DLA
Dienstleistung
Lebensmittel
Analytik GbR

Evaluation Report
proficiency test

DLA 23/2015

Contaminated Food: Heavy Metals (Pb, Cd, Hg, As)

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Contents

1. Introduction

The participation in proficiency testing schemes is an essential element of the quality-management-system of every laboratory testing food and feed. The implementation of proficiency tests enables the participating laboratories to prove their own analytical competence under realistic conditions. At the same time they receive valuable data regarding the validity of the particular testing method.
The purpose of DLA is to offer proficiency tests for selected parameters in concentrations with practical relevance.
Realisation and evaluation of the present proficiency test follows the technical requirements of DIN EN ISO/IEC 17043 (2010) and DIN ISO 13528:2009.

2. Realisation

2.1 Test material

The test material was a plant-powder mixture with a natural content of cadmium (Cd), lead (Pb), mercury (Hg) and arsenic (As) and with an added NaCl content of approx. 1,3% for the homogeneity test.
Approximately 0,75 kg of the material were homogenized and then packaged in portions to approximately 5 g. The portions were numbered chronologically.
The detectability of the heavy metals ((Cd, Pb, Hg, As) was assured.

2.1.1 Homogeneity

The calculation of the repeatability standard deviation of the participants for cadmium was used as an indicator of homogeneity. The result is similar to the repeatability standard deviation of the German official method ASU § 64 LFGB L00.00-135 (11). The repeatability standard deviation of the participants is given in the documentation.

Additionally in the documentation the portion numbers are assigned graphically to the results of cadmium. There is no laboratory-independent trend recognizable in the results which could suggest inhomogeneity.

2.2 Test

Two portions of test material were sent to every participating laboratory in the 19th week of 2015. The testing method was optional. The tests should be finished at 19th June 2015 the latest.

2.3 Results

The participants submitted their results in standard forms, which have been handed out with the samples. The finally calculated concentrations of As, Cd, Hg and Pb as average of duplicate determinations of both numbered samples were used for the statistical evaluation.

In case participants submitted several results for the same parameter obtained by different methods these results were evaluated with the same evaluation number with a letter as a suffix and indication of the related method.

Queried and documented were single results, recovery and the testing method used. All participants have submitted four results in time.

3. Evaluation

3.1 Assigned value

Because the analysed material was no certified reference material the robust mean of the submitted results was used as assigned value X (6).
The distribution of submitted results showed no hint for bimodal distribution or other reasons for a higher variability.

3.2 Standard deviation

For comparison to the target standard deviation a robust standard deviation (S_x) was calculated (6).

3.3 Outliers

Statistical outliers were determined by Mandel´s-h-Statistic (5). Detected outliers were stated for information only, when z-score was < -2 or > 2.

3.4 Target standard deviation

The target standard deviation of the assigned value is determined according to the following methods.

3.4.1 General model (Horwitz)

The relative target standard deviation in % of the assigned value is calculated according to the following equation.

$$\hat{\sigma} \ (\%) = 2^{(1-0,5\log X)}$$

Out of this is calculated the target standard deviation in mg/kg

$$\hat{\sigma} = X * \hat{\sigma} \ (\%) / 100.$$

3.4.2 Precision experiment

Using the reproducibility standard deviation σ_R and the repeatability standard deviation σ_r of a precision experiment the between-laboratories standard deviation (σ_L) can be calculated :

$$\sigma_L = \sqrt{(\sigma_R^2 - \sigma_r^2)} \quad .$$

And then, using the number of replicate measurements n, each participant is to perform, the standard deviation for proficiency assessment is calculated :

$$\hat{\sigma} = \sqrt{(\sigma_L^2 + (\sigma_r^2/n))} \quad .$$

The statistical evaluation was realised with the target standard deviation according to Horwitz.

The target standard deviation according to ASU § 64 LFGB L00.00-135 is given for information.

3.5 z-Score

To assess the results of the participants the z-score is used. It indicates about which multiple of the target standard deviation ($\hat{\sigma}$) the result (x) of the participant is deviating from the assigned value (X)(6).

Participants' z-scores were derived as:

$$z = (x - X) / \hat{\sigma} ;$$

the requirements for the analytical performance are generally considered as fulfilled if

$$-2 \leq z \leq 2$$

3.6 Quotient $S^x/\hat{\sigma}$

Following the Horrat-value the results of a proficiency-test (PT) can be considered convincing, if the quotient of robust standard deviation and target standard deviation does not exceed the value of 2.
A value > 2 means an insufficient precision, i.e. the analytical method is too variable, or the variation between the test participants is higher than estimated. Thus the comparability of the results is not given.

For this PT the results for lead, cadmium, mercury and arsenic showed a suitable comparability.

3.7 Standard uncertainty

The assigned value X has a standard uncertainty u_X that depends on the analytical method, differences between the analytical methods used, the test material, the number of participant laboratories and perhaps on other factors. The standard uncertainty (u_X) for this PT is calculated as follows (6).

$$u_X = 1{,}25 * S^x / \sqrt{(p)}$$

If $u_X \leq 0{,}3 * \hat{\sigma}$ the standard uncertainty of the assigned value needs not be included in the interpretation of the results of the PT (6). The Quotient $u_X/\hat{\sigma}$ is reported in the characteristics of the test.

4. Results

All following tables are anonymized. With the delivering of the evaluation-report the participants are informed about their individual evaluation-number.

In the upper table – test - the characteristics are listed:

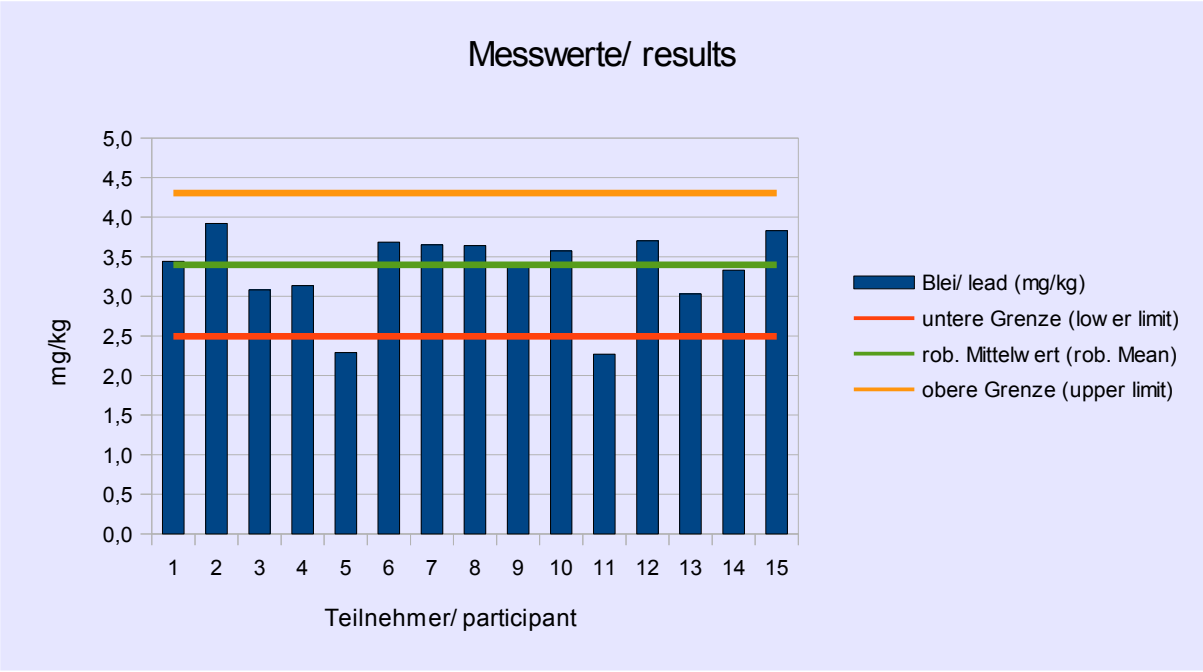
Number of results	
Number of outliers	
Mean	
Median	
Robust mean (X)	
Robust standard deviation (S^x)	
Target standard deviation($\hat{\sigma}$)(Horwitz)	
Target standard deviation (ASU § 64 LFGB L00.00-135 or ASU § 64 LFGB L00.00-19/6 for Information)	
Lower limit of target range	
Upper limit of target range	
Quotient $S^x/\hat{\sigma}$	
Standard uncertainty u_x	
Quotient $u_X/\hat{\sigma}$	
Number of results in the target range	

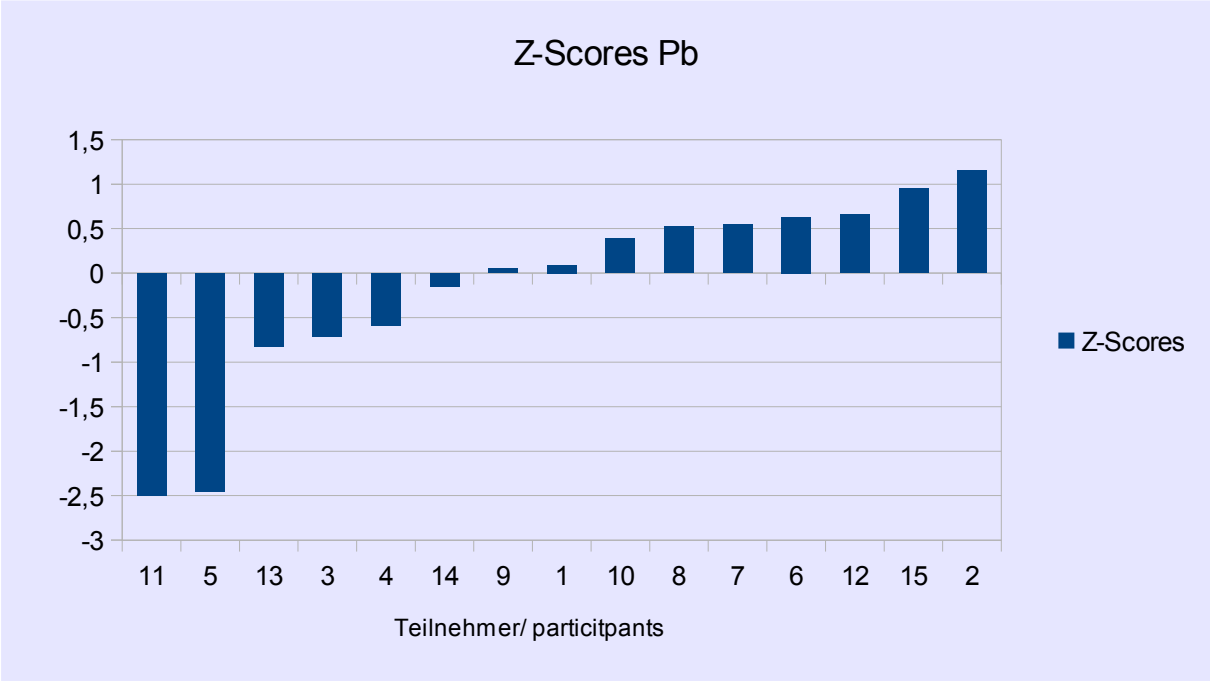
In the lower table - Laboratories - the individual results of the participating laboratories are listed:

Evaluation number	Result	Deviation	z-Score	Remarks

4.1 Lead in mg/kg

Characteristics	
Number of results	15
Number of outliers	2
Mean	3,33
Median	3,44
Robust mean (X)	3,40
Robust standard deviation (S^x)	0,414
Target standard deviation($\hat{\sigma}$)(Horwitz)	0,452
Target standard deviation (ASU § 64 LFGB L00.00-135 for Information)	0,318
Lower limit of target range (X - 2 $\hat{\sigma}$)	2,49
Upper limit of target range (X + 2 $\hat{\sigma}$)	4,30
Quotient $S^x/\hat{\sigma}$	0,92
standard uncertainty u_x	0,134
Quotient $u_X/\hat{\sigma}$	0,30
Number of results in the target range	13 (87%)



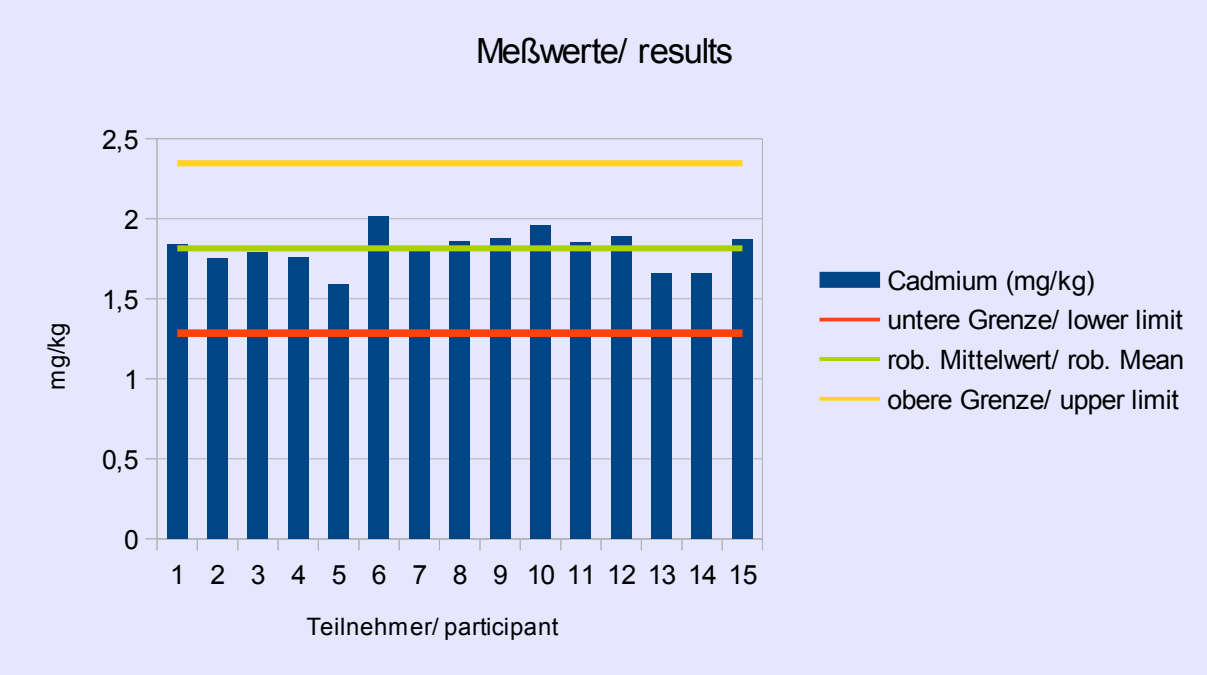


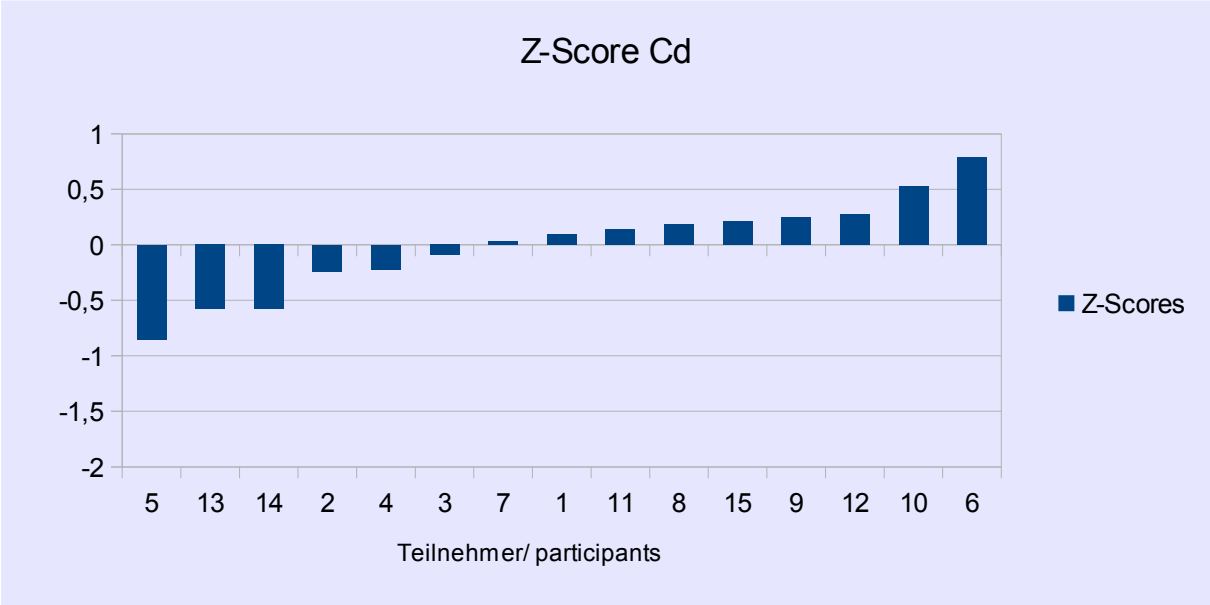
Laboratories

Teilnehmer/ participant	Blei/ lead	Abweichung/ deviation	Z-Score	Bemerkung/ remark
	mg/kg	mg/kg		
1	3,44	0,04	0,1	
2	3,92	0,52	1,2	
3	3,08	-0,32	-0,7	
4	3,13	-0,27	-0,6	
5	2,29	-1,11	-2,5	Ausreißer/ outlier
6	3,69	0,29	0,6	
7	3,65	0,25	0,6	
8	3,64	0,24	0,5	
9	3,42	0,02	0,0	
10	3,58	0,18	0,4	
11	2,27	-1,13	-2,5	Ausreißer/ outlier
12	3,70	0,30	0,7	
13	3,03	-0,37	-0,8	
14	3,33	-0,07	-0,2	
15	3,83	0,43	1,0	

4.2 Cadmium in mg/kg

Characteristics	
Number of results	15
Number of outliers	0
Mean	1,81
Median	1,84
Robust mean (X)	1,81
Robust standard deviation (S^x)	0,121
Target standard deviation($\hat{\sigma}$)(Horwitz)	0,265
Target standard deviation (ASU § 64 LFGB L00.00-135 for Information)	0,154
Lower limit of target range (X - 2 $\hat{\sigma}$)	1,28
Upper limit of target range (X + 2 $\hat{\sigma}$)	2,35
Quotient $S^x/\hat{\sigma}$	0,45
standard uncertainty u_x	0,0389
Quotient $u_X/\hat{\sigma}$	0,15
Number of results in the target range	15 (100%)



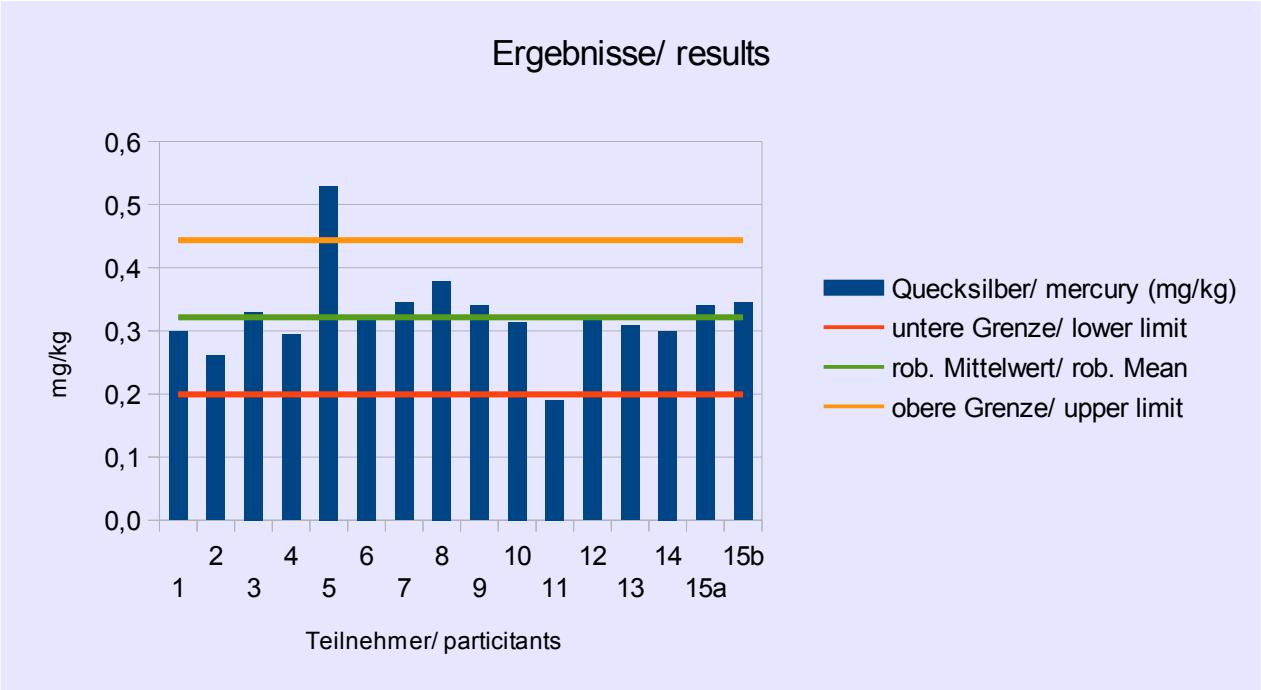


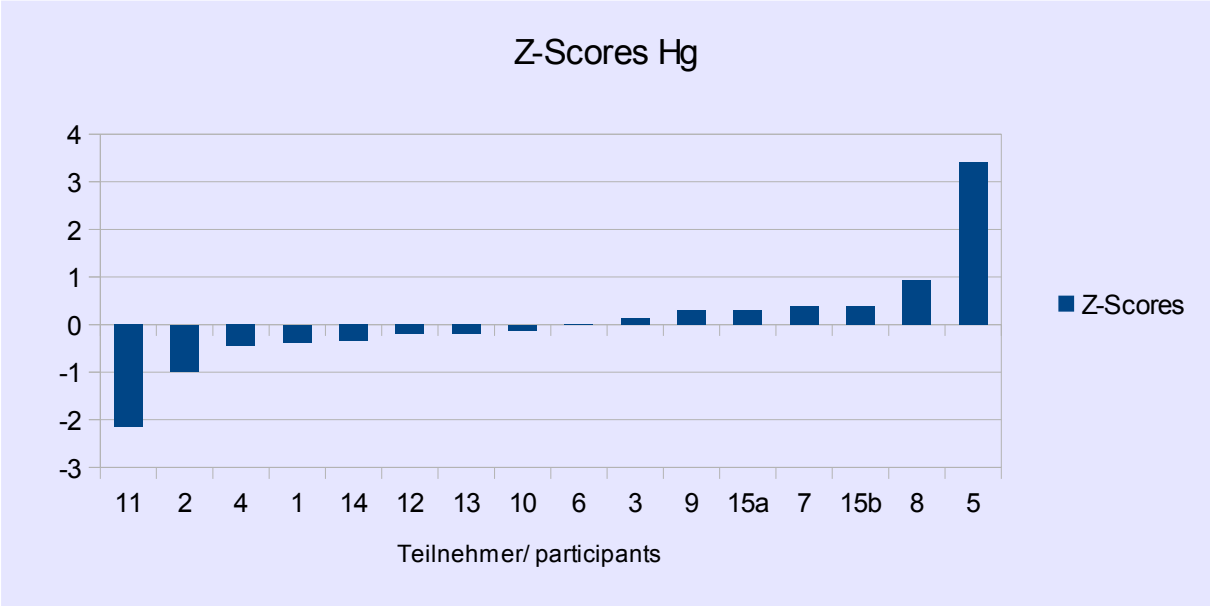
Laboratories

Teilnehmer/ participant	Cadmium	Abweichung/ deviation	Z-Score	Bemerkung/ remark
	mg/kg	mg/kg		
1	1,84	0,03	0,1	
2	1,75	-0,06	-0,2	
3	1,79	-0,02	-0,1	
4	1,76	-0,06	-0,2	
5	1,59	-0,22	-0,8	
6	2,02	0,20	0,8	
7	1,82	0,01	0,0	
8	1,86	0,05	0,2	
9	1,88	0,07	0,2	
10	1,96	0,14	0,5	
11	1,85	0,04	0,1	
12	1,89	0,08	0,3	
13	1,66	-0,15	-0,6	
14	1,66	-0,15	-0,6	
15	1,87	0,06	0,2	

4.3 Mercury in mg/kg

Characteristics	
Number of results	16
Number of outliers	2
Mean	0,326
Median	0,321
Robust mean (X)	0,321
Robust standard deviation (S^x)	0,0376
Target standard deviation($\hat{\sigma}$)(Horwitz)	0,0611
Target standard deviation (ASU § 64 LFGB L00.00-135 for Information)	0,0499
Lower limit of target range (X - 2 $\hat{\sigma}$)	0,199
Upper limit of target range (X + 2 $\hat{\sigma}$)	0,444
Quotient $S^x/\hat{\sigma}$	0,62
standard uncertainty u_x	0,0117
Quotient $u_X/\hat{\sigma}$	0,19
Number of results in the target range	14 (88%)





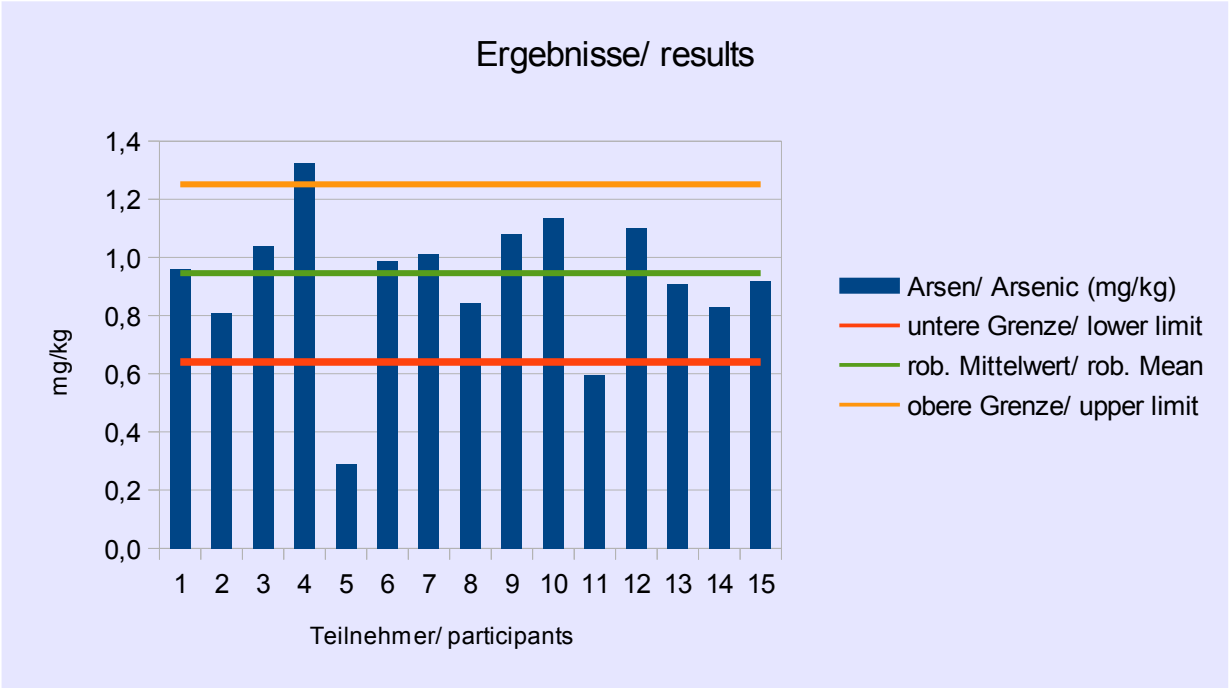
Laboratories

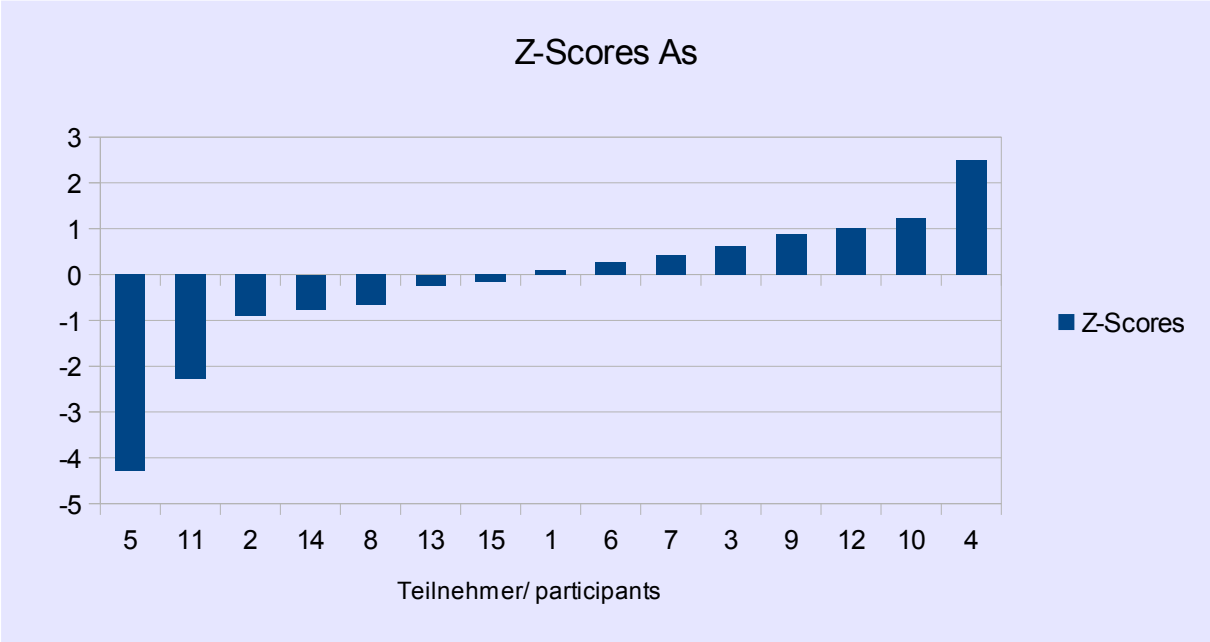
Teilnehmer/ participants	Quecksilber/ mercury	Abweichung/ deviation	Z-Score	Bemerkung/ remark
	mg/kg	mg/kg		
1	0,299	-0,02	-0,4	
2	0,261	-0,06	-1,0	
3	0,330	0,01	0,1	
4	0,294	-0,03	-0,4	
5	0,530	0,21	3,4	Ausreißer/ outlier
6	0,322	0,00	0,0	
7	0,345	0,02	0,4	
8	0,379	0,06	0,9	
9	0,340	0,02	0,3	
10	0,314	-0,01	-0,1	
11	0,190	-0,13	-2,2	Ausreißer/ outlier
12	0,320	0,00	0,0	
13	0,309	-0,01	-0,2	
14	0,300	-0,02	-0,4	
15a	0,340	0,02	0,3	
15b	0,345*	0,02	0,4	

** Result calculated by DLA*

4.4 Arsenic in mg/kg

Characteristics	
Number of results	15
Number of outliers	1
Mean	0,923
Median	0,962
Robust mean (X)	0,946
Robust standard deviation (S^x)	0,182
Target standard deviation($\hat{\sigma}$)(Horwitz)	0,153
Target standard deviation (ASU § 64 LFGB L00.00-135 for Information)	0,0647
Lower limit of target range (X - 2 $\hat{\sigma}$)	0,641
Upper limit of target range (X + 2 $\hat{\sigma}$)	1,25
Quotient $S^x/\hat{\sigma}$	1,2
standard uncertainty u_x	0,0587
Quotient $u_X/\hat{\sigma}$	0,38
Number of results in the target range	12 (80%)





Laboratories

Teilnehmer/ participant	Arsen/ Arsenic	Abweichung/ deviation	Z-Scores	Bemerkung/ remark
	mg/kg	mg/kg		
1	0,96	0,02	0,1	
2	0,81	-0,14	-0,9	
3	1,04	0,09	0,6	
4	1,33	0,38	2,5	
5	0,29	-0,66	-4,3	Ausreißer/ outlier
6	0,99	0,04	0,3	
7	1,01	0,06	0,4	
8	0,84	-0,10	-0,67	
9	1,08	0,13	0,9	
10	1,14	0,19	1,2	
11	0,60	-0,35	-2,3	
12	1,10	0,15	1,0	
13	0,91	-0,04	-0,2	
14	0,83	-0,12	-0,8	
15	0,92	-0,03	-0,2	

5. Documentation

5.1 Primary data in mg/kg

5.1.1 Lead

Teilnehmer/ participant	Ergebnis/ result	DLA-Nr Probe I/ sample I	DLA-Nr Probe II/ sample II	Ergebnis I/ result I	Ergebnis II/ result II
	mg/kg			mg/kg	mg/kg
1	3,44	28	67	3,42	3,47
2	3,92	36	68	3,80	4,03
3	3,08	18	35	3,08	3,07
4	3,134	54	90	3,179	3,089
5	2,29	17	88	2,13	2,38
6	3,69	13	89	3,61	3,76
7	3,649	30	45	3,743	3,555
8	3,641	15	47	3,66	3,623
9	3,42	61	85	3,38	3,46
10	3,575	24	70	3,51	3,64
11	2,269	77	6	2,333	2,204
12	3,7	20	58	3,723	3,602
13	3,03	10	53	3,01	3,04
14	3,33	22	41	3,3	3,36
15	3,83	3	69	3,79	3,84

Teilnehmer/ paticipant	**Ergebnis inkl. Wiederfindung/ result incuding recovery**	**Wiederfindungs-rate/ recovery**	**Wiederfindung mit gleicher Matrix/ recovery with the same matrix**
	yes/no	In %	yes/no
1	no		
2	no	119	no
3	no	-	-
4	yes	71,84	no
5			
6	no	102	no
7	yes	-	yes
8	yes	94,3	yes
9	no	-	-
10	no		
11	yes	107	yes
12		104,6	yes
13	no		
14	no		
15	yes	10	no

5.1.2 Cadmium

Teilnehmer/ participant	Ergebnis/ result	DLA-Nr Probe I/ sample I	DLA-Nr Probe II/ sample II	Ergebnis I/ result I	Ergebnis II/ result II
	mg/kg			mg/kg	mg/kg
1	1,84	28	67	1,83	1,86
2	1,75	36	68	1,75	1,75
3	1,79	18	35	1,80	1,78
4	1,757	54	90	1,792	1,722
5	1,59	17	88	1,59	1,59
6	2,02	13	89	1,95	2,08
7	1,823	30	45	1,843	1,803
8	1,861	15	47	1,848	1,873
9	1,88	61	85	1,85	1,90
10	1,955	24	70	1,93	1,98
11	1,851	77	6	1,988	1,713
12	1,89	20	58	1,895	1,891
13	1,66	10	53	1,65	1,67
14	1,66	22	41	1,67	1,66
15	1,87	3	69	1,85	1,88

Teilnehmer/ paticipant	**Ergebnis inkl. Wiederfindung/ result incuding recovery**	**Wiederfindungs-rate/ recovery**	**Wiederfindung mit gleicher Matrix/ recovery with the same matrix**
	yes/no	In %	yes/no
1	no		
2	no	105	no
3	no	-	-
4	yes	117,54	no
5			
6	no	105	no
7	yes	-	yes
8	yes	95,5	yes
9	no	-	-
10	no		
11	yes	115,6	yes
12		97,5	yes
13	no		
14	no		
15	yes	10	no

5.1.3 Mercury

Teilnehmer/ paticipant	Ergebnis/ result	DLA-Nr Probe I/ sample I	DLA-Nr Probe II/ sample II	Ergebnis I/ result I	Ergebnis II/ result II
	mg/kg			mg/kg	mg/kg
1	0,299	28	67	0,306	0,292
2	0,261	36	68	0,253	0,268
3	0,33	18	35	0,29	0,36
4	0,294	54	90	0,29	0,297
5	0,53	17	88	0,55	0,52
6	0,322	13	89	0,337	0,307
7	0,345	30	45	0,337	0,352
8	0,379	15	47	0,37	0,388
9	0,34	61	85	0,33	0,35
10	0,314	24	70	0,317	0,311
11	0,19	77	6	0,172	0,21
12	0,32	20	58	0,313	0,32
13	0,309	10	53	0,299	0,319
14	0,3	22	41	0,3	0,3
15a	0,34	3	69	0,33	0,34
15b	0,345*	3	69	0,35	0,34

** Result calculated by DLA*

Teilnehmer/ paticipant	Ergebnis inkl. Wiederfindung/ result incuding recovery	Wiederfindungs-rate/ recovery	Wiederfindung mit gleicher Matrix/ recovery with the same matrix
	yes/no	In %	yes/no
1	no		
2	no	97	no
3	no	-	-
4	yes	110,69	no
5			
6	no	96	no
7	yes	-	yes
8	no	-	-
9	no	100,24	no
10	no		
11	yes	86,4	yes
12		98,9	yes
13	no		
14	no		
15a	yes	10	no
15b			

5.1.4 Arsenic

Teilnehmer/ participants	Ergebnis/ result	DLA-Nr Probe I/ sampel I	DLA-Nr Probe II/ sample II	Ergebnis I/ result I	Ergebnis II/ result II
	mg/kg			mg/kg	mg/kg
1	0,962	28	67	0,959	0,966
2	0,809	36	68	0,807	0,810
3	1,04	18	35	1,07	1,00
4	1,326	54	90	1,35	1,302
5	0,29	17	88	0,26	0,31
6	0,988	13	89	0,956	1,02
7	1,011	30	45	1,021	1,001
8	0,844	15	47	0,84	0,849
9	1,08	61	85	1,04	1,11
10	1,135	24	70	1,11	1,16
11	0,597	77	6	0,594	0,6
12	1,1	20	58	1,182	1,036
13	0,91	10	53	0,92	0,90
14	0,83	22	41	0,83	0,84
15	0,92	3	69	0,93	0,9

Teilnehmer/ paticipant	Ergebnis inkl. Wiederfindung/ result incuding recovery	Wiederfindungs- rate/ recovery	Wiederfindung mit gleicher Matrix/ recovery with the same matrix
	yes/no	In %	yes/no
1	no		
2	no	92	no
3	no	-	-
4	yes	95,08	no
5			
6	no	104	no
7	yes	-	yes
8	yes	112,3	yes
9	no	-	-
10	no		
11	yes	93,8	yes
12		127,3	yes
13	no		
14	no		
15	yes	10	no

5.2 DLA-portion-numbers and homogeneity

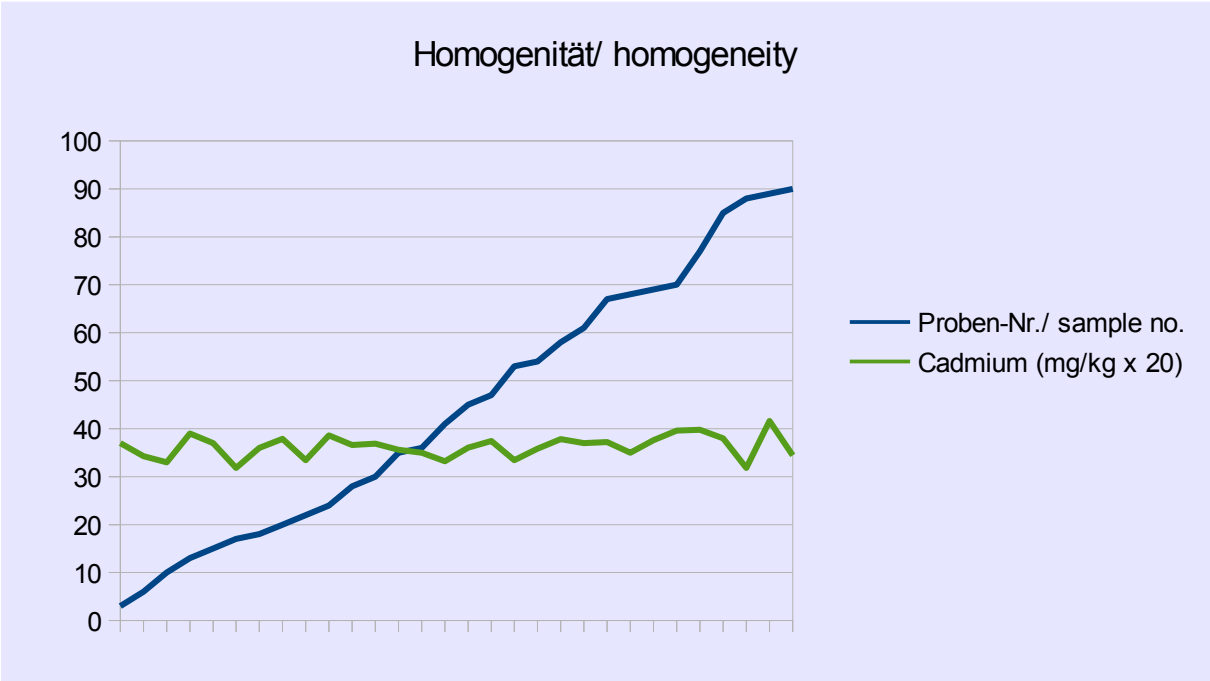
5.2.1 Repeatability standard deviation of participants

The repeatability standard deviation was calculated like under 5.1 documented.
It is to 0,085 mg/kg = 4,7 % of X (= 1,8 mg/kg) for cadmium.

For comparison ASU § 64 LFGB L00.00-135 (11):
For cadmium (shell): 0,07 mg/kg = 3,9 % of X (= 1,7 mg/kg)

5.2.2 Comparison of sample number/test result

From the comparison of the rising sample-numbers and measured cadmium-concentrations (x20) can be seen on homogeneity.



5.3 Analytical methods

Inst.	Method	Details	Accredited
1	As, Cd a. Pb: ASU L 00.00-19/1; ASU L 00.00-135	1. Careful stir before sample weight 2. Microwave pressure digestion 3. 0,5 g 4. PT sample DLA 22-2014 5. external calibration	yes
	Hg: ASU L 00.00-19/1; ASU L 00.00-19/4	1. Careful stir before sample weight 2. Microwave pressure digestion 3. 0,5 g 4. PT sample DLA 22-2014 5. external calibration	yes
2	Cd a. Pb: ASU L 00.00-19/3; DIN EN 14083	1. shaken 2. ASU L 00.00-19/3 DIN EN 14083 3. 1 g 4. Plankton BCR-414 5. multi-point calibration	yes
	As: ASU L 00.00-19/6; DIN 14627	1. shaken 2. ASU L 00.00-19/6 DIN EN 14627 3. 1 g 4. Plankton BCR-414 5. multi-point calibration	yes
	Hg: ASU L 00.00-19/4; DIN 13806	1. shaken 2. ASU L 00.00-19/4 DIN EN 13806 3. 1 g 4. Plankton BCR-414 5. multi-point calibration	yes
3	As, Bp, Cd a. Hg: DIN EN 15762	1. yes 2. Microwave HNO3 3. 0,5 g 4. - 5. External	yes
4	Cd a. Pb: § 64 LFBG L 00.00 19/3 (modified)	1. - 2. Pressure digestion 3. - 4. Boiled sausage 5. -	yes
	Hg: § 64 LFBG L 00.00 19/4 (modified)	1. - 2. Pressure digestion 3. - 4. Boiled sausage 5. -	yes
	As: § 64 LFBG L 12.00 6 (modified)	1. - 2. Pressure digestion 3. - 4. Boiled sausage 5. -	yes
5	As: Far.AC052	1. - 2. - 3. 0,3 g 4. - 5. - 6. Instrument: AA-GF	no

Inst.	Method	Details	Accredited
	Cd a. Pb: UNI EN 14084:2003	1. - 2. - 3. 0,3 g 4. - 5. - 6. Instrument: AA-VGA	yes
	Hg: UNI EN 13806:2003	1. - 2. - 3. 0,3 g 4. - 5. - 6. Instrument: AA-GF	yes
6	As, Cd, Hg a. Pb: ICP-MS, DIN 15763	1. mixing 2. Microwave pressure digestion 3. 100 mg 4. NIST 1567b/1640a 5. external	no
7	As, Cd a. Pb: ICP-MS	1. shake 2. Microwave pressure digestion 3. 0,25 g 4. no 5. external calibration	yes
	Hg: cold vapour AAS	1. shake 2. Microwave pressure digestion 3. 0,25 g 4. no 5. external calibration	yes
8	As, Cd a. Pb: Open vessel acid digestion and analyse using ICP-MS	1. mix well before sampling 2. - 3. 0,7 g 4. - 5. 0,1 - 1000 µg/l 6. validated internal standardization method	no
	Hg: Open vessel acid digestion and analyse using ICP-MS	1. mix well before sampling 2. - 3. 0,7 g 4. - 5. 0,1 - 20 µg/l 6. validated internal standardization method	no
9	Cd a. Pb: ASU L 00.00-19/E-3	1. yes 2. Microwave digestion 3. 0,25 g - 1,00 g 4. - 5. Standard addition	yes
	As: analogue DIN 38405-35-2004-09	1. yes 2. Microwave digestion 3. 0,25 g - 1,00 g 4. - 5. Standard addition	no
	Hg: ASU L 00.00-19/E-4	1. yes 2. Microwave digestion 3. 0,25 g - 1,00 g 4. - 5. Linear (ext. standard)	yes

Inst.	Method	Details	Accredited
10	As, Cd a. Pb: NEN-EN 15763	1. - 2. - 3. 0,8 g 4. yes 5. yes	yes
	Hg: NEN-EN 16277	1. - 2. - 3. 0,05 g 4. yes 5. yes	yes
11	Cd,As, Hg a. Pb: DIN EN ISO 11885	1. yes 2. Microwave 3. 0,5 g 4. LGC 7162 5. ext. Standard	yes
12	Cd,As, Hg a. Pb: acid digestion - ICP-MS	1. - 2. - 3. - 4. - 5. -	no
13	As, Cd a. Pb: DIN EN ISO 17294-2 (E 29) (2005-02)	1. - 2. VDLUFA Mb VII 2.1.3 3. 0,8 g/25 ml 4. - 5. external	yes
	Hg: DIN EN 1483 (2007-07)	1. - 2. VDLUFA Mb VII 2.1.3 3. 0,8 g/25 ml 4. - 5. external	yes
14	As, Cd, Hg a. Pb: Sample preparation: EN 15763; measurement: EN 17294-2	1. no 2. Microwave pressure digestion with HNO3 3. 400 mg 4. - 5. (simple) linear	yes
15	As, Cd a. Pb: DIN EN 15763 mod., SOP M 1474, ICP/MS	1. - 2. HNO3 pressure digestion 3. 0,5 – 1 g 4. apple leaves 5. aqueous standard 6. not established	yes
	Hg: SOP m 2567, solid analyser	1. - 2. burning 3. 0,1 g 4. apple leaves 5. aqueous standard 6. results by ICP-MS: 0,35 and 0,34 mg/kg	yes

1. = Homogenization
2. = Hydrolization/ digestion
3. = Sample weight
4. = Reference material
5. = Calibration
6. = remarks

6. Index of participant laboratories

Teilnehmer/ participants	Ort	Land
		Deutschland
		Deutschland
		Deutschland
		DÄNEMARK
		ITALIEN
		Deutschland
		USA
		SCHWEIZ
		Deutschland
		Deutschland
		Deutschland
		Deutschland
		Deutschland
		NIEDERLANDE
		Deutschland

[Die Adressdaten der Teilnehmer wurden für die allgemeine Veröffentlichung des Auswerte-Berichts nicht angegeben.]

[The address data of the participants were deleted for publication of the evaluation report.]

6. Index of literature

1. DIN EN ISO/IEC 17043:2010; Konformitätsbewertung – Allgemeine Anforderungen an Eignungsprüfungen / Conformity assessment – General requirements for proficiency testing
2. Verordnung / Regulation 882/2004/EU; Verordnung über amtliche Kontrollen / Regulation on official controls
3. DIN EN ISO/IEC 17025:2005; Allgemeine Anforderungen an die Kompetenz von Prüf- und Kalibrierlaboratorien / General requirements for the competence of testing and calibration laboratories
4. Richtlinie / Directive 1993/99/EU; über zusätzliche Maßnahmen im Bereich der amtlichen Lebensmittelüberwachung / on additional measures concerning the official control of foodstuffs
5. ASU §64 LFGB : Planung und statistische Auswertung von Ringversuchen zur Methodenvalidierung
6. ISO 13528:2005; Statistische Verfahren für Eignungsprüfungen durch Ringversuche
7. The International Harmonised Protocol for the Proficiency Testing of Analytical Laboratories ; J.AOAC Int., 76(4), 926 – 940 (1993)
8. The International Harmonised Protocol for the Proficiency Testing of Analytical Chemistry Laboratories ; Pure Appl Chem, 78, 145 – 196 (2006)
9. Evaluation of analytical methods used for regulation of food and drugs;W. Horwitz; Analytical Chemistry, 54, 67-76 (1982)
10. A Horwitz-like funktion describes precision in proficiency test; M. Thompson, P.J. Lowthian; Analyst, 120, 271-272 (1995)
11. ASU §64 LFGB : L00.00-135; Bestimmung von Arsen, Cadmium, Quecksilber und Blei in Lebensmitteln (Jan. 2011)
12. ASU §64 LFGB : L00.00-19/3; Bestimmung von Blei, Cadmium, Chrom und Molybdän in Lebensmitteln (Juli 2004)
13. ASU §64 LFGB : L00.00-19/4; Bestimmung von Quecksilber in Lebensmitteln (Dezember 2003)
14. ASU §64 LFGB : L00.00-19/6; Bestimmung von Gesamtarsen in Lebensmitteln (Juli 2001)