Translation of EU Food Law and Nutrient Reference Values Into Practice: the German Dietary Scheme for the First Year of Life

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ABSTRACT

Objectives: European dietary regulations affect national dietary guidelines for child nutrition. The update of the German Dietary Scheme for the first year of life is used to examine the translation of European nutrient references into food-based guidelines while maintaining traditional habits.

Methods: Within the Dietary Scheme, intake of energy and nutrients was calculated in the complementary feeding period for each of the 3 daily recommended complementary meals (a vegetable-potato-meat meal, a milk-cereal meal, a cereal-fruit meal) in addition to the daily liquid-milk servings (breast milk or follow-on formula). Pureed-home-made complementary meals were assumed. The adequacy of nutrient intake was evaluated by comparison with the European Food Safety Authority (EFSA) Dietary Reference Values. Macronutrient content of meals was compared to the European complementary food directive.

Results: Daily intake of most nutrients following the scheme was well in line with EFSA values, whereas the commonly 'critical' nutrients iron and iodine remained far below EFSA values. Substituting breast milk or whole cow's milk with follow-on formula had only a small impact on nutrient supply. Although the different nutrient profiles of meals were not fully in line with European regulations, they add up to an overall balanced daily diet.

Conclusions: Taken together, European dietary reference values for energy and nutrients can mostly be met by the modular system of the Dietary Scheme as a total diet concept for infant nutrition in Germany. The different proposed meals generally agree with EU regulations for complementary food.

Key Words: breast-feeding, complementary feeding, critical nutrients, food-based dietary guidelines, nutrient reference intakes

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What Is Known

- Usually, dietary recommendations are available as reference daily nutrient intake and general nutrition guidelines.
- A meal-based dietary scheme has traditionally been used for counseling on infant nutrition in Germany.

What Is New

- The updated German Dietary Scheme shows that European nutrient reference values for the complementary feeding period can be transferred into food and meal-based guidelines considering national habits.
- In this modular system using common nonfortified complementary foods, a few nutrients remain far below the reference values, similar to the low intakes observed in European infant populations.

During the first year of life, nutrition changes fundamentally and more than in any other later period, owing to nutritional needs and neuromotor development. Three main stages can be distinguished with smooth transitions between them: exclusive breast-feeding during the first months, introduction of complementary feeding along with partial breast-feeding during the second half of infancy, and introduction of family diet around the end of the first year of life (1). Breast-feeding is unanimously claimed as the 'gold standard' as it has specific advantages for short-term infant health and may also reduce the risk of later diseases in infants and mothers (2). Exclusive breast-feeding from well-nourished mothers covers the requirements of infants during the first months of life (1), and no food legislation is needed for human milk feeding. In contrast, for formula as a substitute for breast milk, nutrient content and information details are specifically regulated by European law. Infant formula and follow-on formula are currently covered by the Commission delegated regulation 2016/127/EU (3), which is based on a Scientific Opinion of the European Food Safety Authority (EFSA) (4), and by the Commission delegated regulation (EU) 2018/561 amending the Delegated Regulation (EU) 2016/127 (5).

With the introduction of complementary feeding, food selection is determined by sociocultural dietary aspects, and may fail to comply with physiological needs owing to common shortfalls in nutrient supply. Almost all European countries have some type of food-based guidelines for complementary feeding (6–8), with

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almost similar main messages addressing single foods and whether they are suitable. Only few countries provide some type of quantitative recommendations, such as food portions (9). Generally, national guidelines recommend conventional foods for home-prepared complementary meals, but commercial products are also available. The European Society for Pediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN) provides overarching guidance on complementary feeding for Europe (10).

In Germany, food-based dietary guidelines on infant nutrition can be traced back to pediatric textbooks from the early 20th century (11); and have continuously evolved over time (12). Some decades ago the original guidelines were summarized and supplemented into a total diet concept by the Research Institute of Child Nutrition as the Dietary Scheme for the first year of life (13). This scheme comprehensively describes the progression of nutrition during infancy considering nutrient requirements, individual neuromotor development, and common foods in Germany. It is particularly challenging to guarantee a balanced nutrient supply through complementary feeding. In practice, this means that complementary meals and the remaining liquid milk part need to add up to a sufficient daily nutrient intake that can then be evaluated against common reference values for nutrient intake (14).

From a European perspective, national complementary feeding guidelines should be in line with European regulations as much as possible. Currently, complementary foods, namely processed cereal-based foods and baby foods for infants and young children, are covered by the Commission Directive 2006/125/EC (15). This directive issues rules for the composition and labeling of specific product categories by providing levels of macronutrients and minimum or maximum levels for several micronutrients. A new EU directive on complementary food is currently in preparation considering among other things recent EFSA guidance on the appropriate age for the introduction of complementary feeding (1). Manufacturers of food products for infants in Europe must respect these specifications.

On the other hand, reference values for nutrient intake usually refer to the total daily diet. In 2013, EFSA provided a summary of observed intake considered to be adequate for the majority of healthy, term, normal-weight infants in Europe (16). In 2017, EFSA summarized its own Dietary Reference Values (DRV) with an update 2019 (17) for all age groups including infants. These DRVs were formally derived and distinguish different evidence levels of reference values. This means that depending on the nutrient, the EFSA reference value may represent a population reference intake (PRI), an average requirement (AR), or an adequate intake (AI) (17). To apply these values in practice, nutrient intake in the total daily diet must be available.

The aim of this study was to examine to what extent European food law and nutrient references for infant nutrition are met by the updated Dietary Scheme for infants in Germany with regard to the complementary feeding period.

METHODS

Definitions of Standard Versus Substitute Scheme

In the Standard Scheme, breast-feeding as liquid milk was assumed along with complementary food. Alternatively, in the substitute version, breast milk was substituted by the follow-on formula. Compared with infant formula, the prescribed level of iron content is higher in follow-on formula (0.6–2.0 vs 0.3–1.3 mg/100 kcal) (2), which is the main relevant nutritional difference between them at present. In a recent web-based product search in Germany (October 2019), an average content of 0.94 mg iron/100 mL was found in follow-on formula (17 products) as compared with 0.59 mg iron/100 mL in infant formula (35 products) (recalculated using the range of 60–70 kcal/100 mL in the EU directive for both formula categories) (18): the higher value was used for the substitute scheme.

Composing Complementary Meals

Conventional nutritious foods were the first choice to make full use of their nutritional potential, considering fortification or supplementation of ‘critical’ nutrients only if common foods were not sufficient.

Complementary feeding in Germany traditionally consists of three pureed meals, namely a vegetable-potato-meat meal (VPM), a milk-cereal meal (MC), and a cereal-fruit meal (CF) along with the remaining liquid milk part (Fig. 1). The amounts of the meals are the same each day (between 185 g [VPM] and 240 g [MC] for

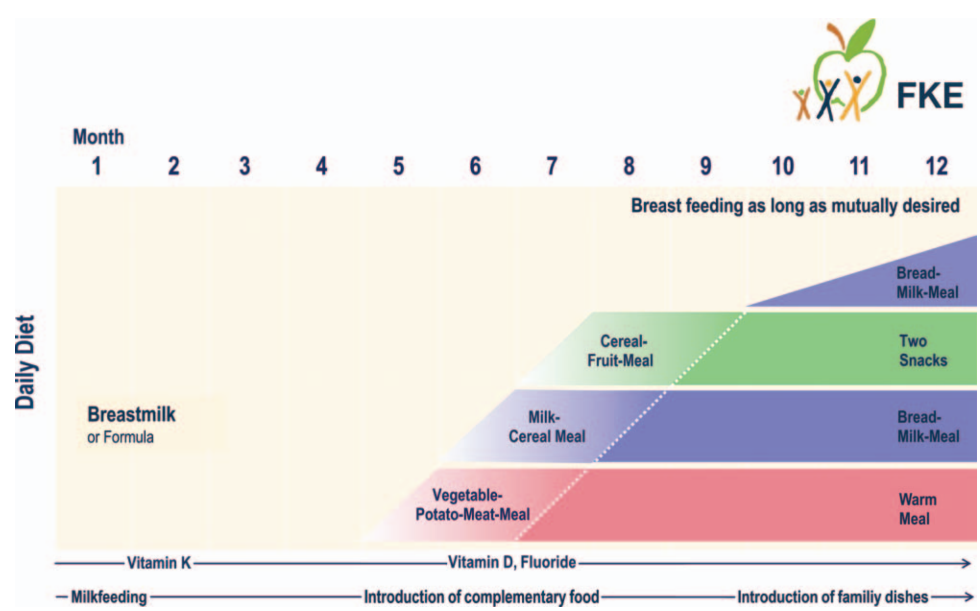

FIGURE 1. Dietary scheme for the first year of life.

complementary meals and 200 mL for liquid milk). In addition, the proportions of the food groups within the complementary meals are fixed, whereas the choice of food within a food group may change for nutritional and sensory reasons (see Supplemental Table 1, Supplemental Digital Content, *http://links.lww.com/MPG/B883*, which shows the recipes of the complementary meals and potential commercial products as alternatives). To allow for variation of foods within food groups, a 7-day model menu was developed referring to the age of approximately 8 months (see Supplemental Table 2A, Supplemental Digital Content, *http://links.lww.com/MPG/B883*, which gives an overview of foods and meals of the 7 individual days). Each day constituted 3 different complementary meals plus the liquid milk part. Vegetables in the first complementary meal provided an early variety of flavors, especially if the selection changed daily (19). A change was suggested in the other ingredients several times per week. Potatoes were substituted by whole grain pasta or rice, fish (oily fish) was recommended once per week as a source of the omega-3 long-chain polyunsaturated fatty acid (LC-PUFA) docosahexaenoic acid (DHA), and cereals were mainly oats or other whole grain cereals. Rapeseed oil (high proportion of omega-3 α-linolenic acid) was added (1 teaspoon) to the 2 meals consisting of low-fat food (VPM, CF) to increase energy density. Generally, no added sugar or salt was allowed.

Nutrient Intakes

For the evaluation of the nutrient supply with the Scheme in the complementary feeding period, EFSA DRV's 2017 given for the second half of the first year of life were applied (for sodium, the most recent EFSA DRV 2019 was used) (20). To calculate the nutrient intake per meal and per day, a common software (DIAT-2020 Soft & Hard, D. Beyer, Rimbach, Germany) was used. Nutrient values were obtained from the German Food Code and Nutrient Database (BLS) (Bundeslebensmittelschlüssel, BLS, Version II.3.1), which has already been used repeatedly for nutrient intake calculation at the European level in the HELENA study (21). The BLS provides values for nutrient losses because of food preparation, such as cooking vegetables or meat.

Additionally, specific data sources were used to complement the database or to enable the following specific assumptions:

(1) breast milk: nutrient values were taken from German Standard Nutrient Tables (22) and missing fatty acids (mainly LC-PUFA) as mean values of recent analyses of term breast milk in European populations (23–30). Regarding iodine, it was assumed that either the breast-feeding mother uses iodine supplementation as recommended in Germany or not (91 vs 64 μg iodine/L milk) (31)
(2) formula: average contents of labeled nutrients were calculated from a recent market survey in Germany (see above)
(3) whole cow's milk: for iodine, it was assumed that the milk for the MC meal is either from conventional livestock farming or organic ('bio') farming (93 vs 56 μg iodine/L milk) (31).

Data Presentation

The results are presented as descriptive values. From the 7-day menu, average daily intakes of energy and nutrients are presented as percentage (%) of energy or as grams (g) (mg, μg) per day and in comparison with EFSA references (as percentage of EFSA values).

Consequences of exchanging whole cow's milk in the MC meal using the follow-on formula for daily nutrient intake are shown exemplarily for nutrients with low and high achievement of EFSA references. To evaluate nutrient distribution within meals, the proportions of protein, total fat, selected fatty acids, and carbohydrates (% of energy per meal) are displayed. Nutrient proportions within complementary meals are compared with the values of the EU Directive for the respective complementary meals, if available. Similarly, the role of individual meals for the supply of specific nutrients is shown (as percentage of daily intake).

RESULTS

Daily Diet

An overview of the mean daily intakes of macronutrients, minerals, and vitamins is given for the Standard Scheme and the Substitute version at the age of approximately 8 months (Table 1).

The standard scheme with breast-feeding as the liquid milk achieves most of the EFSA 2017 values with a daily energy intake close to EFSA. Substitution of breast milk by the follow-on formula increases the intake of most minerals and vitamins (Table 1). Day-to-day variation in daily nutrient intake depends on the choice of individual complementary foods: there is considerable variation (minimum, maximum) between the 7 menu days for specific vitamins (eg, vitamin C 36–152 mg/day, folate 98–132 μg/day) or specific fatty acids (eg, DHA 27–49 mg/day on days without fish, 483 mg/day on the day with fish). Day-to-day variations are smaller for most macronutrients (eg, protein: 11.8–16.2% of energy intake) or energy (659–719 kcal/day) (see Supplemental Table 2B, Supplemental Digital Content, *http://links.lww.com/MPG/B883*, which gives an overview of the nutrient content of the 7 individual days).

In both versions of the Scheme, exchanging whole cow's milk in the MC meal using the follow-on formula resulted in increased amounts of most micronutrients but decreased amounts in others, notably protein and calcium. Irrespective of the milk part of the diet, however, iron and iodine intakes remain 'critically low', and protein intake is twice as high as the EFSA reference (Fig. 2).

The iodine deficiency varies depending on the choice of milk (see Supplemental Figure 1, Supplemental Digital Content, *http://links.lww.com/MPG/B883*, which shows the potential daily iodine intake with different assumptions for milk consumption). The lowest intake (32 μg/day) is visible in the standard breast milk regimen, assuming a nonsupplemented mother, the highest intake (62 μg/day) when substituting breast milk as well as cow's milk in the MC meal by formula.

Meals

The share of macronutrients in the energy content of the meals was different between meal types but leveled out in the daily diet (Fig. 3). Mainly, the high-protein meals with meat (VPM) or cow's milk (MC) are partially balanced by the 2 low-protein meals (breast milk, CF). As expected, the breast milk meal has the highest fat proportion, whereas in meals made from low-fat foods (VPM, CF), added vegetable oil increases energy density. The lowest proportion of PUFAs and the highest proportion of saturated fatty acids were found in the MC meal with whole cow's milk as a fat source.

In addition, meals contribute differently to other nutrients as well (see Supplemental Figure 2, Supplemental Digital Content, *http://links.lww.com/MPG/B883*, which shows the contribution of meals to the daily intake of specific nutrients). For instance, the high contribution of the VPM and CF meals to α-linolenic acid and vitamin E supply are because of the addition of rapeseed oil. The high contribution of DHA in the VPM meal comes from oily fish

TABLE 1. Intake of energy and nutrients per day with the Dietary Scheme in the Standard and Substitute versions and EFSA Dietary Reference Values for comparison

Nutrients		Dietary Scheme Standard version 8 months	Dietary Scheme Substitute version 8 months	EFSA DRV 2017, 7 to 11 months
Energy	kcal	682	681	650
Protein	G	25.5	26.2	10.1
Protein	E%	14.9	15.4	
Fat	E%	38.6	36.7	40.0
Saturated FA*	E%	13.8	11.6	
Monounsaturated FA*	E%	14.1	14.4	
Polyunsaturated FA*	E%	6.6	6.7	
ALA†	E%	1.4	1.5	0.5
LA‡	E%	4.9	5.0	4
ARA§	Mg	67	37	
EPA¶	Mg	49	44	
DHA‖	Mg	99	105	100
Carbohydrates	E%	45.6	47.1	45 to 55#
Sodium	Mg	141	164	200**
Potassium	Mg	1154	1214	750
Calcium	Mg	368	449	280
Magnesium	Mg	122	129	80
Phosphorus	Mg	497	551	160
Iron	Mg	3.7	5.5	11
Zinc	Mg	4.1	5.0	2.9
Iodine	μg	50	60	70
Vitamin A (RE††)	μg	572	561	250
Vitamin B1	Mg	0.53	0.62	0.27‡‡
Vitamin B2	Mg	0.62	0.82	0.4
Vitamin B6	Mg	0.52	0.62	0.3
Folate	μg	115	123	80
Vitamin C	mg	81	88	20
Vitamin E	mg	4.4	5.9	5

EFSA Dietary Reference Values (17).
*FA = fatty acids.
†ALA = α-linolenic acid.
‡LA = linoleic acid.
§ARA = arachidonic acid.
¶EPA = eicosapentaenoic acid.
‖DHA = docosahexaenoic acid.
#EFSA 2013 (16).
**EFSA 2019 (20).
††Retinol-equivalents.
‡‡Recalculated.

(once per week), iodine and calcium mainly come from milk, especially calcium from cow's milk as complementary food in the standard version.

DISCUSSION

To translate the existing nutrient reference values into practice, quantitative recommendations for total daily food intake are needed. This evaluation shows that most of the current EFSA nutrient DRVs for the second half of infancy can be achieved by a well-designed modular dietary concept, even while considering national habits in complementary feeding. Nevertheless, a few nutrients with low intakes in European infants identified by EFSA remain critical within an overall adequate nutrient supply.

Although the main messages on infant nutrition are similar across European countries, slight differences become visible in the especially challenging period of complementary feeding. Most guidelines focus on single foods and their suitability. Only a few countries provide quantitative recommendations, such as daily food portions (6).

Daily Diet

In the German total diet concept, which provides nutrient adequacy in general in the complementary feeding period, single nutrients are either above or below the EFSA references. The remarkable increase in calcium supply when substituting breast milk by the follow-on formula is because of the fact that the mean calcium content of present-day German follow-on formula products is much higher than that of breast milk and of German infant formula products. The choice of follow-on formula instead of infant formula as breast milk substitute in the complementary feeding period is new in the Scheme. Until now infant formula was used as breast milk substitute throughout the first year of life in the Scheme, similar to pediatric recommendations in other countries. In addition,

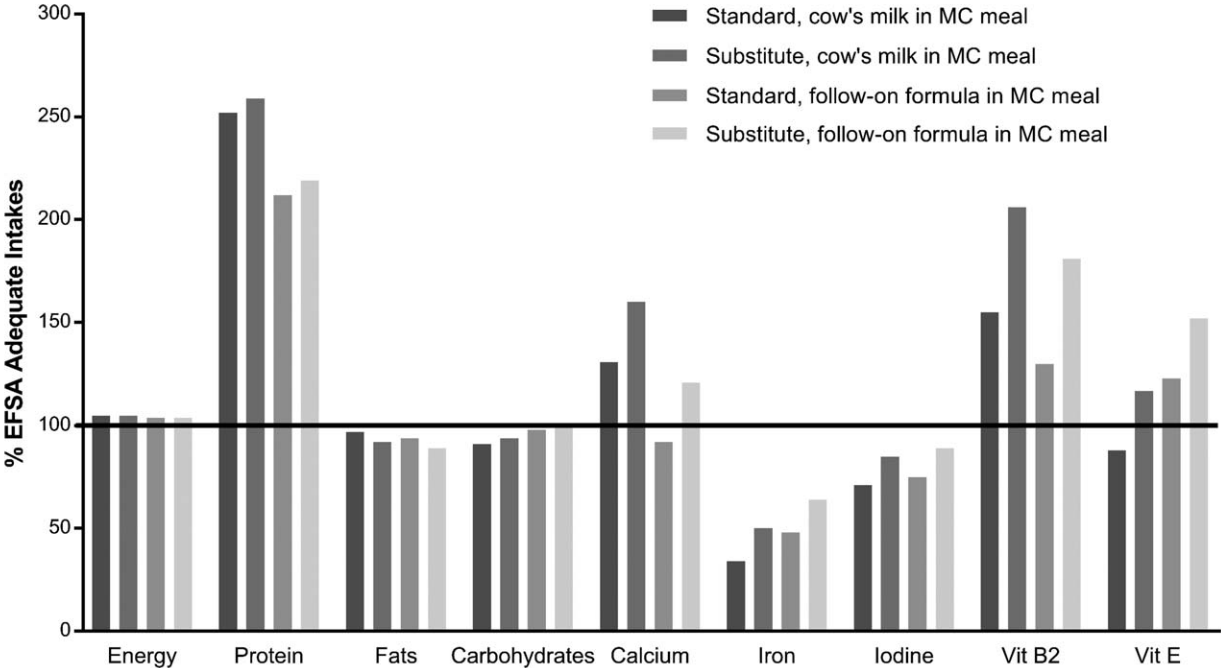

FIGURE 2. Daily intake of selected nutrients in different assumptions of the milk part in the dietary scheme as percentage of actual EFSA reference values (17) MC = milk-cereal meal.

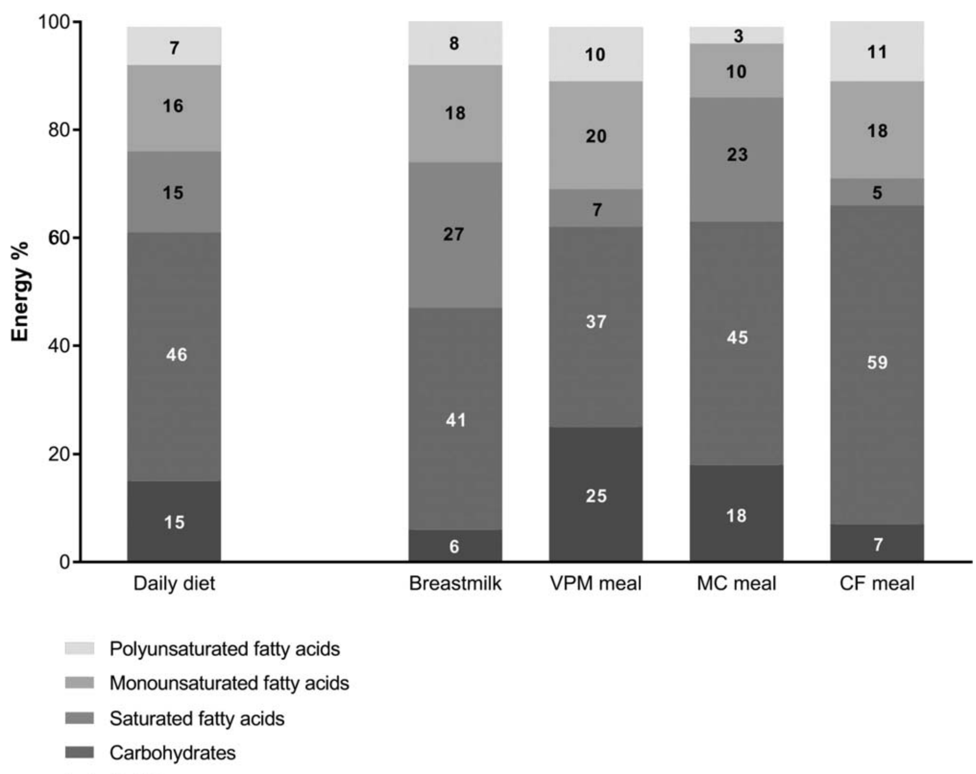

FIGURE 3. Macronutrient proportions as percentage of energy content of the daily diet and of different meals. CF = cereal-fruit meal; MC = milk-cereal meal; VPM = vegetable-potato-meat meal.

the higher iron content as primary reason for preferring follow-on formula in the Scheme, the higher calcium content in the products in Germany might be an additional nutritional advantage of the follow-on formula in the second half of infancy.

Although EFSA was concerned about the low dietary intake of ALA, DHA, iron, vitamin D, and iodine in infants in Europe, only iron and iodine remain critically low in the Scheme. ALA is abundantly supplied by rapeseed oil and DHA, mainly by fish. Vitamin D should not be considered because of the pediatric recommendation for vitamin D supplementation throughout the first year of life is followed to a high degree in Germany, as verified by biomarker data (32).

Critical Nutrients in the Scheme

For nutritional reasons, complementary feeding starts with an iron-rich meal, which in Germany traditionally contains meat because of its high bioavailability of iron (approximately 15% vs 4% in cereals) (33). To use the full potential of meat as a supplier of iron, it is recommended 5 times a week within the scheme. In the 2 subsequent complementary meals of the Scheme, whole grain is combined with vitamin C-rich foods to increase the otherwise low iron absorption. However, iron intake with the Scheme as calculated from food composition tables is clearly below the actual EFSA reference (11 mg/day).

Although bioavailability of iron is optimized in the complementary feeding regimen, in 2 studies in infants in Germany fed according to the Scheme, iron stores were found to be almost exhausted at the age of 10 months in up to 30% of infants independent of breast-feeding or formula but without observed clinical signs of iron deficiency (33–35). These data complied with the EFSA review data (16) and the recent EFSA opinion showing the particular need to consider iron in complementary feeding (1). To meet the shortfall of iron, the scheme could be further adapted either using a food-based approach (36,37) or through supplements. So far, institutions have not, however, explicitly recommended iron supplementation in the second half of infancy provided that food-selection is optimized.

The low iodine supply with the Scheme needs consideration owing to the developmental risks of iodine deficiency at an early age (38). Even if all food sources of iodine are exploited, the daily intake remains far below the actual EFSA reference. Interestingly, the positive effect of iodine supplementation of the breast-feeding mother on infant iodine supply with the Scheme proves to be smaller than the negative effect of replacing conventional cow's milk in the MC meal by organic cow's milk. There are 2 ways to cope with the iodine deficit: exchange of the home-prepared MC meal by a commercial iodine-fortified product or supplementation of iodine (through tablets). A recent market survey showed that almost all commercial MC products in Germany that belong to the EU complementary food category of processed cereal-based foods with added high-protein food (milk) are fortified with iodine (18). Unfortunately, no biomarker data are available on iodine status in infants during the complementary feeding period in Germany.

The high protein intake with the Scheme is caused by the need for nutrient-dense protein-rich foods, including cereals. Protein intake remains high if the traditional cow's milk in the MC meal is exchanged according to the follow-on formula. The potential impact of an early high protein intake on later obesity risk has been discussed mainly for the first months of life (16), while data for the second half of infancy are scarce and not conclusive. A recent EU report also shows that energy and protein intakes of infants and young children living in Europe are generally high when compared with the requirements (6).

Meals in Modular Concept

The meal schedule is a special feature of the scheme. The composition of the meals is well established in Germany and has proved to be practical over decades. The macronutrient proportions of the different meal types, however, are not always in line with the compositional requirements of the existing EU directive for complementary food (15). The VPM meal easily complies with the EU category 'other baby foods' with respect to protein and fat. In contrast, the CF meal belonging to the EU category 'other baby foods, without a protein source', would be too low in protein. The MC meal made with whole cow's milk belonging to the EU category 'processed cereal-based foods', does not achieve the linoleic acid prescription. The daily diet, however, combining the complementary meals and the milk portion, fulfills meal-specific EU macronutrient prescriptions and shows that meal-specific food and nutrient profiles can complement each other to provide an overall balanced diet.

CONCLUSIONS

Taken together, European dietary reference values for energy and nutrients can mostly be met by the modular system of the Dietary Scheme as a total diet concept for infant nutrition in Germany. The different proposed meals generally agree with EU regulations for complementary food.

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