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Opinion 050/2023

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No considerable nickel intake via algae as foods with current consumption behaviour in Germany

Nickel is a metal that occurs in the environment as a component of the Earth's crust. In addition to this natural input paths, nickel can also enter the drinking water supply via industrial applications. In the food chain, nickel is considered an environmental contaminant (i.e. an impurity that can enter plant or animal foods via the soil or water). The European Food Safety Authority (EFSA) has derived a Tolerable Daily Intake (TDI) of 13 micrograms per kilogram (µg/kg) of body weight per day for nickel. This is the amount of a substance that can be ingested daily over a lifetime without any recognisable health risk. The German Federal Institute for Risk Assessment (BfR) now presents its calculations on nickel intake via seaweed/algae, which is used in sushi, among other things.

The result shows that algae make a negligible contribution to nickel intake (exposure) from foods in the general population (less than 1%). This can be explained in particular by the fact that algae are eaten by only a small part of the population and that those who consume algae at all do so only rarely. The BfR has therefore calculated separately the proportion of nickel exposure to algae among the small group of people who regularly consume algae. Even in this population, seaweed does not contribute considerably to the total nickel intake (1–2%). Calculated against the TDI, the nickel exposure of the adult population is low overall and well below the TDI. The food groups "grains and grain-based products" and "coffee, cocoa, tea and infusions" contribute the most to exposure in adults and adolescents (24 and 20%, respectively).

Calculated by body weight, children consume more nickel in their diet than older people; however, their intake is usually below the TDI. A small group (<5%) of children between 0.5 and 5 years of age whose diet is particularly rich in nickel-containing foods exceeds the TDI. However, for this age group, no consumption of algae was reported in the underlying study. This means that the nickel came from other foods. For children, the largest sources of exposure are "grains and grain-based products" (28%), "sugar, confectionery and water-based sweet desserts" (12%), and "milk and dairy products" (10%).

The information on dietary habits in the general population of Germany comes from two representative surveys conducted in 2001/2002 (children) and

2005/2006 (adults). A possible increase in the proportion of the population consuming algae is not taken into account. The data available on the nickel content of marine algae such as wakame from the BfR MEAL Study and the 2018 project monitoring are 81% and 98% below the maximum levels currently under discussion.

BfR-Risk profile: Nickel intake via algae

A Affected persons	Adolescents, adults, children				
B Likelihood of impairment to health from consumption of algae (average)	Very low	Low	Medium	High	Very high
C Severity of impairment to health from consumption of algae (average)	Not known				
D Validity of available data	High: The most important data are available and are internally consistent		Medium: Some important data are missing or contradictory		Low: A large volume of important data are missing or inconsistent
E Controllability by the consumer	Controls not needed	Controllable with pre-cautionary measures		Controllable by avoidance	Not controllable

Fields with a dark grey background indicate the properties of the risk assessed in this Opinion
(for more details, see the text of Opinion number 050/2023 of the BfR dated 19 October 2023.

Explanations
The risk profile is intended to visualise the risk outlined in the BfR Opinion. The profile is not intended to be used to compare risks. The risk profile should be read only in conjunction with the corresponding Opinion.

Row D – Validity of available data:
Medium – there are no data on dietary habits since 2007.

1 Background

In this opinion, the German Federal Institute for Risk Assessment (BfR) assesses the contribution of seaweed to the intake of nickel via foodstuffs. The background is that an advisory document from the Directorate-General for Health and Food Safety (SANTE) of the European Commission is available. It contains proposals on maximum levels of nickel in foodstuffs as well as a draft monitoring recommendation, which, among other things, provides for monitoring the nickel content of fish and seafood. The BfR bases this on its communication on the long-term intake of nickel in the general population of Germany[1] and uses the data from the BfR MEAL Study to estimate the influence of potential maximum levels for nickel in seaweed (30 mg/kg and 40 mg/kg; based on dry matter) on nickel intake via food. In particular, the contribution of fish and seafood to nickel exposure is highlighted, and the proposed maximum levels for nickel in seaweed are compared with nickel levels for seaweed from German food monitoring.

2 Summary

Based on the BfR MEAL Study as the first German Total Diet Study (TDS), the dietary exposure of the general population in Germany to nickel was determined, and the contribution of seaweed and the food group "fish, seafood and invertebrates" to the total intake of nickel was calculated. Additional scenarios were calculated assuming proposed maximum levels for seaweed of 30 and 40 mg/kg, and the proposed maximum levels were compared with monitoring data in accordance with Sections 50–52 German Food and Feed Code (LFGB).

Children have a considerably higher dietary exposure to nickel than adolescents and adults. The European Food Safety Authority (EFSA) derived a Tolerable Daily Intake (TDI)[2] of 13 µg/kg body weight (BW) per day for nickel in 2020 (EFSA, 2020). As shown in BfR Communication No. 033/2022 (BfR, 2022), the chronic dietary exposure in adults and adolescents calculated on the basis of the BfR MEAL Study is considerably below this TDI. In contrast, nickel intake exceeds the TDI in some (<5%) highly exposed children (0.5–5 years).

The consumption of both seaweed and foodstuffs in the food group "fish, seafood and invertebrates" contribute less than 1% each to the total nickel intake from foodstuffs. Because of the small number of people consuming seaweed, this does not change even under the model assumption that all seaweed consumed contains nickel at the proposed maximum levels of 30 or 40 mg/kg. The consumption data used probably underestimate the current proportion of algae consumers in the German population. If only those consuming seaweed were considered, seaweed contributed to <1–2% of the total nickel intake via foodstuffs. The exhaustion of the TDI via total food consumption is between 9 and 36% for those who consume seaweed.

1 "Nickel: estimate of long-term intake via food based on the BfR MEAL Study" (Communication No. 033/2022 dated 22 November 2022).

2 The TDI specifies the quantity of a substance that can be ingested daily over an entire lifetime without a detectable risk to health.

The samples of wakame and other seaweed examined in the 2018 project monitoring are 81% and 98% below the proposed maximum levels.

3 Data sets

3.1 Methodology for obtaining the nickel occurrence data in the BfR MEAL Study

Nickel was investigated in the core module of the BfR MEAL Study in all 356 foods on the MEAL food list. For each main food group, the MEAL food list covers at least 90% of the average food intake of different age groups of the general population of Germany and takes into account rarely consumed foods with known high levels of undesirable substances. The data on this are based on the 24-hour recalls of the NVS II (National Nutrition Survey II) for adults and the VELS data for children (Nutrition survey to determine the food intake of infants and young children for the estimation of an acute toxicity risk from pesticide residues). The MEAL foodstuffs for the nickel analysis were purchased in four different regions throughout Germany between December 2016 and May 2019. The product selection took into account the different shopping habits of the population in Germany as well as regional and seasonal characteristics. The underlying information for this representative compilation of samples was generated from consumer studies as well as from market data. The foods were prepared in the MEAL study kitchen while simulating typical consumer approaches to preparation. The foodstuffs and meals were pooled before being homogenised (Sarvan *et al.*, 2017).

To determine the nickel content, 840 pools, each consisting of 15–20 individual foodstuffs (sub-samples), were formed. The pools represent combinations of various purchasing regions (national, east, south, west and north), purchasing times (non-seasonal, season 1 and season 2) and cultivation/production types (non-specific, organic and conventional). The foods were assigned to non-specific categories (national, non-seasonal, non-specific for type of production) or specific categories (regions, seasons, or production) depending on the substance and expected content.

The 356 MEAL foods can be assigned to 19 main food groups (Table 1).

Table 1: Sampling Nickel – Overview.

Main food group	Number	
	Food	**Pools**
01 Grains and grain-based products	40	97
02 Vegetables and vegetable products	34	152
03 Starchy roots or tubers and products thereof	8	26
04 Legumes, nuts, oilseeds and spices	20	24
05 Fruit and fruit products	22	64
06 Meat and meat products	35	101
07 Fish, seafood and invertebrates	30	39
08 Milk and dairy products	23	37
09 Eggs and egg products	2	10
10 Sugar, confectionery and water-based sweet desserts	15	18
11 Animal and vegetable fats and oils	8	13
12 Fruit and vegetable juices and nectars	10	12
13 Water and water-based beverages	6	12
14 Coffee, cocoa, tea and infusions	9	12
15 Alcoholic beverages	8	11
16 Food products for infants and toddlers	11	15
17 Products for non-standard diets and food imitates	7	8
18 Composite dishes	52	170
19 Seasoning, sauces and condiments	16	19
Total:	*356*	*840*

The samples from the BfR MEAL Study were analysed by an external accredited laboratory using inductively coupled plasma-mass spectrometry (ICP-MS). Depending on the specific matrix, the limits of detection (LODs) were 0.03, 0.006, and 0.0003 mg/kg, and the limits of quantification (LOQs) were 0.1, 0.02, and 0.001 mg/kg.

Within the framework of the BfR MEAL Study, algae were analysed as foodstuffs of the main group “vegetables and vegetable products”. As a non-specifically sampled food, the algae pool is composed of 20 sub-samples. The sub-samples were purchased primarily in a dried state (n = 16). If dried algae were purchased, they were blanched before homogenisation. Another four sub-samples contained fresh algae. These were puréed into a smoothie (n = 2) or cooked (n = 2). For the foodstuff algae, the LOD was 0.006 mg/kg and the LOQ was 0.02 mg/kg; in the BfR MEAL Study, an average nickel content of 0.145 mg/kg was determined.

The main food group “fish, seafood and invertebrates” consists of both processed foods (e.g. fish fingers) and fresh or less processed foods (e.g. trout). In addition to various freshwater and salt-water fish, the main group also includes mussels, which in turn consist of oysters, common mussels, and scallops. A list of foodstuffs in the main group “fish, seafood and invertebrates”, indicating the average nickel content determined, can be found in Table 2.

Table 2: Overview of the foods of the main group "fish, seafood and invertebrates" of the BfR MEAL Study indicating the average nickel contents measured at the food level as well as the limits of detection and quantification (all data in **mg/kg**).

Food	LOD	LOQ	Nickel content	
			mLB[2]	UB[3]
Eel	0.006	0.02	0.006	0.020
Eel, smoked	0.006	0.02	0.009	0.016
Spiny dogfish (*Squalus acanthias*), smoked	0.006	0.02	0.016	0.016
Cod liver	0.006	0.02	0.006	0.020
Fish fillet dish, gratinated	0.006	0.02	0.037	0.037
Fish fingers	0.006	0.02	0.042	0.042
Trout[1] *(Salmo trutta*, *Oncorhynchus mykiss)*	0.006	0.02	0.017	0.021
Trout, smoked[1] *(Salmo trutta*, *Oncorhynchus mykiss)*	0.006	0.02	0.006	0.020
Shrimps/prawns	0.006	0.02	0.044	0.044
Herring, fried herring	0.006	0.02	0.038	0.038
Halibut (*Reinhardtius hippoglossoides*, *Hippoglossus hippoglossus)*	0.006	0.02	0.015	0.022
Halibut (*Reinhardtius hippoglossoides*, *Hippoglossus hippoglossus)*, smoked	0.006	0.02	0.006	0.020
Herring, smoked	0.006	0.02	0.006	0.020
Herring fillet, canned in sauce	0.006	0.02	0.029	0.029
Cod	0.006	0.02	0.018	0.018
Carp[1]	0.006	0.02	0.010	0.018
Pollock (*Pollachius virens*), Alaska pollock (*Gadus chalcogrammus*)	0.006	0.02	0.029	0.029
Salmon	0.006	0.02	0.006	0.020
Salmon, smoked	0.006	0.02	0.006	0.020
Plaice/sole)	0.006	0.02	0.034	0.034
Herring, pickled, young salted herring, Bismarck herring	0.006	0.02	0.006	0.020
Herring, pickled (Roll mops)	0.006	0.02	0.006	0.020
Ocean perch (*Sebastes norvegicus*)	0.006	0.02	0.028	0.028
Tuna (*Thunnus spp.)*	0.006	0.02	0.006	0.020
Tuna (*Thunnus spp.)*, smoked	0.006	0.02	0.024	0.024
Tuna (*Katsuwonus pelamis)*, canned in sauce or own juice	0.006	0.02	0.025	0.025
Tuna (*Katsuwonus pelamis)*, canned in oil	0.006	0.02	0.006	0.020
Squid/octopus	0.006	0.02	0.055	0.055
Mussels	0.006	0.02	0.165	0.165
Striped catfish (*Pangasianodon hypophthalmus*)	0.006	0.02	0.006	0.020

1 stratified sampled foodstuff
2 mLB: modified Lower Bound (if result < LOQ, value = LOD; if result < LOD, value = 0)
3 UB: Upper Bound (if result < LOQ, value = LOQ; if result < LOD, value = LOD)

The proposed maximum levels for nickel in seaweed are compared with nickel occurrence data from monitoring in accordance with Sections 50–52 LFGB. For this purpose, data from the project monitoring carried out in 2018 (Project 4) on marine algae are checked for shortfall or exceeding of the proposed maximum levels for nickel in algae and presented in tabular form. Algae for which it is not unequivocally evident that they are dried are excluded from the evaluation.

3.2 Methodology for the collection of consumption data

National Nutrition Survey II (NVS II)

The data set for consumption by adolescents and adults was taken from the National Nutrition Survey II (NVS II) published by the Max Rubner-Institut (MRI). The NVS II is the current representative study for food consumption in the general population of Germany. The study, which surveyed about 20,000 individuals aged between 14 and 80 on their eating habits using three separate survey methods (dietary history, 24-hour recall and weighing protocol), was conducted between 2005 and 2006 throughout Germany (Krems *et al.* 2006, MRI 2008).

The analyses of consumption are based on the data from the two independent 24-hour recalls from NVS II, which were surveyed in a computer-aided interview using 'EPIC-SOFT'. Data were evaluated from 13,926 people for whom both interviews were available.

VELS study

The nutrition survey to determine the food intake of infants and young children for the estimation of an acute toxicity risk from pesticide residues (VELS) was used as the data basis for consumption for children under 5 years of age (Banasiak *et al.*, 2005; Heseker *et al*., 2003). This nationwide study was carried out from 2001 to 2002 in Germany, covering 816 infants and young children aged from 6 months to 5 years old. The parents logged the food consumed by each child in two nutritional records kept over 3 consecutive days. Children who were no longer breastfed (n = 732) were selected for the exposure estimation.

3.3 Exposure assessment methodology

For each participant of the 24-hour recalls (NVS II) and the VELS study, the long-term consumption quantity was determined by calculating the mean consumption over all days of consumption for each food on the MEAL food list. For exposure assessment, a MEAL food was assigned to each of these consumption events. This assignment allows the identification of the appropriate individual consumption events for each pool.

Based on this assignment, exposure was calculated for each consumption event by multiplying the individual consumption amount based on body weight by the content from each pool from the MEAL results. In cases where more than one analytical result was available in a pool (e.g. double determination), the average of all results was selected. For values below the limit of detection or limit of quantification, a mLB and UB scenario were calculated in each case.

Because the type of production (organic and conventional) has only a minor influence on the nickel content and no tendency towards higher contents of one type of production can be identified, the present exposure estimation is based on the assumption that all individuals have consumed only conventionally produced products provided that a corresponding differentiation in the MEAL food list is available. Accordingly, the nickel contents of both conventional and non-specific foods are taken into account in the following presentation.

The determination of the total exposure is based on all respondents who participated in the dietary survey.

In order to model the hypothetical influence of the proposed maximum nickel levels for seaweed on nickel exposure, the average nickel content of seaweed measured in the BfR MEAL Study (0.145 mg/kg) is replaced by the proposed maximum levels (30 mg/kg and 40 mg/kg), and exposure is calculated as described above. Because non-consumers of algae are included as zero-consumers, this can lead to an underestimation of the consumption quantities for those consuming algae. Therefore, additional evaluations are made for those consuming seaweed. These include the calculation of the total exposure as well as the contribution of nickel uptake by algae to the total exposure. Because no algae were consumed in the VELS study, the additional evaluations are presented exclusively for adolescents and adults.

The exposure is calculated for different sub-groups of the German population. This is subdivided according to sex and different age groups. For young people and adults, a distinction is made between the age groups 14–18 years, 19–24 years, 25–34 years, 35–50 years, 51–64 years, and 65–80 years. For children, the age groups are 0.5–< 1 years, 1–< 2 years, and 2–< 5 years[3]. The exposure is given in µg/kg BW per day. Exposure is reported as mean and median (P50) for average eaters and 95th percentile (P95) for frequent consumers. Contribution of individual main food groups to the total exposure are given in tabular form in percent and refer to the averaged total exposure (mean). Because of the minor differences between the mLB and UB scenarios, only the results in the UB are described in the text.

The exposure assessment was completed using the 'R' software package.

4 Nickel exposure in the general population of Germany as a function of the nickel content of algae

Adolescents and adults

Table 3 shows the nickel exposure for adolescents and adults (stratified by sex and age) calculated in BfR Communication No. 033/2022 (BfR, 2022). According to this, the exposure to nickel (P50) of adolescents and adults in the UB is 1.4 µg/kg BW per day. In frequent consumers (P95), the intake of nickel is 3.2 µg/kg BW per day. The nickel intake of women is about the same as that of men. There are also only minor differences in body weight-related nickel intake between different age groups (BfR, 2022). Algae account for < 0.001% of the

[3] Because of the small number of cases (n = 5), stratification by age and sex is omitted when presenting the nickel exposure of seaweed consumers.

average nickel exposure. The exposure assessment of the communication published in 2022 is based on the nickel content of algae determined in the BfR MEAL Study (0.145 mg/kg). Among the participants of NVS II, only five people were consumers of algae.

Because of the marginal influence of the intake of nickel from algae on the exposure of the total population, the presentation of the total intake of nickel in the scenarios on the proposed maximum levels is omitted. Assuming a nickel content of 30 or 40 mg/kg for algae, the total intake increases by a maximum of 0.0045 or 0.006 µg/kg BW per day (mean[4], age group 51–64 years).

Table 3: Nickel intake in **µg per kg BW per day (µg/kg BW/day)** for adolescents and adults in the general population of Germany assuming consumption of mainly **conventionally produced food** and a nickel content of **0.145 mg/kg for algae*** (basis: NVS II; all respondents).

	N	mLB			UB		
		Mean	P50	P95	Mean	P50	P95
Total	13926	1.3	1.1	2.9	1.6	1.4	3.2
Male	6897	1.3	1.1	2.8	1.6	1.4	3.1
Female	7029	1.4	1.2	2.9	1.7	1.5	3.2
14–18 years	937	1.3	1.1	2.9	1.6	1.4	3.3
19–24 years	1200	1.3	1.1	2.9	1.6	1.3	3.2
25–34 years	1961	1.3	1.2	2.8	1.6	1.5	3.2
35–50 years	4311	1.4	1.2	2.9	1.7	1.5	3.3
51–64 years	2860	1.3	1.1	2.9	1.6	1.4	3.2
65–80 years	2657	1.3	1.1	2.7	1.5	1.3	3.0

N: Number
* nickel content determined in the BfR MEAL Study

[4] The mean value is presented because the small number of people consuming algae results in a strongly right-skewed distribution of exposure from which a median of 0 µg/kg BW per day is derived.

Because of the low consumption of algae in NVS II, higher nickel contents in algae here do not result in a relevant increase in the total intake in the general population. Therefore, the relevance of the nickel content in algae for people consuming algae is also presented. This makes it easier to estimate the relevance of changing levels even if the proportion of algae consumers in the population as a whole is assumed to increase.

Among the five consumers of algae, the contribution of nickel intake from algae to their total intake was in the range of < 1 to 2% (nickel content of algae: 0.145 mg/kg). The total nickel intake of the five algae consumers ranges from 1.1 to 4.6 µg/kg BW per day. Based on the data of the BfR MEAL Study, people consuming algae (n = 5) have an average (mean) nickel exposure of 2.9 µg/kg BW per day. In a scenario with 100% exhaustion of a potential maximum content of algae of 40 mg/kg, a higher nickel intake would result in the range of 27.2 µg/kg BW per day to 84.5 µg/kg BW per day. Similarly, with an increase in the nickel content of algae, an increase in the contribution of algae from 1% to 58–64% of the average nickel exposure can be observed (Table 4).Table 4: Average (mean) nickel intake in **µg per kg BW per day (µg/kg BW per day)** and contribution of algae to nickel exposure **(%)** for adolescents and adults in the general population of Germany assuming consumption of mainly **conventionally produced food** and a nickel content of **0.145*, 30**, and 40 mg/kg** for algae** (basis: NVS II; only those consuming algae [n = 5]).

Nickel content of algae (mg/kg)	mLB		UB	
	Nickel exposure	Contribution of algae	Nickel exposure	Contribution of algae
0.145*	2.6	1	2.9	1
30**	7.4	61	7.7	58
40**	9.0	66	9.3	64

* nickel content determined in the BfR MEAL Study
** proposed maximum content

Children

Based on the data of the BfR MEAL Study, Table 5 shows the total nickel intake from food as detailed in the BfR communication (BfR, 2022). According to this, children, both girls and boys, absorb an average of 5.5 µg nickel/kg BW per day (P50) (Table 5). For frequent consumer (P95) amongst boys and girls, nickel intake is calculated to be 10.8 and 10.4 µg/kg BW per day, respectively. In the youngest age group (0.5–< 1 year), the nickel exposure of 4.4 µg/kg BW per day (P50, UB) is lower than in the age groups 1–< 2 years and 2–< 5 years. At 5.8 µg/kg BW per day, children in the age group 1–< 2 years show the highest nickel exposure. For frequent consumers in this age group, the nickel intake is 11.0 µg/kg BW per day (BfR, 2022). Among the participants of the VELS study, there were no consumers of algae. As a result, algae did not contribute to exposure in these children, and a separate consideration of nickel exposure of those consuming algae is not possible.

Table 5: Nickel intake in **µg per kg BW per day (µg/kg BW/day)** for children in the general population of Germany assuming consumption of mainly **conventionally produced food** and a nickel content of **0.145 mg/kg for algae***(basis: VELS study; all respondents).

	N	mLB			UB		
		Mean	P50	P95	Mean	P50	P95

Total	732	5.4	4.8	10.0	6.1	5.5	10.6
Boys	368	5.5	4.8	10.1	6.2	5.5	10.8
Girls	364	5.3	4.8	9.8	6.0	5.5	10.4
0.5 – < 1 year	95	4.0	3.4	8.0	4.9	4.4	9.0
1 – < 2 years	162	5.5	4.8	10.3	6.3	5.8	11.0
2 – < 5 years	475	5.6	5.1	9.9	6.3	5.7	10.5

N: Number
* nickel content determined in the BfR MEAL Study

4.1 Percentage contribution of fish and seafood to nickel exposure in the general population of Germany

Adolescents and adults

Table 6 shows the percentage contribution of the main food groups to the average nickel intake for adolescents and adults. The largest contributor to the total exposure to nickel among adolescents and adults in the UB is accounted for by foodstuffs of the main group "grains and grain-based products" (24%). This is followed by "coffee, cocoa, tea and infusions" and "water and water-based beverages" with a contribution of 20% and 11%, respectively (BfR, 2022). The contribution of the main food group "fish, seafood and invertebrates" to the average nickel exposure is 0.4%. Within this main group, 52% of the analytical results show a nickel content < LOQ. The highest nickel content is available for mussels with 0.165 mg/kg.

Table 6: Percentage contribution of the main food groups to the average nickel intake for adolescents and adults in the general population of Germany assuming the consumption of mainly **conventionally produced food** and the mean nickel content according to the BfR MEAL Study (basis: NVS II; all respondents; average consumption [mean]).

Main food group*	**Contribution (%)**	
	mLB	**UB**
01 Grains and grain-based products	30	24
02 Vegetables and vegetable products	5	4
03 Starchy roots or tubers and products thereof	3	2
04 Legumes, nuts, oilseeds and spices	4	3
05 Fruit and fruit products	7	6
06 Meat and meat products	2	2
07 Fish, seafood and invertebrates	0	0
08 Milk and dairy products	5	5
09 Eggs and egg products	0	0
10 Sugar, confectionery and water-based sweet desserts	8	7
11 Animal and vegetable fats and oils	0	1

12 Fruit and vegetable juices and nectars	1	2
13 Water and water-based beverages	3	11
14 Coffee, cocoa, tea and infusions	20	20
15 Alcoholic beverages	1	3
17 Products for non-standard diets and food imitates	0	0
18 Composite dishes	9	7
19 Seasoning, sauces and condiments	2	1

* The main food group "Food products for infants and toddlers" is not listed because of no consumption

Children

Table 7 shows the contributions of the individual main food groups to the average nickel exposure of children. For children, too, foodstuffs of the main group "grains and grain-based products" account for the largest contribution to total exposure (28%) in the UB scenario. This is followed by the main food groups "sugar, confectionery, and water-based sweet desserts" (12%), "milk and dairy products" (10%), and "food products for infants and toddlers" (9%) (BfR, 2022). Just as in adolescents and adults, the main food group "fish, seafood and invertebrates" contributes only negligibly (0.3%) to the average nickel exposure in children. This can be attributed to the high proportion of nickel contents < LOQ.

Table 7: Percentage contribution of the main food groups to the average nickel intake for children in the general population of Germany assuming the consumption of mainly **conventionally produced food** and the mean nickel content according to the BfR MEAL Study (basis: VELS study; all respondents; average consumption [mean]).

Main food group	**Contribution (%)**	
	mLB	**UB**
01 Grains and grain-based products	30	28
02 Vegetables and vegetable products	3	3
03 Starchy roots or tubers and products thereof	2	2
04 Legumes, nuts, oilseeds and spices	2	2
05 Fruit and fruit products	9	8
06 Meat and meat products	1	1
07 Fish, seafood and invertebrates	0	0
08 Milk and dairy products	9	10
09 Eggs and egg products	0	0
10 Sugar, confectionery and water-based sweet desserts	13	12
11 Animal and vegetable fats and oils	0	1
12 Fruit and vegetable juices and nectars	2	3
13 Water and water-based beverages	2	5
14 Coffee, cocoa, tea and infusions	6	7

15 Alcoholic beverages	0	0
16 Food products for infants and toddlers	8	9
17 Products for non-standard diets and food imitates	1	1
18 Composite dishes	9	8
19 Seasoning, sauces and condiments	2	1

4.2 Comparison of the proposed maximum levels with nickel occurrence data from monitoring in accordance with Sections 50–52 LFGB (2018)

The proposed maximum nickel content for wakame (40 mg/kg) was exceeded by 9.1% of the samples in the 2018 monitoring (Table 8). The highest measured nickel content for wakame was 44 mg/kg. 2.2% of the samples of other seaweeds (brown algae, red algae, and green algae) are above the proposed maximum level of 30 mg/kg. The highest nickel content measured here was 52.5 mg/kg. Because the species of algae was not determined for 34 samples, a maximum content cannot be clearly assigned. Nevertheless, the nickel content of these samples is well below the proposed maximum levels because of the maximum value of 2.9 mg/kg.

Table 8: Comparison of the nickel contents of algae[1] determined in the monitoring in accordance with Sections 50–52 LFGB (2018) with the proposed maximum nickel levels **30 and 40 mg/kg.**

	N	**MC (mg/kg)**	**Contribution > MC**	**Max. value (mg/kg)**	**Max. LOQ (mg/kg)**	**Contribution <LOQ**
Dried wakame	22	40	9.1%	44	0.6	4.6%
Other seaweed, dried[2]	92	30	2.2%	52.5	0.6	6.5%
Undetermined algae, dried	34	-	–	2.9	0.6	20.1%

N: Number of samples; MC = maximum content; LOQ = limit of quantification

1 Exclusion of samples that are not clearly labelled as “dried”

2 “Other marine algae” include brown algae, red algae, and green algae

5 Reference to uncertainties

The data from the VELS study and the NVS II are the current representative data on the consumption of the general population of Germany. Because of the availability of consumption data on individual days, the method of 24-hour recalls and three-day dietary protocols is suitable for exposure estimates for both acute and chronic risks. However, the data were collected in 2001/2002 (VELS) and 2005/2006 (NVS II). Possible changes in consumption have not been accounted for in the present analysis.

For infrequently consumed foods, the survey period of twice one day of the repeated 24-hour recall of NVS II and to a lesser extent VELS can represent the intra-individual variability

of food intake only to a limited extent, and the consumption for adults can be underestimated.

Because of the uncertainties mentioned above, it can be assumed that the consumption of algae is underestimated. The proportion of people consuming algae is too small to be able to draw any reliable conclusions. However, it can be assumed that the consumption of algae has increased since the surveys of the VELS study and NVS II. At least in the group of children from the KiESEL study (0.5–5 years), the proportion of children who consumed algae as a component of sushi is as low as in the NVS II. More recent consumption data are needed for a more accurate exposure estimate.

The food list used for the BfR MEAL Study covers more than 90% of consumption – but less than 100%. As a result, a slight underestimation of exposure is possible.

The drinking water used in the BfR MEAL Study to prepare the meals and beverages has a comparatively high nickel content of 3 µg/kg (mean in the UB). Also, the drinking water sampled regionally in the BfR MEAL Study (n = 29) has a lower nickel content of 1 µg/kg (mean in the UB). The effect of the higher nickel concentration in the MEAL drinking water is especially pronounced for water-based foods such as tea, coffee and infant formula. Although typically rather nuanced, the regional variability in drinking water concentrations can be only partially accounted for by a TDS approach. However, in regions with lower concentrations in drinking water, one may assume a lower intake of nickel from food that is prepared with drinking water.

The maximum levels of nickel in seaweed proposed by DG SANTE refer to the dried food. As a TDS, the BfR MEAL Study claims to analyse the food ready for consumption. As a result, the algae sampled in the MEAL study are in prepared form (e.g. brewed). When calculating exposure using the proposed maximum levels, the nickel content for dried seaweed is taken into account; however, this may lead to an overestimation of nickel exposure. In the scenarios based on the proposed maximum levels, a considerable overestimation for long-term uptake can be assumed because the mean levels in MEAL and monitoring are considerably below the proposed maximum levels of 30 and 40 mg/kg.

Of the 356 foods in the BfR MEAL Study, 105 foods were stratified by organic and conventional production. The exposure scenarios calculated take into account the occurrence data of the 105 stratified foodstuffs as well as the foods not stratified by production (n = 251). In contrast, neither the NVS II nor the VELS data differentiate between organic and conventional production when documenting the foodstuff consumed. The actual exposure with mainly organic or mainly conventional food choices may thus differ from the scenarios calculated here. The degree of under- or overestimation associated with this depends on individual consumption habits.

Further information on the topic of nickel is available on the BfR website

Metallallergien: Bindungsstellen von Nickel-, Kobalt- und Palladium-Ionen an Immunrezeptoren entdeckt (BfR Communication No. 029/2022 dated 26 October 2022, *in German*)

https://www.bfr.bund.de/cm/343/metallallergien-bindungsstellen-von-nickel-kobalt-und-palladium-ionen-an-immunrezeptoren-entdeckt.pdf

Nickel: estimate of long-term intake via food based on the BfR MEAL Study (BfR Communication No. 033/2022 dated 22 November 2022)

https://www.bfr.bund.de/cm/349/nickel-estimate-of-long-term-intake-via-food-based-on-the-bfr-meal-study.pdf

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About the BfR

The German Federal Institute for Risk Assessment (BfR) is a scientifically independent institution within the portfolio of the Federal Ministry of Food and Agriculture (BMEL) in Germany. The BfR advises the Federal Government and the States ('Laender') on questions of food, chemicals and product safety.
The BfR conducts independent research on topics that are closely linked to its assessment tasks.

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