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BfR MEAL study: no vanadium was detected in most foods

The BfR MEAL study provides information on the average amounts of beneficial and potentially harmful substances contained in the most commonly consumed foods in Germany. The acronym "MEAL" stands for "Meals for Exposure Assessment and Analysis of Food". Since 2016, food has been purchased for the MEAL study in usual places and then prepared according to typical household recipes. Food is cooked, fried and baked in a study kitchen especially set up for the study - exactly as consumers do at home. The food samples are then analysed in the laboratory. The study focuses on more than 300 different substances.

In the study, the individual substances are grouped according to their content into work packages or modules. In the core module, the vanadium levels were examined in pooled samples.

No vanadium content was detected in most of the 356 foods tested (97%). The highest concentrations were measured in chewing gum, cocoa powder and dried spices.

Vanadium is a light grey element that usually occurs in the earth's crust in combination with oxygen, sodium, sulfur or chlorine. Due to its diverse properties, it is used industrially e.g. in alloys for superconductors and semiconductors, ceramic production, energy generation and as a catalyst.

Vanadium can, for example, enter the environment via industrial emissions, fossil fuels or geogenic sources and subsequently into drinking water or food crops.

The BfR MEAL study provided the opportunity to generate a comprehensive database on vanadium levels in food. Vanadium was examined in 356 foods on the MEAL food list in the BfR MEAL study. The foods were purchased between December 2016 and May 2019 in four different regions throughout Germany, with the product selection taking into account the different purchasing habits of the population as well as possible production-specific (organic/conventional production) and seasonal characteristics for some of the foods. In order to achieve a representative compilation of the samples, information on the

preparation behavior of consumers was collected and generated from market data. The foods were prepared in the MEAL study kitchen, replicating typical consumer behavior¹. The foods and dishes were then pooled (combined) and homogenized². For the analysis of vanadium, a total of 869 pools were formed, each consisting of 15 - 20 individual foods. This includes 29 drinking water pools from different regions. The pools represent the combinations of different purchasing regions (national, east, south, west, north), purchasing times (non-seasonal, season 1, season 2)³ and production types (non-specific, organic, conventional)⁴. The pools of the production type 'organic' and the drinking water samples are not included in the present evaluation. Table 1 shows the main food groups as well as the number of samples and the statistical key figures of the vanadium concentrations in samples from non-specific and conventional production. The pools of the production type 'organic' were not taken into account, as there are only marginal differences between organic and conventional production due to the high proportion of non-quantifiable vanadium contents. The foods were assigned to 19 main food groups. The key figures were calculated from the mean values of the pools of each foodstuff. The presentation is based on the modified *lower bound* (mLB) approach (if result < limit of quantification [LOQ] and > limit of detection [LOD], then value = LOD; if result < LOD, then value = 0) and *upper bound* (UB) approach (if result < LOQ, then value = LOQ; if result < LOD, then value = LOD). Overall, about 97 % of the pools from non-specific and conventional production (667 of 690 pools; excluding drinking water) have no detectable or quantifiable vanadium levels.

In view of the high rate of samples with non-detectable or non-quantifiable levels, there is no comparison of the main food groups with each other or between the regions or purchase dates. Similarly, the statistical key figures are derived vastly from the numerical values of the LOQ and LOD due to the high proportion of non-quantifiable vanadium levels. Among the foods examined, chewing gum, cocoa powder and dried spices showed the highest concentrations (Table 2).

In the regional drinking water samples, no vanadium was detected in 27 pools (LOD = 0.0003 mg/kg) and no vanadium was quantifiable in the remaining 2 pools (LOQ = 0.001 mg/kg).

The results regarding the vanadium concentrations of the core module are now also available to the public as a "Public Use File": www.bfr-meal-studie.de/de/public-use-file.html

¹ Hackethal C, Kirsch F, Schwerbel K, Kolbaum AE, Gotte S, Schwerdtle T, Lindtner O, Sarvan I (2023). Filling data gaps to refine exposure assessments by consideration of specific consumer behavior. *German Food Review*, 119 (7), 277-288

² Sarvan I, Bürgelt M, Lindtner O, Greiner M (2017). Exposure assessment of substances in food. The BfR MEAL Study - the first total diet study in Germany. *Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz*, 60 (7): 689-696. doi: [10](https://doi.org/10.1007/s00127-017-0100-0).

³ Season 1: Season with mainly imported goods, as expected. Season 2: Season with, as expected, mainly goods produced in Germany.

⁴ In the case of foods that were not analyzed stratified by type of production, the type of production is referred to as non-specific. This can include samples from both conventional and organic production.

Table 1: Vanadium concentrations of the BfR MEAL study by main food groups in non-specific and conventional production in mg/kg (sample purchase: December 2016 to May 2019).

Main food group	Number of foodstuffs	Number of pools (number of pools with a concentration <LOD/<LOQ)	Concentration (mLB)			Concentration (UB)			Foods with the highest specific concentration
			P50	Min	Max	P50	Min	Max	
01 Cereals and cereal products	40	82 (80)	0	0	0,013	0,020	0,006	0,048 ⁵	Sponge cake
02 Vegetables, vegetable products and mushrooms	34	132 (124)	0	0	0,135	0,006	0,006	0,135	Algae
03 Starchy roots or tubers and products thereof	8	18 (17)	0	0	0,025	0,006	0,006	0,032	Jacket potatoes (unpeeled)
04 Pulses, nuts, oilseeds and spices	20	20 (18)	0	0	0,425	0,030	0,006	0,425	Spices
05 Fruit and fruit products	22	52 (52)	0	0	0,006 ^(a)	0,006	0,006	0,030 ^(a)	Not applicable
06 Meat and meat products	35	85 (84)	0	0	0,023	0,006	0,006	0,023	Cooked sausage, coarse (e.g. beer sausage, hunting sausage)
07 Fish, crustaceans and molluscs and products thereof	30	39 (38)	0	0	0,105	0,006	0,006	0,105	Mussels
08 Milk and dairy produce	23	23 (23)	0	0	0,006 ^(b)	0,006	0,006	0,020 ^(b)	Not applicable
09 Eggs and egg products	2	8 (8)	0	0	0	0,006	0,006	0,006 ^(c)	Not applicable
10 Water-based sugar, confectionery and sweet desserts	15	15 (13)	0	0	0,495	0,030	0,006	0,495	gum
11 Animal and vegetable fats and oils	8	8 (8)	0	0	0	0,030	0,030	0,030 ^(d)	Not applicable

⁵ The values of the maximum result from the values of the LOD (0.03 mg/kg) and LOQ (0.1 mg/kg) for "chia seeds", which are above the quantified vanadium concentration of "cakes made from sponge (e.g. sand cakes, muffins)" of the West and North regions (0.021 mg/kg).

Main food group	Number of foodstuffs	Number of pools (number of pools with a concentration <LOD/<LOQ)	Concentration (mLB)			Concentration (UB)			Foods with the highest specific concentration
			P50	Min	Max	P50	Min	Max	
12 Vegetable juices, fruit juices and nectars	10	10 (9)	0	0	0,062	0,006	0,006	0,062	Fruit juice, grape
13 Water and water-based beverages (excluding drinking water)	6	8 (8)	0	0	0	0,006	0,006	0,006 ^(e)	Not applicable
14 Coffee, cocoa, tea and infusions	9	9 (8)	0	0	0,470	0,006	0,006	0,470	Cocoa powder
15 Alcoholic beverages	8	8 (7)	0,006	0	0,030	0,020	0,006	0,030	Beer
16 Food for infants and young children	11	11 (11)	0	0	0,006 ^(f)	0,020	0,006	0,030 ^(f)	Not applicable
17 products for special diets and food imitations	7	7 (6)	0,006	0	0,014	0,020	0,006	0,021	Tofu
18 Food and dishes	52	136 (135)	0	0	0,027	0,006	0,006	0,027	Sushi
19 Condiments and sauces	16	19 (18)	0,003	0	0,052	0,017	0,006	0,052	Soy sauce

mLB: modified *lower bound*; UB: *upper bound*; P50: median; Min: minimum; Max: maximum; ^aall measurements < LOD (0.006 or 0.03 mg/kg) or < LOQ (0.02 mg/kg); ^ball measurements < LOD (0.006) or < LOQ (0.02 mg/kg); ^call measurements < LOD (0.006 mg/kg); ^dall measurements < LOD (0.03 mg/kg); ^eall measurements < LOD (0.006 or 0.0003 mg/kg); ^fall measurements < LOD (0.006 or 0.03 mg/kg) or < LOQ (0.02 mg/kg or 0.1 mg/kg)

Table 2: The ten foods with the highest vanadium concentration in non-specific and conventional production from the BfR MEAL study (sample purchase from December 2016 to May 2019, mLB scenario).

No.	MEAL food	Pool stratification	Concentration (mg/kg)
1	gum	unspecific	0,50
2	Cocoa powder	unspecific	0,47
3	Spices	Conventional	0,43
4	Algae	unspecific	0,14
5	Dark chocolate, dark chocolate	unspecific	0,14
6	Mussels	unspecific	0,11
7	Kitchen herbs, fresh	Conventional	0,08
8	Grape juice	unspecific	0,06
9	Soy sauce	unspecific	0,05
10	Beer	Conventional	0,03

mLB: modified *Lower Bound*

Further information on the MEAL study

Homepage of the BfR-Meal study

<https://www.bfr-meal-studie.de/en/meal-homepage.html>

Questions and answers about the Meal Study

<https://www.bfr.bund.de/en/frequently-asked-questions-on-the-bfr-meal-study-199370.html>

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