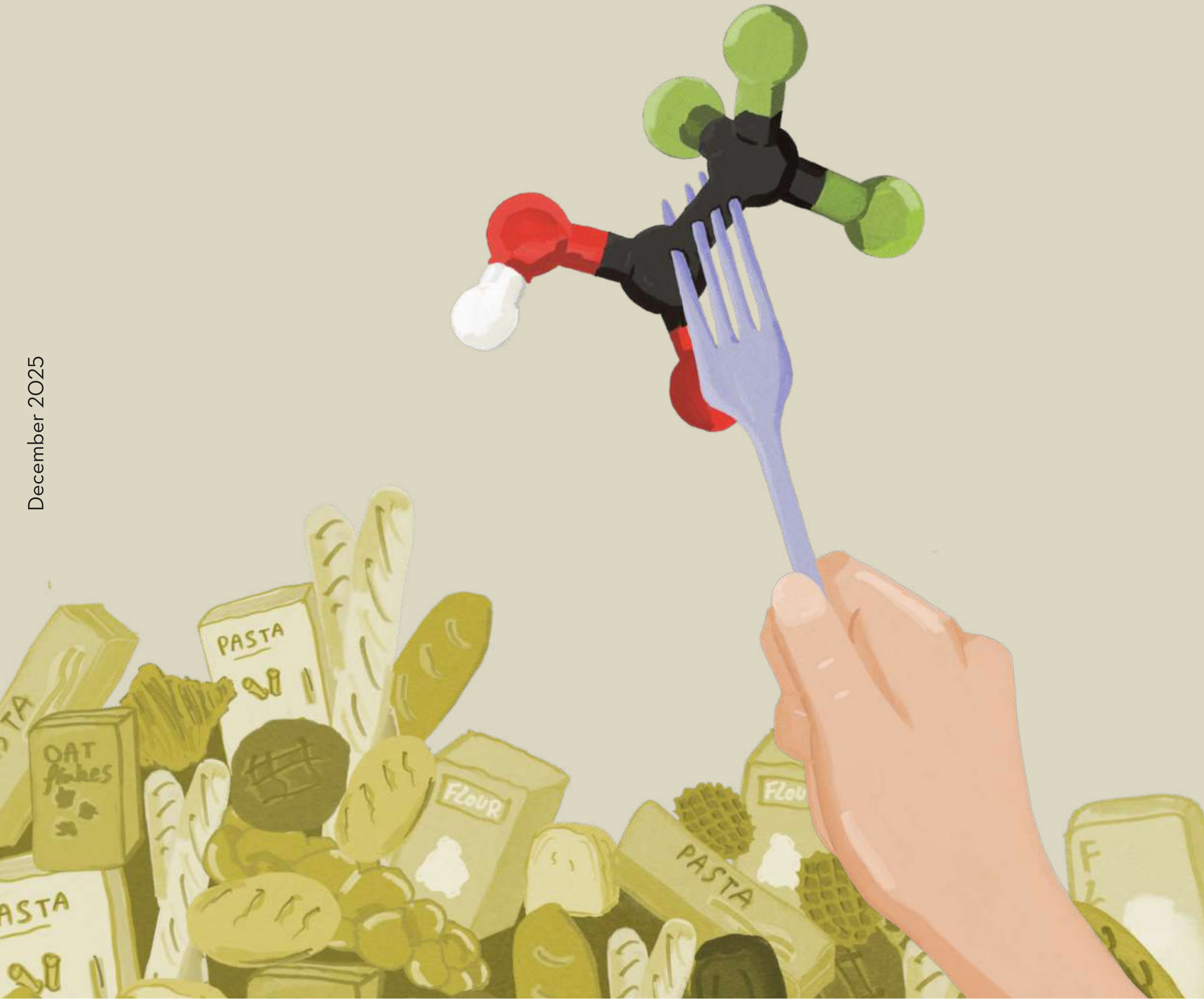
Report

Pesticide Action Network Europe

Unseen and Unregulated:

TFA, the 'forever chemical' in Europe's Cereals



December 2025

Executive Summary

This report presents the first EU-wide assessment of trifluoroacetic acid (TFA) in conventional cereal-based food products and reveals alarming levels of contamination across Europe. TFA is a highly persistent and reprotoxic chemical that currently escapes monitoring by food safety authorities, making these findings unprecedented at the EU level.

The investigation was conducted by the European Pesticide Action Network (PAN Europe) in collaboration with environmental NGOs across 16 European cereal-producing countries. Building on earlier evidence of TFA contamination in European water and wines, this study examined a range of cereal products. The results show that food, particularly staple crops, is a major pathway of human exposure to this persistent and toxic contaminant.

TFA is a highly stable degradation product of many fluorinated chemicals, including PFAS pesticides and F-gases used in refrigeration. Once released, it resists natural breakdown and accumulates in soil and water, earning its classification as a "forever chemical." Earlier studies by PAN Europe have revealed significant TFA contamination in tap and mineral water across the EU. The present findings confirm that TFA's presence also extends into cereal-based foods, suggesting pervasive environmental distribution and bioaccumulation in crops.

Key findings:

- **Widespread contamination across Europe:** TFA was detected in 81.8% of samples (54 out of 66 samples) across 16 European countries.

- **High levels of TFA:** the average TFA concentration was **78.9 µg/kg**, with a median of **39.5 µg/kg** and peak values of up to **360 µg/kg. Wheat products are significantly more contaminated than other cereal-based products.**

- **Food as the main exposure route:** the average TFA concentration found across the samples, 78.9 µg/kg is **107[1] times higher than the average TFA concentration in tap water**, and 19.3 times higher than the highest detected level in our earlier water sampling.

- **Exceedance of precautionary Maximum Residue Levels (MRLs)**. All 54 samples containing TFA exceeded the default MRL value of 0.01 mg/kg (10 µg/kg) for active substances that are classified as reprotoxic 1B. Even though TFA is a degradation product rather than a parent compound, the same high standards are expected.

---

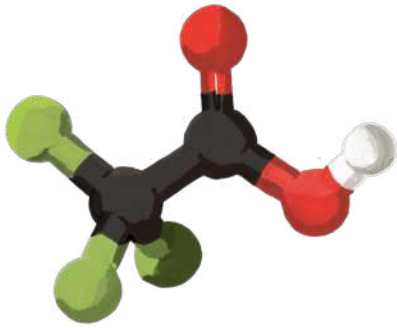
[1] TFA: The Forever Chemical In The Water We Drink (PAN Europe, 2024). Comparison between the mean TFA value in tap water (740 ng/L) and the mean TFA value in the present study (78.9 µg/kg).

- **Exceedance of health-based safety value for children**: the average TFA intake per product is more than a third (36.9%) of PAN Europe's proposed Acceptable Daily Intake, calculated on the basis of the current evidence. When accounting for children's total daily cereal consumption, exposure levels reach nearly twice this value (184.3%).

A previous PAN Europe's report highlighted how **industry actors have systematically downplayed evidence of TFA's harmful effects**. Yet, consistent toxicological findings indicate TFA's impacts on foetal development and have prompted the classification of TFA as "toxic to reproduction" (category 1B) under EU Chemical Law. These studies also revealed adverse effects on thyroid and liver function, immune response, and sperm production. Meanwhile, the European Food Safety Authority (EFSA) has been tasked with revising its outdated and overly optimistic TFA risk assessment from 2014.

These findings provide compelling evidence that TFA has become deeply embedded in the European diet, demanding urgent regulatory action. PAN Europe calls for an **immediate ban on PFAS pesticides**, alongside **a protective acceptable daily intake (ADI)** that accounts for current toxicological uncertainties and vulnerable populations such as children, according to the precautionary principle. This should be complemented by **EU-wide monitoring of TFA in food** and the environment, as well as support for farmers to transition towards safer, non-synthetic crop protection methods.

Contents



1. Introduction

Trifluoroacetic acid (TFA) is a synthetic molecule belonging to the class of per- and polyfluoroalkyl substances **(PFAS)**. Highly stable by industrial design, their inability to break down in the environment[2] has led PFAS to become known as "forever chemicals". Extremely persistent and highly mobile TFA enters the environment primarily through the degradation of other PFAS compounds. The most important precursor substances are fluorinated hydrocarbons ("F-gases") from refrigeration technology and PFAS pesticides from agriculture.

In 2024, PAN Europe and its members raised the alarm on TFA contamination of drinking water (tap and mineral) as an important source of TFA contamination[3].

Although data on human exposure to TFA through food is only emerging, it seems that TFA is ubiquitous across certain fruits, vegetables and cereal grains[4]. Due to the scarcity of these studies and the absence of official monitoring of TFA in food, we do not know how much TFA citizens are exposed to.

Evidence that PFAS pesticides degrade into TFA, leading to its widespread presence in agricultural crops, has been long-standing[5]. Despite this, the regulatory process has failed to deliver a comprehensive safety assessment for this substance. Our recently published report, Manufacturing Doubt: How The Industry Downplays TFA's Toxicity, describes the role played by the industry to delay investigations into TFA's harm and subsequent regulatory action.

In spite of the industry's attempts to distort and downplay evidence of TFA's harm, regulators eventually requested the submission of long-term risk assessments under a formal mandate. The evidence which emerged from these long-overdue studies highlighted the toxicity of TFA for foetal development and revealed new insights on TFA's toxicological profile, including its endocrine disruption potential. Following these developments, the EU competent agencies EFSA and the European Chemicals Agency (ECHA) are reassessing the properties of TFA, including its toxicity and the levels of exposure deemed acceptable to human health.

---

[2] What makes PFAS so resistant to chemical and thermal degradation is the deliberate introduction of carbon-fluorine bonds, amongst the strongest in organic chemistry, into their chemical structure. When PFAS molecules break down, their-CF_3/-CF_2 groups remain. As a result, the degradation product is also a PFAS. TFA, the smallest of the ~ 10,000 PFAS compounds, is the terminal breakdown product of a number of PFAS that contain-CF_3.

[3] PAN Europe: TFA, The Forever Chemical In The Water We Drink (July 2024)

[4] EU-SRLM, 2017: Residues of DFA and TFA in Samples of Plant Origin

[5] In 1998, TFA was first identified as a metabolite of the PFAS pesticide flurtamone, leading the Scientific Committee on Plants (composed of Member State representatives and the European Commission) to acknowledge a risk of groundwater contamination. Despite early indications of possible human health risks associated with TFA exposure, this concern was largely sidelined and did not lead to a thorough risk assessment for TFA. In 2008, TFA was identified as a crop metabolite of the PFAS pesticide fluazinam, revealing its direct entry into the food chain. EFSA acknowledged the generic nature of the problem: 'this metabolite is not specific to fluazinam and can be produced…from a wide range of pesticides containing a C-CF3 moiety'. Existing scientific literature already indicated TFA's 'possible teratogenic effects', as mentioned in the assessment report of fluazinam. Despite this, fluazinam was granted an approval which remains in force to this day, while TFA did not receive further regulatory attention for decades. As evidence for TFA's adverse health impacts continues to mount, fluazinam and 30 other TFA-emitting PFAS pesticides continue to be sprayed on European crop fields, contaminating our food and water with this toxic metabolite.

In relation to residues in food, it is important to note that no maximum residue level (MRL) has been established for TFA. An MRL represents the upper legal limit of a pesticide residue permitted in food and is set to ensure that consumer exposure, particularly among vulnerable groups such as children and pregnant individuals, remains at safe levels.

The aim of the present report is to investigate the extent of EU citizens' exposure to TFA through cereal-based foods, chosen as the focus of this study due to their fundamental role in the diets of EU citizens. Additionally, cereals have large cultivated areas and are widely treated with PFAS pesticides in many EU countries.

A total of 66 samples were collected across 16 European countries by the following organisations: Global 2000 (Austria), Bond Beter Leefmilieu (Belgium - Flanders), Nature & Progrès Belgique (Belgium - Wallonia), Via Pontica Foundation (Bulgaria), Arnika (Czech Republic), Générations Futures (France), Ecocity (Greece), Friends of the Earth Hungary, International Society of Doctors for Environment (Italy), Friends of the Irish Environment (Ireland), Irish Environmental Network (Ireland), Mouvement Écologique (Luxembourg), PAN Germany, PAN Netherlands, Living Earth Coalition (Poland), Romapis (Romania), Ecologistas en Acción (Spain), WWF Switzerland.

The results show that TFA is ubiquitous in everyday staple foods, highlighting the urgent need to ban its sources, including PFAS pesticides, and to adopt a precautionary approach when setting safe exposure levels for this persistent "forever chemical."

2. Background

TFA: a widespread and under-regulated contaminant

TFA's ubiquitous environmental presence

Since its groundwater contamination potential was first discovered by EU regulators in 1998, TFA has become the most widespread, yet largely overlooked contaminant in Europe's water resources and other environmental compartments. Scientific and political attention is increasing towards this chemical, as a growing body of scientific literature shows that TFA is being detected everywhere it is being measured. TFA enters surface water and groundwater and becomes globally distributed in water bodies, where it accumulates - a fact which is especially alarming since TFA cannot be removed using conventional water treatment methods. TFA has been detected in almost every water body, including oceans, lakes, rivers, rainwater and groundwater[6,7,8]. Aside from Europe's water resources, TFA is also detected at high concentrations in soils, wild plants, crops, plant-based foods, including baby foods, and even human blood. TFA's rapid and irreversible accumulation in the environment, observed on an increasingly global scale, has led scientists to name this accumulation a threat to planetary boundaries, due to its potential to disrupt vital Earth system processes[9].

After F-gases, PFAS pesticides are the second source of global TFA contamination. In contrast to the diffuse nature of F-gas emissions, which become globally dispersed in oceans, PFAS pesticides are locally applied to agricultural land. However, almost 100% of the TFA load from PFAS pesticides is directly released into the soil, crops and groundwater, with direct impacts on drinking water supplies. Scientific calculations have demonstrated that PFAS pesticides are the primary source of TFA contamination in agricultural areas, accounting for 76% of groundwater contamination with TFA[10].

Regulatory requirements for TFA violated

Following the proposal from Germany to classify TFA as "presumed toxic to reproduction (category 1B)", as well as very persistent and very mobile (vPvM) in the environment, and persistent, mobile and toxic (PMT), the European Commission acknowledged TFA to be a 'relevant' metabolite of pesticides in groundwater. Under the Pesticide Regulation (EC) 1107/2009, an active substance with toxicologically 'relevant' metabolites exceeding the threshold of 0.1 µg/L in groundwater cannot be approved. In reality, this threshold is frequently and significantly exceeded by TFA across the EU. **Despite this violation of the regulation, 31 TFA-emitting PFAS pesticides remain approved in the EU**, where they continue to contaminate European food supplies and water resources.

---

6 Berg M, Müller SR, Mühlemann J, Wiedmer A, Schwarzenbach RP (2000) Concentrations and mass fluxes of chloroacetic acids and trifluoroacetic acid in rain and natural waters in Switzerland. Environ Sci Technol 34:2675–2683. https://doi.org/10.1021/es990855f

7 Arp, Hans Peter H.et.al, The Global Threat from the Irreversible Accumulation of Trifluoroacetic Acid, 2024/11/12, doi: 10.1021/acs.est.4c06189, Environ. Sci. Technol. 2024, 58, 45, 19925–19935

8 Janda J, Nödler K, Brauch H-J, Zwiener C, Lange FT (2019) Robust trace analysis of polar (C2–C8) perfluorinated carboxylic acids by liquid chromatography-tandem mass spectrometry: method development and application to surface water, groundwater and drinking water. Environ Sci Pollut Res 26:7326–7336. https://doi.org/10.1007/s11356-018-1731-x

9 Arp, Hans Peter H.et.al, The Global Threat from the Irreversible Accumulation of Trifluoroacetic Acid, 2024/11/12, doi: 10.1021/acs.est.4c06189, Environ. Sci. Technol. 2024, 58, 45, 19925–19935

10 According to Table 6 on page 51, the theoretical release of TFA attributed to pesticides is 434 tonnes. When considering the total theoretical TFA release from all sources (434 + 22 + 19 + 96 = 571 tonnes), pesticides account for approximately 76% of the total. UBA.

An October 2025 study[11] has provided the first quantitative estimation of the TFA emissions which leach into groundwater, as a direct result of the crop applications of 24 of these EU-approved PFAS pesticides[12]. Under all groundwater modelling scenarios explored by researchers, TFA emissions exceeded the legal limit of 0.1 µg/L for relevant metabolites for 23 out of the 24 PFAS active substances investigated[13]. Under worst-case scenarios, TFA groundwater emissions from the majority of PFAS active substances even exceeded 10 µg/L, the groundwater limit for non-relevant metabolites. Previously, in April 2024, investigations by PAN Europe and its members[14] had revealed that TFA in drinking water (tap water and bottled waters) frequently exceeded the 0.1 µg/L limit for relevant metabolites. TFA was found in tap water at an average concentration of 0.74 µg/L, reaching up to 4.1 µg/L. Mineral and spring water contained an average TFA concentration of 0.278 µg/L, with a maximum value of 3.2 µg/L. These findings constitute a clear indication that the requirements of the Pesticide Regulation (EC) 1107/2009, namely its Article 4(3) and Article 29(1)(e), and its uniform principles set out in Regulation (UE) 546/2011 are no longer met by pesticide products containing PFAS active substances[15].

As alarming as these findings are, in April 2025, a study[16] by members of PAN Europe showed that levels of TFA in European wines exceeded typical background levels in rainwater by around two orders of magnitude, with average concentrations exceeding 100 µg/L and peaks detected above 300 µg/L. The finding that TFA can accumulate in plants to such a degree is deeply concerning. Even more striking, our data revealed a seemingly exponential rise in TFA levels since 2010. Samples with higher TFA concentrations also contained more synthetic pesticide residues, consistent with earlier evidence that PFAS pesticides are the main source of TFA contamination in the food chain.

TFA's presence in cereal crops

Few studies have investigated the extent of the TFA contamination in cereals or other crops. The present study aims to contribute to filling this gap in knowledge.

The only official published study to date measuring TFA levels in food was carried out in 2017 by the EU Reference Laboratory CVUA Stuttgart on behalf of the European Commission[17]. The study analysed over 1600 wide-ranging samples of

[11] Diehle, M., Schneider, F., Banning, H. et al. Trifluoroacetate leaching potential from fluorinated pesticides: an emission estimation and FOCUS modelling approach. Environ Sci Eur 37, 161 (2025). https://doi.org/10.1186/s12302-025-01215-5

[12] 44 active substances containing a C-CF3-group from the EU pesticide database. Out of the 44 EU-approved pesticide active substances containing a C-CF3-group, 24 were used for modelling on the basis of being authorised in at least half of EU member states and the UK.

[13] 9 PFAS pesticide active substances were identified as the most crucial ones regarding TFA leaching in the EU: diflufenican, flonicamid, fluazifop-P-butyl, fluazinam, flufenacet, fluopyram, flutolanil, picolinafen and trifloxystrobin.

[14] PAN Europe: TFA, The Forever Chemical In The Water We Drink (July 2024)

[15] Point 2.5.1.3 of Regulation (UE) 546/2011.

[16] PAN Europe: Message from the Bottle (April 2025)

[17] EU-SRLM, 2017: Residues of DFA and TFA in Samples of Plant Origin

plant-based foods and beverages, revealing that TFA was found at least in traces in nearly every sample. Conventional cereal products containing TFA over the reporting limit (40 µg/kg) had a median concentration of 58 µg/kg, with a peak value of 280 µg/kg detected.

Eight years on, a study by Global 2000[18] has revealed an approximate 3.5-fold increase in the median TFA contamination in conventional Austrian cereal samples, in comparison to the levels detected by the EU reference laboratory. While conventional samples were two to three times more contaminated than organic ones, both organic and conventional samples were contaminated with TFA, collectively showing a mean value of 119 µg/kg and reaching concentrations up to 420 µg/kg. This is two to three orders of magnitude higher than the average background TFA levels in rainwater, surface water, groundwater, and tap water, indicating a significant accumulation of TFA in plant-based foods.

A small-scale Swiss investigation was additionally conducted in October 2025, revealing the presence of TFA across all 12 bread samples tested, including organic ones. TFA was detected in the range between 29 to 130 µg/kg, averaging 69 µg/kg. This average value is over 86 times higher than the TFA levels found in tap water in a Swiss participatory survey.

The need for a more comprehensive safety assessment

The industry's attempts to obscure and downplay evidence of harm

While TFA has continued to accumulate in our biosphere over several decades, including in our very food, the health risks of this forever chemical have only recently started to be investigated. This stark contrast reflects the failures of European regulators and TFA-precursor manufacturers to correctly assess TFA's health risks and act with a protective and precautionary approach.

TFA was first identified as a groundwater contaminant over 25 years ago, according to a recent investigation. Since then, the industry and its affiliated scientists have strived to weaken and delay restrictions on TFA-emitting PFAS by spreading false narratives that aim to distort public discourse and influence science[19].

A widespread industry myth is that short-chain PFAS like TFA pose no danger to health, and therefore, there is no need to regulate TFA at the same level as longer-chain PFAS. This myth of TFA's harmlessness is now being discredited by a growing body of scientific studies demonstrating its toxicity.

A second industry myth is that TFA is naturally occurring, emitted through deep-sea hydrothermal vents. A critical evaluation of this claim has shown it is not supported by evidence. Moreover, is inconsistent with time trends of TFA concentrations in rain and ice cores[20]. More importantly, what is

[18] Global 2000: The Forever Chemical in Our Daily Bread

[19] Examples of this strategy by the fluorochemical industry have been compiled by Belgian environmental researcher Thomas Goorden in his publication The Dark PFAS Hypothesis- Strategies of Deception

[20] Joudan, S., De Silva, A.O. and Young, C.J., 2021. Insufficient evidence for the existence of natural trifluoroacetic acid. Environmental Science: Processes & Impacts, 23(11), pp.1641-1649.

clear is that the increases in TFA levels observed across environmental compartments in recent years are so steep and rapid that they can only be attributed to anthropogenic activities. This calls for urgent action to prevent further irreversible accumulation in the environment.

New safety limits for TFA

Maximum residue levels

According to Regulation (EC) 396/2005 on Maximum Residue Levels (MRLs) in food and feed, MRLs must be set for residues of pesticides to ensure a high level of consumer protection. These are the legal limit concentrations in food or feed that are considered safe for the most vulnerable population groups, including children. At the time of this report, **MRLs have not been set for TFA** in different food products. In such cases, where no MRLs have been established, the MRLs Regulation considers it appropriate to set a **default value of 0.01 mg/kg[21]**.

This is even more appropriate for TFA, which is to be classified as toxic to reproduction Category 1B. According to the Pesticide Regulation (EC) 1107/2009, active substances that fall under this hazard class should not be detected in food or should be found below this default value of 0.01 mg/kg. Even though TFA is a breakdown product of PFAS active substances, rather than an active substance itself, it is foreseen that the provisions of a high level of protection should be applied to residues of both active substances and any metabolites formed following their use.

EFSA's derivation of a new Acceptable Daily Intake (ADI)

Following recent evidence of TFA's toxicity to human health, EFSA has been requested by the Commission to review the evidence of harm and to propose new EU-wide health-based safety values for TFA. Specifically, EFSA will define a new **Acceptable Daily Intake (ADI)** value, a conclusion which will have important impacts on how TFA is regulated. The ADI is a measure of how much (per kilogram of bodyweight, kg/bw) of a contaminant a person can ingest every day over long periods of time without expecting any adverse health effects.

PAN Europe does not support the opinion of establishing 'safety values' for substances that are endocrine disruptors, as the effects of these substances should be treated as non threshold-based[22]. The principle that the dose makes the poison is not applicable to endocrine disruption. Consequently, this means that no residue should be tolerated, particularly in food consumed by vulnerable groups.

Nevertheless, given the risk of lifelong exposure arising from TFA's extreme persistence and its environmental ubiquity, it is important to examine what such a safe threshold could be based on from the available toxicity tests. Rising emissions of this contaminant, combined with growing evidence of its toxicity and significant uncertainties about additional health risks, make it critical to adopt the most protective and precautionary approach.

For decades, EU regulators have uncritically received the industry's unsubstantiated claims and failed to insist on thorough risk assessments for

[21] Article 18(1)(b) of Regulation (EC) 396/2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin.

[22] Zoeller et al.: Endocrine-disrupting chemicals and public health protection: a statement of principles from The Endocrine Society, Endocrinology, 153, 9, 2012, 4097-4110. doi:10.1210/en.2012-1422

TFA. The tentative ADI proposed by EFSA in 2014 is a figure which was directly lifted from a position paper by Bayer[23]. This value - 0.05 mg/kg (50 µg/kg) of body weight per day (bw/day) - was based on a 90-days rat study (2007). Above the lowest dose of 10 mg/kg, rats exhibited clear signs of hepatic stress, including elevated alanine aminotransferase levels, a key marker of liver damage or disease. Despite these limitations and the absence of critical long-term studies, EFSA applied an additional uncertainty factor (UF) of only 2[24], as recommended by Bayer and concluded that TFA posed no significant health risk. This conclusion subsequently shaped the risk assessment of all active substances that degrade into TFA.

In 2017, ECHA legally compelled the industry to address glaring data gaps on TFA's toxicity by producing long-term risk assessments, including an extended one-generation study on reproductive toxicity[25]. All TFA exposures tested, including the lowest dose of **8.65 mg/kg** (8650 µg/kg) **bw/day**[26], induced adverse effects on the thyroid of rat offspring, indicating that TFA may be an endocrine disruptor[27]. Despite the fact that a No Observed Adverse Effect Level (NOAEL) could not be derived from this study - due to all doses producing adverse effects - EFSA has recently used the results of this study to derive its updated NOAEL and ADI.

In September 2025, EFSA proposed draft values for an **ADI** of **0.03 mg/kg** (30 µg/kg) **bw/day**, derived from a **NOAEL** of **8.65 mg/kg bw/day**, together with an UF of 300 (versus 200 in 2014).

By proposing to set the ADI at 30 µg/kg bw/day, EU regulators are effectively asserting that a 60 kg adult can ingest up to 1800 µg of TFA each day without negative health effects. For children of 6 years (20 kg), this amount goes down to 600 µg, while for infants (1 year) it is 300 µg per day (using the standard OECD reference body weights).

PAN Europe's proposed ADI

As mentioned, PAN Europe supports a no-safe-threshold approach for substances that are toxic to reproduction and/or endocrine disruptors, with the potential to impact children's development.

Nevertheless, if an ADI were to be established, the lowest NOAEL is the one from the 52-week rat study (1.8 mg/kg) when considering the available scientific evidence. This is a chronic toxicity study, and therefore it most closely reflects the reality of long-term TFA exposure sustained in humans. However, EFSA acknowledges itself that the 52-weeks study "does not meet the criteria for a full carcinogenicity assessment". The application of a standard UF of 100 is considered sufficient when the toxicity database is complete. However, an additional UF is warranted where there are deficiencies in the key study and concerns over unacceptable health effects. Since the study did not examine neurotoxicity, immunotoxicity or carcinogenicity, and a neurotoxic potential has been identified in the rat offspring in a previous study (effects on thyroid), it is logical to apply a total combined UF of 1000 to take into account uncertainties around TFA's potential developmental neurotoxicity and immunotoxicity, in the respect of the precautionary principle. Therefore, the ADI should be set at least at **1.8 µg/kg bw per day**.

---

[23] In 2013, Bayer CropScience submitted a position paper on TFA, see EFSA 2014, p. 11.

[24] Combined with the mandatory UF of 100 to account for extrapolation from animal data and differences across human individuals, as stipulated by OECD guidelines, leading to a total combined UF of 200 for this study.

[25] Bayer-Solvay, 2021

[26] Three doses of exposure were examined, of approximately 10, 50 and 250 mg/kg bw/day.

[27] Other TFA-induced effects across all doses included: alterations in blood biochemistry, decreased sperm motility and reduced testis weight; and effects on the immune system, including a decrease in absolute cell counts in the spleen.

Acceptable Daily Intake, No Observed Adverse Effect Level & Uncertainty Factors

The **Acceptable Daily Intake (ADI)** is derived from another value, called the **No Observed Adverse Effect Level (NOAEL)** - the dose of a tested substance at which no harmful effects are observed (compared to the control group) in laboratory animal studies. According to applicable rules, the lowest NOAEL from all available studies must form the basis on which to derive the ADI.

To derive the ADI from the NOAEL, **uncertainty factors (UF)** are applied. The application of a standard UF of 100 is mandatory to account for uncertainties arising from the extrapolation of animal data to humans, and for differences in sensitivity across human individuals. Additional UFs are calculated to account for uncertainties arising from other factors, including deficiencies in the key study, data gaps, and the severity of the observed effects.

National health-based values

In the decade-long absence of an EU-wide safety limit for TFA and adequate regulatory tests, several Member States have developed their own health-based guideline values, defining other acceptable or tolerable daily exposure to TFA. This has resulted in a patchwork of different values across Europe, which differ from each other by orders of magnitude, as a result of employing different risk assessment methods and uncertainty values. Some values are more protective than others depending on the factors and the studies taken into account (Figure 1).

- **EFSA** (2014)[28] - **50 µg/kg bw/day** - relied on a short-term 90-day rat study provided by Bayer in 2007 to extrapolate a potential lifetime exposure risk to humans. The high ADI derived represented a failure to take into account the serious data gaps on TFA's long-term chronic effects.

- **Germany** (2020)[29] - **18 µg/kg bw/day** - used data from a 52-week drinking-water study in rats (Solvay, 2019). However, this ADI does not reflect knowledge gaps around TFA's health impacts - particularly regarding immunotoxicity, reproductive effects, and developmental toxicity.

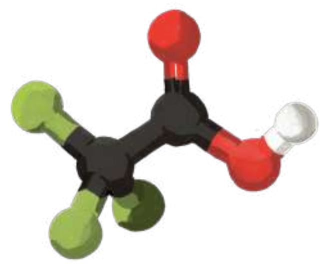
- **Flanders** (2024)[30] - **2.6 µg/kg bw/day** - has chosen to combine data from Bayer's 2007 90-day study and Solvay's 2019 52-week study, rather than relying on a single study. What sets Flanders apart is its choice of an additional safety factor to address the aforementioned knowledge gaps.

- **The Netherlands** (2023)[31] - **0.32 µg/kg bw/day** - have come up with the most protective safety limit for TFA yet, using an innovative method that takes into account the numerous existing datasets on the toxicity of longer-chain PFAS, and factors in the rel-

[28] EFSA, 2014, page 10.
[29] UBA, 2020
[30] ZORG, 2024
[31] RIVM, 2023

ative potency of TFA (relationship between dose and severity of effect) in comparison to these compounds. The Dutch Institute for Public Health and the Environment used the relative potency factor of TFA to calculate a safe drinking water limit of 2.2 µg/L, from which we calculated the safety limit of 0.32 µg/kg bw/day - which is therefore not an official ADI.

- **EFSA** (2025)[32] - **30 µg/kg bw/day** - continues to fail to take gaps in knowledge into account in its current safety assessment of TFA. While all 3 national authorities discussed above have taken the lowest dose from the 52-week study as their reference point, EFSA concludes that the observed effects from the study were not adverse, even at the highest dose. Relying on a different study with a significantly higher NOAEL, and continuing to insufficiently apply UFs, EFSA has arrived at an ADI only slightly lower from the 2014 calculation.



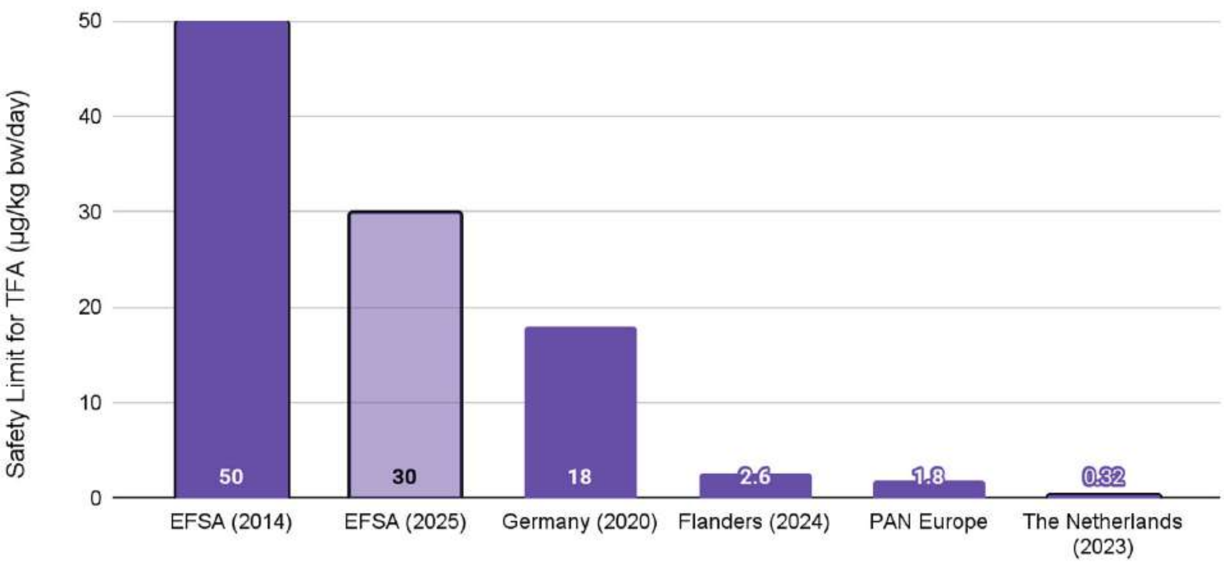


Figure 1: Different health-based safety limits for TFA
The question of how much TFA a person can be exposed to every day without incurring adverse health effects has received very different responses by various national health authorities and EFSA.
The different ADIs calculated, ranging from 0.32 to 50 µg/kg bw/day, reflect the extent to which different scientific authorities have taken into account the available datasets and existing knowledge gaps on TFA's health impacts, in their application of UFs.

[32] Link to consult the EFSA draft statement on consumer health-based guidance values on TFA.

3. Objectives

After the discovery of widespread and high levels of TFA across several types of water sources in 2025 and following the high TFA levels detected in our first study of a plant-based product- wine- the next logical step was to examine whether, and to what extent, this persistent chemical accumulates in other components of the food chain.

As cereal products represent a major staple component of the human diet in Europe, it is important to investigate the extent of TFA contamination in these daily consumed items, in order to consider whether the potential measured levels of contamination may pose health risks.

4. Methodology and Analysis

Sample Selection

Previous studies have found significant differences in the frequency and extent of TFA contamination between organic and conventional cereal-based products and other plant-based products, confirming that TFA contamination in crops is directly linked to the use of PFAS pesticides[33,34,35]. In this study, we have therefore decided to focus exclusively on **conventional products**.

We analysed both processed products, including baked goods such as bread and biscuits, pasta such as noodles and spaghetti, and breakfast items such as oatmeal, as well as the raw materials themselves, in the form of flour.

The products were purchased either in the major supermarket chains of European countries, or in bakeries. Well-known, established brands or supermarket brands were favoured in the purchasing decision. Member organisations selected **traditional and popular products** from their respective countries. This led to a predominance of wheat-based products in the samples (83.3% predominantly wheat (>50% wheat), 9.1% rye, 7.6% other cereals). The origin of the flour could not be known for the majority of products, as this information is generally lacking in the packaging of industrial cereal-based products. The number and type of food samples per country was not equal.

The products were sent to the Institut Dr. Wagner analytical laboratory, where they were analysed for their TFA content. An overview and description of all 66 cereal products- including the analysis results- is made available in the Annex.

Analytical Methods

All analyses were carried out by the internationally EN ISO/IEC 17025 accredited testing laboratory Institut Dr. Wagner, an Austrian laboratory specialising in the analysis of plant and animal foods (www.institut-wagner.at).

TFA levels were analysed according to the method "Quick Method for the Analysis of Highly Polar Pesticides in Food Involving Extraction with Acidified Methanol and LC- or IC-MS/MS Measurement I. Food of Plant Origin (QuPPe-PO-Method, ver-

33 Ex.: EU-SRLM, 2017: Residues of DFA and TFA in Samples of Plant Origin

34 Global 2000: The Forever Chemical in Our Daily Bread

35 Message from the Bottle (April 2025). TFA levels in European wines seem to have risen in an exponential fashion since 2010. Samples containing higher levels of TFA also contained more synthetic pesticide residues- consistent with earlier evidence that PFAS pesticides are the main source of TFA contamination in the food chain.

sion 12.3, 2024)" published by the EU Reference Laboratory for pesticides requiring Single Residue Methods (EURL-SRM, CVUA Stuttgart). All analyses were performed using isotope labelled TFA as an internal standard.

The level of quantification was 0.01 mg/kg (10 µg/kg), which coincides with the 'default MRL' for substances that are classified as toxic to reproduction. For analytical purposes, samples with TFA levels below the limit of quantification were assigned a value of 0 µg/kg. As a result, the calculated average TFA concentrations and estimated intakes may underestimate actual exposure.

Calculating TFA Intake

National cereal consumption data

To estimate chronic consumption of cereal-based products, we used [EFSA's Food Consumption Database](#) and extracted average intake values for the consumer categories adults (18-65 years old) and other children (3-9 years old). For each country represented in our results, the highest available average value was selected from the EFSA database to reflect potentially higher consumption patterns within the national population. An EU-level chronic consumption estimate was then calculated as the average of these national values.

For countries not covered by EFSA's database (due to not being EU Member States) or where specific consumption values for the relevant population groups were unavailable, we derived consumption estimates from national dietary surveys and published scientific literature. In certain cases where no national data could be identified, the average EU consumption across represented countries was applied as a substitute value.

TFA intake calculation

Following EFSA's exposure assessment methodology[36], chronic dietary intake of TFA from cereal-based products was estimated by multiplying measured TFA concentrations in the samples (µg/kg) by the average daily consumption of cereal-based products for adults and children (kg food/kg bw/day).

Comparison with PAN Europe's proposed ADI

To assess potential health risks, estimated TFA intakes (µg/kg bw/day) were compared with PAN Europe's proposed ADI of 1.8 µg/kg bw/day. The percentage of this safety limit that was exceeded or reached was calculated by dividing each intake estimate by 1.8 and multiplying by 100.

The full methodology and sources are available in the Annex.

[36] EFSA Journal 2017;15(1):4581- "Guidance on the EU Menu methodology and dietary exposure assessment."

5. Results

TFA levels are widespread and frequently exceed the default MRL

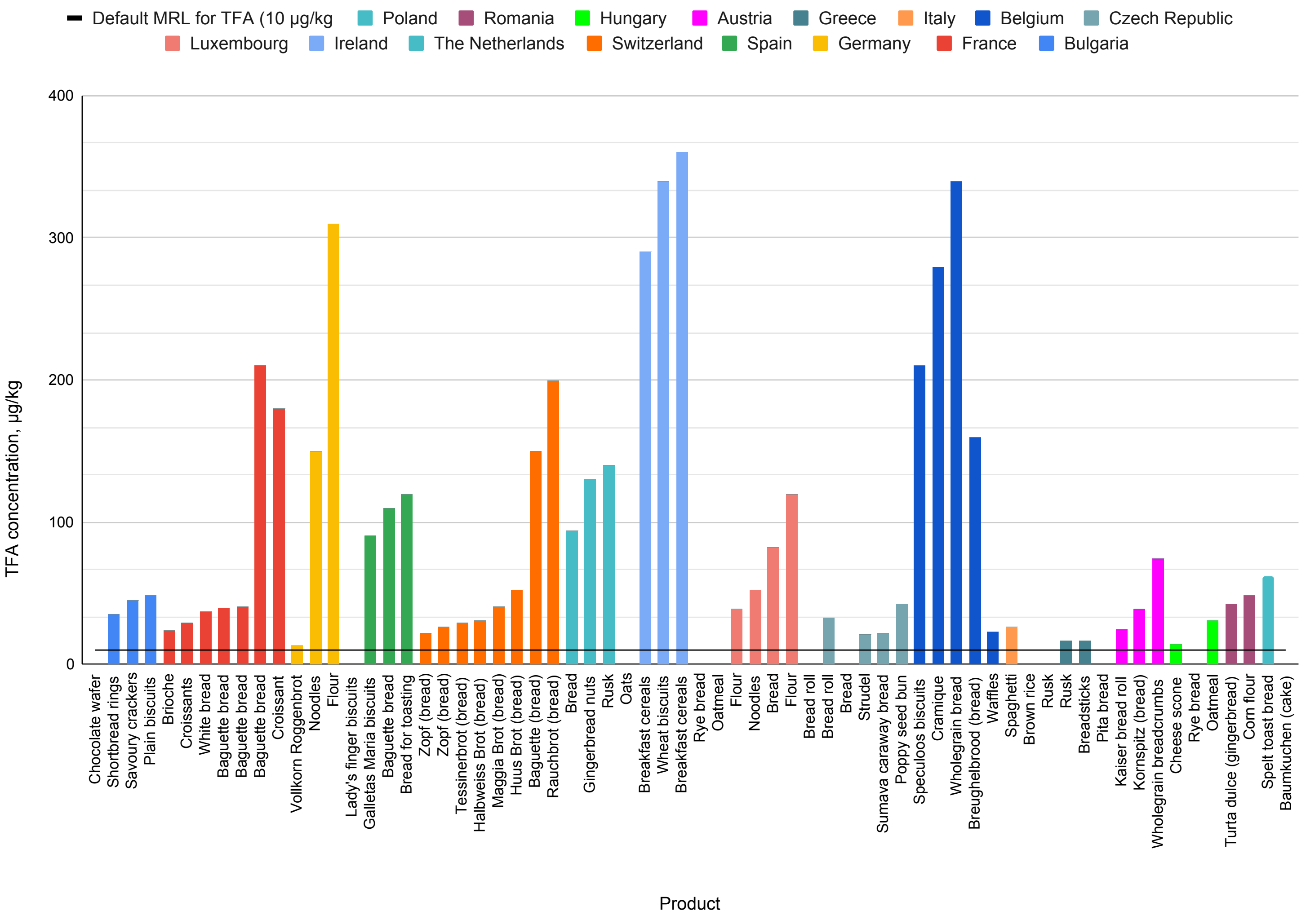


Figure 2: Overview of TFA concentrations across 66 cereal-based samples in 16 EU countries.

In total, 66 samples were collected from 16 EU countries.

The forever chemical **TFA was detected in 83.3% (54 out of 66) of cereal products** analysed above the limit of quantification of 10 µg/kg, which is also the default MRL for reprotoxic substances (see Figure 2).

The range of TFA detections above 10 µg/kg extends from 13 µg/kg TFA (detected in rye bread) to 360 µg/kg (detected in breakfast cereals).

The average contamination across all 65 products was **78.9 µg/kg**.

A detailed overview of all analysed cereal products, labelled with the cereal variety, is available in the Annex. The product brand names which participating members in the study have chosen to disclose are listed in the Annex. A comparison among countries is not possible as the type and number of samples was not equal.

The TFA levels found in cereal-based products **exceed the average contamination levels in tap water by a factor of 107**, indicating a high and widespread accumulation of TFA in certain cereal crop plants across Europe.

Wheat products significantly more contaminated than other products

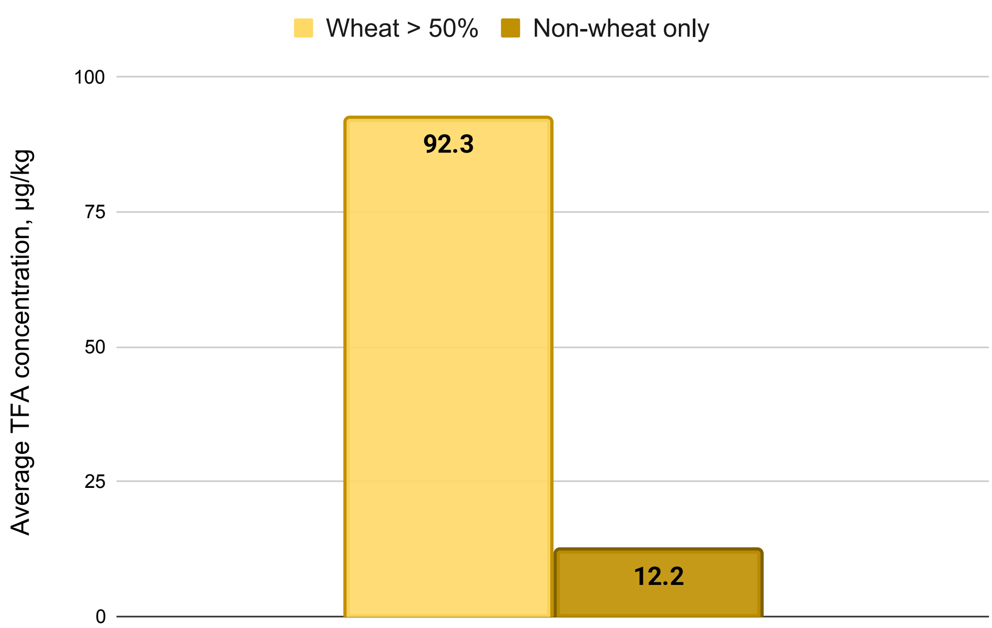


Figure 3: Comparison of the average TFA concentration detected in predominantly wheat-based products (average = 92.3 µg/kg, n=54, S.E.M = 13.3 µg/kg), and non-wheat cereal-based products (average = 12.2 µg/kg, n=11, S.E.M = 5.7 µg/kg); p < 0.0000005.

The average TFA concentration measured in predominantly wheat-based products (including products from a blend of cereals containing at least 50% wheat) was **92.3 µg/kg** (n = 54, standard error of the mean, S.E.M = 13.3 µg/kg). By contrast, products consisting of other cereal varieties, such as rye, oats, maize and rice had a considerably lower mean TFA concentration of **12.2 µg/kg** (n = 11, S.E.M = 5.7 µg/kg).

Statistical analysis using Welch's two-sample t-test (which accounts for unequal variances) indicated that the mean TFA concentration in wheat-based products was significantly higher than that in non-wheat products ($p < 0.0000005$). The wheat-based products contained, on average, approximately **7.6 times more TFA** than the non-wheat products.

Two hypotheses could account for this difference and are addressed here below:

- PFAS pesticides are used in greater quantities and/or more frequently on wheat cereals, and/or
- TFA accumulates more readily in wheat plants as a result of physiological differences across plant species.

Additionally, the cereals may have been imported from countries outside the EU and used in the finished products or flours. As the origins of the cereals could not be determined for the majority of products sampled, this hypothesis could not be verified.

PAN Europe's proposed safety limit exceeded

To assess a potential health risk posed by the measured average TFA contamination in cereal products in this study (78.9 µg/kg), two consumer groups are considered: adults (18- 65 years old) and children (3- 9 years old).

According to EFSA's food consumption database and other consumption data[37], children consume an estimated 8.42 g/kg bw/day of cereal-based products. For adults (18–65 years), the figure is 3.33 g/kg bw/day.

The resulting average daily TFA intake from these cereal-based products is:

- 0.25 µg/kg bw/day for adults
- 0.64 µg/kg bw/day for children

These daily intake amounts reach or exceed PAN Europe's proposed ADI (1.8 µg/kg bw/day) to the following extents:

Children

- The average TFA daily intake makes up 36.9% of PAN Europe's proposed ADI.
- The maximum TFA daily intake makes up 157.2% of PAN Europe's proposed ADI.

Adults

- The average TFA daily intake makes up 14.6% of PAN Europe's proposed ADI.
- The maximum TFA daily intake makes up 68.6% of PAN Europe's proposed ADI.

[37] See Methodology and Analysis section of this report as well as the Annex for a full overview of sources and how data was calculated.

By taking the TFA levels measured in different cereal-based foods from this study and adjusting for typical portion sizes, we have constructed an estimated TFA intake in the daily diet of children and adults from cereal-based foods alone.

Children

Cereal-based food	Portion size, kg	TFA intake, µg
Breakfast cereals (Ireland)	0.03	10.8
Bread, 2 slices (Belgium)	0.08	27.2
Noodles (Germany)	0.06	9
Cramique (Belgium)	0.1	28
Pasta (Italy)	0.05	1.3

Dividing the sum of this TFA intake (76.3 µg) by the standard EFSA body weight for children (23 kg) leads to an estimated daily TFA exposure of 3.32 µg/kg in children from the consumption of cereal-based products alone. This value is **184.3%** of PAN Europe's proposed ADI.

Adults

Cereal-based food	Portion size, kg	TFA intake, µg
Breakfast cereals (Ireland)	0.045	10.8
Bread, 2 slices (Belgium)	0.08	27.2
Noodles (Germany)	0.1	9
Cramique (Belgium)	0.1	28
Pasta (Italy)	0.1	1.3

Dividing the sum of this TFA intake (89 µg) by the standard EFSA body weight for adults (70 kg) leads to an estimated daily TFA exposure of 1.27 µg/kg in adults from the consumption of cereal-based products alone. This value is **70.63%** of PAN Europe's proposed ADI.

While these results in cereal-based products are alarming on their own, TFA has also been detected in a variety of other dietary components, such as vegetables, fruits, and culinary herbs, as well as plant-based beverages such as fruit juices, tea, infusions, wine and beer, and drinking water (tap and mineral). Additionally, TFA exposure in humans has also been recorded through rain, air and dust. Currently, the full extent to which EU citizens are exposed to this toxic substance is unknown; to our knowledge, no attempt to calculate a daily exposure arising from TFA's multiple exposure routes and sources has been carried out. Our findings, echoing those of previous studies, hold important implications for the establishment of a protective 'acceptable' daily intake and the regulation of TFA-precursor substances.

6. Discussion

Wheat may be particularly efficient at taking up TFA

Our review of various national pesticide registers suggests that PFAS pesticides are evenly authorised for use on wheat, spelt and rye. The difference in detection between products based on wheat and other cereal products therefore does not appear to result from a difference in the use of PFAS pesticides on these products.

Although data about what factors influence TFA uptake and accumulation in plants is still scarce, existing studies converge to indicate that plants carry a strong TFA exposure risk, which is increasingly aggravated by rising emissions of TFA in the environment. This risk is attributed to TFA's small molecular size and water solubility. Firstly, these characteristics allow TFA to be more mobile in the soil and to concentrate in soil water, making more TFA available in the rhizosphere for absorption by plant roots. Secondly, they allow TFA to cross the cell membrane of plant roots more easily than longer-chain PFAS, allowing TFA to be readily transported upwards in the plant, where it accumulates in above-ground parts. TFA, already concentrated in the soil water, moreover becomes even more concentrated in plant tissues as the plants transpire excess water via the leaf surface.

Agricultural crops are exposed to TFA through two routes. On one hand, through the direct application of PFAS pesticides. The other, more indirect route is through TFA that has leached into water resources - not only as a degradation product of PFAS pesticides, but also via other sources, such as F-gases and industrial applications.

A 2021 review investigating PFAS bioaccumulation in plants[38], the first to encompass TFA, highlighted the 'special role' played by TFA in plant bioaccumulation amongst all perfluoroalkyl carboxylic acids (PFCAs). TFA was ubiquitous in plants independently of the presence of other PFCAS[39,40], and was even present at 1-2 orders of magnitude higher than other PFCAs, including even short-chained PFCAs. The authors concluded that root uptake is the dominant mechanism for TFA accumulation in plants, as unlike longer-chain PFAS, there was no correlation between air and leaf TFA concentrations. All studies surveyed, whether hydroponic, field or greenhouse studies, found that short-chain PFAS like TFA accumulate more in above-ground plant parts than longer-chain PFAS.

In particular, the review showed that the grass family Poaceae, which includes cereal plants, shows a higher tendency to accumulate PFAS- especially ultra-short-chain PFAS. **Wheat - a staple crop of the European Union - may be particular-**

---

38 Lukas Lesmeister, Frank Thomas Lange, Jörn Breuer, Annegret Biegel-Engler, Evelyn Giese, Marco Scheurer, Extending the knowledge about PFAS bioaccumulation factors for agricultural plants – A review, Science of The Total Environment, Volume 766, 2021, 142640, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2020.142640.

39 Sacher F., Lange F.T., Nödler K., Scheurer M., Müller J., Nürenberg G., et al. Optimierung der EOF-Analytik unter Berücksichtigung der Beiträge verschiedener Stoffklassen poly- und perfluorierter Verbindungen. Forschungsbericht BWPLUS, Förderkennzeichen: L7517011- 16; 2019.

40 Chen, H., Yao, Y., Zhao, Z., Wang, Y., Wang, Q., Ren, C., et al., 2018. Multimedia distribution and transfer of per- and polyfluoroalkyl substances (PFASs) surrounding two fluorochemical manufacturing facilities in Fuxin, China. Environ Sci Technol 52, 8263–8271. https://doi.org/10.1021/acs.est.8b00544.

ly efficient at absorbing TFA, as shown by Zhang et al. (2019)[41], who have provided the only study to our knowledge investigating the mechanisms of TFA uptake in wheat.

TFA accumulated at significantly higher concentrations in the roots and shoots of wheat plants than other investigated PFAS- including the notorious and now-banned PFOS. Wheat plants maintained a fast and steady uptake of TFA in their roots and shoots over a period of 80 hours, showing no tendency to reach a steady state, implying that TFA uptake and accumulation would have continued past this period. In contrast, longer-chain (C4-C8) PFAS, including PFOS, were filtered by the root barrier at an early entry point, therefore they accumulated in the roots and reached equilibrium faster at a lower concentration. As a result, the root uptake of these compounds slowed down after 32 hours, with very low concentrations in the shoots detected throughout.

After just 80 hours of exposure, TFA levels found in wheat roots were over 100 times higher than that of perfluorohexanoic acid (PFHxA), a toxic PFAS classified as a Substance of Very High Concern (SVHC) by ECHA due to its very Persistent and very Bioaccumulative (vPvB) properties.

Compared to perfluorooctanoatic acid (PFOA) - a reprotoxic and carcinogenic substance, now banned in the EU - TFA reached levels 500 times higher in above-ground wheat parts, and 16 times higher in wheat roots.

Considering that TFA is being assessed for classification as toxic for reproduction (Category 1B) by ECHA, and that evidence of its other long-term human health impacts is now emerging, these findings are highly alarming. By the time the EU finally takes action to ban PFAS pesticides and other sources of TFA, what levels of this forever chemical will then be found in Europe's food supply?

Mechanisms of TFA uptake into wheat root cells

Zhang et al. (2019) suggest that **TFA enters the roots of wheat plants primarily through an energy-dependent active process, mediated by carrier proteins.** A comparison with the uptake curves of different PFAS compounds showed that TFA had a comparatively high affinity for carrier proteins in wheat root cells, explaining the higher TFA concentrations found in wheat. TFA was competitive with another ultra-short-chain PFAS, suggesting similar or overlapping pathways for entry into wheat root cells. In contrast, TFA uptake was not affected by the presence of longer-chain PFAS, suggesting different transportation pathways.

[41] Lu Zhang, Hongwen Sun, Qi Wang, Hao Chen, Yiming Yao, Zhen Zhao, Alfredo C. Alder, Uptake mechanisms of perfluoroalkyl acids with different carbon chain lengths (C2-C8) by wheat (Triticum acstivnm L.), Science of The Total Environment, Volume 654, 2019, Pages 19-27, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2018.10.443.

Although wheat is the best studied agricultural crop for PFAS bioaccumulation, the number of studies amounts to around a dozen. Studies focusing specifically on TFA uptake in wheat and other major crops like maize or rye are much scarcer still. Out of all the TFA exposure pathways to humans - including air, dust, water - food is thought to be the main uptake route. While PFAS pesticides continue to be sprayed across agricultural fields, our awareness of our daily exposure to TFA from cereal-based products, as well as from the meat, milk and eggs of animals fed on cereal fodder, remains deeply limited - although existing knowledge points to conclusions that should alarm regulators.

TFA - toxic to reproduction and early life development- is widespread in our daily food

Our study shows that 83.3% (54 out of 66) of cereal-based food items sampled randomly across 16 countries contained TFA above 10µg/kg (0.01 mg/kg). This is already alarming, considering that TFA causes serious adverse effects on reproduction and development in animal studies. These effects ranged from skeletal and eye malformations in rabbit offspring, to decreased sperm quality, disrupted thyroid function, immunotoxicity and liver toxicity in rat offspring, and in certain cases adults. The EU Pesticides Regulation (EC) 1107/2009 has a strict rule for pesticide active substances that cause such effects: they should not be detected in food, or their residue limit should be set at the default MRL of 0.01 mg/kg.

Even though TFA is not an active substance but a breakdown product, the Pesticides Regulation clearly states that residues of plant protection products should not cause any harmful effects to human health, including that of vulnerable groups, or to animal health (Article 4(2a)).

TFA is the breakdown product of PFAS pesticides, and it has been shown that the use of PFAS pesticides is an important source of TFA contamination in agricultural areas. Therefore, our study shows, once again, that all PFAS pesticides that break down to TFA must be banned immediately because of the high levels of TFA contamination in our food.

Conclusions

This study presents the most comprehensive EU-wide dataset to date on TFA contamination in cereal-based foods. TFA- a persistent "forever chemical" associated with reproductive harm, endocrine disruption, and other serious health effects - was detected across a wide range of conventional cereal products, including breads, pasta, breakfast cereals, flours, noodles, and biscuits. **Contamination is widespread and particularly pronounced in wheat-based products, highlighting a systematic presence in Europe's food supply.**

Food is a far more significant source of TFA exposure than drinking water, and concentrations in many samples exceed precautionary maximum residue levels (MRLs) and estimated safe intakes for children. Variations across samples and cereal types underscore gaps in understanding which foods pose the greatest risk, but the overall pattern points to a persistent and growing public health concern.

TFA's ubiquity is directly linked to regulatory inaction on PFAS pesticides and other TFA-generating substances. Decades of continued approval and use of these chemicals have resulted in contamination of soils, crops, and staple foods. Research also indicates strong correlations between TFA residues and PFAS pesticide residues in plant-based foods, confirming that regulatory choices have direct real-world impacts on human exposure.

Given its extreme persistence, rising concentrations, and multiple exposure pathways, TFA represents a clear and escalating health threat. **PAN Europe calls for urgent measures, including banning PFAS active substances in pesticides, lowering the acceptable daily intake (ADI) for TFA, monitoring TFA in food, restricting F-gases under REACH, and supporting farmers in transitioning to safer crop protection methods.** Immediate regulatory action is essential to prevent further accumulation of this harmful chemical in Europe's food supply and environment.

Publication date: **4 December 2025**

Unseen and Unregulated:

TFA, the 'forever chemical' in Europe's Cereals

Authors:

Pauline Ronnet & **Salomé Roynel**.
Reviewed by **Angeliki Lysimachou**.

We are thankful for their contributions*:

Ina Agafonova (Via Pontica), **Eri Bizani** (Ecocity), **Karolína Brabcová** (Arnika), **Helmut Burtscher** (Global 2000 - Friends of the Earth Austria), **Pauline Cervan** (Générations Futures), **Peter Clausing** (PAN Germany), **Tjerk Dalhuisen** (PAN Europe), **Heleen De Smet** (Bond Beter Leefmilieu), **Constantin Dobrescu** (Romapis), **Kristine Garcia** (Ecologistas en Acción), **Eva Goldmann** (WWF Switzerland), **Koldo Hernández** (Ecologistas en Acción), **Caroline Lewis** (Friends of the Irish Environment), **Agnieszka Makowska** (Living Earth Coalition), **Dorota Metera** (Living Earth Coalition), **Markéta Moller** (Arnika), **Bernie O'Connely** (Irish Environmental Network), **Virginie Pissoort** (Nature & Progrès), **Margarita Raykova** (Via Pontica), **Fidrich Róbert** (MTVSZ - Friends of the Earth Hungary), **Francesco Romizi** (International Society of Doctors for the Environment), **Gergely Simon** (PAN Europe), **Susanne Smolka** (PAN Germany), **Sjoerd van de Wouw** (PAN Netherlands), **François Veillerette** (Générations Futures), **Claire Wolff** (Mouvement Écologique).

Pesticide Action Network (PAN) Europe is a science-based organisation bringing together more than 50 consumer, public health and environmental organisations, trade unions, women's groups and farmer associations from across Europe. We work to eliminate the dependency on pesticides and promote alternatives that work instead of fighting against nature.

Contact:

Pesticide Action Network Europe (PAN Europe)
Rue de la Pacification 67, 1000, Brussels, Belgium
www.pan-europe.info
Tel. +32 2 318 62 55

Dr Angeliki Lysimachou, Head of Science and Policy: angeliki@pan-europe.info
Salomé Roynel, Policy Officer: salome@pan-europe.info

*in alphabetical order