Cooking reduces PFAS concentrations in blue food - a meta-analysis

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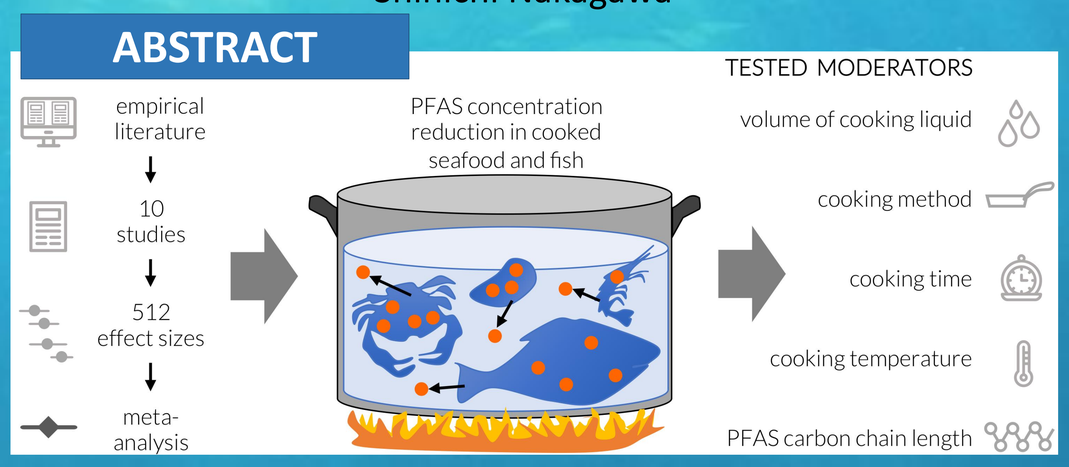
ABSTRACT



INTRODUCTION

What are PFAS? Per- and polyfluoroalkyl substances (PFAS) are a large group of anthropogenic chemicals. Due to their heat-resistant, and oil- and water-repellent properties they have been used in numerous applications including Teflon, fire-fighting foam, and food packaging since the 1950s. PFAS have since leached into waterways and oceans around the globe. People mostly ingest PFAS with blue food and tap water. PFAS exposure is linked to negative health effects.

What is blue food? Blue food includes seafood and edible products of freshwater fish.

What is a meta-analysis? A meta-analysis includes a statistical analysis of data from multiple studies. Studies investigating the same research question often find results contradicting each other. A meta-analysis uses the collective statistical power of those studies, often resulting in a more conclusive answer to the research question.

What are our research questions?

1. Can cooking reduce PFAS concentrations in seafood making it safer to eat?
2. If the answer to 1. is yes, which of the following factors (moderators) drive PFAS reduction: cooking time, liquid/blue food tissue ratio, cooking temperature, PFAS carbon chain length or cooking method?

METHODS

What type of empirical studies did we include in the meta-analysis? To be eligible, studies had to perform experiments comparing the PFAS concentrations of raw and cooked blue foods. We accepted peer-reviewed papers, pre-prints and theses.

How did we find relevant studies? We developed a comprehensive search string and systematically searched the following databases: Scopus, Web of Science, Ebsco, biorxiv, BASE and Mendeley Data. Two authors screened title, abstract and in a second step the full text of potentially eligible papers.

How did we prepare and perform the meta-analysis? We extracted the following data: title, author, year of publication, study species, PFAS compounds studied, cooking category (oil-based, water-based and without adding any liquid), PFAS carbon chain length, cooking temperature, liquid/blue food tissue ratio, cooking time, PFAS concentration pre- and post-cooking to calculate effect size (change of PFAS concentration). Subsequently, we applied phylogenetic multilevel meta-analytic and meta-regression models to the data.

RESULTS

How many papers did we include in the meta-analysis?

From an initial 452 studies we deemed 10 eligible.

What data did these 10 studies contain?

- 38 species, e.g., marine and freshwater fish, crabs, cephalopods, mussels
- 18 PFAS compounds, e.g., PFOS, PFOA, PFNA
- 512 effect sizes (data points indicating the change of PFAS concentration)

What is the impact of the individual factors on PFAS reduction?

- Cooking time:
  - 2min/120s → 18 % PFAS reduction
  - 10min/600s → 56 % PFAS reduction
  - 25min/1500s → 86 % PFAS reduction
- Liquid/blue food tissue ratio:
  - 0ml/g → 9 % PFAS reduction
  - 10ml/g → 75 % PFAS reduction
  - 45ml/g → 89 % PFAS reduction

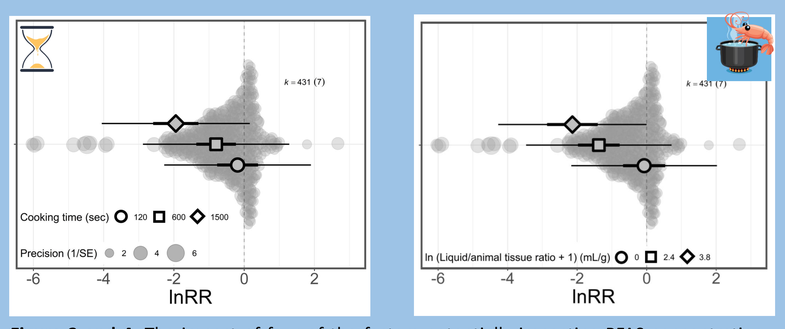


Figure 3 and 4. The impact of four of the factors potentially impacting PFAS concentration change (lnRR) during cooking. The dark grey lines show the predictions from the uni-moderator models with their associated 95% confidence intervals (grey-shaded area). The red lines represent the predictions from the multi-moderator models and their 95% confidence intervals (red-shaded area). Negative lnRR indicate reductions in PFAS concentration.

Does cooking reduce PFAS concentrations in blue food?

- Yes! Across included studies, PFAS concentration was reduced by 29%.

Which factors do mostly drive PFAS reduction?

- Cooking time ✓
- Cooking temperature ✗
- Cooking category ✗
- Liquid/blue food tissue ratios ✓
- PFAS carbon chain length ✗

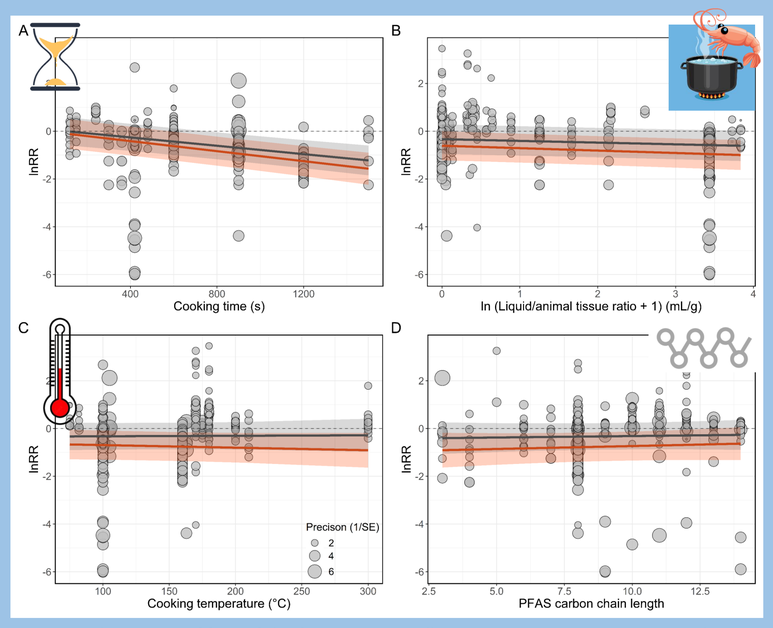


Figure 2. The impact of four of the factors potentially impacting PFAS concentration change (lnRR) during cooking. The dark grey lines show the predictions from the uni-moderator models with their associated 95% confidence intervals (grey-shaded area). The red lines represent the predictions from the multi-moderator models and their 95% confidence intervals (red-shaded area). Negative lnRR indicate reductions in PFAS concentration.

DISCUSSION

How do increased cooking time and large volumes of cooking liquid contribute to reducing PFAS concentrations? We hypothesize that cooking liquids act as solvents and flush out PFAS from food products. The cooking time increases exposure of food products to cooking liquids.

What's the best way of cooking blue foods to reduce as much PFAS as possible?

- Cook with as much oil or water as possible!
- Discard oil or water after use!
- Cook or fry for as long as possible!

Is it possible to remove PFAS concentration in blue food completely? In theory yes, but cooking time and the amount of cooking liquid needed is massive. Food products would be rendered inedible. Therefore, in practice, a significant PFAS reduction is as good as it gets.

What are the limitations of our study? Research is limited to blue food! Terrestrial animal products like beef, pork, eggs and milk can also contain PFAS. However, there are no studies that investigate the potential of cooking to reduce PFAS in any of these products. Further research is needed. Secondly, blue foods can contain many other chemical contaminants (incl. DDT, PCDD, PCBs) and heavy metals. We did not investigate the impact of cooking on those.

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More info on PFAS: livingpfas.org

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