Commercial Complementary Food in Germany: A Market Survey

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Abstract

Background: As consumption of commercial complementary food (CCF) during infancy and toddlerhood is common, the aim of the present study was to describe the current (2020) German market of CCF products with a special focus on ingredients, macronutrients, and the practice of nutrient fortification.

Methods: Information on age declarations, ingredients, energy and nutrient contents, and nutrient fortification of 1057 CCF products was obtained by contacting the producers and searching manufacturers' websites. Each product was assigned to one of thirteen product categories (menus, milk-cereal-meal, fruit-cereal-meal, oil, vegetables, meat, fish, fruits, cereals, snack foods, pouches, desserts, beverages) and stratified into infants' CCF (< 12 months, n=829) and toddlers' CCF (> 12 months, n=228). Descriptive statistics were used in order to give an overview of the available products.

Results: Highest protein content (% of energy content, %E) was found in meat products. More than 50 %E of total sugar was found in pouches, beverages, cereal fruit meals, and fruits. Highest median salt content was found in toddlers' menus and desserts. Around one third of infants' CCF products and one quarter of toddlers' products were fortified with nutrients. Vitamin B1 (thiamin) was the most frequently fortified nutrient, followed by vitamin C, iron, calcium, and vitamin D. Apple was the type of fruit listed most often in products with fruits, whereas carrot was the most frequent vegetable among CCF with vegetables.

Conclusion: The available product categories as well as the high sugar content of most CCFs currently available on the German market may promote unhealthy dietary habits. Parents need to be educated about the optimal selection of products.

Background

The introduction of complementary foods from 4 to 6 months of age is recommended (1–3). While breast milk provides all the essential nutrients after birth, complementary foods are more variable and have to be combined to meet nutrient requirements (3, 1). Furthermore, infants' taste preferences continue to develop with long-lasting effects for later life (4–6).

Parents have to decide whether they self-prepare the infants' meals from fresh foods or whether they use commercial complementary food (CCF) products. Both approaches have some advantages and disadvantages: CCF are processed and convenient products. Home-made complementary food needs more time effort but are less expensive. In addition, home-made complementary food has the potential to provide a greater variety of flavors and textures, whereas food variety in CCF is reported to be lower (7).

In both commercial and home-made complementary food, the composition of ingredients is decisive for energy and nutrient contents. Some characteristics are required by law in the European Union. For example, maximum contents of sucrose or other sweetening foods were set, if these ingredients were added to a product. Furthermore, sodium content is limited (8). Nevertheless, market surveys repeatedly

show that additions of salt and sugars in CCF are common in Europe and other countries (9–12). As consumption of CCF during infancy and toddlerhood is common (9, 13, 14), the aim of the present article was to describe the current market of CCF in Germany with a special focus on ingredients, macronutrients, and the practice of nutrient fortification.

Methods

The survey started with the identification of relevant retailers, manufacturers and brands in April 2020 through visits to supermarkets and websites. Then, the producers were contacted to obtain declared product information (May to July 2020). In case of no response, the necessary information was researched via the manufacturers' websites.

Each product was assigned to one product category:

- Menus: declared as "baby menus" (for age group 5 to 7 months) and "junior menus" (for age group 8 to 12 months), composed of vegetables, starchy food (e.g., potatoes) and protein food (e.g., meat, fish), in part with oil and/or fruit, including soups and stews, offered in jars
- Milk-cereal-meal: declared as "milk porridge", "Porridge", "Good Evening Porridge", "Good Night Porridge", composed of milk and cereals, in part combined with fruit, offered as ready-to-eat meal in jars or bottles (drink meals) or instant products for the preparation with water
- Fruit-cereal-meal: composed of fruit and cereals, often declared as „muesli“, available in jars
- Oil
- Vegetables: Pureed vegetables in jars, in part mixed with potatoes or cereals, and oil
- Meat: Pureed meat, in part with starchy ingredients and/or added oil, offered in jars
- Fish: Pureed fish, in part with potatoes, offered in jars
- Fruits: Pureed fruits, in part mixed with dairy (e.g. yoghurt), cereal, or vegetables, offered in jars
- Cereals: instant flakes or popped cereals, in part mixed with dried fruit pieces, offered as instant products
- Snack foods: biscuits, waffles, rusk, or bars
- Pouches: pureed fruit partly mixed with vegetables, cereals or dairy, offered in compressed plastic bags with a spout and a screw cap, from which the contents can be sucked out
- Desserts: declared as desserts or pudding, offered in jars
- Beverages: juices from fruit or vegetables, in part mixed with water or tea, teas (instant, tea bags or ready-to-drink)

Complete meals (i.e. menus, milk-cereal-meals, and cereal-fruit-meals) correspond to the meals within the German complementary food guidelines (15, 1). Meal components (i.e., cereals, fruits, vegetables, meat, fish, and oil) can be used for the preparation of these meals. Snacks (i.e., pouches, snack foods, and desserts) do not correspond to the recommendations.

Data entry of the surveyed products were performed using Microsoft Excel (version 2016). The product characteristics included brand and product name of the manufacturer, age declaration, declared ingredients, energy and nutrient contents, and nutrient fortification. If sodium was declared instead of salt, the amount of salt was calculated. If nutrient contents were declared as “less than” (e.g., < 20 mg sodium), the threshold value was used instead (20 mg sodium). Products with added sugars (i.e., sugar, syrup, honey, fruit concentrates, as well as fruit juice), salt (i.e., iodized salt, sea salt, table salt), and added fat/oil were identified according to the ingredient list.

Products were stratified into infants’ CCF (declaration < 12 months) and toddlers’ CCF (declaration “after 12 months”, “after 1 year”, or “1-3 years”).

Descriptive statistics were performed with SAS ® procedures (version 9.2; Cary, NC, USA) and included frequencies and percentages for categorical variables and median and quartiles for continuous variables.

As this study does not include humans nor animals, no ethic approval was necessary.

Results

CCF products

Overall, 1057 CCF products of 27 brands were identified (one to 210 products per brand), produced by 21 companies. Of these, 829 CCF products (78 %) were declared for infants, 228 (22 %) products were declared for toddlers (Table 1).

Complete meals made up about one third of infant CCF (Table 1). Among complete meals, more than half were menus (Table 1). Most menus were made with meat (n=98, 54.5 % of menus), followed by vegetarian menus (n=50, 27.7 %) and fish-menus (n=17, 9.4 %). Fifteen menus (8.3 %) were declared as ‘soups’ (data not shown).

Milk-cereals-meals were offered as instant products to be prepared with water (n=49, 57.6 % of milk-cereal-meals) or as ready to eat meals in jars (N=30, 35.3 %). Six products (7.1 %) were offered as drink-meals (data not shown).

Cereal-fruit-meals accounted for around 20 % of complete meals (Table 1).

Among meal components, fruit products accounted for around half of the products (Table 1). The majority of fruit products were made from pure fruits, either single fruits (n=20, 14.6 % of fruit products) or a mix of fruit types (N=89, 65.0 %). Some fruit products were mixed with dairy (N=25, 18.2 % of fruit products) or vegetables (n=3, 2.2 %) (data not shown).

Among vegetable products, single vegetables (n=21, 33.3 %) or mixtures from different types of vegetables (n=19, 30.2 %) accounted for one third of the products. Some vegetables were mixed with

potatoes (n=18, 28.6 %) or fruits (n=5, 7.9 %) (data not shown).

Infant cereals accounted for around 10 % of infants' CCF. Meat, oil, and fish were the meal components with the lowest number of products (Table 1).

The majority of snacks were pouches, followed by snack foods and desserts (Table 1).

Among pouches, three products were made only from vegetables (2.7 %), the other pouches were prepared from fruits (n=42, 37.8%) or mixtures of fruits with dairy (n=9, 8.1 %), vegetables (n=22, 19.8 %) or cereals (N=35, 31.8 %) (data not shown).

Of beverages (Table 1), around two thirds were teas or mixtures from juice and water or tea (n=33, 61.1 %), 21 products (38.9 %) were pure juices (data not shown).

The majority of infant CCF was declared for younger ages ("after 4 months"/"from the age of 5 months"), only 13 % of infant CCF was declared as "from the 10th to 12th months" (Table 1).

Snack foods (n=77, 33.8 %) were the predominant category among toddlers' CCF, followed by pouches (n=60, 26.3 %), menus (n=40, 17.5 %) and beverages (n=26, 11.4 %). Six products (2.6 %) were categorized as desserts. Toddlers' cereals (referred to as mueslis, n=12, 5.3 %), noodles (n=2, 0.9 %) and sauces (n=5, 2.2%) accounted for less than 10 % of toddlers' CCF, respectively. Of toddlers' menus, six products (15.0%) were vegetarian menus and three products were prepared with fish (7.5 %) (data not shown).

Table 1. Product categories and declared age of infants' commercial complementary foods, results of a 2020 market survey in Germany

Product category	Total 1	After 4th month/from the age of 5 months	After 6th/7th month	After 8th/9th month	After 10th/12th month
	N (%) 1	N (%) ²	N (%) ²	N (%) ²	N (%) ²
<i>Complete Meals (N=328)</i>					
Menus	180 (21.7)	38 (21.1)	21 (11.7)	65 (36.1)	56 (31.1)
Milk-Cereal-Meals	85 (10.3)	25 (29.4)	41 (48.2)	10 (11.8)	9 (10.6)
Cereal-Fruit-Meals	63 (7.6)	19 (30.2)	28 (44.4)	11 (17.5)	5 (7.9)
<i>Meal Components (N=288)</i>					
Fruit	137 (16.5)	93 (78.9)	22 (16.1)	6 (4.4)	16 (11.7)
Cereals	68 (8.2)	38 (55.9)	20 (29.4)	4 (5.9)	6 (8.8)
Vegetables	63 (7.6)	53 (84.1)	10 (15.9)	-	-
Meat	12 (1.4)	10 (83.3)	2 (16.7)	-	-
Fish	2 (0.2)	1 (50)	1 (50)		
Oil	6 (0.7)	6 (100)	-	-	-
<i>Snacks (N=159)</i>					
Pouches	111 (13.4)	12 (10.8)	78 (70.3)	14 (12.6)	7 (6.3)
Snack foods	43 (5.2)	-	8 (18.6)	32 (74.4)	3 (7.0)
Desserts	5 (0.6)	-	1 (20.0)	-	4 (80.0)
<i>Beverages (N=54)</i>					
Tea, water, juices	54 (6.5)	45 (83.3)	6 (11.1)	1 (1.9)	2 (3.7)
<i>Total</i>	829	340 (41.0)	238 (28.7)	143 (17.3)	108 (13.0)

(100)

¹ Percentage of all products

² Percentage of the respective product category

Table 2. Declared energy and nutrient contents per 100 g of commercial complementary food products for infants and toddlers, results of a 2020 market survey in Germany ¹

Product category (n)	Energy (kcal)	Protein (g)	Fett (g)	SFA (g)	Carbohydrates (g)	Total sugar (g)	Salt (mg)
Infants							
<i>Complete meals</i>							
Menus (n=180)	66 (61;70)	2.5 (22.2; 2.8)	2.4 (1.9; 2.8)	0.5 (0.4; 0.7)	7.7 (7.0; 8.7)	2.1 (1.6; 2.5)	0.08 (0.05; 0.03)
Milk-cereal-meals (n=85)	92 (76;103)	3.0 (2.6; 3.5)	2.5 (2.2; 2.9)	0.9 (0.7; 1.1)	14.0 (11.0; 16.1)	6.3 (4.8; 7.3)	0.08 (0.07; 0.09)
Fruit-Cereal-meals (n=63)	66 (60; 72)	1.0 (0.8; 1.1)	0.4 (0.3; 0.6)	0.1 (0.0; 0.2)	13.6 (11.9; 15.0)	9.6 (7.6; 10.8)	0.03 (0.01; 0.05)
<i>Meal components</i>							
Fruits (n=137)	57 (52; 62)	0.5 (0.4; 0.7)	0.2 (0.1; 0.5)	0.0 (0.0; 0.2)	11.8 (11.1; 13.0)	10.1 (9.1; 10.8)	0.05 (0.01; 0.05)
Cereals (n=68)	376 (363; 388)	11.0 (9.3; 12.5)	3.2 (2.1; 4.5)	0.7 (0.5; 0.9)	70.0 (6.9; 78.1)	1.5 (0.8; 5.7)	0.01 (0.01; 0.03)
Vegetables (n=63)	41 (31; 54)	0.9 (0.7; 1.2)	1.2 (0.2; 1.8)	0.1 (0.0; 0.2)	6.5 (5.0; 7.5)	2.6 (2.0; 3.8)	0.05 (0.02; 0.08)
Meat (n=12)	102 (90; 108)	8.1 (7.8; 8.9)	4.6 (3.1; 5.8)	1.7 (1.0; 2.1)	6.0 (4.7; 6.4)	0.0 (0.0; 0.2)	0.07 (0.04; 0.08)
Pouches (n=111)	63 (54; 72)	0.8 (0.6; 1.1)	0.5 (0.3; 0.6)	0.1 (0.1; 0.2)	12.0 (11.0; 14.0)	9.9 (8.1; 12.0)	0.01 (0.01; 0.05)
Snack foods (n=43)	390 (370; 429)	8.0 (6.9; 10.0)	4.4 (0.9; 11.0)	0.8 (0.2; 1.5)	76.0 (70.0; 82.0)	7.5 (2.7; 13.0)	0.03 (0.01; 0.05)

Table 2 (continued)

Product category (n)	Energy (kcal)	Protein (g)	Fett (g)	SFA (g)	Carbohydrates (g)	Total sugar (g)	Salt (mg)
Desserts (n=5)	84 (82; 84)	3.5 (3.0; 3.6)	2.7 (1.7; 3.1)	1.2 (1.1; 1.7)	12.4 (11.8; 13.1)	8.4 (8.4; 8.6)	0.13 (0.10; 0.13)
Beverages ² (n=44)	30 (20; 47)	0.2 (0.0; 0.5)	0.1 (0.0; 0.2)	0.0 (0.0; 0.0)	6.5 (4.8; 10.9)	6.2 (4.4; 9.8)	0.05 (0.01; 0.05)
Toddler							
Menu (n=40)	70 (67; 75)	2.6 (2.5; 2.9)	2.4 (2.3; 2.6)	0.5 (0.4; 0.8)	8.8 (8.2; 9.8)	1.6 (1.4; 1.9)	0.43 (0.36; 0.48)
Cereals (n=12)	370 (35; 377)	11.1 (10.5; 12.2)	5.6 (3.8; 5.9)	1.0 (0.7; 1.2)	63.1 (90.7; 67.7)	8.5 (6.3; 10.8)	0.01 (0.01; 0.05)
Pouches (n=60)	59 (55; 64)	0.6 (0.4; 0.8)	0.4 (0.2; 0.5)	0.0 (0.0; 0.2)	12.0 (11.3; 12.9)	10.8 (10.1; 11.5)	0.05 (0.01; 0.05)
Snack foods (n=77)	383 (366; 416)	5.7 (4.4; 7.6)	8.6 (6.6; 13.7)	2.0 (0.9; 3.6)	69.0 (64.8; 72.0)	28.8 (12.1; 41.0)	0.05 (0.03; 0.15)
Desserts (n=6)	84 (82; 90)	3.2 (3.1; 3.6)	2.3 (1.7; 3.3)	1.7 (1.2; 2.2)	12.4 (11.7; 13.3)	8.4 (7.4; 8.6)	0.12 (0.08; 0.15)
Beverages ² (n=25)	18 (16; 21)	0.0 (0.0; 0.1)	0.1 (0.0; 0.1)	0.0 (0.0; 0.0)	3.8 (3.5; 4.5)	3.5 (3.1; 4.2)	0.05 (0.05; 0.05)

Values are median (Quartile 1, Quartile 3), SFA=saturated fatty acids

¹ due to the small number of products, product categories oil and fish were not shown

² Excluding instant teas and bagged teas, missing values for salt content in beverages: n=3 (infant products) and n= 6 (toddler products)

Energy and Nutrient Contents

Energy content was highest in infants' or toddlers' snack foods. Highest protein content was found in cereals. Maximum fat content was found in toddlers' snack foods and cereals. Saturated fatty acids exceeded 1.5 g/100 g only in meat products, and in toddlers' snack foods and desserts. Snack foods and cereals, both for infants and toddlers, had the highest carbohydrate contents (> 60 g/100 g). Total sugar content was around 10 g/100 g in fruit-cereal-meals, fruits, and pouches, and nearly 30 g/100 g in toddlers' snack foods. Except toddlers' menus and desserts, salt content was < 0.9 g/100 g (Table 2).

Expressed as % of energy, highest protein content was found in meat products, followed by menus for infants and toddlers and toddlers' desserts. Carbohydrate content was lowest in meat (20.6%). In all other product groups carbohydrates provided between around 50 % and 90 % of energy content. In meat products, cereals and toddlers' menus, contribution of sugar to energy content was less than 10 %. More than 50 %E sugar was found in pouches, beverages, cereal fruit meals, and fruits (Figure 1).

Fortification

Around one third of infants' CCF products and one quarter of toddlers' products were fortified with nutrients. Highest fortification prevalence among infants' CCF was found in cereals, milk-cereal-menus, snack foods and beverages. In toddlers' CCF, cereals was the category with the highest prevalence of fortification, followed by snack foods and pouches. Vitamin B1 (thiamin) was the most frequently fortified nutrient, followed by vitamin C, iron, calcium, and vitamin D (Table 3).

Table 3. Nutrient fortification¹ in commercial complementary foods (CCF), results of a 2020 market survey in Germany ²

Product category (N)	Total N (%)	Vitamin B1 N (%)	Vitamin C N (%)	Iron N (%)	Calcium N (%)	Vitamin D N (%)	Iodine N (%)
Infants' CCF (829)	264 (31.9)	185 (22.3)	91 (11.0)	63 (7.6)	61 (7.4)	59 (7.1)	32 (3.9)
Menus (180)	22 (12.2)	-	-	22 (12.2)	-	-	-
Milk-cereal-meal (85)	79 (92.9)	77 (90.6)	33 (38.8)	36 (42.4)	57 (67.1)	57 (67.1)	32 (37.7)
Cereal fruit meal (63)	11 (17.5)	7 (11.1)	5 (7.9)	-	-	-	-
Fruits (137)	25 (18.3)	4 (2.9)	22 (16.1)	-	4 (2.9)	-	-
Cereals (68)	68 (100.0)	68 (100.0)	1 (1.5)	1 (1.5)	-	1 (1.5)	-
Vegetables	2 (1.8)	-	1 (1.6)	2 (3.2)	-	-	-
Pouches	2 (1.8)	-	2 (1.8)				
Snack foods (43)	28 (67.4)	28 (65.1)	-	-	-	-	-
Desserts	1 (20 %)	1 (20-0)	1	-	-	1 (20.0)	-
Beverages (54)	26 (48.2)	-	26 (48.2)	2 (3.7)	-	-	-
Toddlers' CCF (228)	53 (23.3)	30 (13.2)	16 (7.0)	9 (4.0)	2 (0.9)	-	-
Menus (23)	3 (13.0)	-	-	3 (13.0)	-	-	-
Cereals (12)	11 (91.7)	11 (91.7)	-	-	-	-	-
Snack foods (77)	21 (27.3)	18 (23.3)	-	4 (5.2)	1 (1.3)	-	-
Pouches (60)	15 (25 %)	-	15 (25)	2 (3.3)	-	-	-
Beverages (26)	2 (7.7)	-	1 (3.9)	-	1 (3.9)	-	-
Pasta (2)	1 (14.3)	1 (14.3)	-	-	-	-	-
Total (1057)	317	215	107	72 (6.8)	63 (6.0)	59 (5.6)	32

¹ Fortification with vitamin B2, vitamin B6, vitamin B12, vitamin K, niacin, biotin, zinc, pantothenic acid: < 1 % of products, fortification with vitamin E, folate < 3 % of products; no fortified products found among oils, meat, fish

² Percentage of fortified products in this category

CCF with cereals (i.e. milk cereal meals, fruit cereal meals and cereals) were the categories most often fortified with vitamin B1, products with fruits (i.e. fruits, beverages, pouches) and milk-cereal-meals with vitamin C. Infant menus and milk-cereal-meals were the categories most often fortified with iron. Milk-cereal-meals were also most often fortified with calcium and vitamin D, and the only category fortified with iodine (Table 3).

Ingredients

Apple was the type of fruit listed most often in products with fruits, whereas carrot was the most frequent vegetable among CCF with vegetables. Poultry (e.g. chicken, turkey) was the most frequent meat. Only two species were used for fish products (salmon and pollack). Four of five infants' and toddlers' menus and vegetables were prepared with added oil, predominately rapeseed oil (Table 4). In 78 products (27.6 %), a combination of rapeseed oil and other oils was used (data not shown).

Sweeteners (i.e. sugar, honey, syrup, juice) were used in 233 products (23.8 % of all CCF products, excluding beverages, n=977). Juice was the sweetener used most often (n=195, 83.7 % of sweetened products), followed by sugar (n=38, 16.3 %), honey and rice syrup (both n=3, 1.3 %) (data not shown). Other sweetener, e.g. glucose, fructose, high fructose corn syrup were not found in CCF.

Among cereal-based products, whole grains were listed as ingredients in 139 products (61.0 %) (data not shown).

Salt was added in n=62 infants' menus (34.4 % of all menus), always as iodized salt. Four infants' pouches were prepared with an oat mixture with added sea salt (3.6 %). In toddlers' menus, 80% (n=32) of products were prepared with added iodized salt, two further products with sea salt (11.7 %). Two toddlers' snack foods were prepared with iodized salt and sea salt, respectively (each 2.4 %) (data not shown).

Flavors, herbs or spices were used in 190 products (18.0 % of all CCF). Vanilla (n=35, 18.4 % of flavored products) was used in milk-cereal-meals (n=16), toddlers' CCF (n=10) and desserts (n=5). Seventeen products (8.9 %) contained cacao, predominantly milk-cereal-meals and snack foods. Six products were flavored with cinnamon and five beverages (teas) were flavored with aroma. Herbs (e.g. parsley, basil, oregano, marjoram, thyme, lovage, dill) were listed as ingredients in 58 infants' or toddler' menus, curry, turmeric and/or ginger in seven products (data not shown).

Table 4. The most frequent ingredients (types of fruits, vegetable, meat, fish, and fat/oil) in commercial complementary foods for infants and toddlers, results of a 2020 market survey in Germany

Product categories	Most frequently ¹ listed ingredients
Type of fruits ¹ in fruit-cereal-meals, fruit products, fruit pouches, milk-cereal-meals in jars (n=398 products)	Apple n=285 (71.6 %), banana n=178 (44.7 %), pear n=100 (25.1 %), berries n=89 (22.4 %), mango n= 65 (16.3 %), peach n=53 (13.3 %), apricot n= 24 (6.0 %), grape n=31 (7.8 %)
Type of vegetables ¹ in menus, vegetables and vegetable pouches (n=308 products)	Carrots n=234 (76.0 %), tomato n= 118 (38.3 %), onions n=125 (40.6 %), parsnip n= 54 (17.5 %), zucchini n= 47 (15.3 %), pea n=44 (14.3 %), corn n= 37 (12.0 %), pepper n = 24 (7.8 %), spinach n = 24 (7.8 %), broccoli n=21 (6.8 %), leek n= 20 (6.5 %), celery n = 17 (5.5 %),
Type of meat menus and meat products (n=142)	Poultry n= 67 (47.2 %), beef n= 59 (41.6 %), pork n= 15 (10.6 %)
Type of fish in fish-menus and fish-jars (n=23)	Salmon n=14 (60.9 %), pollack n=9 (39.1 %)
Type of added fat/oil in menus and vegetable products (n=283)	Rapeseed oil n=210 (74.2), sunflower oil n=67 (23.7 %), corn germ oil n= 36 (12.7 %)

¹ listed in ≥ 5 % of products

Discussion

Products

Compared to a similar study conducted 20 years ago in Germany (16), the number of infants' CCF has increased (in 2020: infants' CCF n=598, toddlers' CCF from n=38). A recent survey of infants' CCF in 10 European countries (17) included between n=99 and n=768 baby foods per country.

Pouches, which made up the largest group in the snack category, were not listed in the 2000 market survey in Germany (16). Pouches are criticized for their ingredients and texture (18) and are supposed to promote caries (19). As in Australia (18), pouches were mainly declared to older children aged 6 months on up, although during this age infants should be gradually accustomed to lumpy or solid foods (20, 21).

Sugar content of fruit juices is similar to soft drinks. The American Academy of Pediatrics recommended to avoid any fruit juice during the first year of life (22). Furthermore, against the background of the early shape of dietary habits, children should be accustomed to water as a drink from the very beginning.

Menus accounted for the largest share of complete meals, the majority of which were meals with meat. As iron requirement during the complementary feeding period is high, meat or iron fortified cereals are recommended (23, 2, 3, 15). It is worth to mention, that in Germany only one iron fortified infant cereal

was available. However, it should be noted that common whole grains, e.g. oat, millet, or wheat, have a high natural iron content, but bioavailability is lower than of iron from meat (23).

In Germany, in contrast to other countries (24, 25), fish has hardly been included in complementary feeding (26). Beside the observed association of fish consumption during weaning and the risk reduction of allergies (25, 24), maritime fish is a good source of iodine, and in case of fatty fish, of long-chain polyunsaturated fatty acids (27). However, 40 % of fish products in our survey were prepared with a low-fat species (pollack).

Iodine is a potential critical nutrient during weaning (28, 3, 16). Except fish, non-fortified complementary food in general is low in iodine whether self-prepared or commercial (28). In our survey, less than 4 % of all products were fortified with iodine.

Fortification

The overall prevalence of fortification has decreased from 70 % in 1998 (16) to around 30 % of products in the current survey. Vitamin B1, calcium and vitamin D were the nutrients most commonly used for fortification. The extent to which this is necessary is questionable, since the reference values for calcium and vitamin B1 can be achieved without fortification (15). As vitamin D is supposed to be generally supplemented in the first year of life (29, 1), the need of vitamin D fortified CCF is also questionable.

Ingredients

International authorities are unanimous in recommending that complementary foods should not be prepared with added sugar (2, 3, 1, 15). The use of classic sweeteners as sugar and honey was low this survey. However, when fruit juice was included in the added sugars definition (17), the proportion of sweetened CCF clearly increased. Furthermore, the intense pureeing process liberates intrinsic sugar from fruits and vegetables. Hence, sugars from these foods can be considered as free sugars, too (17). That is why a large portion of the total sugar as declared on CCF in our survey would have to be considered free sugars. It is noteworthy that total sugar content for nearly all product categories was above 10 %E, the free sugar limit recommended by the WHO for over 2-year-olds (30).

Our survey confirms the low variety of ingredients and tastes in CCF (7, 10). Particularly, bitter tasting types, as spinach, broccoli, and cauliflower, were used in few products. The innate dislike of bitter tasting substances in humans (31) can be overcome by repeated exposure (32). Therefore, the complementary feeding period is regarded as a 'window of opportunity' (33), when exposure to a wider range of flavors increases acceptance and reduces reluctance towards disliked and novel tastes even in the long term (34). By the observed monotony of types of fruits and vegetables in CCF, the chance to shape preferences in the sense of a healthy diet is missed. However, it should not be concealed that the variety of vegetables offered has increased in Germany in recent years. A 2012 review of fruits and vegetables in

complementary foods identified 16 different vegetables in menus and vegetable preparations (7). In the present market survey, there were 21 varieties (plus 31 %).

Benefits of cereals during weaning are the impact on nutrient intake, in particular iron, the promotion of an 'adult like' microbiota, and the semi-solid texture and consistency (35). Due to the higher iron and fiber intake, these benefits can be easier achieved by whole grain products instead of refined grains. In addition, the complementary feeding period is regarded as important period for the acceptance of whole grains later in life (35).

It has not yet been systematically studied what influence the use of spices and flavors has on children's long-term food preferences. Hence, to the best of our knowledge, there is no official recommendation on the use of spices or herbs during infancy.

Strengths and limitations

In our study, all brands and product information in Germany were collected with a high probability. However, we present data on products offered on the German food market, not intake data. However, it can be assumed that the market is regulated by demand and only products are offered that are also bought by families.

Conclusion

Both the categories of the products offered as well as the high sugar content of most products may promote unhealthy dietary habits during infancy and young childhood. As CCF intake is common (9, 13), parents need to be educated about the optimal selection of products. This includes in particular the avoidance of products with added salt and/or sweetened foods, including juice-sweetened products, snack foods, pouches and desserts (and not using fruit products as desserts). Furthermore, parents should be encouraged to select a variety of vegetables that should not be mixed with fruit, as well as products with fish. In addition, parents should be aware, that product fortification is not necessary, in general. Iodine might be the only exception.

Furthermore, our market survey supports the claims of Hutchinson et al. (17), i.e. the ban of added sugars and sweet snacks, the limited use of pureed fruit in some food categories, and the limitation of total sugar content of 'savory' snacks. We would further support to ban the production of sugar sweetened beverages intended to infants, even if the sugar is natural in case of juices and mixtures of juice with tea or water.

Declarations

Ethics approval and consent to participate

As this study does not include humans nor animals, no ethics approval or consent to participate Statement was necessary.

Consent for publication

Not applicable

Availability of data

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

UA received once lecture fee from one company producing commercial complementary food. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Authors' contributions

UA and SK conceived the project. JJD carried out the data collection and data entry. JJD and UA conducted the data analysis and wrote the manuscript. All authors made substantial contributions, critically read and revised the manuscript as well as approved the final version

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Figures

Figure 1

Declared macronutrient content (% of energy content) of commercial complementary food products (means of product category), results of a 2020 market survey in Germany