Occurrence of Trifluoroacetic Acid in Food of Plant Origin – Results from Official Food Control

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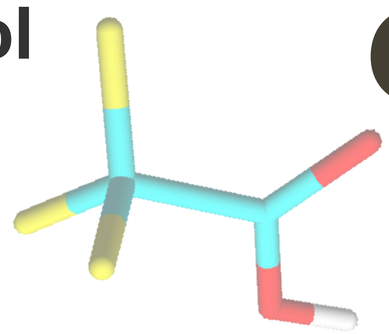

Introduction

Trifluoroacetic acid (TFA) is a fluorinated carboxylic acid that is increasingly viewed as a ubiquitous environmental contaminant due to its persistence, high mobility and numerous sources. It is a potential degradation product of several synthetic substances containing a trifluoromethyl group (-CF_3), such as fluorinated refrigerants, pesticides, fluoropolymers, pharmaceuticals. As a polar, highly water-soluble compound, TFA is widely dispersed via the water cycle and accumulates in soil and plants, through which it enters our food. [1]

Legal and Toxicological Aspects

There are currently no regulatory limits for TFA in food. The European Food Safety Authority (EFSA) has defined a provisional acceptable daily intake (ADI) of 0.05 mg/kg body weight [2]. The German Federal Institute for Risk Assessment (BfR) has categorized TFA as being toxic for reproduction, and the German Environment Agency (UBA) has classified the substance as “very persistent and very mobile”. [3]

Analytical Method

The samples were extracted using the QuPPe (Quick Polar Pesticides) method. After the extraction with acidified methanol, followed by centrifugation and filtration, the extracts were measured by LC- or IC-MS/MS in ESI negative mode. (2016/17 M9 [4], 2024/25 M11 [5])

Results

At CUVA Stuttgart, more than 8,800 food samples of plant origin (23% organic) were analyzed for residues and contamination from TFA in 2016/17 and 2024/25 as part of the official food control. They were all taken from local markets in Baden-Württemberg and originated from a wide variety of countries (EU and non-EU). Altogether, 23% of the samples contained TFA above the LOQ (depending on the commodity group and analytical method: 0.02-0.1 mg/kg).

The positive findings are independent of the type of cultivation (organic vs. conventional) and the country of origin. Regardless of the commodity group, the median values for conventional samples were comparable to those for organic samples and did not vary significantly between the different years. The determined medians ranged from 0.04 mg/kg to 0.07 mg/kg. (see Fig.1)

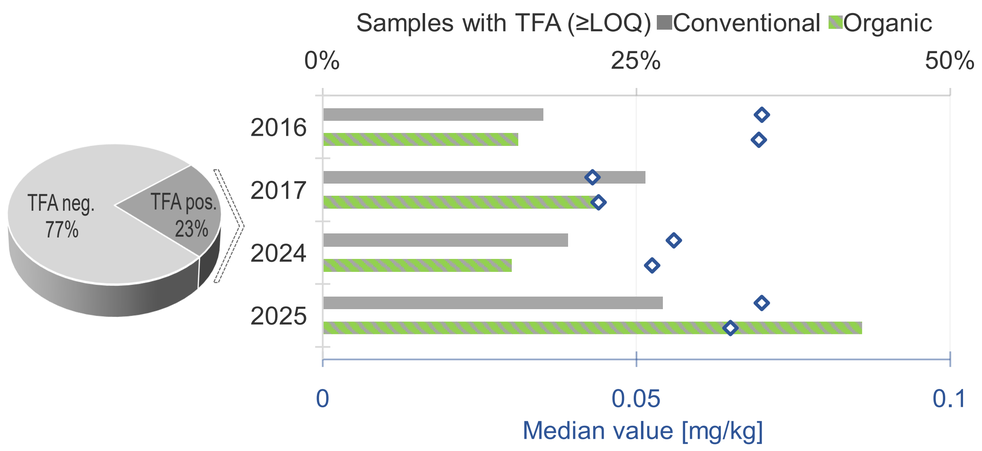

Figure 1: Overview of TFA findings ≥LOQ in food samples of plant origin from 2016/17 and 2024/25

The highest individual values were found in one sample each of fresh rosemary (4.8 mg/kg), lettuce (4.7 mg/kg), hops (4.5 mg/kg), moringa tea (4.2 mg/kg) and dried oregano (3.0 mg/kg).

For dried products, it should be taken into account that TFA is concentrated during the drying process, which leads to higher median values (e.g. spices, coffee and tea, cereals).

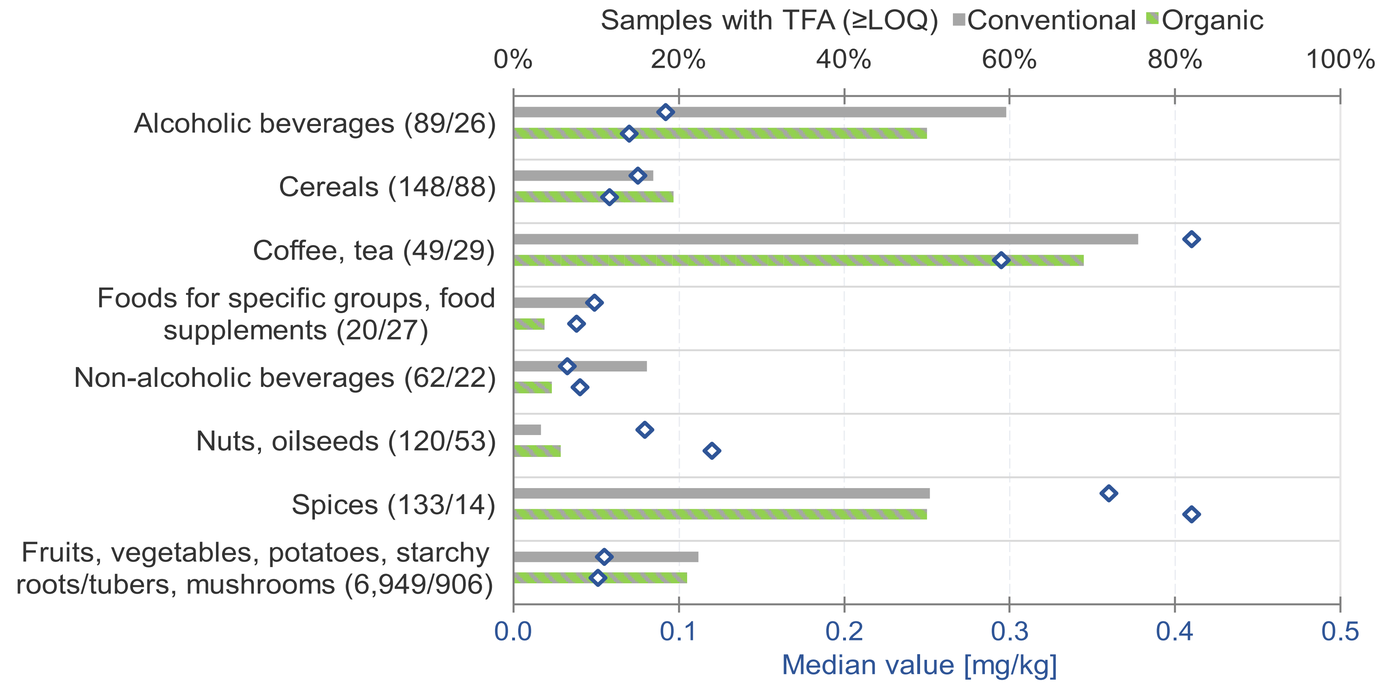

Figure 2: Percentage of TFA findings in various commodity groups of plant origin (No. conventional / organic samples analyzed) and their median value

In the commodity group alcoholic beverages, we analyzed beer and wine as well as their raw materials. We found no TFA in beer samples, but in 60% of the analyzed hops and malt samples. In the case of wine and grapes, we found TFA in 66% of both.

Most of the samples analyzed were from the fruit and vegetable commodity group. The highest number of positive findings was found in herbs. The highest median values for organic products were found in herbs as well, whereas the highest median values for conventional products were in seed vegetables/pulses. (see Tab. 1)

Table 1: Overview of TFA residues in conventional and organic fruits, mushrooms, potatoes, starchy roots/tubers and vegetables

Commodity group	No. of samples		Samples with TFA		Median value [mg/kg]		Max. [mg/kg]
	Org.	Conv.	Org.	Conv.	Org.	Conv.	
Berries	69	963	19%	17%	0.053	0.046	0.63 (Table Grapes/IN)
Citrus fruit	76	459	8%	7%	0.026	0.042	0.15 (Mandarin/ZA)
Exotic fruit	55	597	40%	32%	0.055	0.060	0.76 (Kiwi/IT)
Pome fruit	55	425	-	3%	-	0.052	0.17 (Pear/ES)
Stone fruit	39	616	5%	7%	0.025	0.033	0.14 (Apricot/ES)
Cultivated mushroom	9	139	-	3%	-	0.076	1.20 (Chanterelle/unknown)
Wild mushroom	-	31	-	45%	-	0.061	0.22 (Porcini mushroom/RO)
Potato	41	211	10%	40%	0.029	0.054	0.51 (DE)
Starchy root/tuber	5	21	40%	29%	0.076	0.064	0.41 (Sweet potato/USA)
Fruit vegetables	175	1207	15%	14%	0.038	0.044	0.30 (Eggplant/DE)
Herbs	49	271	61%	65%	0.094	0.079	4.80 (Rosemary/IL)
Leafy vegetables/salads	118	976	31%	34%	0.040	0.056	4.70 (Lettuce/DE)
Onion vegetables	14	93	-	20%	-	0.055	0.27 (Garlic/DE)
Root vegetables	85	325	8%	34%	0.051	0.051	0.43 (Carrot/DE)
Seed vegetables/pulses	64	206	45%	43%	0.058	0.098	1.40 (Lentil/unknown)
Stem/sprout vegetables	19	309	-	23%	-	0.049	0.37 (Asparagus/DE)

Conclusion

Residues or contamination from TFA above the LOQ were detected in 23% of the more than 8,800 food samples of plant origin analyzed – regardless of cultivation method or country of origin. The provisional ADI set by EFSA was not exceeded, even at the highest levels detected. However, regulatory assessment is difficult due to the current lack of a legal maximum residue level. Furthermore, the potential impact of long-term TFA intake cannot yet be assessed due to insufficient toxicological data. In combination with the ubiquitous presence and the high number of positive findings, this underscores the need for critical evaluation (analytical and regulatory) of TFA entering the food chain.

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LITERATURE

[1] Solomon, Keith R et al. (2016): Sources, fates, toxicity, and risks of trifluoroacetic acid and its salts: Relevance to substances regulated under the Montreal and Kyoto Protocols. Journal of toxicology and environmental health part B. doi:10.1080/10937404.2016.1175981

[2] EFSA (2014): Reasoned opinion on the setting of MRLs for saflufenacil in various crops. considering the risk related to the metabolite trifluoroacetic acid (TFA).

[3] UBA (2025): German agencies classify TFA as toxic substance.

[4] EURL-SRM (2024): 5.6.24. Method 9 (M9): „Difluoroacetic acid and Trifluoroacetic acid “. 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). Version 12.3

[5] EURL-SRM (2024): 5.6.24. Method 11 (M11): „GlyCo. by IC on AS19“.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). Version 12.3

Baden-Württemberg