

Executive Summary

Per- and Polyfluoroalkyl Substances (PFAS) Presence in Food: Comparison Among Fresh, Frozen and Ready-to-Eat Vegetables (Food Chemistry, 2023)

This study investigated the presence of per- and polyfluoroalkyl substances (PFAS) in vegetables sold in Italy and compared contamination levels between fresh, frozen, and ready-to-eat products. The research was undertaken because vegetables are recognised as a potentially important route of human exposure to PFAS through the food chain, and concerns exist that industrial processing, handling, and packaging may increase contamination levels.

A total of 41 vegetable samples were analysed, including fresh vegetables, frozen vegetables, and ready-to-eat salad products. The researchers tested for 25 PFAS compounds using a validated laboratory method based on liquid chromatography–mass spectrometry (LC-MS/MS).

The study found that every sample contained at least one detectable PFAS compound. Twelve PFAS compounds were detected above quantifiable levels. Total PFAS concentrations ranged from 0.007 ng/g to 0.391 ng/g across all samples.

Ready-to-eat vegetables contained the highest average PFAS concentrations, followed by fresh vegetables, while frozen vegetables contained the lowest average concentrations. The difference between ready-to-eat and frozen vegetables was statistically significant. The authors suggest that industrial processing, washing, handling, packaging, or other aspects of food preparation may contribute to these differences, although the exact cause could not be determined.

The most frequently detected compounds were:

- Perfluorooctanoic acid (PFOA)
- Perfluorobutanoic acid (PFBA)
- Perfluoroheptanoic acid (PFHpA)
- Perfluoropentanoic acid (PFPeA)
- Perfluorooctane sulfonate (PFOS)
- Perfluorohexanoic acid (PFHxA)

PFBA was the most abundant compound detected overall and was particularly common in leafy vegetables such as lettuce, mixed salads, rocket, and valerian leaves.

The study also found that several vegetable samples exceeded European Commission recommended investigation thresholds for PFOS, PFOA, and PFNA. Most of these exceedances occurred in ready-to-eat products. Frozen vegetables generally remained below the recommended thresholds.

A notable observation was that organically grown vegetables contained lower total PFAS concentrations than comparable conventionally grown vegetables. Although the number of organic samples was small and the authors caution against drawing firm conclusions, they suggest that reduced pesticide use may be one possible explanation requiring further investigation.

The authors note that vegetables can become contaminated through multiple pathways, including:

- Uptake from contaminated soil and groundwater through plant roots.
- Direct atmospheric deposition onto leaves.
- Agricultural chemicals and pesticides.
- Food processing and industrial handling.
- Food-contact packaging materials.

The study concludes that PFAS contamination is widespread across vegetable products and that food processing may influence contamination levels. However, further research is required to determine the relative importance of cultivation practices, industrial processing, packaging, and environmental contamination as sources of PFAS in food.

Overall, the findings support the growing body of evidence that vegetables can act as a route of human PFAS exposure and highlight the need for continued monitoring, improved understanding of contamination pathways, and future regulatory limits for PFAS in vegetable products.