



# PFAS ON OUR PLATE: THE CRITICAL NEED FOR STRONGER FOOD REGULATION AND TESTING

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Science for a Safer World

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## Abstract

Potentially **unsafe levels of per- and polyfluorinated substances (PFAS)** in food and drink have become a major global concern. Increased detection of these environmental and packaging contaminants, and their **association with disorders such as diabetes, cancer, and immune weakening**, has gradually forced some leading governments to introduce new regulations. So far, these consist broadly of maximum permitted levels for PFAS in drinking water in the **European Union (EU)** and the **United States (US)**, as well as for **high-risk foods like seafood and dairy** in Europe.

However, gaps and inconsistencies in PFAS regulations at national and international levels – such as varying maximum limits, differing packaging requirements, and incomplete legislation for all chemicals of concern – create operational challenges that complicate the efforts of food manufacturers to provide nutritious, safe, and compliant products while also avoiding the threat of litigation. These challenges also highlight the urgent need for global collaboration and regulatory harmonisation to protect consumers. Yet the current lack of comprehensive toxicology data for all PFAS compounds at environmentally relevant levels leaves **regulators in a difficult position**.

This whitepaper examines the scale and severity of PFAS contamination in food in light of recent toxicology data, evaluates global regulatory progress, and considers expert opinions on the necessary steps to enhance clarity for the food industry and better safeguard public health. Additionally, we review the impact of advancements in sample processing and analytical techniques such as Liquid Chromatography (LC), Gas Chromatography (GC), Mass Spectrometry (MS), High Resolution Mass Spectrometry (HRMS), and Nuclear Magnetic Resonance (NMR) for detecting and quantifying trace levels of PFAS across various food and packaging matrices.

## Stability, ubiquity, toxicity

PFAS are a class of around 15,000 chemical compounds produced since the 1940s, and widely used in various industries and consumer products – such as **pesticide production, electroplating, packaging, paper making**, pans, paints, and water-resistant clothes. Due to the remarkably strong carbon-fluorine bonds they share, **PFAS display “exceptional environmental stability”** – which means that they have **“a higher tendency to bioaccumulate and resist biodegradation**, leading to significant consequences including environmental contamination and subsequent pollution of food sources.” This tendency to bioaccumulate is also reinforced by their ubiquity – which entails a large number of potential contamination sources – as well as **many PFAS’ ability to migrate from their original products and into waterways and soils**. In combination, all of these factors can result in long term PFAS exposure in humans, and a number of adverse health effects.

**One of the first major studies into the potential dangers of PFAS** was a 69,000-person survey conducted from 2005-6: part of a legal settlement between various communities in West Virginia and the DuPont company, following the contamination of local water supplies by perfluoro octanoic acid (PFOA, or C8) from DuPont’s Washington Works Plant. Based on the results of the study, a three man panel of independent epidemiologists announced that **there was a “probable link” between exposure to PFOA/C8 and testicular and kidney cancer, ulcerative colitis, thyroid disease, high cholesterol, and pregnancy-induced hypertension**. In 2016, an evaluation of human, animal, and laboratory studies by the US National Toxicology Program found that **both PFOA and perfluoro octane sulfonate (PFOS) posed potential immune-related risks to humans**, with “compelling evidence linking both substances to the suppression of the antibody response” – and with PFOS also implicated in the suppression of natural killer cell activity. Meanwhile, more recent studies have revealed a **positive relationship between body weight and liver damage for 13 PFAS**, as well as developmental and **reproductive toxicity caused by PFAS exposure**. Finally, the World Health Organisation’s cancer research agency, IARC, published **a monograph in Lancet Oncology** earlier this year, officially **classifying PFOA as carcinogenic to humans and PFOS as “possibly carcinogenic.”**

TABLE 1

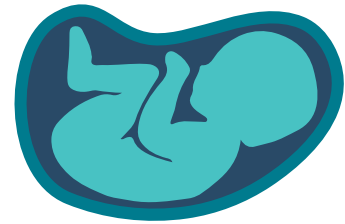
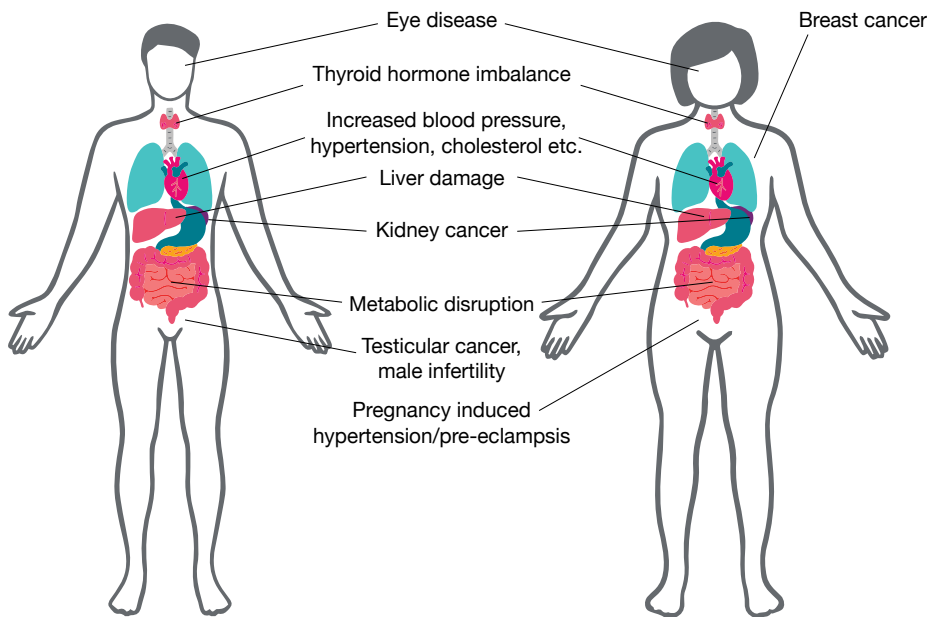
## Understanding common PFAS: short-chain vs. long-chain compounds

PFAS type	Carbon chain length	Characteristics
Perfluoroalkyl Substances (PFOS and PFOA)	Long-chain	Highly persistent environmental contaminant, bioaccumulative, and toxic. Used in industrial as well as consumer products. Banned or phased out in many countries.
Perfluoroalkyl Substances (PFHxS, PFNA, PFDA)	Long-chain	Less persistent in the environment and less toxic than PFOS and PFOA.
Polyfluoroalkyl Substances (GenX, PFBS)	Short-chain	Lower persistence and toxicity compared with long chain PFAS, but little is known about their environmental behavior and potential health effects. Used as alternatives to long-chain PFAS.
Emerging PFAS (PFPeA, PFDoA)	Various	Newer, lesser-known PFAS that are being studied for their environmental persistence and potential health effects. They may have short or long carbon chain lengths. Little is known about their use and exposure levels.

Adapted from Chukwuebuka *et al* 2024

**FIGURE 1**

**Diseases and disorders associated with exposure to PFAS**



**Developmental effects affecting unborn babies**

- Obesity
- Delayed mammary gland development
- Lower birth weight
- Early puberty onset
- Increased miscarriage risk
- Low sperm count and mobility

Adapted from Chukwuebuka et al 2024

**How PFAS get into food**

As one recent study argues, **“For the majority of people, diet is the main way they are exposed to PFAS.”** Research has identified a number of **foodborne exposure pathways**, including the use of PFAS-containing processing and kitchen equipment, as well as cooking food in contaminated water.

**Another main route for forever chemicals to “infiltrate into food and increase exposure” is via Food Contact Materials (FCMs)**, given that **several thousand PFAS are used in food packaging** to add properties such as fat- and water resistance. A pioneering University of Southern California (USC) study into the **associations between dietary intake and longitudinal PFAS concentrations** this year found **evidence of food packaging contamination** in the fact that “burritos, fajitas, tacos, French fries and pizza made at home were associated with lower PFAS concentrations. But those who ate the same dishes prepared at restaurants typically showed increased PFAS concentrations in their blood.” Similarly, while eating nuts was associated with a reduction in blood PFAS levels, **a one-serving higher intake of nut- and seed butters – which are often wrapped in greaseproof paper – was associated with a 35.59% higher PFPeS (perfluoro pentane sulfonic acid) concentration.** “We’re starting to see that **even foods that are metabolically quite healthy can be contaminated with PFAS,**” said study lead author Hailey Hampson, adding: “These findings highlight the need to look at what constitutes ‘healthy’ food in a different way.”

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A wide range of foods – ranging from fruit and vegetable crops to meat from animals that graze on contaminated land – can also become exposed to PFAS via soils and waters. Although early contamination studies focused on **“hotspots” like industrial plants, and military bases** where PFAS firefighting foams were used, the agricultural use of sewage sludge and wastewaters is now thought to be responsible for many of the PFAS present in our foods. As **a review article** published in June this year explains, “The PFAS in biosolids has the potential to leach into groundwater and contaminate drinking water (that) can potentially be absorbed by crops, which exposes humans to them through food.” Such is the prevalence of PFAS that even toilet paper present in sewage sludge presents a threat: **a University of Florida report** last year estimated that toilet paper treated with industrial lubricants to stop it sticking to machinery contributed between 6.4-80 µg/person-year of the **endocrine-disrupting PFAS compound 6:2 diPAP** (6:2 polyfluoroalkyl phosphate diester) – and was **“a potentially major source of PFAS entering wastewater treatment systems.”**



## Seafood, fish and forever chemicals

When it comes to the safety of a fish dish, researchers admit there is **“a significant knowledge gap... in understanding the health impact of (PFAS) in both marine mammals and humans through fish consumption.”**

However, it is believed that fish and seafood may be particularly at risk from PFAS contamination due to a number of factors – including **feeding patterns**, as well as their **proximity to coastal sources of PFAS, like rivers, industrial outflows** and wastewater treatment works. A research paper published in February – claiming to be **the first robust estimate of PFAS transport in a European river system** – calculated that the River Mersey in northern England exported around 68.1kg of PFAS to the sea each year, while early estimates **put the concentration of PFAS in the global oceans** at several thousand ng/L. A number of studies, many of them published this year, have also produced evidence that PFAS are becoming “pervasive” in certain types of seafood, and strongly present or bioaccumulating in other fish species, and therefore pose a potential threat to human health.



### ■ **The view from the Mediterranean**

Analysis from Italy published in May concluded that commonly consumed types of wild seafood from the Mediterranean Sea are a source of potentially harmful PFAS contaminants as well as valuable nutrients. Specifically, it calculated that benthic and demersal seafood – such as clams, squid and cuttlefish – “are more prone to contamination with PFAS such as C9-C14 perfluorocarboxylic acids”. It also estimated that the potential contribution of such wild species to consumers’ PFAS intake could be “well above the provisional health-based guidance value” recommended in Europe. Commenting on the research, *Affidia Journal* said that the **“pervasive presence” of PFAS in fish and seafood** added “a new dimension to the challenge” of keeping foods safe.

### ■ **Hazards in New Hampshire**

In an echo of the Italian study from across the Atlantic, researchers from Dartmouth College also reported that **eating large quantities of certain seafoods could pose a health risk to consumers**. After analysing cod, haddock, lobster, salmon, scallop, shrimp, and tuna purchased from a New Hampshire market, the Dartmouth team found that **shrimp and lobster contained the highest concentrations of PFAS** – with average scores for certain compounds ranging as high as 1.74ng/g of flesh for shrimp, and 3.30ng/g for lobster. Noting that the US had guidelines for safe levels of mercury and other contaminants in seafood but none for PFAS, the study authors said their findings had highlighted **“the need for more rigorous regulations around PFAS contamination** to prevent it from getting into our food chain in the first place.”

### ■ **Risking illness in Illinois**

In June, a team from the University of Illinois published a study of four local waterways that “indicates with certainty the presence of (PFAS) compounds in fish and the associated health effect based on accumulation.” It found “elevated levels of PFOS...in nearly all fish”, while average levels of PFAS across all nine species studied were above state advisory triggers for safe fish consumption. Another concern was that **PFAS levels increased at each trophic level**, with Channel Catfish consistently the most contaminated, “indicating bioaccumulation potential across the food chain.” The research group concluded (a) that “the high levels of PFAS detected... suggest that there may be health risks associated with the consumption of certain types of fish”, and (b) “based on the data provided, a need for regulation and monitoring of PFAS levels in water sources is imminent.”

### ■ **PFOS is biomagnifying in the US Great Lakes**

Research into the concentration of 40 PFAS in the muscle and serum of three trophic levels of fish revealed a **biomagnification factor** of greater than one for **PFOS in all species, in the St Clair and Detroit River food webs**. A total of 23 PFAS varieties were detected, leading to the **novel detection of four PFAS compounds in Great Lakes fish**.

### ■ **An ‘environmental injustice’**

Last year, data analysis of more than 500 composite fish fillet samples collected across the US between 2013 and 2015 confirmed a key trend from many of the above reports: that “an individual’s consumption of freshwater fish is potentially a significant source of exposure to perfluorinated compounds” **The report** – by scientists at Duke University and the advocacy organisation Environmental Working Group – also revealed that “one fish serving can be equivalent to drinking water for a month at 48 ppt PFOS” (**the new US maximum contaminant level for PFOS in drinking water** is 4 ppt). The authors also argued that: “The exposure to (PFAS) chemical pollutants in freshwater fish across the United States is a case of environmental injustice (because it) especially affects communities that depend on fishing for sustenance and for traditional cultural practices.”



## Regulatory confusion, practical challenges

Harmonising international PFAS food regulations is essential for providing a consistent, risk-based approach that helps food producers operating globally to better serve their consumers. While some countries have responded to the emerging threat by setting stringent, enforceable limits for PFAS in food and drinking water, others have yet to establish comprehensive guidelines, creating considerable potential for confusion.

For instance, the EU has set enforceable maximum limits for PFAS in high-risk foods, whereas the US and China have not. In addition, while there is a clear overall trend towards stricter regulation of PFAS in food packaging, approaches and implementation timelines vary widely between jurisdictions – resulting in **a lack of clarity and consistency** that presents food manufacturers and their partners in related industries with operational challenges. For instance, after New York and California's PFAS packaging bans went into effect in 2022 and 2023 respectively, **a well-known butter brand** was withdrawn from stores for about two months in a voluntary recall, while the company confirmed compliance with state packaging laws. Despite the recall, or perhaps because of it, the company was targeted with a class action lawsuit alleging that it falsely marketed its butter as pure, although it may have contained synthetic PFAS.

Even within regions that have made clear progress in responding to the challenge, such as Europe, differing thresholds for restricting PFAS in parallel sets of regulations can add further confusion. For instance, some observers feel that attempts to account for high PFAS environmental backgrounds have moved regulatory thresholds too far from a solid grounding in risk-based analysis. To take a specific example, after considering factors including high levels of contamination and the nutritional value of the food, the EU tolerable weekly intake (TWI) for PFOS in some white fish was set up to **600 times higher** than corresponding maximum levels in the draft **EU Water Framework Directive**. “The level of environmental and health protection regarding a specific chemical should be equivalent in similar regulatory contexts and circumstances,” argues **Jussi Reinikainen**, a senior adviser to the Finnish Environment Institute. While **many acknowledge** the necessity for regulations to consider high PFAS contamination in specific regions, and the significant nutritional value of foods such as fish, **Reinikainen maintains** that: “A regulatory threshold that cannot be complied with or that mostly ignores the risks – in this case due to the widespread occurrence of PFAS – is effectively useless and likely to complicate rather than mitigate reasonable risk-based decision-making”. After carrying out a detailed analysis of **EU PFAS regulatory thresholds**, Reinikainen and his colleagues called earlier this year “for an open dialogue on both the scientific and policy aspects of the current and proposed PFAS thresholds to promote rational regulatory development and sustainable management practices on these chemicals.”

Another significant challenge is that current monitoring and **regulatory frameworks** for food do not capture all PFAS, and tend to focus on a few well-known compounds, such as PFOA, PFOS, perfluoro nonanoic acids (PFNA), and perfluoro hexane sulfonic acid (PFHxS). However, with around 15,000 types of PFAS already in existence, and new compounds continually being produced, this approach severely underestimates the threat and leaves many potentially toxic compounds unmonitored.

More advanced, targeted and non-targeted, approaches to detecting trace levels of PFAS in food could pave the way for future regulations that treat PFAS as a group of chemicals – in a similar manner to **how dioxins and PCBs are regulated**. This type of comprehensive approach would enable a more accurate calculation of cumulative risk, and close regulatory gaps by automatically accounting for new or unknown PFAS. However, without further development of analytical techniques to detect and quantify a wide range of PFAS at very low concentrations – and a

deeper understanding of the causal links between PFAS exposure, toxicity, and health effects – implementation is currently impossible and **unenforceable**.

Philippe Grandjean, adjunct professor of environmental health at Harvard T.H. Chan School of Public Health, meanwhile **argues in favour of a precautionary approach**, commenting: “I’m willing to accept that some PFAS compounds may pose fewer human health risks. But I would like to see the proof of their safety before they’re allowed to be used in products, rather than finding out 10 to 15 years down the road that these compounds don’t break down in the body, that they accumulate, and that women pass them down to their children.”



## Global PFAS regulation so far

PFOS was **the first PFAS compound to be regulated by the EU**, by being included on its Annex XVII list of restricted substances under the REACH programme in 2006. In 2009, PFOA, PFOS, and their precursors were listed as persistent organic pollutants (POPs) under the **Stockholm Convention** and subsequently banned in the EU, as well as countries including the US, Canada, Japan, and Australia. The Stockholm Convention was also **updated in 2022** to include PFHxS, its salts, and related compounds.

### ■ The EU

In drinking water, **the EU has set a maximum limit of 0.1 µg/l (100 ppt) for 20 individual PFAS** – including perfluoro-4 (perfluoro butyl) pentanoic acid (PFPB), perfluoro pentanoic acid (PFPeA), perfluoro hexanoic acid (PFHxA), perfluoro heptanoic acid (PFHpA) and PFOA – as well as an upper limit of 0.5 µg/l (500 parts per trillion, or ppt) for the sum of all listed PFAS. These regulations apply to a range of PFAS, including perfluoroalkyl carboxylic acids (PFCAs) and perfluoro sulfonic acids (PFSAs), with chain lengths from C4 to C13.

**European Food Safety Authority (EFSA) guidelines** also recommend monitoring food products, particularly fish and dairy, and establish a tolerable weekly intake (TWI) of 4.4 ng/kg of body weight per week for combinations of PFAS compounds including PFOS, PFOA, PFNA, and PFHxS. Maximum limits are also set for various foodstuffs, such as 1.7 µg/kg for the sum of the same four PFAS compounds in eggs, 45 µg/kg in certain fish (such as anchovy and eel), and 5 µg/kg in crustaceans and molluscs.

Similarly, the European Chemicals Agency (**ECHA**) is working on banning the use of most PFAS in **food contact materials (FCMs)** in the EU, although some member states have already taken individual action – such as Denmark’s post-2020 ban on PFAS in food contact paper and board materials. Next year, EU members are also expected to consider what the European Chemicals Agency (ECHA) has described as “one of the broadest” restrictions on chemicals in the EU’s history. *Chemistry World* has said that, if passed, the joint proposal from Germany, Denmark, the Netherlands, Norway and Sweden to radically restrict PFAS “would **essentially ban the entire class of more than 10,000 chemicals in a single stroke**, including their **production, use, and sale.**”



## Analytical methods for detecting PFAS in food and packaging

Given the significant health risks associated with reported unsafe levels of PFAS in food and their potential to migrate from FCMs, detecting PFAS in food matrices and packaging materials, such as paper and cardboard, has become a **critical focus** in recent years.

PFAS are complex mixtures of compounds with varying chain lengths, functional groups, and degrees of fluorination. These diverse structures and sample types require high-performance analytical methods to identify trace levels of pollutants. Currently, there is **no universal method** for PFAS analysis. The most common techniques are LC-MS and GC-MS for qualitative and quantitative analysis of PFAS **in complex matrixes**. Various sample **cleanup and extraction methods** have also been applied, including liquid-liquid extraction (LLE), solid phase extraction (SPE) and alkaline digestion, followed by advanced and sensitive detection methods for PFAS in food matrices and packaging.

Recent studies have applied the **QuEChERS** (Quick, Easy, Cheap, Effective, Rugged, and Safe) method to analyse ultra-low traces of PFAS in food matrices. The beauty of this technique lies in its speed and simplicity, achieved through a straightforward two-step process. First an acetonitrile (ACN) salting-out extraction (SOE) efficiently extracts PFAS from the food matrix. This is followed by a secondary dispersive solid phase extraction (d-SPE), using a sorbent such as silica modified with amine groups (PSA) to clean up the extract and remove matrix **interferences**. Combining QuEChERS with advanced analytical techniques such as LC-HRMS and GC tandem MS (GC-MS/MS) is **highly effective** for detecting and quantifying PFAS at ultra-low levels.

To maximise the chances of detecting and identifying all PFAS, both targeted and non-targeted analytical techniques are used. Non-specific methods, such as Particle-induced  $\gamma$ -ray Emission (**PIGE**) spectroscopy and **NMR** can be used to assess total fluorinated compounds in samples. While these methods effectively capture PFAS molecules, they also detect non-PFAS fluorinated compounds. Therefore, a secondary targeted approach, like **LC-MS/MS** analysis, is necessary to specifically identify and quantify PFAS, eliminating other fluorinated molecules.

### ■ The US

The US recently established legally enforceable national drinking water standards for PFAS compounds with the **National Primary Drinking Water Regulation (NPDWR)**. Public water systems must complete initial monitoring of six PFAS by 2027 and, if necessary, implement corrective actions by 2029. The maximum levels are set at 4 ppt for PFOA and PFOS, 10 ppt for PFNA, PFHxS, and HFPO-DA (GenX), as well as 2,000 ppt for PFBS (perfluoro butane sulfonic acid). The cumulative risk of mixtures of PFHxS, PFNA, HFPO-DA, and PFBS must also be calculated, using a **hazards index** approach. The FDA meanwhile approaches PFAS testing in the food supply by sampling **foods prone to contamination**, such as seafood and dairy products, and has developed methods to detect **up to 30 types of PFAS** in food. On **FCMs**, the US has **taken steps at the federal level** to ban long-chain PFAS, and phase out specific short-chain compounds. At the same time, states like California, Washington, and New York have **enacted their own laws** to ban intentionally added PFAS in FCMs.

### ■ China

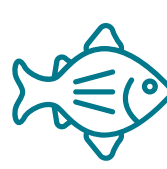
The Chinese Ministry of Ecology and Environment has also initiated guidelines for monitoring PFAS in **drinking water**, with recommended advisory levels of 85 ppt for PFOA and 30 ppt for PFOS. China, too, has been actively monitoring **PFAS in the environment**, and is developing a **regulatory framework** expected to establish clear limits for **PFAS in food**, in broad alignment with international standards.



**TABLE 2**

## Methods for extracting and analysing PFAS in foods and food packaging

No single method has proven suitable for the low-level detection of all PFAS compounds in food and food packaging matrices. The table below provides an overview of various extraction and analysis techniques that have been used successfully across different food and packaging matrices, to achieve sensitive analyte detection and quantification.



	Popcorn bag	Plastic and cardboard materials	Beef	Fish	Eggs
Extraction and pretreatment	Focused ultrasonic solid-liquid extraction	Ultrasonic probe-assisted extraction	QuEChERSER	QuEChERS method	Extraction with Pb(OAc) <sub>2</sub> solution, MeOH, and FA followed by SPE cleanup with Strata-X-AW cartridge
Analysis	LC-QToF-MS	LC-QqQ-MS/MS	UPLC-HRMS	LC-MS/MS	UHPLC-MS/MS
Limit of Detection	0.7-3.5.ng/g	0.5-2.2ng/g	0.0009-0.267 ng/g	0.00369–0.017ng/g	0.025–2.5 ng/g
Limit of Quantitation	0.9-2.2ng/g	0.01-0.5ng/g	0.0027-0.809 ng/g	0.05 except for GenX and C6O4 (0.1 ng g)	0.025–5ng/g
Reference	Zabaleta et al 2017	Zabaleta et al 2016	Taylor et al 2022	Gallocchio et al 2022	Berendson et al 2020



	Raw milk and bagged milk	Blackberries, blueberries, corn kernels (corn), grapes, okra, peaches, pecans, potatoes, squash, and tomatoes	Lettuce, spinach, and tomato	Marine shellfish	Offal
Extraction and pretreatment	DI-SPME with F-BNN-coated fibre	Extraction with basic MeOH solvent followed by SPE cleanup with Oasis WAX SPE cartridge	Oasis SPE-WAX cleanup and extraction with ACN solvent	Extraction with ACN solvent and water	Extraction with MTBE solvent
Analysis	HPLC-MS/MS	LC-QqQ-MS	LC-MS/MS	UHPLC-MS/MS	LC-MS/MS
Limit of Detection	0.9–3.9 (CCβ) MDL	N/A	0.006–1.76 (L-FDS and FHEA, respectively)	0.03–0.1 ng/g (CCa)	0.038 for PFOA and 0.002 for PFOS
Limit of Quantitation	N/A	0.025–0.25ng/g	0.018–5.28ng/g (L-FDS and FHEA, respectively)	0.05 except for GenX and C6O4 (0.1 ng g)	0.125 for PFOA and 0.007ng/g for PFOS
Reference	Enualdi et al 2021	Meng et al 2022	Rawn et al 2022	Abafe et al 2021	Sungur et al (2018)

Adapted from Chukwuebuka *et al.*, 2024 and Lannone *et al.*, 2024

## More foods at risk from PFAS

### ■ Milk

As the US advocacy group the Natural Resources Defense Council (NRDC) points out, **“Milk containing PFAS tends to be particularly potent because the substances bioaccumulate in cows.** Farmers spread sludge on fields, plants take the contaminants up from the soil, then cows eat the grass in great amounts, concentrating the PFAS, which end up in their milk.” NRDC’s website recently reported that one now-closed farm in Maine had stopped using PFAS-containing sludge as a fertiliser in 2004, but its milk still recorded PFAS levels as high as 1,470ppt – or seven times higher than the state action level – more than a decade later. It also points out that **high PFAS levels are particularly “bad for children,** who tend to drink lots of milk and are also more vulnerable to these substances than adults are.”



### ■ Tea

As well as identifying potential packaging contamination risks in takeaway foods and butters, **the USC research** identified that **study participants who reported drinking a lot of tea exhibited higher levels of PFAS at follow-up visits.** It found that just “one additional serving of tea was linked to 24.8% higher perfluoro-hexane sulphonic acid (PFHxS), 16.17% higher perfluoro heptane sulfonic acid (PFHpS) and 12.6% higher perfluorononanoic acid (PFNA).” Study authors also concluded that, since “paper products are a major contamination source for PFAS and tea bags are primarily made of paper... **PFAS in tea bags may be contributing to the associations seen with tea intake.**”



### ■ Eggs

**An investigation last year by the Danish National Food Institute (DTU)** found PFAS in organic eggs produced throughout the country – potentially putting young children who ate just a few eggs at risk of consuming more than European safe limits. According to the DTU, children aged between four and nine who ate more than 2.5 organic eggs a week were “at risk of getting too much of the unwanted substance,” while **those who ate between five and six eggs would be ingesting more than double the recommended ceiling of 4.4 ng/kg body weight per week of PFOA, PFNA, PFHxS and PFOS combined.** The Institute’s Associate Professor, Kit Granby, said the source of the PFAS had been identified as organic fishmeal given to hens, adding: “PFAS is an example of a substance group that can migrate and accumulate through the food chain – from fish to fishmeal, which is included in chicken feed, via the hen to the egg, where it binds to the protein in the yolk and can then be eaten by humans.”



### ■ Processed meats

The USC longitudinal study also found that **“higher intakes of pork, hot dogs, beef and other processed meats were associated with higher PFAS concentrations”** in both groups of young adults it monitored. For example, a **one serving higher intake of hot dogs made from various meats was associated with a 25.4% higher PFNA** concentration, and **one additional serving of pork was associated with 13.4% higher PFOA.** The authors of the study also listed a number of ways that meat products can become contaminated – such as contact with PFAS during processing or cooking in the cases of sausages, bacon and hot dogs, while unprocessed pork and beef may either have come from animals raised in contaminated areas, or could have been packaged in PFAS-containing greaseproof paper.



## Is your business ready for change?

Almost without exception, the authors of the studies referred to in this whitepaper have argued strongly in favour of more research into the prevalence and health effects of PFAS in food, as well as greater regulation. In this, they are part of a larger trend, in which **“PFAS and PFAS contamination are nowadays a ‘hot-topic’** that interest all levels of society, from scientific communities to citizens.” According to one estimate, **the number of scientific papers published on PFAS-related topics increased tenfold between 2017 and 2022**, while a **glance at Google Trends** reveals that searches of the term ‘PFAS’ have also grown exponentially over the last 20 years.

This surge of interest and concern regarding PFAS has prompted some primary regulation (see above) in the EU, US, and China. However, the likelihood is that more official and legal activity is on the way, and that the food industry is likely to be on the receiving end this time. Already, legal and technical firms are offering consultation and advice on navigating the nuances between PFAS food packaging regulations at state level in the **US**, as well as within the **EU**. One recent article by three expert lawyers in *Food Safety Magazine* argued that **“an increase in state and federal regulatory requirements and enforcement, as well as lawsuits concerning PFAS, are a near certainty.”** But while previous controversies and litigation have focused mainly on groundwater and drinking water, military facilities and firefighting foam, “today, downstream users, including food and beverage producers, are being dragged into the fray.”

Although cases against food manufacturers based on the presence of PFAS in food and drink products have been largely unsuccessful in the US to date, a number of plaintiffs have been granted permission to file further or amended claims that “could... serve as test cases... for future litigation.” In addition, “as regulation and scientific and medical literature continue to grow, product liability lawsuits are likely to emerge seeking damages for personal injury.” All of which means that food and beverage producers, and their suppliers, need to “take adequate steps to assess their exposure and allocate responsibility” in order to manage risk. “While the labeling phrase ‘No intentionally added PFAS,’ will satisfy many state regulatory requirements,” the lawyers state, “it begs the question: How much PFAS is in the product, and why?” Finding the answers to difficult questions like these now is likely to pay manufacturers rich dividends in the future.

***“Today, downstream users, including food and beverage producers are being dragged into the fray.”***

## The need for high quality reference standards and proficiency testing

To help ensure the safety of food and beverage products, and align with rapidly evolving PFAS regulations, the food testing industry must be able to constantly amend its analytical procedures. LGC Standards’ portfolio of **more than 300 high-quality PFAS products, including >70 SILS**, is designed precisely to help you adapt to such regulatory and scientific change. We can therefore offer you **over 130 Dr Ehrenstorfer PFAS reference materials certificated to ISO 17034 or ISO 17025** – including the groundbreaking **PFASiMix** kit, which improves your laboratory’s efficiency with its mixture of 27 PFAS analytes, designed for maximum stability. To further support your PFAS analysis, we provide ready-to-use mixtures specifically designed to address key regulations, such as the **EU Drinking Water Directive, UCMR5 and EPA Methods 533 and 537.1**, as well as **EPA Method 1633**.

In tandem with our reference materials offer, LGC AXIO Proficiency Testing provides a range of **more than 300 PT samples designed to help ensure food safety and quality**, including **40+ samples within our Meat and Fish (QMAS) scheme and a dedicated PFAS in food sample supplied in a clam matrix**. Meanwhile, our **extensive TRC range of PFAS analytical standards and research chemicals** facilitate wide-ranging analysis, including research into their potential harmful effects.

Lastly, should you have a **custom request**, we have more than 40 years’ experience working through some of the most complex synthetic pathways to provide you with the right molecule at the requested quality level.

## AUTHORS



### Joe Lackey

Dr Joe Lackey holds a PhD in Molecular Physiology from the University of Dundee, where his research focused on early drug discovery and the role of the PI-3 kinase signalling pathway in tumour growth and development. Over seven years as a Technical Specialist at LGC, Joe has written widely on personalised medicine and explored interests in food and environmental toxicology.

### Andy Blizzard

Andy Blizzard joined LGC Standards as Content Writer in 2021. He previously studied for a BA in History from The University of Warwick and an MA in Public Communication from Westminster University. He is also an NCTJ-qualified journalist with more than 15 years' experience of writing for print and online media.



### Charon Willis

Charon is an experienced food chemist with a master's degree in Food Analysis and Composition and has a passion about not only protecting people and animals, but getting the most enjoyment out of all we eat.



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