Guidelines for infant nutrition in Germany

The updated Dietary Scheme for the first year of life

Mathilde Kersting, Hermann Kalhoff, Susanne Voss, Kathrin Jansen, Thomas Lücke

Abstract

Goals: The updating of the Dietary Scheme for the first year of life by the Research Institute of Child Nutrition in Bochum was intended to ensure implementation of the latest German, Austrian and Swiss (D-A-CH) reference values for nutrient intake during the complementary feeding stage.

Methodology: On the basis of a 7-day model dietary plan for infants around the age of 8 months, the daily intake of energy and nutrients was calculated and compared with the D-A-CH reference values for this age group. It was assumed that the complementary food (CF) was prepared at home. The assumed standard for the milk consumed in addition to CF was breast milk ("breast milk plan") or follow-on formula as a substitute for breast milk ("formula plan").

Results: In the updated Dietary Scheme for the first year of life the daily intake of most nutrients in both versions of the plan is largely in line with D-A-CH reference values. As is a typical finding for nutrition at this age, the intake of iron and iodine - "critical" nutrients for this age group – is low and protein intake is high. The different nutrient profiles of the meals complement each other for a balanced daily diet.

Conclusion: The new calculations open up the modular food and meal-based concept of the Dietary Scheme for scientific discussion.

Keywords: Dietary Scheme, complementary feeding, nutrient intake, meals, child nutrition, infant nutrition

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Introduction

In Germany guidelines for infant nutrition developed on the basis of pioneering work by German paediatricians around 120 years ago. Accurate records of food intake and healthy development enabled the formulation of initial well-founded assumptions on dietary needs and appropriate nutrition [1]. These initial rules were continually further developed [2] and a few decades ago were amalgamated into an overall concept by the Research Institute of Child Nutrition in Dortmund (*Forschungsinstitut für Kinderernährung*, FKE) as what is known as the Dietary Scheme for the first year of life [3].

The Dietary Scheme forms the basis for the corresponding guidelines of the German Society of Pediatrics and Adolescent Medicine (*Deutsche Gesellschaft für Kinder- und Jugendmedizin*, DGKJ) and for the action recommendations of young families information network, *Netzwerk Junge Familie*. These are also in line with European expert societies. The Scheme provides a comprehensive description of nutritional development in infancy from exclusive breastfeeding in the first months of life and the step-by-step introduction of complementary feeding to the transition to family meals and takes account of neuromotor development and common foods in Germany.

Today there are well substantiated reference values for nutrient intake available to enable nutritional evaluation of the daily diet, such as those issued by the nutritional societies of Germany, Austria and Switzerland (D-A-CH) or the European Food Safety Authority (EFSA) [4, 5]. The Dietary Scheme used here describes the nutrition of infants in Germany, therefore the D-A-CH reference values are used as the basis for nutrient intake. The current reference values of both bodies are largely consistent for the intake of most nutrients. In deriving nutrient reference intakes, the gold standard for the first four months of life is generally the nutrient intake of the exclusively breastfed child, for the subse-

quent months, interpolations are generally required, for instance on body weight or energy requirements.
The updated Dietary Scheme was used to examine this well-proven concept of infant nutrition for nutritional advice in Germany against the background of the latest D-A-CH reference values for nutrient intake [4].

The goals of this paper are:
- to present and substantiate the food choices and meal planning in the modular daily concept of the Dietary Scheme for the first year of life,
- to calculate and evaluate the resulting nutrient intake in the CF feeding stage, with particular emphasis on "critical" nutrients.

Principles for the food choices and meal planning in the Dietary Scheme for the first year of life

Complementary feeding stage

The Dietary Scheme for the first year of life (◆ Figure 1) identifies three stages, based on nutritional and developmental reasons, which flow seamlessly into one another:
- exclusive milk diet in the first 4–6 months, with breastfeeding as standard,
- introduction of complementary feeding from 5th–7th month with continued partial breastfeeding,
- introduction of family food towards the end of the first year of life.

In the complementary feeding stage the aim is to combine the types and quantities of the various foods in such a way that, together with the remaining breast milk or formula, the daily diet conforms as far as possible to the current reference values for nutrient intake. This enables the identification of critical nutrients.

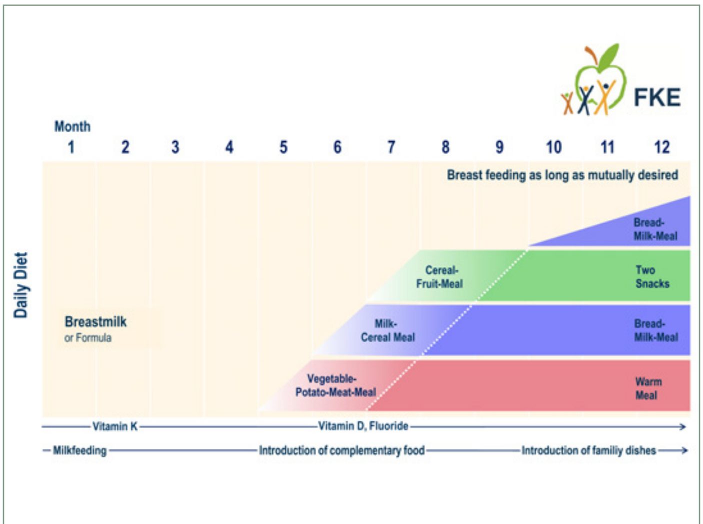

Fig. 1: **Dietary Scheme for the first year of life of the Research Department of Child Nutrition, Bochum** (formerly the Research Institute of Child Nutrition Dortmund)

According to the recommendations of European expert societies and institutions, complementary foods are introduced no earlier than the beginning of the fifth month and no later than the beginning of the seventh month [6, 7]. Fundamental criteria for the introduction of complementary foods are the development of sufficient eating skills and coverage of energy and nutrient requirements in the second six months of life. There is no evidence to support the exclusion of individual foods in complementary feeding to prevent allergies [6, 8]. The continuation of breastfeeding, as long as mother and child so wish, is specifically included in the dietary scheme as an option for providing supplementary liquid milk alongside complementary food.

Foods and meals

Complementary feeding in Germany traditionally consists of three meals: one vegetable-potato-meat meal, one milk-cereal meal and one cereal-fruit meal. ◆ Table 1 shows the current recipes for the complementary meals in the 7-day meal plan around the age of 8 months. For the liquid milk portion (breast milk or follow-on formula) a quantity of 200 ml is assumed.
The quantities of the food groups contained in the complementary meals are set by the Dietary Scheme, whilst the choice of foods within a food group can vary. In order to illustrate the variation of foods within the food groups, a 7-day model meal plan was developed for infants around the age of 8 months (◆ Table 1). Common foods with high levels of nutrients are the first choice. Enrichment or the addition of "critical" nutrients is only considered if standard foods together with the milk are not sufficient to achieve the reference values. No sugar or salt is added.
The fundamental nutritional argument for the introduction of complementary feeding in the case of exclusively breastfed infants is the high need for iron in the second six months of life due to the exhaustion of prenatal iron stores and the high growth requirements [6]. Therefore, the first complementary meal in the Dietary Scheme contains meat (with bivalent iron, high bioavailability), given in the form of a vegetable-potato-meat mixture (5x/week). In the two other complementary meals in the Dietary Scheme cereal is combined with fruit rich in vitamin C to increase the otherwise low iron utilisation from cereals. As a source of n-3 fatty acids, the Dietary Scheme uses rapeseed oil (alpha linoleic acid) as standard with oily

Foods Meals	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Breast milk/ Formula	200 g	200 g	200 g	200 g	200 g	200 g	200 g
Vegetable-potato-meat meal							
Vegetables	100 g carrots	100 g cauliflower	100 g fennel	100 g kohlrabi	100 g zucchini	80 g peppers, 20 g peas	100 g broccoli
Potatoes, pasta, rice	50 g pasta	50 g potatoes	50 g rice	50 g potatoes	50 g potatoes	50 g couscous	50 g potatoes
Meat, fish	30 g beef	30 g beef	30 g turkey	30 g salmon	30 g beef	30 g pork	10 g oat flakes, 30 g orange juice
Rapeseed oil	5 g	5 g	5 g	5 g	5 g	5 g	5 g
Milk-cereal meal							
Cow's milk	200 g	200 g	200 g	200 g	200 g	200 g	200 g
Cereal flakes	20 g oat flakes	20 g oat flakes	20 g wheat flakes	20 g oat flakes	20 g wheat flakes	20 g oat flakes	20 g wheat flakes
Orange juice	20 g	20 g	20 g	20 g	20 g	20 g	20 g
Cereal-fruit meal							
Cereal flakes	20 g oat flakes	20 g wheat flakes	20 g oat flakes	20 g oat flakes	20 g oat flakes	20 g wheat flakes	20 g oat flakes
Fruit	100 g apple	100 g banana	100 g pear	100 g apricot	100 g pear	100 g peach	100 g apple
Water	90 g	90 g	90 g	90 g	90 g	90 g	90 g
Rapeseed oil	5 g	5 g	5 g	5 g	5 g	5 g	5 g

Tab. 1: **Recipes for the three complementary meals (7-day meal plan) of the Dietary Scheme**

fish (docosahexaenoic acid [DHA]) once a week.

A variety of vegetables in the first complementary meals ensures an early range of aromas and flavours, especially if the selection changes daily. It is assumed that this early variety of flavours also encourages long-term acceptance of new foods [9]. The fruit content in the cereal-fruit meal also changes daily. Other ingredients change several times a week: potatoes are replaced by whole grain pasta or rice on three (out of seven) days. Cereal is wholegrain and generally used in the form of oats, otherwise wheat. Cow's milk is a component of one of the complementary meals.

The meals in the Dietary Scheme have proved practical over many years [10].

Methodology

Changes in use of foods

Energy intake in the previous Dietary Scheme was 730 kcal/day. In the recalculation, the energy intake had to be adjusted to the latest D-A-CH reference values for energy intake, which stipulate 650 kcal. In order to achieve this reduction without affecting the intake of minerals and vitamins, the primary approach was to reduce the fat content of the vegetable-potato-meat meal and the quantity of liquid milk.

For the updated Dietary Scheme two versions were used. In the standard version, the "breast milk plan", breastfeeding is assumed as the source of liquid milk (200 ml/day). In the alternative version, the "formula plan", breast milk is replaced by follow-on formula (with the no. "2" in the product name). This serves to improve the critically low iron intake.

In line with the current European Union recommendations for a higher content range of iron in follow-on formula compared to infant formula [11], the iron content in follow-on formula on the German market is currently higher than the level in infant formula [12].

In the vegetable-potato-meat meal the addition of fruit juice was abandoned in the course of the update. The absence of fruit juice means that perception of the vegetable varieties is no longer masked by the monotone fruit acid.

Recalculation of nutrient intake

The daily intake of energy and nutrients was calculated as an average of the 7-day meal plan (Software DIAT-2020 Soft&Hard D. Beyer, Rimbach, Germany). The nutrient content for breast milk was taken from German standard nutrient tables [13]; for fatty acid lacking in

these tables, averages were calculated from the latest analyses of breast milk in Europe [14–21] (reference values of EFSA for fatty acid intake are published [22]). For iodine it was assumed that the breastfeeding mother was taking iodine supplements, as recommended in Germany (91 μg iodine/l breast milk with supplements compared to 64 μg iodine/l without supplements [23]). For follow-on formula "2" the average declared energy and nutrient content in products on the market in Germany was used [12]. The meals ready for consumption were used for intake calculations, i.e. nutrient losses during preparation are taken into account.
The extent to which high protein intake in the second six months of life can be reduced was investigated in a scenario which replaced cow's milk in the milk-cereal meal with follow-on formula "2".

Presentation of the results

The results are presented descriptively. The average daily intake of energy and nutrients calculated from the 7-day meal plan is given as a mean value (with range). In order to evaluate nutrient distribution within the meals the proportions of protein, fat and carbohydrates in the energy content of the meals are given (in %).

Results

Nutrients and foods

◆ Table 2 gives an overview of the average daily intake of energy and selected nutrients for the breast milk plan and the formula plan.
Both versions of the Dietary Scheme achieve the reference values for most nutrients when energy intake is in line with guidelines. The substitution of breast milk with follow-on formula slightly increases intake of most minerals and vitamins. However, regardless of the source of liquid milk, iron and iodine intake remain "critically" low. At the same time, protein intake is twice the reference value. Even when formula is used in the milk-cereal meal, despite the considerable reduction of 20%, the reference value is still significantly exceeded. Sodium intake is higher with the formula plan than with the breast milk plan and is close to the reference value.
The deficit in iodine intake varies depending on the choice of milk in the Dietary Scheme. The lowest intake (32 μg/day) would occur in the breast milk plan under assumption of a mother not taking supplements, the highest intake (62 μg/day) would occur in the formula plan and with replacement of cow's milk for follow-on formula in the milk-cereal meal.
Even after removal of the fruit juice, vitamin C intake in the Dietary Scheme remains high.
The high protein intake in the Scheme results from the use of protein-rich foods with specific micronutrients (meat, milk, cereal). A reduction of meat reduces the already critically low level of iron intake. A reduction of milk reduces calcium, which cannot really be replaced by other foods in this complementary

Nutrients		Breast milk plan			Formula plan			D-A-CH reference values
		M 7 days	Min	Max	M 7 days	Min	Max	
Energy & Macronutrients								
Energy	kcal/d	**682**	659	719	**681**	658	718	**650**
Protein	En%	**14.9**	11.8	16.2	**15.4**	12.2	16.6	
Fat	En%	**38.6**	37.3	42.5	**36.7**	35.4	40.6	**40**
Carbohydrates	En%	**45.6**	41.7	49.8	**47.1**	43.1	51.3	
Minerals								
Sodium	mg/d	**141**	131	153	**164**	153	175	**200**
Calcium	mg/d	**368**	344	419	**449**	426	500	**330**
Iron	mg/d	**3.7**	2.5	4.3	**5.5**	4.3	6.1	**8**
Zinc	mg/d	**4.1**	3.0	5.4	**5.0**	3.9	6.3	**2.5**
Iodine	μg/d	**50.0**	45.2	63.7	**59.8**	55.0	73.5	**80**
Vitamins								
Vitamin A (RE eq)	μg/d	**572**	273	1,823	**561**	262	1,811	**600**
Vitamin B_1	mg/d	**0.5**	0.4	0.7	**0.6**	0.5	0.8	**0.4**
Vitamin B_2	mg/d	**0.6**	0.5	0.7	**0.8**	0.7	0.9	**0.4**
Folate	μg/d	**115**	98	133	**123**	105	140	**80**
Vitamin C	mg/d	**81.1**	35.8	152.2	**88.4**	43.2	159.6	**20**

Tab. 2: **Daily intake of energy and nutrients with the breast milk plan and formula plan and D-A-CH reference values for nutrient intake [4]**
EN% = energy percentage; M = mean; Max = maximum; Min = minimum; RE eq = Retinol equivalents

feeding concept.

Meals

The macronutrient proportions in the energy content of the meals vary between meals (◆ Figure 2); the modular concept of the Dietary Scheme does, however, enables balancing across the three complementary meals including the fluid milk part towards a daily diet in line with reference values.
The high protein content of the meals with meat (vegetable-potato-meat meal) or cows' milk (milk-cereal meal) is partly balanced out by the two meals with low protein content (breast milk, cereal-fruit meal). In meals made up of low-fat foods (vegetable-potato-meat meal, cereal-fruit meal) the added vegetable oil increases the energy density. Rapeseed oil is added due to its favourable fatty acid pattern.

Discussion

Nutrients and foods

The Dietary Scheme for the first year of life as a long proven concept in Germany largely fulfils the latest D-A-CH reference values for nutrient intake in the second six months of life. In contrast to the first six months of life, complementary food provides the majority of the nutrients required between the ages of 6–12 months. The milk proportion becomes smaller in comparison. The critical nutrients iron and iodine remain, the intake of which is described by the EFSA as generally low for infants in Europe [24].
Two studies on infants fed in line with the Dietary Scheme found that iron reserves were exhausted at the age of 10 months, but without any clinical signs of iron deficiency [25, 26]. The assurance of an adequate **iron intake** remains an important task of advice [7]. This is all the more relevant in the case of parents feeding their infants a vegetarian diet [27]. Thus, the main recommendation is use of the Dietary Scheme as a standard plan with emphasis on the first meal containing meat as a source of readily available haem iron.
In the case of home-made baby food and continuation of breastfeeding, as recommended in the Dietary Scheme, **iodine intake** can be effectively increased with a commercial enriched milk-cereal meal (dried) or an iodine supplement. Insufficient iodine intake in infancy can have long-term detrimental effects on child development [23].
The high **protein intake** with the Dietary Scheme in comparison to the reference value reflects infant nutrition in Europe [28]. The possible impact of high protein intake early in life on obesity risk later in life has been discussed mainly for the early months of life [24], whilst data for the second half of infancy is scarce and not unanimous. A recent report by the European Union (EU) shows that the protein intake of infants and toddlers in Europe is generally higher than required [28].
On the other hand, intake of **n-3 fatty acids**, also often evaluated as critical in infants in Europe, are adequate in the Dietary Scheme [24]. The reason for this is use of rapeseed oil (alpha-linoleic acid) and fish high in fat (DHA, eicosapentaenoic acid [EPA]).
The alternation of vegetables reduces the traditional dominance of carrots in vegetables in complementary meals. This not only increases taste variation but also reduces the potential sodium intake, as carrots are one of the vegetables with relatively high sodium content. The positive effect on sodium intake is particularly evident in the formula plan, which already more or less reaches the limit of the sodium re-

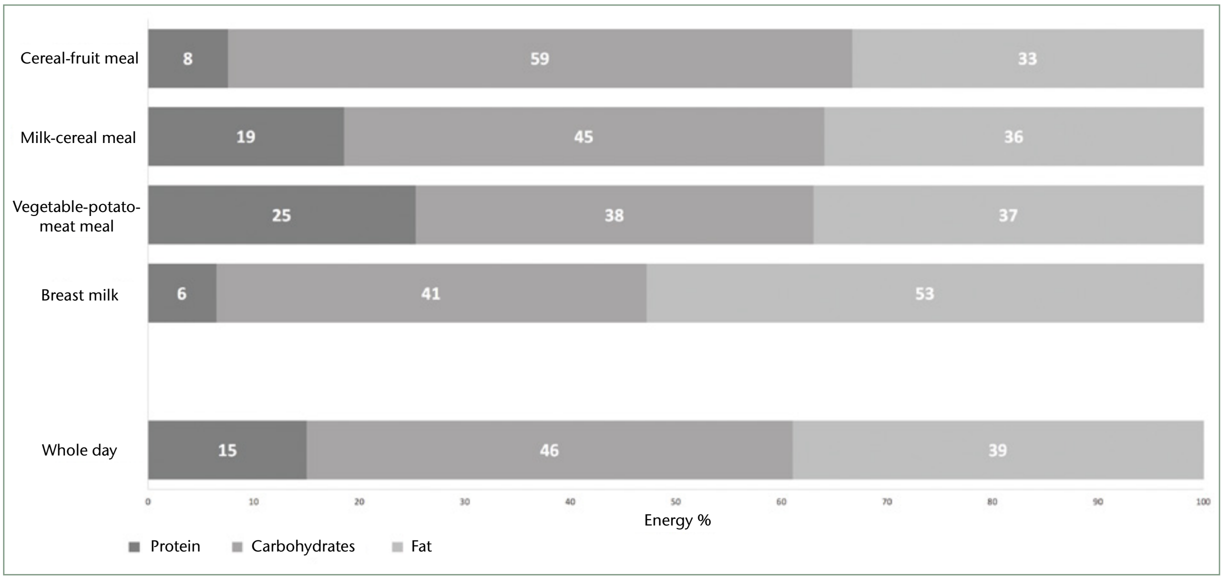

Fig. 2: **Percentages of energy from protein, carbohydrates and fat to the total energy content in the various meals and in overall daily diet energy intake** (in line with [30])

ference value due to the higher sodium content of the follow-on formula compared to breast milk [29]. This fact supports the general recommendation not to add salt to baby food.

Meals

The **modular concept**, in which the nutrient profiles of the meals complement one another for a balanced daily diet, is a specific characteristic of the Dietary Scheme in contrast to complementary feeding recommendations in other European countries [30]. For example, the two low-protein meals (breast milk or follow-on formula, cereal-fruit meal) avoid an even higher protein intake in the Dietary Scheme. However, this does mean that the cereal-fruit meal as a stand-alone product does not correspond to the European Directive on baby foods [31]. Nevertheless, in the modular meal system this element has an important preventive control function in the overall concept of the Dietary Scheme, although it is not strictly an EU-compatible complementary meal.

Limitations

The Dietary Scheme concept is based on the nutritional potential of common foods, which excludes primary nutrient substitution and accepts the low intake levels of the "critical" nutrients which are well-known and dealt with in the discussion. The extent to which the naturally high protein intake associated with the complementary food in the Dietary Scheme is "critical" as regards potential obesity risk remains unclear at present due to the lack of scientific evidence.

As regards calculation, the evaluation of nutrient intake relies on tabular values since the quantities of nutrients actually consumed by the child are not known.

Conclusion

The recalculation opens up the modular food and meal-based concept of the Dietary Scheme for scientific discussion.

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Conflict of Interest
The authors declare no conflict of interest.

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