Occurrence and source characterization of environmental contaminants in novel plant-based foods

A. Macan Schönleben[1,$], F. Cappelli[1,$], Ž. Rekar[2], K.V. Mubiana[3], L. Bervoets[3], T. Kosjek[2], A. Van Nuijs[1], A. Covaci[1], **G. Poma**[1]

1 Toxicological Centre, University of Antwerp (Belgium), 2 Jožef Stefan Institute (Slovenia), 3 Ecosphere, University of Antwerp (Belgium); Contact: *giulia.poma@uantwerpen.be*

$ - current working place: *Flemish Institute for Technological Research (VITO) (Belgium)*

Introduction & Objectives

- The market for **novel plant-based foods (NPBFs)** has grown rapidly in recent years
- Data on their chemical food safety remain limited and so far, has focused on plastic-related compounds, such as organophosphate flame retardants, plasticisers and chlorinated paraffins[1,2]
- This study integrates **targeted and non-targeted analytical** approaches to identify and prioritise other **contaminants of concern** in NPBFs and elucidate potential contamination sources

Materials & Methods

- Quantification of **per- and polyfluoroalkyl substances (PFAS)** via LC-MS/MS[3,4], of **metals** via HR-ICP-MS, and identification of **additional compounds** using high-resolution mass spectrometry (HRMS)-based suspect screening[5,6]
- Analysis of 52 NPBF samples, including various PB meat-, cheese-, and fish-alternatives, purchased in 3 European countries (BE, UK, DE)[1]



Results & Discussion

PFAS

- PFAS levels in NPBFs were generally low, but detectable across all samples (Fig. 1)
- Priority PFAS defined by EFSA[7] (**PFOA, PFNA, PFOS and PFHxS**) were detected in 90%, 80%, 58% and 44% of samples, respectively.

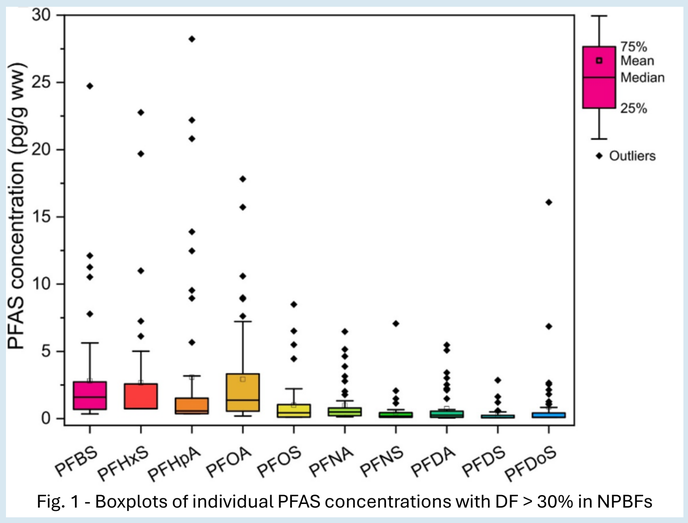


Fig. 1 - Boxplots of individual PFAS concentrations with DF > 30% in NPBFs

- **PB cold meat-alternatives** and **sausage-** were the most contaminated NPBFs with the four priority PFAS (Fig. 2)

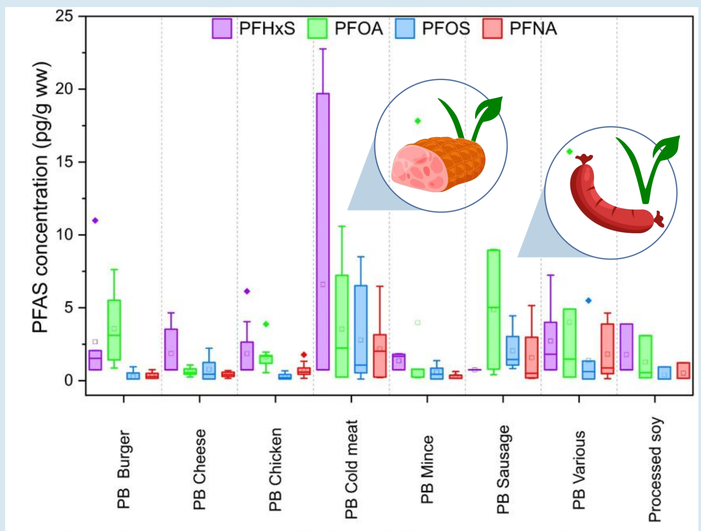


Fig. 2 - Boxplots of 4 priority PFAS per NPBF category with n>3 samples

- NPBF concentrations for priority PFAS were generally lower than existing European **MLs** for available corresponding food categories[8], but there were exceptions (Tab. 1)

Tab. 1 - Available maximum levels set by the European Commission for different food categories. In red, compounds for which the max PFAS concentrations were > MLs

Maximum levels[7,8] (pg/g ww)	PFHxS	PFOA	PFOS	PFNA
Meat	200	800	300	200
Fish	200	200	2000	500
Milk	60	**10**	20	50
Eggs	300	300	1000	700
Vegetables	**15**	**10**	10	**5**

Metals

- Essential metals in NPBFs exhibited the highest concentrations in processed soy (Fig. 3)
- Co – a key component of vitamin B12 – is not naturally occurring in soy, but it is often added to NPBFs as supplement

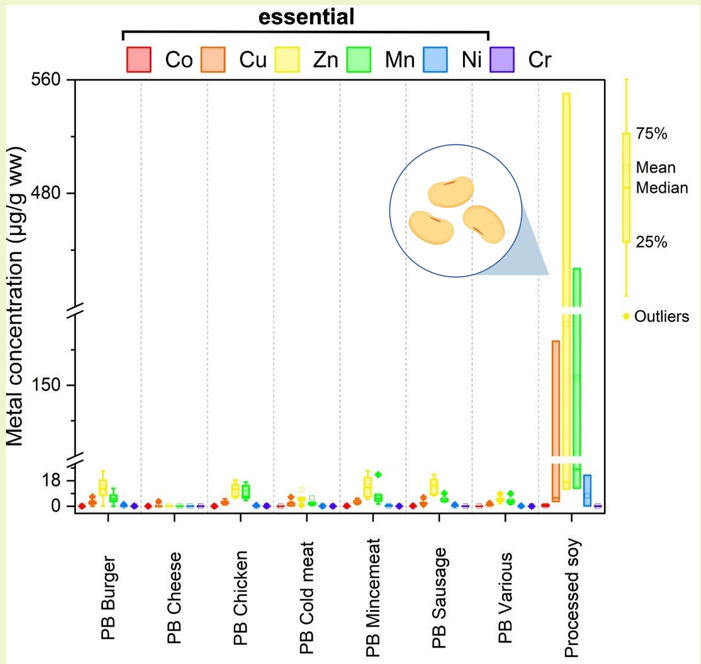


Fig. 3 - Boxplots of essential and non-essential metal concentrations per NPBF category with n>3 samples

- **Cd** and **As** were the most prevalent regulated metals (Fig. 4).
- Soy-based products, and thus vegetarian/vegan diets, have been associated with increased Cd exposure
- Cd level in one dried soy sample (0.5 µg/g ww) exceeded the European MLs permitted in soybeans (0.2 µg/g ww)[7]
- The **base ingredient of NPBFs plays a role in metal contamination**, since the uptake and accumulation of metals are highly dependent on plant types

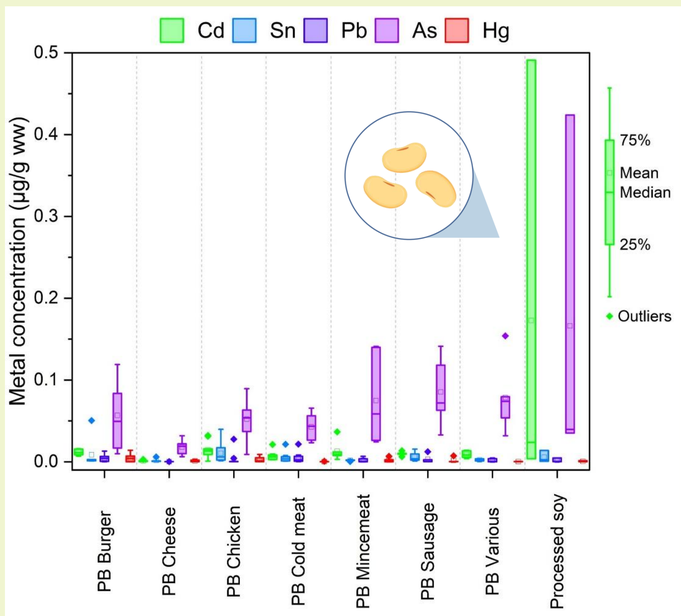


Fig. 4 - Boxplots of regulated toxic metal concentrations per NPBF category with n>3 samples

Suspect screening

- 65 compounds were annotated at CL to CL3, according to the Schimanski scale[9]
- Most identified compounds belonged to the classes of **industrial chemicals and plastic additives** (Fig. 5)
- 1,2-dihydro-2,2,4-trimethylquinoline, a rubber antioxidant banned from food contact materials by the FDA and the European Commission[10], was found at CL1 with DF 48%
- Pesticides were detected less frequently than expected in NPBFs and were most prevalent in processed soy products
- QAC benzylalkyldimethyl ammonium (BAC-C12, DF 23%, used as surfactant) was confirmed at CL1

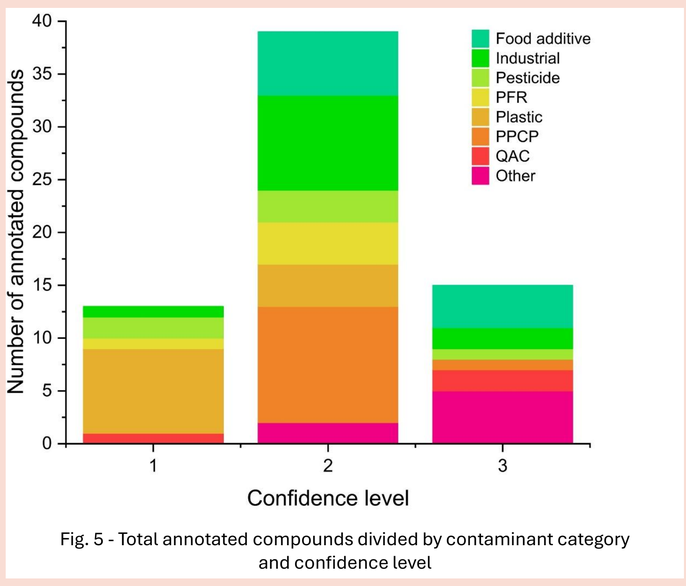


Fig. 5 - Total annotated compounds divided by contaminant category and confidence level

- Most compounds and classes were annotated in the categories of **PB cold meat-alternatives, PB sausage- and PB chicken-alternatives** (Fig. 6)

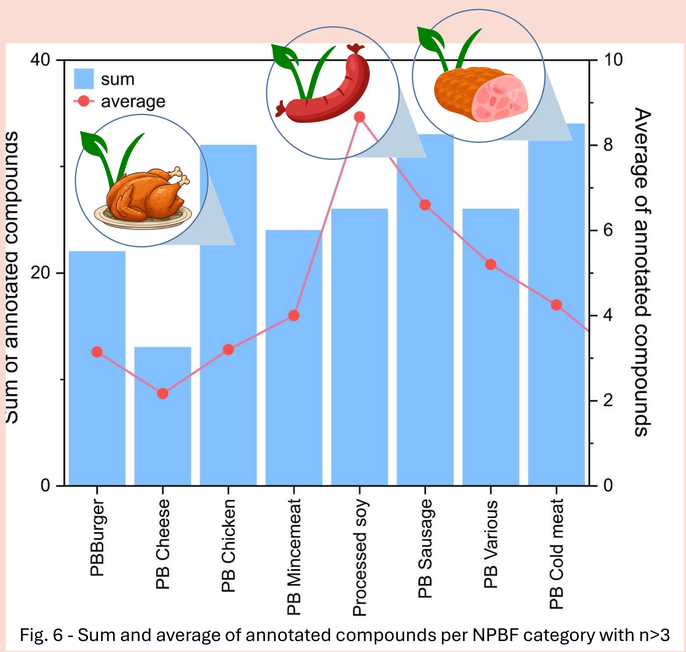


Fig. 6 - Sum and average of annotated compounds per NPBF category with n>3

Conclusions

- Contamination patterns varied between NPBF categories, indicating **distinct contamination sources** which might be linked to product composition and the degree of food processing
- NPBFs with larger proportions of plant ingredients could be more prone to accumulating pesticides or metals
- NPBFs with more extensive processing steps and additive ingredients might be more contaminated with industrial compounds
- NPBFs represent a **relevant and distinct food category** in terms of chemical contamination
- NPBFs should be integrated into **routine food monitoring programs** and future regulatory frameworks to ensure consumer safety

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