

Content of PFAS in fishmeal and via content in organic feed in organic eggs.

## Conclusion

Content of PFAS in organic egg yolks from larger commercial farms around the country with herds between 3000 and 42000 hens, average ~ 20000 hens, was very similar in concentration ( $\Sigma$ allePFAS 2.2-3.7 ng/g) and composition of PFAS compounds. At the same time, content from free-range, scratch or cage hens was low ( $\Sigma$ allePFAS <0.2 ng/g). This indicated that the source was feed, and specifically there was the same composition of individual PFAS in fishmeal, which is a feed ingredient in organic feed. This confirms that PFAS-contaminated fishmeal is the main source of PFAS in Danish organic eggs. Since the half-life from fed hen to egg is 4-7 days, possible substitution with less contaminated feed ingredients can reduce PFAS in eggs within a few weeks. Danes' consumption of organic eggs alone exceeds for the 95th percentile the tolerable weekly intake assessed by EFSA for  $\Sigma$ 4PFAS.

## Background

The DTU Food Institute, in collaboration with the Danish Food and Drug Administration, and the Danish Food and Drug Administration's laboratory in Ringsted, has investigated PFAS in egg yolks from organic and conventional (free-range, scraped or caged) producers in Denmark.

The background was that relatively high contents of e.g. PFOS in organic eggs. With the introduction of the EU limit value applicable from 1 January 2023 for whole eggs of 1.0 ng/g PFOS (linear and branched); 0.3 ng/g for PFOA, PFHxS; 0.7 ng/g PFNA and 1.7  $\mu$ g/kg (~ ng/g) for  $\Sigma$  PFOS, PFOA, PFNA and PFHxS some individual samples would exceed the limit values. At the same time, EFSA has set a tolerable weekly intake (TWI) for  $\Sigma$  PFOS, PFOA, PFNA, PFHxS of 4.4 ng/kg body weight per week in 2020.

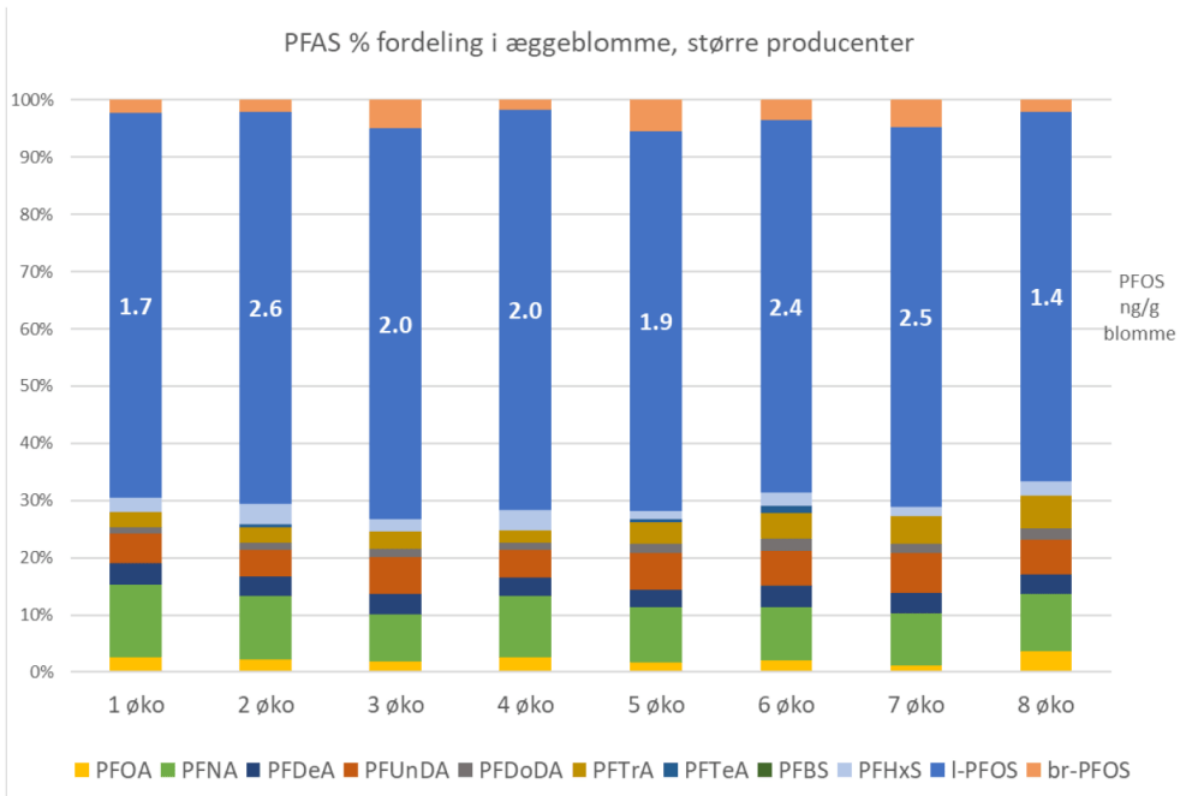
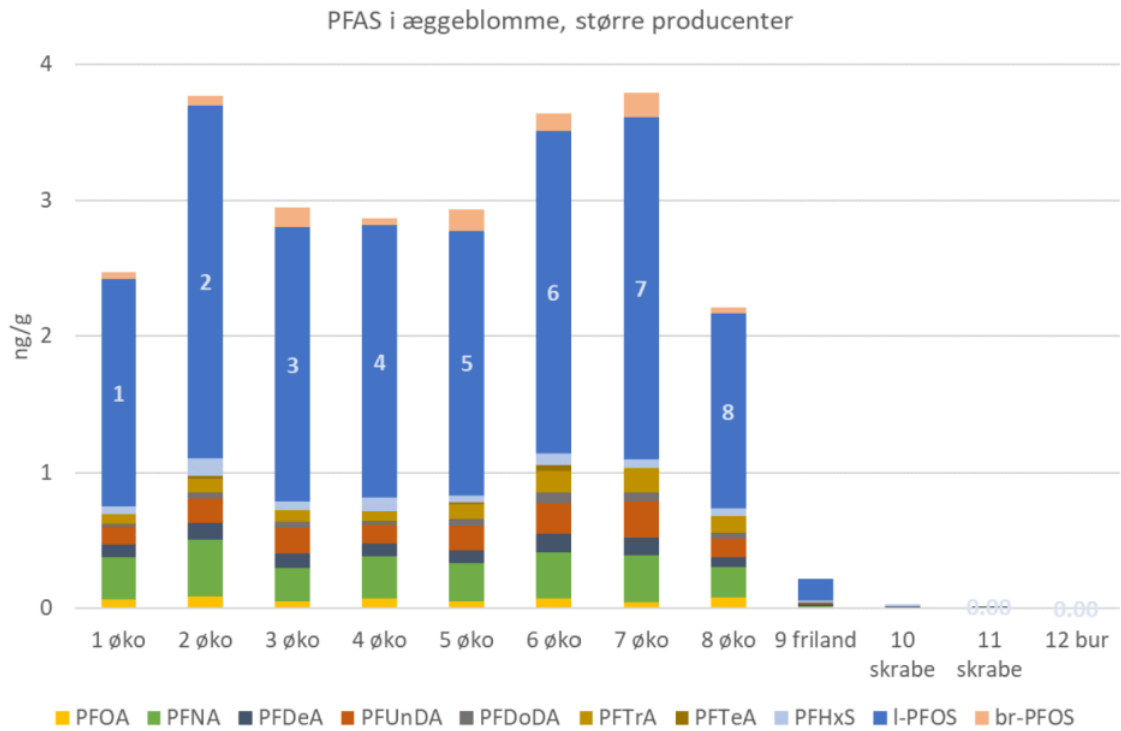
FVST in Ringsted has for several years checked for dioxin and dioxin-like PCBs in egg yolks from commercial larger producers (>500 hens) and commercial smaller producers (<500 hens) collected in Denmark. Including the categories organic, free range, scratch and cage eggs. Samples from 2021 and 2022 have been analyzed by the DTU Food Institute with an accredited method which has sufficiently low detection limits to check for the new limit values.

In connection with the fact that the results of the analyzes showed a somewhat higher content of PFAS in organic than non-organic eggs, and the PFAS results showed the same pattern in composition as fishmeal, which is added to organic feed for laying hens, the Food and Drug Administration's feed specialists in collaboration with the industry have taken feed samples and the feed ingredients organic soybean cake from China as well as fishmeal.

Results of PFAS in organic, free range, scratch and cage eggs as well as in feed ingredients and feed.

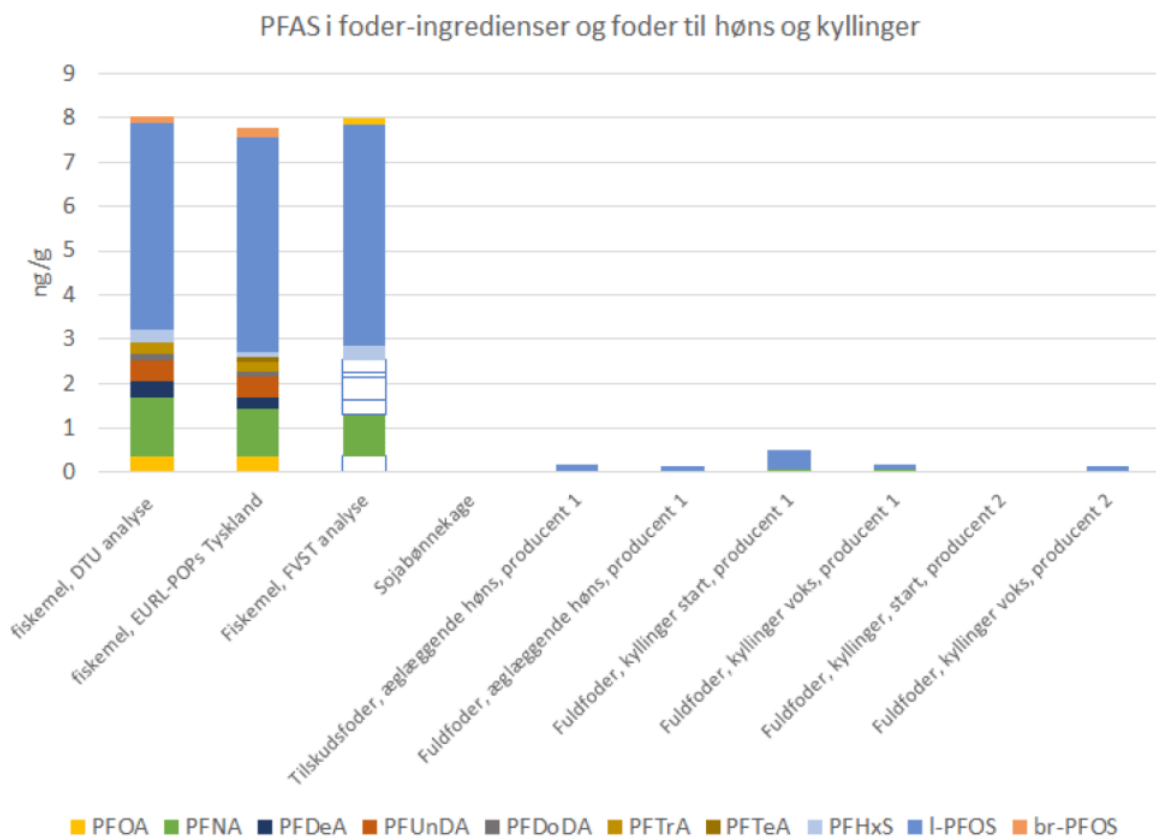
Results of PFAS in egg yolks from larger Danish organic producers showed relatively higher levels of PFAS, and with the same relative PFAS composition, while there were low contents in free-range, scratch and cage hen eggs (figure 1 a,b). Organic flocks between 3000 and 42000 hens, mean ~ 20000 hens were very similar in concentration ( $\Sigma$ allePFAS 2.2-3.7 ng/g egg-yolk)

Figure 1 a.) PFAS in egg yolk from organic, free-range, free range or cage hens and b.) Relative PFAS distribution with PFOS concentration (ng/g yolk) in blue fields.





The results from the smaller producers 2021-2022 show greater dispersion in concentration compared to the larger producers. The composition of the organic egg yolks is, however, the same as for the large producers. The highest PFAS contents were found in samples 9-11 from 2021, where samples 11 and 12 would exceed the limit value for PFOS applicable from 1/1-2023. These producers from 2021 (6, 10/11, 12) have stopped egg production, for 10/11 due to too high dioxin, PCB content.



The Danish Veterinary and Food Administration's feed specialists, in collaboration with the industry, have taken feed samples and the feed ingredients organic soya cake from China and fishmeal. Content of PFAS in samples of feed for chickens and laying hens analyzed at DTU did not show PFAS content that could explain content in egg yolks. Organic soybean cake imported from China did not contain PFAS. On the other hand, there were the same PFAS compounds as in eggs, in fishmeal which was sampled on suspicion of PFAS contamination. The sample has been analyzed both at DTU Food and at FVST's laboratory in Ringsted. Furthermore, the Danish fishmeal sample. In addition, the Danish fishmeal sample has been compared with fishmeal issued as a performance test from the European reference laboratory for persistent organic compounds (EURL-POPs) in Germany. All three laboratories found comparable PFAS concentrations, for the substances that could be detected and with a predominance of PFOS and with a pattern of relatively higher concentrations of odd perfluorocarboxylic acids. It is the same pattern seen in all the organic eggs and it gives a clear indication that fishmeal is the source of PFAS in organic eggs.

Transfer of PFAS from feed to eggs

The German food authorities (www.BfR.bund.de) have assessed PFAS limit values in feed, i.a. for laying hens <sup>4)</sup>. The limit values in feed are estimated on the basis that they must not result in exceeding the EU limit values for eggs. They are based on a German controlled toxicokinetic study which investigated transfer from feed to eggs <sup>2)</sup>, which also showed that the half-life of PFOS and PFOA, PFHxA in eggs from hens that have consumed contaminated feed is 4-7 days .

Table 1 proposed limit values for PFOS and PFOA in feed on the basis that EU limit values in eggs are not exceeded

Tabel 1 forslåede grænseværdier for PFOS og PFOA i foder ud fra at EU grænseværdier i æg ikke overskrides.

PFAS	PFOS	PFOA	PFHxA	PFNA
Æg ng/g friskvægt	1,0	0,3	0,3	0,7
Foder ng/g tørvægt	0,44	0,27	n.d.	n.d.
Transfer faktor	2,26	1,1	n.d.	n.d.

Using the same proportionality, and assuming that fishmeal is the main source of PFOS and PFOA in eggs, the percentage of fishmeal in feed can be estimated. If the analyzed fishmeal is mixed into the feed, it corresponds to 6.6% fishmeal in the feed. It is possible that there has been background contamination with PFOS, so that e.g. has been mixed with 5% fishmeal, which is the percentage it is recommended not to exceed, in order to avoid a fishy taste in eggs. The contents converted to whole eggs do not exceed the EU limit values for PFOS, PFOA, PFNA, PFHxA or Σ4PFAS.

Table 2. Estimate for PFOS content in feed and % fishmeal in feed (average concentration in feed analyzed by DTU Food is 4.84 ng/g)

Tabel 2. Estimat for PFOS indhold i foder og % fiskemel i foder (gennemsnits koncentration i foder analyseret af DTU Food er 4.84 ng/g)

	æg ng/g friskvægt	foder ng/g tørvægt	fiskemel ng/g	% fiskemel
PFOS				
1 Økologisk	0.57	0.25	4.84	5%
2 Økologisk	0.89	0.39	4.84	8%
3 Økologisk	0.72	0.32	4.84	7%
4 Økologisk	0.68	0.30	4.84	6%
5 Økologisk	0.70	0.31	4.84	6%
6 Økologisk	0.83	0.37	4.84	8%
7 Økologisk	0.90	0.40	4.84	8%
8 Økologisk	0.49	0.22	4.84	4%
Middel	<b>0.72</b>	<b>0.32</b>		<b>6.6%</b>
Minimum	<b>0.49</b>	<b>0.22</b>		<b>4%</b>
Maximum	<b>0.90</b>	<b>0.40</b>		<b>8%</b>

Exposure to PFAS at medium intake and high intake (95% percentile) of organic eggs; respectively 'free range, scratch and cage eggs' from larger commercial producers.

The concentration of PFAS in eggs is calculated based on the concentration of PFAS in the egg yolk, as PFAS are almost exclusively found in the egg yolk. Since the PFAS results are analyzed on egg yolk,

the weight of an egg yolk is set to be 1/3 of the egg without the shell, i.e. concentration in the egg is calculated by dividing the concentration in the yolk by three.

Consumption of eggs:

Table 3. Intake of eggs per week in g.

	g/uge gennemsnit	g/uge 95 percentil
Voksne 18-75 år	171	426
Børn, unge 10-17 år	120	328
Børn 4-9 år	125	311

Table 4. Exposure to  $\Sigma$  PFOS, PFOA, PFNA, PFHxS in nanograms per kg body weight per week (ng/kg bw/week) for 78.3 kg adult, 54.23 kg youth and 26.04 kg child

Tabel 4. Eksponering for  $\Sigma$  PFOS, PFOA, PFNA, PFHxS i nanogram per kg kropsvægt per uge (ng/kg kv/uge) for 78,3 kg voksen, 54,23 kg unge og 26,04 kg barn

	Økologiske æg fra større kommercielle producenter 2022		Frilands-, skrabe- eller buræg fra kommercielle producenter 2022	
	ng/kg kv/uge gennemsnit	ng/kg kv/uge 95 percentil	ng/kg kv/uge gennemsnit	ng/kg kv/uge 95 percentil
Voksne 18-75 år	1,9	4,8	0,03	0,09
Børn, unge 10-17 år	1,9	5,3	0,04	0,10
Børn 4-9 år	4,2	10	0,08	0,19

The tolerable weekly intake that EFSA has set in 2020 is 4.4 ng/kg body weight for the sum of PFOS, PFOA, PFNA and PFHxS. It is determined on the basis of the critical effect of PFAS intake, which is associated with a harmful effect on the immune system. In addition, the critical effects are a reduction in birth weight and elevated cholesterol levels. Exposure to mean intake or 95 percentile of free-range, scratch or cage eggs is for all age groups <0.2 ng/kg bw/week, i.e. <4.4% of the tolerable weekly intake of 4.4 ng/kg bw. The average weekly intake of organic eggs for children 4-9 years and the 95 percentile for children and young people 10-17 years, and for adults is at the level of the tolerable weekly intake for  $\Sigma$ 4PFAS of 4.4 ng PFAS/kg body weight. For children 4-9 years, the 95th percentile is more than twice as high as the tolerable weekly intake. Even though the tolerable weekly intake is set on the basis that it must include all exposure, e.g. also from the consumption of other foods such as fish, shellfish and snacks. The half-life of the four PFAS substances in humans is approx. 3-7 years<sup>1</sup>).

References:

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- 4) BfR 2021, PFAS maximum levels in feedstuffs: BfR recommends improved analytical methods BfR opinion No 037/2021 of 24 November 2021, DOI 10.17590/20211124-122122, link: [PFAS maximum levels in feedstuffs: BfR recommends improved analytical methods \(bund.de\)](#)