Per- and polyfluorinated alkyl substances (PFAS) in paper and board Food Contact Materials

SELECTED SAMPLES FROM THE NORWEGIAN MARKET 2017

Per- and polyfluorinated alkyl substances (PFAS) in paper and board Food Contact Materials

This Report is prepared by Kit Granby, Technical University of Denmark and Julie Tesdal Håland, Norwegian Food Safety Authority, December 2018.

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Summary

Per- and polyfluorinated alkyl substances (PFAS) are used in food contact materials (FCM) due to their physical properties. When impregnated to paper and board FCM it makes the material water and fat resistant. For that reason, it is used in for example fast food packaging, disposable cups and plates, paper case for cupcakes, baking paper, liners, wrappers and popcorn beakers.

There is no specific EU regulation covering paper and board FCM, but in Regulation 1935/2004 on materials intended to come into contact with food, it is stated that materials must be manufactured in such a way that they do not transfer chemicals to food in quantities that could endanger human health.

Due to the risk of migration of PFAS from FCM to food, a survey on PFAS in FCM was conducted by the Norwegian Food Safety Authority in collaboration with the Technical University of Denmark, the National Food Institute (DTU Food). During the period August-October 2017, 35 paper and board FCM from the Norwegian market were sampled by the Norwegian Food Safety Authority and sent to DTU Food for PFAS analyses. The extractable amounts of PFAS from the sampled FCM were investigated and migration tests were conducted in the five samples with the highest PFAS contents.

PFAS was found in extracts of 13 of 35 FCM analysed; in seven of 11 plates, two cupcake cups, one cup, a fish food bag, a popcorn beaker and a pizza tray. The sum of concentrations of 11 detected perfluorcarboxylic acids (PFCA) and polyfluorsulphonic acids (PFSA) in the extracts ranged from 0.01- 13.1 µg/kg food. Fluortelomer alcohols were detected in nine sample extracts at concentrations 0.8-13.5 µg/kg. MonoPAPs and diPAPS were not detected.

Five samples with relatively high concentrations of extractable PFAS were migration tested in triplicates. The highest migration of the sum of PFAS were found in three samples of plates from the same manufacturer (∑PFAS: 39.5; 32.0; 17.9 µg/kg food). Furthermore, two paper case for cupcakes contained 9-10 different substances with ∑PFAS concentrations migrating of 20.6 and 15.0 µg/kg food., respectively

In contrast to the previous investigation conducted in 2015, PFASs were detected in several products. It was demonstrated a potential for migration of PFASs from FCM to foods, indicating that FCM could be a source of PFASs in food.

Norsk sammendrag

Per- og polyfluorerte alkylstoffer (PFAS) brukes i matkontaktmaterialer (Food Contact Materials; FCM) på grunn av deres fysiske egenskaper. Impregnering av papir og papp FCM gjør materialet vann- og fettavstøtende og av den grunn blir stoffene brukt i for eksempel emballasje til hurtigmat, engangskopper- og tallerkener, muffinsformer, bakepapir og popkornbeger.

Det er ingen spesifikke EU-regelverk som omfatter matkontaktmaterialer av papir- og papp, men i Forordning (EU) 1935/2004 om materialer som er beregnet på å komme i kontakt med mat, står det at materialer skal produseres på en slik måte at de ikke overfører kjemikalier til mat i mengder som kan være helseskadelige.

På grunn av risikoen for overføring (migrasjon) av PFAS fra matkontaktmaterialer til mat, ble en undersøkelse av PFAS i et utvalg av matkontaktmaterialer utført av Mattilsynet i samarbeid med Danmarks Tekniske Universitet, DTU Fødevareinstituttet. I perioden august-oktober 2017 ble 35 prøver av papir og papp FCM fra det norske markedet tatt ut av Mattilsynet og sendt til DTU Food for PFAS-analyser. Ekstrakt fra alle produktprøvene ble analysert for PFAS, og det ble utført migrasjonstest på de fem produktprøvene med høyest innhold av PFAS.

PFAS ble funnet i 13 av 35 FCM analysert; i syv av 11 tallerkener, i to muffinsformer, en kopp, en papirpose til fisk, et popkornbeger og et pizzabrett. Summen av konsentrasjoner av 11 detekterte perfluorerte karboksylsyrer (PFCA) og polyfluorerte sulfonsyrer (PFSA) i ekstraktene varierte fra 0,01 - 13,1 µg / kg mat. Fluorotelomeralkoholer ble detektert i 9 ekstrakter, og varierte fra 0,8-13,5 µg / kg. MonoPAPs og diPAPs ble ikke detektert.

De fem høyeste konsentrasjonene av summen av per- og polyfluorerte alkylstoffer (PFAS) ble testet for migrasjon i triplikater. Den høyeste migrasjonen av summen av PFAS ble funnet i tre prøver av tallerkener fra samme produsent (ΣPFAS: 39,5; 17,9; 32,0 µg / kg mat). I tillegg inneholdt to muffinsformer 9-10 forskjellige stoffer ved ΣPFAS konsentrasjoner på henholdsvis 20,6 og 15,0 µg / kg.

I motsetning til forrige undersøkelse som ble gjennomført i 2015 ble det detektert PFAS'er i flere av produktene. Undersøkelsen viste at PFAS potensielt kan migrere over i mat, og at matkontaktmaterialer kan være en kilde til PFAS i mat.

1 Preface

This investigation was performed in cooperation between Project Leader Julie Tesdal Håland, Norwegian Food Safety Authority, Chemical Safety and EEA Section and Associate Professor Kit Granby, the Technical University of Denmark, National Food Institute, Research Group for Analytical Food Chemistry.

The laboratory work on extraction and migration testing of food contact material (FCM) samples and chemical analyses of per- and polyfluorinated substances (PFAS) was performed by Laboratory Technician Lene Gram Hansen in collaboration with Associate Professor Kit Granby.

The report was prepared by Associate Professor Kit Granby, DTU in cooperation with project Leader Julie Tesdal Håland, The Norwegian Food Safety Authority.

The DTU DOC-number was 2017/00669 and the Norwegian Food Authority' ePhorte number was 2016/258556

2 Background and aim of project

The per- and polyfluorinated alkyl substances (PFAS) include a large group of different substances that are used to impregnate food contact materials (FCM) of paper and board, in order that they become resistant to fat or water from the food. The typical impregnated packaging is intended for greasy food, high temperature food or long-term food storage. Examples of PFAS impregnated packaging are paper case for cupcakes, cups, plates, paper wrapping, and packaging for storing dry foods (Begley et al. 2005; Trier 2011c; Yuan et al. 2016; Schaider et al. 2017).

Per- and polyfluorinated substances are persistent in the environment and some of the substances and / or their degradation products are toxic, including endocrine disrupting, carcinogenic, and harmful to the fetus (Olsen et al. 2007, White et al. 2011; Norden 2013; Fei et al. 2007; EFSA 2018 and references herein). The European Food Safety Authority (EFSA, 2018) has evaluated perfluoroctanoic acid (PFOA) and perfluoroctane sulphonic acid (PFOS), and other PFAS are under evaluation. They report estimated human half-lives for PFOS and PFOA of about 5 years and 2–4 years, respectively. EFSA has based the health-based guidance values on epidemiological studies: For PFOS the effects of increased cholesterol in adults and decreased antibody response at vaccination in children led to establishment of a tolerable weekly intake (TWI) of 13 ng/kg body weight (bw). Increase in cholesterol was the main critical PFOA effect for establishment of a TWI of 6 ng/kg bw, however reduced birth weight and high serum levels of the liver enzyme alanine aminotransferase (ALT) were also considered. EFSA concludes that the PFAS exposure of a considerable proportion of the population exceeds the proposed TWIs; and it should be noted that the contribution of PFAS from FCM migration is not regarded in the exposure calculations.

Previous results from DTU have shown content of PFAS in popcorn and pancake bags, interlayer papers, dry food bags (such as breakfast products and ready-made mixes), pizza and fritters packaging (Trier et al. 2011a,b,c). In 2009 and 2011 a screening project was carried out on the content of PFAS in paper and cardboard, showing PFAS in one third of the samples. Migration testing to food simulants of a selection of these samples showed migration from microwave popcorn packaging; baking paper and sandwich paper. Control projects in 2013 with official sampling by the Danish Veterinary and Food Administration (DVFA) showed less frequency (4%) and less content of PFAS in 46

samples packaging and food businesses. On the other hand, samples taken by DTU at the retail level had PFAS contents in 12 of 27 samples. In 2015, control of 26 samples of paper and board FCM by DVFA only showed contents above the detection limit in a muffin form corresponding to 0.78 PFOA equivalents / kg food.

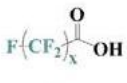
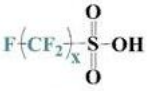
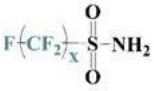
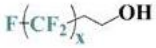
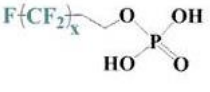
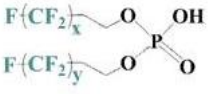
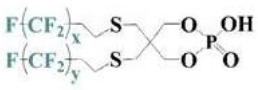
In the 2015-project conducted by DTU, The National Food Institute and the Norwegian Food Safety Authority, PFAS was not found in 53 Norwegian FCM samples (Trier et al. 2016).

The aim of the present project is to analyse samples of relevant food contact materials made of paper and board for the PFAS contents and migration. The project survey PFAS in paper and board Food contact materials in the Norwegian market.

Nomenclature of PFAS

The names and chemical structures of classes of per- and polyfluorinated substances (PFAS) in this project appear from Table 1 and Table 2, and the brutto formulas of individual PFSAs appear from Annex A. The classes analysed for in the present study include the perfluorocarboxylic acids (PFCA, including the subgroup perfluoroctanoic acid; PFOA); the perfluorosulphonic acids (PFSA, including the subgroup perfluoroctane sulphonic acid; PFOS), perfluorosulphone amides (PFSAA), fluorotelomer alcohols (FTOH); mono-polyfluoroalkyl phosphate esters (monoPAPS); di-polyfluoroalkyl phosphate esters (diPAPS).

Table 1. Examples of chemical classes of per- and polyfluorinated alkyl substances (PFAS)

 PFCA	 PFSA	 PFSAA	 FTOH
 monoPAPS	 diPAPS	 S-diPAPS	

3 Regulation

Regulation

There is no specific EU legislation for food contact materials of paper and board but *Regulation 1935/2004 of 27 October 2014 on materials and articles intended to come into contact with food* covers all type of food contact materials (European Commission, 2004). In Article 3 in this regulation it is stated that materials and articles shall be manufactured in compliance with good manufacturing practice so that, under normal and foreseeable conditions of use, they do not transfer their constituents to food in quantities which could endanger human health.

Global phasing-out of a number of previously used perfluorinated substances is being undertaken and recently at European level through REACH, a regulation of PFOA and related substances has been adopted, but only with effect from July 2020 (Regulation EU 2017/1000). In 2014, Germany and Norway in cooperation suggested to ECHA (the European Chemical Agency) a restriction in PFOA and PFOA precursors in consumer products of 2µg/kg. They assessed that the human exposure to PFOA is too high, hence that there is a need to reduce the human exposure to PFOA and PFOA related compounds. The Norwegian Environment Agency has prohibited the presence of PFOA in consumer products. In 2009 Perfluoroctane sulphonic acids and salts hereof were added to Annex B: Persistent Organic Pollutants (POPs) (restriction) to the Stockholm convention.

4 Materials and methods

4.1 Sampling

The FCM were sampled between August 28, 2017 and September 28, 2017 and received at The Technical University of Denmark from August 31, 2017 to October 4, 2017.

Samples of paper and board FCM were collected at importers or at retail shops in Norway. Relevant samples of paper and board FCM in direct contact with the food, for example muffin making cups, baking paper, snack paper, fast food packaging, pizza

trays, coffee / tea cups, bags for microwave oven popcorn and similar products that have a grease and water repellent surface. Samples that have a layer of plastic in direct contact with the food were not included. Sampling was conducted in three Norwegian Food Safety Authority regions: “Greater-Oslo”, “East” and “South and West”. The food inspectors from the regions forwarded the samples to DTU with the accompanying documentation.

DTU received in total 35 samples divided in subgroups of paper and board FCM as shown in Table 3. Detailed sampling information is given in Annex B. Extracts from all samples were analysed for PFAS contents. Next, migration tests using simulants were performed for three samples of plates and two samples of cupcake cups with high PFAS contents (samples exceeding previous (2017) action limit of 5 µg PFOA equivalents/kg food).

Table 3. Types of paper & board Food Contact Material samples analysed in the project.

FCM Sample type	**Number of samples analysed for PFAS content (migration testing)**
Plates	11 (3)
Cupcake cups/ muffin cups, baking tray	5 (2)
Food bag/paper: burger paper, baguette, fishmeal, pizza paper,	5
Hot drink cups	3
Popcorn beaker	3
Candy bag	2
Baking paper	2
Coffee filters	1
Pizza tray	1
French fries tray	1
Snack beaker	1
Total	**35 (5)**

4.2 PFAS analysis

An accredited analytical method (FC430) developed at DTU, based on liquid chromatography tandem mass spectrometry (LC-MS/MS) were used for the PFAS analyses. However, the fluorotelomer alcohols (FTOH) were not yet covered by

accreditation. Analytical certificates with results and assessment of results were sent to the Norwegian Food Safety Authority.

Extraction, migration and calibration standards

Perfluorocarboxylic acids(PFCA)/perfluoro sulphonic acids(PFSA):

Carved square pieces of 6 cm^2 FCM were extracted with 1.00 mL ethanol by placing the FCM samples in microcentrifuge tubes in an ultrasonication bath at 60°C for 1 hour. Subsequently 210 µL extract was transferred to a 0.2 µm filter vial (Whatman Mini uniprep polypropylen 500 µL), together with 40 µL C13-labelled internal standard mixture (final internal standard concentrations 0.5 ng/mL).

For the migration testing 6 cm^2 FCM sample was added 1.50 mL 50% ethanol:water (simulant) and heated for 2 hours at 70°C in a heating block, after which a quantity was transferred to a filter vial and added internal standard as described above.

Quantitation was performed using external calibration standards at 0; 0.1; 0.3; 0.5; 2; 5 ng/mL of perfluorocarboxylic acids (PFCA) / polyfluorosulphonic acids (PFSA) added several corresponding C13-labelled internal standards of 0.5 ng/mL.

Perfluoroalkyl phosphates (PAPs):

Carved square pieces of 6 cm^2 of FCM were extracted with 1.00 mL 50% ethanol:water by placing the FCM samples in microcentrifuge tubes in an ultrasonication bath at 60°C for 1 hour. Subsequently 240 µL extract was transferred to a 0.2 µm filter vial (Whatman Mini uniprep polypropylen 500 µl), together with 10 µL C13-labelled internal standard mixture (final internal standard concentrations 5 ng/mL).

For the migration testing 6 cm^2 FCM sample was added 1.50 mL 50% ethanol:water (simulant) and heated for 2 hours at 70°C in a heating block, after which a quantity was transferred to a filter vial and added internal standard as described above.

Quantitation was performed using external calibration standards of 0, 1, 2, 5 ng/mL of perfluoroalkyl phosphates (PAPs) added several corresponding C13-labelled internal standards of 5 ng/mL.

Fluorotelomer alcohols (FTOH)

Carved square pieces of 6 cm^2 of FCM were extracted with 1.00 mL 50% ethanol:water by placing the FCM samples in microcentrifuge tubes in an ultrasonication bath at 60°C for 1 hour. Subsequently 225 µL extract was transferred to a 0.2 µm filter vial (Whatman Mini uniprep polypropylen 500 µl), together with 25 µL C13-labelled internal standard mixture (final internal standard concentrations 20 ng/mL).

For the migration testing 6 cm^2 FCM sample was added 1.50 mL 50% ethanol:water (simulant) and heated for 2 hours at 70°C in a heating block, after which a quantity was transferred to a filter vial and added internal standard as described above.

Quantitation was performed using external calibration standards of 0, 5, 10, 25, 50, 75 ng/mL of fluorotelomer alcohols (FTOH) added several corresponding C13-labelled internal standards of 20 ng/mL.

Samples for which PFAS concentrations exceeded the calibration curves were diluted prior to addition of internal standard and repeated analysis by LC-MS.

LC-MS/MS detection

The LC-MS/MS detection of the PFAS compounds was performed on a Dionex Ultimate 3000 /Bruker EVOQ Elite UPLC-MS/MS. The LC-MS/MS *m/z>m/z* transitions of PFSA and the general settings of the EVOQ Elite Bruker triple quadrupole with electrospray ionisation interface appears from Annex A, including also the analytical detection limit (LOD) of the individual PFAS.

LC-conditions for perfluorocarboxylic acids(PFCA)/perfluoro sulphonic acids(PFSA):

Phenomenex Luna Omega Polar C18 (100 Å, 1.6 µm, 100 x 2.1 mm) LC column in series with a Waters ACQUITY UPLC CSH C18 (130 Å, 1.7 µm, 100 x 2.1 mm) column; injection volume 5 µL, column oven temp.50°C, autosampler temp.10°C. Eluent flow was initially 0.15mL/min.; eluent A: 2 mM ammonium acetate in 90 % Milli-Q water/10 % methanol, pH adjusted to 9.0, and B: methanol. Eluent programme; 0 min. 10% B; 0.5 min. 10% B, 5.5 min 60% B, 12 min. 95% B at 0.2 mL/min., 16min. 95% B at 0.2 mL/min., 16.1 min 10% B at 0.15 mL/min to end 23 min.

LC-conditions for perfluoroalkyl phosphates (PAPs):

Waters ACQUITY UPLC CSH C18 (130 Å, 1.7 µm, 100 x 2.1 mm) column; injection volume 5 µL, column oven temp.50°C, autosampler temp.10°C. Eluent flow was initially 0.15mL/min.; eluent A: 2 mM ammonium acetate in 90 % Milli-Q water/10 % methanol, pH adjusted to 9.0, and B: methanol. Eluent programme; 0 min. 10% B; 0.5 min. 10% B, 5.5 min 60% B, 12 min. 95% B at 0.2 mL/min., 17.5min. 95% B at 0.2 mL/min., 17.6 min 10% B at 0.15 mL/min.to end 22 min.

LC-conditions for fluorotelomer alcohols (FTOH):

Waters ACQUITY UPLC CSH C18 (130 Å, 1.7 µm, 100 x 2.1 mm) column; injection volume 5 µL, column oven temp.30°C, autosampler temp.10°C. Eluent flow was initially 0.2mL/min.; eluent A: 2 mM ammonium hydroxide in Milli-Q water, pH adjusted to 8.5, and B: methanol. Eluent programme; 0 min. 70% B; 4 min. 99% B, 6.5 min 99% B, 8 min. 99% B at 0.3 mL/min., 11 min. 99% B at 0.3 mL/min, 12 min 70% B at 0.3 mL/min., 13 min 70% B at 0.3 mL/min., 13.5 min 70% B at 0.2 mL/min to end 17 min.

Quality assurance

The Danish accreditation body (DANAK) supervises the chemical methods applied at the DTU Food – National Food Institute. Routines are established for daily quality control of the methods taken into consideration a suitable composition of the analytical batch with respect to number of samples that are analysed in multiplicity, laboratory and solvent blanks and control charts.

5 Results and discussion

In the present project, 35 FCM samples were analysed for PFAS (including PFCAs, PFSAs, monoPAPs, diPAPs and FTOHs). The analysed substances and their specific detection limits (LOD) appear from Annex A.

Information regarding the type of samples (trade name, sampling date, country of origin etc.) are listed in Annex B. Photos of the FCM samples are shown in Annex C.

Occurrence of PFAS in extracts was detected in 13 of the 35 FCMs, e.g. in seven of 11 plates, in two cupcake cups, a cup, a fish food bag, a popcorn beaker and a pizza tray.

The results of individual PFAS compounds in µg/kg food appear from table 5. The results are calculated from the concentrations in extracts to the contents extracted per dm^2 FCM and then converted to the concentration in µg/kg food (by multiplying with 6 based on the assumption that 1 kg food has a surface area of 6 dm^2).

The sum of concentrations of 10 detected perfluorocarboxylic acids (PFCA) detected in 10 samples ranged from 0.01- 13.1 µg/kg food. Perfluorooctane sulphonic acid (PFOS) belonging to perfluoroalkyl sulphonic acids (PFSA) was detected in two samples, however, only in the range of 0.007-0.01 µg/kg food. MonoPAPs and diPAPs were not detected. Fluorotelomer alcohols (FTOH) were detected in nine samples at concentrations of 0.8-13.5 µg/kg food. 6:2 FTOH was found in seven of the samples, and in addition both 8:2 FTOH and 10:2 FTOH were found in two samples of Chinese cupcake cups. The cupcake cups contained a total of 12 different substances comprising ∑PFAS concentrations of 6.1 and 14.1 µg/kg food respectively (sample 228, 229). Moreover, the highest concentrations of ∑PFAS were found in extracts from three samples of plates, all from the same manufacturer from United States (∑PFAS: 19.4; 13.3; 25.3 µg/kg food (sample 210; 220; 221)).

Migration tests in triplicate were performed for the two samples of cupcake cups and the three samples of plates with the high ∑PFAS contents (exceeding the 2017 action limit of 5 µg PFOA equivalents/kg food). The migration conditions: 6 cm^2 in 1.5 mL 50% ethanol/water 2 hours at 70°C were chosen, as the paper plates were labelled as “microwavable”, hence they are expected to reach a high temperature during food preparation and the two cupcake cups and cupcakes were also supposed to reach high temperature conditions during baking.

The results of the individual PFAS and the ∑PFAS in µg migrant /kg food are presented in table 6 as migration in triplicate (1, 2, 3) as well as means and standard deviations.

The results of the migration tests (table 4) of the plate samples showed that the perfluorcarboxylic acids (∑PFCA) migrated in concentrations corresponding to: 16.7±2.0; 7.8±0.5; 14.8±1.1 µg/kg food (sample 210, 220, 221). From the cupcake cups migration of the ∑PFCA were 0.67±0.01 and 0.59±0.13 µg/kg food (sample 228, 229) respectively.

The fluortelomer alcohols (∑FTOH) migrated in concentrations corresponding to 22.8±3.0; 10.1±2.3; 17.2±2.3 µg/kg food from the plates (sample 210, 220, 221) and from

the cupcake cups ∑FTOH migration were 19.9±3.6 and 14.4±1.7 µg/kg food (sample 228, 229) respectively.

Overall, the migrations of ∑PFAS from the plates (sample 210, 220, 221) were 39.5±4.9; 17.9±2.3; 32.0±1.4 µg/kg food; and from the cupcake cups (sample 228, 229) 20.6±3.6; 15.0±1.8 µg/kg (table 4).

The results of PFAS from the migration studies showed higher values compared to the PFAS results of the extracts (Table 7). The reason for that may be that due to the use for microwave oven and as cupcake cups for baking in the oven, higher temperature conditions of 70°C was used for migration compared to the temperature conditions for the extraction of 60°C. Furthermore, in order to have a low detection limit, only 1 mL of solvent was used for the extraction, compared to 1.5 mL of solvent for the migration. At the relatively high concentrations of PFAS the volume of solvent may have been too low to allow PFAS to be dissolved after the extraction.

Regarding comparison to other studies, Yuan et al. (2016) found that in addition to PFCAs, FTOHs were widely detected in various paper-made FCMs from the Chinese market; especially in eco-friendly paper tableware and microwave popcorn bags. 6:2-FTOH was not as frequently found as higher FTOH chain length which is in line with the present finding of 8:2 FTOH and 10:2 FTOH in two cupcake cups from China.

In the present study the PFCA with the highest concentrations in the plates was PFHxA which migrated in concentrations of 11.4±1.6; 6.8±0.6; 9.6±0.6 µg/kg food (sample 210, 220, 221). A study by Xu et al. (2013) found that PFHxA migrated to a higher extent than the higher molecular weight PFCAs. They found that the percentage of migration after 10 days at 40°C ranged from 4.8% to 100% for combinations of two papers and different food simulants tested, and that the migration was highest for PFHxA.

Schaider et al. (2017) studied perfluorinated compounds in United States Fast Food Packaging, and frequently found total fluor contents mostly in bread/burger/cake wrappers and in paperboard and paper cups, demonstrating potentially significant contributions to dietary PFAS exposure.

Zabaleta et al. (2016) studied PFAS in FCM from different surveys worldwide including the Spanish market. They reported PFAS compounds as PFCA, diPAPs in e.g. wrappers, coffee cups, popcorn bags, and they also for the first time identified 6:2 FTCA, 6:2-FTUCA and 5:3-FTCA analytes in microwave popcorn bags.

Table 4. Concentrations of ∑PFAS (PFCA and PFSA) in ng/kg food extracted or **migrated (in bold**) from paper and board FCM.

Sample type	Trade name	Sampling date	Country of origin	Sample ID DTU (K17-)	Sample ID NFSA	Surface to volume ratio	∑PFCA µg/kg	∑FTOH µg/kg	∑PAPs µg/kg	∑PFAS µg/kg
Plates	Blue dish	18-08-2017	China	206	4	6				
	Papptallerken Chinet Art. No 03600/263078	25-08-2017	USA	210	140917/0444 17	6	**16±2**	**22.8±3.0**		**39.5±4.9**
	Eco plates	25-08-2017	Denmark	211	140917/0444 26	6	0.06			
	Cardboard plates	25-08-2017	Denmark	212	24091/0444 30	6				
	Diner plate 18 cm white, art. No 73909	23-08-2017	?	217	240817/0426 23	6				0.01
	Natur plate	23-08-2017	?	218	240817/0426 15	6	0.006	2.4		2.4
	Microwaweble strong fibre bowl 40 cl/dyp fibertallerken	23-08-2017	USA	220	240817/0426 08	6	**7.8±0.5**	**10.1±2.3**		**17.9±2.3**
	Microwawable strong fibre bowl 40 cl/tredelt d:26cm	23-08-2017	USA	221	240817/0426 21	6	**14.8±1.1**	**17.2±2.3**		**32.0±1.4**
	Staples paper bowls, dyp tallerken d:18cm	23-08-2017	Finland	223	250817/0428 09	6	0.21			
	Staples paper plates, flat tallerken d:18cm	23-08-2017	?	225	250817/0428 02	6				
	Paper asiette/Pappasjet d:18cm	28-09-2017	Sweden	235	1	6				
Baking cups etc.	Cupcake cup	18-08-2017	China	204	2	6				
	Cupcake cup	28-08-2017	China	228	290817/0434 07	6	**0.67±0.01**	**19.9±3.6**		**20.6±3.6**
	Cupcake cup with flag	28-08-2017	China	229	290817/0434 15	6	**0.59±0.13**	**14.4±1.7**		**15.0±1.8**
	Cupcake cup	28-09-2017	China	237	3	6				
	Baking tray	28-09-2017	China	238	4	6				

Table 4 continued. Concentrations of ∑PFAS (PFCA and PFSA) in ng/kg food extracted or **migrated (in bold**) from paper and board FCM.

Sample type	Trade name	Sampling date	Country of origin	Sample ID DTU (K17-)	Sample ID NFSA	Surface to volume ratio	∑PFCA µg/kg	∑FTOH µg/kg	∑PAPs µg/kg	∑PFAS µg/kg
Food meal bag/paper	Food paper bag	25-08-2017	Norway?	209	240917/0444 15	6				
	Pizza paper greaseproof	25-08-2017	Turkey?	213	340917/0444 31	6				
	Fish food bag/foret fiskematpose	25-08-2017	Norway	214	4 40917/0444 32	6		0.8		0.8
	Burger paper	28-09-2017	Denmark	240	290917/0623 56	6				
	Baguette bag	28-09-2017	Sweden	241	290917/0623 59	6				
Hot drink cups	Hot cup 250 ml, Bioware	23-08-2017	FInland	222	240817/0426 36	6				
	Let's party paper cup	28-08-2017	China	226	290817/0433 89	6	0.021			
	Nordic Swan cup, Swan labelled	23-08-2017	FInland	230		6				
Popcorn beaker	Popcorn beaker, ID 1953-7, 9x12x5cm	18-08-2017	China	205	3	6				
	Popcorn beaker, red	24-08-2017	China	208	5	6				
	Popcorn beaker	01-09-2017	Sweden	216	140917/0444 45	6		1.3		1.3
Candy bags	Candy bag , paper	24-08-2017	China	207	1	6				
	Candy bag (smågodtpose)	01-09-2017	Sweden	215	140917/0444 50	6				
Baking paper	Bon Apetitt Baking paper , economy, environmentally bleached	23-08-2017	Norway	224	250817/0427 89	6				
	Baking paper in sheets	28-08-2017	Germany	227	290817/0434 06	6				
Coffee filters	Luksus filters, 1 x 4,	23-08-2017	?	219	240817/0426 28	6				
Pizza tray	Pizza trays	28-09-2017	Italy	239	280917/2007 81	6	0.025			
French fries tray	French fries tray	28-09-2017	Sweden	242	290917/0523 58	6				
Snack beaker	BBQ snack beaker	28-09-2017	China	236	2	6				

Table 5. Concentrations of individual PFAS (PFCA and PFSA) in µg/kg food based on extracts from paper and board, **a) PFCA and PFSA** and **b) FTOH**.

a)

	PFCA										PFSA	
sample K17-0-µg/kg	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnDA	PFDoDA	PFTeA	PFTrA	PFOS	**∑PFCA, PFSA**
210	0.467	9.40	0.241	0.149		0.009						**10.3**
211		0.058										**0.058**
217											0.010	**0.010**
218		0.006										**0.006**
220	0.326	4.88	0.111	0.014		0.010						**5.35**
221	0.691	11.90	0.255	0.220		0.018		0.011				**13.1**
223		0.211										**0.211**
226				0.021								**0.021**
228		0.041	0.015	0.177	0.015	0.161	0.020	0.117	0.060	0.014		**0.620**
229	0.011	0.071	0.019	0.167	0.015	0.151	0.037	0.168	0.081	0.026		**0.746**
239							0.007	0.011			0.007	**0.025**

b)

sample K17-0	4:2 FTOH µg/kg	6:2 FTOH µg/kg	8:2 FTOH µg/kg	10:2 FTOH µg/kg	**∑FTOH µg/kg**
210		9.1			**9.1**
211		2.5			**2.5**
214		0.8			**0.8**
216		1.3			**1.3**
218		2.4			**2.4**
220		7.8			**7.9**
221		12.2			**12.2**
228			3.9	9.6	**13.5**
229			3.3	2.0	**5.3**

Table 6. Concentrations of individual PFAS (PFCA, PFSA, PAPs, FTOH) in µg migrant/kg food migrated from paper and board FCM for three independent migration tests per sample.

Migration (µg/kg food)	sample k17-0-	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnDA	PFDoDA	PFTeA	PFTrA	6.2 FTOH	8.2 FTOH	10.2 FTOH	**∑PFAS**
migration 1	210	0.95	10.38	0.28	3.67		0.30					21.3			36.9
migration 2	210	0.70	10.55	0.26	3.67		0.33					20.9			36.4
migration 3	210	1.22	13.17	0.35	3.93		0.30					26.2			45.2
Mean	**210**	***0.96***	***11.37***	***0.30***	***3.76***		***0.31***					***22.8***			***39.5***
Sd	*210*	*0.26*	*1.56*	*0.05*	*0.15*		*0.02*					*3.0*			*4.9*
migration 1	220	0.53	6.85	0.15	0.41		0.20					7.6			15.7
migration 2	220	0.32	7.25	0.12	0.41							12.2			20.3
migration 3	220	0.32	6.13	0.12	0.36		0.26					10.5			17.7
mean	**220**	***0.39***	***6.75***	***0.13***	***0.40***		***0.23***					***10.1***			***17.9***
sd	*220*	*0.12*	*0.57*	*0.02*	*0.03*		*0.05*					*2.3*			*2.3*
migration 1	221	0.68	10.22	0.24	4.65		0.23					14.7			30.7
migration 2	221	0.39	9.04	0.20	4.08		0.23					17.8			31.8
migration 3	221	0.43	9.46	0.20	3.93		0.31					19.1			33.4
mean	**221**	***0.50***	***9.57***	***0.21***	***4.22***		***0.26***					***17.2***			***32.0***
sd	*221*	*0.16*	*0.60*	*0.03*	*0.38*		*0.05*					*2.3*			*1.4*
migration 1	228	0.03	0.05	0.03	0.20	0.02	0.16	0.01	0.10	0.04	0.01		4.6	11.6	16.8
migration 2	228	0.02	0.06	0.03	0.20	0.02	0.14	0.02	0.11	0.04	0.01		7.0	16.1	23.8
migration 3	228	0.02	0.05	0.03	0.21	0.02	0.17	0.02	0.11	0.03	0.01		6.9	13.6	21.2
mean	**228**	***0.02***	***0.06***	***0.03***	***0.20***	***0.02***	***0.16***	***0.02***	***0.11***	***0.04***	***0.01***		***6.2***	***13.8***	***20.6***
sd	*228*	*0.01*	*0.01*	*0.00*	*0.01*	*0.00*	*0.01*	*0.00*	*0.00*	*0.00*	*0.00*		*1.4*	*2.3*	*3.6*
migration 1	229	0.03	0.05	0.02	0.13	0.02	0.11	0.03	0.09	0.03	0.01		7.7	5.3	13.5
migration 2	229	0.03	0.08	0.02	0.19	0.04	0.16	0.03	0.12	0.04	0.02		9.8	6.4	17.0
migration 3	229	0.03	0.05	0.02	0.12	0.03	0.11	0.02	0.08	0.03	0.01		7.2	6.8	14.5
mean	**229**	***0.03***	***0.06***	***0.02***	***0.15***	***0.03***	***0.12***	***0.03***	***0.10***	***0.03***	***0.02***		***8.2***	***6.2***	***15.0***
sd	229	*0.00*	*0.02*	*0.00*	*0.04*	*0.01*	*0.03*	*0.01*	*0.02*	*0.01*	*0.00*		*1.4*	*0.8*	*1.8*

Table 7. Results of migration test (µg/kg food) and comparison to extraction.

Sample type	Sample ID (K17-0)-	∑PFCA, extraction[a] (µg/kg food)	∑PFCA, migration[b,c] (µg/kg food)	Migration /extraction	∑FTOH extraction[a] (µg/kg food)	∑FTOH, migration[b,c] (µg/kg food)	Migration /extraction
Paper plate, small	210	10.3	16.7 ± 2.0	1.6	9.1	22.8 ± 3.0	2.5
Microwaveable strong fibre bowl	220	5.35	7.8 ± 0.5	1.5	7.9	10.1 ± 2.3	1.3
Microwaveable strong fibre plate	221	13.1	14.8 ± 1.1	1.1	12.2	17.2 ± 2.3	1.4
Cupcake form	228	0.62	0.67± 0.01	1.1	13.5	19.9 ± 3.6	1.5
Cupcake form	229	0.75	0.59 ± 0.13	0.8	5.3	14.4. ± 1.7	2.7

[a] Extraction conditions: 6 cm^2 in 1 mL (PFCA in 100% ethanol, FTOH in 50% ethanol)1 hour by ultrasonication at 60°C,
[b] Migration conditions: 6 cm^2 in 1.5 mL 50% ethanol, 70°C, 2 hours.
[c] Triplicate migration tests

6 Conclusion

PFAS was found in 13 of 35 FCM analysed, that is in seven of 11 plates, two cupcake cups, one cup, a fish food bag, a popcorn beaker and a pizza tray. The sum of concentrations of 11 detected perfluorcarboxylic acids (PFCA) and polyfluorsulphonic acids (PFSA) in the extracts ranged from 0.01- 13.1 µg/kg food. Hereof the PFSA detected, in this case perfluoroctane sulphonate (PFOS) did not contribute more than 0.01 µg/kg food. In addition, fluortelomer alcohols were detected in nine samples at concentrations 0.8-13.5 µg/kg. The highest concentrations of perfluoralkyl substances (∑PFAS) found were in three samples of plates, all from the same producer from USA and in two Chinese cupcake cups contained 12 different substances.

These five samples were tested for migration of the specific substances at conditions: 2 hours at 70°C in 50% methanol/water performed in triplicate. The results of the plate samples were that ∑PFAS migrated from sample 210, 220 and 221 in concentrations corresponding to 39.5±4.9; 17.9±2.3; 32.0±1.4 µg/kg food; and from the cupcake cups (sample 228, 229) in concentrations corresponding to 20.6±3.6; 15.0±1.8 µg/kg food.

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References

Begley, T., White, H.K., Honigfort, P, Twaroski, M.L., Neches, R., Walker,R. A. 2005. Perfluorochemicals: potential sources of and migration from food packaging. *Food additives and contaminants*, 22(10), pp.1023.

DTU Food – National Food Institute 2018. Accredited analytical method FA430.1. Determination of per-polyfluorinated substances (PFAS) in food and migrates from food contact materials by LC-MS/MS.

EFSA CONTAM Panel (EFSA Panel on Contaminants in the Food Chain),Knutsen HK, Alexander J, Barreg_ard L, Bignami M, Br€uschweiler B, Ceccatelli S, Cottrill B, Dinovi M,Edler L, Grasl-Kraupp B, Hogstrand C, Hoogenboom LR, Nebbia CS, Oswald IP, Petersen A, Rose M, Roudot A-C, Vleminckx C, Vollmer G, Wallace H, Bodin L, Cravedi J-P, Halldorsson TI, Haug LS, Johansson N, van Loveren H, Gergelova P, Mackay K, Levorato S, van Manen M and Schwerdtle T., 2018. Scientific Opinion on the risk to human health related to the presence of perfluorooctane sulfonic acid and perfluorooctanoic acid in food. EFSA Journal 2018;16(12):5194, 284 pp. https://doi.org/10.2903/j.efsa.2018.5194, ; ISSN 1831-4732.

European Commission 2004. Commission regulation (EU) No. 1935/2004 of 27 October 2004 on materials and articles intended to come into contact with food.

European Union 2017. COMMISSION REGULATION (EU) 2017/1000 of 13 June 2017 amending Annex XVII to Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) as regards perfluorooctanoic acid (PFOA), its salts and PFOA-related substances.

Fei C, McLaughlin JK, Tarone RE, Olsen J. 2007. Perfluorinated chemicals and foetal growth: a study within the Danish National Birth Cohort. Environ Health Perspect. Nov;115(11):1677-82.

Granby, K., Pedersen, G.A. 2018. Vurdering af metode til bestemmelse af total organisk fluor (TOF) i fødevarekontaktmaterialer og bestemmelse af baggrundsniveau for TOF i pap og papir. / Kgs. Lyngby: Danmarks Tekniske Universitet, 2018. 30 p.

Norden (2013) Per- and polyfluorinated substances in the Nordic Countries. Use, occurrence and toxicology. TemaNord 2013:542, ISBN: 978-92-893-2562-2, http://dx.doi.org/10.6027/TN2013-542

Olsen GW, Burris JM, Ehresman DJ, Froehlich JW, Seacat AM, Butenhoff JL, Zobel LR. Half-life of serum elimination of perfluorooctanesulfonate, perfluorohexanesulfonate, and perfluorooctanoate in retired fluorochemical production workers. Environ. Health Perspect. 2007; 115(9):1298–1305.

Schaider LA, Balan,SA; Blum,A.;Andrews,DQ; Strynar,MJ Dickinson,ME; Lunderberg,DM; Lang,JR. Peaslee, GF., 2017. Fluorinated Compounds in U.S. Fast Food Packaging, *Environ. Sci. Technol. Lett.*, 2017, 4,105.

Trier, X., Granby, K. & Christensen, J. H. 2011a. Polyfluorinated surfactants (PFS) in paper and board coatings for food packaging. *Environmental science and pollution research international*, 18(7), pp.1108–20.

Trier, X., Nielsen, N.J. & Christensen, J.H., 2011b. Structural isomers of polyfluorinated di- and tri-alkylated phosphate ester surfactants present in industrial blends and in microwave popcorn bags. *Environmental science and pollution research internationa*l, 18(8), pp.1422–32.

Trier, X., 2011c. *Polyfluorinated surfactants in food packaging of paper and board*. PhD thesis, University of Copenhagen.

Trier, X , Cederberg, T.L.; Jensen, L.K. 2016. Fluorerede stoffer i mademballage af pap og papir. DTU DOC-nummer: 15/35769 og Mattilsynets saksnr.i ePhorte: 2014/274761

White, S.S., Fenton, S.E., Hines, E.P., 2011. Endocrine disrupting properties of perfluorooctanoic acid. J. Steroid Biochem. Mol. Biol. 127, 16–26.

Xu, Y., Noonan G.O., Begley T.H. 2013. Migration of perfluoroalkyl acids from food packaging to food simulants, *Food Add. Contam. A*, 30, 899–908.

Yuan, G.; Peng, H.; Huang, C.; Hu, J. 2016. Ubiquitous Occurrence of fluorotelomer alcohols in eco-friendly paper-made Food Contact Materials and their implication for human exposure. *Environ. Sci. Technol*. 50, 942−950.

Zabaleta, I.,Bizkarguenaga, E., Bilbao,D., Etxebarria,N., Prieto, A., Zuloaga O., 2016. Fast and simple determination of perfluorinated compounds and their potential precursors in different packaging materials *Talanta* 152, 353–363.

Annex A LC-MS/MS Conditions

Spay Voltage	-3000V
Cone temperature	350°C
Heated probe temp.	350°C
Cone gas flow	20
Heated probe gas flow	50
Nebulizer gas flow	50
Exhaust gas	ON

	Abbr.	Limit of detection µg/dm²	Brutto formula (M: precursor)	*m/z* $(M-H)^-$	*m/z* product quantifier	*m/z* product qualifier	t_R (min)
PFBA	C4-PFCA	0.001	C4F7O2H	213.0	168.9	167.9	5.5
PFPeA	C5-PFCA	0.001	C5F9O2H	262.7	218.8	262.7	9.0
PFHxA	C6-PFCA	0.001	C6F11O2H	312.9	268.7	119.0	9.4
PFHpA	C7-PFCA	0.001	C7F13O2H	362.8	318.7	168.8	10.2
PFOA	C8-PFCA	0.001	C8F15O2H	412.7	368.6	168.8	10.8
PFNA	C9-PFCA	0.001	C9F17O2H	462.9	418.7	218.8	11.3
PFDA	C10-PFCA	0.001	C10F19O2H	512.9	468.6	218.8	11.6
PFUnDA	C11-PFCA	0.001	C11F21O2H	562.8	518.6	268.7	12.2
PFDoDA	C12-PFCA	0.001	C12F23O2H	612.8	568.6	168.9	12.5
PFTrDA	C13-PFCA	0.001	C13F25O2H	662.8	618.5	218.8	12.8
PFTeDA	C14-PFCA	0.001	C14F27O2H	712.8	668.4	318.6	13.2
PFBS	C4-PFSA	0.001	C4F9SO3H	298.8	80.1	99.0	8.8
PFHxS	C6-PFSA	0.002	C6F13SO3H	398.8	80.1	99.0	10.3
PFOS	C8-PFSA	0.001	C8F17SO3H	498.9	80.1	99.0	11.3
4H-PFOS	6:2 FTSA	0.001	C8F13H4SO3H	427.0	406.7	81.0	11.0
PFDS	C10-PFSA	0.002	C10F21SO3H	598.8	80.1	99.0	12.2
PFOSA	C8--	0.010	C8H2F17NO2 S	498.1	78.0	168.9	11.0
6:2 monoPAPs		0.001	C8H6F13O4P	442.9	442.7	97.1	8.9
8:2 monoPAPs		0.001	C10H6F17O4P	542.9	542.7	97.1	10.3
6:2/6:2 diPAPs		0.001	C16H8F26O4P	788.9	442.7	97.1	11.8
8:2/8:2 diPAPs		0.001	C20H8F34O4P	988.7	542.6	97.1	12.8
4:2 FTOH		0.3	C6H5F9O	263.0	155.0	203.0	3.1
6:2 FTOH		0.1	C8H5F13O	363.0	255.0	303.0	4.7
8:2 FTOH		0.1	C10H5F17O	463.0	403.0	355.0	5.7
10:2 FTOH		0.1	C12H5F21O	563.0	503.0	455.0	6.4

Annex B. Sampling information of paper & board FCM samples.

Region office	Inspector	Trade name	Producer	Country of origin	Sampling Place	Sampling date	Information on FCM	Sample ID, DTU (K17-)
Sør-Rogaland, sirdal og flekkefjord	Hatju	CUPCAKE CUPS	NINGBO HOME-DOLLER IMP&EXP	CHINA	FJONG AS/ Søstrene Grene avd Sandnes	18.08.2017	-	204
Sør-Rogaland, sirdal og flekkefjord	Piiba	Popcorn beger ID. 1953-7 Stør. 9X12X5 cm		China	UPSTAIRS avd Kvadrat	18.08.2017	Miljøvenlig papir	205
Sør-Rogaland, sirdal og flekkefjord	piiba	Blå fat ID. 1833-12 Stør. 18 cm		China	UPSTAIRS avd Kvadrat	18.08.2017	Miljøvenlig papir	206
Sør-Rogaland, sirdal og flekkefjord	hatju	Godtepose, papir	Ningbo home doller IMP&EXP	CHINA	FJAS AS/ Søstrene Grene avd Stavanger	24.08.2017	-	207
Sør-Rogaland, sirdal og flekkefjord	hatju	Popcornbeger, rød	NINGBO HOME-DOLLER IMP&EXP	CHINA	FJAS AS/ Søstrene Grene avd Stavanger	24.08.2017	-	208
Øst	siseb	Papirpose	Norwegian Paper	Norge?	Olavsen Engros	25.08.2017	-	209
Øst	siseb	Papptallerken Chinet	Huhtamaki	Finland?	Olavsen Engros	25.08.2017	-	210
Øst	Siseb	Eco plates	Abena AS	Danmark	Arne Brekke AS	25.08.2017	Eco plates	211
Øst	Siseb	Cardboard plates	Abena AS	Danmark	Arne Brekke AS	25.08.2017	-	212
Øst	Siseb	Pizzapapir greaseproof	Multiemballasje	Tyrkia?	Arne Brekke AS	25.08.2017	-	213
Øst	Siseb	Forede fiskematposer	Norwegian Paper	Norge	Arne Brekke	25.08.2017	-	214
Øst	siseb	smågodtpose	JD Stenqvist AB	Sverige	Hval Sjokoladefabrikk	01.09.2017	-	215
Øst	siseb	Popcornboks	Sundling	Sverige	Office24	01.09.2017	-	216
Stor-Oslo	wekol	Middagstallerken d:18 cm hvit art.nr 73909	Må etterspørre		Europris, Bryn	23.08.2017	-	217
Stor-Oslo	wekol	Natur tallerkner d: 26 cm av plantefiber, grønn dekor	Produsert for Europris	?	Europris, Bryn	23.08.2017	-	218
Stor-Oslo	wekol	Luksus filterposer 1x4 100 stk.	Etterspør	?	Europris, Bryn	23.08.2017	-	219
Stor-Oslo	pobjo	Chinet Microwaveable bowl 40 cl/dyp tallerken	Huhtamaki	USA	Storcash, Brobekk Oslo	23.08.2017	Eco-friendly	220

Region office	Inspector	Trade name	Producer	Country of origin	Sampling Place	Sampling date	Information on FCM	Sample ID DTU (K17-)
Stor-Oslo	pobjo	Chinet tredelt microwaveable strong fibre plates, d: 26 cm	Huhtamaki	USA	Storcash, Brobekk Oslo	23.08.2017	-	221
Stor-Oslo	pobjo	Paper hot cup 250 ml, BioWare	Huhtamaki	Finland	Storcash, Brobekk Oslo	23.08.2017	*BioWare*	222
Stor-Oslo	pobjo	Staples Paper bowls, dyp tallerken, d: 18 cm	Staples Europe B.V, Nederland	Finland	Staples Alnabru	23.08.2017	-	223
Stor-Oslo	pobjo	Bon Apetitt Bakepapir økonomirull	Norwegian Paper AS, Grimstad	Norge	Staples Alnabru	23.08.2017	Miljøbleget naturfibre	224
Stor-Oslo	pobjo	Paper plates tallerknar d: 18 cm flat	?	?	Staples Alnabru	23.08.2017	-	225
Stor-Oslo	wekol	Let's Party papirkrus		Kina	Per Aarskog/Nille	28.08.2017	-	226
Stor-Oslo	wekol	Bakepapir i ark	Quickpack	Tyskland	Per Aarskog/Nille	28.08.2017	-	227
Stor-Oslo	wekol	Muffinsform 60 stk		Kina	Per Aarskog/Nille	28.08.2017	-	228
Stor-Oslo	wekol	Muffinsform med flagg		Kina	Per Aarskog/Nille	28.08.2017	-	229
Stor-Oslo	pobjo	Nordic Swan Cup, 300 ml, kaffebeger	Huhtamaki	Finland	Storcash, Brobekk Oslo	23.08.2017	Svanemærket	230
Øst, Drammen	LB Holst	Pappasjett 18 cm		Sverige		28.09.2017	-	235
Øst, Drammen	LB Holst	BBQ snackbeger		Kina		28.09.2017	-	236
Øst, Drammen	LB Holst	Unique cupcake kit		Kina		28.09.2017	-	237
Øst, Drammen	LB Holst	Baking tray		Kina		28.09.2017	-	238
Øst, Drammen	LB Holst	Pizzaesker		Italien		28.09.2017	-	239
Sør og Vest, avd. Bergen og omland	Hilde/Jenny	Burgerlomme	Abena	Danmark	Egge Import	28.9.2017	-	240
Sør og Vest, avd. Bergen og omland	Hilde/Jenny	Baguettpose	Tingstad	Sverige	Egge Import	28.9.2017	-	241
Sør og Vest, avd. Bergen og omland	Hilde/Jenny	Pommes frites berger	Tingstad	Sverige	Egge Import	28.9.2017	-	242

Annex C. Action limits set in Denmark

EFSA (2018) has made a scientific opinion suggesting new tolerable weekly intakes (TWI) of 13 ng/kg bw for PFOS and 6 ng/kg bw for PFOA, based on epidemiological effects showing increased serum cholesterol and immunotoxicity. These health-based guidance values are reduced many fold (80 - >1000 times) compared to the previous tolerable daily intake (TDI) of 150 ng/kg bw for PFOS and 1500 ng/kg bw for PFOA (EFSA 2008).

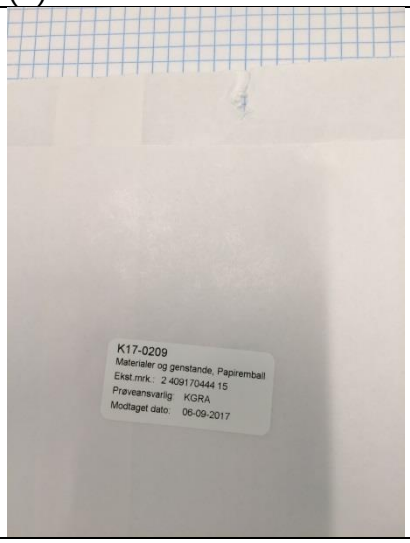
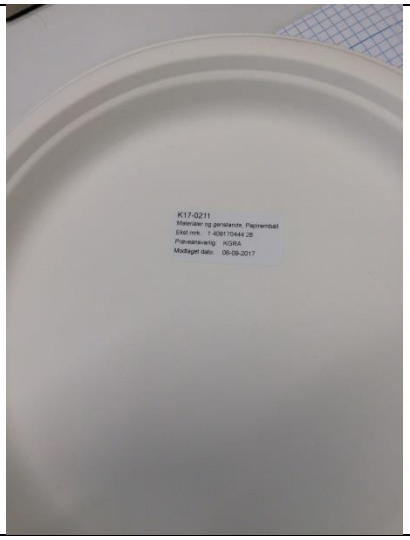
In 2015, Danish Veterinary and Food Administration (DVFA) had, based on scientific advice from DTU, developed guideline action limits originally established from EFSA's previous TDI (tolerable daily intake) for PFOS of 150 ng/kg bw per day and PFOA and their salts 1500 ng/kg bw per day (EFSA, 2008). The guideline limit for total organic fluorine content (TOF) determined by "Combustion Ion Chromatography" of 0.35 µg total organic fluorine content (TOF) per dm^2 in paper and board FCM as determined by "Combustion Ion Chromatography". As some FCM was found to contain higher fluorine background levels (Granby & Pedersen 2018), in April 2018 DVFA has introduced a new indicator value of 10 µg TOF/ dm^2 FCM. It is important to emphasize that the indicator value is not the same as a limit, but can be used as a guidance for business operators.

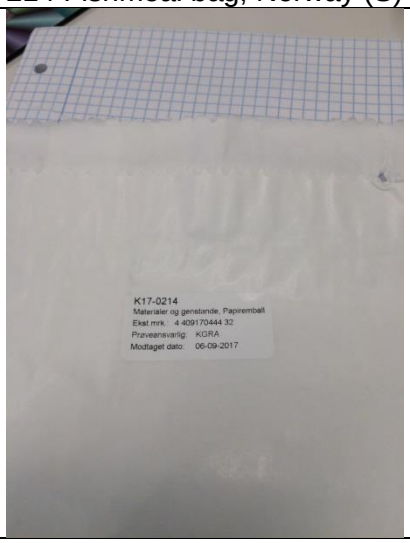
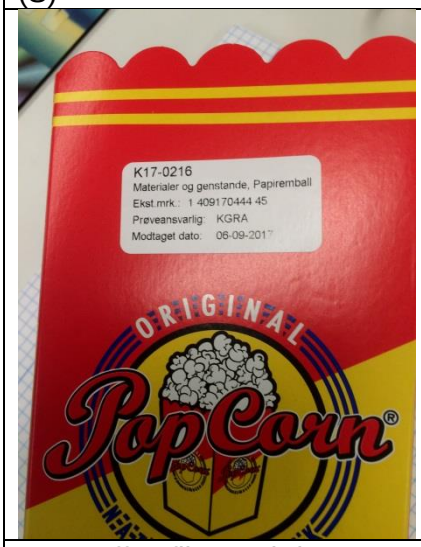
The general conditions for estimating migration from FCM, is based on a 70 kg adult eating 1 kg of food per day, with a volume of 6 dm^2 per kg (unless the actual exposure volume is very different from that). That corresponds to an amount of PFOA in the food of: 6 ng/kg bw/week * 70 kg /(7 kg food/week) = 60 ng/kg food or 0.06 µg/kg food (Table 2). Similarly calculated for PFOS: 13 ng/kg bw/week * 70 kg /(7 kg food/week)= 130 ng/kg food or 0.13 µg/kg food.

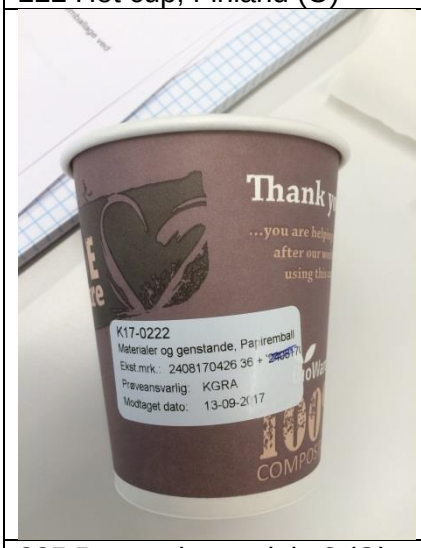
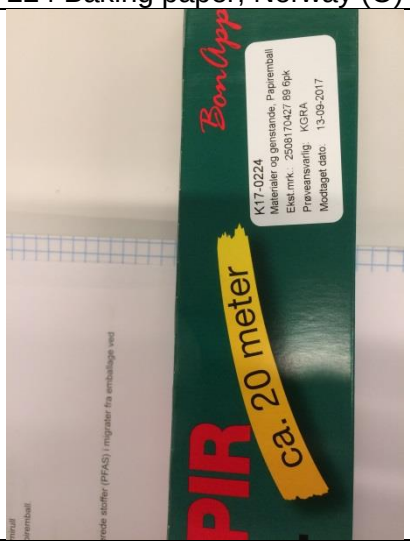
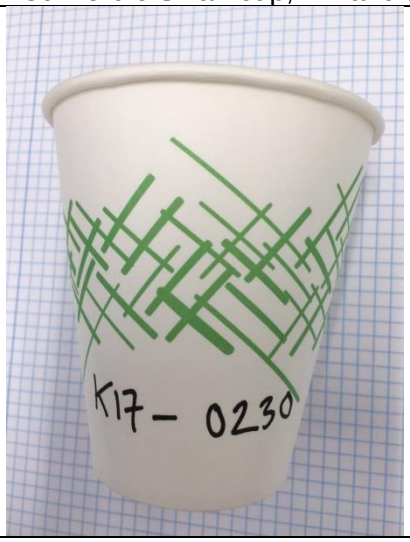
Table 2. **Action limit for migration from paper and board**

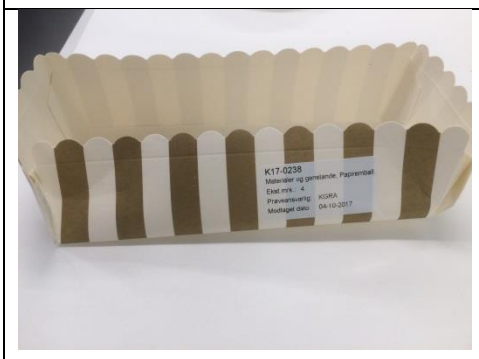
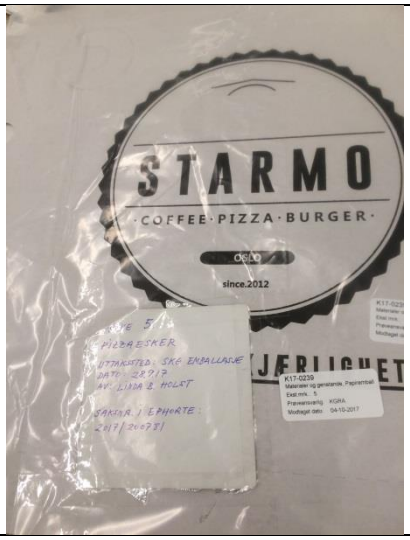
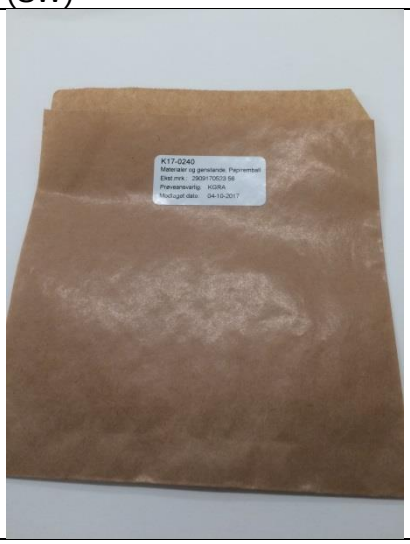
Action limit for migration from paper and board (based on the assumption that a person weigh 70 kg and the person eat 1 kg food/day.	**µg/kg food**
Substances that can degrade to perfluoroctanoic acid ($F(CF_2)_7COOH$ called PFOA), and perfluorocarboxyl acids (PFCA), f.ex. in the chain length: • PFCA $F(CF_2)_{3,4,5,6....-15}COOH$, called C_4-C_{16} PFCA • FTOH $F(CF_2)_{4,6,8,....-16}(CH_2)_2OH$, called 4:2 to 16:2 FTOH • monoPAPs $[F(CF_2)_{4,6,8....16}(CH_2)_2O]$-$PO(OH)_2$, called 4:2 to 16:2 monoPAPs • diPAPs $[F(CF_2)_{4,6,8....16}(CH_2)_2O]_2$-$PO(OH)$, called 4:2 to 16:2 diPAPS	0.06 (sum of all compounds)
Substances that can degrade to perfluoroctane sulfate ($F(CF_2)_8SO_3H$ called PFOS) and perfluoralkyl sulfonaters (PFSA), f.ex. in the chain length: • PFSA $F(CF_2)_{4,5,6....-10}SO_3H$, called C_5-C_{11} PFSA • PFOSA $F(CF_2)_8\,SO_2NH_2$	0.13 (sum of all compounds)

Annex D. Photos of the surveyed samples

204 Cupcake cups, China, South (S)	205 Popcorn beaker, China (S)	206 Blue dish , China (S)
		
207 Candy bag, China (S)	208 Popcorn beaker, China (S)	209 Paper bag, Norway? East (E)
		
210 Plate, Chinet, Finland?t(E)	211 Ecoplate, Denmark (E)	212 Cardboard plate,Denmark (E)
		

213 Pizza paper, Turkey? (S)	214 Fishmeal bag, Norway (S)	215 Candy bag, Sweden (S)
		
216 Popcorn beaker, Sweden (S)	217 Diner plate, origin?, Oslo(O)	218 Nature Plate, ? (O)
		
219 Coffee filter, ? (O)	220 Strong fibre bowl, USA (O)	221 Strong fibre plate,USA (O)
		

222 Hot cup, Finland (O)	223 Paper bowl, Norway (O)	224 Baking paper, Norway (O)
		
225 Paper plate, origin ? (O)	226 Paper cup, China(O)	227 Baking paper sheets Germany(O)
		
228 Cupcake forms, China (O)	229 Cupcake forms, China (O)	230 Nordic Swan cup, Finland (O)
		

235 Paper assiet, Sweden (E)	236 Snack beaker, China (E)	237 Cupcake form, China (E)
		
238 Baking tray, China (E)	239 Pizza tray, Italy (E)	240 Burger paper, Denmark (SW)
		
241 Baguette bag, Sweden (SW)	242 French fries tray, Sweden (SW)