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Survey of Acrylamide and Furans in UK Retail Products: Summaries and Trends for Samples Purchased Between January 2014 and November 2018

A report prepared for the Food Standards Agency

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1. Executive summary

This report refers to work carried out as part of a rolling survey of process contaminants in UK retail foods. The report contains the annual summaries and trends (where possible) for concentrations of acrylamide and furans measured in retail food samples purchased between January 2014 and November 2018:

- A total of 1346 samples (comprising multiple lots) were collected by an independent sampling contractor from retail and fast food outlets in seven regions of the UK
- The selection of samples for acrylamide followed a core annual sampling and analysis plan: some Category changes / samples additions were made by the Agency in 2018.
- Samples were categorised in accordance with the requirements for the submission of data to EFSA[1].
- Where necessary, foods were cooked or prepared according to the manufacturers' guidelines prior to homogenisation and analysis.
- All analyses were carried out using accredited methods: a total of 1331 tests were carried out for acrylamide and 624 tests for furans (furan, 2-methyl furan and 3-methyl furan).
- As expected for a relatively short survey period, trends in annual mean acrylamide amounts for Categories of similar products lacked precision and for most groups, the changes over time were not statistically significant ($P>0.05$).
    - Pre-cooked French fries and potato products for home cooking (Category 3) and biscuits, crackers, crisp bread and similar (Category 6) both indicated mean annual decreases ($p<0.05$) in acrylamide of 12.7% and 9% respectively.
    - There was tentative evidence for mean annual decreases in acrylamide for the Cereal based foods for infants and young children (Category 9: 20.8%; $P=0.07$) and the potato crisps and potato-based crackers (Category 2: 4.8%; $p=0.06$).
- The annual percentage of samples exceeding EC measures showed no statistically significant change ($P>>0.05$) for the survey period (note however there was a change from EC indicative values to benchmark levels during 2018).
- Highest amounts of furans were found in the Category 7 coffee products and the microwave popcorn: although the data was limited, amounts of each furan in the roast

[1] EFSA (European Food Safety Authority), 2017. Specific reporting requirements for contaminants and food additives occurrence data submission in SSD2. EFSA supporting publication 2017:EN-1261. 43 pp. doi:10.2903/sp.efsa.2017.EN-1261.

and instant coffees appeared to follow the trend 2-methyl furan > furan > 3-methyl furan; amounts of each furan in the microwave popcorn appeared to follow the trend furan ≈ 2-methyl furan > 3-methyl furan.

- Comparison of amounts of furans in all samples from Category 7 analysed as received and as consumed indicated that significant losses of all furans (circa 60-75%) occurred during the domestic preparation of the roast and ground coffees.

The domestic preparation of instant coffee appeared to result in much less loss of furan and 2-methyl furan.

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3. Introduction

Acrylamide, furan and alkyl furans (e.g. 2-methyl furan and 3-methyl furan) are organic compounds produced naturally when some foods are subjected to high temperatures during cooking (including home-cooking) and processing. Regular and prolonged exposure over a lifetime to foods containing high levels of acrylamide and furan has the potential to increase the risk of developing cancer. Experts, including the international Joint Food and Agriculture Organisation and the World Health Organisation Expert Committee on Food Additives (JECFA), have previously concluded that current global levels of dietary exposure to acrylamide and furan indicate a human health concern[2]. The UK Food Standards Agency (FSA) has concluded that exposure to acrylamide and furan should be as low as reasonably achievable (ALARA). The FSA has produced advice for consumers in relation to acrylamide in food[3].

3.1 Acrylamide

Acrylamide is a low molecular weight, water soluble organic compound with industrial applications such as the production of polyacrylamides. In 2002 Swedish scientists discovered at acrylamide could form naturally during the preparation of (mostly) starchy foods as temperatures exceeded 120^{o}C. Acrylamide is formed mainly from sugars and the amino acid asparagine, both of which are naturally present in foods. The chemical process that causes this occurs as a minor part of the so called Maillard Reaction; the Maillard Reaction is mainly responsible for the desirable colour and taste of food. Although acrylamide does not occur in foods subjected to lower temperatures and relatively short process times e.g. boiled potatoes, it has been found in a wide range of home-cooked and processed foods, including, bread, coffee, crispbreads, French fries and potato crisps.

3.2 Furan and methyl furans

Furan and methyl furans are volatile organic compounds that are also formed in certain foods during thermal processing. Furan has been found in a variety of products, including coffee, prefabricated potato snacks and canned and jarred products which, during processing, have been subjected to a high temperature heat treatment (e.g. roasting, frying, canning etc). The methyl furans are also known to occur in foods, especially coffee. Furan can be formed in food from a variety of precursors naturally present in food (e.g. amino acids, β-carotene,

[2] Joint FAO/WHO Expert Committee on Food Additives (2010), Summary and conclusions of the Seventy-second meeting, Rome, 16–25 February 2010. Rome, FAO / WHO

[3] www.food.gov.uk/safereating/chemsafe/acrylamide_branch

dehydroascorbic acid, polyunsaturated fatty acids and their triglycerides, sugars and vitamin C) and some food additives (e.g. isoascorbic acid, E315) via complex steps which might involve oxidation or the Maillard reaction. The methyl furans have been shown to form in model reactions, similar to furan, from precursors commonly found in foods. Food characteristics, processing and cooking conditions, and losses of furans mainly due to evaporation during the preparation of food at consumer level, determine the final concentrations in food as consumed.

Furan has been classified by the IARC as a possible human carcinogen. Evidence indicates that the latter may occur via a genotoxic mechanism: The harmful effects of furan result from the formation of a reactive metabolite in the body which can bind to cellular components such as DNA. The 2- and 3-methyl substituted furans are believed to be metabolically activated in a similar fashion as the parent furan.

3.3 EC Recommendations

This survey was conducted in response to two European Commission Recommendations for pan-European activity on process contaminants: (i) European Commission Recommendation (EU) No. 2010/307 to investigate the levels of acrylamide in food, and in particular to monitor the effectiveness of acrylamide reduction measures as specified in the FoodDrinkEurope toolbox and (ii) European Commission Recommendation (EC) No. 2007/196, to monitor the occurrence levels of furan in foodstuffs.

3.4 European Food Safety Authority

Data from this survey was submitted to European Food Safety Authority (EFSA) annually. EFSA collates the acrylamide results with those from other Member States and, in the case of furan and methyl furans, these data will be used by EFSA as the basis of developing a risk assessment. EFSA publishes the acrylamide exposure assessments and trend analyses on their website[4].

On 4th June 2015, EFSA published its Scientific Opinion on acrylamide in food[5]. EFSA agreed with the previous evaluations, that acrylamide in food has the potential to increase the risk of developing cancer. EFSA also considered possible harmful effects of acrylamide on the nervous system and male reproduction, and based on current levels of dietary

[4] Available at: http://www.efsa.europa.eu/en/topics/topic/acrylamide.htm

[5] EFSA CONTAM Panel 2015, Scientific Opinion on acrylamide in food. EFSA Journal 2015;13(6):4104, 321 pp. Available at: https://www.efsa.europa.eu/en/efsajournal/pub/4104 [Accessed June 2016]

exposure, these effects were not considered to be a concern. Further information on acrylamide can be obtained from the EFSA website.

In September 2017, EFSA published its Scientific Opinion on furan and methyl furans in food[6]. While an understanding of all the risks posed to health from the presence of furan and methyl furans in food was incomplete, EFSA has recommended that additional data is needed on the toxicity of methyl furans, their occurrence in foods and the effects of the distinct stages of coffee preparation on furan and methyl furans concentrations for all coffee types.

3.5 Measures concerning acrylamide levels in retail foods

There are no statutory maximum acrylamide levels, however in 2013 the EC introduced a measure for enforcement actions against food business operators found to exceed Indicative Values (IV)[7] for certain categories of foods. The Recommendation was replaced in April 2018 by new legislation establishing best practice, mitigation measures and benchmark levels (BML) for the reduction of the presence of acrylamide in food[8].

3.6 FSA Surveys

Information concerning acrylamide and results for all previous surveys can be accessed from the FSA website[9].

4. Methods

4.1 Sampling

Prior to the commencement of sampling, the FSA agreed a detailed sampling plan with the analytical contractor (Premier Analytical Services) who was responsible for coordinating the purchase and collection of samples (via a sampling contractor[10]). The collection of samples for the surveillance project followed on a core sampling plan for the period 2014-2017 with subsequent modifications in 2018. The sampling plan covered the 11 Categories of food detailed by EFSA[11]: To facilitate the characterisation of any possible trends in acrylamide

[6] EFSA CONTAM Panel 2017, Scientific opinion on the risks for public health related to the presence of furan and methylfurans in food. EFSA Journal 2017;15(10):5005,142 pp.

[7] Commission Recommendation of 8 November 2013 on investigations into the levels of acrylamide in food (2013/647/EU), oj L 301, 15-17, 12.11.13

[8] Commission Regulation (EU) 2017/2158 of 20 November 2017 establishing mitigation measures and benchmark levels for the reduction of the presence of acrylamide in food

[9] Available at: https://www.food.gov.uk/science/acrylamide-0

[10] Sampling Sorbet, Orchard House, 3 Mill Hill, Swaffham Prior, Cambridge, CB25 0JZ

[11] EFSA (European Food Safety Authority), 2017. Specific reporting requirements for contaminants and food additives occurrence data submission in SSD2. EFSA supporting publication 2017:EN-1261. 43 pp. doi:10.2903/sp.efsa.2017.EN-1261.

levels for each food Category every effort was made to obtain the same products from the same retail outlets year on year. Where a previous year's sampled product was no longer available, a similar product was obtained although inevitably slight adjustments had to be made to the sampling programme.

Samples were collected from a wide range of retail and fast food outlets across seven regions of the UK. A summary of the 2014 sampling plan is given in Table 20 of the appendices (see section 6); subsequent annual sampling plans can be found in each of the Annual reports 2015-2018 (see Appendix 6.2).

4.2 Sample preparation and analysis

Samples received at the laboratory were prepared and stored according to the Food Standards Agency "Guidelines for undertaking surveys"[12]. Products for testing as consumed were cooked according to manufacturers' guidelines prior to analysis; because of the volatile nature of the furans, coffee and coffee substitutes were tested before and after preparation for consumption according to manufacturer's guidelines.

Analysis of samples was carried out using UKAS accredited methods: the measurements of acrylamide, furan, 2-methyl furan and 3-methyl furan were based on the guidelines laid down in Commission Recommendations 2007/331/EC and 2007/196/EC. All test results were obtained from methods that used labelled isotope internal standards for recovery correction. Full details of all sample preparation methods, methods of analysis and quality assurance procedures / data can be found in the Annual Survey Reports (see 6.2) available from the Agency.

5. Results summaries

A total of 1346 samples were collected over the period January 2014 - November 2018 for the analysis of acrylamide and furans: A summary of all samples received and tests undertaken is given in Table 1.

[12] Guidelines for undertaking surveys. Available at: www.food.gov.uk/sites/default/files/multimedia/pdfs/fsasurveysguidance.pdf [accessed June 2015]

Table 1. Summary of samples received (Jan 2014 - Nov 2018) and tests undertaken

Food category / sub category[13]	Description	Number of samples received	Analyses			
			acrylamide		Furans[a]	
			As received	As consumed	As received	As consumed
1	French fries, sold as ready-to-eat	190	190	-	-	-
2	Potato crisps	135	135	-	-	-
3	Pre-cooked French fries / potato products for home cooking	119	-	119	-	-
4	Bread	135	135	-	-	-
5	Breakfast cereals	128	120	-	128	-
6	Biscuits / crackers	146	146	-	146	-
7	Coffee and coffee substitutes	92	92	-	92	92
8	Baby foods	121	119	-	119	-
9	Processed cereal based foods for infants & young children	116	116	-	10	-
10	Other products, based on cereals, potatoes, cocoa and coffee	-	-	-	-	-
10.2	Cake and pastry	30	30	-	-	-
10.3	Savoury snacks	13	13	-	2	-
10.4	Other products, based on cereals	25	17	8	-	8

[13] EFSA (European Food Safety Authority), 2017. Specific reporting requirements for contaminants and food additives occurrence data submission in SSD2. EFSA supporting publication 2017:EN-1261. 43 pp. doi:10.2903/sp.efsa.2017.EN-1261.

10.5	Baked potato from fast Other products, based on potatoes	6	6	-	-	-
10.6	Other products, based on cocoa	22	22	-	3	-
11	Other products, not based on cereals, potatoes, cocoa and coffee	-	-	-	-	-
	Battered / bread crumbed fish	2	2	-	-	-
	Canned / jarred black olives	10	10	-	2	-
	Canned prunes	10	10	-	10	-
	Chips / crisps, mixed vegetables	18	18	-	4	-
	Chips / crisps, plantain	2	2	-	-	-
	Dried fruit (dark)	10	10	-	-	-
	Jams and preserves	4	-	-	4	-
	Liquorice	10	10	-	-	-
	Sweet potato fries, sold as ready-to-eat	2	2	-	-	-
	Totals	**1346**	**1205**	**127**	**520**	**100**

[a] furan, 2-methyl furan and 3-methyl furan; [b] some samples comprised multiple batch codes due to limited availability

5.1 Acrylamide

The distribution of acrylamide concentrations measured in the main Categories and sub-Categories for each of the survey years is given in Table 2 through Table 6. Samples from Categories 1-2 and 4-9 were subject to European Commission measures concerning the levels found: For samples purchased during the period Jan 2014 – 11/04/2018 IV levels

applied; samples purchased after this date were subject to BML legislation. The individual sample results for each Category and Survey year can be found in the Annual Survey Reports (see 6.2) available from the Agency.

Table 2. Distribution of acrylamide concentrations in each food category / sub-category: 2014

Food category / sub category[a]		Description	Sampling date[b]	n	Acrylamide (µg/kg)					n>IV
					mean	min	max	SE	IV[c]	
1		**French fries sold as ready to eat**	**2014**	**40**	**157**	**12**	**587**	**21**	**-**	**-**
	1.1	French fries from fresh potatoes	Mar-14[b]	20	186	29	587	37	600	0
			Nov-14[b]	20	129	12	326	19	600	0
2		**Potato crisps and potato-based crackers**	**2014**	**27**	**779**	**88**	**2542**	**122**	**-**	**-**
	2.1	Potato crisp from fresh potatoes	Mar-14[b]	10	861	329	1873	157	1000	4
			Nov-14[b]	10	551	126	1010	83	1000	1
			Dec-14[b]	1	673	-	-	-	1000	0
	2.4	Potato-based crackers	2014	6	1039	88	2542	467	1000	2
3		**Pre-cooked French fries, potato products for home cooking**	**2014**	**29**	**256**	**6**	**1156**	**54**	**-**	**-**
	3.1	Fries baked in the oven (oven fries)	Mar-14[b]	6	405	103	1156	157	-	-
			Nov-14[b]	6	87	13	175	26	-	-
	3.2	Deep fried fries	Mar-14[b]	2	62	19	104	-	-	-
			Nov-14[b]	2	11	6	15	-	-	-
	3.3	Unspecified pre-cooked French fries, potato products for home cooking	Mar-14[b]	6	477	92	1116	143	-	-
			Nov-14[b]	7	211	23	522	62	-	-
4		**Soft bread**	**2014**	**20**	**14**	**4**	**37**	**2**	**-**	**-**
	4.1	Wheat based bread	2014	20	14	4	37	2	80	0
	4.2	Soft bread other than wheat based bread	2014	0	-	-	-	-	150	0
5		**Breakfast cereals (excluding porridge)**	**2014**	**22**	**174**	**41**	**541**	**26**	**-**	**-**
	5.1	Maize, oat, spelt, barley and rice based products	2014	4	77	58	94	7	200	0
	5.3	Bran products and whole grain cereals, gun puffed grain	2014	18	196	41	541	29	400	2

6		**Biscuits, crackers, crisp bread and similar (excluding pastry and cake)**	**2014**	**24**	**347**	**27**	**1324**	**67**	**-**	**-**
	6.1	Crackers with the exception of potato based crackers	2014	6	233	90	544	73	500	1
	6.2	Crisp bread	2014	3	210	107	327	64	450	0
	6.3	Biscuits and wafers	2014	8	301	30	1056	114	500	1
	6.4	Gingerbread	2014	4	803	360	1324	199	1000	1
	6.5	Products similar to the other products in this category	2014	3	227	27	407	110	500	0
7		**Coffee and coffee substitutes**	**2014**	**20**	**455**	**7**	**940**	**70**	**-**	**-**
	7.1	Roasted coffee (dry)	2014	8	222	157	271	14	450	0
	7.2	Instant coffee (dry)	2014	6	820	629	940	47	900	2
	7.3	Substitute coffee (dry) mainly based on cereals	2014	4	560	310	896	136	2000	0
	7.4	Other coffee substitutes (dry)	2014	2	81	7	155	-	4000	0
8		**Baby foods , other than processed cereal based foods**	**2014**	**20**	**12**	**3**	**27**	**1**	**-**	**-**
	8.1	Baby foods not containing prunes	2014	20	12	3	27	1	50	0
	8.2	Baby foods, containing prunes	2014	0	-	-	-	-	-	-
9		**Processed cereal-based foods for infants and young children**	**2014**	**20**	**60**	**4**	**577**	**29**	**-**	**-**
	9.1	Biscuits and rusks for infants and young children	2014	8	65	4	165	20	200	0
	9.2	Other processed cereal-based foods for infants and young children	2014	12	56	4	577	47	50	1
10		**Other products, based on cereals, potatoes, cocoa and coffee**	**2014**	**17**	**135**	**6**	**425**	**29**	**-**	**-**
	10.2	Cake and pastry	2014	6	114	6	332	48	-	-
	10.3	Savoury snacks	2014	2	72	18	126		-	-
	10.4	Other products, based on cereals	2014	5	153	7	233	41	-	-

Table 2 continued…

Food category / sub category[a]	Description	Sampling date[b]	n	Acrylamide (µg/kg)					
				mean	min	max	SE	IV[c]	n>IV
10.5	Other products, based on potatoes	2014	0	-	-	-	-	-	-
10.6	Other products, based on cocoa	2014	4	175	22	425	88	-	-
11	**Other products, not based on cereals, potatoes, cocoa and coffee**	**2014**	**12**	**436**	**12**	**1324**	**125**	**-**	**-**
	Vegetable crisps	2014	4	803	360	1324	199	**-**	**-**
	Black olives, canned	2014	2	650	269	1031	-	-	-
	Prunes, canned	2014	2	189	82	295	-	**-**	**-**
	Liquorice candies	2014	2	157	139	175	-	**-**	**-**
	Dates / prunes	2014	2	14	12	16	-	**-**	**-**

[a] according to EFSA[14,15]; [b] products prepared from seasonal potatoes; [c] EC Indicative Values[16]

[14] European Food Safety Authority, 2014; Specific requirements for chemical contaminants' data submission. EFSA supporting publication 2014:EN-604. 25 pp.

[15] European Food Safety Authority, 2015; Specific requirements for chemical contaminants' data submission. EFSA supporting publication 2015: 2015:EN-833.

[16] Commission Recommendation of 8 November 2013 on investigations into the levels of acrylamide in food (2013/647/EU), oj L 301, 15-17, 12.11.13

Table 3. Distribution of acrylamide concentrations in each food category / sub-category: 2015

Food category / sub category[a]		Description	Sampling date[b]	n	Acrylamide (µg/kg)					n>IV
					mean	min	max	SE	IV[c]	
1		**French fries sold as ready to eat**	**2015**	**40**	**167**	**34**	**472**	**17**	**-**	**-**
	1.1	French fries from fresh potatoes	Mar-15[b]	20	179	34	472	28	600	0
			Nov-15[b]	20	154	41	362	20	600	0
2		**Potato crisps and potato-based crackers**	**2015**	**28**	**691**	**151**	**1909**	**79**	**-**	**-**
	2.1	Potato crisp from fresh potatoes	Mar-15[b]	11	896	302	1909	151	1000	4
			Nov-15[b]	11	517	166	517	65	1000	0
	2.4	Potato-based crackers	2015	6	633	151	1221	179	1000	2
3		**Pre-cooked French fries, potato products for home cooking**	**2015**	**30**	**214**	**4**	**1345**	**55**	**-**	**-**
	3.1	Fries baked in the oven (oven fries)	Mar-15[b]	6	270	18	946	147	-	-
			Nov-15[b]	6	156	156	489	68	-	-
	3.2	Deep fried fries	Mar-15[b]	2	21	9	32	-	-	-
			Nov-15[b]	2	20	4	36	-	-	-
	3.3	Unspecified pre-cooked French fries, potato products for home cooking	Mar-15[b]	7	342	44	1345	175	-	-
			Nov-15[b]	7	199	10	616	79	-	-
4		**Soft bread**	**2015**	**25**	**22**	**4**	**136**	**5**	**-**	**-**
	4.1	Wheat based bread	2015	24	23	4	136	6	80	1
	4.2	Soft bread other than wheat based bread	2015	1	12	-	-	-	-	-
5		**Breakfast cereals (excluding porridge)**	**2015**	**22**	**146**	**21**	**484**	**23**	**-**	**-**
	5.1	Maize, oat, spelt, barley and rice based products	2015	4	90	69	124	12	200	0
	5.3	Bran products and whole grain cereals, gun puffed grain	2015	18	158	21	484	27	400	1
6		**Biscuits, crackers, crisp bread and**	**2015**	**30**	**299**	**26**	**2576**	**89**	**-**	**-**

		similar (excluding pastry and cake)								
	6.1	Crackers with the exception of potato based crackers	2015	6	229	71	583	82	500	1
	6.2	Crisp bread	2015	3	132	40	252	63	450	0
	6.3	Biscuits and wafers	2015	11	307	33	1055	96	500	2
	6.4	Gingerbread	2015	4	120	26	267	53	1000	0
	6.5	Products similar to the other products in this category	2015	6	557	59	2576	405	500	1
7		**Coffee and coffee substitutes**	**2015**	**20**	**411**	**25**	**1087**	**66**	**-**	**-**
	7.1	Roasted coffee (dry)	2015	8	168	128	235	13	450	0
	7.2	Instant coffee (dry)	2015	6	629	574	742	26	900	0
	7.3	Substitute coffee (dry) mainly based on cereals	2015	4	711	323	1087	167	2000	0
	7.4	Other coffee substitutes (dry)	2015	2	136	25	247	-	4000	0
8		**Baby foods , other than processed cereal based foods**	**2015**	**22**	**13**	**3**	**60**	**3**	**-**	**-**
	8.1	Baby foods not containing prunes	2015	20	13	3	60	3	50	1
	8.2	Baby foods, containing prunes	2015	2	7	5	9	-	80	0
9		**Processed cereal-based foods for infants and young children**	**2015**	**21**	**31**	**4**	**218**	**11**	**-**	**-**
	9.1	Biscuits and rusks for infants and young children	2015	7	47	7	138	17	200	0
	9.2	Other processed cereal-based foods for infants and young children	2015	14	23	4	218	15	50	1
10		**Other products, based on cereals, potatoes, cocoa and coffee**	**2015**	**17**	**189**	**4**	**735**	**54**	**-**	**-**
	10.2	Cake and pastry	2015	6	82	4	227	33	-	-
	10.3	Savoury snacks	2015	2	78	77	80	-	-	-
	10.4	Other products, based on cereals	2015	4	287	5	628	129	-	-

Table 3 continued…

Food category / sub category[a]	Description	Sampling date[b]	n	Acrylamide (µg/kg)					
				mean	min	max	SE	IV[c]	n>IV
10.5	Other products, based on potatoes	2015	1	735	-	-	-	-	-
10.6	Other products, based on cocoa	2015	4	170	21	464	100	-	-
11	**Other products, not based on cereals, potatoes, cocoa and coffee**	**2015**	**12**	**392**	**9**	**884**	**95**	**-**	**-**
	Vegetable crisps	2015	4	727	514	884	78	-	-
	Black olives, canned	2015	2	525	331	720	-	-	-
	Prunes, canned	2015	2	248	72	424	-	-	-
	Liquorice candies	2015	2	51	35	68	-	-	-
	Dates / prunes	2015	2	72	9	134	-	-	-

[a] according to EFSA[17,18]; [b] products prepared from seasonal potatoes; [c] EC Indicative Values[19]

[17] European Food Safety Authority, 2014; Specific requirements for chemical contaminants' data submission. EFSA supporting publication 2014:EN-604. 25 pp.

[18] European Food Safety Authority, 2015; Specific requirements for chemical contaminants' data submission. EFSA supporting publication 2015: 2015:EN-833.

[19] Commission Recommendation of 8 November 2013 on investigations into the levels of acrylamide in food (2013/647/EU), oj L 301, 15-17, 12.11.13

Table 4. Distribution of acrylamide concentrations in each food category / sub-category: 2016

Food category / sub category[a]		Description	Sampling date[b]	n	Acrylamide (µg/kg)					n>IV
					mean	min	max	SE	IV[c]	
1		**French fries sold as ready to eat**	**2016**	**40**	**208**	**31**	**774**	**28**	**-**	**-**
	1.1	French fries from fresh potatoes	Mar-16[b]	20	242	31	774	43	600	1
			Nov-16[b]	20	174	39	666	35	600	1
2		**Potato crisps and potato-based crackers**	**2016**	**30**	**617**	**28**	**1438**	**65**	**-**	**-**
	2.1	Potato crisp from fresh potatoes	Mar-16[b]	12	815	453	1438	95	1000	3
			Nov-16[b]	12	497	193	1065	80	1000	1
	2.4	Potato-based crackers	2016	6	463	28	1133	164	1000	1
3		**Pre-cooked French fries, potato products for home cooking**	**2016**	**30**	**191**	**3**	**2026**	**68**	**-**	**-**
	3.1	Fries baked in the oven (oven fries)	Mar-16[b]	6	165	17	334	57	-	-
			Nov-16[b]	6	59	59	127	20	-	-
	3.2	Deep fried fries	Mar-16[b]	2	39	9	68	-	-	-
			Nov-16[b]	2	12	3	22	-	-	-
	3.3	Unspecified pre-cooked French fries, potato products for home cooking	Mar-16[b]	7	471	55	2026	265	-	-
			Nov-16[b]	7	139	21	420	61	-	-
4		**Soft bread**	**2016**	**25**	**18**	**4**	**85**	**3**	**-**	**-**
	4.1	Wheat based bread	2016	24	18	4	85	4	80	1
	4.2	Soft bread other than wheat based bread	2016	1	11	-	-	-	150	0
5		**Breakfast cereals (excluding porridge)**	**2016**	**22**	**154**	**34**	**426**	**25**	**-**	**-**
	5.1	Maize, oat, spelt, barley and rice based products	2016	4	75	51	145	23	200	0
	5.3	Bran products and whole grain cereals, gun puffed grain	2016	18	172	34	426	28	400	1

6		**Biscuits, crackers, crisp bread and similar (excluding pastry and cake)**	**2016**	**30**	**306**	**18**	**1683**	**75**	**-**	**-**
	6.1	Crackers with the exception of potato based crackers	2016	6	210	65	441	66	500	0
	6.2	Crisp bread	2016	3	181	82	282	58	450	0
	6.3	Biscuits and wafers	2016	11	391	38	1383	146	500	2
	6.4	Gingerbread	2016	4	128	95	219	30	1000	0
	6.5	Products similar to the other products in this category	2016	6	425	18	1683	254	500	1
7		**Coffee and coffee substitutes**	**2016**	**20**	**539**	**16**	**1808**	**89**	**-**	**-**
	7.1	Roasted coffee (dry)	2016	6	276	198	384	27	450	0
	7.2	Instant coffee (dry)	2016	6	760	673	873	30	900	0
	7.3	Substitute coffee (dry) mainly based on cereals	2016	4	906	333	1808	320	2000	0
	7.4	Other coffee substitutes (dry)	2016	2	194	16	371	-	4000	0
8		**Baby foods , other than processed cereal based foods**	**2016**	**22**	**12**	**3**	**51**	**3**	**-**	**-**
	8.1	Baby foods not containing prunes	2016	20	13	3	51	3	50	1
	8.2	Baby foods, containing prunes	2016	2	8	4	11	-	80	0
9		**Processed cereal-based foods for infants and young children**	**2016**	**21**	**21**	**3**	**86**	**5**	**-**	**-**
	9.1	Biscuits and rusks for infants and young children	2016	6	47	27	86	9	200	0
	9.2	Other processed cereal-based foods for infants and young children	2016	15	10	3	40	2	50	0
10		**Other products, based on cereals, potatoes, cocoa and coffee**	**2016**	**17**	**194**	**4**	**789**	**52**	**-**	**-**

Table 6 continued…

Food category / sub category[a]	Description	Sampling date[b]	n	Acrylamide (µg/kg)					n>IV
				mean	min	max	SE	IV[c]	
10.2	Cake and pastry	2016	6	140	5	486	72	-	-
10.3	Savoury snacks	2016	2	73	39	108	-	-	-
10.4	Other products, based on cereals	2016	4	221	4	367	84	-	-
10.5	Other products, based on potatoes	2016	1	789	-	-	-	-	-
10.6	Other products, based on cocoa	2016	4	160	23	406	85	-	-
11	**Other products, not based on cereals, potatoes, cocoa and coffee**	**2016**	**12**	**698**	**14**	**2957**	**249**	**-**	**-**
	Vegetable crisps	2016	4	1650	847	2957	455	-	-
	Black olives, canned	2016	2	409	241	578	-	-	-
	Prunes, canned	2016	2	139	85	194	-	-	-
	Liquorice candies	2016	2	319	209	430	-	-	-
	Dates / prunes	2016	2	18	14	21	-	-	-

[a] according to EFSA[20,21]; [b] products prepared from seasonal potatoes; [c] EC Indicative Values[22]

[20] European Food Safety Authority, 2014; Specific requirements for chemical contaminants' data submission. EFSA supporting publication 2014:EN-604. 25 pp.

[21] European Food Safety Authority, 2015; Specific requirements for chemical contaminants' data submission. EFSA supporting publication 2015: 2015:EN-833.

[22] Commission Recommendation of 8 November 2013 on investigations into the levels of acrylamide in food (2013/647/EU), oj L 301, 15-17, 12.11.13

Table 5. Summary of acrylamide concentrations in each food category / sub-category: 2017

Food category / sub category[a]		Description	Sampling date[b]	n	Acrylamide (µg/kg)					n>IV
					mean	min	max	SE	IV[c]	
1		**French fries sold as ready to eat**	**2017**	**40**	**156**	**21**	**550**	**21.8**	**-**	**-**
	1.1	French fries from fresh potatoes	Mar-17[b]	20	164	21	550	28.9	600	0
			Nov-17[b]	20	149	28	548	33.3	600	0
2		**Potato crisps and potato-based crackers**	**2017**	**30**	**631**	**25**	**2214**	**85.3**	**-**	**-**
	2.1	Potato crisp from fresh potatoes	Mar-17[b]	12	626	315	1292	94.7	1000	2
			Nov-17[b]	12	729	219	2214	183.7	1000	4
	2.4	Potato-based crackers	2017	6	447	25	864	140.5	1000	0
3		**Pre-cooked French fries, potato products for home cooking**	**2017**	**30**	**140**	**7**	**538**	**23.1**	**-**	**-**
	3.1	Fries baked in the oven (oven fries)	Mar-17[b]	6	166	16	538	82.1	-	-
			Nov-17[b]	6	129	56	192	20.6	-	-
	3.2	Deep fried fries	Mar-17[b]	2	27	9	44	-	-	-
			Nov-17[b]	2	16	7	26	-	-	-
	3.3	Unspecified pre-cooked French fries, potato products for home cooking	Mar-17[b]	7	174	14	424	55.4	-	-
			Nov-17[b]	7	159	30	292	33.8	-	-
4		**Soft bread**	**2017**	**25**	**23**	**3**	**96**	**4.3**	**-**	**-**
	4.1	Wheat based bread	2017	24	24	3	96	4.5	80	1
	4.2	Soft bread other than wheat based bread	2017	1	8	-	-	-	150	0
5		**Breakfast cereals (excluding porridge)**	**2017**	**22**	**221**	**33**	**744**	**47.0**	**-**	**-**
	5.1	Maize, oat, spelt, barley and rice based products	2017	4	66	38	89	13.3	200	0

	5.3	Bran products and whole grain cereals, gun puffed grain	2017	18	255	33	744	54.3	400	4
6		**Biscuits, crackers, crisp bread and similar (excluding pastry and cake)**	**2017**	**30**	**207**	**34**	**637**	**29.2**	**-**	**-**
	6.1	Crackers with the exception of potato based crackers	2017	6	224	60	470	77.8	500	0
	6.2	Crisp bread	2017	3	166	80	272	56.4	450	0
	6.3	Biscuits and wafers	2017	11	277	74	637	55.9	500	2
	6.4	Gingerbread	2017	4	80	39	182	34.0	1000	0
	6.5	Products similar to the other products in this category	2017	6	165	34	275	39.2	500	0
7		**Coffee and coffee substitutes**	**2017**	**20**	**375**	**6**	**1897**	**93.8**	**-**	**-**
	7.1	Roasted coffee (dry)	2017	8	131	94	164	8.8	450	0
	7.2	Instant coffee (dry)	2017	6	504	312	641	47.4	900	0
	7.3	Substitute coffee (dry) mainly based on cereals	2017	4	818	237	1897	379.5	2000	0
	7.4	Other coffee substitutes (dry)	2017	2	78	6	151	-	4000	0
8		**Baby foods , other than processed cereal based foods**	**2017**	**22**	**9**	**1**	**51**	**2.3**	**-**	**-**
	8.1	Baby foods not containing prunes	2017	20	9	1	51	2.4	50	1
	8.2	Baby foods, containing prunes	2017	2	11	8	14	-	80	0
9		**Processed cereal-based foods for infants and young children**	**2017**	**21**	**17**	**2**	**58**	**4.0**	**-**	**-**

Table 5 continued…

Food category / sub category[a]		Description	Sampling date[b]	n	Acrylamide (µg/kg)					n>IV
					mean	min	max	SE	IV[c]	
	9.1	Biscuits and rusks for infants and young children	2017	6	36	27	58	7.3	200	0
	9.2	Other processed cereal-based foods for infants and young children	2017	12	6	2	12	1.0	50	0
	9.3	Unspecified processed cereal-based foods for infants and young children	2017	3	22	3	56	17	50	1
10		**Other products, based on cereals, potatoes, cocoa and coffee**	**2017**	**17**	**132**	**4**	**326**	**23.1**	**-**	**-**
	10.2	Cake and pastry	2017	6	94	4	186	28.4	-	-
	10.3	Savoury snacks	2017	2	100	40	160	-	-	-
	10.4	Other products, based on cereals	2017	4	136	6	251	50.7	-	-
	10.5	Other products, based on potatoes	2017	1	246	-	-	-	-	-
	10.6	Other products, based on cocoa	2017	4	174	17	326	65.8	-	-
11		**Other products, not based on cereals, potatoes, cocoa and coffee**	**2017**	**12**	**417**	**13**	**1255**	**110.0**	**-**	**-**
		Vegetable crisps	2017	4	806	521	1255	157.2	-	-
		Black olives, canned	2017	2	440	140	740	-	-	-
		Prunes, canned	2017	2	225	97	352	-	-	-
		Liquorice candies	2017	2	201	132	271	-	-	-
		Dates / prunes	2017	2	26	13	38	-	-	-

[a] according to EFSA[23]; [b] products prepared from seasonal potatoes; [c] EC Indicative Values[24]

[23] EFSA (European Food Safety Authority), 2017. Specific reporting requirements for contaminants and food additives occurrence data submission in SSD2. EFSA supporting publication 2017:EN-1261. 43 pp. doi:10.2903/sp.efsa.2017.EN-1261.

[24] Commission Recommendation of 8 November 2013 on investigations into the levels of acrylamide in food (2013/647/EU), oj L 301, 15-17, 12.11.13

Table 6. Distribution of acrylamide concentrations in each food category / sub-category: 2018

Food category[a]	Sub category[a]	Description	Sampling date	n	Acrylamide (µg/kg)						n>IV[c]	n>BML[d]
					mean	min	max	SE	IV	BML		
1	**-**	**French fries sold as ready to eat**	**2018**	**30**	**200**	**12**	**623**	**26.9**	**-**	**-**	**-**	**-**
	1.1	French fries from fresh potatoes[b]	Mar	15	189	47	623	34.5	600	-	1	-
			Nov	15	211	12	540	42.2	-	500	-	1
2	**-**	**Potato crisps and potato-based crackers**	**2018**	**20**	**621**	**33**	**997**	**70.2**	**-**	**-**	**-**	**-**
	2.1	Potato crisp from fresh potatoes[b]	Mar	5	793	503	973	95.3	1000	-	0	-
			Nov	5	533	253	629	70.4	-	750	-	0
	2.2	Potato crisp from potato dough	2018	5	742	382	994	105	-	750	-	3
	2.3	Unspecified potato crisps	2018	5	416	33	997	212	-	750	-	2
4	**-**	**Soft bread**	**2018**	**40**	**17**	**3**	**76**	**2.5**	**-**	**-**	**-**	**-**
	4.1	Wheat based bread	-	28	18	3	76	3.4	80	-	0	-
	4.2	Soft bread other than wheat-based bread	-	12	17	4	41	3.2	150	-	0	-
5	**-**	**Breakfast cereals (excluding porridge)**	**2018**	**32**	**184**	**4**	**808**	**33.9**	**-**	**-**	**-**	**-**
	5.1	Maize, oat, spelt, barley and rice-based products	-	14	129	4	808	54.2	200	-	1	-
	5.3	Bran products and whole grain cereals, gun puffed grain	-	18	227	17	634	41.5	400	-	3	-
6	**-**	**Biscuits, crackers, crisp bread and similar (excluding pastry and cake)**	**2018**	**32**	**223**	**13**	**1321**	**44.0**	**-**	**-**	**-**	**-**
	6.1	Crackers with the exception of potato-based crackers	-	6	210	50	474	70.6	-	400	-	1
	6.2	Crisp bread	-	6	194	13	320	51.6	-	350	-	0
	6.3	Biscuits and wafers	-	14	287	25	1321	91.9	-	350	-	2
	6.4	Gingerbread	-	2	87	71	103	16.1	-	800	-	0

	6.5	Products similar to the other products in this category	-	4	134	56	244	45.4	-	300	-	0
7	**-**	**Coffee and coffee substitutes**	**2018**	**12**	**577**	**227**	**1249**	**87.8**	-	**-**	-	**-**
	7.1	Roasted coffee (dry)	-	4	253	227	273	10.2	-	400	-	0
	7.2	Instant coffee (dry)	-	6	702	609	856	33.7	-	850	-	1
	7.3	Substitute coffee (dry) mainly based on cereals	-	2	847	445	1249	-	-	- [e]	-	-
8	**-**	**Baby foods, other than processed cereal based foods**	**2018**	**32**	**20**	**5**	**71**	**2.6**	-	**-**	-	**-**
	8.1	Baby foods not containing prunes	-	30	19	5	71	2.6	-	40	-	2
	8.2	Baby foods, containing prunes		2	25	16	35	-	-	40	-	0
9		**Processed cereal-based foods for infants and young children**	**2018**	**33**	**48**	**0**	**292**	**12.9**	-	**-**	-	**-**
	9.1	Biscuits and rusks for infants and young children	-	15	98	9	292	22.5	-	150	-	4
	9.2	Other processed cereal-based foods for infants and young children	-	18	7	0	17	0.9	-	40	-	0
10		**Other products, based on cereals, potatoes, cocoa and coffee**	**2018**	**28**	**125**	**5**	**356**	**18.7**	-	**-**	-	**-**
	10.2	Cake and pastry	-	6	67	5	191	28.0	-	-	-	-
	10.3	Savoury snacks	-	5	153	72	268	33.7	-	-	-	-
	10.4	Other products, based on cereals	-	9	122	7	326	40.6	-	-	-	-
	10.5	Other products, based on potatoes		2	170	164	176	-	-	-	-	-
	10.6	Other products, based on cocoa	-	6	148	20	356	47.1	-	-	-	-

Table 6 continued…

Food category[a]	Sub category[a]	Description	Sampling date	n	Acrylamide (µg/kg)						n>IV[c]	n>BML[d]
					mean	min	max	SE	IV	BML		
11	**-**	**Other products, not based on cereals, potatoes, cocoa and coffee**	**2018**	**16**	**297**	**7**	**1329**	**92.0**	-	**-**	-	**-**
	-	Battered / bread crumbed fish	-	2	7	7	8	-	-	-	-	-
		Canned / jarred black olives	-	2	366	340	392	-	-	-	-	-
	-	Canned prunes	-	2	212	70	355	-	-	-	-	-
	-	Chips / crisps, mixed vegetables	-	2	1165	1002	1329	-	-	-	-	-
	-	Chips / crisps, plantain	-	2	228	163	294	-	-	-	-	-
	-	Dried fruit (dark)	-	2	38	26	50	-	-	-	-	-
	-	Liquorice	-	2	111	108	114	-	-	-	-	-
	-	Sweet potato fries sold as ready-to-eat	-	2	249	177	320	-	-	-	-	-

[a] according to EFSA[25]; [b] products prepared from seasonal potatoes; [c] EC Indicative Values[26]; [d] EC Benchmark Levels[27]; [e] Level dependent upon relative proportions of cereals and chicory in the products (not given on packs).

[25] EFSA (European Food Safety Authority), 2017. Specific reporting requirements for contaminants and food additives occurrence data submission in SSD2. EFSA supporting publication 2017:EN-1261. 43 pp. doi:10.2903/sp.efsa.2017.EN-1261.

[26] Commission Recommendation of 8 November 2013 on investigations into the levels of acrylamide in food (2013/647/EU), oj L 301, 15-17, 12.11.13

[27] Commission Regulation (EU) 2017/2158 of 20 November 2017 establishing mitigation measures and benchmark levels for the reduction of the presence of acrylamide in food

5.1.1 Statistical trending

The sampling of products for the surveillance project followed a core sampling plan for the period 2014-2017 with subsequent modifications in 2018. To facilitate the characterisation of any possible trends in acrylamide levels for each food Category every effort was made to obtain the same products from the same retail outlets year on year. Where a previous year's sampled product was no longer available, a similar product was obtained although inevitably slight adjustments had to be made to the sampling programme. In order to establish trending for the period 2014-2018, product sampled during this time was grouped in accordance with the 2014 survey Categories. Consequently, Categories 3, 7, 8, 9 and 11 from the 2018 survey year could not be included in the full trend analysis due to the modifications made to the sampling plan by the Agency that year.

For each of the 11 product groups, the changes in mean acrylamide level for each Category were subjected to regression analysis and expressed as the average annual percentage change in acrylamide (see Table 7). As expected for a relatively short survey period, the wide range of 95% confidence intervals indicated that the estimated changes were not precise and for most groups, the changes over time were not statistically significant (P>0.05).

Table 7. Average annual percentage change in acrylamide concentrations for samples collected between 2014 and 2018, by 2014 classification category

Category	Average annual change (%)	Period [a]	p-value	95% Confidence Interval for Change		
Processed cereal-based foods for infants and young children – Cat 9	-20.8	2014-17	0.07	-46.4	to	4.7
Pre-cooked French fries, potato products for home cooking – Cat 3	-12.7	2014-17	0.01	-17.9	to	-7.5
Biscuits, crackers, crisp bread and similar – Cat 6	-9.0	2014-18	0.03	-16.6	to	-1.3
Baby foods , other than processed cereal based foods – Cat 8	-6.2	2014-17	0.38	-30.3	to	17.9
Potato crisps and potato-based crackers – Cat 2	-4.8	2014-18	0.06	-10.0	to	0.4
Coffee and coffee substitutes – Cat 7	-2.4	2014-17	0.79	-36.8	to	32.0

Other products, based on cereals, potatoes, cocoa and coffee – Cat 10 [b]	-0.1	2014-18	0.99	-48.4	to	48.2
Soft bread – Cat 4	4.0	2014-18	0.62	-19.3	to	27.3
French fries sold as ready to eat – Cat 1	4.8	2014-18	0.41	-11.2	to	20.9
Other products, not based on cereals, potatoes, cocoa and coffee – Cat 11 [c]	5.9	2014-17	0.77	-71.4	to	83.2
Breakfast cereals – Cat 5	6.5	2014-18	0.38	-13.4	to	26.4

[a] period for statistical tending; [b] included: Cake and pastry, Savoury snacks, Other products, based on cereals, Other products, based on potatoes, Other products, based on cocoa; [c] Vegetable crisps, Black olives (canned), Prunes (canned), Liquorice candies, Dates / prunes

Table 7, which has been ordered by decreasing apparent change in acrylamide for each food Category, shows that the largest annual decrease in acrylamide was in the processed cereal-based baby foods for infants and young children (Category 9) with a mean annual percentage decrease of 20.8%. However, the correlation was tentative (p=0.07) for the period of trending and the 95% confidence interval relatively large. There was also tentative evidence (p=0.06) for a reduction in annual acrylamide of 4.8% in the potato crisps and potato-based crackers (Category 2).

Pre-cooked French fries, potato products for home cooking (Category 3) and biscuits, crackers, crisp bread and similar (Category 6) both indicated some evidence for annual reductions ($p<0.05$) in acrylamide of 12.7% and 9% respectively.

There was no statistically significant evidence for annual changes in acrylamide levels for the remaining Categories.

The observed trends in acrylamide levels relate to the products sampled and may not necessarily be completely representative of the UK market.

5.1.1.1 Trends in samples exceeding EC acrylamide measures (IV and BML)

A summary of samples found to exceed EC measures in each survey year is given in Table 8. Regression analysis of the total annual % of samples exceeding EC measures showed no significant change ($P>>0.05$) for the period 2014-2018 (note the change from EC IV to BML during 2018).

Table 8 Samples exceeding EC acrylamide measures in each survey year

Year	IV		BML	
	n [a]	n>IV (%)	n [a]	N>BML (%)
2014	210 [b]	7.1	-	-
2015	208 [b]	6.7	-	-
2016	208 [b]	6.3	-	-
2017	210 [b]	7.1	-	-
2018	92 [c]	5.4	137 [d]	12

[a] number of samples subject to EC IV or BML; [b] Categories 1 and 3-9; [c] Categories 1 (March), 2, 4 and 5; [d] Categories 1 (November) and 6-9

5.2 Furans

Furans were measured in Categories 5 – 11: the selection of samples was reviewed annually to ensure individual Categories from 5-11 were included in at least one survey year. All samples were tested for furan: Following a call for data on other furans[28], testing of products was extended to include 2- and 3-methyl furans from mid-2016 (categories 8, 10 and 11 only in 2016).

The distribution of furan, 2-methyl furan and 3-methyl furan in samples selected for each survey year can be found in sections 5.2.1, 5.2.2 and 5.2.3 respectively. The individual sample results for furans in each Category and Survey year can be found in the Survey Annual Reports (see 6.2) available from the Agency.

[28] Call for furan and its methyl analogues (2-methylfuran and 3 methylfuran) occurrence data in food: Available at: www.efsa.europa.eu/en/consultations/call/160216-1

5.2.1 Distribution of furan in survey samples

Table 9. Distribution of furan concentrations in each survey category: 2014

Food category[a]	Description	Sampling date	n	Furan (µg/kg)			
				Mean[b]	min	max	SE
5	**Breakfast cereals (excluding porridge)**	**2014**	**24**	**38**	**<10**	**263**	**12**
6	**Biscuits, crackers, crisp bread and similar (excluding pastry and cake)**	**2014**	**24**	**34**	**<10**	**135**	**8**
7	**Coffee and coffee substitutes**	**2014**	**20**	**1562**	**N.D.**	**5009**	**366**
	Coffee and coffee substitutes, as consumed	**2014**	**20**	**38**	**N.D.**	**137**	**11**
	Roast	2014	8	3347	1786	5009	333
	Roast, as consumed	2014	8	92	10	137	14
	Instant	2014	6	656	122	1296	204
	Instant, as consumed	2014	6	5	1	9	1
	Other	2014	6	87	<40	231	36
	Other, as consumed	2014	6	1	<1	3	<1
8	**Baby foods, other than processed cereal based foods**	**2014**	**20**	**31**	**6**	**76**	**4**
10	**Other products, based on cereals, potatoes, cocoa and coffee**	**2014**	**9**	**21**	**N.D.**	**77**	**9**
	Cereal bars	2014	2	<10	<10	<10	-
	Cocoa powder	2014	3	<10	<10	26	9
	Corn / Tortilla chips	2014	2	25	18	32	0
	Popcorn	2014	2	56	34	77	-
11	**Other products, not based on cereals, potatoes, cocoa and coffee**	**2014**	**12**	**11**	**N.D.**	**32**	**3**
	Canned prunes	2014	2	22	11	32	-
	Jams	2014	4	1	<2	3	1
	Table olives	2014	2	11	11	11	-
	Vegetable crisps	2014	4	15	12	19	2

[a] according to EFSA[29,30]; [b] Lower bound concentrations (values < LOD = 0)

[29] European Food Safety Authority, 2014; Specific requirements for chemical contaminants' data submission. EFSA supporting publication 2014:EN-604. 25 pp.

[30] European Food Safety Authority, 2015; Specific requirements for chemical contaminants' data submission. EFSA supporting publication 2015: 2015:EN-833.

Table 10. Distribution of furan concentrations in each survey category: 2015

Food category[a]	Description	Sampling date	n	Furan (µg/kg)			
				Mean[b]	min	max	SE
5	**Breakfast cereals (excluding porridge)**	**2015**	**24**	**50**	**<10**	**382**	**17**
6	**Biscuits, crackers, crisp bread and similar (excluding pastry and cake)**	**2015**	**30**	**32**	**N.D.**	**167**	**8**
7	**Coffee and coffee substitutes**	**2015**	**20**	**1612**	**N.D.**	**5242**	**396**
	Coffee and coffee substitutes, as consumed	**2015**	**20**	**50**	**N.D.**	**197**	**16**
	Roast	2015	8	3544	1767	5242	388
	Roast, as consumed	2015	8	119	25	197	22
	Instant	2015	6	556	156	1329	166
	Instant, as consumed	2015	6	5	2	10	1
	Other	2015	6	92	<40	258	38
	Other, as consumed	2015	6	1	<1	4	1
8	**Baby foods, other than processed cereal based foods**	**2015**	**22**	**24**	**3**	**81**	**4**
10	**Other products, based on cereals, potatoes, cocoa and coffee**	**2015**	**2**	**143**	**82**	**205**	**-**
	Cereal bars	2015	0	-	-	-	-
	Cocoa powder	2015	0	-	-	-	-
	Corn / Tortilla chips	2015	0	-	-	-	-
	Popcorn	2015	2	143	82	205	-
11	**Other products, not based on cereals, potatoes, cocoa and coffee**	**2015**	**2**	**40**	**19**	**60**	**-**
	Canned prunes	2015	2	40	19	60	-
	Jams	2015	0	-	-	-	-
	Table olives	2015	0	-	-	-	-
	Vegetable crisps	2015	0	-	-	-	-

[a] according to EFSA[31,32]; [b] Lower bound concentrations (values < LOD = 0)

[31] European Food Safety Authority, 2014; Specific requirements for chemical contaminants' data submission. EFSA supporting publication 2014:EN-604. 25 pp.

[32] European Food Safety Authority, 2015; Specific requirements for chemical contaminants' data submission. EFSA supporting publication 2015: 2015:EN-833.

Table 11. Distribution of furan concentrations in each survey category: 2016

Food category[a]	Description	Sampling date	n	Furan (µg/kg)			
				Mean[b]	min	max	SE
5	**Breakfast cereals (excluding porridge)**	**2016**	**24**	**38**	**0**	**202**	**10**
6	**Biscuits, crackers, crisp bread and similar (excluding pastry and cake)**	**2016**	**30**	**35**	**0**	**216**	**9**
7	**Coffee and coffee substitutes**	**2016**	**20**	**1741**	**0**	**5440**	**435**
	Coffee and coffee substitutes, as consumed	**2016**	**20**	**48**	**0**	**166**	**15**
	Roast	2016	8	3945	2499	5440	343
	Roast, as consumed	2016	8	118	7	166	20
	Instant	2016	6	414	135	555	65
	Instant, as consumed	2016	6	2	0	3	1
	Other	2016	6	130	0	424	64
	Other, as consumed	2016	6	1	0	4	1
8	**Baby foods, other than processed cereal based foods**	**2016**	**22**	**31**	**2**	**108**	**5**
10	**Other products, based on cereals, potatoes, cocoa and coffee**	**2016**	**2**	**129**	**84**	**175**	**-**
	Popcorn	2016	2	129	84	175	-
11	**Other products, not based on cereals, potatoes, cocoa and coffee**	**2016**	**2**	**40**	**19**	**60**	**-**
	Canned prunes	2016	2	9	8	9	-

[a] according to EFSA[33,34]; [b] Lower bound concentrations (values < LOD = 0)

[33] European Food Safety Authority, 2014; Specific requirements for chemical contaminants' data submission. EFSA supporting publication 2014:EN-604. 25 pp.

[34] European Food Safety Authority, 2015; Specific requirements for chemical contaminants' data submission. EFSA supporting publication 2015: 2015:EN-833.

Table 12. Distribution of furan concentrations in each survey category: 2017

Survey category	Description	Sampling date	n	Furan (µg/kg)			
				Mean[a]	min	max	SE
5	**Breakfast cereals (excluding porridge)**	**2017**	**24**	**25**	**0**	**116**	**7.3**
6	**Biscuits, crackers, crisp bread and similar (excluding pastry and cake)**	**2017**	**30**	**31**	**0**	**108**	**6.0**
7	**Coffee and coffee substitutes**	**2017**	**20**	**1431**	**0**	**4498**	**345.2**
	Coffee and coffee substitutes, as consumed	**2017**	**20**	**37**	**0**	**179**	**11.9**
	Roast	2017	8	3160	1564	4498	292.0
	Roast, as consumed	2017	8	88	22	179	17.7
	Instant	2017	6	439	147	592	67.9
	Instant, as consumed	2017	6	3	1	4	0.4
	Other	2017	6	116	0	486	76.0
	Other, as consumed	2017	6	1	0	5	0.7
8	**Baby foods, other than processed cereal based foods**	**2017**	**22**	**23**	**0**	**98**	**4.8**
10	**Other products, based on cereals, potatoes, cocoa and coffee**	**2017**	**2**	**33**	**31**	**36**	**-**
	Popcorn	2017	2	33	31	36	-
11	**Other products, not based on cereals, potatoes, cocoa and coffee**	**2017**	**2**	**12**	**9**	**15**	**-**
	Canned prunes	2017	2	12	9	15	-

[a] Lower bound concentrations (values < LOD = 0)

Table 13. Distribution of furan concentrations in each survey category: 2018

Survey category	Description	Sampling date	n	Furan (µg/kg) [a]			
				Mean	min	max	SE
5	**Breakfast cereals (excluding porridge)**	**2018**	**32**	**23**	**0**	**94**	**4.5**
6	**Biscuits, crackers, crisp bread and similar (excluding pastry and cake)**	**2018**	**32**	**28**	**0**	**152**	**6.4**
7	**Coffee and coffee substitutes**	**2018**	**12**	**1159**	**70**	**4139**	**391.6**
	Coffee and coffee substitutes, as consumed	**2018**	**12**	**22**	**2**	**120**	**11.1**
	Roast	2018	4	2787	1809	4139	584.2
	Roast, as consumed	2018	4	58	6	120	26.3
	Instant	2018	6	422	165	599	60.2
	Instant, as consumed	2018	6	4	2	5	0.5
	Other	2018	2	116	70	161	-
	Other, as consumed	2018	2	2	2	3	-
8	**Baby foods, other than processed cereal based foods**	**2018**	**32**	**36**	**5**	**94**	**3.3**
9	**Processed cereal-based foods for infants and young children**	**2018**	**10**	**6**	**0**	**17**	**1.7**
11	**Other products, not based on cereals, potatoes, cocoa and coffee**	**2018**	**4**	**11**	**5**	**16**	**2.3**
	Canned / Jarred olives	2018	2	13	9	16	-
	Canned prunes	2018	2	9	5	13	-

[a] Lower bound concentrations (values < LOD = 0)

5.2.2 Distribution of 2-methyl furan in survey samples

Table 14. Distribution of 2-methyl furan concentrations in each survey category: 2016

Food category[a]	Description	Sampling date	n	2-methyl furan (µg/kg)			
				Mean[b]	min	max	SE
8	**Baby foods, other than processed cereal based foods**	**2016**	**22**	**2**	**0**	**7**	**2**
10	**Other products, based on cereals, potatoes, cocoa and coffee**	**2016**	**2**	**138**	**72**	**204**	**-**
	Popcorn	2016	2	138	72	204	-
11	**Other products, not based on cereals, potatoes, cocoa and coffee**	**2016**	**2**	**0**	**0**	**0**	**-**
	Canned prunes	2016	2	0	0	0	-

[a] according to EFSA[35,36]; [b] Lower bound concentrations (values < LOD = 0)

Table 15. Distribution of 2-methyl furan concentrations in each survey category: 2017

Survey category	Description	Sampling date	n	2-methyl furan (µg/kg)[a]			
				Mean	min	max	SE
5	**Breakfast cereals (excluding porridge)**	**2017**	**24**	**12**	**0**	**69**	**4.2**
6	**Biscuits, crackers, crisp bread and similar (excluding pastry and cake)**	**2017**	**30**	**30**	**0**	**136**	**6.7**
7	**Coffee and coffee substitutes**	**2017**	**20**	**4830[b]**	**0**	**17639[b]**	**1246.1**
	Coffee and coffee substitutes, as consumed	**2017**	**20**	**91**	**0**	**582**	**32.6**
	Roast	2017	8	10806[b]	4477	17639[b]	1368.7
	Roast, as consumed	2017	8	218	66	582	57.6
	Instant	2017	6	1548	421	2642	304.0
	Instant, as consumed	2017	6	10	3	16	1.8
	Other	2017	6	143	0	599	95.9
	Other, as consumed	2017	6	1	0	6	1.0

[35] European Food Safety Authority, 2014; Specific requirements for chemical contaminants' data submission. EFSA supporting publication 2014:EN-604. 25 pp.

[36] European Food Safety Authority, 2015; Specific requirements for chemical contaminants' data submission. EFSA supporting publication 2015: 2015:EN-833.

8	**Baby foods, other than processed cereal based foods**	**2017**	**22**	**1**	**0**	**6**	**0.4**
10	**Other products, based on cereals, potatoes, cocoa and coffee**	**2017**	**2**	**18**	**17**	**19**	**-**
	Popcorn	2017	2	18	17	19	-
11	**Other products, not based on cereals, potatoes, cocoa and coffee**	**2017**	**2**	**0**	**0**	**0**	**-**
	Canned prunes	2017	2	0	0	0	-

[a] Lower bound concentrations (values < LOD = 0); [b] extrapolated values (in excess of upper calibration limit)

Table 16. Distribution of 2-methyl furan concentrations in each survey category: 2018

Survey category	Description	Sampling date	n	2-methyl furan (µg/kg)[a]			
				Mean	min	max	SE
5	**Breakfast cereals (excluding porridge)**	**2018**	**32**	**18**	**0**	**70**	**3.3**
6	**Biscuits, crackers, crisp bread and similar (excluding pastry and cake)**	**2018**	**32**	**26**	**2**	**137**	**5.6**
7	**Coffee and coffee substitutes**	**2018**	**12**	**4898[b,c]**	**77**	**18129[b]**	**1847.6**
	Coffee and coffee substitutes, as consumed	**2018**	**12**	**62**	**1**	**382**	**33.8**
	Roast	2018	4	12281[b,c]	6751	18129[b]	3147.8
	Roast, as consumed	2018	4	170	22	382	82.1
	Instant	2018	6	1554	602	2375	241.4
	Instant, as consumed	2018	6	10	4	17	1.8
	Other	2018	2	164	77	251	-
	Other, as consumed	2018	2	2	1	3	-
8	**Baby foods, other than processed cereal based foods**	**2018**	**32**	**4**	**0**	**11**	**0.4**
9	**Processed cereal-based foods for infants and young children**	**2018**	**10**	**4**	**1**	**16**	**1.5**
11	**Other products, not based on cereals, potatoes, cocoa and coffee**	**2018**	**4**	**3**	**0**	**7**	**1.6**
	Canned / Jarred olives	2018	2	6	4	7	-
	Canned prunes	2018	2	1	0	1	-

[a] Lower bound concentrations (values < LOD = 0); [b] extrapolated value(s) in excess of upper calibration limit; [c] semi-quantitative value - spike recovery on roast coffee below expected level

5.2.3 Distribution of 3-methyl furan in survey samples

Table 17. Distribution of 3-methyl furan concentrations in each survey category: 2016

Food category[a]	Description	Sampling date	n	3-methyl furan (µg/kg)			
				Mean[b]	min	max	SE
8	**Baby foods, other than processed cereal based foods**	**2016**	**22**	**1**	**0**	**6**	**0.4**
10	**Other products, based on cereals, potatoes, cocoa and coffee**	**2016**	**2**	**28**	**27**	**30**	**-**
	Popcorn	2016	2	28	27	30	-
11	**Other products, not based on cereals, potatoes, cocoa and coffee**	**2016**	**2**	**0**	**0**	**0**	**-**
	Canned prunes	2016	2	0	0	0	-

[a] according to EFSA[37,38]; [b] Lower bound concentrations (values < LOD = 0)

Table 18. Distribution of 3-methyl furan concentrations in each survey category: 2017

Survey category	Description	Sampling date	n	3-methyl furan (µg/kg)[a]			
				Mean	min	max	SE
5	**Breakfast cereals (excluding porridge)**	**2017**	**24**	**0**	**0**	**0**	**0.0**
6	**Biscuits, crackers, crisp bread and similar (excluding pastry and cake)**	**2017**	**30**	**0**	**0**	**14**	**0.5**
7	**Coffee and coffee substitutes**	**2017**	**20**	**187**	**0**	**563**	**46.9**
	Coffee and coffee substitutes, as consumed	**2017**	**20**	**3**	**0**	**16**	**1.1**
	Roast	2017	8	422	255	563	38.2
	Roast, as consumed	2017	8	8	3	16	1.5
	Instant	2017	6	60	0	99	13.4
	Instant, as consumed	2017	6	0	0	0	0.0
	Other	2017	6	0	0	0	0.0
	Other, as consumed	2017	6	0	0	0	0.0
8	**Baby foods, other than processed cereal based foods**	**2017**	**22**	**1**	**0**	**7**	**0.4**

[37] European Food Safety Authority, 2014; Specific requirements for chemical contaminants' data submission. EFSA supporting publication 2014:EN-604. 25 pp.

[38] European Food Safety Authority, 2015; Specific requirements for chemical contaminants' data submission. EFSA supporting publication 2015: 2015:EN-833.

10	**Other products, based on cereals, potatoes, cocoa and coffee**	**2017**	**2**	**0**	**0**	**0**	**-**
	Popcorn	2017	2	0	0	0	-
11	**Other products, not based on cereals, potatoes, cocoa and coffee**	**2017**	**2**	**0**	**0**	**0**	**-**
	Canned prunes	2017	2	0	0	0	-

[a] Lower bound concentrations (values < LOD = 0)

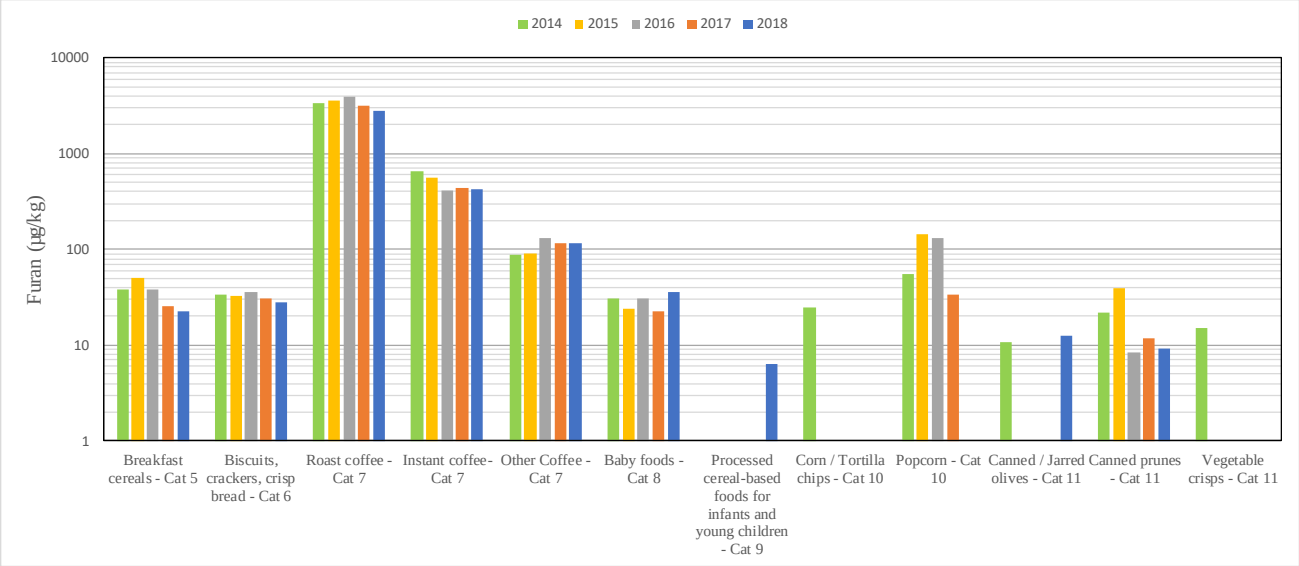
Table 19. Distribution of 3-methyl furan concentrations in each survey category: 2018

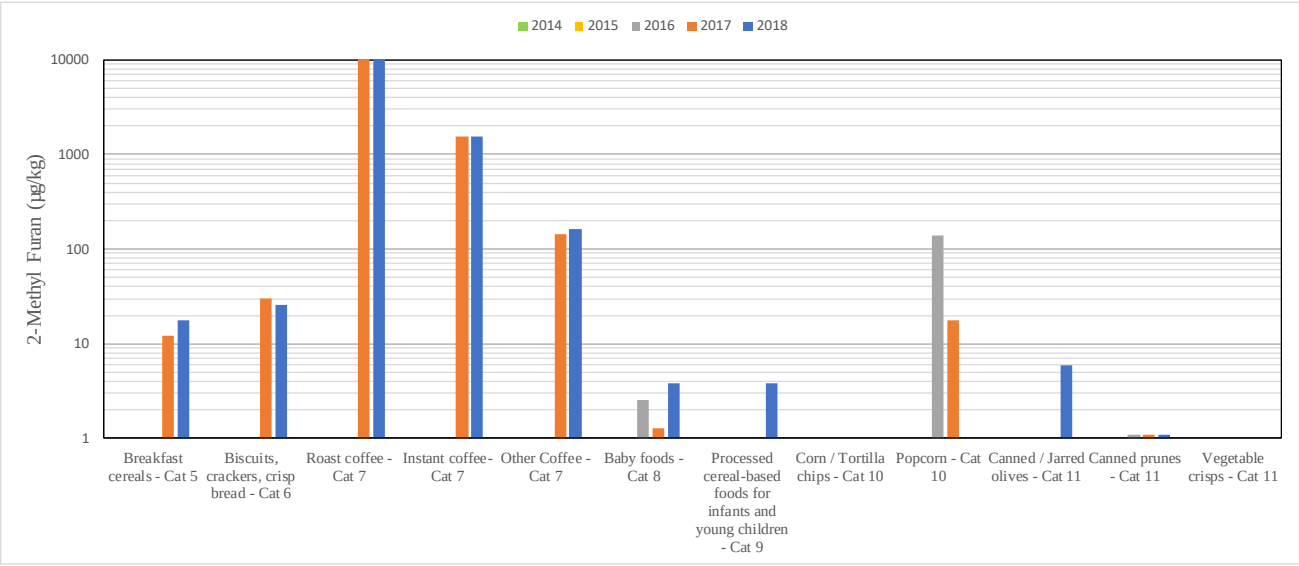
Survey category	Description	Sampling date	n	3-methyl furan (µg/kg)[a]			
				Mean	min	max	SE
5	**Breakfast cereals (excluding porridge)**	**2018**	**32**	**0**	**0**	**0**	**0**
6	**Biscuits, crackers, crisp bread and similar (excluding pastry and cake)**	**2018**	**32**	**2**	**0**	**15**	**3.7**
7	**Coffee and coffee substitutes**	**2018**	**12**	**213**	**24**	**652**	**64.8**
	Coffee and coffee substitutes, as consumed	**2018**	**12**	**2**	**0**	**16**	**1.4**
	Roast	2018	4	480	303	652	99.6
	Roast, as consumed	2018	4	7	1	16	3.4
	Instant	2018	6	98	73	125	7.24
	Instant, as consumed	2018	6	0	0	1	0.1
	Other	2018	2	26	24	28	-
	Other, as consumed	2018	2	0	0	0	-
8	**Baby foods, other than processed cereal based foods**	**2018**	**32**	**3**	**0**	**10**	**0.43**
9	**Other products, based on cereals, potatoes, cocoa and coffee**	**2018**	**10**	**1**	**0**	**4**	**0.4**
11	**Other products, not based on cereals, potatoes, cocoa and coffee**	**2018**	**4**	**5**	**2**	**9**	**2**
	Canned / Jarred olives	2018	2	9	8	9	-
	Canned prunes	2018	2	2	2	2	-

[a] Lower bound concentrations (values < LOD = 0)

5.2.4 Trends in furans 2014 – 2018

Graphical summaries of the mean concentrations of furan, 2-methyl furan and 3-methyl furan in the various categories tested for each survey year are shown in Figure 1. Highest amounts of furans were found in the Category 7 coffee products and the microwave popcorn: although the data was limited, amounts of each furan in the roast and instant coffees appeared to follow the trend 2-methyl furan > furan > 3-methyl furan; amounts of each furan in the microwave popcorn appeared to follow the trend furan ≈ 2-methyl furan > 3-methyl furan.





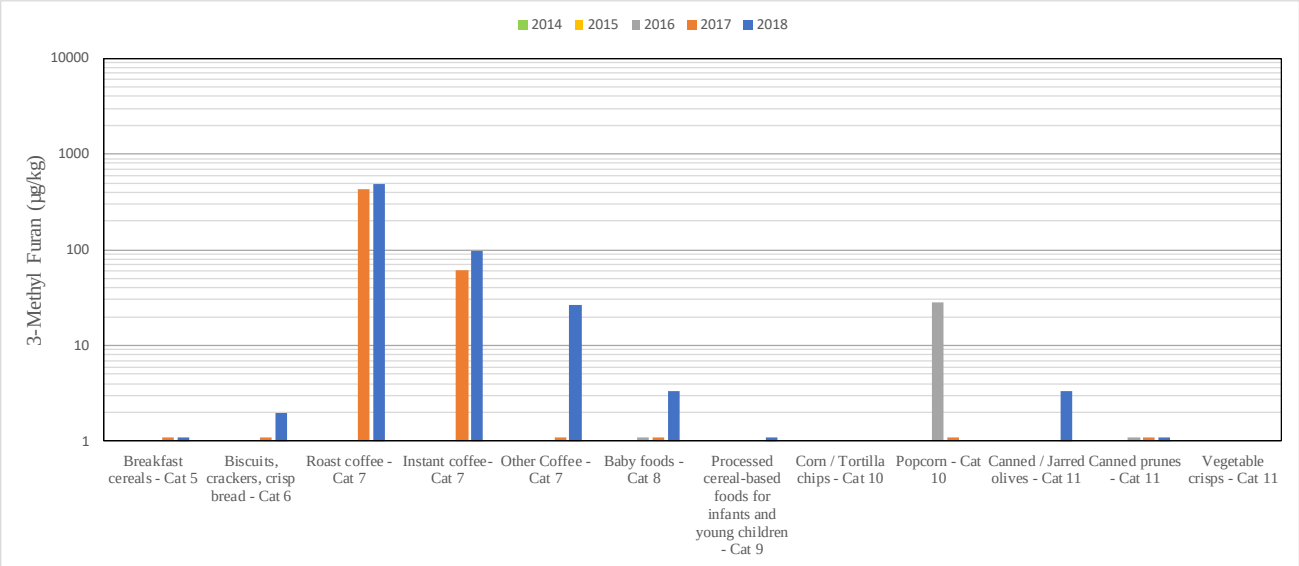


Figure 1. Comparison of the mean concentrations of furan, 2-methyl furan and 3-methyl furan in product categories tested for each survey year

5.2.5 Effects of domestic preparation on furans in coffee

All samples from Category 7 were analysed as received and as consumed to determine potential losses of furans during domestic preparation. When the results as consumed were normalised to a solids basis, greatest losses of all furans (circa 60-75%) occurred during the preparation of the roast and ground coffees. The preparation of instant coffee on the other hand appeared to result in much less loss of furan and 2-methyl furan although it is not known if this effect was due to an enhanced “extraction” of each furan during the addition of hot water or in situ formation at elevated temperature. These results are summarised in Figure 8 (2018 data) and were consistent with previous findings for furan[39].

[39] Hamlet, C. G., Asuncion, L., & Liang, L., (2014) Survey of acrylamide and furan in UK retail products–analysis phase: Summary report for samples purchased between November 2011 and December 2013. Report No. C030 prepared for the UK Food Standards Agency. High Wycombe: Premier Analytical Services.

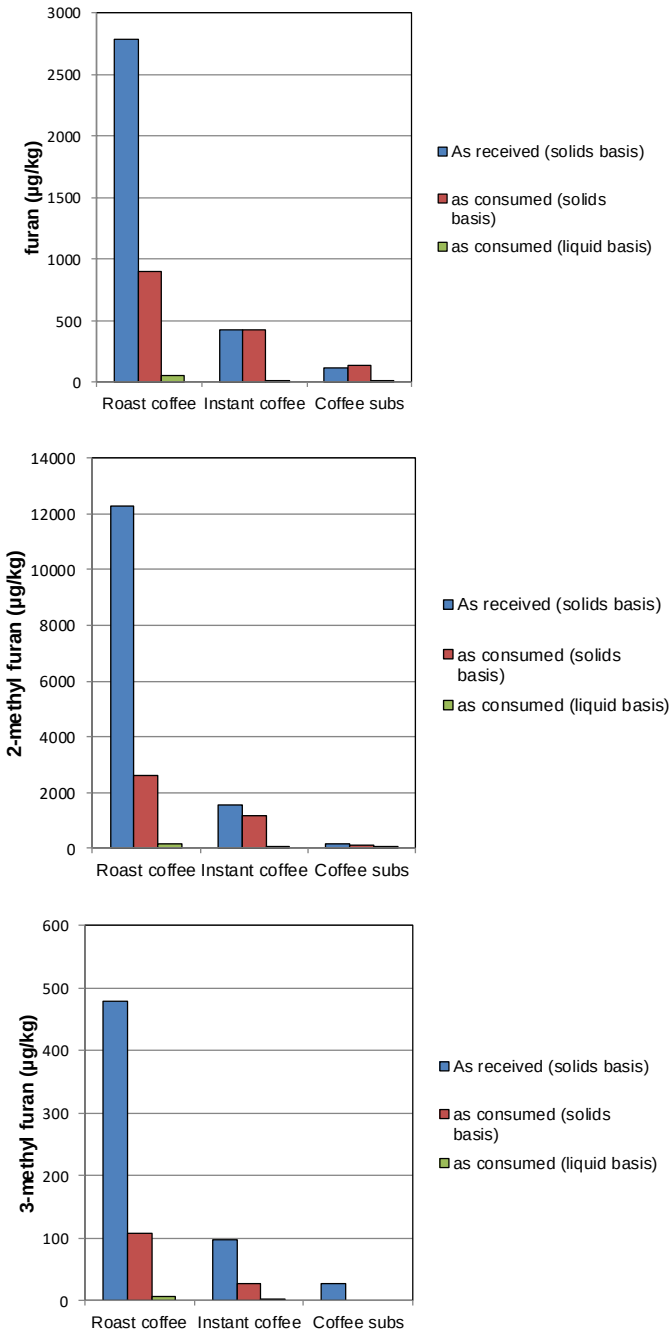


Figure 2. Effects of domestic preparation of coffee and coffee substitutes on amounts of furans: results are expressed as received and as consumed (solids and liquid basis)

6. Appendices

6.1 Sampling plan

Table 20. Sampling plan Jan - Nov 2014

	Sample numbers in product category																																		
Category	1. French fries sold as ready to eat			2. Potato crisps and potato-based crackers			3. Pre-cooked French fries, potato products for home cooking			4. Soft bread	5. Breakfast cereals (excluding porridge)		6. Biscuits, crackers, crisp bread and similar (excluding pastry and cake)					7. Coffee and coffee substitutes				8. Baby foods , other than processed cereal based foods	9. Processed cereal-based foods for infants and young children		10. Other products, based on cereals, potatoes, cocoa and coffee					11. Other products, not based on cereals, potatoes, cocoa and coffee	**Total**
Sub category	1.1			2.1	2.2	2.4	3.1	3.2	3.3	4.1	5.1	5.3	6.1	6.2	6.3	6.4	6.5	7.1	7.2	7.3	7.4	8.1	9.1	9.2	10.2	10.3	10.4	10.5	10.6		
Month																																			
Jan										20																									**20**
Feb											5	19																							**24**

Mar	8[a]	4[b]	8[c]	10			6	2	6																						**44**
Apr																															
May													6	3	8	4	3														**24**
Jun																		8	6	4	2										**20**
Jul																						20									**20**
Aug																							10	10							**20**
Sep																									6	2	3			4	**15**
Oct					1	5																					1		4	12	**23**
Nov	8[a]	4[b]	8[c]	10			6	2	7																			1			**47**
Dec				1																											
TOTALS	16	8	16	21	1	5	12	4	13	20	5	19	6	3	8	4	3	8	6	4	2	20	10	10	6	2	4	1	4	16	**257**
by category	40			27			29			20	24		24					20				20	20		17					16	**257**

[a] Restaurants; [b] Fast food outlets; [c] Chip Shops

6.2 Annual summary reports from this survey

The following annual summary reports for this Survey are available from the UK Food Standards Agency.

Hamlet, C. G., Liang, L., Andreou, A., & Carbone, L., (2016) Survey of acrylamide and furan in UK retail products: Summary report for samples purchased between January 2014 and November 2015. Report No. C037 prepared for the UK Food Standards Agency. High Wycombe: Premier Analytical Services.

Hamlet, C. G., Liang, L., Andreou, A., & Carbone, L., (2017) Survey of acrylamide and furan in UK retail products: Summary report for samples purchased between January 2016 and November 2016. Report No. C038 prepared for the UK Food Standards Agency. High Wycombe: Premier Analytical Services.

Hamlet, C. G., Liang, L., Baxter, B., & Apostilova, D., (2018) Survey of acrylamide and furans in UK retail products: Summary report for samples purchased between January 2017 and November 2017. Report No. C039 prepared for the UK Food Standards Agency. High Wycombe: Premier Analytical Services.

Hamlet, C. G., Liang, L., Baxter, B., Apostilova, D., & Ali, R., (2019) Survey of acrylamide and furans in UK retail products: Summary report for samples purchased between January 2018 and November 2018. Report No. C040 prepared for the UK Food Standards Agency. High Wycombe: Premier Analytical Services.