Údarás Sábháilteachta Bia na hÉireann
Food Safety Authority of Ireland

Report of the Scientific Committee
of the Food Safety Authority of Ireland

2025

Parameter/foodstuff combinations for consideration in the next Total Diet Study and the selection of appropriate biomarkers to support risk assessment in Ireland

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Published by:

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ISBN: 978-1-910348-91-8

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Glossary

Term	Text
ADI	Acceptable daily intake
EPA	Environmental Protection Agency
EFSA	European Food Safety Authority
EU	European Union
FSAI	Food Safety Authority of Ireland
HBGV	Health-based guidance value
HBM	Human biomonitoring
HBM4EU	European Human Biomonitoring Initiative
IARC	International Agency for Research on Cancer
IUNA	Irish Universities Nutrition Alliance
JECFA	Joint FAO/WHO Expert Committee for Food Additives
MLs	Maximum levels
MDL	Method detection limits
NANS	National Adult Nutrition Survey
PARC	Partnership for Assessment of Risks from Chemicals
PNEC	Predicted No Effect Concentration
RfD	Reference dose
TDI	Tolerable Daily Intake
TDS	Total Diet Study

1. Executive summary

Food safety risk assessment is a process of identifying hazards in food and quantifying or qualifying their impact on health at estimated concentrations ingested by the population. In the field of chemical risk assessment for food safety there are a number of approaches that provide estimates of health impact with differing levels of uncertainty. Two such approaches are total diet study (TDS) and human biomonitoring study (HBS). A total diet study seeks to estimate the intake of chemicals from food as prepared and consumed by the population using food consumption data to determine the typical diet. Human biomonitoring studies are risk assessment approaches that integrate exposure to chemicals from all sources and routes (food and non-food) and quantify the cumulative presence of chemicals in the human body through collection and analysis of human biological samples e.g. blood, urine, or breast milk. The Food Safety Authority of Ireland (FSAI) has carried out two total diet studies and wishes to carry out an updated study in the near future. Hence the Scientific Committee was asked:

1. Are the food groups that were included in the previous TDS still relevant? Should other food groups be included due to changes in dietary patterns over the last ten years?
2. Are the chemical parameters included in the previous TDS appropriate, or should other chemicals regulated since also be considered for inclusion and are there any that no longer need to be included?

The FSAI also wishes to encourage human biomonitoring studies in Ireland to support better food safety risk management decisions to control chemical exposure from food. Hence the Scientific Committee was asked:

3. What biomarkers are most appropriate and feasible to support and enhance risk assessment in Ireland as necessary?

In answering questions 1 and 2 regarding the TDS, the Scientific Committee provided a list of 143 food types across 17 food categories in which to analyse for a list of 33 recommended chemicals including, 13 heavy metals, 5 processing contaminants, 7 mycotoxins, 5 natural plant toxins, 2 food contact material chemicals and 1 group of halogenated persistent organic pollutants. Eleven chemical parameters were new and not included in previous Irish TDS and two new food types were included based on recorded consumption patterns in the latest national adult nutrition survey (IUNA).

In answering question 3 regarding human biomarkers for chemical intake, the Scientific Committee considered 2 existing priority lists developed by European research projects; Human Biomonitoring for the European Union (HBM4EU) and a draft list developed by the Partnership for the

Assessment of Risk from Chemicals (PARC). A list of 14 categories of chemicals was proposed covering 78 chemical substances for which 103 biomarkers were listed as applicable for testing in relevant matrix samples of urine, whole blood, blood serum, serum plasma, human milk and human hair.

In developing this advice to the FSAI, the Scientific Committee was aided by its Chemical Safety Subcommittee who formed a Total Diet Study and Biomonitoring Working Group. Members are listed at the end of the report.

2. Parameter and food lists for consideration in the next Total Diet Study

2.1 Background

A Total Diet Study (TDS) is a public health tool for the determination of dietary exposure to chemical substances such as contaminants, pesticides, additives and nutrients across a population's entire diet. It consists of selecting and collecting commonly consumed foods purchased at retail level, processing and preparing these foods as they would be prepared for consumption and analysing them for harmful and/or beneficial chemical substances (EFSA/FAO/WHO, 2011). These occurrence data will be combined with food consumption data from the Irish Universities Nutrition Alliance (IUNA) dietary surveys to provide an estimate of the dietary exposure to chemicals in the Irish diet. A comparison of these dietary exposure estimates for each chemical parameter with its respective health-based guidance value (HBGV) provides a realistic estimate of the risk of exposure, or inadequate consumption in the case of nutrients, for the Irish population from these chemicals in food. The results of a TDS can be used as a priority-setting tool to enable risk managers to focus their limited resources on those chemicals and foods which are considered to pose the most significant risks to public health (FSAI, 2016).

As part of the TDS undertaken by the Food Safety Authority of Ireland (FSAI) during the period 2012–2014, a total of 141 food groups were analysed for the presence of 22 different parameters. The outcome of this study showed that the Irish population is generally not at risk from exposure above the relevant HBGV or inadequate consumption in the case of nutrients with respect to the chemicals analysed. However, potential concerns were identified for exposure to acrylamide and aflatoxins.

To assist the FSAI with its next TDS, the Scientific Committee was tasked with proposing a parameter and food list for inclusion in the study, subject to funding.

2.2 Parameter list

The following parameter list is based primarily on the 22 parameters included in the 2012–2014 TDS. Some parameters which were included in the 2001–2005 TDS but were excluded from the 2012–2014 TDS have also been included in the list. The rationale for inclusion/exclusion is provided in Table 1 along with the final inclusion/exclusion recommendation. New parameters were proposed for inclusion in the list if a potential concern for health was identified by EFSA and/or based on regulatory developments in the European Union and/or other considerations.

Table 1 List of parameters and recommendations for their inclusion/exclusion from the next FSAI TDS

Parameters	Rationale	Recommendation
Metals and other elements		
Aluminium	Included in 2001–2005 and 2012–2014 TDS.	Include
Total Arsenic	Included in 2012–2014 and 2001–2005 TDS.	Include
Inorganic Arsenic	Included in 2012–2014 and 2001–2005 TDS.	Include
Cadmium	Included in 2012–2014 and 2001–2005 TDS.	Include
Chromium	Included in 2012–2014 TDS.	Include
Lead	Included in 2012–2014 and 2001–2005 TDS.	Include
Total Mercury	Included in 2012–2014 and 2001–2005 TDS.	Include
NEW: Methyl Mercury	Risk characterisation for mercury would benefit from the quantification of methyl mercury.	Include
Selenium	Included in 2012–2014 and 2001–2005 TDS.	Include
Iodine	Included in 2012–2014 and 2001–2005 TDS. The inclusion of iodine has been prioritised in order to support consideration of potential iodine deficiencies in the Irish population due to changes in dietary patterns.	Include
NEW: Nickel	Now subject to European Union (EU) maximum levels. Concern raised by the European Food Safety Authority (EFSA, 2020a) for the younger population.	Include
Tin	Included in 2012–2014 and 2001–2005 TDS.	Include

Parameters	Rationale	Recommendation
NEW: Uranium	Recommended for monitoring by the Food Safety Authority of Ireland (FSAI) for the past few years in National Chemical Sampling Plan.	Include
Fluoride	There was an extensive TDS in 2014–2016 specifically for fluoride. Only tea and water made a significant contribution to intake. The latter is carefully monitored in Ireland and the former is a result of geological factors at source. Both are unlikely to have changed since 2016. No health concerns were identified for exposure to fluoride from foods and beverages following that extensive 2016 study, and health-based guideline values for this substance remain unchanged since then. This does not warrant inclusion of fluoride in the 2024–2026 TDS.	Exclude
Strontium	Strontium was included in the 2001–2005 TDS. Estimated daily intakes lay between 1.58 mg (mean) and 2.79 mg (97.5th percentile), equivalent to 0.02 or 0.04 mg/kg bw/day respectively. The intakes were well below the Environmental Protection Agency (EPA) chronic reference dose (RfD) of 0.6 mg/kg bw/day for strontium (US EPA, 1992). The major contributing source of strontium were cereals (33.1% of total intake), followed by bottled water (22.3% of total intake), vegetables (12.0% of total intake), fruit and sweet preserves (8.0% of total intake) and dairy produce (7.7% of total intake). The World Health Organization Concise International Chemical Assessment Documents (2010) has since established a Tolerable Daily Intake (TDI) of 0.13 mg/kg bw/day. This is almost 5 times lower than the chronic reference point used in the first TDS of 0.6 mg/kg bw/day but is still more than 3 times the 97.5 percentile of 0.04 mg/kg bw/day observed in the 2001–2005 study. Although consumption of the highest contributing sources is likely to have increased, this is not likely to have increased sufficiently to bring the estimated daily intake above the new TDI. This new information would not warrant strontium being included in the 2024–2026 TDS.	Exclude

Parameters	Rationale	Recommendation
Copper	Copper was previously assessed in the 2001–2005 TDS but not assessed in the 2012-2014 TDS. In 2023, EFSA established an acceptable daily intake (ADI) of 0.07 mg/kg bw/day for the adult population. EFSA concluded that dietary exposure to total copper does not exceed the Health Based Guideline Values (HBGV) in adolescents, adults, elderly, and the very old. Neither hepatic copper retention nor adverse effects are expected to occur from the estimated copper exposure in children due to higher nutrient requirements related to growth (EFSA, 2023a). On the basis of EFSA's assessment in 2023 it is not justified to include copper in the 2024–2026 TDS.	Exclude
Processing Contaminants		
Polycyclic Aromatic Hydrocarbons (PAHs)	Included in 2012–2014 and 2001–2005 TDS.	Include
Acrylamide	Included in 2012–2014 and 2001–2005 TDS.	Include
NEW: 3-Monochloropropane-1,2-diol (3-MCPD)	EFSA identified a concern for younger age groups in 2018. Maximum levels (MLs) have been in place since 2018. New MLs are under discussion for composite products (EFSA 2018a).	Include
NEW: Sum of 3-monochloropropanediol *(3-MCPD and 3-MCPD fatty acid esters, expressed as 3-MCPD*)	EFSA identified a concern for younger age groups in 2018. Maximum levels (MLs) have been in place since 2018. New MLs are under discussion for composite products (EFSA 2018a).	Include
NEW: Glycidyl esters	EFSA identified a concern for younger age groups in 2016 (EFSA 2016). Maximum levels (MLs) have been in place since 2018. New MLs are under discussion for composite products.	Include
Mycotoxins		
Aflatoxins: *(B1, B2, G1, G2 and total aflatoxins)*	Included in 2012–2014 and 2001–2005 TDS.	Include
Aflatoxin M1	Included in 2012–2014 and 2001–2005 TDS.	Include
Ochratoxin A	Included in 2012–2014 and 2001–2005 TDS.	Include

Parameters	Rationale	Recommendation
Fumonisins B1, B2 and the sum of B1 and B2.	Included in 2012–2014 and 2001–2005 TDS.	Include
Trichothecenes: *(deoxynivalenol, nivalenol, 3-Acetyldeoxynivalenol (3-AcDON), 15-Acetyldeoxynivalenol (15-AcDON), diacetoxyscirpenol (DAS), T-2 toxin, HT-2 toxin)*	Included in 2012–2014 and 2001–2005 TDS.	Include
Zearalenone	Included in 2012–2014 TDS.	Include
Patulin	Included in 2012–2014 and 2001–2005 TDS.	Include
Natural Plant Toxins		
NEW: Ergot alkaloids: *(ergocornine/ergocorninine; ergocristine/ergocristinine; ergocryptine/ergocryptinine (α- and β-form); ergometrine/ergometrinine; ergosine/ergosinine; ergotamine/ergotaminine)*	EFSA's (2017a) Opinion identified a concern for toddlers (95th percentile upper bound (UB) exposure) and possible acute risk for other children (95th percentile middle bound (MB) exposure). Maximum levels (MLs) have been in place since 2022.	Include
NEW: Tropane alkaloids	EFSA identified a concern for acute exposure in their 2018 Opinion for toddlers and other children (Lower Bound 95th percentile) and for all age groups (UB 95th percentile) (EFSA, 2018b). MLs have been in place since 2016, with additional MLs introduced in 2022.	Include
NEW: Pyrrolizidine alkaloids (21 regulated PAs as per Regulation 2023/915)	In 2017, EFSA identified a concern for chronic exposure, particularly for consumers of tea/herbal infusions (EFSA, 2017b). EFSA noted that consumption of certain food supplements could cause acute toxicity. Maximum limits (MLs) have been in place since 2022.	Include
NEW: Opium alkaloids	In 2018, EFSA identified a concern for acute exposure to poppy seeds containing opium alkaloids (EFSA, 2018c). MLs have been in place since 2022.	Include
Other Agricultural Contaminants		

Parameters	Rationale	Recommendation
Nitrate[1]	Included in 2012–2014 TDS.	Include
Food Contact Materials		
Bisphenol A (BPA)	Included in 2012–2014 TDS.	Include
Phthalates	Included in 2012–2014 TDS.	Include
Halogenated Persistent Organic Pollutants		
NEW: Perfluoroalkyl substances: (particularly PFOS, PFOA, PFNA and PFHxS, but also considering PFBA, PFPeA, PFHpA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFPeDA, PFHxDA, PFOSA)	In 2020, EFSA identified a concern for chronic exposure for parts of the EU population (EFSA, 2020b). MLs have been in place since 2023.	Include
Additives		
Nitrites (E 249 – 250)	Nitrites are already covered by extensive annual surveys. Nitrites were not identified as a concern in last TDS.	Exclude
Sulphites	Sulphites are already covered by extensive annual surveys. Sulphites were not included in the 2012–2014 TDS.	Exclude
Sorbates Benzoates Acesulfame-K Aspartame Tartrazine Sunset Yellow	These additives were included in the 2001-2005 TDS but were not identified as a concern. They were subsequently removed from the 2012–2014 TDS. It is not justified to include them in the 2024–2026 TDS. Moreover, there will be a dedicated EU Monitoring Programme for food additives commencing in 2024 (European Commission, 2023). For aspartame, EFSA's assessment in 2013 did not raise a concern (EFSA, 2013). In 2023, the Joint FAO/WHO	Exclude

[1]. Nitrate is found naturally in vegetables, with the highest concentrations occurring in leafy vegetables like spinach and lettuce. It can also enter the food chain as an environmental contaminant in water, due to its use in intensive farming methods, livestock production and sewage discharge. Sodium and potassium salts of nitrate (E 251-252) are authorised as food additives in the EU. They are used in meat, fish and cheese products. However, Nitrates as additives are already covered by extensive annual surveys and were not identified as a concern in last TDS. Hence the new TDS will only consider nitrate from an agricultural contaminant perspective.

Parameters	Rationale	Recommendation
	Expert Committee for Food Additives (JECFA) and the International Agency for Research on Cancer (IARC) independently assessed the risks associated with aspartame and published a summary of their findings. Citing “limited evidence” for carcinogenicity in humans, IARC classified aspartame as ‘possibly carcinogenic to humans (IARC Group 2B)’ and JECFA concluded that there was no convincing evidence from experimental animal or human data that aspartame has adverse effects after ingestion (JECFA/IARC, 2023). This led to JECFA reaffirming its previous ADI of 40 mg/kg bw. Both conclusions of the EFSA and JECFA assessments would not provide justification for the inclusion of aspartame in the 2024–2026 TDS.	
Pesticides		
Pesticides multi-screen	The majority of results from the last TDS were non-detects. Residues below the respective maximum residue level and at low levels were found in 41 samples. Regarding Glyphosate, the most recent peer review of the pesticides risk assessment of the active substance glyphosate did not identify any critical areas of concern (EFSA 2023b). Based on the conclusions of the EFSA peer-review assessment, it was agreed that it was not justified to include glyphosate in the 2024–2026 TDS.	Exclude
Aldicarb	Aldicarb was not identified as an issue in the 2001–2005 TDS and was subsequently removed in the 2012–2014 TDS. It is not justified to include aldicarb in the 2024–2026 TDS.	Exclude

2.3 Food list

2.3.1 New food categories not listed in the 2012–2014 TDS

The following new food categories for consideration in the next FSAI TDS are those which have been identified as new categories in the draft second National Adult Nutrition Survey (NANSII) carried out by the Irish Universities Nutritional Alliance (IUNA) and shown in Table 2. In general, for the development of a food list, a food intake assessment is often completed. The results of the intake assessments are arranged in descending order of the foodstuffs with the highest contribution to the total diet (by weight) and the foodstuffs contributing to at least 90% of the food intake are included in the list (Charrondiere, 2013). In this case, a formal food intake assessment was not possible as the draft NANSII was not ready to be used for an intake assessment. However, for the food categories in the NANSII, the percentage of consumers and the average intakes on a total population basis were calculated to inform the decision on inclusion/exclusion in the list. For example, if there were 100 consumers of a food category, this was multiplied by the total number of participants in the survey (1000 consumers) and the resultant value multiplied by 100 to determine the percentage of consumers. Whilst there is no generally recognised threshold for the percentage of consumers that could be used to justify the inclusion of food categories in a TDS list, 10% of consumers was considered as a reasonable threshold for inclusion.

It was agreed that the category “Cereal/protein/fibre bars & balls” would be the only new category included in the TDS. The other food category of interest, “Non-dairy alternative beverages of interest”, is already an existing food category in the TDS food list. To note, the food category “Squashes & cordials (added sugar)” is already covered under an existing TDS food category.

Table 2 Recommendation on inclusion/exclusion of new food categories identified in the NANSII IUNA consumption survey

New food categories identified in NANSII	Rationale for inclusion/exclusion and notes	Recommendation
NOTE: Intakes and percentage of consumers (% of consumers) are only for information purposes as the NANSII is being finalised.		
Infant biscuits/rusks	The TDS is not intended to cover foods for infants and young children. This would require a separate specific study to consider infants and young children (aged 0-3 years).	Exclude

New food categories identified in NANSII	Rationale for inclusion/exclusion and notes	Recommendation
Infant desserts (excluding pureed fruit)	The TDS is not intended to cover foods for infants and young children. This would require a separate specific study to consider infants and young children (aged 0-3 years).	Exclude
NEW: Cereal/protein/fibre bars & balls	Percentage of consumers: 10.3 % of the total population consumed this food category over the 2 days of the survey. For comparison, 56% of participants in the study consumed biscuits. Intake: 4.6 g/day on average (total population) • It was agreed that this category should be included on the basis of the higher number of consumers. • This category includes bars and balls containing a variety of primary ingredients, including cereals, fruits, nuts, chocolate, protein (e.g. milk or soya protein) or fibre (e.g. chicory root extract), as well as other lesser ingredients. The primary ingredients are often present in mixtures and no ingredient is particularly dominant. This category includes bars and balls marketed as high in protein or fibre. • The category should not be split.	Include
Non-dairy alternative beverages	Percentage of consumers: 10.7 % of the total population consumed this food category over the 2 days of the survey compared with 48.8% of participants in the survey consuming whole milk, and 43% of participants consuming low fat milk. The figure of 10.7% (above) is higher than for the category described as 'other milk' in the 2012-2014 TDS which as 5.3% of participants. Intake: 16.0 g/day on average (total population) This category is already covered under the existing "other milk" category that was present in the 2012-2014 TDS and which will be updated to "Non-dairy alternative beverages" in line with the nomenclature change in the NANSII survey.	Exclude
Non-dairy alternatives to yogurt	Percentage of consumers: 2.2% of the total population consumed this food category over the 2 days of the survey. Low when compared 39.6% of participants in the study consuming "Yoghurts" Intake: 2.7 g/day on average (total population)	Exclude

New food categories identified in NANSII	Rationale for inclusion/exclusion and notes	Recommendation
	The low number of consumers of this category would make it difficult to draw useful conclusions.	
Non-dairy alternative to cheese	Percentage of consumers: 1.2% of the total population consumed this food category over the 2 days of the survey. This is low when compared to the % of consumers of cheese (59.7%) Intake: 0.4 g/day on average (total population) The low number of consumers of this category would make it difficult to draw useful conclusions.	Exclude
Meat alternatives including dishes	Percentage of consumers: 3.5% of the total population consumed this food category over the 2 days of the survey. Intake: 4.2 g/day on average (total population) The low number of consumers in this category would make it difficult to draw useful conclusions.	Exclude
Non-alcoholic beverages (beers, wines, spirits)	Percentage of consumers: 2.1% of the total population consumed this food category over the 2 days of the survey compared with 36.8% for "alcoholic beverages". Intake: 10.8 ml/day on average (total population) compared with 279.1 ml/day for alcoholic beverages. There are relatively low number of consumers and ingredients and manufacture of these products is not likely to be significantly different than their alcoholic equivalents, i.e. will not lead to a higher occurrence of contaminants.	Exclude
Squashes & cordials (added sugar)	Percentage of consumers: 2.9% of the total population consumed this food category over the 2 days of the survey Intake: 7.9 g/day on average (total population) Whilst this category is separate to the existing “Squashes & cordials (no added sugar)” category in the NANSII, from an analytical perspective (i.e. presence of contaminants), it is not justified to split the category. Both categories will be merged for the purposes of the TDS.	Exclude
Protein & other shakes	Percentage of consumers: 4.8% of the total population consumed this food category over the 2 days of the survey	Include

New food categories identified in NANSII	Rationale for inclusion/exclusion and notes	Recommendation
	Intake: 18.8 g/day on average (total population) Other: Whilst the percentage of consumers for this food category is relatively low, it is included as it is considered that it may be increasing and may be concentrated in specific sectors. This category is intended to be taken to supplement the diet.	

2.3.2 Existing food categories from the 2012-2014 TDS

All the existing TDS food categories from the 2012-2014 study can be included in the 2024-2026 TDS with some minor amendments to the descriptions below for category 16, 20 and 32. No categories were removed (see Table 3).

Table 3 List of Food Categories and recommendations for inclusion/exclusion

Food list from the 2012-2014 TDS	Comments/proposed changes	Recommendation
CEREALS		
1. White flour		Include
2. Wholemeal flour		Include
3. White bread/rolls		Include
4. Granary/wholegrain breads		Include
5. Brown bread and rolls		Include
6. Plain biscuits		Include
7. Chocolate biscuits		Include
8. Other biscuits		Include
9. Cakes		Include
10. Other cakes, buns and pastries		Include
11. Pasta	Cereal based noodles will be included in this category	Include
12. Rice	Rice based noodles will be included in this category	Include

Food list from the 2012-2014 TDS	Comments/proposed changes	Recommendation
13. Cornflakes		Include
14. Bran flakes		Include
15. Wheat type cereals		Include
16. Muesli/Granola	This category will now include granola in line with an update to the category in the NANSII	Include
17. Oat flakes		Include
18. Rice type cereals		Include
DAIRY		
19. Whole milk	This category will now include fortified milks.	Include
20. Low fat, 1% and skimmed milk	The name has been changed in line with a change in the NANS II category name. The category will still include fortified milks.	Include
21. Cream		Include
22. Cheese (hard)		Include
23. Cheese (continental style)		Include
24. Cheese (soft and semi-soft)		Include
25. Yogurts		Include
26. Custard		Include
27. Vanilla ice-cream		Include
28. Butter		Include
29. Dairy spreads		Include
30. Non-dairy spreads		Include
31. Other ice-creams		Include
32. Non-dairy alternative beverages	The name has been changed in line with a change in the NANS II category name.	Include
EGGS		
33. Eggs (fried)		Include
MEAT		

Food list from the 2012-2014 TDS	Comments/proposed changes	Recommendation
34. Pork		Include
35. Ham		Include
36. Pork sausage		Include
37. Bacon rashers		Include
38. Beef		Include
39. Beef mince		Include
40. Beef burger		Include
41. Chicken		Include
42. Turkey		Include
43. Lamb		Include
44. Offal (kidney)		Include
45. Offal (liver)		Include
46. Pudding (black and white)		Include
FISH		
47. Cod and other white fish		Include
48. Oily fish other than salmon		Include
49. Salmon		Include
50. Canned tuna		Include
51. Tinned fish (excluding salmon & tuna)		Include
52. Tinned salmon		Include
53. Smoked salmon		Include
54. Smoked fish (excluding salmon)		Include
55. Mussels		Include
56. Prawns		Include
57. Crab		Include

Food list from the 2012-2014 TDS	Comments/proposed changes	Recommendation
POTATOES		
58. Potatoes without skin (boiled)		Include
59. Potatoes with skin (microwaved)		Include
60. Chips (homemade, from frozen pre-prepared)		Include
VEGETABLES		
61. Onion (fried)		Include
62. Tomatoes		Include
63. Canned tomatoes		Include
64. Tomato canned/concentrate		Include
65. Peppers		Include
66. Cucumber		Include
67. Mushrooms		Include
68. Canned sweetcorn		Include
69. Carrots (boiled)		Include
70. Carrots		Include
71. Celery		Include
72. Peas		Include
73. Canned peas		Include
74. Green beans		Include
75. Baked beans		Include
76. Legumes (excluding peas)		Include
77. Canned legumes (excluding peas)		Include
78. Cabbage (raw)		Include
79. Cabbage (boiled)		Include

Food list from the 2012-2014 TDS	Comments/proposed changes	Recommendation
80. Broccoli		Include
81. Cauliflower		Include
82. Root vegetables (excluding carrots)		Include
83. Stir fry vegetables		Include
84. Lettuce		Include
85. Other Leafy Vegetables		Include
FRUIT		
86. Apples		Include
87. Oranges		Include
88. Bananas		Include
89. Grapes		Include
90. Pears		Include
91. Peaches and nectarines		Include
92. Canned Peaches		Include
93. Plums		Include
94. Berries		Include
95. Other fruit		Include
96. Canned fruit (other)		Include
FRUIT DRIED		
97. Dried raisins		Include
98. Dried Fruit (other)		Include
NUTS SEEDS		
99. Nuts		Include
100. Seeds		Include
HERBS SPICES		
101. Herbs		Include
102. Spices		Include

Food list from the 2012-2014 TDS	Comments/proposed changes	Recommendation
SOUPS		
103. Stock cubes, bovril and marmite		Include
104. Soup, fresh (tetrapak)		Include
105. Soups (canned)		Include
106. Soups (dried packet)		Include
SAUCES		
107. Tomato sauce		Include
108. Mayonnaise		Include
109. Gravy		Include
110. Cooking sauces (other)		Include
111. Cooking sauces tomato based		Include
112. Other sauces and condiments		Include
113. Soy sauce		Include
CONFECTIONERY		
114. Chocolate confectionery		Include
115. Non-chocolate confectionery		Include
SUGAR AND PRESERVES		
116. Sugar and Sugar Substitutes		Include
117. Honey		Include
118. Marmalade		Include
119. Jam		Include
BEVERAGES		
120. Lager		Include

Food list from the 2012-2014 TDS	Comments/proposed changes	Recommendation
121. Stout		Include
122. White/red wine		Include
123. Spirits		Include
124. Alcoholic drinks (apple based)		Include
125. Carbonated soft drinks		Include
126. Squashes		Include
127. Apple juice		Include
128. Orange juice		Include
129. Other fruit juices		Include
130. Tea		Include
131. Instant coffee		Include
132. Filter coffee		Include
133. Herbal tea		Include
134. Bottled water		Include
135. Tap water		Include
FATS OILS		
136. Olive oil		Include
137. Vegetable oil	Rapeseed oil will also be considered in this category.	Include
138. Fat, hard cooking fat		Include
SNACKS		
139. Crisps		Include
140. Other savoury snacks		Include
COMPOSITE FOOD		
141. Pizza		Include

3. Selection of appropriate biomarkers to support risk assessment in Ireland

3.1 Background

For the purposes of this document a biomarker is defined as any substance, structure or degradation product(s) thereof, or any process that can be measured in biological samples from the human body which influences and/or assists in estimating the occurrence of outcome or disease (WHO, 2001). Biomarkers can be classified into biomarkers of exposure, biomarkers of effects, or biomarkers of susceptibility (Apel *et al.*, 2020).

In respect to risk assessment, a human biomonitoring (HBM) study can be used to validate and support risk assessment by evaluating total exposure of the human body to a chemical from various sources. This can assist in determining the exposure, evaluating temporal changes in a population's exposure and regional/population differences, identifying highly exposed or vulnerable groups. It can also support determining whether there is a link between exposure and adverse health effects. Biomarkers are primarily used in population and occupational studies and may provide a more comprehensive assessment of actual human exposure (body burden) to a chemical from all sources and routes compared to risk assessment models based only on dietary exposure.

Several HBM studies have previously been carried out in Ireland. Examples include mercury in hair and urinary phthalate concentrations in mother/child pairs (Cullen *et al.*, 2014; 2017), persistent organic pollutants in human breast milk (Houlihan *et al.*, 2021), glyphosate in urine (Connolly *et al.*, 2018a; 2018b; 2019; 2022) and lead in blood from residents in the Silvermines area of Co. Tipperary (EPA, 2004).

More recently, to address the need for harmonisation in HBM studies and to advance research on biomarkers, the European Human Biomonitoring Initiative (HBM4EU) (www.hbm4eu.eu) was set up under the scope of the European Commission and has been continued and built on within the Partnership for Assessment of Risks from Chemicals (PARC).

3.2 Approach for determining a suitable list of biomarkers

Two existing priority lists developed by the HBM4EU and a priority list developed by PARC have been considered as a basis for a list of appropriate and feasible biomarkers to support and enhance risk assessment in Ireland:

1. Suggested list of biomarkers, matrices and analytical methods for the 1st prioritisation round of substances in HBM4EU

2. Suggested list of biomarkers, matrices and analytical methods for the 2nd prioritisation round of substances in HBM4EU (Further information can be found in the following scoping document)
3. Suggested list of biomarkers, matrices and analytical methods proposed by PARC.

The lists were compiled by the HBM4EU and PARC based on the level of information available on each of the exposure biomarker and matrix pairs. Only biomarkers and matrix pairs which have been classified by HBM4EU or PARC as having sufficient data (category A) or insufficient data (category B) are included in the lists. Pairs with very limited data (category C) were excluded[2].

In addition, the lists were evaluated by HBM4EU and PARC using the following criteria: specificity, biological sensitivity, half-life, stability after sampling, stability during storage, matrix availability and sample collection, method detection limits (MDL), and measurement validity. Thresholds for each of these evaluation criteria are described by Vorkamp *et al.* (2021).

Several selection criteria were initially considered for Ireland but it was concluded that many were already sufficiently addressed by the HBM4EU Group when compiling their priority lists and by their successor, PARC.

The criteria which were considered inherent in the HBM4EU lists include:

- **Specificity:** HBM4EU determined that the biomarker would reflect exogenous exposure to the chemical of concern and exclusively because of environmental or occupational exposure.
- **Biological sensitivity:** HBM4EU determined that the measured concentration of the biomarker in the chosen matrix correlates strongly with the substance intake dose and can be measured at levels expected to arise from environmental exposures. This would also demonstrate the relevance of the chosen matrix for the biomarker of interest.
- **Relevance and comparability to HBM studies in other countries:** Both HBM4EU lists include biomarker and matrix pairs which would be of relevance to all countries involved. Therefore, these aspects are inherent in the HBM4EU lists and were not considered by the Biomarkers WG.
- **Relevance of the substance for Ireland:** Exposure to certain substances may be related to specific sources (e.g. consumer products, ethnic foods) which are not available in Ireland.

[2]The approach used by Vorkamp *et al.* 2021 to evaluate the level of information available in the literature for each biomarker and matrix pair, and associated analytical method involved the classification against three categories, i.e. category A, B and C. Vorkamp *et al.* considered category B ("insufficient data") to have a greater level of information available than category C ("very limited data").

However, the HBM4EU lists include biomarkers and matrix pairs which are relevant for several EU Members States and therefore likely to be relevant for Ireland too.

- **Availability of a suitable analytical laboratory for each biomarker:** The HBM4EU lists include biomarkers and matrix pairs for which validated analytical methods are available in multiple laboratories. HBM4EU evaluated suitable analytical methods for each biomarker and matrix pair based on the following criteria: sample preparation, standards, validation, selectivity, sensitivity, accuracy, recovery and range/linearity.

  HBM4EU noted that reference standards were available for all biomarkers within category A, whereas standards may not be available or only available from a limited number of suppliers in category B. Accreditation of the laboratory against ISO/IEC 17025:2017 and the inclusion of the analytical method on its scope of accreditation was not an evaluation criterion used by HBM4EU.

  Although it is desirable that the methods should be on the scope of accreditation of the laboratory performing the analysis, it is not a legal requirement for HBM studies. If the method is not on the laboratory's scope of accreditation, then it would be desirable that the laboratory participates in proficiency testing schemes and/or inter-laboratory comparison studies. An important consideration for the successful planning and implementation of a HBM study is the availability of sufficient laboratory resources and funding for the chosen laboratory.

For some of the criteria, it was agreed that they would be important for the planning and implementation stages of a HBM study in Ireland and to a lesser extent for the identification of a suitable list of biomarkers to support risk assessment.

The criteria which were excluded on the basis that it would be more relevant for the planning and implementation of a HBM study include:

- **Availability and access to samples from previous (i.e. biobank samples) or ongoing HBM studies:** Whilst this selection criterion was initially considered, it was noted that it would reflect the status quo at the time of preparation of this list of biomarkers and may quickly become outdated. The availability of existing HBM samples and associated survey/questionnaire responses is an important factor which should be considered when developing a HBM study, as it may help reduce the resources required for a HBM study. Furthermore, it would be important to consider HBM studies which may be at an early stage of development and have samples available or collaborative studies whereby one laboratory completes the analysis for interested parties, e.g. PARC. Ethical approval and

data protection aspects would also need to be considered when determining the accessibility of the samples.

- **Availability of trained personnel to conduct questionnaires and take samples:** This is a consideration which is important for the planning stage of a HBM study and is related to the choice of sample matrix to be monitored. It would be difficult to include this as an evaluation criterion as the information on the number of trained personnel is not readily available and would reflect status quo at the time of preparation of this list of biomarkers.
- **Practicality:**
  - Ethical considerations: The collection of some biological samples is less invasive and therefore they may be more straightforward to collect from participants. For example, hair and urine (particularly for studies involving children) may be easily obtained and collection poses a negligible risk, whereas blood is more difficult to obtain and collection may pose a greater risk to study participants. HBM4EU prioritised biomarkers requiring less invasive sampling methods and those where a high volume/quantity of sample matrix would be available for specific population groups (i.e. urine, placenta) and across the whole population (i.e. urine, blood, saliva). The limitations on the volume of blood available for sampling was noted as a methodological issue.
  - Logistics:
    - taking of samples (blood, hair, urine, etc.)
    - perishability of samples and ability to store.
  - Containers: Some parameters have specific requirements (e.g. PFAS)
  - Amount of sample required: Limited by amount available.
  - Obtaining informed consent, including for the reanalysis of samples in future studies.
- Can the analyses be done within the existing public laboratory network? INAB Accreditation Certificates may be used to identify Irish public laboratories with capability.
- **Cost:**
  - The cost per analysis can be an important factor in the selection of biomarkers for inclusion in a HBM study. Cost per analysis and unexpected costs were included as general considerations in the HBM4EU lists, but HBM4EU did not establish thresholds for these criteria.
  - What is the cost associated with taking the sample, e.g. trained personnel required to take certain sample types?

The criteria used to determine a list of suitable biomarkers to support and enhance risk assessment in Ireland include:

- **Relevance to food/beverages:** This criterion is intended to decide whether the biomarker is relevant for determining exposure from food/beverages/drinking water[3] as a source. If the substance of concern could foreseeably end up in food or beverages, due to its intentional use (e.g. pesticides, food contact materials) or unintentional presence (e.g. environmental contamination, process contaminants), then it has been deemed relevant. Substances without a plausible route of exposure from food or beverages have been excluded from the proposed list of biomarkers.
- **Risk criteria:** It is important that a proposed list of biomarkers is justified based on the potential risk to Irish consumers. In the context of this document, risk is defined as "the probability of an adverse effect in an organism, system or (sub)- population caused under specified circumstances by exposure to an agent" (International Programme on Chemical Safety, 2009). The biomarkers included in the HBM4EU lists have been justified with toxicological information on each substance group. To complete a risk characterisation, it is important that toxicological reference values are available for each substance to enable comparison with the measured exposure. Several sources to assist with the hazard characterisation of substances have been considered by the Working Group. Biomarkers without toxicological reference values or HBM thresholds in the following databases were excluded from the list:
  - The FSAI Toxicity Score which has been assigned to specific substances by the FSAI's Toxicological Focus Group according to the criteria included in the FSAI's Risk Ranking Model for Chemical Contaminants in Food (FSAI, 2019), i.e. nature of hazard and potency
  - Health-based guidance values available from risk assessments by the European Food Safety Authority (EFSA)
  - Human Biomonitoring Health-Based Guidance Value (HB2GV) from the International Society of Exposure Science (ISES) i-HBM Working Group dashboard
  - Human biomonitoring (HBM) values derived by the Human Biomonitoring Commission of the German Environment Agency.

[3] Microplastics were considered as a parameter with relevance in drinking water but was not included in the list due to the absence of suitable biomarkers.

3.3 Proposed list of possible biomarkers

Table 4 Proposed list of possible biomarkers

Group	CAS No.	Substance	Biomarker	Matrix
Phthalates	117-81-7	Di(2-ethylhexyl) phthalate (DEHP)	Mono(2-ethylhexyl) phthalate (MEHP)	Urine
			Mono(2-ethyl-5-hydroxy-hexyl) phthalate (5OH-MEHP, MEHHP)	Urine
			Mono(2-ethyl-5-oxo-hexyl) phthalate (5oxo-MEHP, MEOHP)	Urine
			Mono(2-ethyl-5-carboxy-pentyl) phthalate (5cx-MEPP, MECPP)	Urine
			Mono-[2-(carboxymethyl)hexyl] phthalate (MCMHP, 2cx-MMHP)	Urine
	85-68-7	Butyl benzyl phthalate (BBzP)	Mono-benzyl phthalate (MBzP)	Urine
	84-74-2	Di-n-butyl phthalate (DnBP)	Mono-n-butyl phthalate (MnBP)	Urine
			3-OH-Mono-n-butyl phthalate (OH-MnBP)	Urine
	84-69-5	Di-isobutyl phthalate (DiBP)	Mono-isobutyl phthalate (MiBP)	Urine
			2-OH-Mono-iso-butylphthalate (OH-MiBP)	Urine
	28553-12-0	Di-isononyl phthalate (DiNP)	Mono-isononyl phthalate (MiNP)	Urine
			7-OH-(Mono-methyl-octyl) phthalate (OH-MiNP, MHNP)	Urine
			7-Oxo-(Mono-methyl-octyl) phthalate (oxo-MiNP, MONP)	Urine
			7-Carboxy-(mono-methyl-heptyl) phthalate (cx-MiNP, MCOP)	Urine
	26761-40-0		Mono-iso decyl-phthalate (MiDP)	Urine

Group	CAS No.	Substance	Biomarker	Matrix
		Di-isodecyl phthalate (DiDP) (all C10 phthalates including DPHP)	6-OH-Mono-propyl-heptyl phthalate (OH-MiDP)	Urine
			6-Oxo-Mono-propyl-heptyl phthalate (oxo-MiDP)	Urine
			Mono(2,7-methyl-7-carboxy-heptyl) phthalate (cx-MiDP, MCNP)	Urine
Plasticisers	166412-78-8	Di-isononyl cyclohexane-1,2-dicarboxylate (DINCH)	cyclohexane-1,2-dicarboxylic acid-mono(isononyl) ester (MINCH)	Urine
			cyclohexane-1,2-dicarboxylate-mono-(7-carboxylate-4-methyl)heptyl ester (cx-MINCH, MCOCH)	Urine
			cyclohexane-1,2-dicarboxylate-mono-(7-hydroxy-4-methyl)octyl ester (OH-MINCH, MHNCH)	Urine
			cyclohexane-1,2-dicarboxylate-mono-(7-oxo-4-methyl)octyl ester (oxo-MINCH, MONCH)	Urine
	6422-86-2	Di(2-ethylhexyl) terephthalate (DEHTP)	1-mono-(2-ethyl-5-caboxylpentyl) benzene-1,4-dicarboxylate (5-cx-MEPTP)	Urine
			1-mono-(2-ethyl-5-oxohexyl) benzene-1,4-dicarboxylate (5oxo-MEHTP)	Urine
	103-23-1	Di(2-ethylhexyl) adipate (DEHA)	Mono-2-ethyl-5-hydroxyhexyl adipate (5OH-MEHA)	Urine
			Mono-5-carboxy-2-ethylpentyl adipate (5cx-MEPA)	Urine
Per- and polyfluoroalkyl substances (PFAS)	335-67-1	Perfluorooctanoic acid (PFOA)	PFOA	Serum
	375-95-1	Perfluorononanoic acid (PFNA)	PFNA	Serum
	335-76-2	Perfluorodecanoic acid (PFDA)	PFDA	Serum

Group	CAS No.	Substance	Biomarker	Matrix
	2058-94-8	Perfluoroundecanoic acid (PFUnDA)	PFUnDA	Serum
	307-55-1	Perfluorododecanoic acid (PFDoDA)	PFDoDA	Serum
	72629-94-8	Perfluorotridecanoic acid (PFTrDA)	PFTrDA	Serum
	376-06-7	Perfluorotetradecanoic acid (PFTeDA)	PFTeDA	Serum
	355-46-4	Perfluorohexane sulfonic acid (PFHxS)	PFHxS	Serum
	1763-23-1	Perfluorooctane sulfonic acid (PFOS)	PFOS	Serum
	307-24-4	Perfluorohexanoix acid (PFHxA)	PFHxA	Serum
	375-85-9	Perfluoroheptanoic acid (PFHpA)	PFHpA	Serum
	76-05-1	Trifluoroacetic acid (TFA)	TFA	Serum
	375-73-5	Perfluorobutane sulfonic acid (PFBS)	PFBS	Serum

Group	CAS No.	Substance	Biomarker	Matrix
	335-77-3	Perfluorodecane sulfonic acid (PFDS)	PFDS	Serum
	27619-97-2	6:2 fluorotelomer sulfonic acid (6:2 FTSA)	6:2 FTSA	Serum
	161094-75-3	6:2 Fluorotelomer unsaturated carboxylic acid (6:2 FTUCA)	6:2 FTUCA	Whole blood
Flame retardants (FRs)	41318-75	Polybrominated diphenylether-28 (BDE-28)	Polybrominated diphenylether-28 (BDE-28)	Serum
	5436- 43-1	Polybrominated diphenylether-47 (BDE-47)	Polybrominated diphenylether-47 (BDE-47)	Serum
	60348- 60-9	Polybrominated diphenylether-99 (BDE-99)	Polybrominated diphenylether-99 (BDE-99)	Serum
	189054- 64-8	Polybrominated diphenylether-100 (BDE-100)	Polybrominated diphenylether-100 (BDE-100)	Serum
	68631- 49-2	Polybrominated diphenylether-153 (BDE-153)	Polybrominated diphenylether-153 (BDE-153)	Serum

Group	CAS No.	Substance	Biomarker	Matrix
	207122-15- 4	Polybrominated diphenylether-154 (BDE-154)	Polybrominated diphenylether-154 (BDE-154)	Serum
	207122-16-5	Polybrominated diphenylether-183 (BDE-183)	Polybrominated diphenylether-183 (BDE-183)	Serum
	134237-50-6	α-Hexabromocyclododecane (α-HBCDD)	α-Hexabromocyclododecane (α-HBCDs)	Serum
	134237-51-7	β -Hexabromocyclododecane (β -HBCDD)	β -Hexabromocyclododecane (β -HBCDs)	Serum
	134237-52-8	γ -Hexabromocyclododecane (γ-HBCDD)	γ -Hexabromocyclododecane (γ-HBCDD)	Serum
	79-94-7	Tetrabromo bisphenol A (TBBPA)	Tetrabromo bisphenol A (TBBPA)	Serum
Bisphenols (BPs)	80-05-7	Bisphenol A (BPA)	Bisphenol A (BPA)	Urine
				Serum, plasma, whole blood
Polyaromatic hydrocarbons (PAHs)	91-20-3	Naphthalene (NAPH)	1-hydroxynaphthalene 2-hydroxynaphthalene	Urine
	218-01-9	Chrysene (CRY)	1-, 6-hydroxychrysene	Urine
	50-32-8	Benzo[c]-phenanthrene (BcPh)	3-hydroxybenzo[c]-phenanthrene	Urine

Group	CAS No.	Substance	Biomarker	Matrix
	56-55-3	Benz[a]anthracene (BaA)	1-hydroxybenz[a]anthracene	Urine
Anilines and MOCA	62-53-3	Aniline	Aniline	Urine
			N-acetylaniline, N-acetyl-4-aminophenol	Urine
	106-47-8	4-Chloroaniline (4CA)	4-Chloroaniline (4CA)	Urine
Acrylamide	79-06-1	Acrylamide	N-Acetyl-S-(2-carbamoyl-ethyl)cysteine (AAMA)	Urine
			N-Acetyl-S-(2-carbamoyl-2-hydroxyethyl)cysteine (GAMA)	Urine
			N-(2-Carbamoylethyl)valine (AAVal)	Whole blood
			N-(2-Carbamoyl-2-hydroxyethyl)valine (GAVal)	Whole blood
Aprotic solvents	872-50-4	N-methyl-2-pyrrolidone (NMP)	5-hydroxy-N-methyl-2-pyrrolidone (5-HNMP)	Urine
			2-hydroxy-N-methylsuccinimide (2-HMSI)	Urine
Metals and other elements	7440-43-9	Cadmium (Cd)	Cadmium (Cd)	Whole blood
				Urine
	7440-47-3	Chromium (Cr)	Chromium VI (Cr VI)	Blood serum
			Chromium VI and III (Cr VI and III)	Urine
	7440-38-2	Arsenic	Arsenic (total)	Urine
			Arsenic (inorganic form)	Urine
			Arsenic (III)	Urine
			Arsenic (V)	Urine

Group	CAS No.	Substance	Biomarker	Matrix
			Arsenobetaine (AsB), Arsenocholine (AsC), Methylarsonic acid (MMA) and dimethylarsinic acid (DMA)	Urine
	7439-92-1	Lead	Lead	Whole blood
				Urine
	7439-97-6	Mercury	Mercury (total)	Urine/whole blood
				Hair
			Methyl mercury	Whole blood
				Hair
Mycotoxins	1162-65-8	Aflatoxin B1 (AFB 1)	Aflatoxin B1 -lysine	Serum
			Aflatoxin B1	Urine
			Aflatoxin M1 (AFM1)	Urine
			Aflatoxin B1	Plasma
				Dried blood spot
			Aflatoxin B1 -N7-guanine	Urine
			Aflatoxin M1 (AFM1)	Plasma
				Human milk
	51481-10-8	Deoxynivalenol (DON) 3-acetyl-DON 15-acetyl-DON DON-3-glucoside	Deoxynivalenol (total deoxynivalenol after deconjugation = sum free deoxynivalenol + deoxynivalenol-15-glucuronide + deoxynivalenol-3-glucuronide)	Urine

Group	CAS No.	Substance	Biomarker	Matrix
	116355-83-0	Fumonisin B1 (FB1)	Fumonisin B1 (FB1)	Urine
Pesticides, including pyrethroids	2921-88-2	Chlorpyrifos	3,5,6-trichloro-2-pyridinol (TCPy)	Urine
	1071-83-6	Glyphosate	Glyphosate	Urine
			Aminomethylphosphonic acid (AMPA)	Urine
	26002-80-2	Phenothrin	trans-Chrysanthemumdicarboxyli c acid (trans-CDCA)	Urine
	584-79-2	Pyrethrum		Urine
	10453-86-8	Resmethrin		Urine
	82657-04-3	Bifenthrin	cis-3-(2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2-dimethylcyclopropanecarbo xylic acid (ClF3CA)	Urine
	82657-04-3	(lambda)cyhalothrin		Urine
	79538-32-2	Tefluthrin		Urine
	101007-06-1	Acrinathrin	3-phenoxybenzoic acid (3PBA)	Urine
	52918-63-5	Deltamethrin		Urine
	80844-07-1	Etofenprox		Urine
	52315-07-8	Cypermethrin		Urine
	26002-80-2	Phenothrin		Urine
	66230-04-4	(es)fenvalerate		Urine
	102851-06-9	Fluvalinate		Urine
	101007-06-1	Cyhalothrin		Urine

Group	CAS No.	Substance	Biomarker	Matrix
	39515-41-8	Fenpropathrin		Urine
	70124-77-5	Flucythrinate		Urine
	68359-37-5	Cyfluthrin	cis-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane-1-carboxylic acid (cis-DCCA)	Urine
	52315-07-8	Cypermethrin		Urine
				Urine
	52918-63-5	Deltamethrin	cis-(2,2-dibromovinyl)-2,2-dimethylcyclopropanecarbo xylic acid (DBCA)	Urine
	120068-37-3	Fipronil	Fipronil sulfone	Serum/plasma
Organophosphate pesticide	60-51-5	Dimethoate	Dimethyl phosphate (DMP)	Urine
			Dimethyl thiophosphate (DMTP)	Urine
			Dimethyl dithiophosphate (DMDTP)	Urine
UV filters-benzophenones	119-61-9	Benzophenone (BP)	Benzophenone (BP)	Urine
Neonicotinoids	135410-20-7	Acetamiprid	N-desmethyl acetamiprid (CAS No. 190604-92-3) Acetamiprid (CAS No. 135410-20-7)	Urine
	138261-41-3	Imidacloprid	Imidacloprid (CAS No. 138261-41-3) Imidacloprid olefin (CAS No. 115086-54-9) Imidacloprid 5-hydroxy	Urine

References

Apel, P., Rousselle, C., Lange, R., Sissoko, F., Kolossa-Gehring, M., Ougier, E. (2020). Human biomonitoring initiative (HBM4EU)—Strategy to derive human biomonitoring guidance values (HBM-GVs) for health risk assessment. *Int. J. Hyg. Environ. Health.* 230, 113622.

Charrondiere, U.R. (2013). Preparing a Food List for a Total Diet Study. In: Moy, G., Vannoort, R. (eds) Total Diet Studies. Springer, New York, NY. https://doi.org/10.1007/978-1-4419-7689-5_6

Connolly, A., Basinas, I., Jones, K., Galea, K.S., Kenny, L., McGowan, P., Coggins, M. (2018). Characterising glyphosate exposures among amenity horticulturists using multiple spot urine samples, *Int. J. Hyg. Environ. Health.* 221(7), 1012-1022.

Connolly, A., Jones, K., Basinas, I., Galea, K.S., Kenny, L., McGowan, P., Coggins, M. (2019). Exploring the half-life of glyphosate in human urine samples, *Int. J. Hyg. Environ. Health.* 222(2), 205-210.

Connolly, A., Coggins, M., Galea, K.S., Jones, K., Kenny, L., McGowan, P., Basinas, I. (2019). Evaluating glyphosate exposure routes and their contribution to total body burden: A study among amenity horticulturalists, *Annals of Work Exposures and Health*, 63(2), 133–147.

Connolly, A., Koch, H.M., Bury, D., Koslitz, S., Kolossa-Gehring, M., Conrad, A., Murawski, A., McGrath, J.A., Leahy, M., Brüning, T., *et al*. (2022). A human biomonitoring study assessing glyphosate and aminomethylphosphonic acid (AMPA) exposures among farm and non-farm families. *Toxics*, 10(11), 690.

Cullen, E., Evans, D., Davidson, F., Burke, P., Burns, D., Flanagan, A., Griffin, C., Kellegher, A., Mannion, R., Mulcahy, M., Ryan, M., Biot, P., Casteleyn, L., Castaño, A., Angerer, J., Koch, H., Esteban, M., Schindler, B., Navarro, C., Kolossa-Gehring, M., Fiddicke, U., Schoeters, G., Hond, E., Sepai, O., Exley, K., Bloemen, L., Knudsen, L., Joas, R., Joas, A., Aerts, D. (2014). Mercury exposure in Ireland: Results of the DEMOCOPHES human biomonitoring study. *International Journal of Environmental Research and Public Health,* 11(9), 9760–9775.

Cullen, E., Evans, D., Griffin, C., Burke, P., Mannion, R., Burns, D., Flanagan, A., Kellegher, A., Schoeters, G., Govarts, E., Biot, P., Casteleyn, L., Castaño, A., Kolossa-Gehring, M., Esteban, M., Schwedler, G., Koch, H., Angerer, J., Knudsen, L., Joas, R., Joas, A., Dumez, B., Sepai, O., Exley, K., Aerts, D. (2017). Urinary phthalate concentrations in mothers and their children in Ireland: Results of the DEMOCOPHES human biomonitoring study*. International Journal of Environmental Research and Public Health*, 14(12), 1456.

EFSA/FAO/WHO (2011). Towards a harmonised Total Diet Study approach: a guidance document. EFSA Journal, 9(11):2450. Available: doi: 10.2903/j.efsa.2011.2450.

EFSA (2013). Scientific Opinion on the re-evaluation of aspartame (E 951) as a food additive. EFSA Journal, . 11(12):3496. Available: doi: 10.2903/j.efsa.2011.2450

EFSA (2016). Risks for human health related to the presence of 3- and 2-monochloropropanediol (MCPD), and their fatty acid esters, and glycidyl fatty acid esters in food. EFSA Journal, . 14(5):4426. Available: doi: 10.2903/j.efsa.2016.4426

EFSA (2017a). Human and animal dietary exposure to ergot alkaloids. EFSA Journal, . 15(7):4902. Available: doi: 10.2903/j.efsa.2017.4902

EFSA (2017b). Risks for human health related to the presence of pyrrolizidine alkaloids in honey, tea, herbal infusions and food supplements. EFSA Journal, . 15(7):4908. Available: doi: 10.2903/j.efsa.2017.4908

EFSA (2018a). Update of the risk assessment on 3-monochloropropane diol and its fatty acid esters. EFSA Journal, . 16(1):5083. Available: doi: 10.2903/j.efsa.2018.5083

EFSA (2018b). Human acute exposure assessment to tropane alkaloids. EFSA Journal, . 16(2):5160. Available: doi: 10.2903/j.efsa.2018.5160

EFSA (2018c). Update of the Scientific Opinion on opium alkaloids in poppy seeds. EFSA Journal, . 16(5):5243. Available: doi: 10.2903/j.efsa.2018.5243

EFSA (2020a). Update of the risk assessment of nickel in food and drinking water. EFSA Journal, . 18(11):626. Available: doi: 10.2903/j.efsa.2020.6268.

EFSA (2020b). Risk to human health related to the presence of perfluoroalkyl substances in food, . 18(9):6223. Available: doi: 10.2903/j.efsa.2020.6223

EFSA (2023a). Re-evaluation of the existing health-based guidance values for copper and exposure assessment from all sources. EFSA Journal, . 21(1):7728. Available: doi: 10.2903/j.efsa.2023.7728

EFSA (2023b). Peer review of the pesticide risk assessment of the active substance glyphosate. EFSA Journal, . 21(7):8164. Available: doi: 10.2903/j.efsa.2023.8164

Environmental Protection Agency (2004). Final report of Expert Group for Silvermines County Tipperary - Lead and other relevant metals. Wexford: Office of Environmental Enforcement, Environmental Protection Agency. Available: https://www.epa.ie/publications/monitoring--assessment/assessment/land-and-soil/EPA_final_report_silvermines_2004.pdf

European Commission (2023). Commission Recommendation (EU) 2023/965 of 12 May 2023 on the methodology for the monitoring of food additive and food flavouring intake. Official Journal. 129, 17–24.

FSAI (2016). Report on a total diet study carried out by the Food Safety Authority of Ireland in the period 2012 – 2014. Dublin: Food Safety Authority of Ireland, Available: https://www.fsai.ie/publications/report-on-a-total-diet-study-carried-out-by-the-fo.

HBM4EU (2017). Criteria for prioritisation of biomarkers of effect. Available: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwj5lZfjiKyIAxW0UEEAHeASGtsQFnoECCMQAQ&url=https%3A%2F%2Fec.europa.eu%2Fresearch%2Fparticipants%2Fdocuments%2FdownloadPublic%3FdocumentIds%3D080166e5b1f6ccb5%26appId%3DPPGMS&usg=AOvVaw15PshZqPnZhSgc2h66s2Hb&opi=89978449

Houlihan M., Wemken N., Keogh M., O'Riordain C., Noone C., Tierney J., Cellarius C., Cleere K., Morrison J. J., Daly S., Harrad S., Tlustos C., Coggins M. (2021). Concentrations of polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs) in human milk from Ireland: temporal trends and implications for nursing infant exposure. *J Environ Expo Assess,* 1(2), 1-15

International Programme on Chemical Safety. (2009). Principles and methods for the risk assessment of chemicals in food. Geneva: World Health Organization (WHO). Available at: https://iris.who.int/bitstream/handle/10665/44065/WHO_EHC_240_eng.pdf.

International Programme on Chemical Safety & Inter-Organization Programme for the Sound Management of Chemicals. (2010). Strontium and strontium compounds. World Health Organization. Available at: https://iris.who.int/handle/10665/44280

JECFA/IARC (2023). Summary of findings of the evaluation of aspartame at the International Agency for Research on Cancer (IARC) Monographs Programme's 134th Meeting, 6–13 June 2023 and The JOINT FAO/WHO EXPERT COMMITTEE ON FOOD ADDITIVES (JECFA) 96th meeting, 27 June–6 July 2023. Available at: https://www.who.int/publications/m/item/summary-of-findings-of-the-evaluation-of-aspartame-at-the-international-agency-for-research-on-cancer-(iarc)-monographs-programme-s-134th-meeting--and-the-joint-fao-who-expert-committee-on-food-additives-(jecfa)-96th-meeting

US EPA (1992). Strontium. Integrated Risk Information System (IRIS) Chemical Assessment Summary. United States Environmental Protection Agency. Available at: Strontium (CASRN 7440-24-6) | IRIS | US EPA

Vorkamp, A., Castaño, K., Antignac, J., L. Boada, D., Cequier, E., Covaci, A., Lopez, M.E, Haug, L.S., Kasper-Sonnenberg, M., Koch, H.M., Pérez Luzardo, O., Osīte, A., Rambaud, L., Pinorini, M.T., Sabbioni, G., Thomsen C. (2021). Biomarkers, matrices and analytical methods targeting human exposure to chemicals selected for a European human biomonitoring initiative. *Environ. Int.*, 146, 106082.

World Health Organization & International Programme on Chemical Safety (2001). Biomarkers In risk assessment: Validity and validation. Geneva: World Health Organization. Available: https://www.inchem.org/documents/ehc/ehc/ehc222.htm#1.0

Appendix 1 Request for Advice from the Scientific Committee

Topic Title: Parameter/foodstuff combinations for consideration in the next Total Diet Study and the selection of appropriate biomarkers to support risk assessment in Ireland.

Date Requested: 12 May 2023

Date Accepted: 22 May 2023

Target Deadline for Advice: November 2023

Form of Advice required: Internal advice to the FSAI

Subcommittee: Chemical Safety Subcommittee

Background/Context

A Total Diet Study (TDS) is a public health tool for the determination of dietary exposure to chemical substances such as contaminants, pesticides, additives and nutrients across a population's entire diet. It consists of selecting and collecting commonly consumed foods purchased at retail level, processing and preparing these foods as they would be prepared for consumption and analysing them for harmful and/or beneficial chemical substances (EFSA/FAO/WHO, 2011). These occurrence data are combined with food consumption data from the Irish Universities Nutrition Alliance dietary surveys to provide an estimate of the dietary exposure to chemicals in the Irish diet. A comparison of these dietary exposure estimates for each chemical parameter with its respective health-based guidance value (HBGV) provides a realistic estimate of the risk of exposure or inadequate consumption in the case of nutrients to the Irish population from these chemicals in food. The results of a TDS can be used as a priority-setting tool to enable risk managers to focus their limited resources on those chemicals and foods which are considered to pose risks to public health (FSAI, 2016). The outcomes of the 2012-2014 TDS have been used to inform the FSAI risk ranking model which in turn is used to prioritise the substances for monitoring as part of the annual National Chemical Sampling Programme.

As part of the TDS undertaken by the FSAI during the period 2012-2014, a total of 141 food groups were analysed for the presence of 22 different parameters (See Appendix 1). The outcome of this study showed that the Irish population is generally not at risk from exposure above the relevant HBGV. Potential concerns were identified for exposure to acrylamide, aflatoxins, and lead. While the TDS methodology is excellent for estimating dietary exposure, it doesn't take into account

exposure from other sources. A human biomonitoring study (HBM) can be used to validate and support risk assessment by integrating exposure from all sources and routes and quantifying the presence of chemicals in the human body. A biological marker, or biomarker, has been defined by the WHO *"in a broad sense to include almost any measurement reflecting an interaction between a biological system and an environmental agent, which may be chemical, physical or biological"* (WHO, 1993). Measurement of biomarkers may be used to assess change in the biological systems. In the context of this document the biological system of interest is the human body. Biomarkers are primarily used in population studies to assess exposure and to determine whether there is a link between exposure and adverse health effects. In terms of risk assessment, biomarkers may provide a more comprehensive assessment of actual human exposure (body burden) to a xenobiotic from all sources and routes compared to risk assessment models based dietary exposure. A HBM study was used to supplement the cadmium findings in the 2012-2014 TDS, wherein urine samples collected from Irish subjects partaking in the National Adult Nutrition Survey (2008-2010) were analysed for a biomarker representative of the body burden and the cumulative amount of cadmium in the kidneys.

Several HBM studies have previously been carried out in Ireland, such as mercury in hair and urinary phthalate in mother/child pairs (Cullen *et al.*, 2014; 2017), persistent organic pollutants in human breast milk (Houlihan *et al.*, 2021) and lead in blood from residents in the Silvermines area of Co. Tipperary (EPA, 2004). More recently, to address the need for harmonisation in HBM studies and to advance research on biomarkers, the European Human Biomonitoring Initiative (HBM4EU) (www.hbm4eu.eu) was set up under the scope of the European Commission. For the purpose of facilitating the need for a more comprehensive estimation of the Irish population's exposure to chemical substances, the FSAI is seeking expert advice on potential biomarkers to include in a HBM study which could be used to supplement the findings of the next TDS and enhance future risk assessment projects in Ireland. Furthermore, the identification of a list of appropriate biomarkers of relevance in the Irish context will support and enhance future risk assessment projects in Ireland and could be a useful resource in the event that there is concern relating to the exposure to a specific substance or following a food incident.

Questions to be addressed by the Scientific Committee

4. Are the food groups that were included in the previous TDS still relevant? Should other food groups be included due to changes in dietary patterns over the last ten years?

5. Are the chemical parameters included in the previous TDS appropriate or should other contaminants regulated since, also be considered for inclusion and are there any that no longer need to be included?

   In addressing questions one and two, consideration should be given to the outcome of the risk ranking exercise and other relevant factors.

6. What biomarkers are most appropriate and feasible to support and enhance risk assessment in Ireland as necessary? In addressing this question, consideration should be given to the limiting/constraining factors, and it should also be taken into account that a biomarker should be sensitive, specific, biologically relevant, practical, inexpensive and available.

References

Cullen, E., Evans, D., Davidson, F., Burke, P., Burns, D., Flanagan, A., Griffin, C., Kellegher, A., Mannion, R., Mulcahy, M., Ryan, M., Biot, P., Casteleyn, L., Castaño, A., Angerer, J., Koch, H., Esteban, M., Schindler, B., Navarro, C., Kolossa-Gehring, M., Fiddicke, U., Schoeters, G., Hond, E., Sepai, O., Exley, K., Bloemen, L., Knudsen, L., Joas, R., Joas, A., Aerts, D. (2014). Mercury Exposure in Ireland: Results of the DEMOCOPHES Human Biomonitoring Study, International Journal of Environmental Research and Public Health, 11(9), 9760–9775.

Cullen, E., Evans, D., Griffin, C., Burke, P., Mannion, R., Burns, D., Flanagan, A., Kellegher, A., Schoeters, G., Govarts, E., Biot, P., Casteleyn, L., Castaño, A., Kolossa-Gehring, M., Esteban, M., Schwedler, G., Koch, H., Angerer, J., Knudsen, L., Joas, R., Joas, A., Dumez, B., Sepai, O., Exley, K., Aerts, D. (2017). Urinary Phthalate Concentrations in Mothers and Their Children in Ireland: Results of the DEMOCOPHES Human Biomonitoring Study, International Journal of Environmental Research and Public Health, 14(12), 1456.

EFSA/FAO/WHO (2011). Towards a harmonised Total Diet Study approach: a guidance document. EFSA Journal, 9(11):2450. Available: doi: 10.2903/j.efsa.2011.2450.

EPA (2004). Final Report of Expert Group for Silvermines County Tipperary - Lead and Other Relevant Metals. Wexford: Office of Environmental Enforcement, Environmental Protection Agency. Available: https://www.epa.ie/publications/monitoring--assessment/assessment/land-and-soil/EPA_final_report_silvermines_2004.pdf

FSAI (2016). Report on a total diet study carried out by the Food Safety Authority of Ireland in the period 2012 – 2014. Dublin: Food Safety Authority of Ireland, Available: https://www.fsai.ie/publications/report-on-a-total-diet-study-carried-out-by-the-fo.

Houlihan M., Wemken N., Keogh M., O'Riordain C. Noone C., Tierney J., Cellarius C., Cleere K., Morrison J. J., Daly S., Harrad S., Tlustos C., Coggins M. (2021) Concentrations of polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs) in human milk from Ireland: temporal trends and implications for nursing infant exposure, *J Environ Expo Assess, 1(2), 1-15*

World Health Organization & International Programme on Chemical Safety (1993). Biomarkers and risk assessment: concepts and principles / published under the joint sponsorship of the United Nations environment Programme, the International Labour Organisation, and the World Health Organization. Geneva: World Health Organization.
Available: https://apps.who.int/iris/handle/10665/39037.

Appendix 1

Table 1. List of food additives, contaminants, food contact materials and nutrients analysed in the 2012–2014 FSAI TDS

Aluminium	Mercury	Bisphenol A (BPA)
Arsenic	Selenium	Phthalates
Inorganic Arsenic	Tin	Pesticide Multi-screen[4]
Cadmium	Acrylamide	Aflatoxins
Chromium	Nitrates	Fumonisins
Iodine	Nitrites	Ochratoxin A
Lead	PAHs	Patulin
Aluminium	Mercury	Trichothecenes
Zearalenone		

[4] Refer to Annex I of the Report on a Total Diet Study carried out by the Food Safety Authority of Ireland in the period 2012–2014 (FSAI, 2016)

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