Proficiency test for dioxins, dioxin-like PCBs and non-dioxin-like PCBs in fish meal (PT2025-03)

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This research has been carried out by Wageningen Food Safety Research, institute within the legal entity Wageningen Research Foundation subsidised by the Dutch Ministry of Agriculture, Fisheries, Food Security and Nature (LVVN) and Netherlands Food and Consumer Product Safety Authority (NVWA).

Wageningen, 18 December 2025

WFSR Report 2025.018

Meijer T, J.M. Straver, 2025. *Proficiency test for dioxins, dioxin-like PCBs and non-dioxin-like PCBs in fish meal (PT2025-03).* Wageningen, Wageningen Food Safety Research, WFSR Report 2025.018. 56 pp.; 39 fig.; 5 tab.; 9 ref.

Project number: 1257248801
BAS-code: WOT-02-004-004
Project title: Borging Private Laboratoria
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This report can be downloaded for free at https://doi.org/10.18174/705820.

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WFSR Report 2025.018

Distribution list:
- Participating laboratories

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Summary

A proficiency test (PT) for dioxins, dioxin-like polychlorinated biphenyls (dl-PCBs) and non-dioxin-like polychlorinated biphenyls (ndl-PCBs) in fish meal was organised from June to July 2025 by Wageningen Food Safety Research (WFSR), part of Wageningen University & Research. This PT was performed by Wageningen Food Safety Research (WFSR) under accreditation (R013, Dutch Accreditation Council RvA, ISO/IEC 17043) on behalf of the Dutch Ministry of Agriculture, Fisheries, Food Security and Nature and Netherlands Food and the Consumer Product Safety Authority.

For this PT, one fish meal material was prepared from naturally contaminated fish meal samples which were mixed and homogenized. During homogeneity testing, the material proved to be sufficiently homogenous for proficiency testing. Target levels in the material were approximately 1x action threshold for dioxins (sum polychlorinated dibenzo-para-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs)), 0.4x action threshold for dl-PCBs, 0.4x maximum level for sum of dioxins and dl-PCBs and 0.2x maximum level for ndl-PCBs.
Twenty-three laboratories subscribed for participation in this test. Twenty-one laboratories reported results. Six laboratories were situated in The Netherlands, twelve in the EU and three outside of the EU.

In this PT the robust mean was used as consensus value, based on results generated by the participating laboratories. The proficiency of the participants was assessed as z-scores, calculated using the consensus values and a relative target standard deviation.

A total of 628 z-scores was calculated to assess the performance of the participating laboratories. With regard to the accuracy, 13% of the z-scores were outside the range of -2 to 2, which means results were questionable or unsatisfactory.

Fifteen participants reported dioxins, dl-PCBs and ndl-PCBs, five only ndl-PCBs and one participant reported dl- and ndl-PCBs. Of the 21 reporting participants, six participants reported satisfactory results for all values (sum-values and individual analytes). Sixteen participants reported satisfactory results for the sum-values.

Based on the results of this PT it can be concluded that most of the reporting participants have an analytical method capable of analysing dioxins and dl-PCBs and/or ndl-PCBs in fish meal at levels equal or below TEQ and/or sum values which are stated in the EU regulation. However, for a limited number of participants, further efforts are needed to refine and improve their analytical methods as indicated by questionable or unsatisfactory z-scores.

1 Introduction

Proficiency testing is conducted to provide participants with a tool to evaluate and demonstrate the reliability of the data that are produced by the laboratory. Proficiency testing is an important requirement and demanded by ISO/IEC 17025 [1].

The aim of this proficiency test (PT) was to give participants the opportunity to evaluate or demonstrate their competence for the analysis of dioxins, dioxin-like PCBs (dl-PCBs) and non-dioxin-like PCBs (ndl-PCBs) in fish meal.

This proficiency test was conducted in accordance with guidelines ISO 17043 [2] (R013 at www.rva.nl) and ISO 13528 [6]. The preparations of the materials, including the suitability testing of the materials and the evaluation of the quantitative results were carried out by Wageningen Food Safety Research (WFSR).

2 PT material and methods

2.1 Scope of the PT

This PT focused on the dioxins, dl-PCBs and ndl-PCBs which are regulated in feed in the EU [3].

The maximum levels (ML) and action thresholds (AT) for fish meal are presented in Table 1.

Table 1 *Maximum levels (ML) and action thresholds (AT) in animal feed (Fish, other aquatic animals, and products derived thereof with the exception of fish oil and fish protein, hydrolysed, containing more than 20% fat) relative to a feed with a moisture content of 12% [3].*

Compounds[1]	Unit[1]	Maximum level	Action threshold
Dioxins	ng WHO-PCDD/F-TEQ ub	1.25	0.75
Dioxin-like PCBs	ng-WHO-PCB-TEQ ub	-	2.0
Sum of dioxins and dioxin-like PCBs	ug WHO-PCDD/F-PCB-TEQ ub	4.0	-
Non-dioxin-like PCBs	ug/kg ub	30	-

[1] For more explanation on compounds and TEQ calculation the reader is referred to Annex 1.

2.2 Material preparation

For preparation of the PT material, multiple fish meal samples which were naturally contaminated were used. Target levels in the material are approximately 1x AT for dioxins, 0.4x AT dl-PCBs, 0.4x ML for sum of dioxins and dl-PCBs and 0.2x ML for ndl- PCBs. The materials were milled under nitrogen using a tubemill (tubemill 100 control, IKA) to obtain a particle size of <500 µm. The materials were combined and homogenized using a homogenizer (Stephan cutter, UM 12). A total of approximately 2 kilograms of final fish meal material was obtained.

2.3 Sample identification

After homogenisation, the material was divided into sub-portions of approximately 50 grams and stored in plastic containers at room temperature until use.

The samples provided to participants were randomly selected and coded through the WFSRT PT website application. One randomly selected sample was prepared for each participant. The codes of the samples are shown in Annex 2. Samples for homogeneity testing were also randomly selected.

2.4 Participants

Invitations were sent on April 30th, 2025 (Annex 4). 24 laboratories registered for the PT.
Three laboratories did not report their results of which one without an explanation. Each participant was free to use their method of choice, reflecting their routine procedures. The participants were asked to report their results through the WFSR PT website application.

2.5 Homogeneity study

The homogeneity of the material was evaluated according to the International Harmonized Protocol for Proficiency Testing of Analytical Laboratories [5] and ISO 13528 [5], taking into account the insights discussed by Thompson [4] regarding the Horwitz equation. With this procedure the between-sample standard deviation (s_s) and the within-sample standard deviation (s_w) are compared with the standard deviation for proficiency assessment derived from the Horwitz equation (σ_P, §3.3). The method applied for homogeneity testing is considered suitable if $s_w < 0.5*\sigma_P$ and a material is considered adequately homogeneous if $s_s < 0.3*\sigma_P$.
Ten containers of the PT material were analysed in duplicate for PCB 118 and PCB 153 to determine the homogeneity of the materials. The homogeneity of other compounds in the materials was not tested, because the homogeneity test of PCB 118 and PCB 153 was considered adequate to prove the sufficient homogeneity of the material. The results of the homogeneity study and their statistical evaluation are presented in Annex 3. Both materials demonstrated to be sufficiently homogeneous for use in the proficiency test.

2.6 Material distribution and instructions

Each participant received a randomly assigned laboratory code (Annex 2), generated by the web application designed for proficiency tests. The sample, with a unique number (Annex 2), was packed in a carton box and was dispatched to the participants immediately by courier on June 3rd, 2025.
Participants were instructed to store and analyse the sample using their routine methods. As reported by participants, all samples were received in good condition.

The sample was accompanied by an instruction letter (Annex 5) and an acknowledgement of receipt form. In addition, each participant received instructions by e-mail on how to use the web application to report their results. Results were to be reported as ng/kg (dioxins, dl-PCBs) or µg/kg (ndl-PCBs) product, relative to a feed with a moisture content of 12% (assuming 0% moisture in the sample).

The deadline for submitting results was July 18th, 2025, allowing the participants 6 weeks for analysis of the test samples. All reported results were submitted within the deadline.

2.7 Stability of the materials

No stability tests were performed since dioxins and PCBs are persistent and very stable compounds.

3 Evaluation of results

The statistical evaluation was carried out according to the International Harmonized Protocol for the Proficiency Testing of Analytical Laboratories [5], elaborated by ISO, IUPAC and AOAC and ISO 13528 [6] in combination with the insights published by the Analytical Methods Committee [7, 8] regarding robust statistics.

Results were evaluated based on the consensus values, its uncertainty, and the standard deviation for proficiency assessment (σ_P), from which z-scores were calculated to classify participants' performance.

3.1 Calculation of the consensus value (C)

The consensus value (C) was determined using robust statistics, Algorithm A [6,7,8]. The advantage of robust statistics is that all values are taken into account: outlying observations are retained, but given less weight. Furthermore, it is not expected to receive normally distributed data in a proficiency test. When using robust statistics, the data do not have to be normally distributed in contrast to conventional outlier elimination methods.

The robust mean of the reported results of all participants, calculated from an iterative process that starts at the median of the reported results using a cut-off value depending on the number of results, was used as the consensus value [7,8]. This approach was chosen out of the five possible ways to determine the consensus value [8] since it is the most time-efficient and cost-effective way when no (certified) reference material or reference method is available.

Results which were reported with 'nd', smaller than values ('<'), 'detected' or 'positive' were changed to the corresponding detection limits and taken into account for the calculation of the consensus value.

3.2 Calculation of the uncertainty of the consensus value (u)

The uncertainty of the consensus value is calculated to determine the influence of this uncertainty on the evaluation of the laboratories. A high uncertainty of the consensus value will lead to a high uncertainty of the calculated participants z-scores. If the uncertainty of the consensus value and thus the uncertainty of the z-score is high, the evaluation could indicate unsatisfactory method performance without any cause within the laboratory. In other words, illegitimate conclusions could be drawn regarding the performance of the participating laboratories from the calculated z-scores if the uncertainty of the consensus value is not taken into account.

The uncertainty of the consensus value (the robust mean) is calculated from the estimation of the standard deviation of the consensus value and the number of values used for the calculation of the consensus value [6]:

$$u = 1.25 * \frac{\hat{\sigma}}{\sqrt{n}}$$

where:

u	=	uncertainty of the consensus value;
n	=	number of values used to calculate the consensus value;
$\hat{\sigma}$	=	estimate of the standard deviation of the consensus value resulting from robust statistics.

According to ISO 13528 [6] the uncertainty of the consensus value (u) is negligible and therefore does not have to be included in the statistical evaluation if:

$u \leq 0.3\sigma_P$

where:

u	=	the uncertainty of the consensus value;
σ_P	=	standard deviation for proficiency assessment (§3.3).

In case the uncertainty of the consensus value does not comply with this criterion, the uncertainty of the consensus value should be taken into account when evaluating the performance of the participants regarding the accuracy (§4.4). In case the uncertainty is > $0.7\sigma_P$ the calculated z-scores should not be used for evaluation of laboratories' performance and are presented for information only.

3.3 Calculation of the standard deviation for proficiency assessment (σ_P)

According to Commission Implementing Regulation 2021/808/EC [9], the coefficient of variation for the repeated analysis of a reference or fortified material under reproducibility conditions, shall not exceed the level calculated by the Horwitz equation. The Horwitz equation, $\sigma_H = 0.02c^{0.8495}$, presents a useful and widespread applied relation between the expected relative standard deviation of a singular analysis result under reproducibility conditions, and the concentration, c (g/g). It expresses inter-laboratory precision expected in inter-laboratory trials. Therefore, this relation is suitable for calculating the standard deviation for proficiency assessment.

Thompson [5] demonstrated that the Horwitz equation is not applicable to the lower concentration range (<120 µg/kg). Therefore a complementary model is suggested:

For analyte concentrations <120 µg/kg:

$\sigma_P = 0.22c$

where:

σ_P	=	standard deviation in proficiency assessment;
c	=	concentration of the analyte (g/g).

3.4 Performance characteristics with regard to the accuracy

For illustrating the performance of the participating laboratories concerning the accuracy a z-score is calculated. For the evaluation of the performance of the laboratories, ISO 13528 [6] is applied. According to these guidelines z-scores are classified as presented in Table 2.

Table 2 *Classification of z-scores.*

$\|z\| \leq 2$	Satisfactory
$2 < \|z\| < 3$	Questionable
$\|z\| \geq 3$	Unsatisfactory

If the calculated uncertainty of the consensus value complies with the criterion mentioned in §3.2, the uncertainty is negligible. In this case the accuracy z-score is calculated from:

$$z = \frac{x-C}{\sigma_p} \qquad \text{Equation 1}$$

where:

z = z-score;
x = the result of the laboratory;
C = consensus value;
σ_P = standard deviation for proficiency assessment.

However, if the uncertainty of the consensus value does not comply with the criterion mentioned in §3.2, it could influence the evaluation of the laboratories. Although, according to ISO 13528 in this case no z-scores can be calculated if a consensus value is used as the consensus value, we feel that evaluation of the participating laboratories is of main importance justifying the participating laboratories' effort. Therefore in this case, the uncertainty is taken into account by calculating the accuracy z'-score [6]:

$$z' = \frac{x-C}{\sqrt{\sigma_p^2+u^2}} \qquad \text{Equation II}$$

where:

z' = z-score taking into account the uncertainty of the consensus value;
x = the result reported by the laboratory;
C = consensus value;
σ_p = target standard deviation for proficiency testing;
u = uncertainty of the consensus value.

4 Performance assessment

A total of 21 out of 24 participants submitted results. An overview of the applied methods by the participants is presented in Annex 6 and the reported expanded measurement uncertainty in Annex 7. Thirteen laboratories applied (HR)GC-(HR)MS/MS as detection method, three laboratories GC-ECD and the remaining five laboratories did not specify the applied detection method. A total of 628 z-scores were calculated for individual compounds and TEQ or sum-concentrations (Annex 8), a graphical representation of the z-scores can be found in Annex 9.
A summary of the reported results is presented in Table 3. Results and z-scores for the TEQs, sums and individual compounds for each participant are presented in Table 4. Results which were reported with 'nd', smaller than values ('<'), 'detected' or 'positive' were changed to the corresponding detection limits and taken into account for the calculation of the consensus value.
When there are less than 7 quantitative results or the uncertainty (u) is > $0.7\sigma_p$, no statistical evaluation is possible (§3.2).

Table 3 *Reported results per TEQ, sum of compounds or compound.*

Analyte	Consensus value	unit	# of z-scores	# of z-scores ≤2
WHO-PCDD/F-PCB-TEQ ub	1.3	ng/kg	14	13
WHO-PCDD/F-PCB-TEQ mb	1.3	ng/kg	13	13
WHO-PCDD/F-PCB-TEQ lb	1.3	ng/kg	14	14
WHO-PCDD/F-TEQ ub	0.64	ng/kg	15	14
WHO-PCDD/F-TEQ mb	0.61	ng/kg	13	13
WHO-PCDD/F-TEQ lb	0.61	ng/kg	14	14
2,3,7,8-TCDD	0.047	ng/kg	15	13
1,2,3,7,8-PeCDD	0.13	ng/kg	15	15
1,2,3,4,7,8-HxCDD	0.037	ng/kg	no statistical evaluation possible	
1,2,3,6,7,8-HxCDD	0.097	ng/kg	15	14
1,2,3,7,8,9-HxCDD	0.035	ng/kg	no statistical evaluation possible	
1,2,3,4,6,7,8-HpCDD	0.077	ng/kg	13	11
OCDD	0.21	ng/kg	no statistical evaluation possible	
2,3,7,8-TCDF	1.1	ng/kg	15	12
1,2,3,7,8-PeCDF	0.18	ng/kg	15	15
2,3,4,7,8-PeCDF	0.98	ng/kg	15	14
1,2,3,4,7,8-HxCDF	0.080	ng/kg	15	14
1,2,3,6,7,8-HxCDF	0.082	ng/kg	15	15
2,3,4,6,7,8-HxCDF	0.089	ng/kg	15	13
1,2,3,7,8,9-HxCDF	0.029	ng/kg	no statistical evaluation possible	
1,2,3,4,6,7,8-HpCDF	0.059	ng/kg	no statistical evaluation possible	
1,2,3,4,7,8,9-HpCDF	0.038	ng/kg	no statistical evaluation possible	
OCDF	0.053	ng/kg	no statistical evaluation possible	
WHO-PCB-TEQ ub	0.70	ng/kg	15	13
WHO-PCB-TEQ mb	0.70	ng/kg	13	11
WHO-PCB-TEQ lb	0.68	ng/kg	14	12
PCB 105	322	ng/kg	16	14
PCB 114	17	ng/kg	16	14
PCB 118	950	ng/kg	17	12
PCB 123	16	ng/kg	16	10
PCB 156	110	ng/kg	16	14
PCB 157	32	ng/kg	16	13
PCB 167	76	ng/kg	16	13
PCB 189	12	ng/kg	16	13
PCB 77	17	ng/kg	16	13
PCB 81	0.92	ng/kg	no statistical evaluation possible	
PCB 126	5.8	ng/kg	16	13
PCB 169	1.9	ng/kg	16	14
Sum ndl-PCB ub	6.7	µg/kg	20	18
Sum ndl-PCB mb	6.6	µg/kg	16	14
Sum ndl-PCB lb	6.4	µg/kg	18	16
PCB 28	0.25	µg/kg	20	15
PCB 52	0.38	µg/kg	20	17
PCB 101	0.88	µg/kg	21	18
PCB 138	1.7	µg/kg	21	17
PCB 153	2.5	µg/kg	21	19
PCB 180	0.61	µg/kg	21	17

5 Conclusions

Twenty-one laboratories participated in the PT dioxins, dl-PCBS and ndl-PCBs in fish meal.
Fifteen laboratories reported results for dioxins and (non)dioxin-like PCBs. Five laboratories reported results for only non-dioxin-like PCBs. One laboratory reported results for dioxin-like PCBs and non-dioxin-like PCBs.
A total of 628 z-scores were calculated for individual compounds and TEQ or sum-concentrations.
From the 21 laboratories (six times Netherlands, twelve times EU, three times outside EU), sixteen laboratories (three times Netherlands, eleven times EU, two times outside EU) reported satisfactory results for the regulatory compound groups listed in Table 1. From these sixteen laboratories, eleven laboratories (three times Netherlands, seven times EU, once outside EU) reported WHO-PCDD/F-PCB-TEQ ub, WHO-PCDD/F-TEQ ub, WHO-PCB-TEQ ub and Sum ndl-PCB ub and five (four times EU, once outside EU) laboratories reported only Sum ndl-PCB result.

Table 4 *Results of z-scores of regulatory compound groups (see Table 1) per laboratory (in bold the laboratories without questionable and unsatisfactory z-scores).*

	Regulatory compound groups			
Lab	**Sum of dioxin and dl-PCBs**	**Dioxins**	**dl-PCBs**	**Sum ndl-PCBs**
PT7242	s	s	s	s
PT7243	q	s	q	s
PT7244	s	s	u	s
PT7245	x	u	s	s
PT7246	s	s	s	s
PT7247**	x	x	x	s
PT7249**	x	x	x	s
PT7250	s	s	s	s
PT7251	s	s	s	s
PT7252	s	s	s	s
PT7253	s	s	s	s
PT7254	s	s	s	s
PT7255	s	s	s	u
PT7256	s	s	s	s
PT7259**	x	x	x	s
PT7260***	x	x	x	q
PT7261	s	s	s	s
PT7262**	x	x	x	x
PT7264	s	s	s	s
PT7265**	x	x	x	s
PT7266	s	s	s	s

s=satisfactory z-score.

q=questionable z-score.

u=unsatisfactory z-score.

x=not reported.

**Only ndl-PCBs reported.

***Only dl- and ndl-PCBs reported.

Table 5 *Results of all z-scores per laboratory (in bold the laboratories without questionable and unsatisfactory z-scores).*

Material fish meal									
Lab	**individual compounds**			**TEQ or sum concentrations***			**total**		
	total	**q**	**u**	**total**	**q**	**u**	**total**	**q**	**u**
PT7242	27	0	0	12	0	0	39	0	0
PT7243	27	4	2	12	5	0	39	9	2
PT7244	27	0	4	10	0	3	37	0	7
PT7245	24	0	3	3	0	1	27	0	4
PT7246	27	0	3	12	0	0	39	0	3
PT7247**	7	0	0	2	0	0	9	0	0
PT7249**	6	0	0	3	0	0	9	0	0
PT7250	27	0	3	12	0	0	39	0	3
PT7251	27	0	0	12	0	0	39	0	0
PT7252	27	0	0	12	0	0	39	0	0
PT7253	27	0	1	8	0	0	35	0	1
PT7254	26	0	2	12	0	0	38	0	2
PT7255	27	0	16	12	0	3	39	0	19
PT7256	27	0	0	12	0	0	39	0	0
PT7259**	6	1	3	3	0	0	9	1	3
PT7260	17	0	17	3	3	0	20	3	17
PT7261	27	0	1	12	0	0	39	0	1
PT7262**	6	0	1	0	0	0	6	0	1
PT7264***	27	0	2	12	0	0	39	0	2
PT7265**	6	0	2	3	0	0	9	0	2
PT7266	27	0	1	12	0	0	39	0	1

q=questionable z-score.

u=unsatisfactory z-score.

*WHO-PCDD/F-TEQ, WHO-PCDD/F-PCB-TEQ, WHO-PCB-TEQ, sum ndl-PCB.

**Only ndl-PCBs reported.

***Only dl- and ndl-PCBs reported.

A total of 81 |z-scores|>2 (13%) were reported. 66 questionable/unsatisfactory z-scores were reported for individual compounds and fifteen for sum-concentrations.
Six participants (29%) reported satisfactory results for all values (individual compounds and sum-concentrations). Another sixteen participants (76%) reported satisfactory results for the sum-concentrations.

Based on the results of this PT it can be concluded that most of the participants apply an analytical method capable of analysing dioxins and dl-PCBs and/or ndl-PCBs in fish meal at levels equal or below TEQ and/or sum values which are stated in the EU regulation. However, for a limited number of participants, further efforts are needed to refine and improve their analytical methods as reflected with the questionable or unsatisfactory z-scores.

References

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[9] Commission Implementing Regulation EU/2021/808. 21 May 2021. https://data.europa.eu/eli/reg_impl/2021/808/

Annex 1 Compounds and TEQ calculations

Compounds	Reported value	TEF WHO 2005	unit
Sum dioxin and dl-PCB			
WHO-PCDD/F-PCB-TEQ ub	Calculated sum		ng/kg
WHO-PCDD/F-PCB-TEQ mb	Calculated sum		ng/kg
WHO-PCDD/F-PCB-TEQ lb	Calculated sum		ng/kg
Dioxin			
WHO-PCDD/F-TEQ ub	Calculated sum		ng/kg
WHO-PCDD/F-TEQ mb	Calculated sum		ng/kg
WHO-PCDD/F-TEQ lb	Calculated sum		ng/kg
2,3,7,8-TCDD	Analysis result	1	ng/kg
1,2,3,7,8-PeCDD	Analysis result	1	ng/kg
1,2,3,4,7,8-HxCDD	Analysis result	0.1	ng/kg
1,2,3,6,7,8-HxCDD	Analysis result	0.1	ng/kg
1,2,3,7,8,9-HxCDD	Analysis result	0.1	ng/kg
1,2,3,4,6,7,8-HpCDD	Analysis result	0.01	ng/kg
OCDD	Analysis result	0.0003	ng/kg
2,3,7,8-TCDF	Analysis result	0.1	ng/kg
1,2,3,7,8-PeCDF	Analysis result	0.03	ng/kg
2,3,4,7,8-PeCDF	Analysis result	0.3	ng/kg
1,2,3,4,7,8-HxCDF	Analysis result	0.1	ng/kg
1,2,3,6,7,8-HxCDF	Analysis result	0.1	ng/kg
2,3,4,6,7,8-HxCDF	Analysis result	0.1	ng/kg
1,2,3,7,8,9-HxCDF	Analysis result	0.1	ng/kg
1,2,3,4,6,7,8-HpCDF	Analysis result	0.01	ng/kg
1,2,3,4,7,8,9-HpCDF	Analysis result	0.01	ng/kg
OCDF	Analysis result	0.0003	ng/kg
dl-PCBs			
WHO-PCB-TEQ ub	Calculated sum		ng/kg
WHO-PCB-TEQ mb	Calculated sum		ng/kg
WHO-PCB-TEQ lb	Calculated sum		ng/kg
PCB 105	Analysis result	0.00003	ng/kg
PCB 114	Analysis result	0.00003	ng/kg
PCB 118	Analysis result	0.00003	ng/kg
PCB 123	Analysis result	0.00003	ng/kg
PCB 156	Analysis result	0.00003	ng/kg
PCB 157	Analysis result	0.00003	ng/kg
PCB 167	Analysis result	0.00003	ng/kg
PCB 189	Analysis result	0.00003	ng/kg
PCB 77	Analysis result	0.0001	ng/kg
PCB 81	Analysis result	0.0003	ng/kg
PCB 126	Analysis result	0.1	ng/kg
PCB 169	Analysis result	0.03	ng/kg
Ndl-PCBs			
Sum ndl-PCB ub	Calculated sum		µg/kg
Sum ndl-PCB mb	Calculated sum		µg/kg
Sum ndl-PCB lb	Calculated sum		µg/kg
PCB 28	Analysis result	(1)	µg/kg
PCB 52	Analysis result	(1)	µg/kg
PCB 101	Analysis result	(1)	µg/kg
PCB 138	Analysis result	(1)	µg/kg
PCB 153	Analysis result	(1)	µg/kg
PCB 180	Analysis result	(1)	µg/kg

1 Calculated sum should be obtained by multiplying the individual analysis results by the TEF values and summing these values together to obtain values in TEQ, lb lowerbound (analysis result<LOQ=0), mb= medium bound (analysis result<LOQ: 0,5 LOQ, ub= upperbound (result analysis <LOQ=LOQ).

2 Abbreviations: T= tetra, Pe= penta, Hx= hexa, Hp= hepta, O= octa, CDD= chlorodibenzodioxin, CFD= chlorodibenzofuran, CB= chlorobiphenyl.

Annex 2 Codification of the samples

Participant's codes	Material fish meal*
PT7242	210
PT7243	188
PT7244	176
PT7245	284
PT7246	357
PT7247	927
PT7249	304
PT7250	773
PT7251	480
PT7252	230
PT7253	994
PT7254	108
PT7255	334
PT7256	283
PT7259	477
PT7260	434
PT7261	884
PT7262	544
PT7264	348
PT7265	443
PT7266	129

* All sample codes start with DIOX/2025-03/fish meal/.

Annex 3 Statistical evaluation of homogeneity data

	PCB 118 (µg/kg)	
Sample No.	**Replicate 1**	**Replicate 2**
HOM-01	0.99	1.1
HOM-02	1.0	1.1
HOM-03	1.0	1.1
HOM-04	1.0	1.1
HOM-05	0.93	0.98
HOM-06	0.99	1.1
HOM-07	0.92	1.0
HOM-08	0.99	1.1
HOM-09	1.0	1.1
HOM-10	0.99	1.0
Grand mean	1.0	
Cochran's test		
C	0.24	
Ccrit	0.60	
C < Ccrit?	NO OUTLIERS	
Target s = σ_P	0.23	
s_x	0.038	
s_w	0.051	
s_s	0.014	
Critical= 0.3 σ_P	0.067	
s_s < critical?	ACCEPTED	
s_w < 0.5 σ_P?	ACCEPTED	

s_x = Standard deviation of the sample averages. s_w = Within-sample standard deviation. s_s = Between-sample standard deviation.

	PCB 153 (µg/kg)	
Sample No.	**Replicate 1**	**Replicate 2**
HOM-01	2.7	2.7
HOM-02	2.6	2.6
HOM-03	2.5	2.7
HOM-04	2.6	2.7
HOM-05	2.3	2.8
HOM-06	2.8	2.7
HOM-07	2.3	2.9
HOM-08	2.9	2.8
HOM-09	2.6	2.8
HOM-10	2.7	2.7
Grand mean	2.7	
Cochran's test		
C	0.44	
Ccrit	0.60	
C < Ccrit?	NO OUTLIERS	
Target s = σ_P	0.59	
s_x	0.073	
s_w	0.18	
s_s	0.00	
Critical= 0.3 σ_P	0.18	
s_s < critical?	ACCEPTED	
s_w < 0.5 σ_P?	ACCEPTED	

s_x = Standard deviation of the sample averages. s_w = Within-sample standard deviation. s_s = Between-sample standard deviation.

Annex 4 Invitation letter

WAGENINGEN
UNIVERSITY & RESEARCH

P.O. Box 230 | 6700 AE Wageningen | The Netherlands

DATE
April 30, 2025

SUBJECT
Proficiency test for dioxins and (non)dioxin-like PCBs in fish meal

POSTAL ADDRESS
P.O. Box 230
6700 AE Wageningen
The Netherlands

HANDLED BY
Thijs Meijer

TELEPHONE
+31 317 482638

EMAIL
pt.wfsr@wur.nl

Dear colleague,

Hereby I would like to invite you to participate in the proficiency test for dioxins and (non)dioxin-like PCBs in the feed material fish meal (PT code 2025-03). This proficiency test is initiated by the Dutch Ministry of Agriculture, Fisheries, Food Security and Nature and will be organised by Wageningen Food Safety Research (WFSR), part of Wageningen University & Research. WFSR is accredited for the organization of proficiency tests in the field of contaminants in feed according to ISO 17043 (www.rva.nl – R013).

Participation in relevant proficiency tests is one of the requirements for certification for both public and private laboratories. Opportunities to fulfil this requirement are not always frequently offered and the Netherlands Ministry of Agriculture, Fisheries, Food Security and Nature has therefore taken the initiative to organise a relevant proficiency test.

This PT will focus on the quantification of dioxin and (non)dioxin-like PCBs in fish meal, for which EU directive 2002/32/EC defines action thresholds and maximum contents.

The primary goal of this proficiency test is to give laboratories the opportunity to evaluate or demonstrate their performance regarding the analysis of dioxins and (non)dioxin-like PCBs in fish meal. The number of participants is limited to 25; if the number of participants is insufficient, the proficiency test cannot proceed. Laboratories located in the Netherlands and Europe are given priority.

The following issues are important for participation in the proficiency test:

1. Test material
- One fish meal sample (approximately 50 grams) will be supplied for the screening and/or quantitative analysis of dioxins and (non)dioxin-like PCBs.
- Samples will be sent in May 2025. The distribution of the samples will be announced by e-mail.
- The participant should arrange the necessary import permits for the sample materials.

2. Scope of analysis

Laboratories should report results according to 2002/32/EC:
- Sum of dioxins and dioxin-like PCBs (sum of polychlorinated dibenzo-*para*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs) expressed in World Health Organisation (WHO) toxic equivalents, using the WHO-TEFs (toxic equivalency factors), 2005 (*))

- Dioxins (sum of polychlorinated dibenzo-*para*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) expressed in World Health Organisation (WHO) toxic equivalents, using the WHO-TEFs (toxic equivalency factors, 2005) [2]]
- Dioxin-like PCBs (sum of polychlorinated biphenyls (PCBs) expressed in World Health Organisation (WHO) toxic equivalents, using the WHO-TEFs (toxic equivalency factors, 2005) [1])
- Non-dioxin-like PCBs (sum of PCB 28, PCB 52, PCB 101, PCB 138, PCB 153 and PCB 180 (ICES – 6) [1])

In addition, results of individual dioxin congeners and PCBs mentioned in those sums should be reported.

3. Deadline
- The results have to be reported within 6 weeks after shipment of the samples.

4. Report
- A report of the proficiency test will be dispatched in October/November 2025.
- The evaluation of the results will be based on a consensus value using Algorithm A of ISO 13528.
- Quantitative, qualitative, false positive, false negative results and z-scores will be taken into account for the evaluation of the performance.
- Results of the proficiency test will be presented anonymously.

5. Additional information
- WFSR is allowed to use the anonymous results of the proficiency test in presentations, seminars and publications.
- WFSR will never inform third parties (e.g. accreditation bodies) on specific laboratory results without informing the laboratory first.

6. Costs
- Participation is free of charge.
- If an extra batch of the sample is needed after the first shipping, the courier costs will be charged.

If you would like to participate, please fill out the participation form (preferably digitally) and send it to me before May 19, 2025 by e-mail (pt.wfsr@wur.nl).

Hoping to welcome you for this proficiency test,

Yours sincerely,

Thijs Meijer
Proficiency tests
WSFR Wageningen University & Research
Netherlands

Annex 5 Instruction letter

WAGENINGEN
UNIVERSITY & RESEARCH

P.O. Box 230 | 6700 AE WAGENINGEN | The Netherlands

Wageningen Food
Safety Research

Veterinary Drugs

DATE
June 3, 2025

SUBJECT
Proficiencytest
PTcode 2025-03

OUR REFERENCE
2513645/WFSR

POSTAL ADDRESS
P.O. Box 230
6700 AE WAGENINGEN
The Netherlands

VISITORS' ADDRESS
Wageningen Campus
Building 123
Akkermaalsbos 2
6708 WB WAGENINGEN

INTERNET
www.wur.nl

CoC NUMBER
09098104

HANDLED BY
Thijs Meijer

TELEPHONE
+31 (0)317 482 638

EMAIL
pt.wfsr@wur.nl

Dear participant,

Thank you very much for your interest in the proficiency test for the analysis of dioxins and (non)dioxin-like PCBs in the feed material fish meal (PT code 2025-03).

The parcel shipped to you should contain:

- One randomly coded sample. The sample unit contains approximately 50 grams of test material.

Instructions:

- After arrival store the samples according to your laboratory's procedures.
- Please fill in the accompanied 'acknowledgement of receipt form' and return it immediately upon receipt of the samples by e-mail (pt.wfsr@wur.nl).
- Before analysis, (re)homogenise the samples according to your laboratory's procedure.
- Treat the test material as a sample for routine analysis according to your laboratory' s standard procedure.

Reporting:

- Report results according 2002/32/EC:
  - Sum of dioxins and dioxin-like PCBs (sum of polychlorinated dibenzo-*para*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs) expressed in World Health Organisation (WHO) toxic equivalents, using the WHO-TEFs (toxic equivalency factors), 2005 [2])
  - Dioxins (sum of polychlorinated dibenzo-*para*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) expressed in World Health Organisation (WHO) toxic equivalents, using the WHO-TEFs (toxic equivalency factors, 2005) [2]
  - Dioxin-like PCBs (sum of polychlorinated biphenyls (PCBs) expressed in World Health Organisation (WHO) toxic equivalents, using the WHO-TEFs (toxic equivalency factors, 2005) [1])
  - Non-dioxin-like PCBs (sum of PCB 28, PCB 52, PCB 101, PCB 138, PCB 153 and PCB 180 (ICES – 6) [1])

In addition, results of individual dioxin congeners and PCBs mentioned in those sums should be reported.

- Report all results **relative to a feed with a moisture content of 12% (assuming 0% moisture in the sample).**
- Please use the web application for entering your results (https://crlwebshop.wur.nl/ordsp/f?p=307:LOGIN). Information about the use of this web application was sent to you earlier by e-mail.
- The deadline for submitting test-results for this PT is **18th of July 2025.**

- Your username is:
- Your password is:
- Your lab code to enter this proficiency test is:

- Please provide information about the method and detection technique you applied via the web application.

Please contact me if you have any questions or need any assistance.

With kind regards,

Thijs Meijer
Organiser proficiency tests
pt.wfsr@wur.nl

Annex 6 Analytical methods details

Lab code	Sample preparation	Internal standard	Detection technique
PT7242			GCMSMS
PT7243			
PT7244	First an extraction with solvent to collect oil. Clean-up extract: AgNO3/Silicagel and H2SO4/silicagel, Carbon column, Aluminia column.	Yes, c13-labelled internal standard.	GC-HRMS
PT7245			
PT7246			
PT7247	Homogenization Soxhlet GPC SPE	PCB 207	GC-ECD
PT7249	Extraction: accelerated solvent extraction (ASE) using hexane. Clean-up: gravity column filled with silica gel (containing 44% sulphuric acid), using hexane for elution.	Isotope-labelled internal standards: PCB-28-13C12, PCB-52-13C12, PCB-101-13C12, PCB-138-13C12, PCB-153-13C12, PCB-180-13C12 Surrogate: PCB-70-13C12, PCB-111-13C12, PCB-170-13C12	GC-MS/MS
PT7250			
PT7251	Soxhlet-extraction, 10 h (toluene:acetone 70:30) 3-column clean-up	ILIS for all congeners (PCDD/F, DL-PCB, NDL-PCB)	GC-MS/MS
PT7252	extraction: Toluol; clean-up: DexTech	CIL ED-910; CIL EDF-4067; CIL EC-4937; CIL EC-4058	GC-HRMS
PT7253	Soxhlet extraction with toluene, column clean-up	13C labled	GC-HRMS
PT7254	ASE - Toluene / Acetone	C13 - 15 internal std C13 - 2 Recovery std	HRGC/HRMS
PT7255			

Lab code	Sample preparation	Internal standard	Detection technique
PT7256	Extraction technique: Twisselmann Extraction solvent (relative amounts (v/v)): Cyclohexan / Toluol (1:1, v/v) Extraction time: 6h Clean-up: Silica/sulfuric acid column, alumina column, carbon column (DexTech-System)	Use of isotope-labelled internal standards for all relevant PCDD/F congeners, DL-PCB congeners and NDL-PCB congeners	GC-HRMS measurement: GC injection: PTV (PCDD/Fs, non-ortho-DL-PCBs) SSL (mono-ortho-DL-PCBs, indicator PCBs); Stationary phase Dioxins: RtxDioxin2; Stationary Phase: non-ortho-PCB: RtxDioxin2; Stationary-Phase di-ortho-PCB: HT8-PCB; Detector: HRMS
PT7259	Extraction with hexane Silica gel column purification	PCB 209	GC-ECD
PT7260	d-SPE	No	GC-MS/MS
PT7261	Sample preparation: pre-treatment: the sample was mixed with sodium sulphate before extraction; Extraction technique: withextraction with Soxhlet Extraction solvent: DCM:Hexane (50:50) Extraction time: 20 hours clean-up:FMS powerpr	17 C13 labelled congeeners for the Dioxins/furan; 12 C13 labelled congeeners for the PCBs; 6 C13 labelled congeeners for the Indicator PCBs	HRGC-HRMS system: Mat-95 XP from Thermo Bremem
PT7262	Microwave extraction, Sulfuric acid treatment for fat removal and Silica gel cleanup.		Gas Chromatography with Electron Capture Detector (GC-ECD)
PT7264			
PT7265	Addition of water and sodium chloride, shaking, Extraktion with acetone/hexane 2/1 (16h) Clean-up: GPC, silica column (2x)	13C-ISTD for each ndl-PCB	GC-MS/MS
PT7266	ASE with hexane, temp. 100 celsius, 2 cycles 5min, pressure 10 MPa. Cleanup with silicia/sulfuric acid, alumina, silver nitrate and carbon column.	C13 standards and isotope dilution calculation of all analytes with two exeptions; 123789-HxCDD and OCDF.	Dioxins, furanes and non-ortho PCBs on DFS system, GC-HRMS. Splitless, 2ul, 5% diphenyl/95% dimethyl polysiloxane 30m column. Mono-ortho PCBs and NDL-PCBs on GC-MSMS-EI, pulsed splitless, 1 ul, DB-XLB 30m column.

Annex 7 Expanded measurement uncertainty

	Expanded measurement uncertainty u (%)								
	Labcode								
Analyte	**PT7243**	**PT7249**	**PT7251**	**PT7252**	**PT7253**	**PT7256**	**PT7262**	**PT7265**	**PT7266**
WHO-PCDD/F-PCB-TEQ ub	23			25		0.28			25
WHO-PCDD/F-PCB-TEQ mb	23			25		0.28			25
WHO-PCDD/F-PCB-TEQ lb	23			25		0.28			25
WHO-PCDD/F-TEQ ub	24			25	0.237	0.13			30
WHO-PCDD/F-TEQ mb	24			25		0.13			30
WHO-PCDD/F-TEQ lb	24			25	0.248	0.13			30
2,3,7,8-TCDD	44		30	25					35
1,2,3,7,8-PeCDD	31			25					35
1,2,3,4,7,8-HxCDD	44			25					35
1,2,3,6,7,8-HxCDD	46			25					35
1,2,3,7,8,9-HxCDD	41			25					35
1,2,3,4,6,7,8-HpCDD	34			25					35
1,2,3,4,6,7,8,9-OCDD	49			25					35
2,3,7,8-TCDF	27			25					25
1,2,3,7,8-PeCDF	31			25					35
2,3,4,7,8-PeCDF	29			25					25
1,2,3,4,7,8-HxCDF	37			25					35
1,2,3,6,7,8-HxCD	25			25					35
2,3,4,6,7,8-HxCDF	32			25					35
1,2,3,7,8,9-HxCDF	41			25					35
1,2,3,4,6,7,8-HpCDF	25			25					35
1,2,3,4,7,8,9-HpCDF	28			25					35
1,2,3,4,6,7,8,9-OCDF	27			25					35
WHO-PCB-TEQ ub	24			25	0.272	0.15			30
WHO-PCB-TEQ mb	24			25		0.15			30
WHO-PCB-TEQ lb	24			25	0.274	0.15			30
PCB 105	51		30	25					30
PCB 114	32		30	25					35
PCB 118	44		30	25					30
PCB 123	36		30	25					50
PCB 156	36		30	25					30
PCB 157	37		30	25					30
PCB 167	35		30	25					30
PCB 189	37		30	25					50
PCB 77	39		30	25					35
PCB 81	32		30	25					40
PCB 126	26		30	25					35
PCB 169	53		30	25					40
Sum ndl-PCB ub	25	20		25	1.366	1		55	30
Sum ndl-PCB mb	25	20		25		1		55	30
Sum ndl-PCB lb	25	20		25	1.366	1		55	30
PCB 28	27	20	25	25			21		30
PCB 52	27	20	25	25			21		30
PCB 101	21	20	25	25			23		30
PCB 138	32	20	25	25			31		30
PCB 153	27	20	25	25			21		30
PCB 180	28	20	25	25			15		30

Annex 8 Reported results and z-scores for each participant for each TEQ, sum of compounds or compound

	PCDD/F-PCB-TEQ ub CV: 1.3 ng TEQ/kg Uncertainty: 0.052 ng/kg Target sd: 0.29 ng/kg Robust sd: 0.16 ng/kg		PCDD/F-PCB-TEQ mb CV: 1.3 ng TEQ/kg Uncertainty: 0.056 ng/kg Target sd: 0.29 ng/kg Robust sd: 0.16 ng/kg		PCDD/F-PCB-TEQ lb CV: 1.3 ng TEQ/kg Uncertainty: 0.051 ng/kg Target sd: 0.29 ng/kg Robust sd: 0.15 ng/kg	
Lab code	**Result (ng/kg)**	**z-score**	**Result (ng/kg)**	**z-score**	**Result (ng/kg)**	**z-score**
PT7242	1.368	0.18	1.357	0.15	1.346	0.13
PT7243	1.9	2.01	1.9	2.04	1.8	1.71
PT7244	1.102	-0.74	1.0985	-0.74	1.095	-0.74
PT7245						
PT7246	1.427	0.38	1.42	0.37	1.412	0.36
PT7247						
PT7249						
PT7250	0.85	-1.60	0.84	-1.62	0.8348	-1.64
PT7251	1.321	0.01	1.318	0.02	1.315	0.02
PT7252	1.46	0.49	1.46	0.51	1.46	0.53
PT7253	1.319	0.01			1.318	0.03
PT7254	1.09	-0.80	1.08	-0.81	1.074	-0.81
PT7255	1.12	-0.68	1.11	-0.70	1.11	-0.69
PT7256	1.25	-0.23	1.25	-0.22	1.25	-0.20
PT7259						
PT7260						
PT7261	1.436	0.41	1.435	0.42	1.433	0.43
PT7262						
PT7264	1.357	0.14	1.357	0.15	1.357	0.17
PT7265						
PT7266	1.4	0.29	1.37	0.20	1.35	0.15

CV = consensus value.

sd = standard deviation.

	WHO-PCDD/F-TEQ ub CV: 0.64 ng TEQ/kg Uncertainty: 0.047 ng/kg Target sd: 0.14 ng/kg Robust sd: 0.15 ng/kg		WHO-PCDD/F-TEQ mb CV: 0.61 ng TEQ/kg Uncertainty: 0.046 ng/kg Target sd: 0.13 ng/kg Robust sd: 0.13 ng/kg		WHO-PCDD/F-TEQ lb CV: 0.61 ng TEQ/kg Uncertainty: 0.043 ng/kg Target sd: 0.13 ng/kg Robust sd: 0.13 ng/kg	
Lab code	**Result (ng/kg)**	**z'-score**	**Result (ng/kg)**	**z'-score**	**Result (ng/kg)**	**z'-score**
PT7242	0.625	-0.10	0.615	0.04	0.606	-0.05
PT7243	0.79	1.01	0.76	1.06	0.73	0.83
PT7244	0.583	-0.38	0.5795	-0.21	0.576	-0.26
PT7245	1.76	7.54				
PT7246	0.713	0.49	0.705	0.68	0.697	0.60
PT7247						
PT7249						
PT7250	0.4178	-1.50	0.4093	-1.41	0.4009	-1.50
PT7251	0.617	-0.15	0.615	0.04	0.612	0.00
PT7252	0.742	0.69	0.741	0.93	0.739	0.89
PT7253	0.737	0.65			0.735	0.87
PT7254	0.501	-0.94	0.495	-0.81	0.489	-0.87
PT7255	0.441	-1.34	0.438	-1.21	0.436	-1.25
PT7256	0.59	-0.34	0.59	-0.14	0.59	-0.16
PT7259						
PT7260						
PT7261	0.769	0.87	0.768	1.12	0.766	1.09
PT7262						
PT7264	0.562	-0.53	0.562	-0.33	0.562	-0.36
PT7265						
PT7266	0.65	0.07	0.63	0.15	0.61	-0.02

Lab code	2,3,7,8-TCDD CV: 0.047 ng/kg Uncertainty: 0.0043 ng/kg Target sd: 0.010 ng/kg Robust sd: 0.013 ng/kg		1,2,3,7,8-PeCDD CV: 0.13 ng/kg Uncertainty: 0.012 ng/kg Target sd: 0.029 ng/kg Robust sd: 0.038 ng/kg		1,2,3,4,7,8-HxCDD CV: 0.037 ng/kg Uncertainty: 0.0061 ng/kg Target sd: x ng/kg Robust sd: x ng/kg	1,2,3,6,7,8-HxCDD CV: 0.097 ng/kg Uncertainty: 0.0085 ng/kg Target sd: 0.0.021 ng/kg Robust sd: 0.0.026 ng/kg		1,2,3,7,8,9-HxCDD CV: 0.035 ng/kg Uncertainty: 0.0056 ng/kg Target sd: x ng/kg Robust sd: x ng/kg
	Result (ng/kg)	z'-score	Result (ng/kg)	z'-score	Result (ng/kg)	Result (ng/kg)	z'-score	Result (ng/kg)
					NO STATISTICAL EVALUATION POSSIBLE			NO STATISTICAL EVALUATION POSSIBLE
PT7242	0.058	0.97	0.114	0.04	0.044	0.107	0.45	0.044
PT7243	0.05	0.24	0.18	1.06	0.05	0.09	-0.29	0.05
PT7244	0.04	-0.66	0.1	-0.21	0.025	0.08	-0.73	0.025
PT7245	0.09	3.86	0.15			0.12	1.02	
PT7246	0.05	0.24	0.16	0.68	0.05	0.1	0.15	0.05
PT7247								
PT7249								
PT7250	0.0361	-1.01	0.0713	-1.41	0.05	0.066	-1.34	0.05
PT7251	0.0426	-0.43	0.1362	0.04	0.0259	0.1019	0.23	0.0212
PT7252	0.053	0.51	0.16	0.93	0.032	0.13	1.45	0.067
PT7253	0.06	1.15	0.17		0.02	0.13	1.45	0.03
PT7254	0.04	-0.66	0.12	-0.81	0.06	0.09	-0.29	
PT7255	0.0291	-1.65	0.0816	-1.21	0.0394	0.0788	-0.78	0.02
PT7256	0.047	-0.03	0.12	-0.14	0.027	0.12	1.02	0.026
PT7259								
PT7260								
PT7261	0.0709	2.13	0.173	1.12	0.0089	0.1079	0.49	0.0075
PT7262								
PT7264	0.043	-0.39	0.11	-0.33	0.025	0.07	-1.16	0.041
PT7265								
PT7266	0.034	-1.20	0.13	0.15	0.07	0.05	-2.04	0.03

Lab code	1,2,3,4,6,7,8-HpCDD CV: 0.074 ng/kg Uncertainty: 0.010 ng/kg Target sd: 0.016 ng/kg Robust sd: 0.026 ng/kg		1,2,3,4,6,7,8,9-OCDD CV: 0.21 ng/kg Uncertainty: 0.038 ng/kg Target sd: x ng/kg Robust sd: x ng/kg	2,3,7,8-TCDF CV: 1.1 ng/kg Uncertainty: 0.094 ng/kg Target sd: 0.24 ng/kg Robust sd: 0.29 ng/kg		1,2,3,7,8-PeCDF CV: 0.18 ng/kg Uncertainty: 0.018 ng/kg Target sd: 0.040 ng/kg Robust sd: 0.056 ng/kg		2,3,4,7,8-PeCDF CV: 0.98 ng/kg Uncertainty: 0.061 ng/kg Target sd: 0.22 ng/kg Robust sd: 0.19 ng/kg	
	Result (ng/kg)	z'-score	Result (ng/kg)	Result (ng/kg)	z'-score	Result (ng/kg)	z'-score	Result (ng/kg)	z-score
			NO STATISTICAL EVALUATION POSSIBLE						
PT7242	0.176	4.90	1.76	1.206	0.38	0.189	0.18	0.895	-0.40
PT7243	0.05	-1.32	0.25	1.7	2.28	0.23	1.12	1.2	1.02
PT7244	0.16	4.11	0.39	0.95	-0.60	0.16	-0.48	0.99	0.04
PT7245				1.77	2.54	0.25	1.57	1.45	2.18
PT7246	0.11	1.64	3.6	1.1	-0.02	0.2	0.43	1.1	0.55
PT7247									
PT7249									
PT7250	0.0484	-1.40	2	0.6283	-1.83	0.1082	-1.67	0.6776	-1.40
PT7251	0.0669	-0.49	0.1122	1.125	0.07	0.173	-0.19	0.928	-0.24
PT7252	0.082	0.26	0.17	1.3	0.74	0.22	0.89	1.1	0.55
PT7253	0.08	0.16	0.19	1.4	1.13	0.18	-0.03	1.09	0.51
PT7254			0.13	0.65	-1.75	0.14	-0.94	0.71	-1.25
PT7255	0.0436	-1.64	0.0575	0.58	-2.02	0.123	-1.33	0.784	-0.91
PT7256	0.08	0.16	0.14	0.98	-0.48	0.17	-0.25	0.92	-0.28
PT7259									
PT7260									
PT7261	0.0774	0.03	0.185	1.273	0.64	0.218	0.84	1.15	0.79
PT7262									
PT7264	0.061	-0.78	0.094	1.048	-0.22	0.256	1.71	0.778	-0.94
PT7265									
PT7266	0.05	-1.32	0.25	1.08	-0.10	0.1	-1.85	1.04	0.28

Lab code	1,2,3,4,7,8-HxCDF CV: 0.080 ng/kg Uncertainty: 0.0078 ng/kg Target sd: 0.018 ng/kg Robust sd: 0.024 ng/kg		1,2,3,6,7,8-HxCDF CV: 0.082 ng/kg Uncertainty: 0.0040 ng/kg Target sd: 0.018 ng/kg Robust sd: 0.012 ng/kg		2,3,4,6,7,8-HxCDF CV: 0.089 ng/kg Uncertainty: 0.0073 ng/kg Target sd: 0.020 ng/kg Robust sd: 0.023 ng/kg		1,2,3,7,8,9-HxCDF CV: 0.029 ng/kg Uncertainty: 0.0071 ng/kg Target sd: x ng/kg Robust sd: x ng/kg	1,2,3,4,6,7,8-HpCDF CV: 0.059 ng/kg Uncertainty: 0.012 ng/kg Target sd: x ng/kg Robust sd: x ng/kg
	Result (ng/kg)	z'-score	Result (ng/kg)	z-score	Result (ng/kg)	z'-score	Result (ng/kg)	Result (ng/kg)
							NO STATISTICAL EVALUATION POSSIBLE	NO STATISTICAL EVALUATION POSSIBLE
PT7242	0.102	1.14	0.092	0.56	0.084	-0.24	0.044	0.176
PT7243	0.09	0.52	0.05	-1.77	0.08	-0.43	0.05	0.05
PT7244	0.07	-0.52	0.08	-0.10	0.11	1.01	0.025	0.1
PT7245	0.09	0.52	0.09	0.45	0.13	1.96		
PT7246	0.11	1.55	0.09	0.45	0.07	-0.91	0.05	0.1
PT7247								
PT7249								
PT7250	0.0493	-1.60	0.0625	-1.07	0.059	-1.44	0.05	0.15
PT7251	0.065	-0.78	0.067	-0.82	0.079	-0.48		0.04
PT7252	0.091	0.57	0.091	0.51	0.098	0.43	0.03	0.047
PT7253	0.06	-1.04	0.07	-0.66	0.1	0.53	0.008	0.04
PT7254	0.12	2.07	0.09	0.45	0.08	-0.43		
PT7255	0.051	-1.51	0.0656	-0.90	0.0471	-2.01	0.02	0.0232
PT7256	0.071	-0.47	0.07	-0.66	0.079	-0.48	0.003	0.032
PT7259								
PT7260								
PT7261	0.104	1.24	0.107	1.40	0.103	0.67	0.0089	0.0431
PT7262								
PT7264	0.066	-0.73	0.085	0.18	0.17	3.88	0.029	0.084
PT7265								
PT7266	0.07	-0.52	0.09	0.45	0.1	0.53	0.027	0.02

Lab code	1,2,3,4,7,8,9-HpCDF CV: 0.038 ng/kg Uncertainty: 0.012 ng/kg Target sd: x ng/kg Robust sd: x ng/kg Result (ng/kg)	1,2,3,4,6,7,8,9-OCDF CV: 0.053 ng/kg Uncertainty: 0.019 ng/kg Target sd: x ng/kg Robust sd: x ng/kg Result (ng/kg)
	NO STATISTICAL EVALUATION POSSIBLE	NO STATISTICAL EVALUATION POSSIBLE
PT7242	0.176	
PT7243	0.05	0.05
PT7244	0.025	0.1
PT7245		
PT7246	0.1	0.2
PT7247		
PT7249		
PT7250	0.15	2
PT7251		
PT7252	0.03	0.019
PT7253	0.009	0.015
PT7254		
PT7255	0.02	0.05
PT7256	0.0005	0.008
PT7259		
PT7260		
PT7261	0.0082	0.021
PT7262		
PT7264	0.055	0.066
PT7265		
PT7266	0.03	0.017

	WHO-PCB-TEQ ub CV: 0.70 ng TEQ/kg Uncertainty: 0.026 ng/kg Target sd: 0.15 ng/kg Robust sd: 0.081 ng/kg		WHO-PCB-TEQ mb CV: 0.70 ng TEQ/kg Uncertainty: 0.024 ng/kg Target sd: 0.15 ng/kg Robust sd: 0.069 ng/kg		WHO-PCB-TEQ lb CV: 0.68 ng TEQ/kg Uncertainty: 0.030 ng/kg Target sd: 0.15 ng/kg Robust sd: 0.090 ng/kg	
Lab code	**Result (ng/kg)**	**z-score**	**Result (ng/kg)**	**z-score**	**Result (ng/kg)**	**z-score**
PT7242	0.743	0.30	0.742	0.29	0.74	0.39
PT7243	1.1	2.63	1.1	2.63	1.1	2.79
PT7244	0.096	-3.92	0.069	-4.10	0.041	-4.27
PT7245	0.8	0.67				
PT7246	0.715	0.12	0.714	0.11	0.714	0.21
PT7247						
PT7249						
PT7250	0.4344	-1.71	0.4342	-1.71	0.4339	-1.65
PT7251	0.704	0.04	0.704	0.05	0.704	0.15
PT7252	0.719	0.14	0.719	0.14	0.719	0.25
PT7253	0.583	-0.74			0.583	-0.66
PT7254	0.584	-0.74	0.584	-0.74	0.584	-0.65
PT7255	0.676	-0.14	0.676	-0.14	0.676	-0.04
PT7256	0.66	-0.24	0.66	-0.24	0.66	-0.15
PT7259						
PT7260						
PT7261	0.6671	-0.20	0.6671	-0.19	0.6671	-0.10
PT7262						
PT7264	0.795	0.64	0.795	0.64	0.795	0.75
PT7265						
PT7266	0.745	0.31	0.744	0.31	0.744	0.41

	PCB 105 CV: 322 ng/kg Uncertainty: 21 ng/kg Target sd: 61 ng/kg Robust sd: 66 ng/kg		PCB 114 CV: 17 ng/kg Uncertainty: 2.1 ng/kg Target sd: 3.8 ng/kg Robust sd: 6.6 ng/kg		PCB 118 CV: 950 ng/kg Uncertainty: 62 ng/kg Target sd: 153 ng/kg Robust sd: 205 ng/kg		PCB 123 CV: 16 ng/kg Uncertainty: 2.5 ng/kg Target sd: 3.6 ng/kg Robust sd: 7.9 ng/kg		PCB 156 CV: 110 ng/kg Uncertainty: 7.0 ng/kg Target sd: 24 ng/kg Robust sd: 22 ng/kg	
Labcode	**Result (ng/kg)**	**z'-score**	**Result (ng/kg)**	**z'-score**	**Result (ng/kg)**	**z'-score**	**Result (ng/kg)**	**z'-score**	**Result (ng/kg)**	**z-score**
PT7242	318.74	-0.05	15.9	-0.32	940.72	-0.05	18.44	0.51	113.78	0.17
PT7243	420	1.52	22	1.08	1400	2.73	1500	342	130	0.84
PT7244	283.31	-0.60	15.03	-0.53	868.11	-0.49	10.2	-1.38	98.14	-0.48
PT7245	341.1	0.30	19.5	0.51	1013.7	0.39	14.1	-0.48	115.2	0.22
PT7246	410	1.37	22	1.08	1400	2.73	29	2.95	150	1.67
PT7247					797	-0.92				
PT7249										
PT7250	198.7	-1.91	8.8	-1.96	483.5	-2.82	75.72	13.7	68.47	-1.71
PT7251	331.94	0.16	10.638	-1.54	884.521	-0.39	12.667	-0.81	110.331	0.02
PT7252	347	0.39	18	0.16	995	0.27	10	-1.43	110	0.01
PT7253	242	-1.24	10.8	-1.50	731	-1.32	20	0.87	84.9	-1.03
PT7254	255.32	-1.03	23.87	1.51	801.22	-0.90	9.87	-1.46	91.79	-0.74
PT7255	1270	14.7	80.9	14.7	8080	43.2	0.1	-3.71	439.5	13.7
PT7256	283	-0.60	12.4	-1.13	834	-0.70	9.74	-1.49	103	-0.28
PT7259										
PT7260	3000	41.5	3000	688	3000	12.4	3000	687	3000	120
PT7261	302.11	-0.31	16.99	-0.07	941.13	-0.05	14.97	-0.28	108.59	-0.05
PT7262										
PT7264	278.9	-0.66	12.06	-1.21	813	-0.83	123.4	24.7	91.78	-0.75
PT7265										
PT7266	320	-0.03	15	-0.53	994	0.27	11	-1.20	100	-0.40

	PCB 157 CV: 32 ng/kg Uncertainty: 2.0 ng/kg Target sd: 6.9 ng/kg Robust sd: 6.3 ng/kg		PCB 167 CV: 76 ng/kg Uncertainty: 6.3 ng/kg Target sd: 17 ng/kg Robust sd: 20 ng/kg		PCB 189 CV: 12 ng/kg Uncertainty: 0.89 ng/kg Target sd: 2.7 ng/kg Robust sd: 2.8 ng/kg		PCB 77 CV: 17 ng/kg Uncertainty: 1.6 ng/kg Target sd: 3.8 ng/kg Robust sd: 5.0 ng/kg		PCB 81 CV: 0.92 ng/kg Uncertainty: 0.16 ng/kg Target sd: x ng/kg Robust sd: x ng/kg
Lab code	**Result (ng/kg)**	**z-score**	**Result (ng/kg)**	**z'-score**	**Result (ng/kg)**	**z'-score**	**Result (ng/kg)**	**z'-score**	**Result (ng/kg)**
									NO STATISTICAL EVALUATION POSSIBLE
PT7242	31.63	0.01	76.37	0.04	12.58	0.16	20.59	0.75	8.8
PT7243	130	14.2	92	0.92	14	0.66	27	2.30	0.87
PT7244	27.54	-0.58	53.34	-1.25	10.04	-0.74	1	-3.97	1
PT7245	33.6	0.30	73.4	-0.13	14.6	0.88	17.3	-0.04	
PT7246	44	1.79	93	0.98	18	2.09	20	0.61	2
PT7247									
PT7249									
PT7250	20.09	-1.65	45.15	-1.71	7.432	-1.67	11.13	-1.53	1
PT7251	29.433	-0.30	72.9	-0.15	11.693	-0.16	17.11	-0.08	0.585
PT7252	33	0.21	73	-0.15	12	-0.05	22	1.10	0.64
PT7253	24.5	-1.02	195	6.71	9.46	-0.95	12.8	-1.13	0.44
PT7254	28.57	-0.43	66.78	-0.50	9.98	-0.77	20.66	0.77	0.86
PT7255	135.5	15.0	309.5	13.2	44.45	11.5	10.7	-1.63	0.254
PT7256	27.5	-0.58	66.4	-0.52	10.9	-0.44	15.5	-0.47	0.56
PT7259									
PT7260	3000	428	3000	164	3000	1062	3000	720	3000
PT7261	30.92	-0.09	73.21	-0.14	12.32	0.07	18.1	0.15	0.94
PT7262									
PT7264	25.44	-0.88	54.32	-1.20	9.987	-0.76	15.49	-0.48	6.677
PT7265									
PT7266	32	0.07	66	-0.54	11	-0.40	18	0.13	0.53

	PCB 126 CV: 5.8 ng/kg Uncertainty: 0.49 ng/kg Target sd: 1.3 ng/kg Robust sd: 1.6 ng/kg		PCB 169 CV: 1.9 ng/kg Uncertainty: 0.13 ng/kg Target sd: 0.42 ng/kg Robust sd: 0.42 ng/kg	
Lab code	**Result (ng/kg)**	**z'-score**	**Result (ng/kg)**	**z'-score**
PT7242	6.29	0.35	2.11	0.48
PT7243	9	2.33	2.6	1.60
PT7244	0.25	-4.06	1	-2.06
PT7245	7.12	0.95	2.32	0.96
PT7246	5.8	-0.01	2.1	0.45
PT7247				
PT7249				
PT7250	3.641	-1.59	1.392	-1.16
PT7251	5.995	0.13	1.941	0.09
PT7252	6.1	0.21	2	0.23
PT7253	4.93	-0.65	1.63	-0.62
PT7254	4.88	-0.68	1.84	-0.14
PT7255	3.27	-1.86	1.245	-1.50
PT7256	5.62	-0.14	1.86	-0.09
PT7259				
PT7260	3000	2186	3000	6843
PT7261	5.65	-0.12	1.84	-0.14
PT7262				
PT7264	7.002	0.87	1.634	-0.61
PT7265				
PT7266	6.3	0.35	2.15	0.57

	Sum ndl-PCB ub CV: 6.7 µg/kg Uncertainty: 0.44 µg/kg Target sd: 1.5 µg/kg Robust sd: 1.6 µg/kg		Sum ndl-PCB mb CV: 6.6 µg/kg Uncertainty: 0.44 µg/kg Target sd: 1.5 µg/kg Robust sd: 1.4 µg/kg		Sum ndl-PCB lb CV: 6.4 µg/kg Uncertainty: 0.30 µg/kg Target sd: 1.4 µg/kg Robust sd: 1.0 µg/kg	
Lab code	**Result (ng/kg)**	**z'-score**	**Result (ng/kg)**	**z-score**	**Result (ng/kg)**	**z-score**
PT7242	6.99	0.21	6.99	0.24	6.99	0.41
PT7243	6.7	0.01	6.7	0.05	6.7	0.21
PT7244	5.051	-1.11				
PT7245	7.7	0.69				
PT7246	6.6	-0.05	6.6	-0.01	6.6	0.14
PT7247	5.11	-1.07			4.14	-1.61
PT7249	5.31	-0.93	5.31	-0.86	5.31	-0.78
PT7250	5.089	-1.08	4.429	-1.44	3.769	-1.87
PT7251	5.992	-0.47	5.992	-0.41	5.992	-0.29
PT7252	7.57	0.61	7.57	0.63	7.57	0.83
PT7253	6.83	0.10			6.83	0.30
PT7254	6.04	-0.44	6.04	-0.38	6.04	-0.26
PT7255	2130	1445	2130	1396	2130	1507
PT7256	4.98	-1.16	4.98	-1.08	4.98	-1.01
PT7259	9.12	1.66	7.62	0.66	6.12	-0.20
PT7260	10	2.26	10	2.22	10	2.55
PT7261	6.51	-0.12	6.51	-0.07	6.51	0.07
PT7262						
PT7264	5.314	-0.93	5.314	-0.86	5.314	-0.78
PT7265	8.18	1.02	7.68	0.70	7.18	0.55
PT7266	6.68	0.00	6.68	0.04	6.68	0.19

	PCB 28 CV: 0.25 µg/kg Uncertainty: 0.019 µg/kg Target sd: 0.056 µg/kg Robust sd: 0.068 µg/kg		PCB 52 CV: 0.38 µg/kg Uncertainty: 0.028 µg/kg Target sd: 0.084 µg/kg Robust sd: 0.10 µg/kg		PCB 101 CV: 0.88 µg/kg Uncertainty: 0.050 µg/kg Target sd: 0.19 µg/kg Robust sd: 0.18 µg/kg		PCB 138 CV: 1.7 µg/kg Uncertainty: 0.098 µg/kg Target sd: 0.38 µg/kg Robust sd: 0.36 µg/kg		PCB 153 CV: 2.5 µg/kg Uncertainty: 0.16 µg/kg Target sd: 0.56 µg/kg Robust sd: 0.58 µg/kg	
Lab code	**Result (ng/kg)**	**z'-score**	**Result (ng/kg)**	**z'-score**	**Result (ng/kg)**	**z-score**	**Result (ng/kg)**	**z-score**	**Result (ng/kg)**	**z'-score**
PT7242	0.3	0.79	0.36	-0.26	1.01	0.67	1.78	0.14	2.78	0.41
PT7243	0.24	-0.23	0.31	-0.82	0.9	0.10	2.1	0.99	2.6	0.09
PT7244	0.2	-0.91	0.32	-0.71	0.64	-1.24	1.29	-1.15	2.09	-0.82
PT7245					1.04	0.83	1.9	0.46	2.85	0.54
PT7246	0.3	0.79	0.38	-0.03	0.98	0.52	1.7	-0.07	2.9	0.63
PT7247	0.21	-0.74	0.31	-0.82	0.67	-1.08	1.32	-1.07	1.87	-1.21
PT7249	0.2	-0.91	0.3	-0.93	0.8	-0.41	1.4	-0.86	2.08	-0.83
PT7250	0.1335	-2.04	0.2272	-1.75	0.6014	-1.44	1.4603	-0.70	1.9399	-1.08
PT7251	0.211	-0.72	0.334	-0.55	0.862	-0.09	1.555	-0.45	2.498	-0.09
PT7252	0.24	-0.23	0.38	-0.03	1	0.62	1.7	-0.07	2.7	0.27
PT7253	0.25	-0.06	0.48	1.10	1.07	0.98	1.57	-0.41	2.79	0.43
PT7254	0.19	-1.08	0.5	1.32	0.86	-0.10	1.49	-0.62	2.43	-0.21
PT7255	51.9	877	62.85	704	221	1137	527	1384	771.5	1372
PT7256	0.18	-1.25	0.29	-1.04	0.73	-0.78	1.32	-1.07	1.95	-1.07
PT7259	0.5	4.19	2.04	18.7	0.5	-1.96	2.52	2.09	1.56	-1.76
PT7260	3	46.6	3	29.5	3	11.0	3	3.36	10	13.3
PT7261	0.25	-0.06	0.37	-0.14	0.9	0.10	1.84	0.30	2.46	-0.16
PT7262	0.278	0.42	0.385	0.030	0.477	-2.08	1.851	0.33	3.14	1.06
PT7264	0.225	-0.48	0.302	-0.91	0.817	-0.33	1.472	-0.67	2.054	-0.88
PT7265	0.5	4.19	0.5	1.32	0.99	0.57	2.49	2.01	3.06	0.91
PT7266	0.27	0.28	0.37	-0.14	0.93	0.26	1.71	-0.04	2.81	0.47

	PCB 180 CV: 0.61 µg/kg Uncertainty: 0.042 µg/kg Target sd: 0.13 µg/kg Robust sd: 0.15 µg/kg	
Lab code	**Result (ng/kg)**	**z'-score**
PT7242	0.77	1.13
PT7243	0.57	-0.29
PT7244	0.51	-0.72
PT7245	0.85	1.70
PT7246	0.74	0.92
PT7247	0.42	-1.35
PT7249	0.55	-0.43
PT7250	0.4884	-0.87
PT7251	0.532	-0.56
PT7252	0.68	0.49
PT7253	0.67	0.42
PT7254	0.32	-2.07
PT7255	494.5	3509
PT7256	0.51	-0.72
PT7259	0.5	-0.79
PT7260	3	17.0
PT7261	0.69	0.56
PT7262	0.732	0.86
PT7264	0.445	-1.18
PT7265	0.62	0.07
PT7266	0.59	-0.15

Annex 9 Graphical representations of the z-scores of dioxins and n(dl)-PCBs

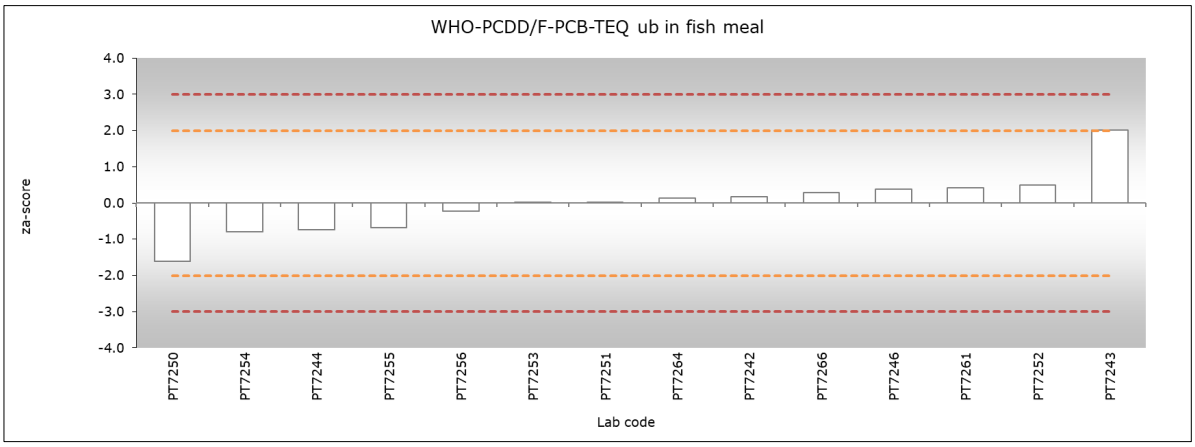

Figure 1 *Graphical representation of the z-scores for WHO-PCDD/F-PCB-TEQ ub in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

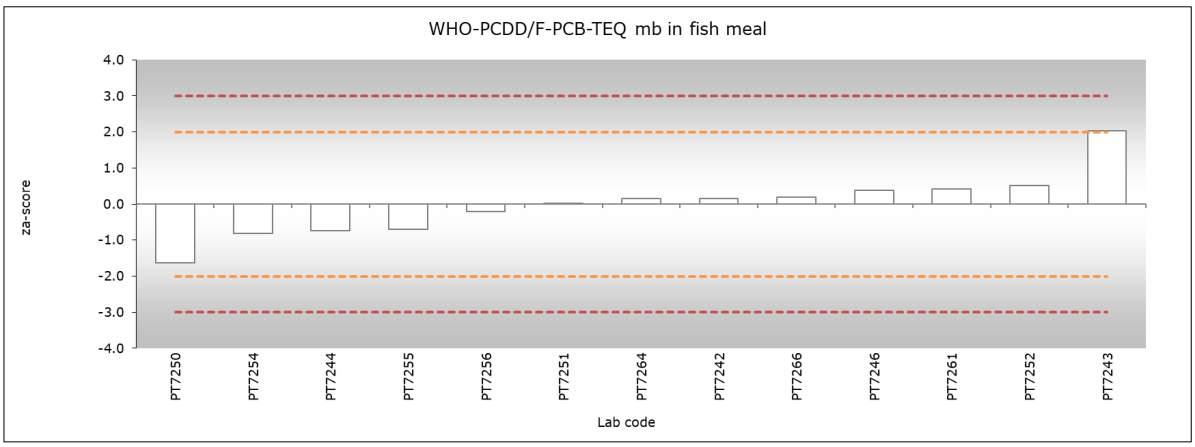

Figure 2 *Graphical representation of the z-scores for WHO-PCDD/F-PCB-TEQ mb in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

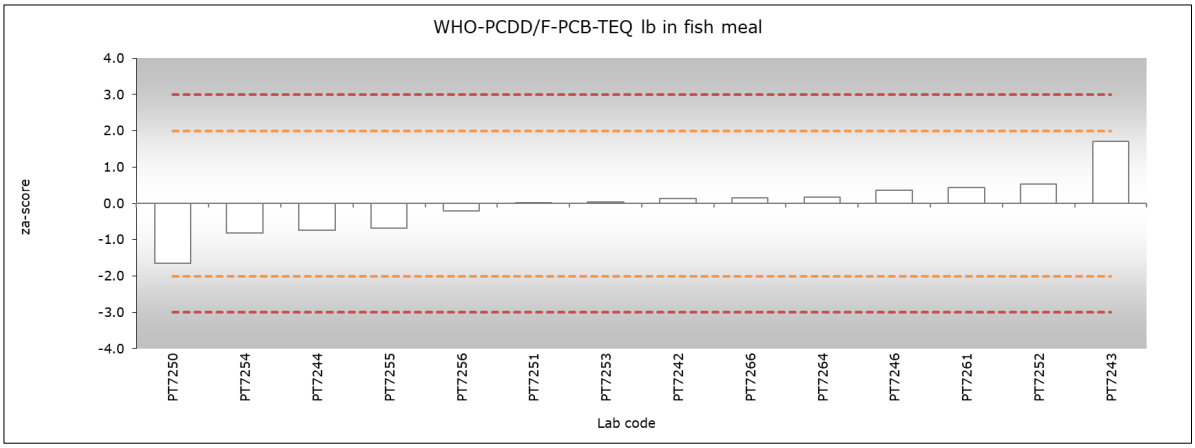

Figure 3 *Graphical representation of the z-scores for WHO-PCDD/F-PCB-TEQ lb in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

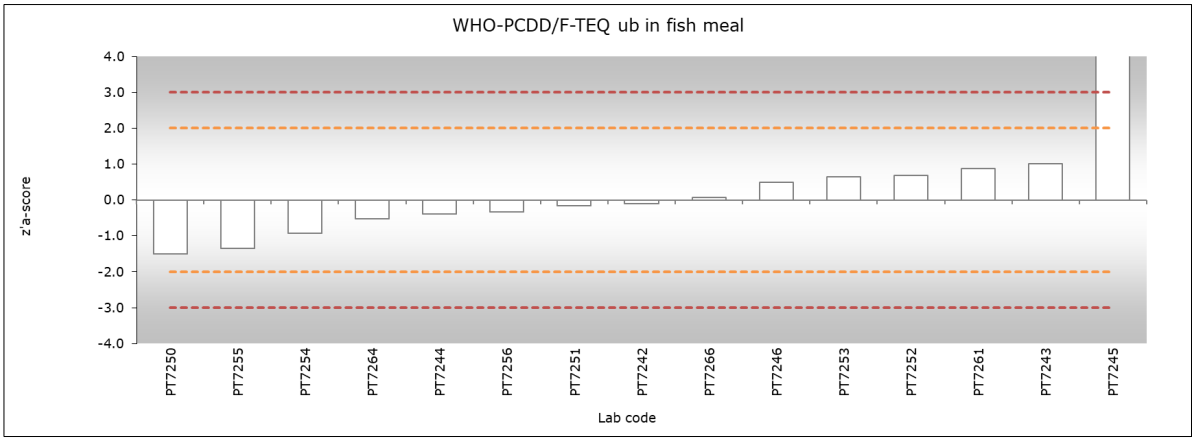

Figure 4 *Graphical representation of the z'-scores for WHO-PCDD/F-TEQ ub in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

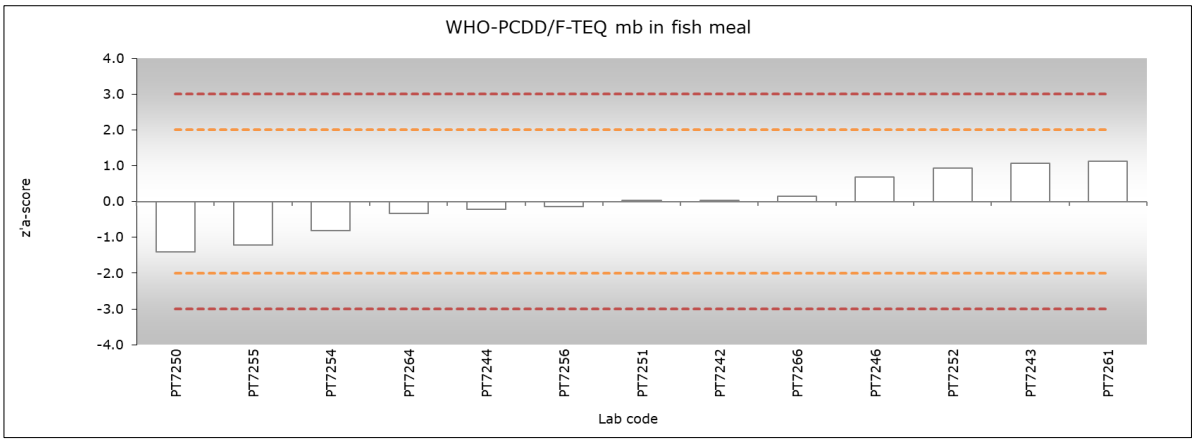

Figure 5 *Graphical representation of the z'-scores for WHO-PCDD/F-TEQ mb in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

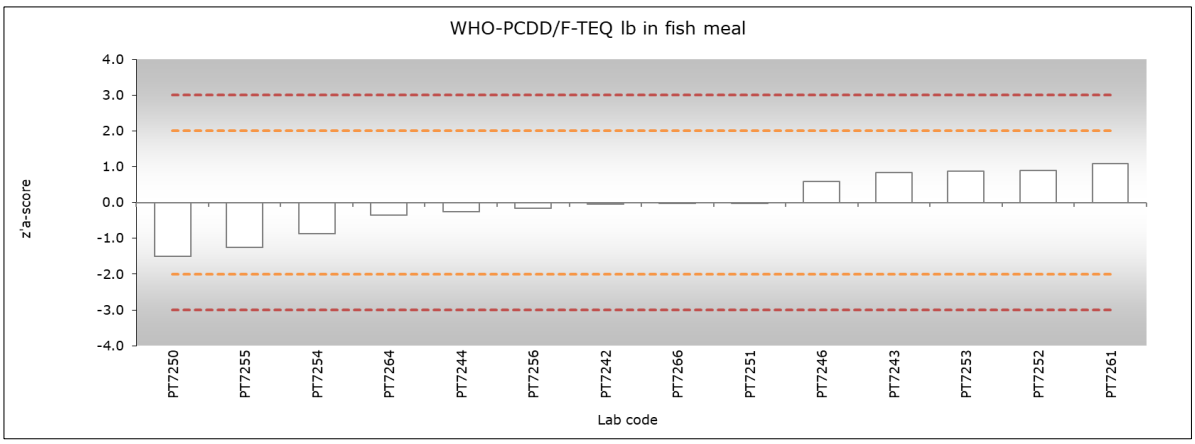

Figure 6 *Graphical representation of the z'-scores for WHO-PCDD/F-TEQ lb in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

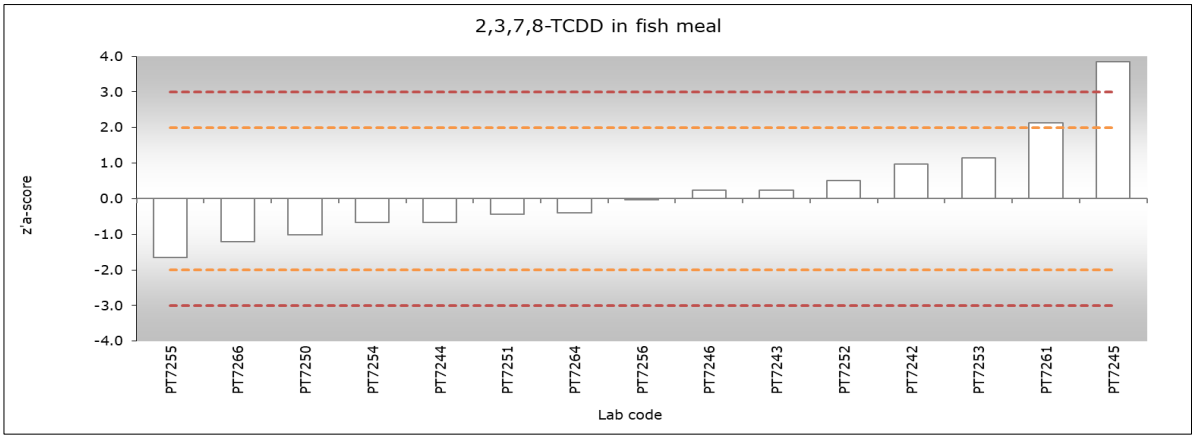

Figure 7 *Graphical representation of the z'-scores for 2,3,7,8-TCDD in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

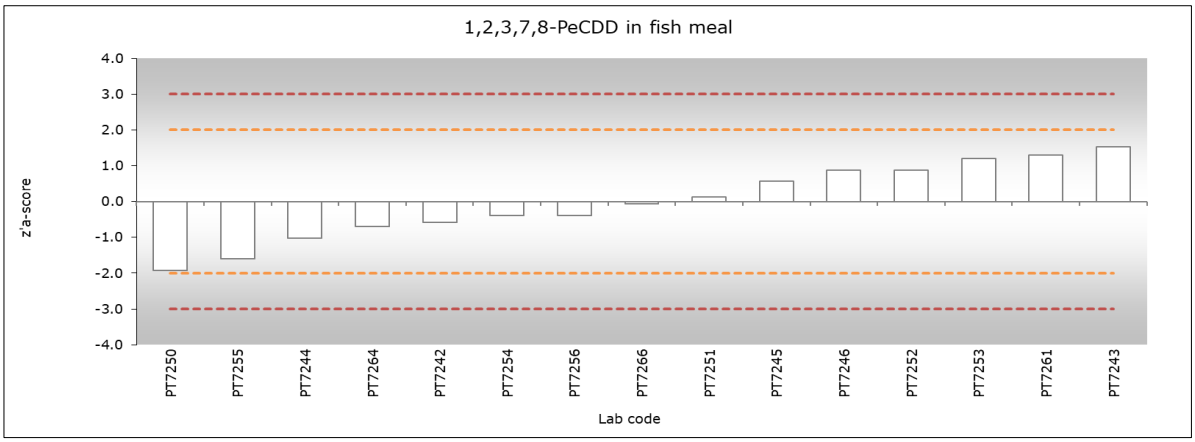

Figure 8 *Graphical representation of the z'-scores for 1,2,3,7,8-PeCDD in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

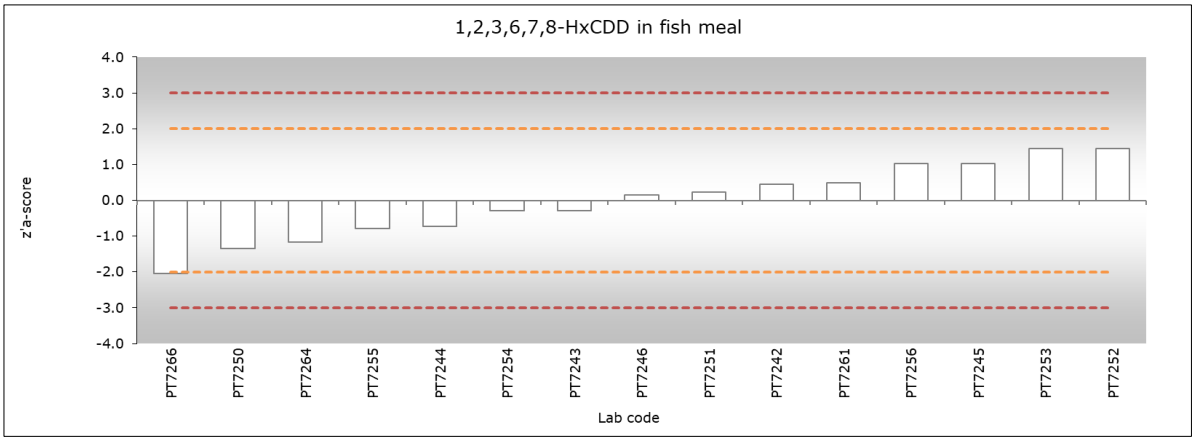

Figure 9 *Graphical representation of the z'-scores for 1,2,3,6,7,8-HxCDD in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

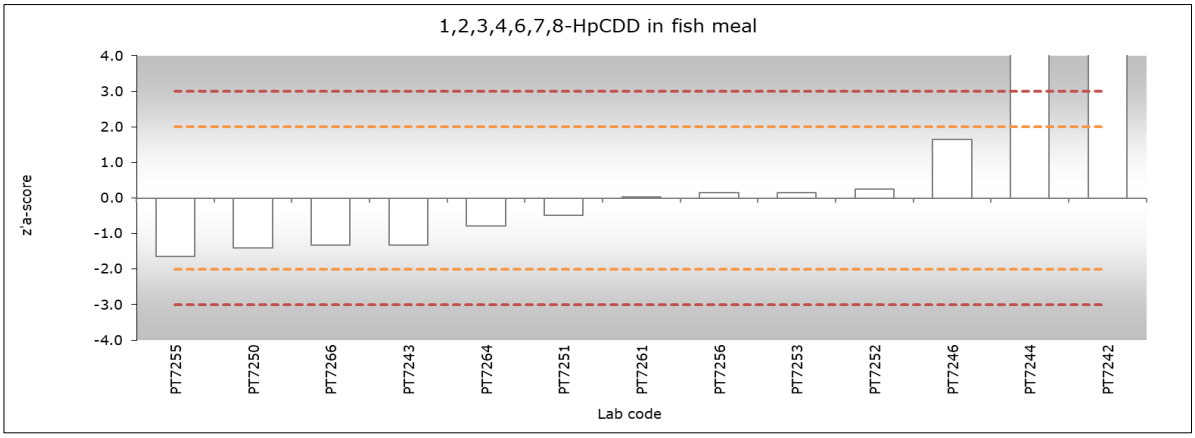

Figure 10 *Graphical representation of the z'-scores for 1,2,3,4,6,7,8-HpCDD in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

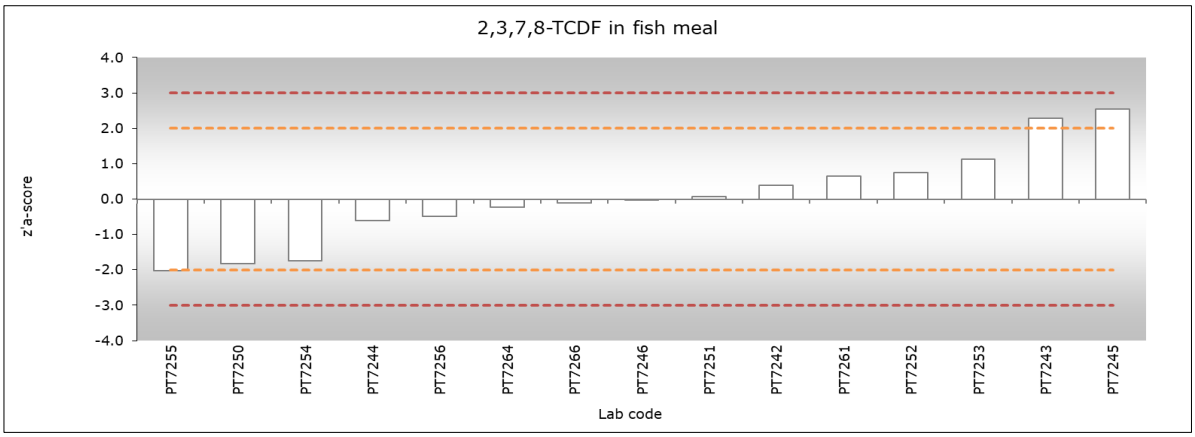

Figure 11 *Graphical representation of the z'-scores for 2,3,7,8-TCDF in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

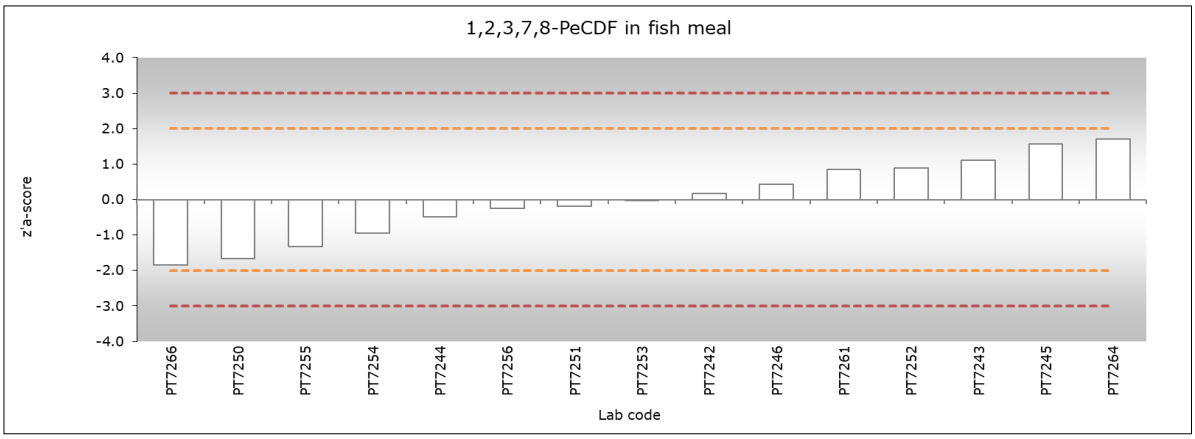

Figure 12 *Graphical representation of the z'-scores for 1,2,3,7,8-PeCDF in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

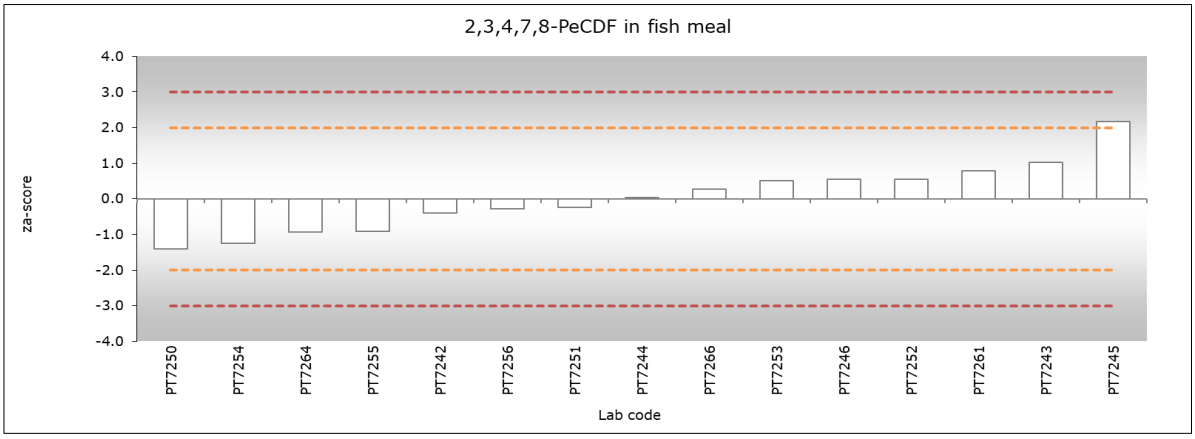

Figure 13 *Graphical representation of the z-scores for 2,3,4,7,8-PeCDF in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

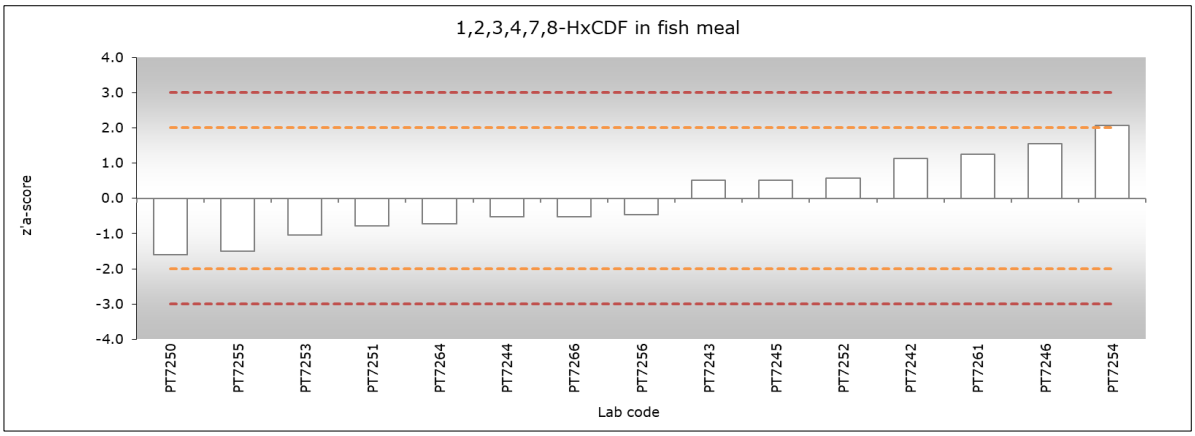

Figure 14 *Graphical representation of the z'-scores for 1,2,3,4,7,8-HxCDF in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

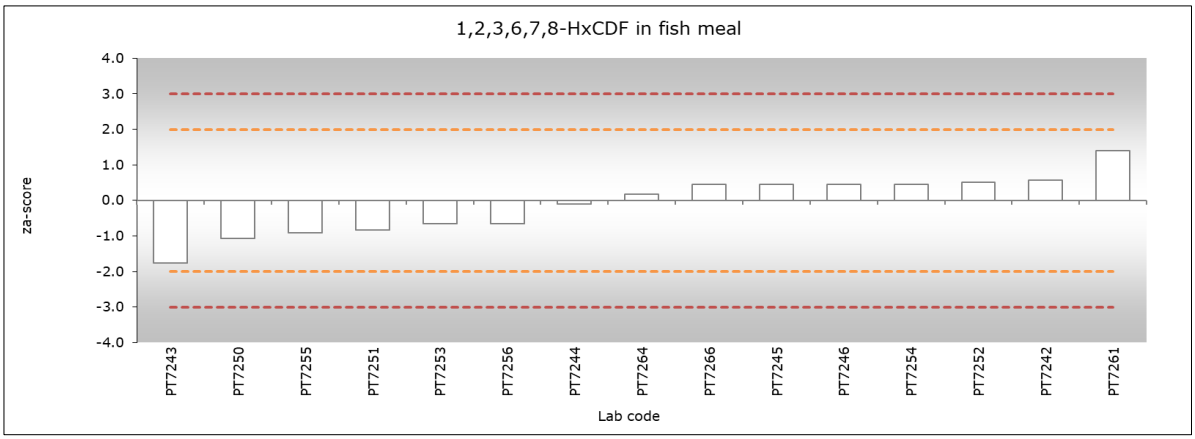

Figure 15 *Graphical representation of the z-scores for 1,2,3,6,7,8-HxCDF in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

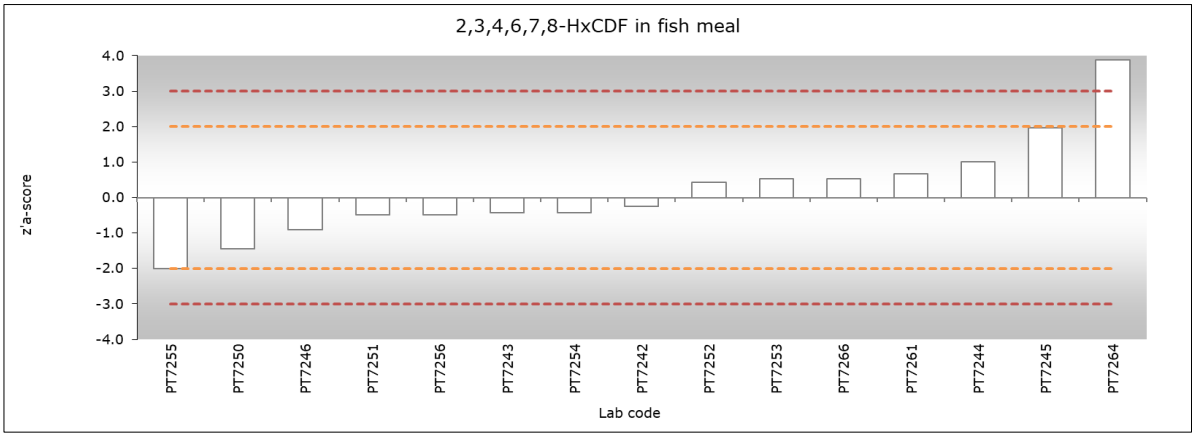

Figure 16 *Graphical representation of the z'-scores for 2,3,4,6,7,8-HxCDF in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

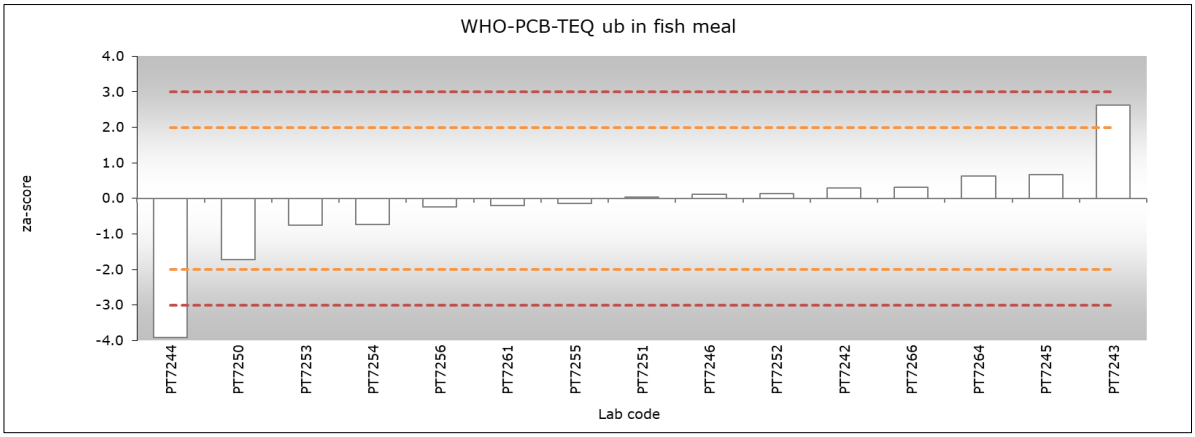

Figure 17 *Graphical representation of the z-scores for WHO-PCB-TEQ ub in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

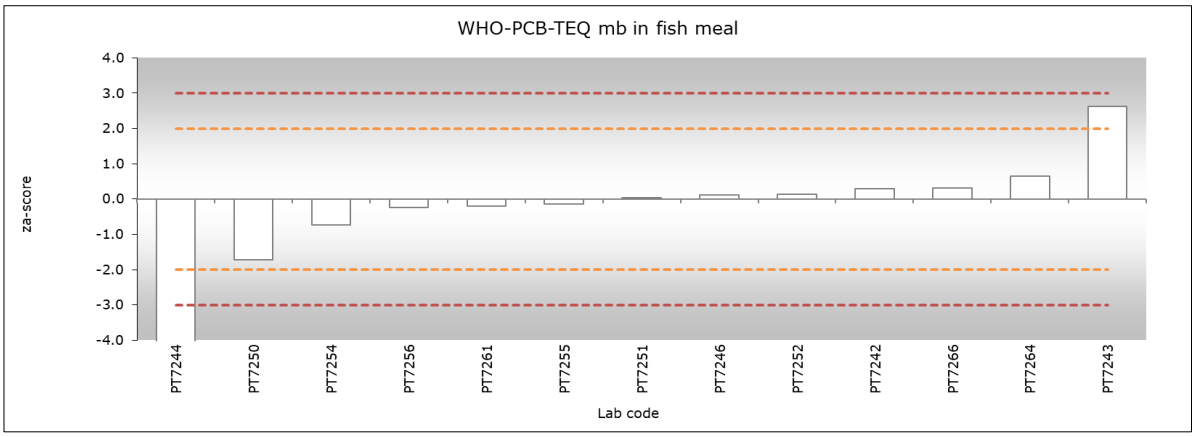

Figure 18 *Graphical representation of the z-scores for WHO-PCB-TEQ mb in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

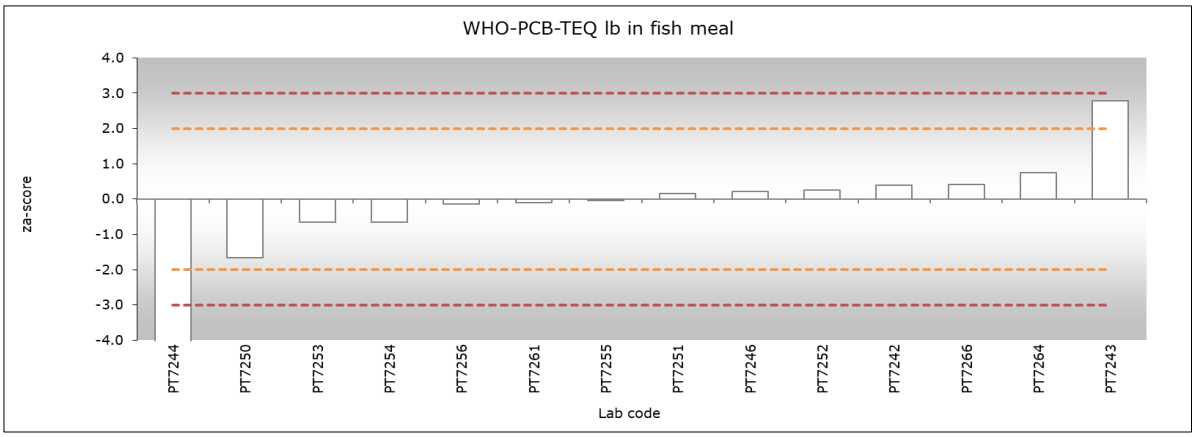

Figure 19 *Graphical representation of the z-scores for WHO-PCB-TEQ lb in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

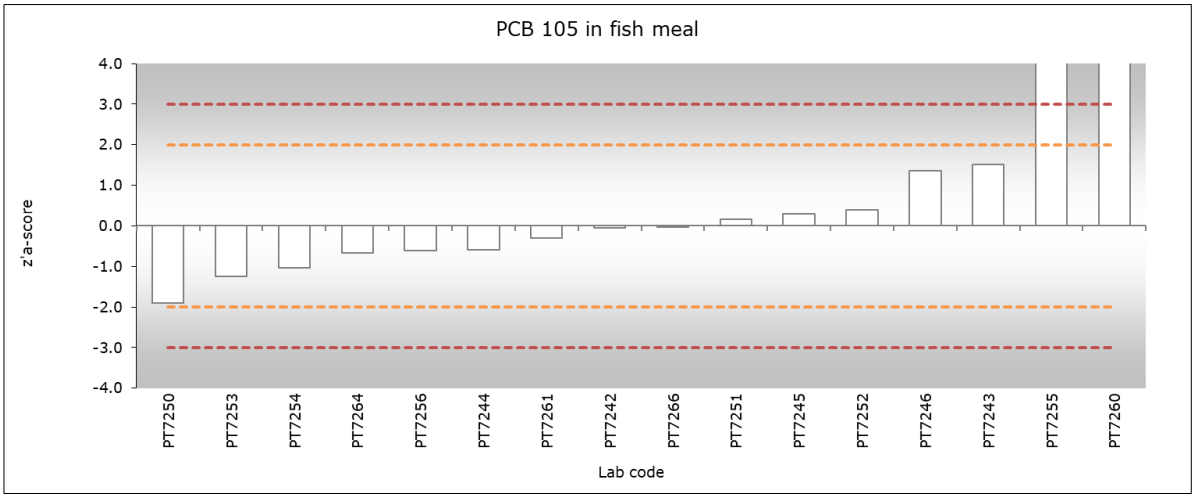

Figure 20 *Graphical representation of the z'-scores for PCB 105 in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

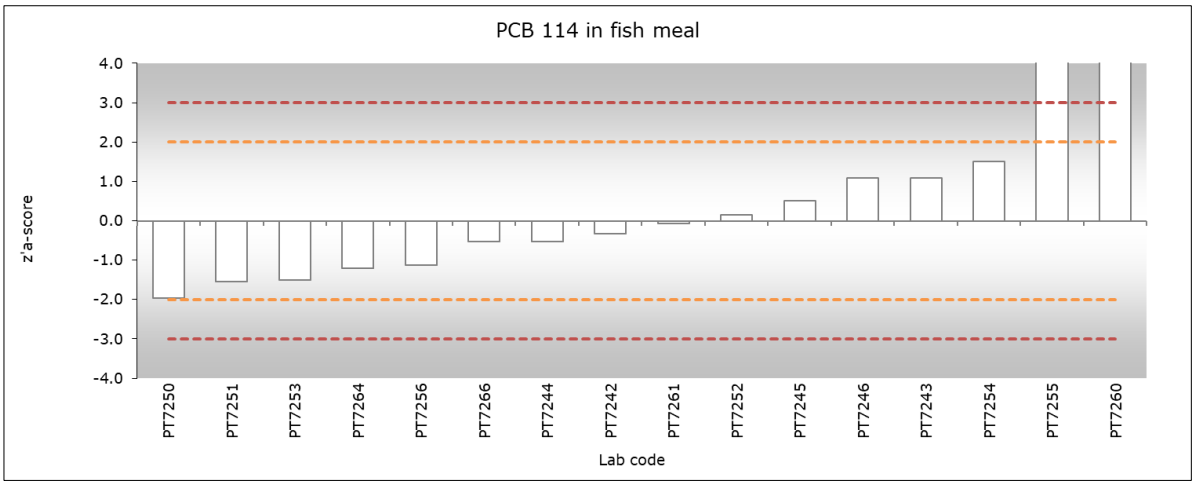

Figure 21 *Graphical representation of the z'-scores for PCB 114 in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

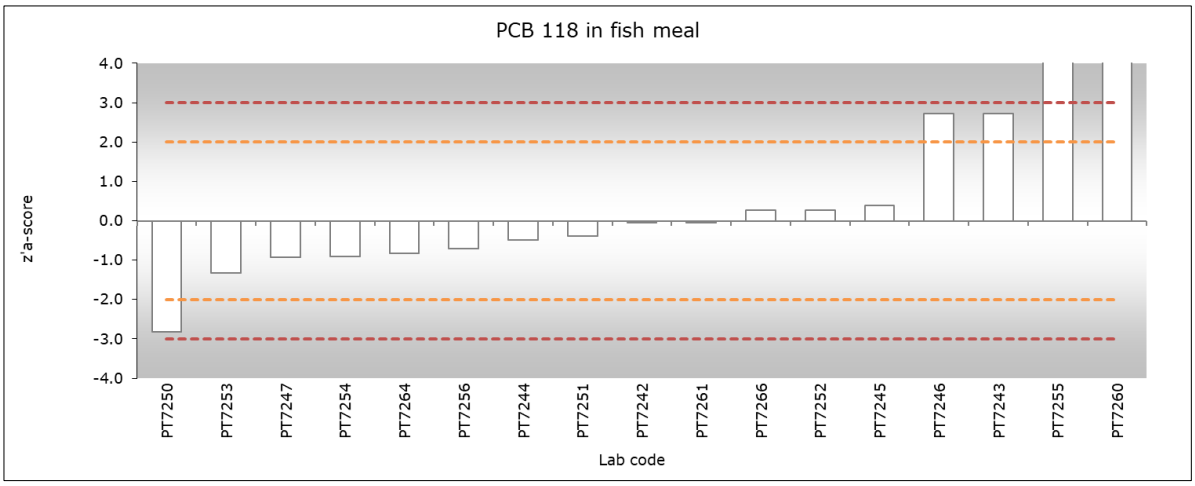

Figure 22 *Graphical representation of the z'-scores for PCB 118 in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

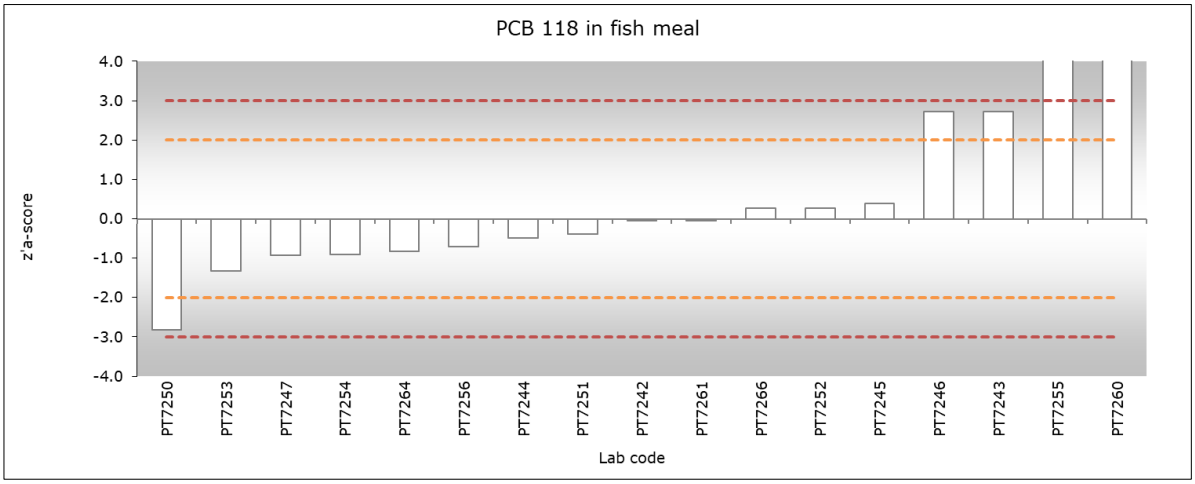

Figure 23 *Graphical representation of the z'-scores for PCB 123 in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

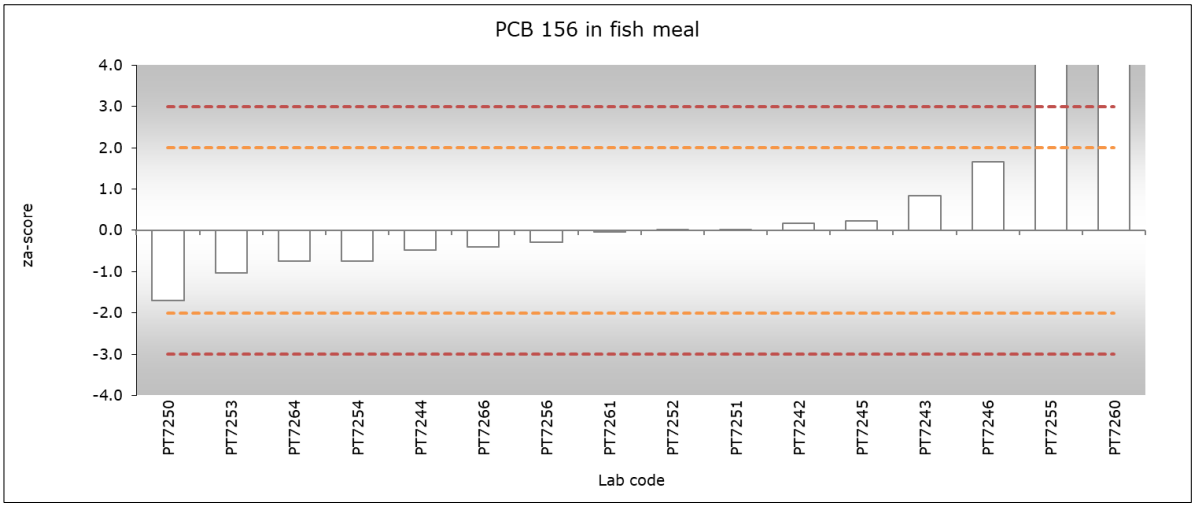

Figure 24 *Graphical representation of the z-scores for PCB 156 in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

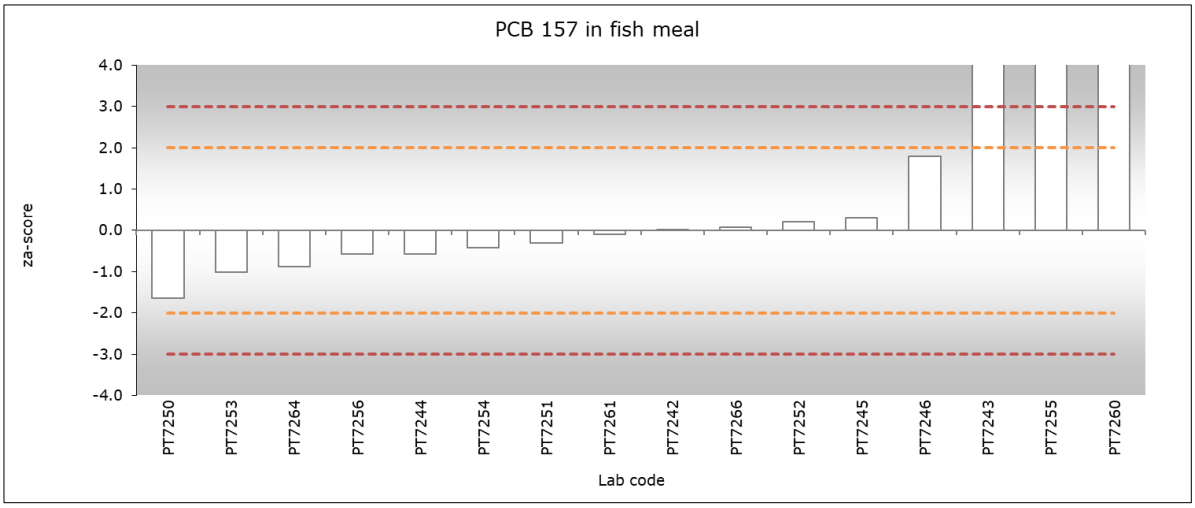

Figure 25 *Graphical representation of the z-scores for PCB 157 in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

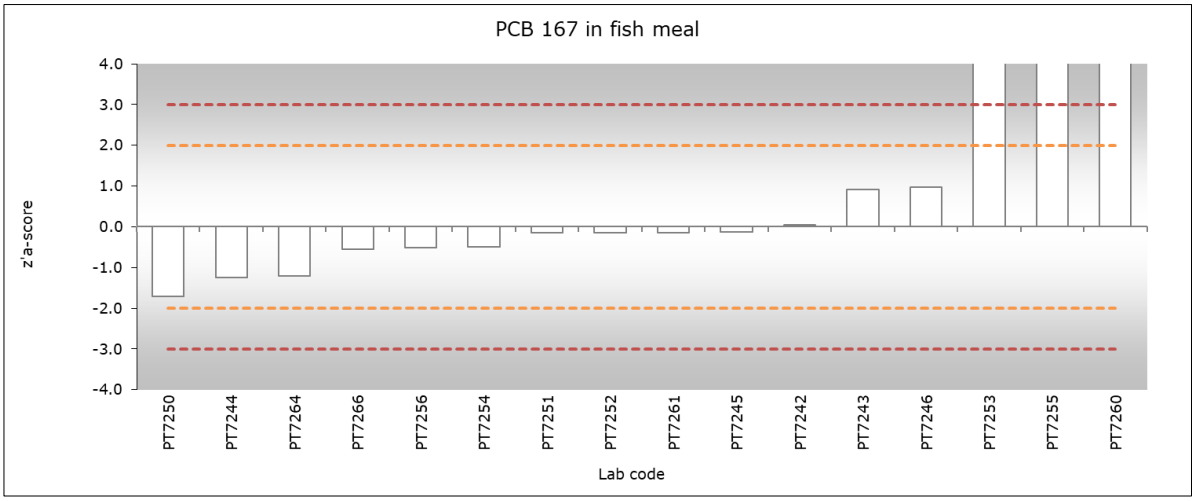

Figure 26 *Graphical representation of the z'-scores for PCB 167 in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

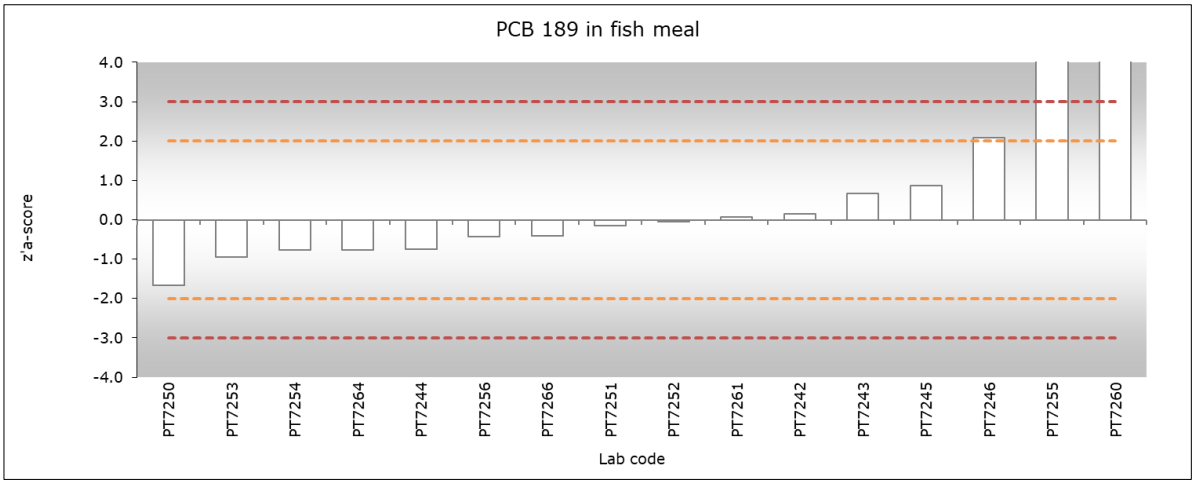

Figure 27 *Graphical representation of the z'-scores for PCB 189 in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

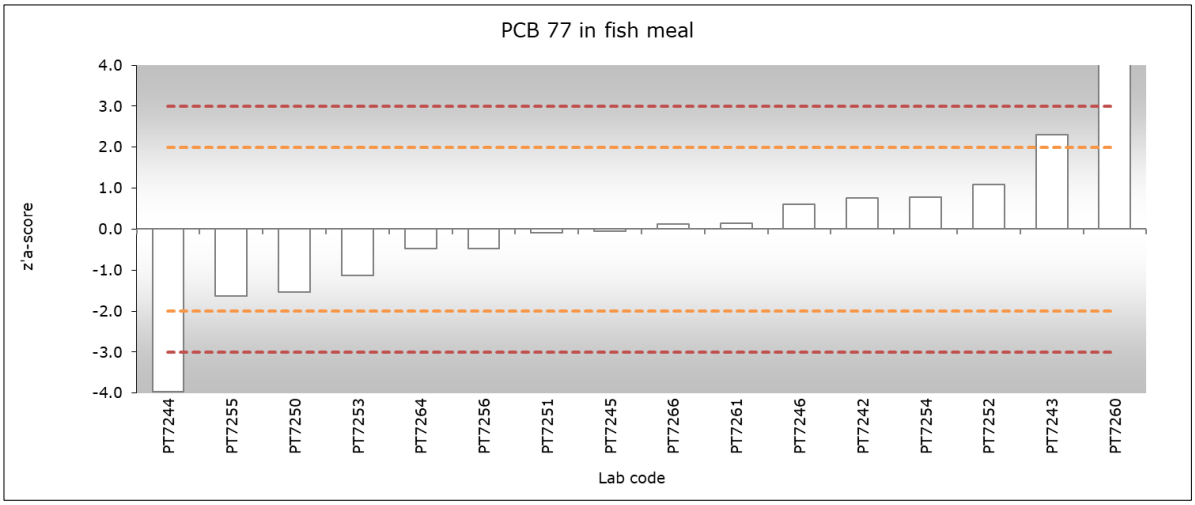

Figure 28 *Graphical representation of the z'-scores for PCB 77 in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

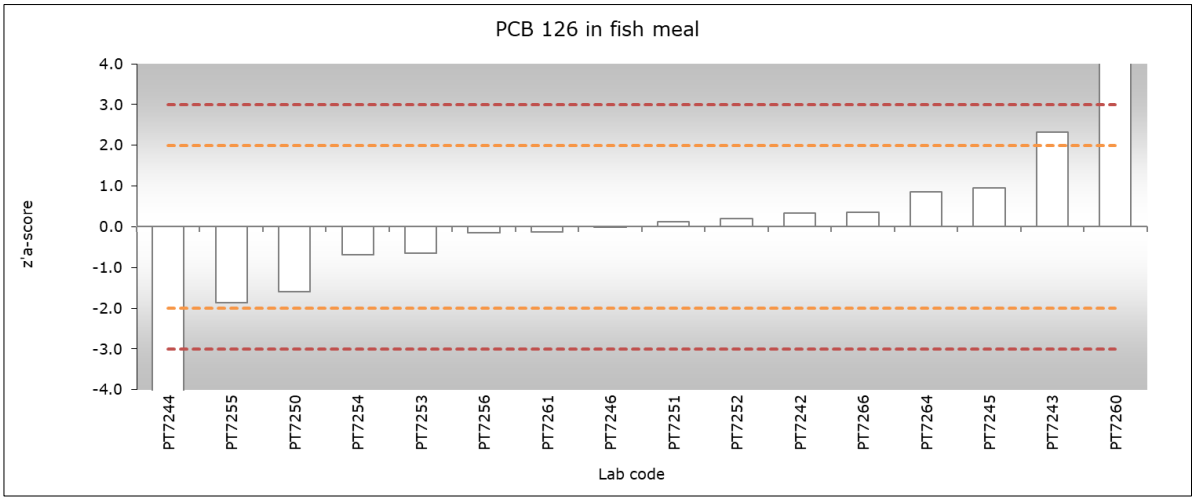

Figure 29 *Graphical representation of the z'-scores for PCB 126 in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

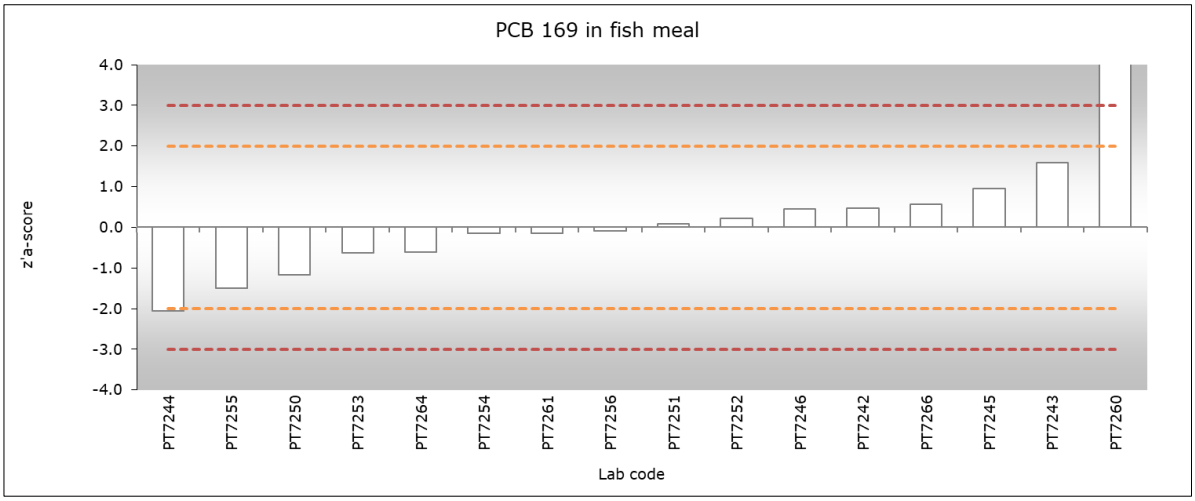

Figure 30 *Graphical representation of the z'-scores for PCB 169 in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in ng/kg).*

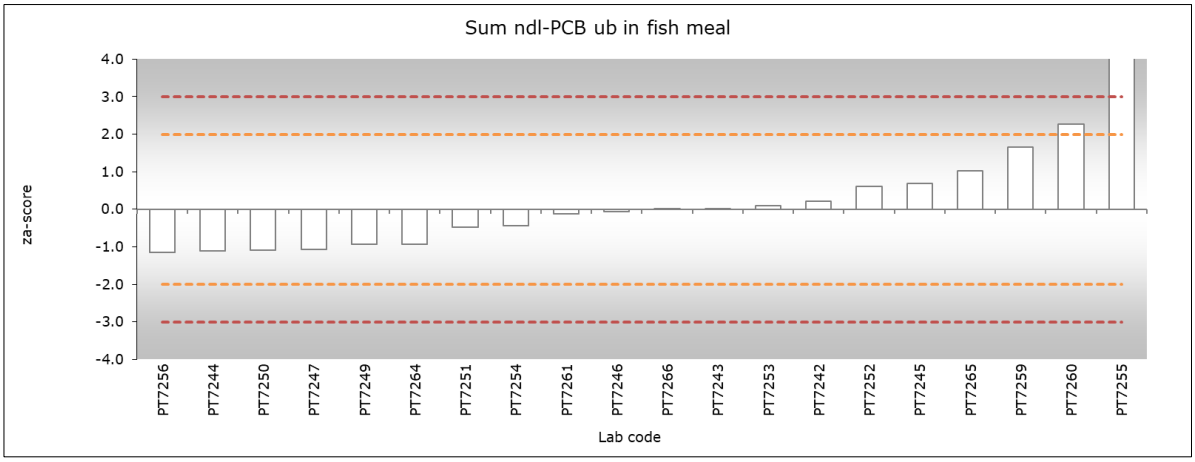

Figure 31 *Graphical representation of the z-scores for sum ndl-PCB ub in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in µg/kg).*

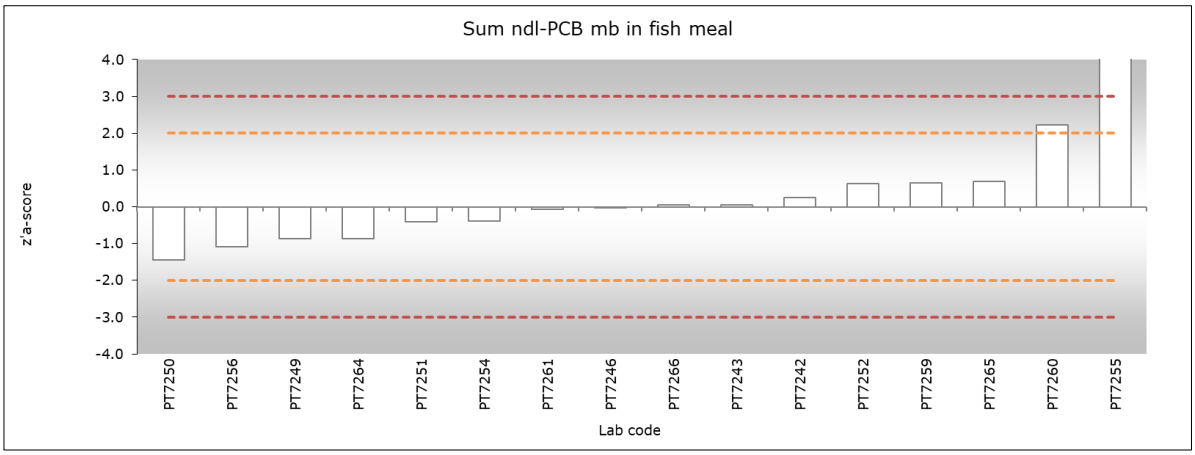

Figure 32 *Graphical representation of the z'-scores for sum ndl-PCB mb in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in µg/kg).*

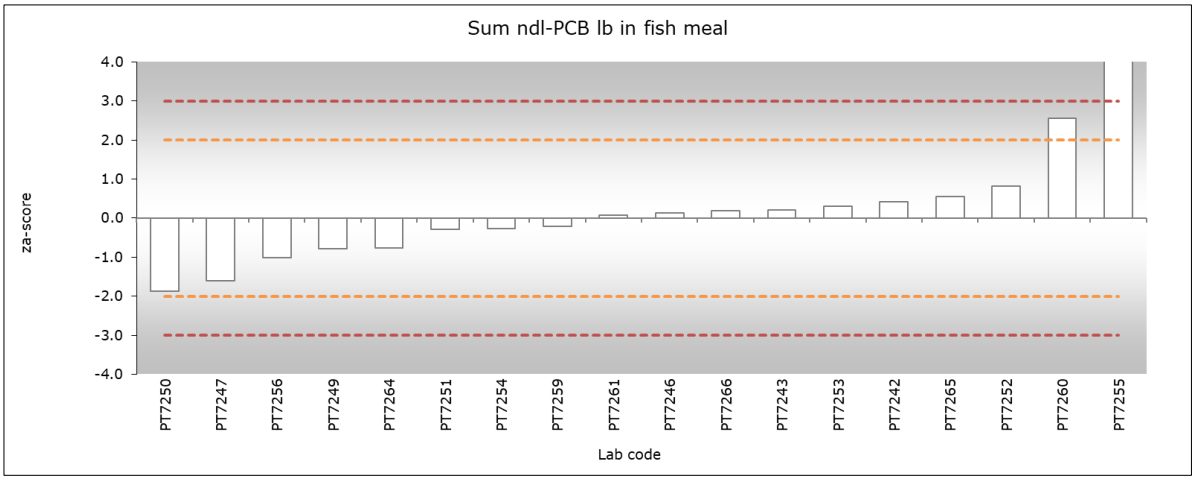

Figure 33 *Graphical representation of the z-scores for sum ndl-PCB lb in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in µg/kg).*

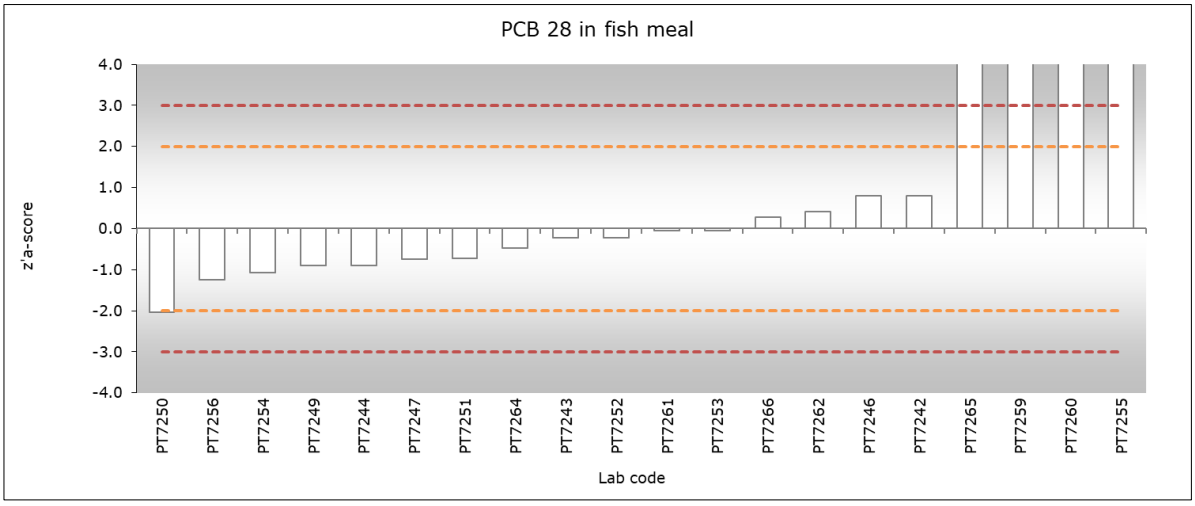

Figure 34 *Graphical representation of the z'-scores for PCB 28 in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in µg/kg).*

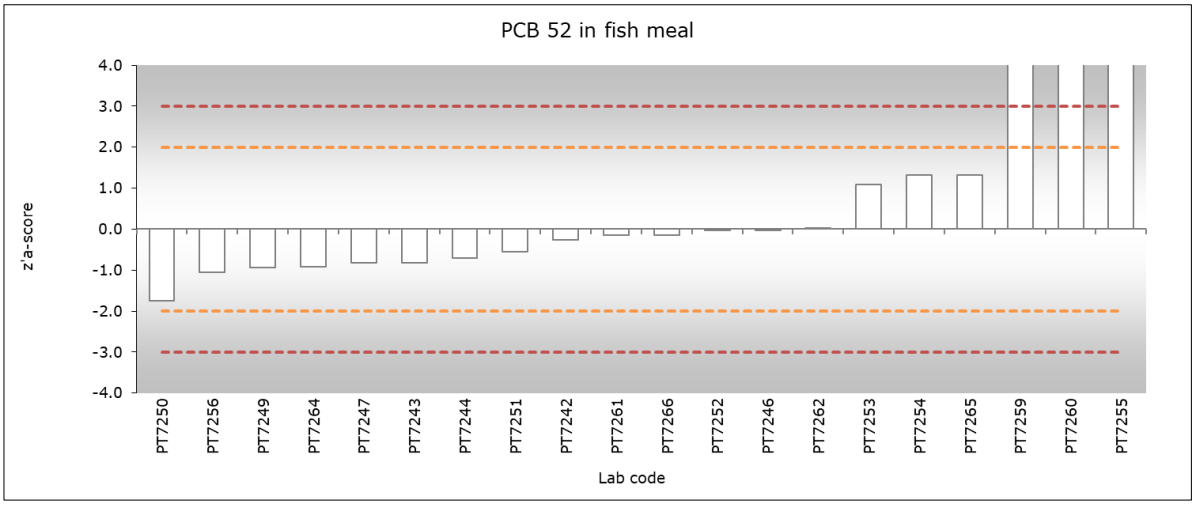

Figure 35 *Graphical representation of the z'-scores for PCB 52 in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in µg/kg).*

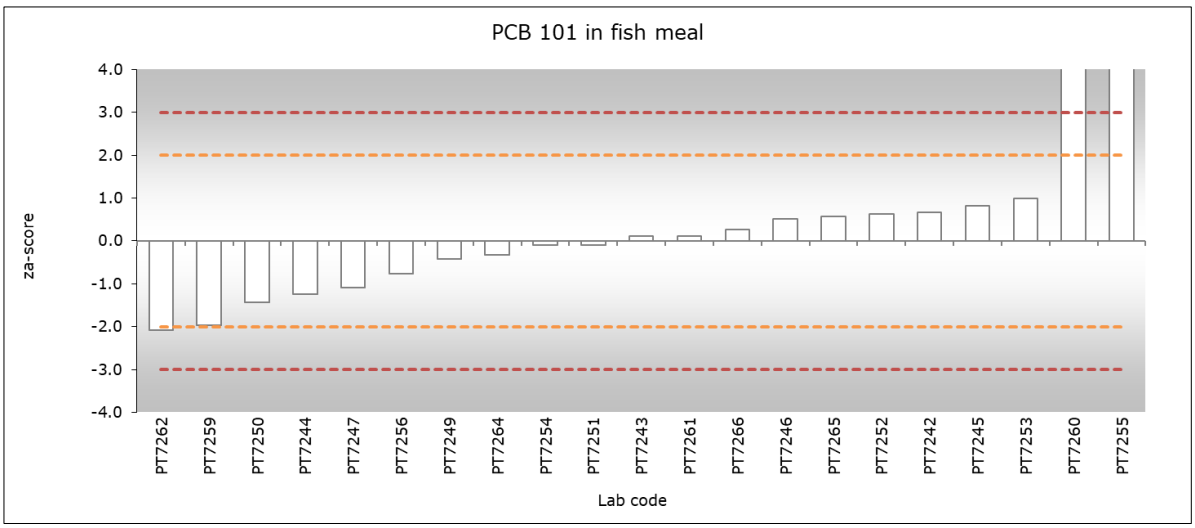

Figure 36 *Graphical representation of the z-scores for PCB 101 in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in µg/kg).*

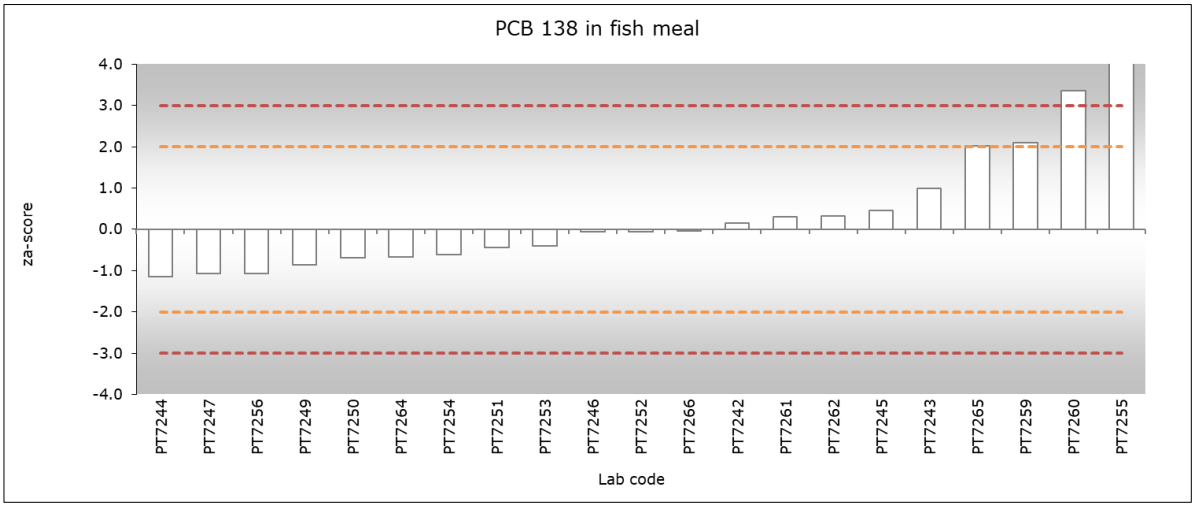

Figure 37 *Graphical representation of the z-scores for PCB 138 in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in µg/kg).*

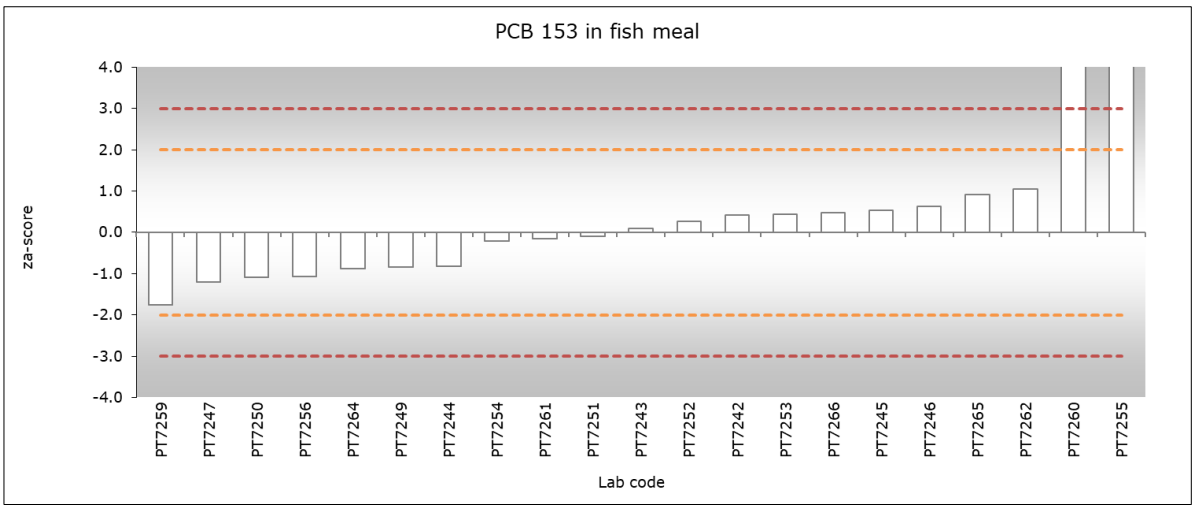

Figure 38 *Graphical representation of the z-scores for PCB 153 in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in µg/kg).*

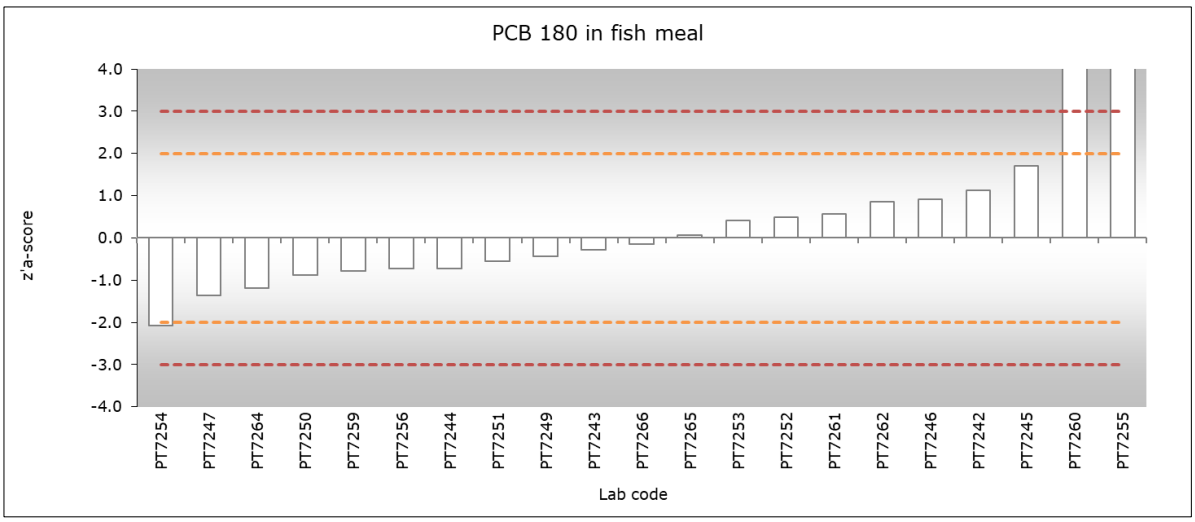

Figure 39 *Graphical representation of the z'-scores for PCB 180 in PT material fish meal. Dotted lines show PT performance boundaries ± 2 and ± 3 (in µg/kg).*

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WFSR Report 2025.018

The mission of Wageningen University & Research is "To explore the potential of nature to improve the quality of life". Under the banner Wageningen University & Research, Wageningen University and the specialised research institutes of the Wageningen Research Foundation have joined forces in contributing to finding solutions to important questions in the domain of healthy food and living environment. With its roughly 30 branches, 7,700 employees (7,000 fte), 2,500 PhD and EngD candidates, 13,100 students and over 150,000 participants to WUR's Life Long Learning, Wageningen University & Research is one of the leading organisations in its domain. The unique Wageningen approach lies in its integrated approach to issues and the collaboration between different disciplines.

To explore the potential of nature to improve the quality of life

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