PFAS in food and migration from contact materials into real food

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Improved PFAS method; and study on PFAS in Danish eggs

In 2020 EFSA reduced the PFAS tolerable weekly intake (TWI) of

Σ PFOS, PFOA, PFNA, PFHxS to 4.4 ng/kg body weight;

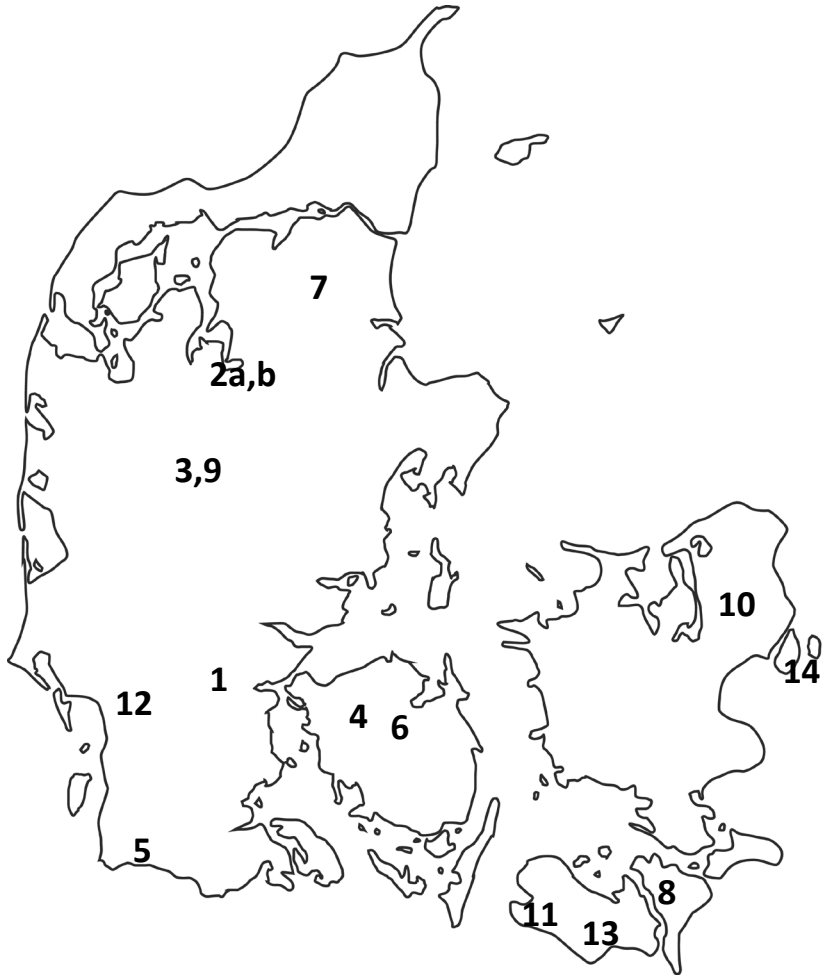
Since 1 Jan 2023		Maximum Levels µg/kg				
		PFOS	PFOA	PFNA	PFHxS	Σ4PFAS
	Eggs	1.0	0.30	0.70	0.30	1.70

DTU Food validated a more sensitive PFAS method and analyzed eggs sampled within projects carried out by the Danish Veterinary and Food Administration's Laboratory.

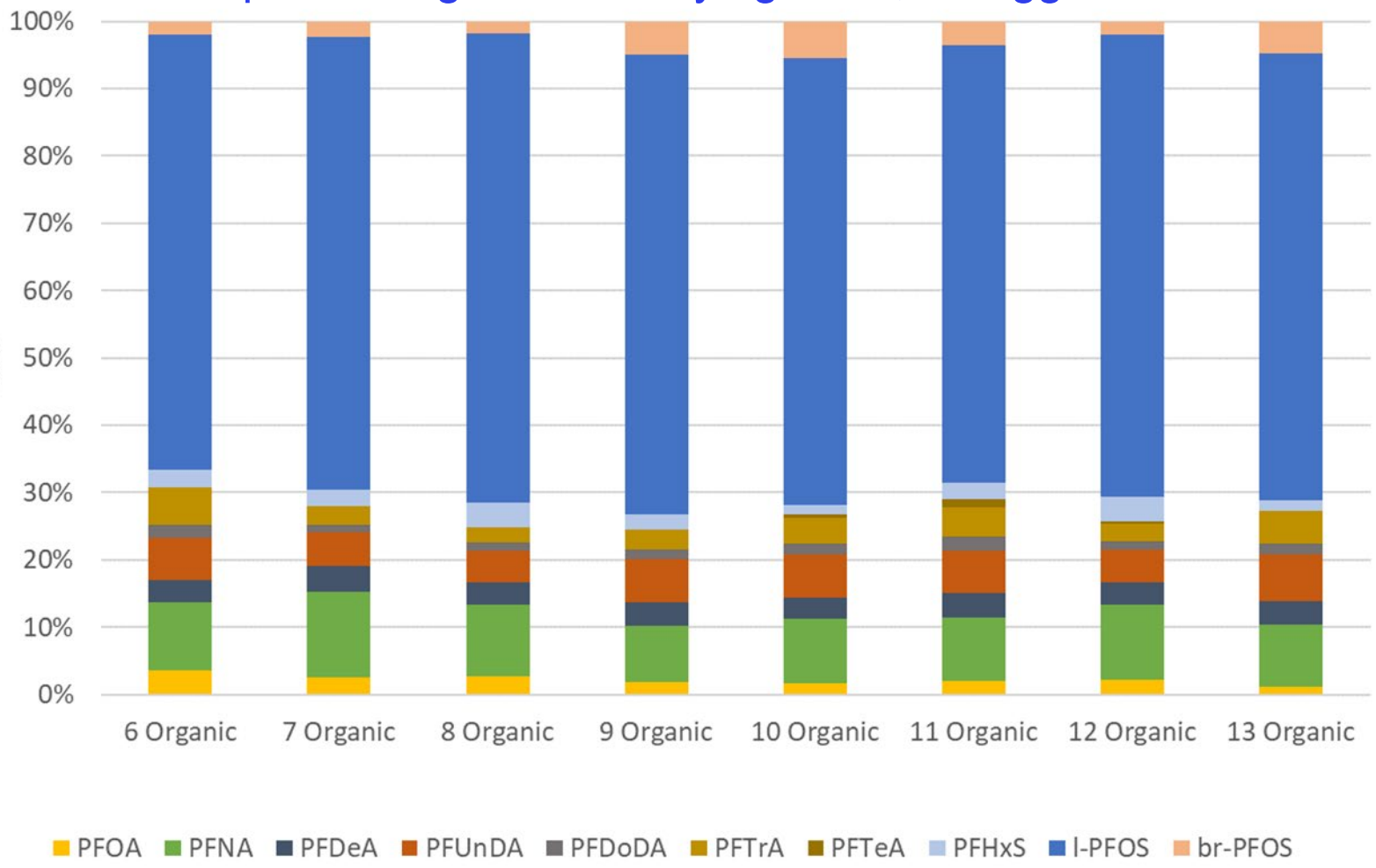
Distribution of PFAS in organic eggs from 8 large farms, Sept. 2022

∑4PFAS~85%±2% of the sum. Normalised to PFOS and logaritmised:

significant differences between other individual PFASs (*p*=1.4E-25), reflecting identical profiles



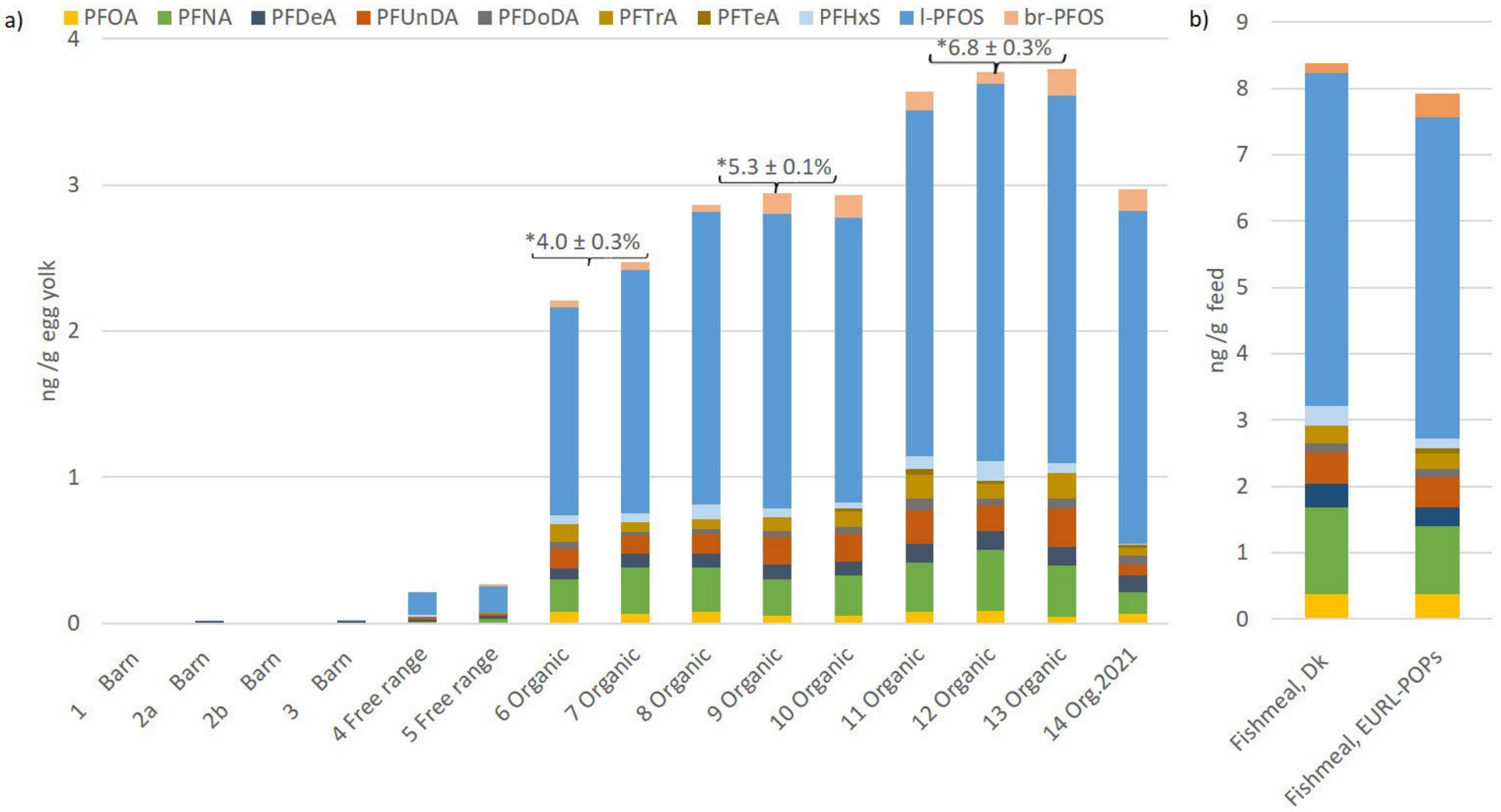
Representing 132.500 laying hens, 30 eggs/farm



Ref. MAP Denmark, Colourbox

Large farms‘ egg yolk samples Sept. 2022, and estimated % fishmeal in feed

Fishmeal 2022 from Danish producer



Higher concentrations of odd relative to even C8-C14 PFCAs for fishmeal and egg yolks

Information on fishmeal, the same in Proficiency test from EURL-POPs and fishmeal used as supplementary feed in Denmark

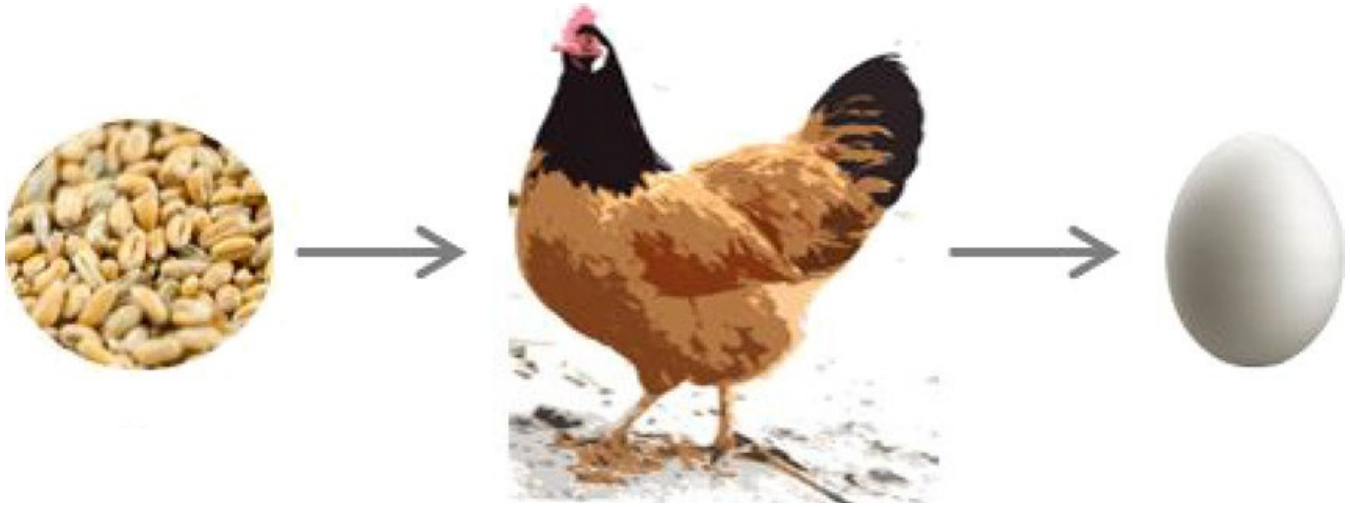
Both fishmeal samples were from the same Danish producer and consisted of herring from the Baltic Sea, from the Bothnian Sea and Southern Central Baltic – West, relatively PFAS polluted areas.

Uneven dominance is characteristic of PFAS distribution in fishmeal worldwide (Li et al 2019 J Hazard. Materials 367, p559.)

Fishmeal PFAS higher in the Northern hemisphere.

Long-chain PFCAs (PFNA, PFDA, PFUnDA, PFDoDA ,PFTrDA) were higher in industrial areas.

Transfer of PFAS from contaminated feed to egg
(based on controlled feeding trial from BfR Germany)



Halflives ($t½$) from feed to egg:
PFOS 4.3 days
PFOA 4.5 days
PFHxS 7.6 days

Transfer factor from feed to egg:

	Transfer factor feed to egg	Reference
PFOS	2.26	BfR 2021
PFOA	1.1	BfR 2021
PFNA	1.4	estimated
PFDeDA	1.7	estimated
PFUnDA	2.2	estimated
PFDoDA	2.1	estimated
PFTrDA	2.4	estimated

represent 132,500 laying hens with pools of 30 eggs from eight farms

References: **Kowalczyk J. et al 2020 J. Agric. Food Chem.68, 45, 12539-12548**

BfR 2021, PFAS maximum levels in feedstuffs: BfR recommends improved analytical methods BfR opinion No 037/2021, DOI 10.17590/20211124-122122

Exposure from commercial large farms' organic egg of Σ4PFAS ~ 0.874 ng/g

Children and adults eating mean~2 and 3 eggs/week (95 perc.~ 5 and 6 eggs/week)

	No. participants	Body weight kg	Egg consumption g/week Mean	Egg consumption g/week 95th perc.	Exposure ng/kg bw/week Mean	Exposure ng/kg bw/week 95th perc.	% Tolerable weekly intake mean	% Tolerable weekly intake 95th perc.
Children 4-9 years	421	26.04	125	311	4.2	10.4	95%	237%
Adolescents 10-17 years	509	54.23	120	328	1.9	5.3	44%	120%
Adults 18-75 years	3016	78.30	171	426	1.9	4.6	43%	108%

When children are at risk of being exposed to more than twice as much PFAS solely from eggs, as the amount that is the limit for a safe intake, the risk is noticeable.

Press release DTU Food 23 Jan. 2023:

PFAS found in organic eggs in Denmark

The environmental contaminant PFAS has been found in organic egg yolks in Denmark. Especially children who eat many organic eggs are at risk. The substances are most likely transferred via fishmeal, which is included in feed for the hens. This was found in a study from the DTU National Food Institute carried out in collaboration with the Danish Veterinary and Food Administration.

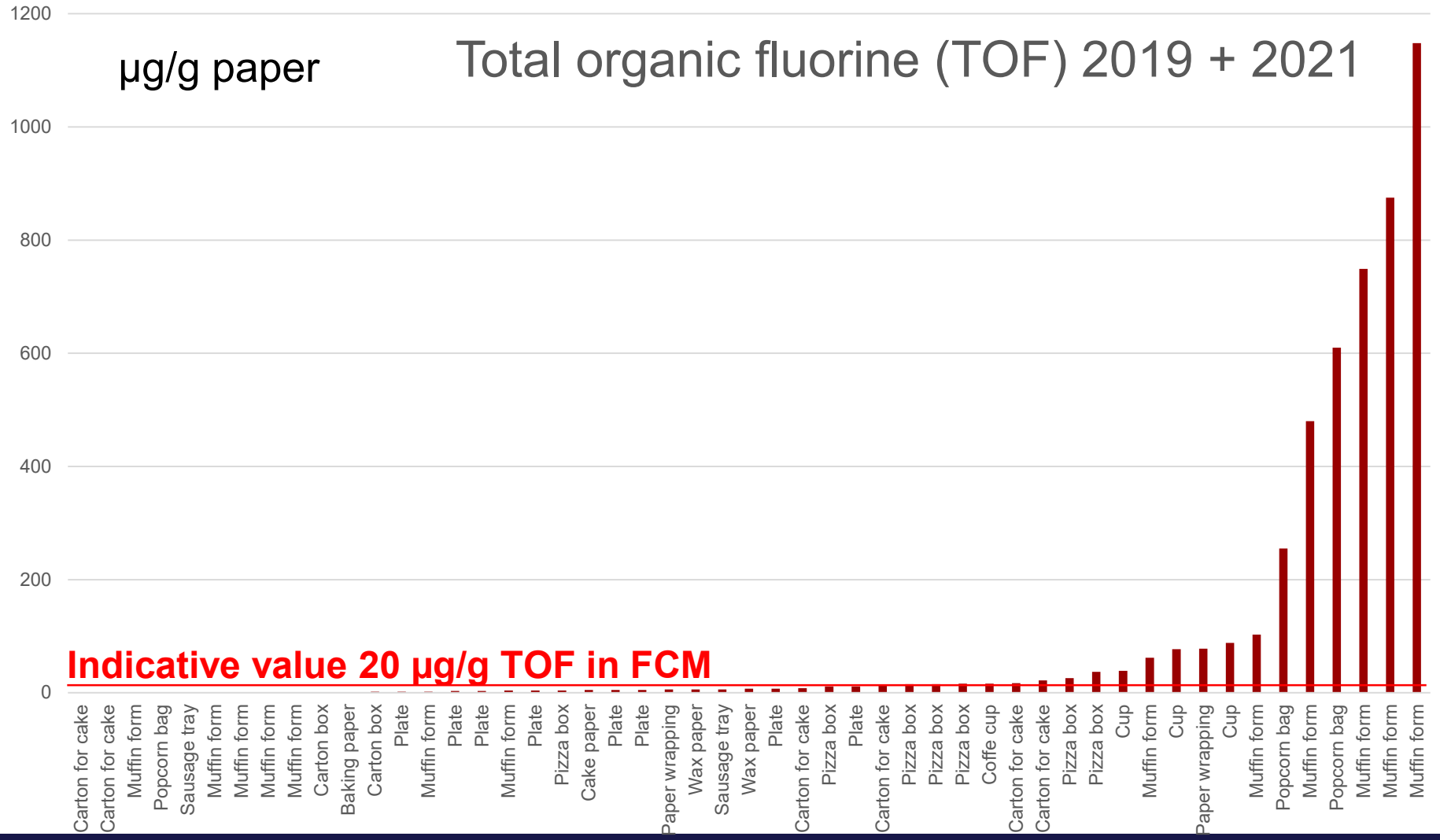
2 months after press release and egg producers' voluntary withdrawal of fishmeal from feed, no/very low PFAS was found in organic eggs:

Ministeriet for Fødevarer, Landbrug og Fiskeri

Økologiske æg har ikke længere forhøjede niveauer af PFAS

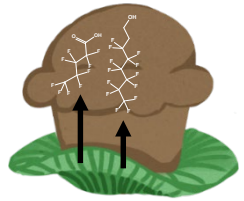
19.4.2023 06:30:00 CEST | Ministeriet for Fødevarer, Landbrug og Fiskeri

Danish ban on intentional use of PFAS in paper&board food contact materials, indicator value 20 µg TOF /g FCM, 1/7-2020



Ref:
DVFA and DTU Food

Study of migration into real food



Ref:Lerch, M., Nguyen, K.H., Granby, K. 2022. Food Chemistry, 393, 133375

FCM samples

→ Sampled on the Scandinavian Market

→ Known to contain PFAS

→ Samples for high temperature conditions:

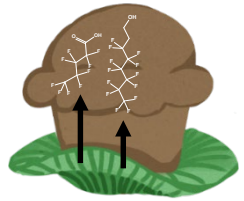
→ Microwavable disposable paper plates (n=3)

→ Muffin cups (n=3)

Food/food simulants & Contact Conditions	Test Food	Food Simulants
Selection	Muffins (dough with 15% fat) Oatmeal Porridge (8% fat) Tomato Soup (3% fat)	50% Ethanol 50% Ethanol 20% Ethanol
Migration conditions	High-temperature application: Baking Microwave	Total immersion of FCM sample

→ **Comparison of migration into real food and food simulants**

→ **Using realistic high temperature conditions with the food**



Test conditions

Migration tests

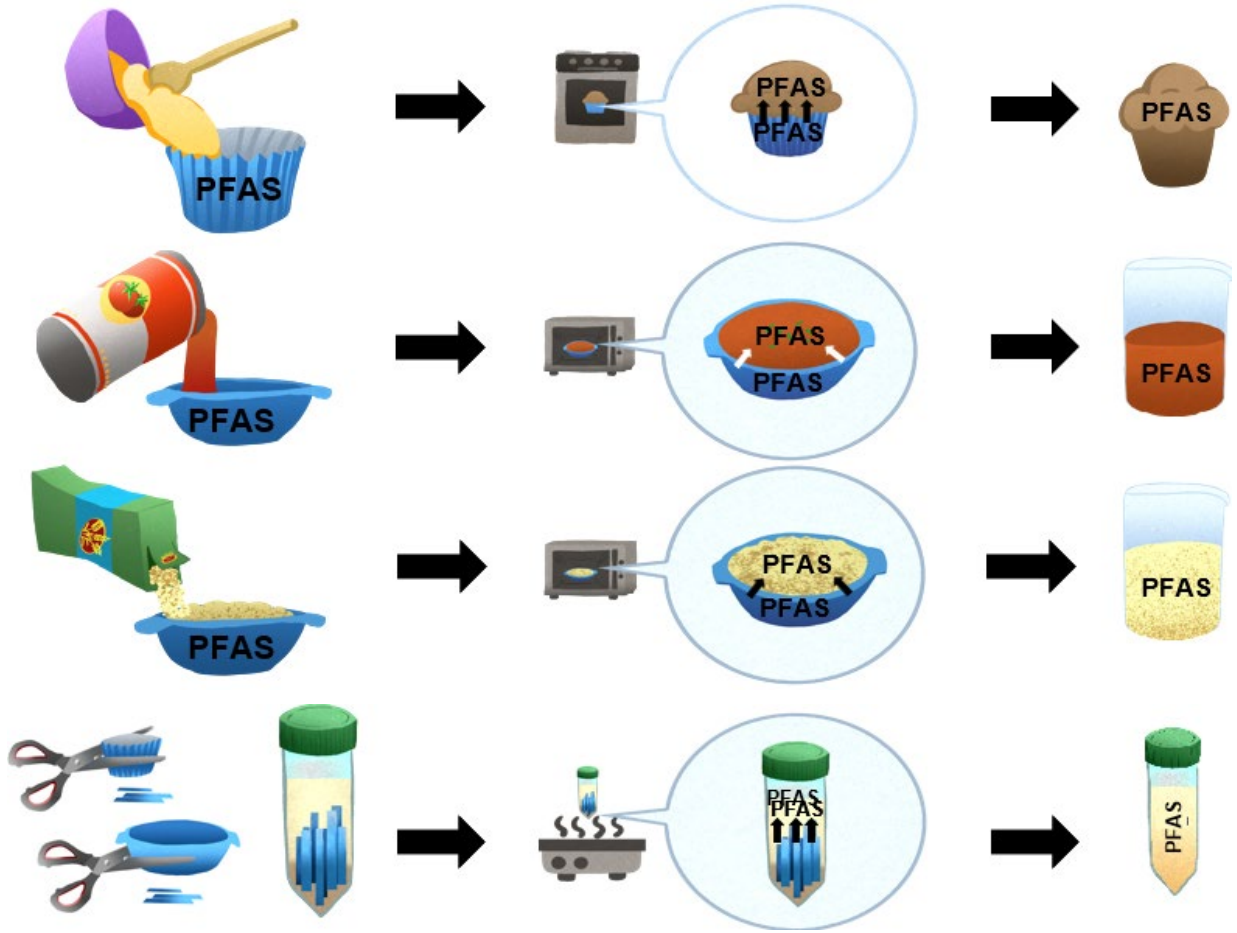
Food

- **Baking**
  13 min at 200° C
- **Microwaving**
  1 min at 800 W

Food Simulants

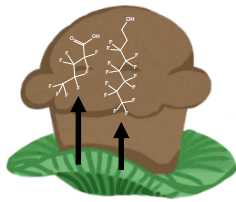
- **Incubation in water bath: 2 h for 70 ° C (EC 10/2011)**

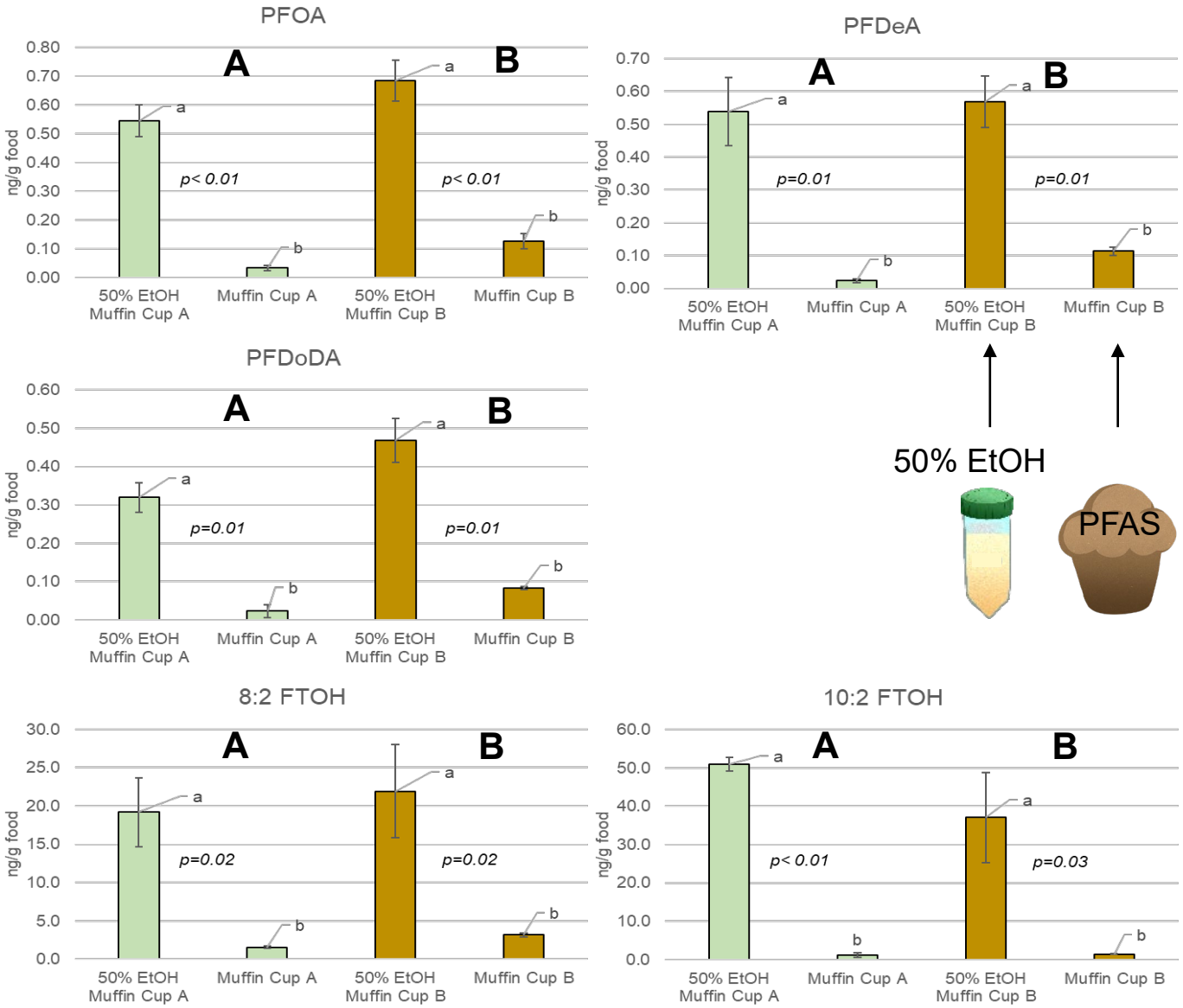
Migration of PFAS into real food using **realistic contact conditions:**



~ What do we know about migration of PFAS from paper based FCMs? ~

Results migration into muffins





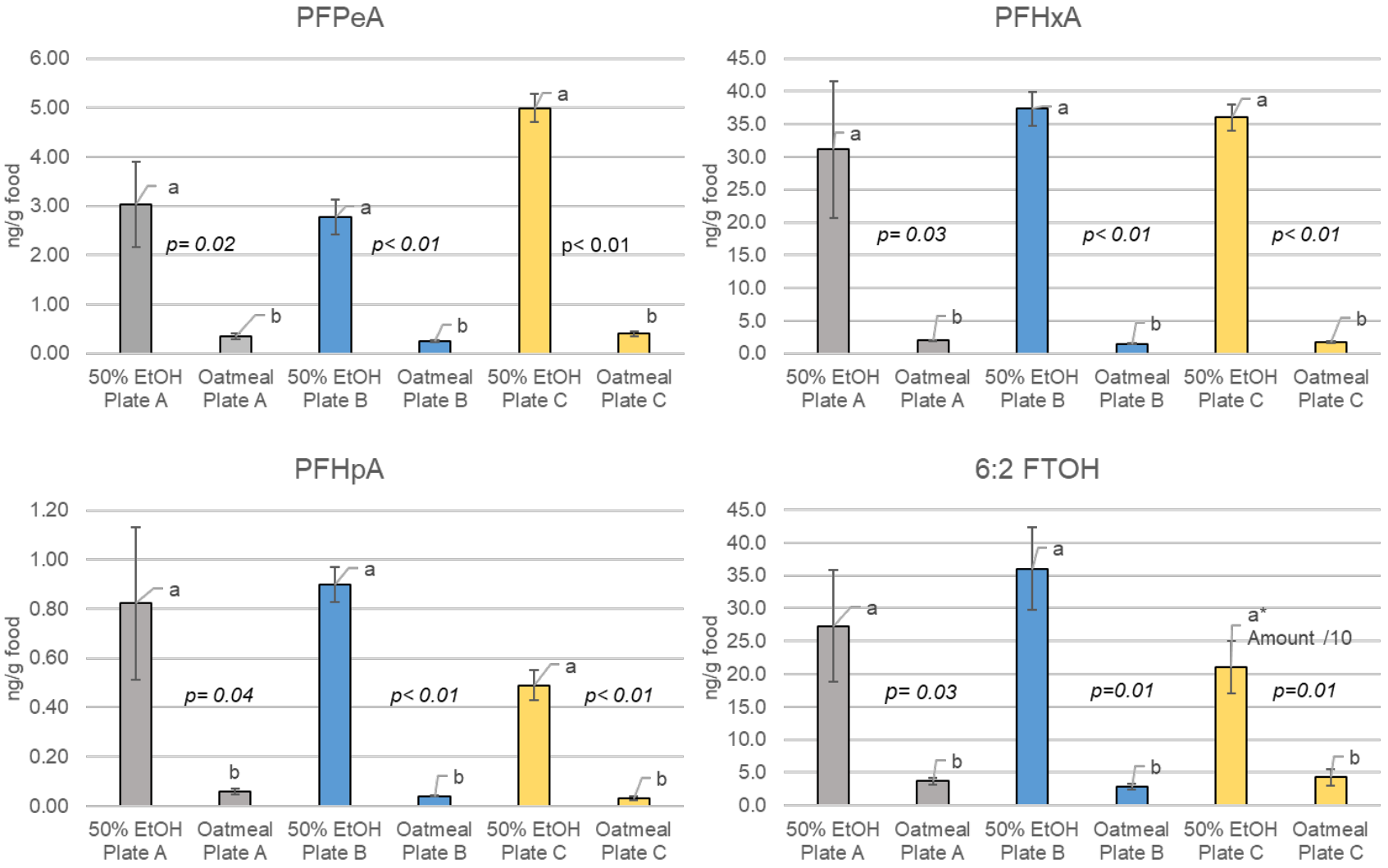
- Migration of PFCAs and FTOHs into 50% ethanol significantly higher than into food (transfer to muffin~ 5-20%)
- Only detected in 50% ethanol:
  - PFPeA, PFHxA, PFHpA, PFTrDA, PFTeDA
  - The short chain PFCA's are potentially lost during baking (200ºC)

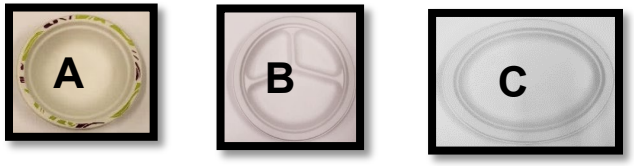
~ What do we know about migration of PFAS from paper based FCMs? ~

Results migration into oatmeal porridge

Results

Food vs Food simulants





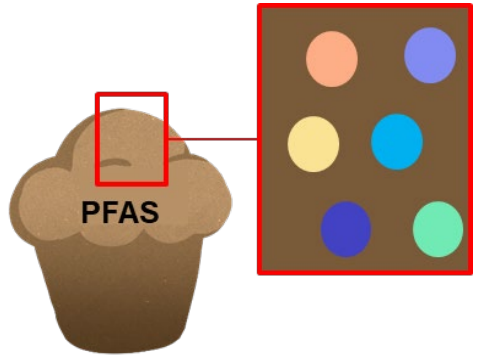
- Migration into 50% ethanol significantly higher

- Only detected in 50% ethanol: PFOA, PFNA, PFDeA
- However, 6:2 diPAP only detected (<LOQ) in OMP

→ Presence of emulsifiers in OMP could increase migration (lowered surface tension)

Three scenarios to calculate PFAS in dietary exposure

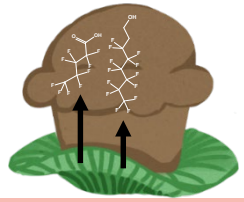
$$Dietary\ exposure = \Sigma\ \left(PFAS\ \left[\frac{ng}{g\ food}\right]\right) x\ \frac{weight\ of\ each\ \boldsymbol{serving}[g]}{body\ weight\ [kg]}$$



Dietary exposure =	Occurrence estimation x
Total PFAS $\Sigma\ (PFAS)$	Sum of all detected PFAS concentrations in food
PFAS4 $\Sigma\ (PFOA, PFOS, PFNA, PFHxS$	Sum of PFOA and PFNA (no PFOS and PFHxS detected) ✖
Relative Potency Factor (RPF) - Approach $\Sigma\ (PFOA\ equivalent)$ Bil et al. (2021), Environ.Toxicol.Chem. 40, 859–870.	Each compound → define a RPF value based on hepatoxicity and is relative to the toxicity of PFOA C_{PFAS} x RPF = PFOA equivalent Sum of PFOA equivalents

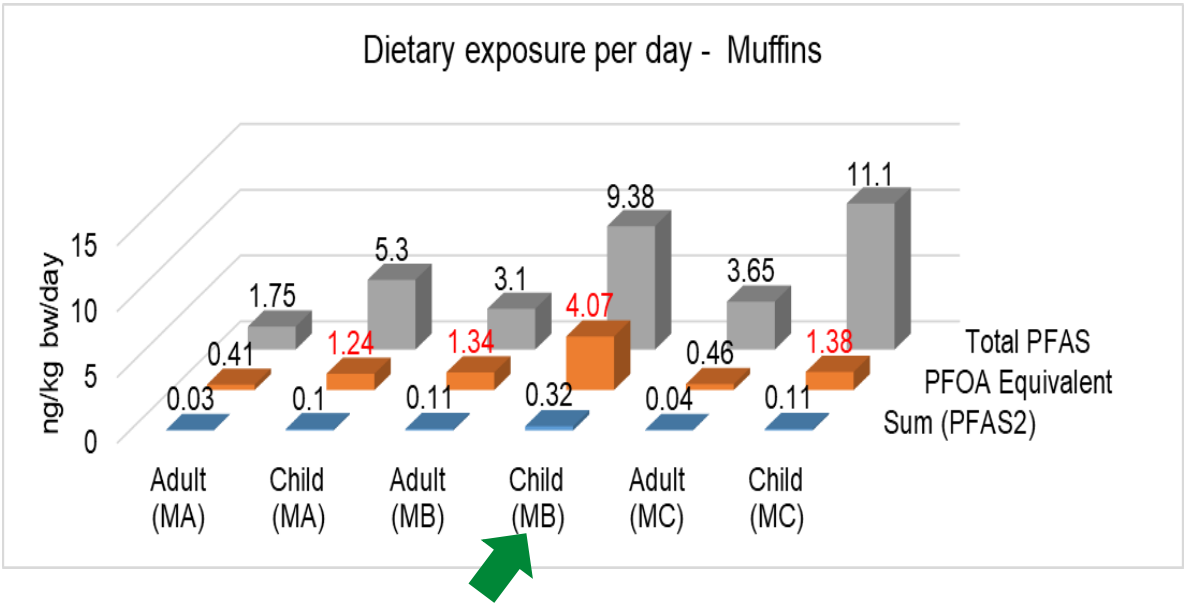
Relative potency factor:	
PFOA	1
PFPeA	0.05
PFHxA	0.01
PFHpA	0.01
PFNA	10
PFDeA	10
PFUnA	4
PFDoDA	3
6:2 DiPAP	0.02
6:2FTOH	0.02
8:2FTOH	0.04
10:2FTOH	0.04

~ *Is the use of PFAS treated paper based FCMs safe?* ~
For high-temperature applications



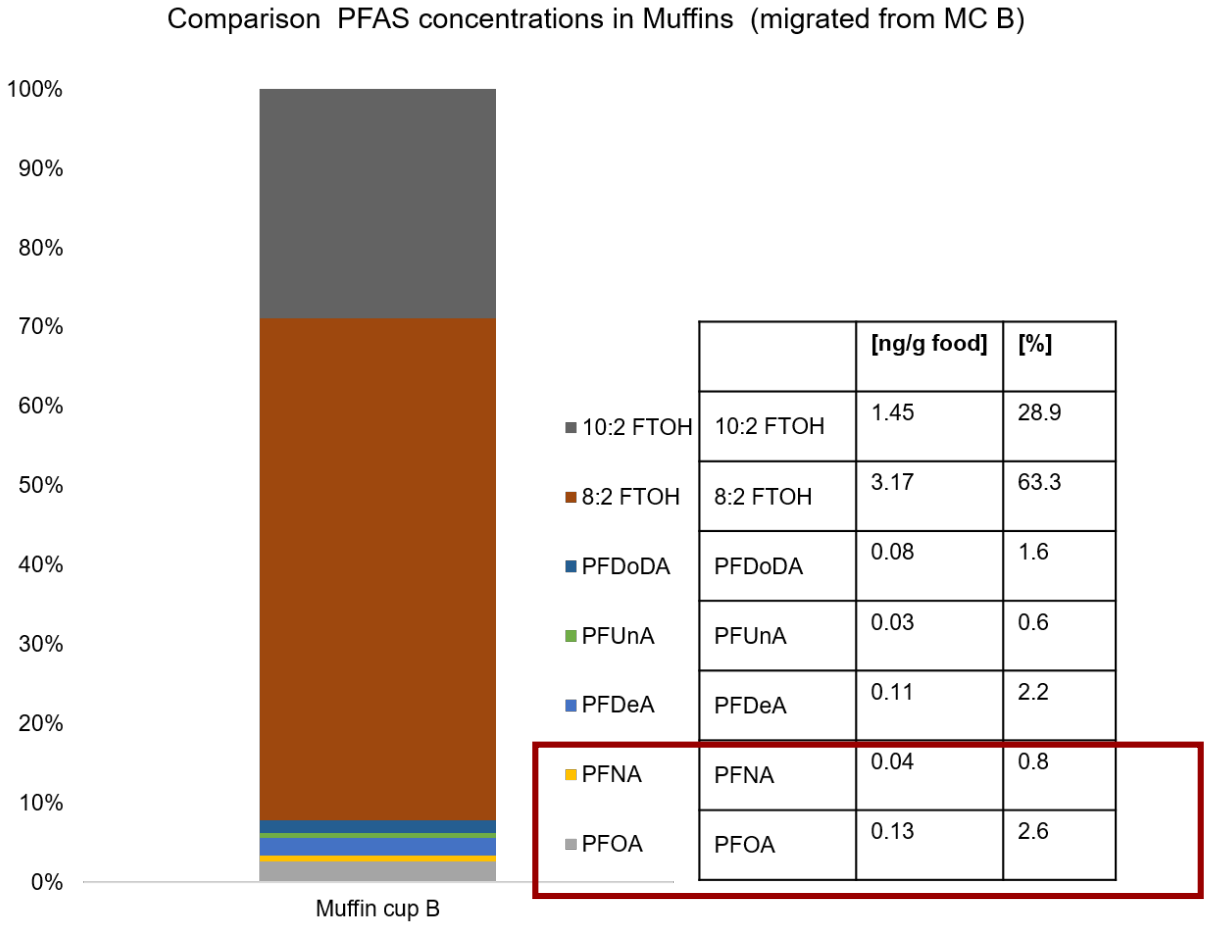
Dietary exposure estimates for muffins by different approaches

TWI ~ 0.63 ng/kg bw/day for ∑4PFAS



	Children muffin cup B	
Dietary exposure per serving [ng/kgbw/day]	Sum (PFAS2)	0.32
	RPF-Approach	**4.07**

Dietary exposure estimated to be more than 12 times higher by the RPF approach.



	[ng/g food]	[%]
10:2 FTOH	1.45	28.9
8:2 FTOH	3.17	63.3
PFDoDA	0.08	1.6
PFUnA	0.03	0.6
PFDeA	0.11	2.2
PFNA	0.04	0.8
PFOA	0.13	2.6

Migration of 5.01 ng/g PFAS into the muffin (MB) was set to100%

~ *Is the use of PFAS treated paper based FCMs safe?* ~

For high-temperature applications, No

Migration (ng/g) into food and dietary exposure (ng/kg bw/day) by 3 different approaches **TWI ~ 0.63 ng/kg bw/day for ∑4PFAS**

			Paper Plate A		Paper Plate B		Paper Plate C		Muffin Cup A	Muffin Cup B	Muffin Cup C
			Oatmeal Porridge	Tomato Soup	Oatmeal Porridge	Tomato Soup	Oatmeal Porridge	Tomato Soup	Muffin	Muffin	Muffin
Total PFAS		Total Σ (PFAS) [ng/g food]	6.13	3.50	4.70	3.54	6.48	14.1	2.83	5.01	6.00
	Adult	Dietary exposure per serving [ng/kgbw/day]	14.3	10.4	11.0	10.5	15.1	41.9	1.75	3.10	3.65
	Child	Dietary exposure per serving [ng/kgbw/day]	43.4	31.5	33.3	31.8	45.9	127	5.30	9.38	11.1
Sum of PFOA/PFNA		Σ (PFOA/PFNA) [ng/g food]	0.03	0.00	0.03	0.04	0.00	0.05	0.06	0.17	0.06
	Adult	Dietary exposure per serving [ng/kgbw/day]	0.06	0.00	0.06	0.12	0.00	0.15	0.03	0.11	0.04
	Child	Dietary exposure per serving [ng/kgbw/day]	0.18	0.00	0.18	0.36	0.00	0.45	0.10	0.32	0.11
RPF Approach		Σ (PFOA equivalent) [ng/g food]	0.20	0.22	0.15	0.29	0.15	0.63	0.66	2.17	0.75
	Adult	Dietary exposure per serving [ng/kgbw/day]	0.46	0.66	0.35	0.87	0.36	1.87	0.41	1.34	0.46
	Child	Dietary exposure per serving [ng/kgbw/day]	1.39	1.99	1.06	2.63	1.09	5.67	1.24	4.07	1.38

THANK YOU FOR LISTENING