 2013) and 20 µg (IoM, 2000b; Afssa, 2001) per day), the Panel decided not to use the PRI of the SCF (1993b) but proposes to take as a basis the AI of NHMRC (2006), which was derived by allometric scaling from young infants.

Taking the AI of NHMRC (2006) as a basis, the Panel considers that a selenium intake of 15 µg per day is adequate for the majority of infants from 6 to < 12 months.

<u>12 to < 36 months</u>

The SCF (1993b) has derived a PRI for selenium for young children of 10 µg per day by extrapolation from the adult value.

More recent reference values of other scientific or authoritative bodies are in the range of 10 to 40 µg per day (i.e. 10–40 µg (D-A-CH, 2013), 17 µg (WHO/FAO, 2004), 20 µg (IoM, 2000b; Afssa, 2001) and 20–25 µg (NHMRC, 2006; Nordic Council of Ministers, 2013) per day. The Panel decided not to use the PRI of the SCF (1993b) but proposes to take as a basis the PRI of IoM (2000b), which was based on selenium intakes that would maximise glutathioneperoxidase (GPX) activity in plasma.

Taking the PRI of IoM (2000b) as a basis, the Panel considers that a selenium intake of 20 µg per day is adequate for the majority of young children.

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4.15. Iodine

The most critical physiological role for iodine is the normal functioning of the thyroid gland. Iodine deficiency is the most common cause of preventable mental retardation in the world. Inadequate intake of iodine results in a reduction in thyroid hormone production. Diminished thyroid iodine content and increased turnover make neonates the age group most vulnerable to the effects of iodine deficiency (Houston, 2005).

A UL for iodine was set at 200 µg per day for children aged one to three years based on biochemical changes in thyroid-stimulating hormone (TSH) levels (SCF, 2002e).

<u>0 to < 6 months</u>

The iodine content of breast milk does not reflect the iodine requirement of the (breast-fed) infant, as it depends on the iodine status of the mother. After initial high concentrations in colostrum, the iodine concentration decreases. In Portugal, a median iodine concentration of 95 µg/L (interquartile range (IQR) 68–143 µg/L) was measured at day 3 and of 70 µg/L (IQR 50–102 µg/L) at three months post partum (Costeira et al., 2009). However, there is a large overlap of breast milk iodine concentrations between iodine-sufficient and iodine-deficient countries (Zimmermann, 2007).

The Panel assumes that the iodine concentration of mature breast milk of European women is in the range 50–100 µg/L. Assuming a milk intake of 0.8 L per day, between 40 and 80 µg iodine per day would be consumed.

Taking into account that the reported iodine concentrations in human milk may include data from women with low iodine status and that the iodine requirement of the young infant may be high because of the need to acquire iodine stores in the thyroid and that a urinary iodine concentration of > 100 µg/L has been found to be associated with the smallest thyroid volume in three-month-old children (Böhles et al., 1993), the Panel considers that an iodine intake of 90 µg per day is adequate for the majority of infants in the first half-year of life.

<u>6 to < 12 months</u>

The SCF (1993b) has derived an AI for iodine for infants in the second half of the first year of life of 50 µg per day.

More recent reference values of other scientific or authoritative bodies are in the range of 50 to 130 µg per day (i.e. 50 µg (D-A-CH, 2013, for Switzerland; Nordic Council of Ministers, 2013), 80 µg (D-A-CH, 2013, for Germany and Austria), 90 µg (Afssa, 2001; WHO/FAO, 2004), 110 µg (NHMRC, 2006) and 130 µg (IoM, 2001) per day).

The Panel decided not to use the AI of the SCF (1993b). The Panel notes the wide range of reference values and decided to take the mid-point of this range as a basis.

The Panel considers that an iodine intake of 90 µg per day is adequate for the majority of infants in the second half of the first year of life.

<u>12 to < 36 months</u>

The SCF (1993b) has derived an AI for iodine for young children of 70 µg per day.

More recent reference values of other scientific or authoritative bodies are in the range of 80 to 100 µg per day (i.e. 80 µg (Afssa, 2001), 70–90 µg (Nordic Council of Ministers, 2013), 90 µg (IoM, 2001; WHO/FAO, 2004; NHMRC, 2006; D-A-CH, 2013, for Switzerland) and 100 µg (D-A-CH, 2013, for Germany and Austria) per day).

The Panel decided not to use the AI of the SCF (1993b) but to take the AI/PRIs of other bodies (i.e. (IoM, 2001; WHO/FAO, 2004; NHMRC, 2006; D-A-CH, 2013, for Switzerland; Nordic Council of Ministers, 2013) as a basis, which were mainly based on urinary iodine excretion and balance studies. The Panel considers that an iodine intake of 90 µg per day is adequate for the majority of young children.

4.16. Chromium

Chromium(III) is ubiquitous, occurring in water, soil and biological systems. No function of chromium in normal human metabolism has been identified, although it has been reported to influence carbohydrate, lipid, and protein metabolism via an effect on insulin action. Dietary chromium is poorly absorbed (only 0.4 to 2.5 %) and less than 1 % of an ingested dose is retained (SCF, 1993b). Some authors have suggested that cases of dietary chromium deficiency occurred in malnourished infants (Hopkins et al., 1968).

The SCF (2003e) did not derive DRVs for chromium. Owing to limited data the SCF (2003e) was also unable to set a UL.

The Panel considers that owing to the limited evidence available no conclusions can be drawn on any levels of chromium intakes which can be considered adequate for the majority of infants and young children.

4.17. Molybdenum

In humans, sulphite oxidase, xanthine oxidoreductase, aldehyde oxidase and mitochondrial amidoxime-reducing component require molybdenum linked with a pterin (molybdopterin) as cofactor (Reiss and Hahnewald, 2011). These enzymes are involved in the catabolism of sulphur-containing amino acids and of heterocyclic compounds, including purines, pyrimidines, pteridins and pyridines, and in the metabolism of aromatic aldehydes (EFSA NDA Panel, 2013e). A distinct molybdenum deficiency syndrome has not been observed in animals when subjected to molybdenum restriction, despite considerable reduction in the activity of molybdoenzymes (Cohen et al., 1973; Johnson et al., 1974). In humans, a single case report of a syndrome suggestive of dietary molybdenum deficiency in a patient on total parenteral nutrition for several months has been reported (Abumrad et al., 1981), but clinical signs of molybdenum deficiency in otherwise healthy humans have not been observed.

A UL for molybdenum for children older than one year was set at 0.1 to 0.5 mg/day (SCF, 2000a).

<u>0 to < 6 months</u>

Mean molybdenum concentrations in human milk were reported to range between 0.72 and 4 µg/L with a mean of around 2.5 µg/L (EFSA NDA Panel, 2013e).

The Panel considers that observed mean molybdenum intakes from breast milk of 2 µg per day (i.e. 2.5 µg/L × 0.8 L) are adequate for the majority of infants in the first half-year of life.

<u>6 to < 12 months</u>

The Panel has recently set an AI for molybdenum of 10 µg per day for infants from 6 to < 12 months, derived by extrapolation from the AI for adults (EFSA NDA Panel, 2013e).

<u>12 to < 36 months</u>

The Panel has recently set an AI for molybdenum of 15 µg per day for children aged from 12 to < 36 months, derived by extrapolation from the AI for adults (EFSA NDA Panel, 2013e).

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4.18. Manganese

Manganese is a component of metalloenzymes such as superoxide dismutase, arginase and pyruvate carboxylase, and is involved in amino acid, lipid and carbohydrate metabolism. Glycosyltransferases and xylosyltransferases, which are involved in proteoglycan synthesis, are sensitive to manganese status in animals (Nielsen, 1999). Manganese-deficient animals exhibit impaired growth, skeletal abnormalities, reproductive deficits, ataxia of the newborn and defects in lipid and carbohydrate metabolism. A specific deficiency syndrome has not been described in humans (SCF, 1993b).

As a no observed adverse effect level (NOAEL) for critical endpoints from animal studies was not available, and because of the limitations of the data on potential neurotoxic effect of high dietary intakes of manganese in humans, a UL could not be set (SCF, 2000c).

<u>0 to < 6 months</u>

The mean manganese concentrations of human milk vary from 0.8 to 30 µg/L (3–30 µg/L in Europe), but most values are around 4 µg/L (Mullee et al., 2012).

The Panel considers that observed mean manganese intakes from breast milk of 3 µg per day (i.e. 4 µg/L × 0.8 L) are adequate for the majority of infants in the first half-year of life.

<u>6 to < 12 months</u>

The Panel recently set a range of AIs for manganese for infants from 6 to < 12 months of 0.02 to 0.5 mg per day (EFSA NDA Panel, 2013f). The lower value was chosen as the estimated intake resulting from upwards extrapolation of manganese intakes in fully breast-fed infants. The higher value of the range was chosen at the intermediate level between the observed intakes of manganese in infants aged 6 and 12 months of 0.65 mg per day and the value of 0.4 mg per day estimated from extrapolation of the adult AI by isometric scaling.

<u>12 to < 36 months</u>

The Panel (EFSA NDA Panel, 2013f) recently set an AI of 0.5 mg per day for young children based on isometric scaling from the AI for adults.

4.19. Fluoride

Fluoride is the anionic form of fluorine. Fluoride occurs naturally after reaction of fluorine, which is the most electronegative and reactive of all elements, with metallic elements or with hydrogen (IoM, 1997). Fluoride in the body is mainly associated with calcified tissue (bone and teeth). Fluoride has been known to be useful in the control of caries development for more than a hundred years (Sampaio and Levy, 2011). No signs of fluoride deficiency have been identified in humans. A lack of fluoride intake during development will not alter tooth development but may result in increased susceptibility of enamel to acid attacks after eruption. However, caries is not a fluoride deficiency disease and fluoride is not an essential nutrient (EFSA NDA Panel, 2013d).

The SCF (2003c) has recommended a maximum fluoride level of 0.6 to 0.7 mg/L in infant formula and follow-on formula, equivalent to an intake of about 0.1 mg per kg body weight per day in infants during the first six months of life (body weight 5 kg). In the case of powdered formula, this maximum will be exceeded if water containing more than 0.7 mg/L fluoride is used for its preparation. Based on its effects on dental fluorosis, the UL for fluoride was set at 1.5 mg per day for children aged one to three years (EFSA, 2005b).

<u>0 to < 6 months</u>

Fluoride concentrations in human milk vary from non-detectable to 100 µg/L, with a trend for lower concentrations in regions with low fluoride concentrations in drinking water (≤ 0.3 mg/L), with the

exception of a study reporting values of around 500 µg/L for both ionic and total fluoride (Pasternak et al., 1998).

The Panel considers that observed mean fluoride intakes from breast milk of 80 µg per day (i.e. 100 µg/L × 0.8 L) are adequate for the majority of infants in the first half-year of life (EFSA NDA Panel, 2013d).

6 to < 12 months

The Panel has recently set an AI for fluoride for infants from 6 to < 12 months of 0.4 mg per day, based on a dose–response relationship between caries incidence and consumption of drinking water with different fluoride concentrations (EFSA NDA Panel, 2013d).

12 to < 36 months

The Panel has recently set an AI for fluoride of 0.6 mg per day for young children, based on a dose–response relationship between caries incidence and consumption of drinking water with different fluoride concentrations (EFSA NDA Panel, 2013d).

4.20. Vitamin A

Vitamin A is the common name of various all-*trans*-retinol chemical compounds including both the naturally occurring forms of vitamin A as well as the many synthetic analogues of retinol. Vitamin A has several important functions, including a role in vision, maintenance of epithelial surfaces, immune competence, growth, development and reproduction (Nordic Council of Ministers, 2013). Early indications of vitamin A deficiency are impaired night vision. At later stages dryness of the conjuctiva and cornea develops (SCF, 1993b)

A UL for preformed vitamin A (retinol and retinyl esters) of 800 µg retinol equivalents (RE; 1 RE = 6 µg β-carotene or 1 µg retinol) per day has been set based on the risk of hepatotoxicity and teratogenicity and subsequent extrapolation to children (SCF, 2002c). Infants given single doses of 15 and 30 mg RE showed no adverse effects (Humphrey et al., 1998).

0 to < 6 months

Vitamin A concentrations in human milk in Western countries were traditionally considered to be between 450 and 600 µg/L, whereas considerably lower values were reported in two recent studies: 80 µg/L (Tijerina-Saenz et al., 2009) and 85 µg/L (Szlagatys-Sidorkiewicz et al., 2012).

Taking the content of vitamin A in human milk to be 450 µg/L, the Panel considers that observed mean vitamin A intakes from breast milk of 350 µg RE per day (i.e. 450 µg/L × 0.8 L) are adequate for the majority of infants in the first half-year of life.

6 to < 12 months

The SCF (1993b) set an AI of 350 µg RE per day for infants from 6 to < 12 months, which was based on observed mean intakes from breast milk.

This is in line with more recent reference values from other scientific or authoritative bodies, which range from 300 to 600 µg RE per day (i.e. 300 µg (Nordic Council of Ministers, 2013), 350 µg (Afssa, 2001), 400 µg (WHO/FAO, 2004), 430 µg (NHMRC, 2006), 500 µg (IoM, 2001) and 600 µg (D-A-CH, 2013) RE per day).

Taking the AI of the SCF (1993b) as a basis, the Panel considers that a vitamin A intake of 350 µg RE per day is adequate for the majority of infants from 6 to < 12 months.

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12 to < 36 months

The SCF (1993b) set an AI of 400 µg RE per day for young children.

This is in line with more recent reference values from other scientific or authoritative bodies, which range from 300 to 600 RE µg per day (i.e. 300 µg (IoM, 2001; NHMRC, 2006), 300–350 µg (Nordic Council of Ministers, 2013), 400 µg (Afssa, 2001; WHO/FAO, 2004) and 600 µg (D-A-CH, 2013) per day).

Taking the AI of the SCF (1993b) as a basis, the Panel considers 400 µg RE per day to be adequate to cover the dietary needs of children aged from 12 to < 36 months.

4.21. Vitamin D

Vitamin D (vitamin D_3, cholecalciferol) may come from the diet but can also be synthesised from 7-dehydrocholesterol in the skin under the influence of ultraviolet B light. Though sufficient exposure of the skin to sunshine may fully cover vitamin D requirements, depending on geographical area and lifestyle factors, there might be a need to provide vitamin D via the diet. However, the diverse origin of vitamin D in the organism makes it difficult to determine exact dietary requirements. The principal function of the active vitamin D metabolite ($1,25(OH)_2D$) is to maintain intracellular and extracellular calcium concentrations within a physiologically acceptable range that supports cellular processes, neuromuscular function and bone ossification. This regulation is accomplished by enhancing the efficiency of the small intestine in absorbing dietary calcium and phosphorus, and by mobilising calcium and phosphorus from the bone (EFSA NDA Panel, 2012c; Braegger et al., 2013). Early signs of vitamin D deficiency are subclinical and include decreased serum concentrations of calcium and phosphorus while later signs comprise inadequate skeletal mineralisation (rickets and osteomalacia), bone deformities, bone pain, and alterations in muscle metabolism and respiratory function (SCF, 1993b).

The best indicator of vitamin D status is considered to be 25(OH)D vitamin serum concentrations. 25(OH)D vitamin serum concentrations < 50 nmol/L are usually accepted as indicators of vitamin D deficiency, whereas values < 25 nmol/L are generally considered as signs of severe vitamin D deficiency (Braegger et al., 2013). However, the use of a 25(OH)D serum concentrations of 50 nmol/L to indicate sufficiency is supported mainly by studies in adult bone health.

ULs were set by the Panel (EFSA NDA Panel, 2012c) for infants at 25 µg per day and for young children at 50 µg per day based on data relating high vitamin D intakes to impaired growth and hypercalcaemia.

0 to < 6 months

The mean vitamin D content of breast milk in healthy women has been reported to be in the range 0.25 to 2 µg/L (Dawodu and Tsang, 2012). There is general agreement that human milk does not contain sufficient vitamin D to prevent rickets, even if the mother takes vitamin D supplements (Olafsdottir et al., 2001). Because of its low content in breast milk, vitamin D concentrations in human milk are considered not to be a good reference to set an AI for infants aged from 0 to < 6 months.

It has been reported that clinical deficiencies in infants receiving vitamin D at doses of 10 µg per day have not been observed and an intake of 10 µg per day appears to maintain serum 25(OH)D concentrations generally above 50 nmol/L throughout infancy (Braegger et al., 2013). In a recent study, 38 out of 39 Canadian infants receiving 10 µg of vitamin D per day exhibited serum or plasma 25(OH)D concentrations ≥ 50 nmol/L by three months of age, and this concentration was sustained in 37 infants at 12 months (Gallo et al., 2013).

On the basis of these considerations, the Panel considers that a vitamin D intake of 10 µg per day is adequate for the majority of infants in the first half-year of life.

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6 to < 12 months

The SCF (1993b) previously set an AI for vitamin D for infants aged from 6 to < 12 months of 10–25 µg per day based on 25(OH)D serum concentrations.

This is in line with more recent reference values from other scientific or authoritative bodies, which range from 5 to 25 µg per day (i.e. 5 µg (WHO/FAO, 2004; NHMRC, 2006), 10 µg (Gezondheidsraad, 2000; IoM, 2011; D-A-CH, 2013; Nordic Council of Ministers, 2013) and 20–25 µg (Afssa, 2001) per day).

Taking the AI of the SCF (1993b) as a basis, the Panel considers that a vitamin D intake of 10 µg per day is adequate for the majority of infants aged from 6 to < 12 months having minimal sun exposure.

12 to < 36 months

The SCF (1993b) previously set an AI for vitamin D for young children of 10 µg per day based on 25(OH)D serum concentrations.

This is in line with more recent reference values from other scientific or authoritative bodies, which range from 5 to 20 µg per day (i.e. 5 µg (WHO/FAO, 2004; NHMRC, 2006), 10 µg (Afssa, 2001; Gezondheidsraad, 2012; Nordic Council of Ministers, 2013), 15 µg (IoM, 2011) and 20 µg (D-A-CH, 2013) per day).

Taking the AI of the SCF (1993b) as a basis, the Panel considers that a vitamin D intake of 10 µg per day is adequate for the majority of young children having minimal sun exposure.

4.22. Vitamin E

Within the chemical family of tocopherols and tocotrienols, today only alpha-tocopherol is considered to play a role in covering human nutritional requirements.

The major biological role of alpha-tocopherol is antioxidant activity contributing to the prevention of propagation of free radicals in various lipid structures within the organism. In addition to its antioxidant activity, alpha-tocopherol is also suggested to play a role in immune enhancement, inhibition of platelet aggregation and anti-inflammatory functions (Nordic Council of Ministers, 2013). Vitamin E deficiency is rare and develops only after years during which plasma tocopherol concentrations are extremely low in children and adults unable to utilise vitamin E adequately, who subsequently develop a characteristic and progressive neurological syndrome (SCF, 1993b).

Because of its role in preventing lipid peroxidation, alpha-tocopherol requirements should theoretically be related to PUFA intakes (Aggett et al., 1998). However, difficulties in precisely defining the PUFA content of foods ready to be consumed make it impracticable to include this parameter in formulating alpha-tocopherol requirements.

Alpha-tocopherol intakes provided by food sources have not been associated with any adverse effect and the SCF (2003a) did not propose a UL for infants and children. For adults, a UL of 300 mg per day was proposed.

0 to < 6 months

The value traditionally used for characterising alpha-tocopherol content in human milk was 3.49 mg alpha-tocopherol equivalents (TE)/L (Jansson et al., 1981). This value was closely corroborated in three-month-old infants in one recent study (3.48 mg/L) (Antonakou et al., 2011), whereas different values have been reported in other studies (2.32 mg/L (Tijerina-Saenz et al., 2009) and 1.10 mg/L (Szlagatys-Sidorkiewicz et al., 2012)).

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The Panel considers that observed mean vitamin E intakes of 3 mg TE per day from breast milk (i.e. 3.5 mg/L × 0.8 L) are adequate for the majority of infants in the first half-year of life.

6 to < 12 months

In its Opinion, the SCF (1993b) concluded on an AI of 0.4 mg alpha-TE per gram PUFA intake for all population groups. Owing to the inherent impracticability of such a recommendation and uncertainties about mean PUFA intakes in this population group, the Panel reviewed more recent reference values from other scientific or authoritative bodies. These AIs ranged from 3 to 5 mg per day (i.e. 3 mg per day (Nordic Council of Ministers, 2013) based on a ratio of alpha-tocopherol to total PUFAs of 0.6, 4 mg per day (Afssa, 2001; D-A-CH, 2013) and 5 mg per day (IoM, 2000b; NHMRC, 2006) extrapolated from the AI of younger infants).

Taking the AI of IoM (2000b) and NHMRC (2006) as a basis, the Panel considers that an alpha-tocopherol intake of 5 mg per day is adequate for the majority of infants aged from 6 to < 12 months. This covers also infants with the highest observed PUFA intakes (i.e. 5.30 ± 2 g (mean ± SD) PUFAs per day (Hilbig, 2005)), if related to PUFA intakes.

12 to < 36 months

As for older infants, the Panel decided not to use the AI set by the SCF (1993b).

More recent reference values for young children set by other scientific or authoritative bodies are in the range of 4 to 6 mg TE per day (i.e. 4–5 mg per day (NHMRC, 2006; Nordic Council of Ministers, 2013) based on a ratio of alpha-tocopherol to total PUFAs of 0.6 or on observed mean intakes of 6 mg per day (IoM, 2000b; Afssa, 2001; D-A-CH, 2013) based on interpolation between adults and infants or on extrapolation from adults).

Taking the AI of IoM (2000b), Afssa (2001) and D-A-CH (2013) as a basis, the Panel considers that alpha-tocopherol intakes of 6 mg per day are adequate for the majority of young children. This covers also young children with the highest observed PUFA intakes (i.e. mean ± SD: 6.0 ± 1.7 g, 6.0 ± 2.2 g and 6.5 ± 0.2 g PUFA per day (Ulbak et al., 2004; Hilbig, 2005; de Boer et al., 2006)), if related to PUFA intakes.

4.23. Vitamin K

Vitamin K activity is shown mostly by phylloquinone but also by several other compounds containing a naphthoquinone structure. Besides dietary intake of preformed vitamin K, bacterial synthesis in the intestine also contributes to covering requirements. Vitamin K is needed primarily for the synthesis of various factors and proteins involved in blood coagulation. While low vitamin K stores at birth may predispose to haemorrhages in healthy neonates and young infants, later in life clinical consequences of vitamin K deficiency are seen almost exclusively in sick children. Therefore, in several countries different parenteral or oral regimens of vitamin K supplementation of neonates are in place.

There are no appropriate data from which to derive a numerical UL for vitamin K, but there is no evidence of adverse effects associated with supplementary intakes of vitamin K in the form of phylloquinone of up to 10 mg per day for limited periods of time (SCF, 2003b).

0 to < 6 months

Mean vitamin K concentrations in human milk are around 2.5 µg/L but vary considerably from 0.85 to 9.2 µg/L (IoM, 2001).

The SCF (1993b) did not set a DRV for vitamin K but indicated that an intake of 1 µg per kg body weight per day appeared to be adequate for all age groups. This would amount to 5 µg per day, considering an average weight of 5 kg for infants aged from 0 to < 6 months.

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This is in line with more recent reference values from other scientific or authoritative bodies ranging from 2 µg to 10 µg per day (i.e. 2 µg (IoM, 2001; NHMRC, 2006), 4 µg up to four months (D-A-CH, 2013), 5 µg (WHO/FAO, 2004) and 5–10 µg (Afssa, 2001) per day).

The Panel considers that a vitamin K intake of 5 µg per day is adequate for the majority of infants in the first half-year of life, assuming that infants also receive prophylactic vitamin K at birth in amounts recommended by health authorities in the different Member States.

6 to < 12 months

Taking the guidance of the SCF (1993b) of 1 µg vitamin K per kg body weight per day as basis, this would lead to an AI of 8.5 µg per day, considering an average weight of 8.5 kg for infants in the second half of the first year of life.

This is in line with more recent reference values from other scientific or authoritative bodies ranging from 2.5 µg to 10 µg per day (i.e. 2.5 µg (IoM, 2001; NHMRC, 2006), 5–10 µg (Afssa, 2001) and 10 µg (WHO/FAO, 2004; D-A-CH, 2013) per day.

The Panel considers that a vitamin K intake of 8.5 µg per day is adequate for the majority of infants aged from 6 to < 12 months.

12 to < 36 months

Assuming an average weight of 11.8 kg for young children and taking as the basis 1 µg per kg body weight per day, as suggested by the SCF (1993b), this would amount to an intake of vitamin K of 12 µg per day.

More recent reference values from other scientific or authoritative bodies range from 15 µg to 30 µg per day (i.e. 15 µg (Afssa, 2001; WHO/FAO, 2004; D-A-CH, 2013), 25 µg (NHMRC, 2006) and 30 µg (IoM, 2001) per day).

Even though more recent advice given by other bodies is slightly above the guidance value derived by the SCF, the Panel decided to use the value of the SCF (1993b) and considers that a vitamin K intake of 12 µg per day is adequate for the majority of young children.

4.24. Thiamin (vitamin B_1)

The principal metabolic function of thiamin is as a precursor for thiamin pyrophosphate which is the coenzyme for a number of reactions involved in carbohydrate and branched-chain amino acid metabolism and in central energy-yielding metabolic pathways. Lack of thiamin causes the deficiency disease beriberi (SCF, 1993b).

The SCF concluded that, although no UL could be established for thiamin, existing evidence indicates that current levels of intake of thiamin from all sources do not represent a health risk for the general population (SCF, 2001c).

0 to < 6 months

The average content of thiamin in human milk is 0.2 mg/L (IoM, 1998) with a range of 0.15 to 0.33 mg/L (SCF, 2003c).

The Panel considers that observed mean intakes of thiamin from breast milk (i.e. 0.2 mg/L × 0.8 L) and rounding up to 0.2 mg per day are adequate for the majority of infants in the first half-year of life.

6 to < 12 months

In its Opinion, the SCF (1993b) considered the requirement for thiamin to depend on the utilisation of energy-yielding substrates and set a PRI of 100 µg per MJ.

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Taking the PRI of the SCF (1993b) as a basis and the average energy requirement of infants at nine months of age to be 2.8 MJ per day, the Panel considers that a thiamin intake of 0.3 mg per day is adequate for the majority of infants aged from 6 to < 12 months.

This is in line with more recent reference values given by other scientific or authoritative bodies, which range from 0.2 to 0.4 mg per day (i.e. 0.2 mg (Gezondheidsraad, 2000; Afssa, 2001), 0.3 mg (IoM, 1998; WHO/FAO, 2004; NHMRC, 2006) and 0.4 mg (D-A-CH, 2013; Nordic Council of Ministers, 2013) per day).

12 to < 36 months

As for infants in the second half of the first year of life, the Panel decided to use the PRI of the SCF (1993b). Taking into account an average energy requirement of 4.2 MJ per day of 24-month-old children and rounding up, the Panel considers that a thiamin intake of 0.5 mg per day is adequate for the majority of young children.

This is also in line with more recent reference values given by other scientific or authoritative bodies, which range from 0.3 to 0.6 mg per day (i.e. 0.3 mg (Gezondheidsraad, 2000), 0.4 mg (Afssa, 2001), 0.5 mg (IoM, 1998; WHO/FAO, 2004; NHMRC, 2006), 0.5–0.6 mg (Nordic Council of Ministers, 2013) and 0.6 mg (D-A-CH, 2013) per day).

4.25. Riboflavin (vitamin B_2)

Riboflavin functions as a coenzyme in numerous redox reactions. Riboflavin is a precursor of certain essential coenzymes such as flavin mononucleotide (FMN) and flavin-adenine dinucleotide (FAD). In these coenzyme forms riboflavin functions as a catalyst for redox reactions. Isolated dietary riboflavin deficiency usually does not occur, but deficiency can be observed in association with other nutritional deficiencies (SCF, 2000e; Powers, 2003).

Although no numerical UL could be established by the SCF for riboflavin, it concluded that existing evidence indicates that current levels of intake of riboflavin from all sources do not represent a health risk for the general population (SCF, 2000e).

0 to < 6 months

The average content of riboflavin in human milk is 0.35 mg/L (IoM, 1998).

The Panel considers that observed mean riboflavin intakes from breast milk (i.e. 0.35 mg/L × 0.8 L) and rounding up to 0.3 mg per day are adequate for the majority of infants in the first half-year of life.

6 to < 12 months

The SCF (1993b) set an AI for riboflavin of 0.4 mg per day for infants aged from 6 to < 12 months, which was based on observed mean intakes that restored the erythrocyte glutathione reductase activation coefficient to normal in this population group.

This value is in line with more recent reference values from other scientific or authoritative bodies, which are set at 0.4 mg per day (IoM, 1998; Gezondheidsraad, 2000; Afssa, 2001; WHO/FAO, 2004; NHMRC, 2006; D-A-CH, 2013) and 0.5 mg per day (Nordic Council of Ministers, 2013).

Taking the AI of the SCF (1993b) as a basis, the Panel considers that a riboflavin intake of 0.4 mg per day is adequate for the majority of infants aged from 6 to < 12 months.

12 to < 36 months

The SCF (1993b) derived an AI for riboflavin of 0.8 mg per day for young children, which was derived from the AI of young adults on the basis of the energy expenditure.

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This value is in line with more recent reference values from other scientific or authoritative bodies, which range from 0.5 to 0.8 mg per day (i.e. 0.5 mg (IoM, 1998; Gezondheidsraad, 2000; WHO/FAO, 2004; NHMRC, 2006), 0.6–0.7 mg (Nordic Council of Ministers, 2013), 0.7 mg (D-A-CH, 2013) and 0.8 mg (Afssa, 2001) per day).

Taking the AI of the SCF (1993b) as a basis, the Panel considers that a riboflavin intake of 0.8 mg per day is adequate for the majority of young children.

4.26. Niacin

Niacin is the term used to describe two related compounds, nicotinic acid and nicotinamide, both of which have biological activity. Tryptophan can be used for niacin biosynthesis and 60 mg of tryptophan is considered to be 1 mg of niacin equivalent (NE). Niacin is the precursor for two cofactors, NAD (nicotinamide adenine dinucleotide) and NADP (nicotinamide adenine dinucleotide phosphate), which are essential for the functioning of a wide range of enzymes involved in redox reactions. A deficiency of niacin leads to characteristic changes, known as pellagra, and may include gastrointestinal and central nervous system symptoms (SCF, 1993b).

In adults, nicotinic acid has been used in the treatment of hypercholesterolaemia and dose-related adverse effects have been reported. Flushing is the most common side effect and can occur at relatively low doses. Chronic toxicity in the form of hepatotoxicity, hyperglycaemia, hyperuricaemia and adverse ophthalmological effects has been reported frequently. There are no reports of acute toxicity with nicotinamide, but high doses over longer periods of time have been associated with liver dysfunction. The UL for children aged one to three years of nicotinic acid (2 mg per day) and nicotinamide (150 mg per day) have been derived from adult values on the basis of reference body weights (SCF, 2002d).

<u>0 to < 6 months</u>

The average content of niacin in human milk is 1.8 mg/L (IoM, 1998).

The Panel considers that observed mean niacin intakes from breast milk (i.e. 1.8 mg/L × 0.8 L) and rounding up to 2 mg NE per day are adequate for the majority of infants in the first half-year of life.

<u>6 to < 12 months</u>

The SCF (1993b) derived a PRI of 1.6 mg NE/MJ, which was based on the results of depletion–repletion studies. After expressing it as mg NE per day, the SCF concluded on a PRI of 5 mg NE per day based on the AR for energy set by the SCF (1993b).

This value is consistent with more recent reference values from other scientific or authoritative bodies, which range from 2 to 5 mg NE per day (i.e. 2 mg (Gezondheidsraad (2000), 3 mg (Afssa, 2001), 4 mg (IoM, 1998; WHO/FAO, 2004; NHMRC, 2006) and 5 mg (Nordic Council of Ministers, 2004; D-A-CH, 2013) NE per day).

Taking the PRI of the SCF (1993b) as a basis, the Panel considers that a niacin intake of 5 mg NE per day is adequate for the majority of infants aged from 6 to < 12 months.

<u>12 to < 36 months</u>

Using the above-mentioned considerations, the SCF (1993b) derived a PRI of 9 mg NE per day for young children.

This value is consistent with more recent reference values from other scientific or authoritative bodies, which range from 4 mg to 9 mg NE per day (i.e. 4 mg (Gezondheidsraad, 2000), 6 mg (IoM, 1998; Afssa, 2001; WHO/FAO, 2004; NHMRC, 2006), 7 mg (D-A-CH, 2013) and 7–9 mg (Nordic Council of Ministers, 2013) NE per day).

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Taking the PRI of the SCF (1993b) as a basis, the Panel considers that a niacin intake of 9 mg NE per day is adequate for the majority of young children.

4.27. Pantothenic acid

Pantothenic acid is required in the synthesis of coenzyme A and acyl carrier proteins and thus has a central role in a wide variety of metabolic pathways. Pantothenic acid deficiency is rare because of the widespread nature of the vitamin. Deficiency has been observed only in individuals on a diet free of pantothenic acid or given an antagonist to pantothenic acid (SCF, 1993b).

The SCF estimated that, although no numerical UL could be established for pantothenic acid, existing evidence indicates that current levels of intake of pantothenic acid from all sources do not represent a health risk for the general population (SCF, 2002b).

0 to < 6 months

The average content of pantothenic acid in human milk is reported to be 2.5 mg/L (EFSA NDA Panel, 2013a).

The Panel considers that observed mean pantothenic acid intakes from breast milk (i.e. 2.5 mg/L × 0.8 L) of 2 mg per day are adequate for the majority of infants in the first half-year of life.

6 to < 12 months

In its opinion undergoing public consultation (EFSA NDA Panel, 2013a), the Panel proposed an AI for pantothenic acid of 3 mg per day for infants in the second half of the first year of life on the basis of extrapolation of the AI of younger infants using allometric scaling based on reference body weights.

The Panel considers that a pantothenic acid intake of 3 mg per day is adequate for the majority of infants aged from 6 to < 12 months.

12 to < 36 months

In its opinion undergoing public consultation (EFSA NDA Panel, 2013a), the Panel proposed an AI for pantothenic acid of 4 mg per day for young children based on observed intakes in this age group from European countries.

The Panel considers that a pantothenic acid intake of 4 mg per day is adequate for the majority of young children.

4.28. Pyridoxine (vitamin B_6)

Pyridoxine comprises six compounds—pyridoxal, pyridoxine, pyridoxamine and their corresponding 5′-phosphates. Interconversion is possible between all forms. Pyridoxine acts as a coenzyme in the metabolism of amino acids, glycogen, PUFAs and phospholipids. Clinical symptoms of vitamin B_6 deficiency are very rare since the vitamin is widely distributed in food (SCF, 1993b).

A UL for young children of 5 mg per day has been set by extrapolation from adults based on the risk of neurotoxicity (SCF, 2000g).

0 to < 6 months

The content of pyridoxine in breast milk varies greatly and is dependent on maternal intakes. The average concentration of pyridoxine in milk of unsupplemented well-nourished mothers is 0.13 mg/L, reflecting a maternal pyridoxine intake of less than 2.5 mg per day (IoM, 1998).

The Panel considers that observed pyridoxine intakes from breast milk (i.e. 0.13 mg/L × 0.8 L) and rounding to 0.1 mg per day are adequate for the majority of infants in the first half-year of life.

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This is consistent with the requirement of 15 µg per gram of ingested protein assumed by the SCF (1993b).

6 to < 12 months

The SCF (1993b) derived a PRI for pyridoxine of 0.4 mg per day for infants aged from 6 to < 12 months based on the adult PRI of 15 µg pyridoxine per gram of dietary protein.

This value is consistent with more recent reference values from other scientific or authoritative bodies, which range from 0.2 to 0.4 mg per day (i.e. 0.2 mg (Gezondheidsraad, 2003), 0.3 mg (IoM, 1998; Afssa, 2001; WHO/FAO, 2004; NHMRC, 2006; D-A-CH, 2013) and 0.4 mg (Nordic Council of Ministers, 2013) per day).

Taking the PRI of the SCF (1993b) as a basis, the Panel considers that a pyridoxine intake of 0.4 mg per day is adequate for the majority of infants aged from 6 to < 12 months.

12 to < 36 months

The SCF (1993b) established a PRI for pyridoxine of 0.7 mg per day for young children based on the adult PRI of 15 µg pyridoxine per gram of dietary protein.

This value is consistent with more recent reference values from other scientific or authoritative bodies that range from 0.4 to 0.7 mg per day (i.e. 0.4 mg (IoM, 1998; Gezondheidsraad, 2003; D-A-CH, 2013), 0.5 mg (WHO/FAO, 2004; NHMRC, 2006), 0.6 mg (Afssa, 2001) and 0.5–0.7 mg (Nordic Council of Ministers, 2013) per day).

Taking the PRI of the SCF (1993b) as a basis, the Panel considers that a pyridoxine intake of 0.7 mg per day is adequate for the majority of young children.

4.29. Biotin

Biotin functions as a coenzyme for several carboxylases and plays a role in metabolism of carbohydrates, fats and amino acids. Biotin deficiency is very rare. It has been described following prolonged consumption of large amounts of raw egg whites (biotin bound by avidin and not available for absorption) and during biotin-free long-term parenteral nutrition. Biotin deficiency has also been described in inherited biotidinase deficiency (SCF, 1993b).

The SCF estimated that, although no numerical UL could be established for biotin, existing evidence indicates that current levels of intake of biotin from all sources do not represent a health risk for the general population (SCF, 2001a).

0 to < 6 months

The average content of biotin in human milk is 5 µg/L (EFSA NDA Panel, 2013g).

The Panel considers that observed mean biotin intakes from breast milk (i.e. 5 µg/L × 0.8 L) of 4 µg per day are adequate for the majority of infants in the first half-year of life.

6 to < 12 months

In its opinion undergoing public consultation (EFSA NDA Panel, 2013g), the Panel proposed an AI for biotin of 6 µg per day for infants in the second half of the first year of life on the basis of extrapolation of the AI of younger infants using allometric scaling based on reference body weights.

The Panel considers that a biotin intake of 6 µg per day is adequate for the majority of infants aged from 6 to < 12 months.

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12 to < 36 months

In its opinion undergoing public consultation (EFSA NDA Panel, 2013g), the Panel proposed an AI for biotin of 20 µg per day for young children based on observed intakes in this age group from European countries.

The Panel considers that a biotin intake of 20 µg per day is adequate for the majority of young children.

4.30. Folate

Folate is the generic term used for a group of compounds with a basic structure consisting of a double aromatic pteridine ring linked through a methylene bridge to *p*-aminobenzoic acid to which one or more glutamate residues are linked by γ-peptide bonds. Folate is essential for the synthesis of ribonucleic acid (RNA) and DNA, and consequently for cell division and tissue growth. Folate deficiency impairs DNA replication and cell division, which adversely affects rapidly proliferating tissues such as bone marrow and results in decreased production of blood cells. It has also been reported that folate deficiency is associated with structural damage of DNA, which might have implications for cancer development (Crider et al., 2012).

Because the absorption efficiency of folates varies depending on their chemical form, dietary folate equivalents (DFE) have been defined by IoM (1998) as 1 DFE = 1 µg food folate = 0.6 µg folic acid from fortified food or as a supplement consumed with food = 0.5 µg of a folic acid supplement taken on an empty stomach.

A UL for folic acid of 200 µg per day was set by the SCF (2000d) for children aged one to three years. A UL for food folate was not derived.

0 to < 6 months

The average content of folate in human milk was found to be 80 µg/L (Houghton et al., 2009).

The Panel considers that observed mean folate intakes from breast milk (i.e. 80 µg/L × 0.8 L) and rounding up to 65 µg DFE per day are adequate for the majority of infants in the first half-year of life.

6 to < 12 months

The SCF (1993b) proposed a PRI of 50 µg per day for older infants based on a study which found that 3.6 µg folic acid per kg body weight appeared to maintain plasma concentrations.

More recent reference values from other scientific or authoritative bodies range from 50 to 85 µg per day (i.e. 50 µg (Nordic Council of Ministers, 2013), 60 µg (Gezondheidsraad, 2003), 70 µg (Afssa, 2001), 80 µg (IoM, 1998; WHO/FAO, 2004; NHMRC, 2006) and 85 µg (D-A-CH, 2013) per day).

The Panel decided not to use the PRI set by the SCF (1993b) but to use as a basis the AI of the IoM (1998) and the NHMRC (2006), which was derived by extrapolating from the AI for infants aged from 0 to < 6 months using metabolic weight.

Taking the AI of these bodies as a basis, the Panel considers that a folate intake of 80 µg DFE per day is adequate for the majority of infants aged from 6 to < 12 months.

12 to < 36 months

The SCF (1993b) proposed a PRI of 100 µg per day for young children extrapolated from adults on the basis of energy expenditure.

This is in line with more recent reference values from other scientific or authoritative bodies, which range from 60 to 150 µg per day (i.e. 60–80 µg (Nordic Council of Ministers, 2013), 85 µg

(Gezondheidsraad, 2003), 100 µg (Afssa, 2001), 120 µg (D-A-CH, 2013) and 150 µg (IoM, 1998; WHO/FAO, 2004; NHMRC, 2006) per day).

Taking the PRI of the SCF (1993b) as a basis, the Panel considers that a folate intake of 100 µg DFE per day is adequate for the majority of young children.

4.31. Cobalamin (vitamin B_{12})

Vitamin B_{12} is the generic name for a specific group of cobalt-containing corrinoids with biological activity in humans. This group of biologically active corrinoids is also described as cobalamins. Cobalamin functions primarily as a coenzyme in intermediary metabolism. Cobalamin deficiency is very rare in infants and young children, provided that they do not receive a vegan diet or breast milk from a mother on a vegan diet not receiving cobalamin supplements (Dror and Allen, 2008). The most obvious sign of cobalamin deficiency is impairment of neurological development (Black, 2008).

No UL could be established by the SCF for cobalamin, but existing evidence indicates that current levels of intake of cobalamin from all sources do not represent a health risk for the general population (SCF, 2000b).

<u>0 to < 6 months</u>

The average content of cobalamin in human milk ranges from around 0.31 to 0.42 µg/L (IoM, 1998).

The Panel considers that observed mean cobalamin intakes from breast milk at the higher observed concentrations (i.e. 0.42 µg/L × 0.8 L) and rounding up to 0.4 µg per day are adequate for the majority of infants in the first half-year of life.

<u>6 to < 12 months</u>

The SCF (1993b) had proposed a PRI for cobalamin for infants in the second half of the first year of life of 0.5 µg per day based on the amount of cobalamin needed for alleviating deficiency symptoms.

This is in line with more recent reference values from other scientific or authoritative bodies that are in the range of 0.5 to 0.8 µg per day (i.e. 0.5 µg (IoM, 1998; Afssa, 2001; Gezondheidsraad, 2003; NHMRC, 2006; Nordic Council of Ministers, 2013), 0.7 µg (WHO/FAO, 2004) and 0.8 µg (D-A-CH, 2013) per day).

Taking the PRI of the SCF as a basis, the Panel considers that a cobalamin intake of 0.5 µg per day is adequate for the majority of infants aged from 6 to < 12 months.

<u>12 to < 36 months</u>

For young children, the SCF (1993b) set a PRI of 0.7 µg per day based on extrapolation from the PRI of adults on the basis of the energy expenditure, with adult PRIs having been based on studies on vitamin turnover and on biochemical deficiency.

More recent reference values from other scientific or authoritative bodies are in the range of 0.6 to 1 µg per day (i.e. 0.6–0.8 µg (Nordic Council of Ministers, 2013), 0.7 µg (Gezondheidsraad, 2003), 0.8 µg (Afssa, 2001), 0.9 µg (IoM, 1998; WHO/FAO, 2004; NHMRC, 2006) and 1 µg (D-A-CH, 2013) per day). These values were mainly derived by extrapolation from adults, except for the German-speaking countries (D-A-CH, 2013), values for which were based extrapolation from young infants.

The Panel decided not to use the PRI set by the SCF (1993b) but to use the PRI set by the IoM (1998), WHO/FAO (2004) and the NHMRC (2006).

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Taking the PRI of these bodies as a basis, the Panel considers that a cobalamin intake of 0.9 µg per day is adequate for the majority of young children.

4.32. Vitamin C

Vitamin C (L-ascorbic acid and dehydroascorbic acid) is an enzyme cofactor for biochemical reactions catalysed by mono-oxygenases, dioxygenases and mixed function oxygenases. Vitamin C plays an important role in the biosynthesis of collagen, is essential for the synthesis of carnitine and catecholamines, and is also involved in the metabolism of cholesterol to bile acids. Vitamin C in aqueous solution readily scavenges reactive oxygen and nitrogen species, as well as singlet oxygen and hypochlorite, and is part of the antioxidant network of the body (EFSA NDA Panel, 2013c). Frank vitamin C deficiency in children leads to scurvy but has been observed only after the sixth month of life in infants fed a diet consisting of cow's milk with no fruits and vegetables (Fomon, 2001).

Vitamin C is of low acute toxicity and available data on adverse effects are limited. No UL has been set by the Panel but available human data suggest that supplemental daily doses of vitamin C up to about 1 g in addition to normal dietary intakes in adults are not associated with adverse effects (EFSA, 2004b).

<u>0 to < 12 months</u>

The amount of vitamin C excreted via breast milk depends on the vitamin C status of the mother, and the vitamin C content in human milk reflects maternal vitamin C intake more than the infant's requirement (WHO/FAO, 2004). Therefore, vitamin C intakes from breast milk may result in intakes much higher than the requirement.

In its Opinion on DRVs for vitamin C (EFSA NDA Panel, 2013c), the Panel used the AI for vitamin C for infants in the second half of the first year of life set by the SCF (1993b). This AI was derived as three times the amount known to prevent scurvy.

The Panel considers that this value can also be extended to younger infants and considers that a vitamin C intake of 20 mg is adequate for the majority of infants aged from 0 to < 12 months.

<u>12 to < 36 months</u>

In its previous Opinion (EFSA NDA Panel, 2013c), the Panel had used isometric scaling from the AR for adults which was determined by the quantity of vitamin C that balances metabolic vitamin C losses (EFSA NDA Panel, 2013c) to derive an AR of 15 mg per day and a PRI of 20 mg per day for young children.

The Panel considers that a vitamin C intake of 20 mg per day is adequate for the majority of young children.

4.33. Choline

Choline is a component of phospholipids, which are critical for normal membrane structure and function. In addition, as the major precursor of betaine, choline is used by the kidney to maintain water balance and by the liver as a source of methyl groups for the removal of homocysteine in methionine formation. Choline is also used in the production of acetylcholine. Although there is significant capacity for biosynthesis of the choline moiety in the liver, choline deficiency can occur in humans. Adults deprived of dietary choline become depleted of choline in their tissues and develop liver and muscle damage (Zhu and Zeisel, 2005).

No UL has been set by the SCF for choline.

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0 to < 6 months

In human milk, the majority of choline is found as phospho- and glycerophosphocholine, with smaller amounts of free choline, phosphatidylcholine and sphingomyelin. Choline concentrations in human milk are influenced by choline intake and genetic polymorphisms. In one study (reported in two publications) choline levels were found to range between 144 to 170 mg/L (Ilcol et al., 2005; Allen, 2012). In a second study (Fischer et al., 2010) comparing breast milk concentrations in unsupplemented and supplemented mothers, the average choline content in breast milk amounted to 125 and 149 mg/L, respectively.

Assuming an average content of choline in breast milk of around 160 mg/L, the Panel considers that observed choline intakes from breast milk (i.e. 160 mg/L × 0.8 L) and rounding up to 130 mg per day are adequate for the majority of infants in the first half-year of life.

6 to < 12 months

No DRVs for choline have been set by the SCF (1993b) for infants in the first half of the second year of life, while the IoM (1998) derived an AI of 150 mg per day by extrapolation from the AI for younger infants or extrapolation from adults, yielding the same results.

Taking the AI of the IoM (1998) as a basis, the Panel considers that a choline intake of 150 mg per day is adequate for the majority of infants aged from 6 to < 12 months.

12 to < 36 months

No DRVs for choline have been set by the SCF (1993b). The IoM (1998) derived an AI of 200 mg per day by extrapolation from adults.

Taking the AI of the IoM (1998) as a basis, the Panel considers that a choline intake of 200 mg per day is adequate for the majority of young children.

Table 6 summarises the intakes of energy and nutrients which are considered by the Panel to be adequate for the majority of infants and young children.

Table 6: Summary of intakes of energy and nutrients which are considered adequate for the majority of infants and young children

Nutrient	Unit	0 to <6 months			6 to <12 months			12 to <36 months		
		Months	Boys	Girls	Months	Boys	Girls	Months	Boys	Girls
Energy	MJ/d	0-<1	1.5	1.4	6-<7	2.5	2.3	12	3.3	3.0
		1-<2	2.1	1.9	7-<8	2.7	2.4	24	4.3	4.0
		2-<3	2.2	2.0	8-<9	2.8	2.5	36	4.9	4.6
		3-<4	2.1	1.9	9-<10	2.9	2.6			
		4-<5	2.3	2.1	10-<11	3.0	2.7			
		5-<6	2.4	2.3	11-<12	3.1	2.8			
Protein	g/d	0-<1	---	---	6-<7	9	8	12	11	10
		1-<2	8	7	7-<8	11	10	18	11	11
		2-<3	8	8	8-<9	11	10	24	12	11
		3-<4	9	8	9-<10	11	10	36	13	13
		4-<5	9	8	10-<11	11	10			
		5-<6	9	8	11-<12	11	10			
Fats	E%	50-55			40			35-40		
LA	E%	4			4			4		
ALA	E%	0.5			0.5			0.5		
DHA	mg/d	100			100			100 (<24 months)		
DHA+EPA	mg/d	---			---			250 (>24 months)		
ARA	mg/d	140			---			---		
Carbohydrates	E%	40-45			45-55			45-60		
Fibre	g/d	---			---			10		
Water	mL/d	700-1000			800-1000			1100-1300		
Calcium	mg/d	200			400			600		
Phosphorus	mg/d	100			300			460		
Magnesium	mg/d	25			80			85		
Sodium	mg/d	120			170-370			170-370		
Chloride	mg/d	300			270-570			270-570		
Potassium	mg/d	400			800			800		
Iron	mg/d	0.3 (breast-fed infants)			8			8		
Zinc	mg/d	2 (breast-fed infants)			4			4		
Copper	mg/d	0.3			0.3			0.4		
Selenium	µg/d	12.5			15			20		
Iodine	µg/d	90			90			90		
Chromium		---			----			---		
Molybdenum	µg/d	2			10			15		
Manganese	mg/d	0.003			0.02-0.5			0.5		
Fluoride	mg/d	0.08			0.4			0.6		
Vitamin A	µg RE/d	350			350			400		
Vitamin D	µg/d	10			10			10		
Vitamin E	mg TE/d	3			5			6		
Vitamin K	µg/d	5			8.5			12		
Thiamin	mg/d	0.2			0.3			0.5		
Riboflavin	mg/d	0.3			0.4			0.8		
Niacin	mg NE/d	2			5			9		
Pantothenic acid	mg/d	2			3			4		
Pyridoxine	mg/d	0.1			0.4			0.7		
Biotin	µg/d	4			6			20		
Folate	µg DFE/d	65			80			100		
Cobalamin	µg/d	0.4			0.5			0.9		
Vitamin C	mg/d	20			20			20		
Choline	mg/d	130			150			200		

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5. Dietary intake

5.1. Dietary surveys

The Panel identified in total 29 publications reporting on nutrient intakes in infants and young children living in Europe.

Of these, nine surveys were conducted on a representative sample of the population in the country (i.e. Bulgaria (Petrova, 1998), Germany (Verzehrsstudie zur Ermittlung der Lebensmittelaufnahme von Säuglingen und Kleinkindern (VELS) (DGE, 2008), France (Fantino and Gourmet, 2008), Iceland (Thorsdottir et al., 2008), Ireland (IUNA, 2012), Italy (Sette et al., 2011), the Netherlands (de Boer et al., 2006; Ocké et al., 2008) and Norway (two surveys in different age groups) (Kristiansen et al., 2009; Overby et al., 2009).

Ten publications assessed dietary intakes at different time points in infants and young children participating in cohort studies, i.e. the German Dortmund Nutritional and Anthropometric Longitudinally Designed (DONALD) study (Hilbig, 2005; Schwartz et al., 2010), the UK Avon Longitudinal Study of Parents and Children (ALSPAC) (Noble and Emmett, 2001; Emmett et al., 2002; Rogers et al., 2003; Noble and Emmett, 2006), the UK Southampton Women's Survey (SWS) (Marriott et al., 2008; Marriott et al., 2009), and the Finnish Type 1 Diabetes Prediction and Prevention (DIPP) study (Kyttälä et al., 2008; Kyttälä et al., 2010).

One study (Lagström et al., 1997) recruited children included in the Special Turku Coronary Risk Factor Intervention Project (STRIP) cohort study to participate in a nutrition intervention and data from the group not receiving any intervention were included in the present evaluation of the Panel.

One publication reported on nutrient intakes in an intervention study conducted in one city in Denmark (Ulbak et al., 2004).

The remaining studies were cross-sectional studies conducted on a regional level in Flanders, Belgium (Huybrechts and De Henauw, 2007; Sioen et al., 2007), in Helsinki, Finland (Räsanen and Ylonen, 1992), in Oslo, Norway (Andersen et al., 2003; Andersen et al., 2004), in five counties of Greece (Manios, 2006) and in Iceland (Gunnarsdottir et al., 2008).

In most surveys, dietary intake was assessed by dietary records with two (non-consecutive) to seven assessment days, with the majority using three-day dietary records. Twenty-four-hour recalls were used in three surveys (Petrova, 1998; Manios, 2006; Noble and Emmett, 2006), and two studies used semi-quantitative food frequency questionnaires (SFFQs) (Kristiansen et al., 2009; Overby et al., 2009).

The Panel decided not to consider further the two Norwegian surveys (Kristiansen et al., 2009; Overby et al., 2009) that used a SFFQ because of possible overestimation of nutrient intakes by this assessment method.

The Panel also did not consider further the Bulgarian survey (Petrova, 1998), which was conducted in a situation of socioeconomic decline seriously affecting the purchasing power of the population and the food supply (FAO, 1997) in the country and thus may no longer be representative of the nutritional situation of Bulgarian infants and young children of today.

<u>0 to < 6 months</u>

One survey available for infants aged from 0 to < 6 months was conducted in a representative sample of infants in France (Fantino and Gourmet, 2008). Data were also available from the DONALD study (Hilbig, 2005; Schwartz et al., 2010) and the ALSPAC study (Noble and Emmett, 2006).

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While the data reported from the DONALD study (Hilbig, 2005; Schwartz et al., 2010) included intakes from both breast-fed and formula-fed infants at three months of age, the data presented in the reports from the ALSPAC study (Noble and Emmett, 2006) and by Fantino and Gourmet (2008) were derived from formula-fed infants at the age of four months and one to three months, respectively. These surveys included a total of 925 infants with a range of 64 to 262 infants per study group.

In all surveys conducted in this population group, mean and median energy and protein intakes were generally above the AR for energy or PRI for protein while mean and median vitamin D intakes were systematically below the AI. Mean or median intakes below the AI were also observed for vitamin E, thiamin, copper, iron and zinc in one study (Hilbig, 2005) and for folate in two surveys (Hilbig, 2005; Noble and Emmett, 2006).

6 to < 12 months

For infants in the second half of the first year of life, intake data were available from nine publications, of which four included data obtained in a representative sample of infants: the German VELS study (DGE, 2008) on infants aged between 6 and 12 months: the Dutch National Food Consumption Survey (de Boer et al., 2006) for 9-month-old infants the study by Thorsdottir et al. (2008) in 9- and 12-month-old Icelandic infants; and the study by Fantino and Gourmet (2008), from which data at 6 months and 10 to 12 months were considered by the Panel.

Data were available from the German DONALD study (Hilbig, 2005; Schwartz et al., 2010) for children aged six and nine months, from the UK SWS study (Marriott et al., 2008) for children aged six months, from the ALSPAC study (Noble and Emmett, 2001) for eight-month-old infants and from a sample of children participating in the Finnish STRIP study (Lagström et al., 1997) also for eight-month-old infants.

These surveys included a total of 2 785 infants, with between 43 and 618 infants per surveyed group.

As for younger infants, mean and median energy and protein intakes were above the AR or PRI, respectively. For vitamin D and iron, almost all studies reported mean and median intakes below the AI and PRI, respectively. Mean and median vitamin E and zinc intakes below the AI and the PRI, respectively, were reported for the two German surveys (Hilbig, 2005; DGE, 2008). Mean and median magnesium intakes just at the AI were reported in two surveys from the UK and France (Fantino and Gourmet, 2008; Marriott et al., 2008). Mean DHA intakes well below the AI were reported in the German DONALD study (Schwartz et al., 2010). However, DHA intakes in this study did not follow a normal distribution and any conclusions based on mean intakes may therefore not be robust.

12 to < 36 months

Nutrient intakes in young children were reported in 21 publications, of which six reported on five representative surveys in young children in the country. These were the publications by de Boer et al. (2006) and Ocké et al. (2008) for the Netherlands, reporting on intakes of 12- and 18-month-old children and two- to three-year-old children, respectively; the survey coordinated by IUNA (2012) for Ireland, from which data for one-, two- and three-year-old children were available; the VELS study (DGE, 2008) for Germany, which provided intakes for children aged 1 to 3.9 years; the study by Sette et al. (2011) for Italy, reporting on intakes in children aged 0 to 2.9 years; and the study by Fantino and Gourmet (2008) in France, from which data on children aged 19 to 24 months and 31 to 36 months were considered.

From the cohort studies. four publications provided data for 12-month-old children from the UK, Germany and Finland (Hilbig, 2005; Kyttälä et al., 2008; Marriott et al., 2009; Kyttälä et al., 2010), two for 18-month-old children from the UK (Emmett et al., 2002; Rogers et al., 2003), and three publications each for two- and three-year-old children from Germany and Finland (Hilbig, 2005; Kyttälä et al., 2008; Kyttälä et al., 2010).

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The regionally conducted studies investigated Norwegian children aged 12 and 24 months (Andersen et al., 2003; Andersen et al., 2004), Greek children aged one to three years (Manios, 2006), Finnish children aged one to three years (Räsanen and Ylonen, 1992; Lagström et al., 1997), Belgian children aged 30–48 months (Huybrechts and De Henauw, 2007; Sioen et al., 2007), Danish children at the age of 2.5 years (Ulbak et al., 2004) and Icelandic children at the age of three years (Gunnarsdottir et al., 2008).

These studies reported on a total of 9 107 children with 46 to 824 children per surveyed group.

Reported mean and median energy and protein intakes of young children were in all surveys above the AR or PRI, respectively, and reported iron, vitamin D and vitamin E intakes were generally below the PRI or AI, respectively. In addition, in around half of the surveys fibre intakes did not reach the AI. Mean and/or median vitamin A, DHA, thiamine, and selenium intakes below the AI or PRI were reported in one survey each (i.e. Finland, vitamin A (Kyttälä et al., 2008; Kyttälä et al., 2010); Belgium, DHA (Sioen et al., 2007); Germany, thiamin (Hilbig, 2005), the Netherlands, selenium (de Boer et al., 2006)). For calcium the surveys in German and Norwegian children reported intakes below the PRI (Andersen et al., 2003; Andersen et al., 2004; Hilbig, 2005; DGE, 2008). Intakes below the PRI for iodine were reported in German children (Hilbig, 2005; DGE, 2008) but not in the surveys from the UK and Finland (Emmett et al., 2002; Kyttälä et al., 2008; Kyttälä et al., 2010).

5.2. Risk of inadequate nutrient intakes

The Panel notes that intakes below the values which were considered by the Panel to be adequate for the majority of infants and young children do not necessarily mean that intakes in the given population group are at risk of inadequacy.

As outlined in section 3.1, if values that were considered adequate by the Panel for the majority of infants or young children were based on AIs and observed mean intakes were below these AIs, no conclusions can be drawn with respect to the risk of inadequacy of nutrient intakes in this population group without additional information on the nutrient status of the population, whereas groups with mean intakes at or above the AI can be assumed to have a low risk of inadequate intakes. Therefore, the Panel will not address further those nutrients of which the mean intakes of infants and young children studied in the dietary surveys described above were at or above the AI, i.e. biotin, riboflavin, magnesium, molybdenum and pantothenic acid, and for which overt deficiencies in infants and young children living in Europe have not been reported.

Even though it cannot be taken for granted that groups with mean or median intakes above the PRI have a low risk of inadequate intakes, the Panel decided not to consider further niacin, vitamin C, pyridoxine, cobalamin and phosphorus, of which observed mean intakes were generally at or above the PRI and overt deficiencies in infants and young children living in Europe have not been reported.

The Panel will also not address further fluoride, chromium, manganese and choline, for which no or only very limited intake data were available in the absence of any reported deficiencies in infants and young children living in Europe.

Intakes of sodium and potassium are generally above the PRI once complementary feeding is introduced. However, the Panel considers that these levels of intakes do not raise any specific concerns even though no ULs for sodium, potassium and chloride were derived by the Panel owing to insufficient data (EFSA, 2005a, 2005d, 2005c). These nutrients will therefore not be addressed further.

Furthermore, the Panel considers that intakes of water and carbohydrates in infants and young children living in Europe are not of concern and will not consider them further.

The Panel will therefore address in the following section whether intakes of energy, protein, essential fatty acids and n-3 PUFAs, dietary fibre, calcium, iron, zinc, copper, selenium, iodine, vitamin A,

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vitamin D, vitamin E, vitamin K, thiamin and folate in infants and children living in Europe are at risk of being inadequate.

5.2.1. Energy

The Panel notes that observed average energy intakes in infants and young children living in Europe are generally above the AR. This Panel considers that energy intakes above requirements will lead to an unfavourable gain in body mass.

5.2.2. Protein

As for energy, protein intakes in infants and young children living in Europe were above the AR in all surveys and all population groups and were around 9 E% in infants aged from 0 to < 6 months, 10 to 15 E% in infants in the second half of the first year of life and 12 to 19 E% in young children.

In infants, a very high protein intake (around 20 E%) can impair the water balance, particularly when no other liquids are consumed and/or extrarenal water losses are increased. Consequently, such high protein intakes should be avoided in the first year of life. In adults, intakes of three to four times the PRI have been observed without apparent adverse effects or benefits (EFSA NDA Panel, 2012a).

The Panel considers that there is no conclusive evidence that protein intakes of the magnitude observed in the surveys considered by the Panel have adverse health consequences in the short or long term.

5.2.3. Essential fatty acids and LC-PUFAs

There are numerous reports on the fatty acid composition of breast milk from different European countries, but information on intakes of essential fatty acids and LC-PUFAs in infants aged less than six months were available only for German infants (Hilbig, 2005; Schwartz et al., 2010). In these infants mean intakes ranged from 5.81 to 6.70 E% for LA and from 0.67 to 0.77 E% for ALA. This is above the AI for LA of 4 E% and for ALA of 0.5 E% for infants aged from 0 to < 6 months. Intakes of ARA were reported to be 103 ± 55 mg per day, which is below the AI of 140 mg per day, and intakes of DHA were 57 ± 38 mg per day, which is below the AI of 100 mg per day for infants aged from 0 to < 6 months.

In the case of infants aged from 6 to < 12 months, mean intakes of LA in Germany (Schwartz et al., 2010), France (Fantino and Gourmet, 2008), the Netherlands (de Boer et al., 2006) and Finland (Lagström et al., 1997) were reported to be in the range of 3.4 to 6.8 E%, which is mostly above the AI of 4 E% for infants in the second half of the first year of life, except in the case of 10- to 12-month-old French infants, whose mean intake was reported to be 3.4 E%.

Mean intakes of ALA ranged from 0.46 to 0.86 E%, with intake being below the AI of 0.5 E% again only in French infants aged 10 to 12 months. Information on DHA intakes was available only from the German DONALD study, with mean intakes of 47 ± 119 mg per day at six months. The Panel notes the skewed intake distribution and considers that in the absence of information on median intakes no conclusions can be drawn from these values.

Information on fatty acid intakes in young children was available for French (Fantino and Gourmet, 2008), Dutch (de Boer et al., 2006), Belgian (Sioen et al., 2007) and Finnish (Räsanen and Ylonen, 1992; Lagström et al., 1997) children. Mean LA intakes ranged from 2.70 to 4.62 E%, with mean intakes generally below the AI of 4 E% and only Belgian children and some sub-groups of Finnish and Dutch children having intakes above the AI. Mean intakes of ALA were below or at the AI of 0.5 E% and ranged from 0.32 to 0.50 E%. A mean DHA intake of 43 mg per day was reported for Belgian children (no SD provided) with an IQR of 5–39 mg per day.

Intake of essential fatty acids is reflected in tissue levels of these fatty acids. Erythrocyte (red blood cell, RBC) LA and DHA and plasma levels of these fatty acids are generally accepted as good

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biomarkers of intake over the past months and thus markers of n-6 and n-3 PUFA status. Deficiency of LA is indicated by appearance of the unusual Mead acid (20:3, n-9) in plasma, but no studies have reported any significant levels of this fatty acid in plasma of infants and young children living in Europe. It has been observed in adults that there is a positive association between the intake of total n-3 PUFAs and RBC DHA concentrations, which levels off at about 8 % of total fatty acids (Harris et al., 2008). However, no well-defined cut-off levels for status markers have been set to indicate deficiency/sufficiency of n-3 PUFAs in infants and young children.

The RBC DHA levels in nine-month-old healthy Danish infants has been shown to range from 2 to 12 % of total fatty acids (Engel et al., 2013). In another cohort of Danish infants, the mean (± SD) RBC DHA levels were found to be 6.6 ± 1.9 % of total fatty acids at nine months (n = 409) and 7.1 ± 1.3 % of total fatty acids at three years (n = 176) (Harsløf et al., 2013). The mean RBC DHA concentration in 183 Dutch neonates was found to be 4.73 % of total fatty acids (Vlaardingerbroek and Hornstra, 2004). These levels have been shown to be determined by fatty acid desaturase genotype, fish intake and breast-feeding (Harsløf et al., 2013).

The Panel notes that data on intakes and status of LA in infants and young children living in Europe are of no concern.

The Panel notes that mean intakes of both ALA and DHA have been reported to be below the AI in some populations of infants and young children. The Panel considers that, in the absence of a clear relationship between intakes or biomarkers of n-3 PUFA status and clinical outcomes, the risk of inadequate intakes of ALA and DHA in infants and young children living in Europe cannot be quantified.

5.2.4. Dietary fibre

In young children, mean fibre intakes ranges from around 6 to 15 g per day, with around half of the surveys reporting mean intakes below the AI of 10 g per day for young children.

The Panel considers that, even though mean fibre intakes below the AI have been observed in some surveys, these levels of intake are not of concern.

5.2.5. Calcium

In none of the surveys were mean or median calcium intakes in infants and young children below the AI (200 and 400 mg per day for infants aged from 0 to < 6 months and from 6 to < 12 months, respectively) or AR (470 mg per day for young children) for the age group.

In the Dutch national survey (Ocké et al., 2008) the P5 of calcium intakes of two- to three-year-old boys was 452 mg per day and that of girls was 432 mg, which in both cases is below the AR of 470 mg per day for young children. For Irish children (IUNA, 2012), calcium intakes at P5 were 440, 416 and 386 mg per day at the ages of one, two and three years, respectively. However, almost 50 % of the Norwegian one- and two-year-old children (Andersen et al., 2003; Andersen et al., 2004) had calcium intakes below the AR.

Serum calcium concentrations are of limited use as a biomarker as they are tightly controlled and therefore do not reflect calcium status. In addition, urinary calcium excretion is of limited use as it can be influenced by factors other than calcium status, such as by vitamin D status.

The Panel considers that calcium intakes in infants and young children living in Europe generally do not give rise to concern over the risk of inadequate intakes.

5.2.6. Iron

None of the surveys reporting on iron intakes in infants below the age of six months reported mean or median intakes below the AI for infants aged from 0 to < 6 months of 0.3 mg per day. For infants in

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the second half of the first year of life and young children, the Panel will compare intakes with the AI of 8 mg per day set by Nordic Council of Ministers (2013).

Median/mean intakes below the AI of 8 mg per day infants aged from 6 to < 12 months were observed in British infants at six and eight months of age (Noble and Emmett, 2001; Marriott et al., 2008) and in German infants at six and nine months (Hilbig, 2005) and at 6 to 12 months (DGE, 2008) of age, as well as in 9- and 12-month-old Icelandic infants (Thorsdottir et al., 2008). More than 50 % of the British infants (P50: 6.9 mg per day) studied by Marriott et al. (2008) and around 25 % of Dutch infants (P25: 8.3 mg per day) (de Boer et al., 2006) had intakes below the AI.

In almost all surveys which investigated iron intakes in Dutch, Irish, German, Italian, French, British, Finish, Norwegian, Belgian and Icelandic young children, iron intakes were below the AI of 8 mg for young children (Räsanen and Ylonen, 1992; Emmett et al., 2002; Andersen et al., 2003; Rogers et al., 2003; Andersen et al., 2004; Hilbig, 2005; de Boer et al., 2006 ; Huybrechts and De Henauw, 2007; DGE, 2008; Fantino and Gourmet, 2008; Gunnarsdottir et al., 2008; Kyttälä et al., 2008; Ocké et al., 2008; Marriott et al., 2009; Kyttälä et al., 2010; Sette et al., 2011; IUNA, 2012), except for 12-month-old Dutch children (de Boer et al., 2006).

Information on the use of supplements was available for one- to three-year-old Finnish young children (Kyttälä et al., 2010): such use was reported in 0.7–4 % of children, contributing, on average, around 7.5–12.1 mg per day to iron intakes.

A number of laboratory tests can be used to assess iron status, including determining serum ferritin (SF) concentrations, free erythrocyte protoporphyrin concentrations, zinc protoporphyrin–haem ratio, transferrin saturation (TSAT), serum transferrin receptor (TfR) concentrations, haemoglobin (Hb) concentrations or haematocrit and RBC indices (AAP Committee on Nutrition, 2009), with different markers estimating different aspects of iron status (Aggett et al., 2002). In spite of this plethora of markers of iron status, none of them is sufficiently validated in children (Domellöf et al., 2002b) and none of them is suitable to assess iron deficiency in the absence of anaemia (Aggett et al., 2002). Furthermore, reference ranges and cut-offs for the different iron status biomarkers are poorly defined in infants and young children, and the use of cut-offs defined for older ages is usually inappropriate for infants and young children owing to the large physiological changes in iron status and RBC morphology occurring during the first year of life (Domellöf et al., 2002b). SF is the most specific biochemical marker because it is correlated with total body iron stores, and low SF concentrations reflect depleted iron stores in the absence of inflammation, but are difficult to interpret at times of rapid systemic iron use, such as during rapid growth. Although SF concentrations during the first part of infancy seem to reflect relative changes in iron stores, no firm data indicate the exact cut-offs for when iron stores are depleted with functional consequences. Therefore, concentrations below the cut-off do not necessarily reflect depleted iron stores and the cut-off values currently in use with respect to anaemia (Hb < 110 g/L) and depleted iron stores (SF < 12 µg/L) may overestimate the prevalence of iron depletion and iron deficiency anaemia (Aggett et al., 2002).

In a cross-sectional sample of the Euro-Growth study (Male et al., 2001) iron status was determined in 488 healthy term infants at 12 months of age from 11 study centres (i.e. Athens, Bilbao, Budapest, Dublin, Madrid, Naples, Porto, Rostock, Santiago, Umeå and Vienna) with the objective of assessing the prevalence of iron deficiency and iron deficiency anaemia in a representative sample of European infants. Iron deficiency was defined as the presence of two or more abnormal values of four iron status indicators: mean corpuscular volume (MCV) (< 70 fL), SF concentration (< 10 µg/L), TSAT (< 10 %) and serum TfR concentrations (> 4.4 mg/L). Iron deficiency anaemia was defined as Hb < 110 g/L plus two or more abnormal values of iron status indicators. Iron deficiency was observed in 7.2 % of the sample, with a higher prevalence in boys (9.2 %) than in girls (4.8 %). Iron deficiency anaemia occurred in 2.3 % of the sample (3.1 % of all boys surveyed and 1.3 % of girls). Duration of cow's milk consumption in this study was negatively correlated with iron status and formula feeding was associated with a lower risk of iron deficiency. Iron deficiency anaemia was significantly more frequent in children from a low (5.1 %) than from a high socioeconomic background (0 %).

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Several studies assessed iron status in infants and young children at a national or regional level in European countries. However, different definitions of iron depletion, iron deficiency and iron deficiency anaemia and different cut-off values used in these studies make comparisons of the prevalence of iron deficiency in different populations difficult. While iron deficiency was distinguished from iron depletion in some studies by applying additional criteria other than SF concentrations, this was not done in other studies, in which iron deficiency was considered to occur when SF concentrations were below a certain cut-off value. For the purpose of the present Opinion, iron deficiency will be taken to have occurred when additional status markers were included in the definition of iron deficiency by the authors. Results based on SF concentrations will be classified only as iron depletion. The results of these studies are summarised in Tables 7 to 9.

Table 7: Prevalence of iron depletion reported in studies conducted in infants and young children in Europe on a national or regional level

Iron depletion					**Defined as**
Study	Country	Age	n	Prevalence	SF (µg/L)
Tuthill et al. (2002)	UK	3 mo	88	1.1 %	<10
Dube et al. (2010a)	DE	4 mo	76	6 % breast-fed 4 % formula-fed	<12
Lind et al. (2003)	SE	6 mo	467	9 %	<12
Hay et al. (2004)	NO	6 mo	281	4 %	<12
Hay et al. (2004)	NO	6 mo	281	2 %	<10
Michaelsen et al. (1995)	DK	6 mo	57	0 %	<13
Öhlund et al. (2008)	SE	6 mo	105	7 %	<12
Dube et al. (2010a)	DE	7 mo	76	19 % breast-fed 0 % formula-fed	<12
Hopkins et al. (2007)	UK	8 mo	649	3 %	<16
Capozzi et al. (2010)	IT	8 mo	385	8.1 %	<15
Gondolf et al. (2013)	DK	9 mo	260	7.8 %	<12
Michaelsen et al. (1995)	DK	9 mo	94	2 %	<13
Dube et al. (2010a)	DE	10 mo	76	21 % breast-fed 0 % formula-fed	<12
Vendt et al. (2007)	EE	9-12 mo	171	31.6 %	<12 or MCV < 74 fL
Lind et al. (2003)	SE	12 mo	467	16 %	<12
Bramhagen et al. (2011)	SE	12 mo	87	10.3 %	≤12
Thorisdottir et al. (2012)	IS	12 mo	255	21.8 %	≤12
Thorisdottir et al. (2013a)	IS	12 mo	108	5.7 %	<12
Hay et al. (2004)	NO	12 mo	249	10 %	<12
Hay et al. (2004)	NO	12 mo	249	5 %	<10
Hopkins et al. (2007)	UK	12 mo	644	5 %	<16
Thorisdottir et al. (2011)	IS	12 mo	141	5.8 %	<12
Thorsdottir et al. (2003)	IS	12 mo	111	41 %	<12
Freeman et al. (1998)	IE	12 mo	121	23 %	<10
Capozzi et al. (2010)	IT	12 mo	302	6.2 %	<15
Tuthill et al. (2002)	UK	12 mo	76	5.2 %	<10
Öhlund et al. (2008)	SE	12 mo	105	18 %	<12
Öhlund et al. (2008)	SE	18 mo	105	12 %	<12
Gompakis et al. (2007)	GR	8 mo-2 y	369	34.1 %	<10
Hay et al. (2004)	NO	24 mo	231	13 %	<12
Hay et al. (2004)	NO	24 mo	231	9 %	<10
Freeman et al. (1998)	IE	24 mo	121	50 %	<10
Bramhagen and Axelsson (1999)	SE	2.5 y	367	10 %	<12
Freeman et al. (1998)	IE	3 y	121	46 %	<10
Thane and Bates (2000)	UK	1.5-3 y	334	34 % (omnivores)	<12
Thane and Bates (2000)	UK	1.5-3 y	11	73 % (vegetarians)	<12
Grant (1990)	UK	1-4 y	311	17 %	<10 or MCV < 75 fl
Gibson (1999)	UK	1.5-4.5 y	904	20 %	<10
Thane et al. (2000)	UK	1.5-4.5 y	1003	20 %	<10
Gompakis et al. (2007)	GR	2-6 y	676	24.4 %	<10

mo: months, y: years

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Table 8: Prevalence of iron deficiency reported in studies conducted in infants and young children in Europe on a national or regional level

Study	Iron deficiency Country	Age	n	Prevalence	Defined as SF (µg/L)	S-iron (µmol/L)	MCV (fL)	TSAT (%)	TfR (mg/L)
Bramhagen et al. (2011)	SE	12 mo	87	2.3 %	≤12[(a)]	---	≤72	---	<2.5
Thorisdottir et al. (2011)	IS	12 mo	141	1.4 %	<12	---	<74	---	---
Thorsdottir et al. (2003)	IS	12 mo	114	20 %	<12	---	<74	---	---
Gunnarsson et al. (2004)	IS	2 y	71	9 %	<12	---	<74	---	---
Bramhagen and Axelsson (1999)	SE	2.5 y	367	10 %	<12[(b)]	<10	≤75	<10	---

(a): At least two out of three abnormal parameters
(b): SF < 12 µg/L plus one abnormal other parameter or SF in the range of 12–19 µg/L plus MCV and TSAT at abnormal level
mo: months, y: years, S: serum

Table 9: Prevalence of iron deficiency anaemia reported in studies conducted in infants and young children in Europe on a national or regional level

Study	Iron deficiency anaemia Country	Age	n	Prevalence	Defined as SF (µg/L)	S-iron (µmol/L)	MCV (fL)	TSAT (%)	Hb (g/L)
Dube et al. (2010a)	DE	4 mo	76	0 %	<12	---	---	---	<105
Lind et al. (2003)	SE	6 mo	467	2 %	<12	---	<73	---	<110
Hay et al. (2004)	NO	6 mo	281	3 %	<15	---	---	---	<110
Hay et al. (2004)	NO	6 mo	281	1 %	<15	---	<73	---	<110
Dube et al. (2010a)	DE	7 mo	76	4 %	<12	---	---	---	<105
Gondolf et al. (2013)	DK	9 mo	260	0.7 %	<12	---	---	----	<100
Dube et al. (2010a)	DE	10 mo	76	2 %	<12	---	---	---	<105
Vendt et al. (2007)	EE	9-12 mo	171	9.4 %	<12	---	<74	----	<105
Lind et al. (2003)	SE	12 mo	467	1 %	<12	---	<73	---	<110
Thorisdottir et al. (2011)	IS	12 mo	141	0 %	<12	---	<74	---	<105
Thorsdottir et al. (2003)	IS	12 mo	114	2.7 %	<12	---	<74	---	<105
Hay et al. (2004)	NO	12 mo	249	10 %	<15	---	---	---	<110
Hay et al. (2004)	NO	12 mo	249	3 %	<15	---	<73	---	<110
Tympa-Psirropoulou et al. (2005)	GR	1.5 y	938	8 %	<10	---	<70	<14	<110
Hay et al. (2004)	NO	24 mo	231	12 %	<15	---	---	---	<110
Hay et al. (2004)	NO	24 mo	231	4 %	<15	---	<73	---	<110
Gompakis et al. (2007)	GR	0.8 mo-2y	369	16.1 %	<10	---	---	---	<110
Gunnarsson et al. (2004)	IS	2 y	71	1.4 %	<12	---	<74	---	<105
Bramhagen and Axelsson (1999)	SE	2.5 y	367	7 %	<12[(a)]	<10	≤75	<10	<110
Grant (1990)	UK	1-4 y	311	2.5 %	<10[(b)]	---	<75	---	<105
Thane and Bates (2000)	UK	1.5-3 y	334	5 % (omnivores)	<12	---	---	---	<110
Thane and Bates (2000)	UK	1.5-3 y	11	18 % (vegetarians)	<12	---	---	---	<110
Thane et al. (2000)	UK	1.5-4.5 y	1003	3.4 %	<10	---	---	---	<110
Gompakis et al. (2007)	GR	2-6 y	676	3.4 %	<10	---	---	---	<110

(a): Iron deficiency + abnormal Hb concentrations
(b): Either SF < 10 µg/L or MCV < 75 fL
mo: months, y: year, S: serum

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The Panel notes that the prevalence of iron depletion (according to SF concentrations) as reported in national or regional surveys in European infants aged 0 to < 6 months ranged from 1 to 6 %. Among infants aged 6 to < 12 months, the prevalence of iron depletion ranged from 0 to around 32 %, and among young children it ranged from around 5 to 50 %. However, study populations were not necessarily representative of the population of the country in which the study was carried out. The prevalence of iron deficiency in Europe was estimated in a representative sample of European 12-month-old children at 7.2 %. In national and regional surveys, the prevalence of iron deficiency in young children was found to be around 1 to 20 %. The prevalence of iron deficiency anaemia in Europe was reported to be 2.3 % in a representative sample of European 12-month-old children. In national and regional surveys, the prevalence of iron deficiency anaemia was found to be 0 % in one study in infants < 6 months of age, 0.7 to 9.4 % in infants in the second half-year of life and 0 to 10 % in young children. However, these estimates are highly dependent on the cut-off values used and therefore difficult to compare.

In view of the poor iron status of some sub-groups of infants and young children living in Europe, the Panel considers that an inappropriate supply of dietary iron may increase the risk of inadequacy in some populations of infants and young children. However, there may be other reasons for this than an inappropriate supply of dietary iron, and the causes of poor iron status should be further investigated.

5.2.7. Zinc

In none of the studies investigating zinc intakes in infants below six months of age were mean intakes below the AI of 2 mg per day. For infants in the second half of the first year of life, only the study by Hilbig (2005) reported mean (2.8 mg per day) and median (3.1 mg per day) intakes below the AR of 3.15 mg for infants of this age range, while none of the 13 surveys reporting on this nutrient observed intakes in young children below the AR of 3.15 mg.

Only around 5 % of Irish children (P5 at one year and two years 3.0 mg and at three years 3.1 mg per day) (IUNA, 2012) and Dutch children (P5 at two to three years: 3.5 mg in boys and 3.4 mg in girls) (Ocké et al., 2008) had zinc intakes below the AR. Other surveys did not report on a sufficient number of percentiles to make any judgement.

There is a lack of sensitive biomarkers of zinc status. Plasma or serum zinc concentrations, albeit imperfect, are the most commonly used biomarkers of zinc status. The major biological limitations of plasma/serum zinc concentration include its low sensitivity to indicate marginal zinc status, its responsiveness as a negative acute-phase reactant to acute and chronic inflammation and its fluctuation in response to meals and time of day (Krebs, 2013).

On a population basis, WHO has recommended three indicators for assessing zinc status with cut-offs for the prevalence considered indicative of elevated risk and of public health concern. These indices are prevalence of inadequate zinc intakes > 25 %, prevalence of low serum zinc concentrations > 20 % and stunting > 20 % (de Benoist et al., 2007). No universally agreed cut-off values for low plasma/serum zinc concentrations are available, but a value of 10.7 µmol/L has been suggested by WHO/FAO (2006).

In a study in 66 French infants and young children aged less than three years (Bouglé et al., 2000), 21 % showed a serum zinc concentration < 12 µmol/L, the cut-off value applied in this study. In another study in 300 Swedish infants (Lind et al., 2003), serum zinc concentrations < 10.7 µmol/L were observed in 22 % of six-month-old infants and around 25 % 12-month-old infants. In Turkish infants, serum zinc concentrations < 10.7 µmol/L were observed in 17 % of 111 two-month-old infants, in 21 % of 132 six-month-old infants and in 13 % of 136 one-year-old infants (Özden et al., 2012). In a sample of 100 Turkish breast-fed infants and young children between the age of 6 and 28 months (Sezer et al., 2013), 56 % were reported to have zinc concentrations < 10.7 µmol/L. In Belgian infants and children, mean (± SD) serum zinc concentrations were reported to be 11.6 ± 2.81 µmol/L in 126 infants aged up to one year and 12.8 ± 3.7 µmol/L in 157 children aged one

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to four years. Around 25 % of the studied population of children aged 0 to 14 years had serum zinc concentrations below 10.4 µmol/L (Van Biervliet et al., 2003).

The Panel notes that the majority of infants and young children studied in the surveys considered by the Panel had zinc intakes above the AR. The results of studies investigating plasma/serum zinc concentrations could be interpreted as suggesting that zinc status is inadequate in a significant proportion of healthy infants and young children living in Europe. However, the Panel notes that plasma/serum zinc concentrations are not a sensitive marker of zinc status and that overt zinc deficiency with stunting in infants and young children living in Europe has not been reported.

The Panel considers that in the absence of a sensitive marker of marginal zinc deficiency, which is more likely to occur in infants and young children living in Europe than overt zinc deficiency with stunting, the risk of inadequate zinc intakes in infants and young children living in Europe cannot be quantified.

5.2.8. Copper

Only one survey investigated dietary copper intakes of infants below six months of age (Hilbig, 2005). Mean intakes were at the AI of 0.3 mg per day, with the median (0.2 mg per day) below the AI.

The two surveys (Hilbig, 2005; Marriott et al., 2008) which reported on copper intakes in infants in the second half of the first year of life both reported mean and median intakes well above the AR of 0.22 mg per day for infants aged from 6 to < 12 months. For young children, copper intakes were available from a representative sample of Irish (IUNA, 2012) and Dutch (Ocké et al., 2008) children, as well as for German (Hilbig, 2005), British (Marriott et al., 2009) and Finnish (Räsanen and Ylonen, 1992) children. For young children, too, mean and median intakes were well above the AR of 0.29 mg per day in all of these surveys.

Around 95 % of one- to three-year-old Irish children (IUNA, 2012) and two- to three-year-old Dutch children (Ocké et al., 2008) and around 75 % of British children (Marriott et al., 2009) had intakes above the AR. Other surveys did not report on a sufficient number of percentiles to make any judgement.

Markers of copper status have been reported to be copper in serum or plasma (640 to 1 560 µg/L), caeruloplasmin in serum (180 to 400 mg/L), and activity of copper/zinc superoxide dismutase (CuZn-SOD), glutathione peroxidase or cytochrome C oxidase.

Copper concentrations in serum or plasma increase with infant age. This is believed to be a physiological increase due to changes in infant copper metabolism during the first year of life, and infant copper concentrations in serum may not accurately reflect copper status, at least up to the age of nine months (Domellöf et al., 2005). Low plasma/serum concentrations of copper are nearly always a consequence of severe copper deficiency, but plasma/serum copper concentrations are insensitive to marginal copper deficiency, a condition more likely to occur in infants than overt clinical deficiency (Lönnerdal, 1998; Milne, 1998).

Copper status was investigated in a study in 96 healthy Swedish infants. Mean (± SD) plasma copper concentrations were 910 ± 210 µg/L at four months, 1 040 ± 230 µg/L at six months and 1 090 ± 220 µg/L at nine months. CuZn-SOD activity at nine months was 0.93 ± 0.21 U/mg Hb (Domellöf et al., 2005). In another study in Turkey (Gürgöze et al., 2006) examining 49 healthy and 52 anaemic children between one and four years of age, mean ± SD serum copper concentration was reported to be 1 391 ± 241 µg/L and 1 595 ± 368 µg/L, respectively.

The Panel notes that the percentage of European infants and children with copper intakes below the AR is low and that the results of two studies investigating plasma/serum copper concentrations in healthy infants and young children do not raise any concerns.

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The Panel considers that copper intakes in infants and young children living in Europe generally do not give rise to concern over the risk of inadequate intakes.

5.2.9. Selenium

No information on selenium intakes in infants below six months of age was available. For infants in the second half of the first year of life, the only survey which reported selenium intakes was the Dutch national survey (de Boer et al., 2006), in which a mean ± SD selenium intake of 19 ± 4 µg (median: 19 µg) per day for infants at the age of nine months was reported. This is well above the AI of 15 µg per day for infants aged from 6 to < 12 months.

Mean and median selenium intakes in young children reported in Finland, Iceland and the Netherlands (Räsanen and Ylonen, 1992; de Boer et al., 2006; Gunnarsdottir et al., 2008; Kyttälä et al., 2008; Ocké et al., 2008; Kyttälä et al., 2010) were above the AR for young children of 17 µg per day.

Around 95 % of Dutch children aged two to three years old had selenium intakes above the AR (Ocké et al., 2008). Other surveys did not report on a sufficient number of percentiles to make any judgement.

Selenium concentrations in plasma/serum are a biomarker for selenium status, but can be influenced by age, diseases and the chemical nature of the dietary selenium. Functional markers of selenium status are selenoprotein P levels in plasma or GPX activity in plasma, platelets and blood. Selenium intakes that are associated with maximal activity of selenoproteins, particularly selenoprotein P, can serve as indicators of selenium requirement (Fairweather-Tait et al., 2011).

A cut-off value of 0.8 to 1.1 µmol/L of selenium in plasma/serum has been proposed for all population groups to define selenium deficiency (WHO/FAO, 2006). However, the Panel notes the limitation of this marker to characterise selenium deficiency because of its age dependency and the influence the chemical form of ingested selenium has on this marker.

A study aimed at establishing age-related reference values for selenium concentrations in serum of infants and children (Muntau et al., 2002) reported reference ranges (P2.5 to P97.5 of a sample of 166 German infants and 221 young children aged one to five years) for selenium concentrations in serum for different age groups as 0.19–1.35 µmol/L for infants less than one month of age; 0.19-1.27 µmol/L for infants aged one to two months; 0.13–1.18 µmol/L for infants aged two to four months; 0.17–1.47 µmol/L for infants aged 4–12 months; and 0.43–1.63 µmol/L for young children aged one to five years. Median serum concentrations of selenium in this study were 0.64 µmol/L for infants aged less than one month, 0.44 µmol/L at two to four months, 0.62 µmol/L at 4 to 12 months and 0.90 µmol/L in young children.

Mean/median plasma/serum selenium concentrations were reported to be 0.40 ± 0.18 µmol/L in one-month-old Italian infants (Strambi et al., 2004), 0.39–0.58 µmol/L in four-month-old German infants (Sievers et al., 2001), 0.30 ± 0.11 µmol/L in Polish infants aged 0 to 12 months and 0.36 ± 0.12 µmol/L in Polish children between one and three years of age (Wasowicz et al., 2003), 0.37 µmol/L in Belgian infants aged 0 to 12 months and 0.70 µmol/L in Belgian children aged one to four years (Van Biervliet et al., 2001), 0.94 ± 0.12 µmol/L in one- to two-year-old Slovenian children (Mičetić-Turk et al., 1996), and 1.25 µmol/L in Finnish children aged below three years (Wang et al., 1998). In Finland selenium supplementation is implemented through the addition of selenium to fertilisers.

The Panel notes that only limited information on dietary intakes of selenium in infants and young children living in Europe is available, but that reported levels selenium intake do not give rise to concern. The Panel also notes the limitation of plasma/serum selenium concentrations as a marker of selenium status.

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The Panel considers that selenium intakes in infants and young children living in Europe generally do not raise give rise to concern over the risk of inadequate intakes.

5.2.10. Iodine

Only two of the surveys investigated dietary iodine intake in infants below six months of age. Both reported mean and median iodine intakes below the proposed AI (i.e. 90 µg per day) for infants aged from 0 to < 6 months (Hilbig, 2005; Noble and Emmett, 2006). In three-month-old German infants (Hilbig, 2005), median iodine intakes were reported to be 17.9 µg per day. In British four-month-old infants (Noble and Emmett, 2006), mean intakes were reported to be 50 ± 18 and 54 ± 19 µg per day (median 49 and 52 µg per day) in girls and boys respectively.

In all four surveys which reported on iodine intakes in infants in the second half of the first year of life (Noble and Emmett, 2001; Hilbig, 2005; DGE, 2008; Thorsdottir et al., 2008) mean and median intakes were below the AI (i.e. 90 µg per day) for infants aged from 6 to < 12 months, with mean intakes ranging from 42 to 85 µg per day (median (where reported) 33 to 77 µg per day).

Two out of the five surveys which investigated dietary iodine intake in young children found mean and median intakes below the proposed AI for young children (i.e. 90 µg per day). These were the surveys conducted in German children (Hilbig, 2005; DGE, 2008), which reported mean iodine intakes ranging from 35 to 43.6 µg per day (median: 30 to 60.6 µg per day). The three remaining surveys, in Finnish (Kyttälä et al., 2008; Kyttälä et al., 2010), Icelandic (Gunnarsdottir et al., 2008; Thorsdottir et al., 2008) and British children (Emmett et al., 2002), reported mean and median intakes above the AI.

Urinary iodine is usually used as an indicator of iodine intake and status on a population basis. Serum concentrations of thyroglobulin (Tg), thyroxine (T4) and TSH were found to be useful biomarkers of iodine status depending on age and population group and their iodine status (WHO/UNICEF/ICCIDD, 2007).

According to WHO, a median urinary iodine concentration in children of 100 to 299 µg/L together with less than 20 % of the population showing an urinary iodine concentrations of < 50 µg/L (defined as moderate to severe iodine deficiency) can be used as an indicator of a sufficient iodine supply in a population of children (WHO/UNICEF/ICCIDD, 2007).

In a cross-sectional sample of 875 exclusively breast-fed Swiss infants (Andersson et al., 2010) followed from three to four days after birth until one year, median urinary iodine concentrations were 91 µg/L in three- to four-day-old infants (n = 368), 91 µg/L in six-month-old infants (n = 279) and 103 µg/L in 12-month-old children (n = 228). The percentage of infants with urinary iodine concentration < 100 µg/L was 58 %, 55 % and 48 %, respectively, and with iodine concentration < 50 µg/L was 22 %, 24 % and 20 %, respectively.

In 63 Portuguese infants (Costeira et al., 2009) at three months of age, the median urinary iodine concentration was reported to be 96 µg/L (IQR 58 to 200 µg/L), with 52 % of infants having an iodine concentration of less than 100 µg/L and 21 % of less than 50 µg/L.

Urinary iodine concentration was also studied in 95 French infants below one year of age (Pouessel et al., 2008). Median urinary iodine concentration was 328 µg/L, with 20 % of infants having urinary iodine concentrations < 100 µg/L and 11 % below 50 µg/L. However, 25 % of infants showed excessive urinary iodine concentrations > 400 µg/L.

In 111 Belgian children aged six months to three years (Delange et al., 2001), the median urinary iodine concentration in 244 samples collected from these subjects was 101 µg/L, with 49 % of children having a urinary iodine concentration < 100 µg/L and 21 % < 50 µg/L.

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In the German Health Interview and Examination Survey for Children and Adolescents (KiGGS) around 45 % of infants and young children aged zero to two years (number of samples not reported) showed urinary iodine concentrations < 100 µg/L and around 24 % of below 50 µg/L. Median iodine concentration in spot urine samples was 125, 115 and 110 µg/L, respectively, in boys aged 0 to < 12 months, 12 to < 24 months and 24 to < 36 months and 100, 75 and 80 µg/L, respectively, in girls aged 0 to < 12 months, 12 to < 24 months and 24 to < 36 months (Thamm et al., 2007; DGE, 2008).

In a sample of 130 Spanish children aged six months to three years (Arena Ansótegui and Emparanza Knörr, 2012), the median urinary iron concentration was 127 µg/L, with 36.9 % of the children having a urinary iodine concentration of less than 100 µg/L. The percentage of children with a urinary iodine concentration < 50 µg/L was not reported.

Taking into account the definition used by WHO to define iodine sufficiency of a population on the basis of iodine concentrations of urine samples and the data available from some European countries, the Panel considers that some sub-groups of infants and young children may be at risk of iodine inadequacy.

5.2.11. Vitamin A

Mean and median vitamin A intakes in infants and young children were generally at or above the AIs in all age groups (i.e. 350 µg RE per day for infants aged from 0 to < 12 months and 400 µg per day for young children), except in one survey (Kyttälä et al., 2008; Kyttälä et al., 2010) in Finnish children aged one and two years (but not in three-year-old children assessed in the same survey), in which mean ± SD vitamin A intakes were reported to be 315 ± 268 µg RE per day and 383 ± 391 µg RE per day, respectively, with medians not given. The Panel notes the skewed distribution of these intakes and that in the absence of information on median intakes no conclusions can be drawn from these values.

Assessment of vitamin A status is difficult, but is usually monitored by measuring plasma/serum retinol and retinol-binding protein (RBP) concentrations (AAP Committee on Nutrition, 2009). Serum retinol is homeostatically controlled, and it does not drop until liver reserves are very low (Tanumihardjo, 2012). Moreover, plasma/serum retinol and RBP concentrations fall during periods of infection. In children values of plasma/serum retinol < 0.35 µmol/L may indicate deficiency (Tanumihardjo, 2004). However, if no infection is present in the population under study, a value of 0.70 µmol/L may be more descriptive of the actual status (Tanumihardjo, 2012).

In a study in 139 healthy, mostly formula-fed, Belgian infants aged 0 to 12 months and 193 children aged one to four years (Van Biervliet et al., 2001) the percentage of infants below the cut-off value (0.64 µmol/L) of serum retinol concentrations used in this study to characterise low vitamin A status was 0.7 %. For young children this was 0.05 %. One study in British young children (Thane and Bates, 2000) reported mean plasma retinol concentrations of 1.02 µmol/L for 265 omnivorous children aged 1.5 to 3 years. In 10 vegetarian children, the mean concentration was 1.07 µmol/L. In 32 Norwegian breast-fed infants at one month of age (Henriksen et al., 2006), the median plasma retinol concentration was 0.72 µmol/L (IQR 0.62 to 0.86 µmol/L).

The Panel notes that vitamin A intakes of infants and children were generally at or above the AI and that the results of studies investigating plasma/serum retinol concentrations in healthy infants and young children do not raise any concerns but notes the limitation of plasma/serum retinol concentrations as a marker of vitamin A status.

The Panel considers that vitamin A intakes in infants and young children living in Europe generally do not give rise to concern over the risk of inadequate intakes.

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5.2.12. Vitamin D

In all studies reporting on vitamin D intakes in infants and young children, vitamin D intakes were below the AI of 10 µg per day for infants and young children, except in one-year-old Finnish children (Kyttälä et al., 2008; Kyttälä et al., 2010) and nine-month-old Dutch infants (de Boer et al., 2006). The highest intakes were observed in formula-fed infants (mean 8.5 to 9.1 µg per day) (Noble and Emmett, 2001; Fantino and Gourmet, 2008). Intakes were found to decline with increasing age, with mean intakes of infants in the second half-year of life reported to be in the range of 4.5 to 10.4 µg per day, with the majority of values around 5 µg per day. Mean intakes in young children ranged from 1.2 to 12.2 µg per day, with highest mean intakes (7 to 12.2 µg per day) being found in one survey in Finnish one- to three-year-old children (Kyttälä et al., 2008; Kyttälä et al., 2010) and in Dutch infants at 12 months of age (6.8 µg per day) (de Boer et al., 2006). In the remaining surveys conducted in young children, intakes were below 5 µg per day, with the majority of values around 2 µg per day.

The use of supplements was reported in 47 to 86 % of Finnish children aged one to three years (Kyttälä et al., 2010), declining with age and contributing on average around 6 to 7 µg vitamin D per day. Supplemental intake of vitamin D in two- to six-year-old German children in the VELS study (Sichert-Hellert et al., 2006) contributed around half of the dietary vitamin D intake in those children consuming supplements.

The best indicator of vitamin D status is considered to be 25(OH)D vitamin serum concentrations. 25(OH)D vitamin serum concentrations < 50 nmol/L are usually accepted as indicators of vitamin D deficiency, whereas values < 25 nmol/L are generally considered a sign of severe vitamin D deficiency (Braegger et al., 2013).

The vitamin D status of infants and young children was assessed in the German National Health Interview and Examination Survey for Children and Adolescents (KiGGS) (Hintzpeter et al., 2008) in around 1 240 children aged one to two years with non-immigrant and immigrant background. Vitamin D supplementation in this group ranged from 20.5 % in non-immigrant boys to 32.5 % in immigrant girls. In this population, 25(OH)D a vitamin serum concentration < 50 nmol/L was observed in 31.2 % of non-immigrant boys, in 40.5 % of immigrant boys, in 36.4 % of non-immigrant girls and in 45.5 % of immigrant girls.

In a cross-sectional study (Arnberg et al., 2011; Østergård et al., 2011) of 255 Danish nine-month-old infants, of whom 97 % were supplemented with 10 µg of vitamin D per day, 11 % of infants had a 25(OH)D vitamin serum concentration < 50 nmol/L.

In a study on Polish infants (Pludowski et al., 2011) aged six months (n = 134) and 12 months (n = 98), of whom 88 % received vitamin D supplementation > 10 µg per day at the age of six months and 70 % at the age of 12 months, 6 % had a 25(OH)D vitamin serum concentration < 50 nmol/L at the age of six months and 20 % at the age of 12 months.

In a study of 66 Greek breast-fed unsupplemented infants (Challa et al., 2005) followed from birth to the age of six months, mean 25(OH)D vitamin serum concentrations were consistently < 50 nmol/L at the first and the third months of life (i.e. around 17 to 28 nmol/L). At six months of age, mean 25(OH)D vitamin serum concentrations approached 50 nmol/L (i.e. 48 ± 7 nmol/L for infants born in winter and 33 ± 4 nmol/L for infants born in summer). The percentage of infants with 25(OH)D concentrations < 50 nmol/L was not reported.

In a representative sample of British children aged 1.5 to 4.5 years (Davies et al., 1999), geometric mean 25(OH)D vitamin plasma concentrations were reported to have been 51.8 nmol/L in winter (n = 206, 16 % supplement users) and 74 nmol/L in springtime (n = 186, 10 % supplement users) with no statistically significant differences between regions. Average dietary vitamin D intake (including supplements) in these children was around 1.2 µg per day.

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The Panel notes that almost all surveys report vitamin D intakes below the AI, even when supplement use is considered in the analysis. The Panel also notes that studies reporting on vitamin D status found a prevalence of vitamin D deficiency of 10 to 30 % in infants and young children, even in populations with a high percentage of supplement users, indicating that endogenous synthesis is not sufficient to compensate for low dietary intakes.

In view of the poor vitamin D status of some sub-groups of infants and young children living in Europe, the Panel considers that the total vitamin D supply originating from the diet and from endogenous synthesis is insufficient for most infants and young children living in Europe depending on the season.

5.2.13. Vitamin E

Only two of the surveys investigated dietary vitamin E intakes in infants below six months of age (Hilbig, 2005; Fantino and Gourmet, 2008). Vitamin E intakes were above the AI of 3 mg TE per day for infants for infants aged from 0 to < 6 months.

Five surveys reported on vitamin E intakes in infants in the second half of the first year of life (Hilbig, 2005; DGE, 2008; Fantino and Gourmet, 2008; Marriott et al., 2008; Thorsdottir et al., 2008). Mean and median intakes in French, Icelandic and British infants aged from 6 to < 12 months were reported to be above the AI of 5 mg TE per day for this age group, while mean/median intakes (4.5 mg TE per day) of German infants aged between 6 and < 12 months did not reach the level of the AI (Hilbig, 2005; DGE, 2008).

Two out of the 11 surveys which investigated dietary vitamin E intakes in young children, those in Dutch (Ocké et al., 2008) and Icelandic young children (Gunnarsdottir et al., 2008), reported mean and median intakes above the AI of 6 mg TE per day for young children. Mean and median intakes in British, Norwegian, Finnish, French, German and Italian children were below the AI with a range of mean intakes of 2.9 to 5.2 mg TE per day (Andersen et al., 2003; Rogers et al., 2003; Andersen et al., 2004; Hilbig, 2005; DGE, 2008; Fantino and Gourmet, 2008; Kyttälä et al., 2008; Marriott et al., 2009; Kyttälä et al., 2010; Sette et al., 2011).

Serum alpha-tocopherol concentrations are commonly used to characterise alpha-tocopherol status and can be reliably measured by high-performance liquid chromatography (HPLC) methods. Because alpha-tocopherol plasma concentrations are closely correlated with plasma cholesterol concentrations, adjustment for plasma cholesterol is also suggested (Mayne, 2003).

Serum alpha-tocopherol concentrations were investigated in 139 healthy, mostly formula-fed, Belgian infants aged 0 to 12 months and in 193 children aged one to four years (Van Biervliet et al., 2001). A cut-off value of < 11.6 µmol/L was defined as indicating insufficient vitamin E status in this study. The median serum alpha-tocopherol concentration was 23.2 µmol/L (IQR18.6 to 30.2 µmol/L) at the age of 0 to 12 months and 18.6 µmol/L (IQR 16.2 to 23.2 µmol/L) at the age of one to four years. The serum alpha-tocopherol concentration was below the cut-off value for sufficiency established in this study in 1.4 % of infants and 8 % of young children. A study in 32 four-week-old Norwegian infants (Henriksen et al., 2006) reported a median plasma alpha-tocopherol concentration of 22.6 µmol/L (IQR 19.3 to 25.8 µmol/L).

The Panel notes that, although vitamin E intakes in several European countries were reported to have been below the AI, the two studies investigating vitamin E status did not give rise to concerns.

The Panel considers that vitamin E intakes in infants and young children living in Europe generally do not rise to concern over the risk of inadequate intakes.

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5.2.14. Vitamin K

Only limited information on dietary intakes of vitamin K in infants and young children living in Europe is available. In the German DONALD study, the authors (Sichert-Hellert et al., 2006) reported mean intakes of vitamin K higher than 200 % of the US FDA reference values in many age groups (data not provided).

As indicators of vitamin K status, plasma phylloquinone, the ratio of undercarboxylated osteocalcin (ucCO) to carboxylated osteocalcin (cCO) and undercarboxylated prothrombin (PIVKA-II) have been used (Thane et al., 2006; Nimptsch et al., 2009; Dituri et al., 2012; Truong et al., 2012).

No studies which assessed the vitamin K status in infants and young children living in Europe were available to the Panel.

The Panel notes that no information is available on vitamin K intakes and vitamin K status of infants and young children.

The Panel considers that vitamin K intakes in infants and young children living in Europe generally do not give rise to concern over the risk of inadequate intakes when the recommendations of the health authorities of different Member States for vitamin K supplementation at birth are followed.

5.2.15. Thiamin (vitamin B_1)

Mean and median intakes in infants and children are generally above the AI of 0.2 mg per day established for infants below six months of age and above the ARs established for infants in the second half of the first year of life and young children, except for German three-month-old infants, in whom median intakes (0.13 mg/day) were reported to be below the AI for infants aged from 0 to < 6 months (Hilbig, 2005).

Intakes below the AR were reported in fewer than 5 % of Irish, Dutch and Italian children (Ocké et al., 2008; Sette et al., 2011; IUNA, 2012). Other surveys did not report on a sufficient number of percentiles to make any judgement.

Thiamin transketolase activity coefficient (ETKA) is the most widely used test to determine thiamine status, although it correlates poorly with dietary thiamin intake. Thiamin urine excretion is also a biomarker for thiamine status, which reflects recent intakes. The thiamin pyrophosphate effect (TPPE) assay is also used to determine thiamin status and is especially useful in infants because only a small sample volume of blood is needed for this test (Körner et al., 2009).

No studies which assessed thiamin status in European infants (other than newborns) and young children were available to the Panel.

The Panel notes that the percentage of infants and children with thiamin intakes below the AR is low. No information on thiamin status of infants and young children living in Europe is available.

The Panel considers that thiamin intakes in infants and young children living in Europe generally do not give rise to concern over the risk of inadequate intakes.

5.2.16. Folate

Mean or median folate intakes below the AI of 65 µg per day for infants aged 0 to < 6 months were reported for German infants (Hilbig, 2005), with mean intakes of 32.2 µg per day, and in British female infants (Noble and Emmett, 2001), with mean intakes of 64 µg per day, while mean and median folate intakes in British boys and French infants (Fantino and Gourmet, 2008) were above the AI.

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In the case of older infants, only the two surveys in German infants (Hilbig, 2005; DGE, 2008) reported mean and median folate intakes below the AI of 80 µg DFE per day for infants aged from 6 to < 12 months, with median folate intakes ranging from 47 to 78 µg per day, while mean intakes in British, Dutch, Icelandic and French infants were above the AI.

Mean or median intakes in young children above the AR of 70 µg per day were reported in all surveys.

Only around 5 % of Dutch children aged two to three years and Irish children aged one to three years had folate intakes below the AR (Ocké et al., 2008; IUNA, 2012). However, 50 % of German children aged one to three years had folate intakes below the AR (Hilbig, 2005). Other surveys did not report on a sufficient number of percentiles to make any judgement.

Folate status is routinely assessed by measurement of folate concentrations in plasma/serum or RBC. RBC folate is considered to be the best index of longer-term status (i.e. over the previous months), while serum folate reflects more recent dietary intake. The measurement of plasma total homocysteine concentration provides a functional marker of folate status, on the basis that normal homocysteine metabolism requires an adequate supply of folate. When folate status is low or deficient, elevated plasma homocysteine is invariably observed (McNulty and Scott, 2008), but this marker is not specific for folate and may also be affected by changes in status of cobalamin and pyridoxine.

Serum folate concentrations < 10 nmol/L and RBC folate concentrations of < 305 nmol/L are commonly considered to indicate folate deficiency (WHO/FAO, 2006).

Folate status in infants and young children has been assessed in five studies from Norway. Median/geometric mean serum folate concentrations were 23.7 nmol/L (IQR 18.0 to 29.3 nmol/L) in infants aged six weeks and 47.9 nmol/L (IQR 32.5 to 62.1 nmol/L) at four months of age (Bjørke-Monsen et al., 2008), 56 nmol/L (95 % CI 52 to 60 nmol/L) in infants aged six months (Hay et al., 2010), 31.6 nmol/L (IQR 21.3 to 43.3 nmol/L) in infants from six weeks to six months of life (Bjørke-Monsen et al., 2003) and 19 nmol/L (IQR 14.1 to 23.5 nmol/L) in two-year-old children (Hay et al., 2011). In the fifth study, serum folate concentrations reported as P5–P95 were 23 to 120 nmol/L in infants at the age of six months, 16 to 72 nmol/L in infants aged 12 months and 9 to 46 nmol/L in children at the age of two years (Hay et al., 2008). In a study in Turkish infants, mean serum folate concentration was 30 nmol/L (range 17 to 45 nmol/L) in breast-fed infants and 45 nmol/L (range 20 to 45 nmol/L) in formula-fed infants at six months (Karademir et al., 2007).

The Panel notes that mean or median folate intakes below the AI for infants were reported for one country, and that in the same country around half of all young children had intakes below the AR, while for other countries the percentage of young children with intakes below the AR was low. Studies investigating folate status did not raise concerns over insufficient folate status in the populations investigated. However, these studies were mainly done in Norwegian infants and young children, for whom no folate intake data were available to the Panel.

The Panel considers that folate intakes in infants and young children living in Europe generally do not give rise to concern over the risk of inadequate intakes.

5.3. Critical nutrients in European infants' and young children's diets

Based on the information available, the Panel considers that dietary intakes of LA, calcium, phosphorus, magnesium, copper, selenium, chromium, molybdenum, manganese, fluoride, vitamin A, vitamin E, vitamin K, thiamin, riboflavin, niacin, pantothenic acid, pyridoxine, biotin, folate cobalamin, vitamin C and choline in infants and young children living in Europe do not give rise to concern over the risk of inadequate intakes.

Intakes of energy, protein, salt and potassium of infants and young children living in Europe are generally high and intakes of dietary fibre low. Intakes of protein, salt and potassium do not reach

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levels which are of concern. The Panel notes that energy intakes above requirements may lead to an unfavourable gain in body mass.

For n-3 PUFAs and zinc, the Panel could not quantify the risk of inadequate intakes in infants and young children living in Europe. However, as zinc intakes were mainly above the AR and no overt deficiency in this population group in Europe was reported, the Panel considers that current zinc intakes in infants and young children living in Europe are not of particular concern.

For n-3 PUFAs, intakes of both ALA and DHA have been reported to be below the AI in some populations of infants and young children living in Europe. The Panel considers that particular attention should be paid to an appropriate n-3 PUFA supply in those infants and young children in whom intakes are low owing to the physiological role of these fatty acids.

Iron and vitamin D intakes in infants and young children living in Europe are generally low. Iron deficiency and iron deficiency anaemia were reported in 7.2 and 2.3 %, respectively, of a representative sample of 12-month-old European children. The prevalence of vitamin D deficiency reported in national or regional studies in infants and young children in European countries was in the range of 10 to 30 %, indicating that endogenous synthesis is not sufficient to compensate for low dietary intakes. The Panel considers that, in view of the poor iron and vitamin D status of some sub-groups of infants and young children living in Europe, particular attention should be paid to ensuring an appropriate supply of iron and vitamin D in these infants and young children.

In some European countries, intakes of iodine in infants and young children are low, with a prevalence of moderate iodine deficiency of around 20 %. The Panel considers that particular attention should be paid to ensuring an appropriate supply of iodine in infants and young children with inadequate iodine status.

The Panel considers that intakes of n-3 PUFAs, iron, vitamin D and iodine in some infants and young children living in Europe are critical and that some sub-groups in this population may be at risk of inadequacy.

6. Strategies to improve intakes of critical nutrients in European infants' and young children's diets

Food Based Dietary Guidelines (FBDG) constitute science-based policy recommendations in the form of guidelines for healthy eating. They provide nutrition education and dietary guidance for individual members of the general public to reach nutritional goals and to assist them in selecting a diet to meet their needs for health. This includes the choice of foods which are sources of nutrients of public health importance for which an improved intake in a given population is desirable (EFSA NDA Panel, 2010b).

Several European countries have translated nutrient intake recommendations for infants and young children into such FBDG to assist caregivers in the choice of age-appropriate foods to meet dietary needs.

Based on the information provided to EFSA from the Focal Points of 20 EU Member States (Austria, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Lithuania, the Netherlands, Romania, Slovak Republic, Slovenia, Sweden, the UK) as well as from the Focal Points from Iceland, Norway and Switzerland, 17 countries have established FBDG for infants and 11 for young children (Norwegian National Council on Nutrition and Physical Activity, 2001; Hasunen et al., 2004; Ministère de la Santé et des Solidaités et al., 2005; Petrova and Rangel, 2008; Hungarian Infant and Pediatric Advisory Board and National Committee for the Support of Breastfeeding, 2009; Slovenian Ministry of Health, 2010; FSAI, 2011; Icelandic Centre for Child Health, 2011b, 2011a; Icelandic Directorate of Health, 2011; SGE, 2011; Hilbig et al., 2012; Kersting and Hilbig, 2012; ÖGKJ, 2012; Public Health Agency for Northern Ireland, 2012; SGE,

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2012; Swedish National Food Authority, 2012a, 2012b; Uibo et al., 2012; Ravnbøl and Trolle, 2013; NHS, online; Voedingscentrum, year not given).

In particular, the German Institute for Research in Child Nutrition (Forschungsinstitut für Kinderernährung (FKE)) has developed a modular dietary schedule for the first year of life (Kersting, 2001) and an optimised mixed diet for children aged 1 to 18 years (Kersting et al., 2005; Alexy et al., 2008) specifically designed to provide an adequate energy and nutrient supply for these age groups, with the exception of vitamin D.

The modular dietary schedule for the first year of life (Kersting, 2001) recommends that complementary foods be introduced into the diet of infants between four and six months, with one (breast) milk meal being gradually replaced by complementary food every month. A vegetable–potato–meat purée (90–100 g vegetables, 40–60 g potatoes, 20–30 g meat and 8–10 g vegetable oil) is recommended as one of the first complementary foods in order to ensure a sufficient iron supply. This is followed by a full-fat milk–cereal purée (200 g full-fat milk, 20 g cereals and 20 g fruit juice/purée) and finally by a cereal–fruit purée (20 g cereals, 90 g water, 100 g fruits and 5 g butter). This specific modular dietary schedule is designed to meet dietary needs of infants who are continuing to be breast- or formula-fed, except for vitamin D, for which supplementation is recommended. Iodine is supplied by this diet at a level of 80 µg per day, which is slightly below the AI of 90 µg per day for infants.

The basis of the optimised mixed diet (Kersting et al., 2005; Alexy et al., 2008) are exemplary seven-day menus for four- to six-year-old children which can be extrapolated, based on energy requirements, to other age groups. This diet provides 100 % of nutrient requirements when fortified salt is used and 90 % of the energy requirements and includes, for example, the consumption of 600 mL water, 120 g vegetables, 120 g fruits, 120 g potatoes, pasta or rice, 80 g bread and cereals, 300 g milk or milk products, 30 g meat or cold cuts and 15 g oil, margarine or butter per day and 25 g fish and one to two eggs per week at one year of age; and 700 mL water, 150 g vegetables, 150 g fruits, 140 g potatoes, pasta or rice, 120 g bread and cereals, 330 g milk or milk products, 35 g meat or cold cuts and 20 g oil, margarine or butter per day and 35 g fish and one to two eggs per week at two to three years of age. About 10 % of energy intake is left to be provided by sweets and snacks.

The Panel notes that these diets are based on dietary patterns commonly found in Germany and that dietary habits in other EU Member States are likely to differ. However, the Panel considers that these diets can be taken as one example of dietary patterns which can ensure a sufficient energy and nutrient supply in infants and young children (except for vitamin D).

Despite the fact that an adequate amount of energy and nutrients can be supplied by a balanced and varied diet, intakes of n-3 PUFAs, iron, vitamin D and iodine in some infants and young children living in Europe are critical, and some sub-groups in this population may be at risk of inadequacy, as summarised in section 5. Several dietary strategies have been proposed on a national level to improve the status of these nutrients.

6.1. n-3 PUFAs

Most FBDG recommend the consumption of a variety of fish as a source of DHA in the diet, one to three times per week, and starting with the introduction of complementary feeding; larger, predatory fish species should be avoided in order to limit consumption of contaminants. In Norway, supplementation of DHA is recommended for infants fed formula not containing this fatty acid. And in some countries, rapeseed oil is recommended as a source of ALA.

In an intervention study (Schwartz et al., 2009) nested in the study by Dube et al. (2010b), 132 German infants aged between four and six months were assigned to receive either complementary foods prepared with corn oil and containing LA at a level of 55 % of total fatty acids and ALA at a level of 1 % of total fatty acids with an LA/ALA ratio of 55 (control, n = 66) or complementary foods prepared with rapeseed oil and containing LA at a level of 20 % of total fatty acids and ALA at a level of 9 % of total fatty acids with an LA/ALA ratio of 2.2 (intervention, n = 66). One hundred and two

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infants were included in the analysis at 10 months of age. The intervention did not increase plasma concentrations of ALA, but plasma concentrations of its long-chain metabolites, EPA and DHA, were significantly higher in the intervention group than in the control group.

Brenna et al. (2009) reviewed human studies investigating the effects of ALA supplementation on plasma fatty acid composition. In the studies reviewed, addition of ALA to the diets of formula-fed infants raised RBC DHA concentrations, but no level of ALA tested raised DHA to levels achievable with preformed DHA at intakes similar to typical human milk DHA supply. In adults consuming Western diets, which are rich in LA, supplemental ALA raised EPA and DPA in plasma or RBC, but not DHA, to a significant extent.

The effect of daily consumption of formulae providing DHA at levels of 0 mg (n = 28), 43 mg (n = 29) and 130 mg (n = 29) per day for 60 days on RBC DHA was investigated in US children aged 18 to 36 months (Minns et al., 2010). After adjustment for baseline values, a significant linear dose–response relationship was observed between DHA intakes and DHA concentrations in RBCs and plasma ($p < 0.001$). When adding a quadratic term to the model, the dose–response relationship remained significant.

The Panel considers that an increase in ALA intakes in infants leads to an increase in RBC or plasma DHA. No studies are available on the effect of ALA intakes on DHA status in young children. The Panel also considers that an increase in DHA intakes leads to an increase in plasma or RBC DHA concentrations.

6.2. Iron

All FBDG encourage the introduction into the diet of the weaning infant, as early as possible, of foods that are by nature a good source of iron. These include meat, fish, pulses, tofu and iron-fortified infant cereals. A few countries recommend the occasional consumption of small amounts of liver from young animals, while other countries discourage such consumption. The consumption of vegetable foods rich in iron together with vitamin C from fruits is also encouraged in some of the FBDG.

Specific recommendations for iron supplementation are given in the FBDG of seven (Bulgaria, Denmark, France, Iceland, Norway, Romania, Sweden) of the 25 European countries from which information was available to EFSA, mainly through the use of iron-fortified cereals, fortified milk products including formulae, or through the use of iron supplements in the form of drops or tablets (one country (Denmark)).

The impact of the Danish recommendations that infants are given iron supplements (8 mg per day) if they do not receive at least 400 mL of infant or follow-on formula on iron status in nine-month-old infants was investigated by Gondolf et al. (2013) in a retrospective cohort study. Of the 260 infants included in the analysis, 127 infants received iron drops, 64 formulae and in 69 supplementation recommendations were not met. There was a statistically significant difference between the supplemented and unsupplemented groups with respect to log SF concentrations adjusted for sex, cow's milk intake, birth weight and growth (31.9 vs. 30.2 µg/L), with SF concentration being below the cut-off value of < 12 µg/L in 5.9 % and 13.4 % of children in the supplemented and unsupplemented group, respectively. There was no statistically significant difference in Hb concentrations. These were below the cut-off of ≤ 100 g/L in 0.5 % and 2.9 % of children in the supplemented and unsupplemented group, respectively. There were no statistically significant differences between the two methods of supplementation (i.e. iron supplements and iron-fortified formula) with respect to the proportions of children below the cut-off values for SF and Hb.

The Panel notes that this study shows an association between iron supplementation in the form of iron drops or iron-fortified formula and a lower prevalence of iron depletion, with a statistically significant but moderate increase in SF concentrations in the supplemented infants, with no differences between the two methods of supplementation. No statistically significant effect on Hb concentrations was observed.

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The effect of iron-fortified formulae was studied in six randomised controlled trials (RCTs) and one cohort study.

The six intervention studies (reported in seven publications) (Fuchs et al., 1993; Stevens and Nelson, 1995; Daly et al., 1996; Gill et al., 1997; Morley et al., 1999; Williams et al., 1999; Maldonado Lozano et al., 2007) investigated the effect of iron supplementation in the form of formulae containing 1.2–1.3 mg iron per 100 mL compared with non-fortified formula or cow's milk. In the majority of studies, infants were enrolled between the age of six and nine months, except in the study by Maldonado Lozano et al. (2007), in which children were enrolled at an age of 12 to 30 months. Interventions lasted for 4 to 12 months. In all except one study (Stevens and Nelson, 1995), SF concentrations were reported to have been statistically significantly higher and the proportion of children below a SF cut-off value statistically significantly lower in the groups consuming iron-fortified formulae than in the groups consuming cow's milk or unfortified formula. Hb concentrations were reported to have been statistically significantly different between groups in two studies (Daly et al., 1996; Morley et al., 1999; Williams et al., 1999), while in two other studies this was not the case (Stevens and Nelson, 1995; Maldonado Lozano et al., 2007). The remaining studies either did not report on this outcome (Maldonado Lozano et al., 2007) or baseline Hb concentrations differed between groups (Stevens and Nelson, 1995) so that no conclusions could be drawn with respect to this outcome from this study.

The Panel notes that these studies show an effect on iron status of iron supplementation in the form of iron fortified formulae compared with non-fortified formulae or cow's milk.

The effect of predominant consumption of iron-fortified formulae compared with breast milk and cow's milk at nine months of age was investigated in two cohorts of Icelandic children (Thorisdottir et al., 2012). Weighed dietary records were obtained from 255 children at nine months of age and markers of iron status were analysed at 12 months of age. Around 34 % of the children investigated received breast milk, around 34 % cow's milk and around 30 % iron-fortified follow-on formula. Iron depletion was defined as SF < 12 µg/L, iron deficiency as iron depletion plus MCV < 74 fL and iron deficiency anaemia as iron depletion plus Hb < 105 g/L. At 12 months of age, iron depletion was found in 42, 14.9 and 4.3 % of children in the cow's milk, breast milk and formula group, respectively. The prevalence of iron deficiency was 20.5, 2.6 and 1.4 % in these groups, while iron deficiency anaemia was observed only in the group consuming cow's milk and was reported in 3.6 % of children in this group.

The Panel notes that this study shows an association between iron supplementation in the form of iron-fortified formula and iron status.

The effect of using fortified cow's milk as a vehicle for iron supplementation compared with unfortified cow's milk or red meat was studied in two RCTs (Virtanen et al., 2001; Szymlek-Gay et al., 2009) in children aged around 12 months with adequate iron status. Fortified milks (1.5 mg/100 mL) were consumed for five to six months. Although SF concentrations were significantly higher in the groups consuming fortified cow's milk or red meat than in the group consuming unfortified cow's milk in one study (Szymlek-Gay et al., 2009), the consumption of unfortified cow's milk did not lead a higher risk of developing sub-optimal iron status compared with consumption of iron-fortified cow's milk.

The Panel notes that, in these studies in populations of children with adequate iron status, consumption of unfortified cow's milk for five to six months did not lead to a higher risk of developing sub-optimal iron status compared with consumption of iron-fortified cow's milk or red meat and iron status remained adequate in all groups. Consumption of both meat and iron-fortified cow's milk led to an increase in SF concentrations in one study, but this finding was of no clinical relevance in this population of children with adequate iron status.

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The effect on iron status of consumption of meat and/or iron-fortified cereals as one of the first complementary foods was studied in four RCTs (Engelmann et al., 1998; Krebs et al., 2006; Dube et al., 2010b; Krebs et al., 2013). In all of these studies there was no difference in the occurrence of iron depletion between groups consuming iron-fortified cereal or meat as first complementary food for three to six months or between groups consuming different amounts of meat in the diet. In addition, SF and Hb concentrations were not statistically significantly different between groups.

The Panel notes that these studies show that the early introduction of meat and the early introduction of iron-fortified cereal into complementary feeding have similar effects on iron status.

The Panel notes that in the majority of studies an increase in iron intake, either through the use of iron supplements, iron-fortified cow's milk, iron-fortified formulae or iron-fortified infant cereals or through the early introduction of meat into complementary feeding and its regular consumption, increased or maintained SF concentrations with little or no effect on Hb concentrations and with no apparent differences between different types of foods. This effect was associated with a lower prevalence of iron depletion in some studies, depending on the baseline iron status of the population under study. In studies in children with adequate iron status, iron status at the end of the study was determined more by baseline iron status than by the consumption of additional iron through fortified foods.

The Panel considers that increased iron intake, achieved either through consumption of iron supplements, iron-fortified cow's milk, iron-fortified formula or iron-fortified infant cereals or by choosing foods that are by nature a good source of iron, such as meat, helps to increase iron status in infants and children with inadequate or at risk of inadequate iron status, such as infants and young children from low socio-economic backgrounds or living in areas with a high prevalence of iron deficiency anaemia. The selection of the appropriate form and vehicle through which iron is provided in the diet will depend on national dietary habits, health authorities, the regulatory context and caregivers' preference.

6.3. Vitamin D

In 18 of the 23 countries from which information was available to EFSA, vitamin D supplementation, mainly in the form of drops or tablets, but also cod liver oil in Nordic countries, is recommended on a national level. The duration of supplementation, however, varies and ranges from the first year of life to 18 years.

The consumption of fatty fish, egg yolk or fortified dairy products as a source of vitamin D is also recommended.

The effect of vitamin D supplementation in the form of supplements was investigated in one cross-sectional study.

In a study in 255 Danish infants aged nine months (Arnberg et al., 2011; Østergård et al., 2011), of whom 97 % received vitamin D supplementation at a dose of 10 µg of vitamin D per day was associated with 25(OH)D serum concentrations of 12 to 151 nmol/L, with the concentrations in 11 % of infants being below the cut-off of < 50 nmol/L.

The effect of vitamin D supplementation in the form of fortified formula was studied in one RCT.

In this study, 80 German children aged from two to around seven years (Hower et al., 2013) were randomised to consume either vitamin D-fortified formula (n = 46) or semi skimmed cow's milk (n = 34) for nine months. The fortified formula provided 2.85 µg/100 g vitamin D. The median daily intake of the formula was 234 mL, providing 7.1 µg of vitamin D. Serum concentrations of 25(OH)D were assessed before winter, after winter and during summer. Fifty-three children completed the study, 35 in the formula group and 18 in the cow's milk group. After the winter period, 25(OH)D serum concentrations were statistically significantly lower in the cow's milk group than in the group

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consuming fortified formula. This difference disappeared during the summer months. At baseline (before winter) 46 % of children in the formula group and 55.8 % of children in the cow's milk group had 25(OH)D serum concentrations < 50 nmol/L. After winter this percentage was 25.6 % in the formula group and 79 % in the cow's milk group and this difference was statistically significant. During summer the percentage of children with 25(OH)D serum concentrations < 50 nmol/L was 8.6 % and 11.1 % in the formula and cow's milk group respectively.

The Panel notes the high drop-out rate in this study, in particular in the cow's milk group. The Panel also notes that this study shows that consumption of vitamin D-fortified formula for nine months led to a lower prevalence of vitamin D deficiency after the winter months than consumption of cow's milk. Most likely, endogenous vitamin D synthesis during the summer months compensated for the lower vitamin D intakes in the cow's milk group, so that differences in prevalence of vitamin D deficiency were not maintained during the summer months.

The effect of vitamin D supplementation in the form of fortified cow's milk was studied in two RCTs.

A secondary analysis (Houghton et al., 2011) of the data generated in the RCT in 225 children from New Zealand aged 12 to 20 months by Szymlek-Gay et al. (2009) investigated the impact on 25(OH)D serum concentrations of *ad libitum* consumption for 20 weeks of red meat provided as frozen meals (control, n = 90), of vitamin D-fortified cow's milk providing 0.8 µg/100 g vitamin D (n = 90) or of vitamin D-fortified cow's milk providing 1 µg/100 g vitamin D (n = 45). The two fortified milks contributed on average 3.6 to 3.9 µg per day to daily vitamin D intakes. At the end of the study 25(OH)D serum concentrations were statistically significantly higher in the groups consuming fortified cow's milk than in the red meat group. There was also a statistically significant difference between groups in the prevalence of 25(OH)D serum concentrations < 50 nmol/L at week 20 (i.e. 43, 15 and 12 %, in the meat group, the group consuming cow's milk providing 0.8 µg/100 g vitamin D and the group consuming cow's milk providing 1 µg/100 g vitamin D, respectively).

The Panel notes that this study shows that consumption of vitamin D-fortified cow's milk for 20 weeks led to a lower prevalence of vitamin D deficiency.

One cluster randomised trial was performed in older children (4 to 17 years) and adults (Madsen et al., 2013) and investigated the effect on 25(OH)D serum concentrations of consumption of vitamin D-fortified cow's milk plus vitamin D-fortified bread, compared with consumption of unfortified cow's milk and unfortified bread, for six months during the winter. Vitamin D intakes from fortified milk, fortified bread and the usual diet were, on average, 2.3, 5.6 and 2.3 µg per day, respectively, in the study population of children. At the end of the study, 16 % of subjects (children and adults combined) in the fortification group, compared with 65 % of subjects in the control group, had 25(OH)D concentrations < 50 nmol/L, a difference which was statistically significantly different.

The Panel notes that, although this study was not conducted in the target population of infants and young children, it provides supportive evidence that consumption of vitamin D-fortified cow's milk and/or vitamin D-fortified bread leads to a lower prevalence of vitamin D deficiency in infants and young children.

The Panel notes that these studies consistently show that an increase in vitamin D intake, through the use of either vitamin D supplements, vitamin D-fortified cow's milk, vitamin D-fortified formula or vitamin D-fortified cereal-based foods, is associated with a lower prevalence of vitamin D deficiency with no apparent differences between different types of foods. The Panel also notes that recommendations for vitamin D supplementation of infants in the form of drops or tablets are already part of feeding recommendations in the majority of European countries.

The Panel considers that an increase in vitamin D intake, achieved through the consumption of either vitamin D supplements, vitamin D-fortified cow's milk, vitamin D-fortified formula or vitamin D-fortified cereal-based foods, helps to increase vitamin D status in infants and children, in particular

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during winter months when endogenous synthesis is low. It is, however, recommended that guidelines for vitamin D supplementation of infants and children established at national level be followed. Vitamin D-fortified cow's milk, formula or other foods may provide additional vitamin D in populations not receiving any vitamin D supplements and/or with low sun exposure. The selection of the appropriate form and vehicle through which iron is provided in the diet will depend on national dietary habits, health authorities, the regulatory context and caregivers' preference.

6.4. Iodine

Most FBDG do not specifically address iodine supply, but sea fish is usually indicated as a good source of iodine as well as of vitamin D, DHA and selenium. The German FBDG encourages the use of iodine enriched cereals.

In nine European countries (Austria, Bulgaria, Croatia, Denmark, Lithuania, Poland, Romania, Slovakia and Slovenia) iodine fortification of salt is mandatory, with mandatory fortification mainly being restricted to table and cooking salt. Other European countries have introduced salt fortification on a voluntary basis. Iodised salt is usually considered the main intervention strategy for iodine deficiency control and prevention (WHO/UNICEF, 2007). However, the use of table salt is discouraged in infants and children up to two years of age, but will be an important source of iodine for children above two years of age in those countries where iodised salt is on the market.

In contrast to the minor direct role of iodised salt in the diet of infants and young children, salt iodisation significantly influences iodine content of breast milk and, consequently, iodine status of infants and young children (WHO Secretariat et al., 2007).

In the EU, feed for cattle and chicken may be fortified with iodine, which leads to an increase in the iodine content of milk and eggs. In Norway, cow's milk has become a more important source of iodine for the population than iodised table salt (Nordic Council of Ministers, 2013) or sea fish for inland populations (Dahl et al., 2003).

In two Spanish cross-sectional studies reported in Soriguer et al. (2011), urinary iodine concentrations in 757 children aged 4 to 16 years and 1 205 children aged 10.8 ± 3 years were significantly associated with the frequency of cow's milk consumption.

The Panel considers that an increase in iodine intake, achieved either through the consumption of iodine supplements, iodine-fortified cow's milk, iodine-fortified formulae or iodine-fortified infant cereals or through the choice of foods that are a natural source of iodine, such as sea fish, or by the use of iodised salt, helps to increase iodine status in infants and children with inadequate or at risk of inadequate iodine status, such as infants and children living in European countries with documented low iodine intakes. The selection of the appropriate form and vehicle through which iodine is provided in the diet will depend on national dietary habits, health authorities, the regulatory context and caregivers' preference.

6.5. The role of milk in the diet of infants and young children

There is consensus that breast milk alone is able to meet the energy and nutrient requirements of most healthy, term infants for the first four to six months and that breast milk is the most appropriate liquid part of a progressively diversified diet when complementary feeding is introduced (EFSA NDA Panel, 2009). When breast-feeding is not possible or no longer possible, formula can be given in addition to complementary food during the first year of life.

The FBDG of most European countries discourage the introduction of cow's milk, especially as a main milk drink, into the diet of infants in the first year of life. Some countries' guidelines (Denmark, Estonia, Germany, the UK) state that small quantities of cow's milk can be safely used in the preparation of foods from six to seven months of age onwards. After the first year of life, FBDG

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generally advise the use of cow's milk in moderate quantities (around 300 to 500 mL per day) as an important source of nutrients for young children.

In the first year of life, formulae (infant and follow-on formulae) provide caregivers with a safe alternative to breast milk when breast milk is not available to the infant, and in replacement of cow's milk, the consumption of which in large amounts in the first year of life is generally discouraged in infant feeding recommendations and FBDG of European countries.

When formulae are consumed after the first year of life, they continue to replace cow's milk in whole or in part in the diet of young children which contains little or no ALA, DHA and iron and small amounts of vitamin D (see also Appendix A). However, at this age cow's milk consumption is no longer discouraged and no recommendations for replacement of this food category by other alternatives exist from medical societies at European level.

6.5.1. The role of young-child formulae in providing critical nutrients to European young children compared with other milk products

As described in sections 6.1 to 6.5, formulae, including young-child formulae, are one of the means to increase n-3 PUFA, iron and vitamin D intakes in infants and young children living in Europe with inadequate or at risk of inadequate status of these nutrients. However, other means, such as fortified cow's milk, fortified cereals and cereal-based foods, supplements or the early introduction of meat and fish into complementary feeding and their continued regular consumption, are other efficient alternatives to increase intakes of these nutrients.

There is as yet no European legislation covering the composition and main characteristics of young-child formulae. In Appendix A, the nutrient composition and energy content of young-child formulae currently on the EU market are compared with the essential composition of cow's milk-based infant and follow-on formulae as laid down in Directive 2006/141/EC and with full-fat cow's milk.

The median (P5–P95) ALA content of young-child formulae is reported to be 103.0 (57.6 to 169.1) mg/100 kcal, compared with the minimum content of ALA in infant and follow-on formulae according to Directive 2006/141/EC of > 50 mg/100 kcal. In comparison, full-fat cow's milk provides no ALA. No explicit maximum amounts for ALA are given in the Directive, but they can be calculated to be 240 mg/100 kcal from the lowest permitted LA/ALA ratio in infant and follow-on formula of 5 and from the maximum permitted LA concentrations of 1 200 mg/100 kcal. This is higher than the reported concentrations in currently available young-child formulae. Around 4 % of young-child formulae provide less ALA than the minimum amount specified for infant and follow-on formulae.

No information on the content of DHA in infant and follow-on formulae or on the percentage of infant and follow-on formulae to which DHA is added is available to the Panel. In young-child formulae DHA is added to only around 13 % of products which are currently on the market. When DHA is added, median (P5–P95) concentrations are 6.4 (2.2 to 22.3) mg/100 kcal. In comparison, full-fat cow's milk provides no DHA.

The median (P5–P95) iron content of young-child formulae is reported to be 1.8 (1.3 to 2.4) mg/100 kcal. The permitted range of iron content of infant and follow-on formulae is 0.3 to 1.3 mg/100 kcal and 0.6 to 2.0 mg/100 kcal, respectively. In comparison, full-fat cow's milk provides < 0.1 mg iron per 100 kcal. Although the iron content of young-child formulae is higher than that of infant formulae, the median iron content of young-child formulae is within the permitted range of iron in follow-on formulae. Around 10 % of currently marketed young-child formulae provide > 2 mg iron per 100 kcal, and none provides less than the minimum amount in infant and follow-on formulae.

The median (P5–P95) vitamin D content of young-child formulae is reported to be 2.1 (1.4 to 3.3) µg/100 kcal and is within the permitted range of vitamin D content of infant and follow-on formulae, which is 1.0 to 2.5 µg/100 kcal and 1.0 to 3.0 µg/100 kcal, respectively. In comparison, full-

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fat cow's milk provides around 0.1 µg vitamin D per 100 kcal. Around 10 % of young-child formulae provide > 3 µg vitamin D per 100 kcal and 1.3 % provide less than 1 µg/100 kcal.

The iodine content of young-child formulae which are currently on the EU market is similar to the iodine content of cow's milk and similar to the content currently required and permitted in infant and follow-on formulae, which is 10 to 50 µg/100 kcal. The median (P5–P95) iodine concentration in young-child formulae has been reported to be 20.2 (12.2–34.8) µg/100 kcal. The mean concentrations in full-fat cow's milk has been reported to be 23 µg/100 kcal.

The Panel considers that, in comparison with cow's milk, currently marketed young-child formulae contain more ALA, DHA (if added), iron and vitamin D but similar amounts of iodine. The median content of these nutrients in young-child formulae is within the range of permitted concentrations in follow-on formulae and, except for iron, also in infant formulae. Therefore, no unique role of young-child formulae with respect to the provision of critical nutrients in the diet of infants and young children living in Europe can be identified, so they cannot be considered as necessary to satisfy the nutritional requirements of young children when compared with other foods that may be included in the normal diet of young children (such as breast milk, infant formulae, follow-on formulae and cow's milk).

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CONCLUSIONS

The Panel concludes that:

- The following levels of nutrient and energy intakes are considered adequate for the majority of infants and young children:

Nutrient	Unit	0 to <6 months			6 to <12 months			12 to <36 months		
		Months	Boys	Girls	Months	Boys	Girls	Months	Boys	Girls
Energy	MJ/d	0-<1	1.5	1.4	6-<7	2.5	2.3	12	3.3	3.0
		1-<2	2.1	1.9	7-<8	2.7	2.4	24	4.3	4.0
		2-<3	2.2	2.0	8-<9	2.8	2.5	36	4.9	4.6
		3-<4	2.1	1.9	9-<10	2.9	2.6			
		4-<5	2.3	2.1	10-<11	3.0	2.7			
		5-<6	2.4	2.3	11-<12	3.1	2.8			
Protein	g/d	0-<1	---	---	6-<7	9	8	12	11	10
		1-<2	8	7	7-<8	11	10	18	11	11
		2-<3	8	8	8-<9	11	10	24	12	11
		3-<4	9	8	9-<10	11	10	36	13	13
		4-<5	9	8	10-<11	11	10			
		5-<6	9	8	11-<12	11	10			
Fats	E%	50-55			40			35-40		
LA	E%	4			4			4		
ALA	E%	0.5			0.5			0.5		
DHA	mg/d	100			100			100 (<24 months)		
DHA+EPA	mg/d	---			---			250 (>24 months)		
ARA	mg/d	140			---			---		
Carbohydrates	E%	40-45			45-55			45-60		
Fibre	g/d	---			---			10		
Water	mL/d	700-1000			800-1000			1100-1300		
Calcium	mg/d	200			400			600		
Phosphorus	mg/d	100			300			460		
Magnesium	mg/d	25			80			85		
Sodium	mg/d	120			170-370			170-370		
Chloride	mg/d	300			270-570			270-570		
Potassium	mg/d	400			800			800		
Iron	mg/d	0.3 (breast-fed infants)			8			8		
Zinc	mg/d	2 (breast-fed infants)			4			4		
Copper	mg/d	0.3			0.3			0.4		
Selenium	µg/d	12.5			15			20		
Iodine	µg/d	90			90			90		
Chromium		---			----			---		
Molybdenum	µg/d	2			10			15		
Manganese	mg/d	0.003			0.02-0.5			0.5		
Fluoride	mg/d	0.08			0.4			0.6		
Vitamin A	µg RE/d	350			350			400		
Vitamin D	µg/d	10			10			10		
Vitamin E	mg TE/d	3			5			6		
Vitamin K	µg/d	5			8.5			12		
Thiamin	mg/d	0.2			0.3			0.5		
Riboflavin	mg/d	0.3			0.4			0.8		
Niacin	mg NE/d	2			5			9		
Pantothenic acid	mg/d	2			3			4		
Pyridoxine	mg/d	0.1			0.4			0.7		
Biotin	µg/d	4			6			20		
Folate	µg DFE/d	65			80			100		
Cobalamin	µg/d	0.4			0.5			0.9		
Vitamin C	mg/d	20			20			20		
Choline	mg/d	130			150			200		

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- Dietary intakes of LA, calcium, phosphorus, magnesium, copper, selenium, chromium, molybdenum, manganese, fluoride, vitamin A, vitamin E, vitamin K, thiamin, riboflavin, niacin, pantothenic acid, pyridoxine, biotin, folate, cobalamin, vitamin C and choline in infants and young children living in Europe do not give rise to concern over the risk of inadequate intakes.

- Dietary intakes of energy, protein, salt and potassium of infants and young children living in Europe are generally high while intakes of dietary fibre in young children are low. Intakes of protein, salt, potassium and dietary fibre are not at levels which are of concern, whereas energy intakes above requirements may play a role in an unfavourable gain in body mass.

- For n-3 PUFAs and zinc, the risk of inadequate intakes in infants and young children living in Europe cannot be quantified. However, as zinc intakes were mainly above the AR and no overt deficiency in this population group in Europe was reported, it is considered that current zinc intakes in infants and young children living in Europe are not of particular concern.

- For ALA, DHA, iron, vitamin D and iodine (in some European countries), dietary intakes in infants and young children living in Europe were low and particular attention should be paid to ensuring an appropriate supply of ALA, DHA, iron, vitamin D and iodine in infants and young children with inadequate or at risk of inadequate status of these nutrients, in particular in view of the poor iron, vitamin D and iodine status of some sub-groups of infants and young children living in Europe.

- Several European countries have translated nutrient intake recommendations for infants and young children into FBDG to help caregivers in the choice of age-appropriate foods to meet dietary needs. It has been shown in one European country that a specific modular dietary schedule for the first year of life and an optimised mixed diet for children aged 1 to 18 years are able to provide an adequate energy and nutrient supply for these age groups, with the exception of vitamin D.

- Although dietary habits markedly differ within Member States, these diets can be taken as one example of dietary patterns which can ensure a sufficient energy and nutrient supply in infants and young children.

- Fortified formulae, including young-child formulae, are one of several means to increase n-3 PUFA, iron, vitamin D and iodine intakes in infants and young children living in Europe with inadequate or at risk of inadequate status of these nutrients. However, other means, such as fortified cow's milk, fortified cereals and cereal-based foods, supplements or the early introduction of meat and fish into complementary feeding and their continued regular consumption, are efficient alternatives to increase intakes of these nutrients. The selection of the appropriate form and vehicle through which these nutrients are provided in the diet will depend on national dietary habits, health authorities, the regulatory context and caregivers' preference. However, it is recommended that guidelines for vitamin D supplementation of infants and children established at national level be followed.

- In comparison with cow's milk, currently marketed young-child formulae contain more ALA, DHA (if added), iron and vitamin D but similar amounts of iodine.

- The mean content of these nutrients in young-child formulae is within the range of permitted concentrations in follow-on formulae and, except for iron, also in infant formulae.

- No unique role of young-child formula with respect to the provision of critical nutrients in the diet of infants and young children living in Europe can be identified, so that they cannot be considered as a necessity to satisfy the nutritional requirements of young children when compared to other foods that may be included in the normal diet of young children (such as breast milk, infant formulae, follow-on formulae and cow's milk).

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DOCUMENTATION PROVIDED TO EFSA

1. Compositional information on young-child formula currently available on the market in the European Union provided by AINIA following a procurement procedure and by SNE via the European Commission.

2. Draft evidence report related to an extensive literature search and review as preparatory work for the evaluation of the essential composition of infant and follow-on formulae and growing-up milks provided by Pallas Health Research and Consultancy following a procurement procedure.

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Appendix A. Nutrient composition and energy content of cow's milk-based young-child formulae currently on the EU market, of infant and follow-on formulae (cow's milk based) as per Directive 2006/141/EC and of full-fat cow's milk [(a)]

	Young-child formula (cow's milk based) [(b)]			Follow-on formula (cow's milk based)		Infant formula (cow's milk based)		Cow's milk, full fat
	P5	**Median**	**P95**	**Min**	**Max**	**Min**	**Max**	**Mean**
Energy (kJ/100 g)	209.0	281.0	339.0	251.0	293.0	251.0	293.0	289.0
Energy (kcal/100 g)	50.0	67.0	81.0	60.0	70.0	60.0	70.0	69.0
Nutrient per 100 kcal	**P5** [(c)]	**Median**	**P95**	**Min**	**Max**	**Min**	**Max**	**Mean**
Protein (g/100 kcal)	2.1	2.6	3.6	1.8	3.5	1.8	3.0	4.8
Taurine (mg/100 kcal) [(d)]	7.0	8.1	15	–	< 12	–	< 12	–
Carbohydrates (g/100 kcal)	11.1	12.6	14.3	9.0	14.0	9.0	14.0	6.8
Fat (g/100 kcal)	3.5	4.3	4.8	4.0	6.0	4.4	6.0	6.1
SFA (g/100 kcal)	0.4	1.4	2.1	–	–	–	–	–
ARA (mg/100 kcal) [(e)]	1.1	4.1	14.3	–	–	–	–	0.0
DHA (mg/100 kcal) [(f)]	2.2	6.4	22.3	–	–	–	–	0.0
ALA (mg/100 kcal) [(g)]	57.6	103.0	169.0	> 50	240	>50	240	0
LA (mg/100 kcal) [(h)]	500.0	758.0	1 043.0	300.0	1 200.0	300.0	1 200.0	70.0
Sodium (mg/100 kcal)	27.6	40.3	57.1	20.0	60.0	20.0	60.0	64.3
Chloride (mg/100 kcal)	61.2	75.0	114.0	50.0	160.0	50.0	160.0	146.5
Potassium (mg/100 kcal)	101.0	127.0	199.0	60.0	160.0	60.0	160.0	215.1
Calcium (mg/100 kcal)	94.4	127.0	220.0	50.0	140.0	50.0	140.0	176.7
Phosphorus (mg/100 kcal)	58.4	77.3	134.0	25.0	90.0	25.0	90.0	138.3
Copper (µg/100 kcal)	35.0	61.5	118.0	35.0	100.0	35.0	100.0	0.0
Iodine (µg/100 kcal)	12.2	20.2	34.8	10.0	50.0	10.0	50.0	23.0
Iron (mg/100 kcal)	1.3	1.8	2.4	0.6	2.0	0.3	1.3	< 0.1
Magnesium (mg/100 kcal)	8.1	10.4	20.0	5.0	15.0	5.0	15.0	16.8
Manganese (µg/100 kcal)	5.9	14.6	106.0	1.0	100.0	1.0	100.0	0.0
Selenium (µg/100 kcal)	1.4	1.6	5.5	1.0	9.0	1.0	9.0	1.9
Zinc (mg/100 kcal)	0.7	1.2	2.0	0.5	1.5	0.5	1.5	0.6
Vitamin A (µg RE/100 kcal)	77.8	102.0	141.0	60.0	180.0	60.0	180.0	57.5
Vitamin D (µg/100 kcal)	1.4	2.1	3.3	1.0	3.0	1.0	2.5	0.1
Vitamin E (mg TE/100 kcal)	0.9	1.6	3.1	0.5/g PUFA, not < 0.5 mg/ 100 kcal	5.0	0.5/g PUFA, not < 0.5 mg/ 100 kcal	5.0	0.1
Vitamin K (µg/100 kcal)	4.5	7.5	11.8	4.0	25.0	4.0	25.0	0.0

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	Young-child formula (cow's milk based) [b]			Follow-on formula (cow's milk based)		Infant formula (cow's milk based)		Cow's milk, full fat
	P5	**Median**	**P95**	**Min**	**Max**	**Min**	**Max**	**Mean**
Thiamine (mg/100 kcal)	0.07	0.12	0.27	0.06	0.3	0.06	0.3	0.0
Riboflavin (mg/100 kcal)	0.14	0.20	0.35	0.08	0.4	0.08	0.4	0.3
Pyridoxine (mg/100 kcal)	0.06	0.10	0.30	0.035	0.175	0.035	0.175	0.0
Cobalamin (mg/100 kcal)	0.18	0.27	0.59	0.1	0.5	0.1	0.5	0.7
Biotin (µg/100 kcal)	2.2	3.1	6.6	1.5	7.5	1.5	7.5	4.3
Folate (µg/100 kcal)	7.3	22.4	38.6	10.0	50.0	10.0	50.0	9.1
Niacin (mg/100 kcal)	0.57	0.90	3.1	0.3	1.5	0.3	1.5	1.0
Pantothenic acid (mg/100 kcal)	0.42	0.71	1.3	0.4	2.0	0.4	2.0	0.6
Vitamin C (mg/100 kcal)	8.7	15.9	23.4	10.0	30.0	10.0	30.0	1.9
Choline (mg/100 kcal) [i]	10.0	14.9	23.0	–	–	7	12	
Inositol (mg/100 kcal) [j]	4.0	6.3	13.5	–	–	4	40	

(a): Data sources described in section 3.3.
(b): Based on 234 products.
(d): Percentiles are based on formulae containing the nutrient.
(d): In 31 % of all young-child formulae.
(e): In 12 % of all young-child formulae.
(f): In 13 % of all young-child formulae.
(g): In 78 % of all young-child formulae.
(h): In 80 % of all young-child formulae.
(i): In 34 % of all young-child formulae.
(j): In 11 % of all young-child formulae.

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ABBREVIATIONS

Afssa	Agence française de sécurité sanitaire des aliments
AI	Adequate Intake
AINIA	Asociación de Investigación de la Industria Agroalimentaria
ALA	alpha-linolenic acid
AR	Average Requirement
ARA	arachidonic acid
ATP	adenosine triphosphate
BMI	body mass index
cCO	carboxylated osteocalcin
CI	confidence interval
CuZn-SOD	copper/zinc superoxide dismutase
D-A-CH	Germany–Austria–Switzerland
DFE	dietary folate equivalents
DHA	docosahexaenoic acid
DNA	deoxyribonucleic acid
DRV	Dietary Reference Value
EPA	eicosapentaenoic acid
ETKA	thiamine transketolase activity coefficient
FAD	flavin-adenine dinucleotide
FADS	fatty acid desaturase
FBDG	food-based dietary guidelines
FMN	flavin mononucleotide
FOS	fructo-oligosaccharides
GOS	galacto-oligosaccharides
GPX	glutathioneperoxidase
Hb	haemoglobin

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HPLC	high-performance liquid chromatography
IGF-1	insulin-like growth factor-1
IGFBP	IGF-binding protein
IoM	Institute of Medicine
IQR	interquartile range
LA	linoleic acid
LC-PUFA	long-chain polyunsaturated fatty acid
MCV	mean corpuscular volume
MRL	maximum residue level
NAD	nicotinamide adenine dinucleotide
NADP	nicotinamide adenine dinucleotide phosphate
NE	niacin equivalent
NHMRC	Medical Research Council of the Commonwealth of Australia
NOAEL	no observed adverse effect level
P	percentile
PAL	physical activity level
PDX	polydextrose
PIVKA-II	protein induced by vitamin K absence or agonist II
PRI	population reference intake
PUFA	polyunsaturated fatty acid
RBC	red blood cell
RBP	retinol-binding protein
RCT	randomised controlled trial
RE	retinol equivalents
REE	resting energy expenditure
RI	Reference Intake ranges for macronutrients
RNA	ribonucleic acid
SCF	Scientific Committee on Food

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SCFA	short-chain fatty acid
SD	standard deviation
SF	serum ferritin
SFFQ	semi-quantitative food frequency questionnaire
SNP	single-nucleotide polymorphism
T4	thyroxine
TE	tocopherol equivalent
TEE	total energy expenditure
TfR	transferrin receptor
Tg	thyroglobulin
ToR	terms of reference
TPPE	thiamin pyrophosphate effect
TSAT	transferrin saturation
TSH	thyroid-stimulating hormone
UL	Tolerable Upper Intake Level
ucCO	undercarboxylated osteocalcin
WHO	World Health Organization

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