Ministry for Primary Industries
Manatū Ahu Matua

National Chemical Contaminants Programme

Dairy Products and Raw Milk
Dioxin, Dioxin-like PCB, and Indicator PCB Results (2014, 2015, and 2016)

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Requests for further copies should be directed to:

Publications Logistics Officer
Ministry for Primary Industries
PO Box 2526
WELLINGTON 6140

Email: brand@mpi.govt.nz
Telephone: 0800 00 83 33
Facsimile: 04-894 0300

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1 Summary

This National Chemical Contaminants Programme (NCCP) report provides results for dioxins, dioxin-like polychlorinated biphenyls (dioxin-like PCBs), and some non-dioxin like polychlorinated biphenyls (indicator PCBs) in a range of dairy products and milk, sampled over the 2014, 2015 and 2016 dairy seasons. The results support the conclusion that the levels of dioxins, dioxin-like PCBs[1] in New Zealand dairy products are likely to be well below those of any concern.

Dioxins and PCBs are unintended, or undesired by-products of chemical processes in the chlorine-based chemical industry, and any combustion process involving chlorine or organic carbon under specific circumstances (such as temperatures between 250°C and 800°C and specific residence times). These substances are referred to as environmental contaminants, and can enter foodstuffs through air, soil or sediments.

New Zealand is geographically isolated and not heavily industrialised, so the risk of dioxins or PCBs entering the milk supply is very low. This has been confirmed in historic surveys. Nonetheless, surveys of dairy products and milk for dioxins and PCBs are periodically undertaken to confirm the suitability of manufacturing practices and environments, and to support the NCCP monitoring of raw milk used for the manufacture of dairy products.

The NCCP monitoring programmes combine to provide a high level of confidence in the safety and suitability of New Zealand dairy products.

This report will be updated with results from ongoing surveys of dairy products and milk.

2 What We Tested

- 12 individual targeted raw milk samples collected at individual farms at the farm bulk by recognised persons, who are part of a MPI recognised agency, over the 2015 and 2016 dairy seasons; and
- 4 and 6 dairy product samples collected over the 2014 and 2015 dairy seasons. These samples were from a range of dairy products manufactured in New Zealand including anhydrous milk fat, butter, cheese, and cream.

All the sampling of raw milk occurred at the farm bulk milk tank prior to any further consolidation, co-mingling or dilution. The samples were tested for dioxins, dioxin-like PCBs and some non-dioxin like PCBs (indicator PCBs) using International Accreditation New Zealand (IANZ) accredited test methods at an MPI recognised dairy laboratory.

[1] WHO- PCDD/F-PCB- TEQ

3 European Union Limits for Dioxins and PCBs in Food

Dioxins cover a group of 75 polychlorinated dibenzo-p-dioxin (PCDD) congeners and 135 polychlorinated dibenzofuran (PCDF) congeners, of which 17 are of toxicological concern. Polychlorinated biphenyls (PCBs) are a group of 209 different congeners which can be divided into two groups according to their toxicological properties; 12 congeners exhibit toxicological properties similar to dioxins and are therefore often termed 'dioxin-like PCBs' (DL-PCB). The other PCBs do not exhibit dioxin-like toxicity but have a different toxicological profile and are referred to as 'non dioxin-like PCBs' (NDL-PCB). The sum of the six marker or indicator PCBs (PCB 28, 52, 101, 138, 153 and 180) comprises about half of the amount of total NDL-PCB present in feed and food. That sum is considered as an appropriate marker for occurrence and human exposure to NDL-PCB and should be set as a maximum level. Figure 1 sets out the basic structure of dioxins, furans and PCBs.

Each congener of dioxins or dioxin-like PCBs exhibits a different level of toxicity. In order to be able to sum up the toxicity of these different congeners, the concept of toxic equivalency factors (TEFs) was introduced to facilitate risk assessment and regulatory control. This means that the analytical results relating to all the individual dioxin and dioxin-like PCBs congeners of toxicological concern are expressed in terms of a quantifiable unit, namely the TCDD toxic equivalent (TEQ). Appendix 6.1 sets out the WHO derived toxic equivalency factors (WHO-TEFs) for human risk assessment used to calculate the TEQ values.

The European Union (EU) have set maximum levels for dioxins, sum of dioxins and dioxin-like PCBs, and the sum of the six marker or indicator PCBs (PCB 28, 52, 101, 138, 153 and 180) in various types of food. New Zealand has not set maximum levels in dairy products, and along with many other countries, uses the EU maximum levels as a guideline for assessment of the test results.

The EU have also recommended non-binding action levels to limit the presence of dioxins and dioxin-like PCBs in food. Action levels are intended as a tool to highlight those cases where significant levels of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDD/Fs) above the normal background level were found and, where appropriate, to identify a source of contamination and to take measures for its reduction or elimination.

Table 1 sets out the current EU maximum and action levels for dioxins and PCBs in foodstuffs:

Table 1: European Commission maximum levels for dioxins (the sum of PCDDs and PCDFs) and PCBs in foodstuffs and recommendation on action levels for dioxins and PCBs in foodstuffs

Food	EU action level [1]		EU maximum level [2]		
	Dioxins + Furans [3] (WHO-TEQ) [8]	Dioxin-like PCBs [4] (WHO-TEQ) [8]	Sum of dioxins [5] (WHO-PCDD/F-TEQ) [8]	Sum of dioxins and dioxin-like PCBs [6] (WHO-PCDD/F-PCB-TEQ) [8]	Sum of PCB28, PCB52, PCB101, PCB138, PCB153 and PCB180 (ICES – 6) [8] [10]
Raw milk and dairy products, including butter fat	1.75 pg/g fat [7]	2.0 pg/g fat [7]	2.5 pg/g fat [9]	5.5 pg/g fat [9]	40 ng/g fat [9]

Notes

1 Commission Recommendation of 11 September 2014 amending the Annex to Recommendation 2013/711/EU on the reduction of the presence of dioxins, furans and PCBs in feed and food (2014/663/EU; Official Journal of the European Union No. L 272, p. 17-18).

2 Commission Regulation (EU) No 1259/2011 of 2 December 2011 amending Regulation (EC) No 1881/2006 as regards maximum levels for dioxins, dioxin-like PCBs and non-dioxin-like PCBs in foodstuffs (OJ L 320, 03/12/2011, p. 18–23).

3 'Dioxins + furans (WHO-TEQ)' means the sum of polychlorinated dibenzo-para-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), expressed as World Health Organisation (WHO) toxic equivalent using the WHO-toxic equivalency factors (WHO-TEFs).

4 'Dioxin-like PCBs (WHO-TEQ)' means the sum of polychlorinated biphenyls (PCBs), expressed as WHO toxic equivalent using the WHO-TEFs

5 'Sum of dioxins (WHO-PCDD/F-TEQ)' means the sum of polychlorinated dibenzo-para-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), expressed as WHO toxic equivalent using the WHO-toxic equivalency factors (WHO-TEFs).

6 'Sum of dioxins and dioxin-like PCBs (WHO-PCDD/F-PCB-TEQ)' means the sum of polychlorinated dibenzo-para-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs), expressed as WHO toxic equivalent using the WHO-toxic equivalency factors (WHO-TEFs).

7 The action levels are not applicable for food products containing < 2 % fat.

8 Upperbound concentrations: Upperbound concentrations are calculated assuming that all the values of the different congeners less than the limit of quantification are equal to the limit of quantification.

9 The maximum level expressed on fat is not applicable for foods containing < 2 % fat. For foods containing less than 2 % fat, the maximum level applicable is the level on product basis corresponding to the level on product basis for the food containing 2 % fat, calculated from the maximum level established on fat basis, making use of following formula:
Maximum level expressed on product basis for foods containing less than 2 % fat = maximum level expressed on fat for that food x 0.02.

10 'ICES – 6' means International Council for the Exploration of the Seas – 6 Indicator PCBs (PCB28, PCB52, PCB 101, PCB138, PCB 153 and PCB180).

4 What We Found

There are a total of 156 (2014), 468 (2015), and 234 (2016) test results comprising individual congener and sum of dioxins, dioxin-like PCBs, sum of dioxins and dioxin-like PCBs, and sum of the indicator PCBs (PCB 28, 52, 101, 138, 153 and 180).

Of the 16 (2014), 48 (2015), and 24 (2016) sum of dioxins, dioxin-like PCBs, sum of dioxins and dioxin-like PCBs, and sum of the indicator PCBs results, there were no detections recorded as exceeding either the EU action levels (early warning system) or the EU regulatory maximum levels threshold.

Table 2 provides a summary of dioxin and PCB results by sample type for 2014, 2015, and 2016. Table 3 provides a summary of upper bound values for the dairy product and raw milk samples tested. Appendix 6.1 sets out the WHO derived toxic equivalency factors (WHO-TEFs) for human risk assessment used to calculate the total toxic equivalence (TEQ) values.

The results of the testing do not exceed the most appropriate science-based overseas standards for the sum of dioxins and PCBs. This means that the risk of dioxins or PCBs entering the milk supply is very low and that in this regard, the dairy products manufactured are safe and suitable for their intended purpose.

Table 2: Summary of dioxin and PCB results by sample type and dairy season

Dairy Season	Sample Type	No. Samples Tested	Sum of dioxins (WHO-PCDD/ F-TEQ) pg/g fat		Dioxin-like PCBs (WHO-TEQ) pg/g fat	Sum of dioxins and dioxin-like PCBs (WHO-PCDD/F-PCB-TEQ) pg/g fat	Sum of PCB28, PCB52, PCB101, PCB138, PCB153 and PCB180 (ICES – 6) ng/g fat
			Above EU Action Level	Above EU Maximum Level	Above EU Action Level	Above EU Maximum Level	Above EU Maximum Level
2014	Anhydrous Milk Fat	1	0	0	0	0	0
	Butter	1	0	0	0	0	0
	Cheese	1	0	0	0	0	0
	Cream	1	0	0	0	0	0
	Total	4	0	0	0	0	0
2015	Anhydrous Milk Fat	1	0	0	0	0	0
	Butter	5	0	0	0	0	0
	Milk	6	0	0	0	0	0
	Total	12	0	0	0	0	0
2016	Milk	6	0	0	0	0	0
	Total	6	0	0	0	0	0

Note
No detections above LOR reported above the EU regulatory action and maximum levels.

Table 3: Summary of upper bound values for the dairy product and raw milk samples tested

Dairy Season	Sample ID	Sample Type	Sum of dioxins (WHO-PCDD/F-TEQ)	Dioxin-like PCBs (WHO-TEQ)	Sum of dioxins and dioxin-like PCBs (WHO-PCDD/F-PCB-TEQ)	Sum of PCB28, PCB52, PCB101, PCB138, PCB153 and PCB180 (ICES – 6)
			Upper Bound Value (pg/g fat)	Upper Bound Value (pg/g fat)	Upper Bound Value (pg/g fat)	Upper Bound Value (ng/g fat)
2014	D1491	Cheese	0.524	0.654	1.18	0.136
2014	D1492	Butter	0.523	0.654	1.18	0.14
2014	D1493	Anhydrous Milk Fat	0.556	0.66	1.22	0.385
2014	D1500	Cream	0.523	0.654	1.18	0.0991
2015	D219	Milk	1.04	0.655	1.7	0.544
2015	D220	Milk	1.04	0.655	1.7	0.527
2015	D221	Milk	1.04	0.654	1.69	0.308
2015	D222	Butter (Unsalted)	0.523	0.655	1.18	0.215
2015	D223	Butter (Salted)	0.523	0.654	1.18	0.2
2015	D224	Anhydrous Milk Fat	0.523	0.659	1.18	0.384
2015	D225	Butter	0.523	0.654	1.18	0.21
2015	D226	Butter	0.523	0.654	1.18	0.196
2015	D227	Butter	0.623	0.654	1.28	0.187
2015	D228	Milk	1.04	0.655	1.7	0.439
2015	D229	Milk	1.04	0.657	1.7	0.886
2015	D230	Milk	1.04	0.654	1.69	0.155
2016	D345	Milk	1.04	0.654	1.69	0.0764
2016	D373	Milk	1.04	0.66	1.7	0.483
2016	D412	Milk	1.05	0.657	1.71	1.31
2016	D460	Milk	1.05	0.656	1.71	0.698
2016	D507	Milk	1.04	0.656	1.7	0.964
2016	D508	Milk	1.04	0.654	1.69	0.224

Note
The total toxic equivalence (TEQ) was calculated for the samples using WHO toxic equivalency factors (WHO-TEFs; Van den Berg et al., 2006).

5 Conclusion

These results, in association with New Zealand's geographical isolation and relatively low level of industrialisation, support the conclusion that dairy cattle within New Zealand are not significantly exposed to dioxins and PCBs and that any levels in dairy products manufactured from New Zealand raw milk are unlikely to pose any concern relative to international action levels and/or limits.

6 Appendices

6.1 WHO DERIVED TOXIC EQUIVALENCY FACTORS FOR HUMAN RISK ASSESSMENT

Table 4: WHO derived Toxic Equivalency Factors for human risk assessment

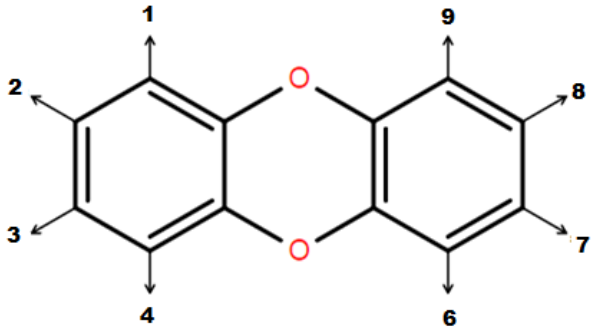
Compound	WHO 2005 TEF
Dibenzo-*p*-dioxins ('PCDDs')	
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	1
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.0003
Dibenzofurans ('PCDFs')	
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.03
2,3,4,7,8-PeCDF	0.3
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01
OCDF	0.0003
'Dioxin-like' PCBs *Non-ortho* PCBs + *Mono-ortho* PCBs	
Non-ortho PCBs	
PCB 77	0.0001
PCB 81	0.0003
PCB 126	0.1
PCB 169	0.03
Mono-ortho PCBs	
PCB 105	0.00003
PCB 114	0.00003
PCB 118	0.00003
PCB 123	0.00003
PCB 156	0.00003
PCB 157	0.00003
PCB 167	0.00003
PCB 189	0.00003

Source
Martin van den Berg et al., (2006). The 2005 World Health Organization Re-evaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds. *Toxicological Sciences 93*(2), 223–241.

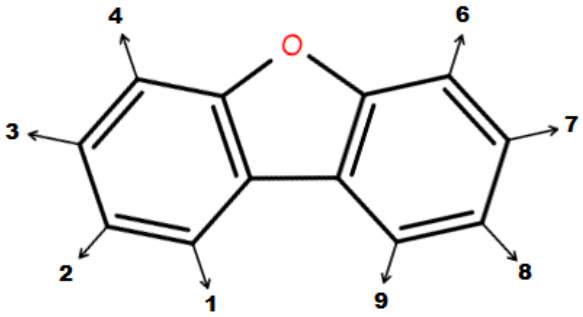
6.2 STRUCTURE AND NOMENCLATURE OF DIOXINS, FURANS AND PCBS

Figure 1: Basic structure of dioxins, furans and PCBs

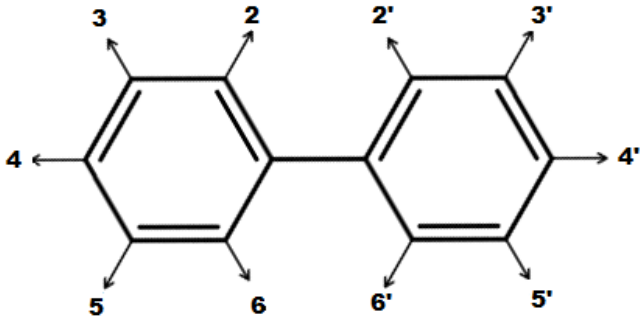
Polychlorinated dibenzo-*p*-dioxins (Dioxins) – Basic structure:



Polychlorinated dibenzofurans (Furans) – Basic structure:



Polychlorinated biphenyls (PCBs) – Basic Structure:



Nomenclature

The nomenclature of the specific dioxin, furan and PCB congener is based on the binding of chlorines to the numbering schemes. For example 2,3,7,8-Tetrachlorodibenzodioxin (TCDD) has chlorines bound to substituents 2, 3, 7 and 8. Octachlordibenzodioxin (OCDD) has chlorines bound to all 8 available binding sites. 2,3,3',4,4',5-Hexachlorobiphenyl (PCB-156) has six chlorines bound to the sites 2, 3, 3', 4, 4' and 5.

Table 6: Congeners Tested in NCCP Programme

Compound Shorthand	Compound Full Name
Dibenzo-*p*-dioxins ('PCDDs')	
2,3,7,8-TCDD	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin
1,2,3,7,8-PeCDD	1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin
1,2,3,4,7,8-HxCDD	1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin
1,2,3,6,7,8-HxCDD	1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin
1,2,3,7,8,9-HxCDD	1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin
1,2,3,4,6,7,8-HpCDD	1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin
OCDD	1,2,3,4,6,7,8,9-Octachlorodibenzo-*p*-dioxin
Dibenzofurans ('PCDFs')	
2,3,7,8-TCDF	2,3,7,8-Tetrachlorodibenzofuran
1,2,3,7,8-PeCDF	1,2,3,7,8-Pentachlorodibenzofuran
2,3,4,7,8-PeCDF	2,3,4,7,8-Pentachlorodibenzofuran
1,2,3,4,7,8-HxCDF	1,2,3,4,7,8-Hexachlorodibenzofuran
1,2,3,6,7,8-HxCDF	1,2,3,6,7,8-Hexachlorodibenzofuran
1,2,3,7,8,9-HxCDF	1,2,3,7,8,9-Hexachlorodibenzofuran
2,3,4,6,7,8-HxCDF	2,3,4,6,7,8-Hexachlorodibenzofuran
1,2,3,4,6,7,8-HpCDF	1,2,3,4,6,7,8-Heptachlorodibenzofuran
1,2,3,4,7,8,9-HpCDF	1,2,3,4,7,8,9-Heptachlorodibenzofuran
OCDF	1,2,3,4,6,7,8,9-Octachlorodibenzofuran
'Dioxin-like' PCBs (*Non-ortho* PCBs + *Mono-ortho* PCBs)	
Non-ortho PCBs	
PCB 77	3,3',4,4'-Tetrachlorobiphenyl
PCB 81	3,4,4',5-Tetrachlorobiphenyl
PCB 126	3,3',4,4',5-Pentachlorobiphenyl
PCB 169	3,3',4,4',5,5'-Hexachlorobiphenyl
Mono-ortho PCBs	
PCB 105	2,3,3',4,4'-Pentachlorobiphenyl
PCB 114	2,3,4,4',5-Pentachlorobiphenyl
PCB 118	2,3',4,4',5-Pentachlorobiphenyl
PCB 123	2,3',4,4',5'-Pentachlorobiphenyl
PCB 156	2,3,3',4,4',5-Hexachlorobiphenyl
PCB 157	2,3,3',4,4',5'-Hexachlorobiphenyl
PCB 167	2,3',4,4',5,5'-Hexachlorobiphenyl
PCB 189	2,3,3',4,4',5,5'-Heptachlorobiphenyl