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Sugar Alternatives: How Much Sweetener Is There in Soft Drinks?

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The Federal Ministry of Food and Agriculture (BMEL) plans to gradually reduce sugar, fat and salt content in certain foods such as soft drinks through the National Reduction and Innovation Strategy for Sugar, Fat and Salt in Processed Foods (NRI).

As can be seen from the product monitoring of the Max Rubner Institute (MRI), the sugar content in soft drinks decreased slightly between 2018 and 2019, while the proportion of soft drinks sweetened exclusively with sweeteners increased slightly. The German Federal Institute for Risk Assessment (BfR) investigated the concentrations of sweeteners in soft drinks as part of the BfR MEAL Study (meals for exposure assessment and analysis of food). For this purpose, the concentrations of nine sweeteners, including aspartame, cyclamate and steviol glycosides, were determined in 92 market relevant soft drinks, either calorie-reduced or with no added sugar.

The result: Some of the sweeteners (acesulfame K, aspartame, cyclamate, saccharin, sucralose, steviol glycosides) were detected in high concentrations (acesulfame K: 5 – 365 mg/l, aspartame: <1 – 492 mg/l, cyclamate: 5 – 263 mg/l, saccharin: <1 – 68 mg/l, sucralose: 2 – 127 mg/l and steviol glycosides: <1 – 38 mg/l). Three sweeteners (neohesperidin DC, neotame and advantame) were not detected in any soft drink. 87 out of 92 soft drinks contained more than one sweetener.

1 Introduction and Objective

The BfR MEAL Study is the first total diet study in Germany to determine average concentrations of substances in foods as typically consumed. The results of the BfR MEAL study will enable the BfR to reliably estimate chronic intake for a large number of substances in the future. Around 300 different substances are clustered into nine modules of the BfR MEAL Study. Within the modules, the total diet study design is adapted to the respective requirements of the different substance groups.

The BfR MEAL Study has been in progress since 2015. The second of the two field phases was completed in summer 2021. The data is currently being evaluated.

For the module “Food additives” of the BfR MEAL Study, ten food additives or food additive groups were prioritised via a selection process involving substance-specific experts. As there were no suitable methods of analysis or offers in the tendering process for the analysis service, four groups of additives were incorporated (sorbates, benzoates, nitrites and sulphites), but none of the prioritised sweeteners.

As part of the National Reduction and Innovation Strategy (NRI), the food industry has committed itself to reduce sugar and calorific content, e.g. of soft drinks. Based on the product monitoring of the Max Rubner Institute (MRI), the Federal Ministry of Food and Agriculture (BMEL) assumes that the proportion of soft drinks sweetened exclusively with sweeteners has increased slightly and would like to examine additionally if the quantities of sweeteners used in soft drinks have also increased.

Against this background, the BMEL requested an extension of the BfR MEAL Study's food additives module with the aim of providing figures for sweetener concentrations in market-relevant soft drinks, sweetened exclusively or partially with sweeteners or steviol glycosides. In the following, the sampling, the analysis and the concentrations of acesulfame K, aspartame, cyclamate, neohesperidin DC, neotame, saccharin, sucralose, steviol glycosides [stevioside, rebaudioside A] and advantame are shown for 92 soft drinks.

2 Methodology

2.1 Selection and purchase of soft drinks

Sampling was limited to market-relevant soft drinks on the basis of the MRI's product monitoring and with regard to cost-efficient implementation of the module extension. The products were selected from the list of MRI's product monitoring from 2019. The MRI's product monitoring considered 1,801 soft drinks, 1,709 of which were products from the group of sweetened soft drinks. Of these, 271 sweetened soft drinks were classified as market-relevant. The use of sweeteners or steviol glycosides was documented for 95 of the 271 products (Demuth et al. 2020). Based on this information, 92 low-calorie soft drinks and soft drinks with no added sugar from seven product groups were examined (Table 1).

Table 1: Overview of sampling and the number of sweeteners used in the product groups of the sample

Product groups	Calorie-reduced		No added sugar		Total	
	n	Number of Sweetener* Median (Min - Max)	n	Number of Sweetener* Median (Min - Max)	n	Number of Sweetener* Median (Min - Max)
Cola-type drinks	1	2	37	3 (2 – 4)	38	3 (2 – 4)
Energy drinks	0	–	2	2 (2 – 2)	2	2 (2 – 2)
Fruit juice drinks	0	–	4	3 (2 – 3)	4	3 (2 – 3)
Isotonic drinks	4	2 (2 – 2)	0	–	4	2 (2 – 2)
Lemonades	4	3 (2 – 4)	30	3 (2 – 5)	34	3 (2 – 5)
Tea-based cold drinks	5	1 (1 – 1)	3	2 (2 – 3)	8	1 (1 – 3)
Flavoured water	2	3 (3 – 3)	0	–	2	3 (3 – 3)
Total	16		76		92	

n = number of samples per product group; * number of proven sweeteners

Soft drinks were primarily purchased from food retailers in the area of Berlin, but also in internet stores, when soft drinks were not available through local retailers. It was assumed that the sweetener concentration of the same product does not differ across Germany. The soft drinks were stored at room temperature until the samples were generated.

2.2 Sample Preparation, Storage and Delivery

For each sample, three packaging units of a soft drink were weighed out with equal weight (Precisa 321 LT 6200C) and homogenised (Retsch Grindomix GM300; grinding container made of plastic). Carbonated beverages were homogenised for at least three minutes to degas. 100-millilitre polypropylene vessels were filled with the homogenised samples and stored at – 20 °C until delivery to the laboratory.

The samples were handed over to an external laboratory on dry ice and stored at – 20 °C until analysis.

2.3 Analysis of sweeteners

Liquid chromatography coupled to mass spectrometry (LC-MS/MS) was used to determine concentrations of the sweeteners acesulfame K, aspartame, cyclamate, neohesperidin DC, neotame, saccharin, sucralose, steviol glycosides [stevioside, rebaudioside A] and advantame in 92 samples.

3 Results and Comparison with Results of the Federal Control Plan

Three different sweeteners were used in combination in 48 samples, two sweeteners in 26 samples and four sweeteners in twelve samples. In one sample, five sweeteners were used in combination, and in five samples only steviol glycosides were used (Table 2).

A combination of the three sweeteners acesulfame K, aspartame and cyclamate was used most frequently among the soft drinks (n = 35), followed by the combination of acesulfame K and aspartame (n = 12) and the combination of acesulfame K, aspartame, cyclamate and saccharin (n = 10) (Appendix A 1). In the most extensive product group “Cola-type drinks”, 92% of the samples showed one of the two most frequently used combinations. Lemonades showed a combination of acesulfame K, aspartame, cyclamate and saccharin most frequently (n = 9) as well as the most diverse combinations of various sweeteners across the product groups. Isotonic drinks (n = 4) only showed a combination of cyclamate and saccharin.

Table 2: Number of samples with different numbers of sweetener combinations used in soft drink product groups (n)

Number Sweetener*	Cola/mixed cola drinks	Energy drinks	Fruit juice drinks	Isotonic drinks	Fizzy drinks	Tea-based cold drinks	Flavoured water	Sample total
1	0	0	0	0	0	5	0	5
2	11	2	2	4	5	2	0	26
3	26	0	2	0	17	1	2	48
4	1	0	0	0	11	0	0	12
5	0	0	0	0	1	0	0	1

*Number (combined) of sweeteners used in a sample (use = concentration > LOQ)

Highest concentrations of acesulfame K (365 mg/l), aspartame (492 mg/l), cyclamate (263 mg/l) and sucralose (127 mg/l) were detected in four “Cola-type drinks” with no added sugar. Steviol glycosides are often used as sole sweetener in calorie-reduced soft drinks and in higher concentrations than in soft drinks with no added sugar (Table 4).

The three sweeteners neohesperidin DC, neotame and advantame were not detected in any soft drink.

The declared use of sweeteners was confirmed for 89 of the 92 samples. One sample showed undeclared use of cyclamate at a concentration of 5.1 mg/L; further two samples showed either undeclared use of aspartame (0.048 mg/L) or an undeclared use of saccharin (0.59 mg/L). These three concentrations were the lowest concentrations of the respective sweetener. One Cola-type drink showed a concentration of acesulfame K of 365 mg/l, which is at the maximum limit for this sweetener of 350 mg/l. Cyclamate concentrations of 259 mg/l

and 263 mg/l were detected in a lemonade and in Cola-type drinks with no added sugar. Both concentrations are also at the maximum limit of this sweetener of 250 mg/l. Further four samples showed cyclamate concentrations of 242 – 246 mg/l. In some other samples, the concentrations were well below the legal maximum limit, but could also be in the range of the maximum limit, taking into account the expanded measurement uncertainty. Because the concentrations are close to the legal maximum, it cannot be assumed that the maximum has been exceeded or not, due to the measurement uncertainty of the analysis method.

The concentrations of sweeteners (acesulfame K, aspartame, cyclamate, saccharin, sucralose) showed large ranges both in energy-reduced soft drinks and in soft drinks with no added sugar (Table 3). The ranges are reduced for “Flavoured water” and “Energy drinks” when the product groups are considered separately (Table 4, **Appendix A 2**).

Table 3: Concentrations of sweeteners in energy-reduced soft drinks and soft drinks with no added sugar (mg/l)

Sweeteners	Energy-reduced			No added sugar		
	n	Mean ± SD	Min – max	n	Mean ± SD	Min – max
Acesulfame K	5	43.0 ± 43.8	9.31 – 105	65	92.8 ± 66.1	4.70 – 365
Aspartame	3	19.7 ± 23.2	0.05 – 45.3	64	74.9 ± 82.3	11.0 – 492
Cyclamate	9	144 ± 87.7	7.80 – 246	59	172 ± 79.7	5.10 – 263
Saccharin	8	19.7 ± 20.4	1.90 – 68.2	22	22.9 ± 12.0	0.59 – 37.1
Sucralose	1	93.2	–	10	41.3 ± 40.5	1.90 – 127
Steviol glycoside [§]	6	23.9 ± 9.14	14.7 – 38.1	2	0.72 ± 0.13	0.63 – 0.81

n = number of samples containing the sweetener; SD = standard deviation; [§] calculated as steviol equivalent

In 2007, the Federal Control Plan (BÜp) determined the concentrations of four sweeteners in soft drinks (Hartmann 2008). In the following, trends between the statistical parameters of the BÜp-report and the results of this study are discussed. For the category “Other soft drinks” in comparison with the BÜp report, the results of the BfR MEAL Study indicate a higher number of samples using acesulfame K (70 and 28, respectively) and aspartame (67 and 21, respectively), higher maximum concentrations of acesulfame K (365 and 134 mg/l, respectively) and aspartame (492 and 444 mg/l, respectively) and lower minimum concentrations (Table 5). The aspartame concentration on the 95th percentile in the BÜp-report, on the other hand, is higher than the comparative value of the BfR MEAL Study (349 and 271 mg/l, respectively). The concentrations of cyclamate (656 and 246 mg/l, respectively) and saccharin (101 and 37.1 mg/l, respectively) in the BÜp sample are higher at the 95th percentile. This was also found for the maximum concentrations of these two sweeteners.

Table 4: Concentrations of sweeteners in different product groups of soft drinks (mg/l)

Product group	Acesulfame K			Aspartame			Cyclamate			Saccharin			Sucralose			Steviol glycoside [§]		
	n	μ ± sd	Min – max	n	μ ± sd	Min – max	n	μ ± sd	Min – max	n	μ ± sd	Min – max	n	μ ± sd	Min – max	n	μ ± sd	Min – max
Cola/mixed cola drinks	38	100 ± 65.2	9.40 – 365	36	89.7 ± 103	11.0 – 492	27	194 ± 61.9	5.10 – 263	1	0.59	–	2	110 ± 23.8	93.2 – 127	0	–	–
Energy drinks	2	185 ± 11.3	177 – 193	1	144	–	0	–	–	0	–	–	1	24.0	–	0	–	–
Fruit juice drinks	0	–	–	0	–	–	4	149 ± 82.2	26.0 – 198	4	29.7 ± 1.96	27.3 – 32.1	2	3.36 ± 2.06	1.90 – 4.82	0	–	–
Isotonic drinks	0	–	–	0	–	–	4	210 ± 25.8	188 – 246	4	10.3 ± 5.69	1.90 – 14.4	0	–	–	0	–	–
Fizzy drinks	25	78.5 ± 61.7	5.00 – 246	29	49.9 ± 34.2	0.05 – 117	30	152 ± 88.8	15.0 – 259	19	24.3 ± 15.9	3.10 – 68.2	4	39.2 ± 21.1	7.90 – 52.2	3	10.4 ± 16.7	0.63 – 29.7
Tea-based cold drinks	3	30.8 ± 34.4	4.70 – 69.8	1	31.8	–	1	149	–	0	–	–	2	49.3 ± 52.7	12.0 – 86.5	5	22.7 ± 9.71	14.7 – 38.1
Flavoured water	2	13.5 ± 3.11	11.3 – 15.7	0	–	–	2	8.65 ± 1.20	7.80 – 9.50	2	19.4 ± 0.11	19.3 – 19.5	0	–	–	0	–	–

n = number of measurements > LOQ; μ = arithmetic mean; sd = standard deviation; § calculated as steviol equivalent

Table 5: Comparison of concentrations of acesulfame K, aspartame, cyclamate and saccharin with results from BÜp (mg/l)

Product group	Source	Acesulfame K				Aspartame				Cyclamate				Saccharin			
		n	μ	P95	Min – max	n	μ	P95	Min – max	n	μ	P95	Min – max	n	μ	P95	Min – max
Fruit juice drinks	BÜp	30	65.2	168	14.0 – 206	29	85.4	340	11.0 – 381	21	239	386	123 – 1,013	36	58.2	101	10.0 – 107
	BfR MEAL Study	0	–	–	–	0	–	–	–	4	149	–	26.0 – 198	4	29.7	–	27.3 – 32.1
Other soft drinks	BÜp	28	61.3	125	15.0 – 134	21	115	349	18.0 – 444	33	257	665	118 – 1,321	36	59.5	101	17.0 – 106
	BfR MEAL Study [§]	70	90.1	193	4.70 – 365	67	72.4	271	0.05 – 492	64	169	246	5.10 – 263	26	20.9	37.1	0.59 – 68.2

n = number of measurements > LOQ; μ = arithmetic mean, P95 = 95th percentile; BÜp = Federal Monitoring Plan 2007 (Hartmann 2008); § excl. fruit juice drinks

4 References

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- (3) Hartmann F (2008): Zusatzstoffe in Getränken. In: Berichte zur Lebensmittelsicherheit 2007 – Bundesweiter Überwachungsplan 2007. Publ.: Bundesamt für Verbraucherschutz und Lebensmittelsicherheit. Band 3, Heft 3. URL: https://www.bvl.bund.de/SharedDocs/Downloads/01_Lebensmittel/02_BUEp_dokumente/buep_berichte_archiv/BUEp_Bericht_2007.pdf?blob=publicationFile&v=6. Birkhäuser Verlag Basel

Further information about sweeteners is available on the BfR website:

https://www.bfr.bund.de/en/a-z_index/sweeteners-130251.html



BfR "Opinions app"

Appendix A

Table A 1: Composition of the sample

MEAL code	Sample	A	B	Product group
L13040Z0S11	Sample 1 ^a		x	Cola-type drinks
	Sample ^a		x	Cola-type drinks
	Sample ^b		x	Cola-type drinks
L13040Z0S14	Sample 2 ^b		x	Cola-type drinks
L13040Z0S41	Sample 3 ^c		x	Cola-type drinks
	Sample ^c		x	Cola-type drinks
L13040Z0S38	Sample 4		x	Cola-type drinks
L13040Z0S02	Sample 5		x	Cola-type drinks
L13040Z0S27	Sample 6		x	Cola-type drinks
L13040Z0S58	Sample 7		x	Cola-type drinks
L13040Z0S45	Sample 8		x	Cola-type drinks
L13040Z0S01	Sample 9		x	Cola-type drinks
L13040Z0S28	Sample 10		x	Cola-type drinks
L13040Z0S73	Sample 11		x	Cola-type drinks

MEAL code	Sample	A	B	Product group
L13040Z0S43	Sample 12		x	Cola-type drinks
L13040Z0S48	Sample 13		x	Cola-type drinks
L13040Z0S19	Sample 14		x	Cola-type drinks
L13040Z0S50	Sample 15		x	Cola-type drinks
L13040Z0S65	Sample 16		x	Cola-type drinks
L13040Z0S25	Sample 17		x	Cola-type drinks
L13040Z0S07	Sample 18		x	Cola-type drinks
L13040Z0S06	Sample 19		x	Cola-type drinks
L13040Z0S40	Sample 20		x	Cola-type drinks
L13040Z0S34	Sample 21		x	Cola-type drinks
L13040Z0S22	Sample 22		x	Cola-type drinks
L13040Z0S23	Sample 23		x	Cola-type drinks
L13040Z0S15	Sample 24		x	Cola-type drinks
L13040Z0S57	Sample 25		x	Cola-type drinks
L13040Z0S54	Sample 26		x	Cola-type drinks
L13040Z0S03	Sample 27		x	Cola-type drinks
L13040Z0S04	Sample 28		x	Cola-type drinks
L13040Z0S13	Sample 29		x	Cola-type drinks
L13040Z0S66	Sample 30		x	Cola-type drinks
L13040Z0S36	Sample 31		x	Cola-type drinks
L13040Z0S72	Sample 32		x	Cola-type drinks
L13040Z0S05	Sample 33		x	Cola-type drinks
L13040Z0S37	Sample 34		x	Cola-type drinks
L13040Z0S16	Sample 35		x	Cola-type drinks
L13120Z0S02	Sample 36		x	Cola-type drinks
L13040Z0S69	Sample 37		x	Cola-type drinks
L13120Z0S03	Sample 38	x		Cola-type drinks
L13020Z0S01	Sample 39		x	Energy drinks
L13020Z0S02	Sample 40		x	Energy drinks
	Sample [§]		x	Fruit juice drinks
L13070Z0S02	Sample 41		x	Fruit juice drinks
L13070Z0S05	Sample 42		x	Fruit juice drinks
L13070Z0S04	Sample 43		x	Fruit juice drinks
L13070Z0S01	Sample 44		x	Fruit juice drinks
L13090Z0S02	Sample 45 ^d	x		Isotonic drinks
	Sample ^d	x		Isotonic drinks
L13090Z0S03	Sample 46	x		Isotonic drinks
L13090Z0S05	Sample 47	x		Isotonic drinks
L13090Z0S04	Sample 48	x		Isotonic drinks
L13040Z0S29	Sample 49		x	Lemonade

MEAL code	Sample	A	B	Product group
L13040Z0S12	Sample 50 ^e		x	Lemonade
	Sample ^e		x	Lemonade
L13040Z0S49	Sample 51 ^f		x	Lemonade
	Sample ^f		x	Lemonade
L13040Z0S74	Sample 52		x	Lemonade
L13040Z0S75	Sample 53		x	Lemonade
L13040Z0S64	Sample 54		x	Lemonade
L13040Z0S31	Sample 55		x	Lemonade
L13040Z0S63	Sample 56		x	Lemonade
L13040Z0S68	Sample 57		x	Lemonade
L13040Z0S67	Sample 58		x	Lemonade
L13040Z0S51	Sample 59		x	Lemonade
L13040Z0S44	Sample 60		x	Lemonade
L13040Z0S53	Sample 61		x	Lemonade
L13040Z0S52	Sample 62		x	Lemonade
L13040Z0S55	Sample 63		x	Lemonade
L13040Z0S21	Sample 64		x	Lemonade
	Sample ^g		x	Lemonade
L13040Z0S62	Sample 65 ^g		x	Lemonade
L13040Z0S71	Sample 66		x	Lemonade
L13040Z0S47	Sample 67		x	Lemonade
L13040Z0S61	Sample 68		x	Lemonade
L13040Z0S20	Sample 69 ^h		x	Lemonade
	Sample ^h		x	Lemonade
L13040Z0S09	Sample 70		x	Lemonade
L13040Z0S33	Sample 71		x	Lemonade
L13040Z0S59	Sample 72		x	Lemonade
L13040Z0S26	Sample 73		x	Lemonade
L13040Z0S17	Sample 74		x	Lemonade
L13040Z0S56	Sample 75		x	Lemonade
L13040Z0S70	Sample 76		x	Lemonade
L13120Z0S01	Sample 77		x	Lemonade
L13040Z0S30	Sample 78		x	Lemonade
L13040Z0S10	Sample 79	x		Lemonade
L13040Z0S46	Sample 80	x		Lemonade
	Sample ^j	x		Lemonade
	Sample ^k	x		Lemonade
L13040Z0S35	Sample 81 ^{j, k}	x		Lemonade
	Sample ^m	x		Lemonade
L13040Z0S60	Sample 82 ^m	x		Lemonade

MEAL code	Sample	A	B	Product group
L13010Z0S02	Sample 83		x	Tea-based cold drinks
L13010Z0S05	Sample 84		x	Tea-based cold drinks
L13010Z0S04	Sample 85		x	Tea-based cold drinks
L13010Z0S08	Sample 86	x		Tea-based cold drinks
L13010Z0S07	Sample 87	x		Tea-based cold drinks
L13010Z0S03	Sample 88	x		Tea-based cold drinks
L13010Z0S01	Sample 89	x		Tea-based cold drinks
L13010Z0S06	Sample 90	x		Tea-based cold drinks
L13100Z0S02	Sample 91	x		Flavoured water
L13100Z0S01	Sample 92	x		Flavoured water

A = energy-reduced; B = no added sugar; § sample withdrawn without replacement as no equivalent replacement sample available; Sample ^{a-m} (grey letters; without MEAL code): market-relevant samples that were not available and for which an equivalent replacement sample was considered according to the second-best concept; Sample [number] ^{a-m} (black types; with MEAL code): Replacement samples for market-relevant samples that were not available (market-relevant sample and its replacement sample are marked with the same letters)

Table A 2: Detection and quantification limits of the analytical method ($\mu\text{g/L}$)

Sweeteners	Limit of detection	Limit of quantification
Acesulfame K	20	50
Advantame	2	5
Aspartame	5	15
Cyclamate	20	50
Neohesperidin DC	20	50
Neotame	2	5
Rebaudioside A	20	50
Saccharin	20	50
Stevioside	20	50
Sucralose	90	300

Appendix A 1: Sweetener Combinations in Product Groups of Sweetened Soft Drinks (n)

	Cola-type drinks	Lemon-ade	Tea-based cold drinks	Fruit juice drinks	Isotonic drinks	Energy drinks	Flavoured water	Total
Acesulfame K, aspartame, Cyclamate	26	8	1	0	0	0	0	35
Acesulfame K, aspartame	9	2	0	0	0	1	0	12
Acesulfame K, aspartame, Cyclamate, Saccharin	1	9	0	0	0	0	0	10
Aspartame, Cyclamate, Saccharin	0	7	0	0	0	0	0	7
Cyclamate, Saccharin	0	1	0	2	4	0	0	7
Acesulfame K, sucralose	2	0	2	0	0	1	0	5
Steviol glycoside	0	0	5	0	0	0	0	5
Acesulfame K, cyclamate, Saccharin	0	0	0	0	0	0	2	2
Cyclamate, Saccharin, Sucralose	0	0	0	2	0	0	0	2
Acesulfame K, aspartame, Cyclamate, Saccharin, Sucralose	0	1	0	0	0	0	0	1
Acesulfame K, aspartame, Sucralose	0	1	0	0	0	0	0	1
Acesulfame K, cyclamate	0	1	0	0	0	0	0	1
Acesulfame K, cyclamate, Saccharin, Steviol glycoside	0	1	0	0	0	0	0	1
Acesulfame K, cyclamate, Sucralose	0	1	0	0	0	0	0	1
Acesulfame K, cyclamate, Sucralose, Steviol glycoside	0	1	0	0	0	0	0	1
Aspartame, Steviol glycoside	0	1	0	0	0	0	0	1
Total	38	34	8	4	4	2	2	

Appendix A 2: Concentration of sweetener in Soft Drinks (mg/L)

MEAL code	Sample	Analyte	LOD	LOQ	Concentration
L13010Z0S01	Sample 89	Steviol glycoside	0.02	0.05	17.3
L13010Z0S02	Sample 83	Acesulfame K	0.02	0.05	69.8
L13010Z0S02	Sample 83	Aspartame	0.005	0.015	31.8
L13010Z0S02	Sample 83	Cyclamate	0.02	0.05	149
L13010Z0S03	Sample 88	Steviol glycoside	0.02	0.05	14.7
L13010Z0S04	Sample 85	Acesulfame K	0.02	0.05	108
L13010Z0S04	Sample 85	Sucralose	0.1	0.3	102
L13010Z0S05	Sample 84	Acesulfame K	0.02	0.05	40.7
L13010Z0S05	Sample 84	Sucralose	0.1	0.3	86.5
L13010Z0S06	Sample 90	Steviol glycoside	0.02	0.05	38.1
L13010Z0S07	Sample 87	Steviol glycoside	0.02	0.05	17.1
L13010Z0S08	Sample 86	Steviol glycoside	0.02	0.05	26.3
L13020Z0S01	Sample 39	Acesulfame K	0.02	0.05	193
L13020Z0S01	Sample 39	Aspartame	0.005	0.015	144
L13020Z0S02	Sample 40	Acesulfame K	0.02	0.05	177
L13020Z0S02	Sample 40	Sucralose	0.1	0.3	240
L13040Z0S01	Sample 9	Acesulfame K	0.02	0.05	154
L13040Z0S01	Sample 9	Aspartame	0.005	0.015	85.8
L13040Z0S01	Sample 9	Cyclamate	0.02	0.05	230
L13040Z0S02	Sample 5	Acesulfame K	0.02	0.05	147
L13040Z0S02	Sample 5	Aspartame	0.005	0.015	73.2
L13040Z0S02	Sample 5	Cyclamate	0.02	0.05	235
L13040Z0S03	Sample 27	Acesulfame K	0.02	0.05	93.9
L13040Z0S03	Sample 27	Aspartame	0.005	0.015	271
L13040Z0S04	Sample 28	Acesulfame K	0.02	0.05	42.8
L13040Z0S04	Sample 28	Aspartame	0.005	0.015	358
L13040Z0S05	Sample 33	Acesulfame K	0.02	0.05	97.6
L13040Z0S05	Sample 33	Aspartame	0.005	0.015	288
L13040Z0S06	Sample 19	Acesulfame K	0.02	0.05	125
L13040Z0S06	Sample 19	Aspartame	0.005	0.015	81.9
L13040Z0S06	Sample 19	Cyclamate	0.02	0.05	263
L13040Z0S07	Sample 18	Acesulfame K	0.02	0.05	140
L13040Z0S07	Sample 18	Aspartame	0.005	0.015	76.6
L13040Z0S07	Sample 18	Cyclamate	0.02	0.05	231
L13040Z0S09	Sample 70	Acesulfame K	0.02	0.05	110
L13040Z0S09	Sample 70	Aspartame	0.005	0.015	62.0
L13040Z0S09	Sample 70	Cyclamate	0.02	0.05	204
L13040Z0S10	Sample 79	Aspartame	0.005	0.015	0.05
L13040Z0S10	Sample 79	Steviol glycoside	0.02	0.05	29.7

MEAL code	Sample	Analyte	LOD	LOQ	Concentration
L13040Z0S11	Sample 1	Acesulfame K	0.02	0.05	138
L13040Z0S11	Sample 1	Aspartame	0.005	0.015	104
L13040Z0S11	Sample 1	Cyclamate	0.02	0.05	237
L13040Z0S12	Sample 50	Acesulfame K	0.02	0.05	106
L13040Z0S12	Sample 50	Aspartame	0.005	0.015	83.6
L13040Z0S12	Sample 50	Cyclamate	0.02	0.05	202
L13040Z0S13	Sample 29	Acesulfame K	0.02	0.05	47.8
L13040Z0S13	Sample 29	Aspartame	0.005	0.015	492
L13040Z0S14	Sample 2	Acesulfame K	0.02	0.05	141
L13040Z0S14	Sample 2	Aspartame	0.005	0.015	131
L13040Z0S14	Sample 2	Cyclamate	0.02	0.05	244
L13040Z0S15	Sample 24	Acesulfame K	0.02	0.05	103
L13040Z0S15	Sample 24	Aspartame	0.005	0.015	101
L13040Z0S15	Sample 24	Cyclamate	0.02	0.05	134
L13040Z0S16	Sample 35	Acesulfame K	0.02	0.05	81.9
L13040Z0S16	Sample 35	Aspartame	0.005	0.015	308
L13040Z0S17	Sample 74	Aspartame	0.005	0.015	110
L13040Z0S17	Sample 74	Saccharin	0.02	0.05	37.1
L13040Z0S17	Sample 74	Cyclamate	0.02	0.05	210
L13040Z0S19	Sample 14	Acesulfame K	0.02	0.05	120
L13040Z0S19	Sample 14	Aspartame	0.005	0.015	126
L13040Z0S19	Sample 14	Cyclamate	0.02	0.05	226
L13040Z0S20	Sample 69	Acesulfame K	0.02	0.05	51.6
L13040Z0S20	Sample 69	Aspartame	0.005	0.015	21.3
L13040Z0S20	Sample 69	Saccharin	0.02	0.05	28.2
L13040Z0S20	Sample 69	Cyclamate	0.02	0.05	246
L13040Z0S21	Sample 64	Acesulfame K	0.02	0.05	127
L13040Z0S21	Sample 64	Cyclamate	0.02	0.05	150
L13040Z0S21	Sample 64	Sucralose	0.1	0.3	45.2
L13040Z0S22	Sample 22	Acesulfame K	0.02	0.05	111
L13040Z0S22	Sample 22	Aspartame	0.005	0.015	96.9
L13040Z0S22	Sample 22	Cyclamate	0.02	0.05	213
L13040Z0S23	Sample 23	Acesulfame K	0.02	0.05	42.1
L13040Z0S23	Sample 23	Aspartame	0.005	0.015	307
L13040Z0S25	Sample 17	Acesulfame K	0.02	0.05	114
L13040Z0S25	Sample 17	Aspartame	0.005	0.015	75.4
L13040Z0S25	Sample 17	Cyclamate	0.02	0.05	235
L13040Z0S26	Sample 73	Acesulfame K	0.02	0.05	111
L13040Z0S26	Sample 73	Aspartame	0.005	0.015	63.6
L13040Z0S26	Sample 73	Cyclamate	0.02	0.05	196
L13040Z0S27	Sample 6	Acesulfame K	0.02	0.05	151
L13040Z0S27	Sample 6	Aspartame	0.005	0.015	61.5

MEAL code	Sample	Analyte	LOD	LOQ	Concentration
L13040Z0S27	Sample 6	Cyclamate	0.02	0.05	215
L13040Z0S28	Sample 10	Acesulfame K	0.02	0.05	149
L13040Z0S28	Sample 10	Aspartame	0.005	0.015	77.2
L13040Z0S28	Sample 10	Cyclamate	0.02	0.05	225
L13040Z0S29	Sample 49	Acesulfame K	0.02	0.05	85.4
L13040Z0S29	Sample 49	Aspartame	0.005	0.015	260
L13040Z0S30	Sample 78	Aspartame	0.005	0.015	92.2
L13040Z0S30	Sample 78	Saccharin	0.02	0.05	30.1
L13040Z0S30	Sample 78	Cyclamate	0.02	0.05	214
L13040Z0S31	Sample 55	Acesulfame K	0.02	0.05	45.2
L13040Z0S31	Sample 55	Aspartame	0.005	0.015	15.9
L13040Z0S31	Sample 55	Saccharin	0.02	0.05	24.0
L13040Z0S31	Sample 55	Cyclamate	0.02	0.05	204
L13040Z0S33	Sample 71	Aspartame	0.005	0.015	73.5
L13040Z0S33	Sample 71	Saccharin	0.02	0.05	23.7
L13040Z0S33	Sample 71	Cyclamate	0.02	0.05	186
L13040Z0S34	Sample 21	Acesulfame K	0.02	0.05	115
L13040Z0S34	Sample 21	Aspartame	0.005	0.015	65.1
L13040Z0S34	Sample 21	Cyclamate	0.02	0.05	185
L13040Z0S35	Sample 81	Acesulfame K	0.02	0.05	73.8
L13040Z0S35	Sample 81	Aspartame	0.005	0.015	45.3
L13040Z0S35	Sample 81	Cyclamate	0.02	0.05	93.2
L13040Z0S36	Sample 31	Acesulfame K	0.02	0.05	129
L13040Z0S36	Sample 31	Aspartame	0.005	0.015	38.4
L13040Z0S36	Sample 31	Cyclamate	0.02	0.05	207
L13040Z0S37	Sample 34	Acesulfame K	0.02	0.05	85.2
L13040Z0S37	Sample 34	Aspartame	0.005	0.015	260
L13040Z0S38	Sample 4	Acesulfame K	0.02	0.05	142
L13040Z0S38	Sample 4	Aspartame	0.005	0.015	44.7
L13040Z0S38	Sample 4	Cyclamate	0.02	0.05	232
L13040Z0S40	Sample 20	Acesulfame K	0.02	0.05	105
L13040Z0S40	Sample 20	Aspartame	0.005	0.015	54.7
L13040Z0S40	Sample 20	Cyclamate	0.02	0.05	164
L13040Z0S41	Sample 3	Acesulfame K	0.02	0.05	365
L13040Z0S41	Sample 3	Aspartame	0.005	0.015	122
L13040Z0S41	Sample 3	Cyclamate	0.02	0.05	5.10
L13040Z0S43	Sample 12	Acesulfame K	0.02	0.05	41.3
L13040Z0S43	Sample 12	Aspartame	0.005	0.015	309
L13040Z0S44	Sample 60	Aspartame	0.005	0.015	115
L13040Z0S44	Sample 60	Saccharin	0.02	0.05	35.5
L13040Z0S44	Sample 60	Cyclamate	0.02	0.05	259
L13040Z0S45	Sample 8	Acesulfame K	0.02	0.05	166

MEAL code	Sample	Analyte	LOD	LOQ	Concentration
L13040Z0S45	Sample 8	Aspartame	0.005	0.015	108
L13040Z0S45	Sample 8	Cyclamate	0.02	0.05	229
L13040Z0S46	Sample 80	Acesulfame K	0.02	0.05	9.31
L13040Z0S46	Sample 80	Aspartame	0.005	0.015	13.6
L13040Z0S46	Sample 80	Saccharin	0.02	0.05	9.59
L13040Z0S46	Sample 80	Cyclamate	0.02	0.05	148
L13040Z0S47	Sample 67	Acesulfame K	0.02	0.05	118
L13040Z0S47	Sample 67	Aspartame	0.005	0.015	86.1
L13040Z0S47	Sample 67	Cyclamate	0.02	0.05	183
L13040Z0S48	Sample 13	Acesulfame K	0.02	0.05	106
L13040Z0S48	Sample 13	Aspartame	0.005	0.015	108
L13040Z0S48	Sample 13	Cyclamate	0.02	0.05	143
L13040Z0S49	Sample 51	Aspartame	0.005	0.015	117
L13040Z0S49	Sample 51	Saccharin	0.02	0.05	36.1
L13040Z0S49	Sample 51	Cyclamate	0.02	0.05	218
L13040Z0S50	Sample 15	Acesulfame K	0.02	0.05	117
L13040Z0S50	Sample 15	Aspartame	0.005	0.015	73.5
L13040Z0S50	Sample 15	Cyclamate	0.02	0.05	194
L13040Z0S51	Sample 59	Acesulfame K	0.02	0.05	129
L13040Z0S51	Sample 59	Aspartame	0.005	0.015	91.8
L13040Z0S51	Sample 59	Cyclamate	0.02	0.05	202
L13040Z0S52	Sample 62	Acesulfame K	0.02	0.05	158
L13040Z0S52	Sample 62	Aspartame	0.005	0.015	72.5
L13040Z0S52	Sample 62	Sucralose	0.1	0.3	51.5
L13040Z0S53	Sample 61	Acesulfame K	0.02	0.05	246
L13040Z0S53	Sample 61	Aspartame	0.005	0.015	53.5
L13040Z0S53	Sample 61	Cyclamate	0.02	0.05	204
L13040Z0S54	Sample 26	Acesulfame K	0.02	0.05	143
L13040Z0S54	Sample 26	Aspartame	0.005	0.015	59.3
L13040Z0S54	Sample 26	Cyclamate	0.02	0.05	198
L13040Z0S55	Sample 63	Acesulfame K	0.02	0.05	209
L13040Z0S55	Sample 63	Cyclamate	0.02	0.05	197
L13040Z0S55	Sample 63	Sucralose	0.1	0.3	52.2
L13040Z0S55	Sample 63	Steviol glycoside	0.02	0.05	3.60
L13040Z0S56	Sample 75	Acesulfame K	0.02	0.05	56.7
L13040Z0S56	Sample 75	Aspartame	0.005	0.015	49.0
L13040Z0S56	Sample 75	Saccharin	0.02	0.05	21.2
L13040Z0S56	Sample 75	Cyclamate	0.02	0.05	224
L13040Z0S57	Sample 25	Acesulfame K	0.02	0.05	79.5
L13040Z0S57	Sample 25	Aspartame	0.005	0.015	34.2
L13040Z0S57	Sample 25	Cyclamate	0.02	0.05	224
L13040Z0S58	Sample 7	Acesulfame K	0.02	0.05	113

MEAL code	Sample	Analyte	LOD	LOQ	Concentration
L13040Z0S58	Sample 7	Aspartame	0.005	0.015	46.6
L13040Z0S58	Sample 7	Cyclamate	0.02	0.05	182
L13040Z0S59	Sample 72	Acesulfame K	0.02	0.05	78.6
L13040Z0S59	Sample 72	Aspartame	0.005	0.015	230
L13040Z0S60	Sample 82	Saccharin	0.02	0.05	68.2
L13040Z0S60	Sample 82	Cyclamate	0.02	0.05	196
L13040Z0S61	Sample 68	Aspartame	0.005	0.015	84.1
L13040Z0S61	Sample 68	Saccharin	0.02	0.05	28.8
L13040Z0S61	Sample 68	Cyclamate	0.02	0.05	199
L13040Z0S62	Sample 65	Acesulfame K	0.02	0.05	80.4
L13040Z0S62	Sample 65	Saccharin	0.02	0.05	40.4
L13040Z0S62	Sample 65	Cyclamate	0.02	0.05	141
L13040Z0S62	Sample 65	Steviol glycoside	0.02	0.05	0.81
L13040Z0S63	Sample 56	Acesulfame K	0.02	0.05	50.0
L13040Z0S63	Sample 56	Aspartame	0.005	0.015	13.9
L13040Z0S63	Sample 56	Saccharin	0.02	0.05	29.9
L13040Z0S63	Sample 56	Cyclamate	0.02	0.05	230
L13040Z0S64	Sample 54	Acesulfame K	0.02	0.05	45.4
L13040Z0S64	Sample 54	Aspartame	0.005	0.015	13.3
L13040Z0S64	Sample 54	Saccharin	0.02	0.05	28.9
L13040Z0S64	Sample 54	Cyclamate	0.02	0.05	237
L13040Z0S65	Sample 16	Acesulfame K	0.02	0.05	141
L13040Z0S65	Sample 16	Aspartame	0.005	0.015	47.4
L13040Z0S65	Sample 16	Cyclamate	0.02	0.05	236
L13040Z0S66	Sample 30	Acesulfame K	0.02	0.05	90.4
L13040Z0S66	Sample 30	Aspartame	0.005	0.015	330
L13040Z0S67	Sample 58	Acesulfame K	0.02	0.05	61.7
L13040Z0S67	Sample 58	Aspartame	0.005	0.015	21.9
L13040Z0S67	Sample 58	Saccharin	0.02	0.05	29.6
L13040Z0S67	Sample 58	Cyclamate	0.02	0.05	234
L13040Z0S68	Sample 57	Acesulfame K	0.02	0.05	37.6
L13040Z0S68	Sample 57	Aspartame	0.005	0.015	15.8
L13040Z0S68	Sample 57	Saccharin	0.02	0.05	30.5
L13040Z0S68	Sample 57	Cyclamate	0.02	0.05	242
L13040Z0S69	Sample 37	Acesulfame K	0.02	0.05	81.6
L13040Z0S69	Sample 37	Aspartame	0.005	0.015	42.9
L13040Z0S69	Sample 37	Cyclamate	0.02	0.05	189
L13040Z0S70	Sample 76	Aspartame	0.005	0.015	73.0
L13040Z0S70	Sample 76	Saccharin	0.02	0.05	40.1
L13040Z0S70	Sample 76	Cyclamate	0.02	0.05	226
L13040Z0S71	Sample 66	Acesulfame K	0.02	0.05	46.5
L13040Z0S71	Sample 66	Aspartame	0.005	0.015	18.5

MEAL code	Sample	Analyte	LOD	LOQ	Concentration
L13040Z0S71	Sample 66	Saccharin	0.02	0.05	31.4
L13040Z0S71	Sample 66	Cyclamate	0.02	0.05	235
L13040Z0S72	Sample 32	Acesulfame K	0.02	0.05	82.5
L13040Z0S72	Sample 32	Aspartame	0.005	0.015	31.0
L13040Z0S72	Sample 32	Cyclamate	0.02	0.05	219
L13040Z0S73	Sample 11	Acesulfame K	0.02	0.05	117
L13040Z0S73	Sample 11	Aspartame	0.005	0.015	41.4
L13040Z0S73	Sample 11	Saccharin	0.02	0.05	0.59
L13040Z0S73	Sample 11	Cyclamate	0.02	0.05	124
L13040Z0S74	Sample 52	Acesulfame K	0.02	0.05	111
L13040Z0S74	Sample 52	Aspartame	0.005	0.015	63.6
L13040Z0S74	Sample 52	Cyclamate	0.02	0.05	99.8
L13040Z0S75	Sample 53	Acesulfame K	0.02	0.05	97.6
L13040Z0S75	Sample 53	Aspartame	0.005	0.015	26.2
L13040Z0S75	Sample 53	Saccharin	0.02	0.05	14.6
L13040Z0S75	Sample 53	Cyclamate	0.02	0.05	235
L13040Z0S75	Sample 53	Sucralose	0.1	0.3	7.90
L13070Z0S01	Sample 44	Saccharin	0.02	0.05	29.9
L13070Z0S01	Sample 44	Cyclamate	0.02	0.05	206
L13070Z0S01	Sample 44	Sucralose	0.1	0.3	10.9
L13070Z0S02	Sample 41	Saccharin	0.02	0.05	29.7
L13070Z0S02	Sample 41	Cyclamate	0.02	0.05	188
L13070Z0S04	Sample 43	Saccharin	0.02	0.05	27.3
L13070Z0S04	Sample 43	Cyclamate	0.02	0.05	184
L13070Z0S04	Sample 43	Sucralose	0.1	0.3	4.82
L13070Z0S05	Sample 42	Saccharin	0.02	0.05	32.1
L13070Z0S05	Sample 42	Cyclamate	0.02	0.05	198
L13090Z0S02	Sample 45	Saccharin	0.02	0.05	11.1
L13090Z0S02	Sample 45	Cyclamate	0.02	0.05	188
L13090Z0S03	Sample 46	Saccharin	0.02	0.05	14.4
L13090Z0S03	Sample 46	Cyclamate	0.02	0.05	246
L13090Z0S04	Sample 48	Saccharin	0.02	0.05	10.9
L13090Z0S04	Sample 48	Cyclamate	0.02	0.05	196
L13090Z0S05	Sample 47	Saccharin	0.02	0.05	13.2
L13090Z0S05	Sample 47	Cyclamate	0.02	0.05	212
L13100Z0S01	Sample 92	Acesulfame K	0.02	0.05	15.7
L13100Z0S01	Sample 92	Saccharin	0.02	0.05	19.5
L13100Z0S01	Sample 92	Cyclamate	0.02	0.05	90.1
L13100Z0S02	Sample 91	Acesulfame K	0.02	0.05	11.3
L13100Z0S02	Sample 91	Saccharin	0.02	0.05	19.3
L13100Z0S02	Sample 91	Cyclamate	0.02	0.05	70.8
L13120Z0S01	Sample 77	Acesulfame K	0.02	0.05	203 [§]

MEAL code	Sample	Analyte	LOD	LOQ	Concentration
L13120Z0S01	Sample 77	Cyclamate	0.02	0.05	191 [§]
L13120Z0S02	Sample 36	Acesulfame K	0.02	0.05	56.8 [§]
L13120Z0S02	Sample 36	Sucralose	0.1	0.3	127 [§]
L13120Z0S03	Sample 38	Acesulfame K	0.02	0.05	105 [*]
L13120Z0S03	Sample 38	Sucralose	0.1	0.3	93.2 [*]

[§] calculated as a reconstituted drink using manufacturer's standard dilution (dilution factor of 0.04); [§] calculated as a reconstituted drink at manufacturer's standard dilution (dilution factor of 0.04); ^{*} calculated as a reconstituted drink using manufacturer's standard dilution (dilution factor of 0.0466); Steviol glycosides presented as steviol equivalent

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. It advises the German 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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