European Food Safety Authority

EFSA Journal 2012;10(10):2938

SCIENTIFIC REPORT OF EFSA

Update on acrylamide levels in food from monitoring years 2007 to 2010 [1]

European Food Safety Authority[2, 3]

European Food Safety Authority (EFSA), Parma, Italy

ABSTRACT

Recommendations on the monitoring of acrylamide levels in food by the European Commission (EC) were extended in 2010 (EC, 2010). The new Recommendation includes a revised categorisation of food products for monitoring purposes. This report describes the results of European acrylamide monitoring during the period from 2007 to 2010 using the revised product categorisation with 10 main food categories and an additional 26 sub-categories. Twenty-five European countries submitted a total of 13 162 acrylamide results for the four-year period including 2 200 results for the year 2010. During the monitoring period, time trends in acrylamide levels for the food categories were estimated. In 2010, middle bound mean acrylamide values ranged from 31 µg/kg for 'other processed cereal based foods for infants and young children' to 1 350 µg/kg for 'coffee substitutes'. The highest 95th percentile value of 8 044 µg/kg was reported for 'instant coffee'. The trend analysis showed only few changes in acrylamide levels from 2007 to 2010. At main food category level, a 'common European trend' was a decrease in acrylamide levels for 'processed cereal based foods for infants and young children' and an increase for 'coffee and coffee substitutes'. As a 'common European trend' at sub-category level, acrylamide levels of 'biscuits and rusks for infants and young children' and 'non-potato savoury snacks' showed a decrease and an increase was seen for 'crisp bread'. A marginal decrease was observed for the sub-category 'other processed cereal based foods for infants and young children' and a marginal increase was observed for 'French fries from fresh potatoes' as well as for 'instant coffee'. Although only applicable from 2011, acrylamide levels were compared with indicative values recommended by the EC. Indicative values were exceeded in the case of 3-20 % of samples in different food categories based on 2010 monitoring data. An extended time period and detailed descriptions of sample sources would be needed for a more accurate trend evaluation.

KEY WORDS

Acrylamide, food, monitoring, French fries, potato crisps, coffee, cereal products, food categorisation

[1] On request from the European Commission. Question No EFSA-Q- 2012-00697, approved on 18 October 2012.

[2] Correspondence: dcm@efsa.europa.eu

[3] Acknowledgement: EFSA wishes to thank all the Member States and Norway for providing acrylamide occurrence data in food and EFSA's staff members Liisa Valsta and José Cortiñas Abrahantes for the preparatory work on this scientific output. DCM unit staff members are acknowledged for their input and comments as well as Leif Busk, Josef Schlatter and Thomas Wenzl for reviewing the final report.

Suggested citation: European Food Safety Authority; Update on acrylamide levels in food from monitoring years 2007 to 2010. EFSA Journal 2012;10(10):2938. [38 pp.] doi:10.2903/j.efsa.2012.2938. Available online: www.efsa.europa.eu/efsajournal

SUMMARY

Commission Recommendation 2007/331/EC on the monitoring of acrylamide levels in food was extended in 2010 by Commission Recommendation 2010/307/EU. The new Recommendation also includes a revised categorisation of food products for monitoring purposes (EC, 2010). This report describes the results from European acrylamide monitoring during the period from 2007 to 2010 using the revised product categorisation with 10 main food categories, 16 sub-categories and an additional 10 sub-categories for 'other' or 'unspecified' foods.

Twenty-five European countries submitted a total of 13 162 acrylamide results for the four-year period of which 2 200 results were from the year 2010 from 19 countries. Analytical results with a limit of detection (LOD) or a limit of quantification (LOQ) of 75 µg/kg or lower and 100 µg/kg or lower, respectively, were included in the analyses to facilitate comparability with the previous update report (EFSA, 2011). The time trends in acrylamide levels for selected food categories and sub-categories were calculated for the time period of 2007 to 2010. Since the 2008 monitoring period, the number of analytical results submitted to EFSA declined; in the 2010 monitoring period on average only 57 % of the minimum number of samples set by the European Commission (EC) per food category were submitted (EC, 2010). This impacts the reliability of the trend analysis. However, the completeness of the reported datasets improved since the 2007 monitoring period. In 2010, accurate descriptions of the analytical methods used were obtained for all submitted sample results. Sensitivity of the analytical methods used to analyse acrylamide increased during the latter part of the period. This resulted in a decrease in the proportion of left-censored (LC) data in the last two years compared to the first two years of the reporting period.

In 2010, middle bound (MB) mean acrylamide levels ranged from 31 µg/kg for the food category 'other processed cereal based foods for infants and young children' to 1 350 µg/kg for 'coffee substitutes'. The highest 95th percentile value of 8 044 µg/kg was reported for 'instant coffee'. During the period of 2007 to 2010, lowest levels of acrylamide were found in 'cereal products for infants and young children' as well as in 'soft bread'.

The trend analysis showed only few changes in acrylamide levels from 2007 to 2010. For the main food categories, a 'common European trend' was a decrease in acrylamide levels for 'processed cereal based foods for infants and young children' and an increase trend for 'coffee and coffee substitutes'. As a 'common European trend' at sub-category level acrylamide levels of 'biscuits and rusks for infants and young children' and 'non-potato savoury snacks' showed a decrease and an increase was seen for 'crisp bread'. A marginal decrease was observed for the sub-category 'other processed cereal based foods for infants and young children' and a marginal increase was observed for 'French fries from fresh potatoes' and 'instant coffee'.

In summary, the trend analysis did not show any major changes in acrylamide levels during the 2007 to 2010 monitoring period. Overall, an indication of a decrease in acrylamide levels was seen only in a few food categories.

Although only applicable from 2011, acrylamide levels were compared with indicative values recommended by the EC. Indicative values were exceeded in case of 3-20 % of samples in different food categories based on 2010 monitoring data.

An extended time period and detailed descriptions of sample sources would be needed for a more accurate trend evaluation.

TABLE OF CONTENTS

BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION

Commission Recommendation 2010/307/EU of 2 June 2010 on the monitoring of acrylamide levels in food, which extends Commission Recommendation 2007/331/EC of 3 May 2007, stipulates that Member States should perform annually the monitoring of acrylamide levels in certain food products, and to report monitoring results to EFSA by 1 June of each year in the format as set out by EFSA for compilation into one database.

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

In order to give the Commission an overview of the data collected during the years 2007, 2008, 2009 and 2010, EFSA is asked to compile the 2010 data with the existing database for the years 2007 to 2009 compiled previously by EFSA, to apply the revised product categorisation to the whole database and to update the occurrence report comparing the results for the different years.

CONTEXT OF THE SCIENTIFIC OUTPUT

Update of European acrylamide monitoring during the period of 2007 to 2010.

1. Introduction

Acrylamide is a process contaminant in foods. It is a colourless and odourless crystalline solid compound formed from the hydration of acrylonitrile (Zhang & Zhang 2007) with genotoxic and carcinogenic properties, and in high doses also neurotoxic properties (IARC, 1994). Its occurrence in food has been studied since the original report of elevated levels found in foods processed at high temperatures (SNFA, 2002; Tareke et al., 2002), and evaluations by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) have indicated a human health concern (FAO/WHO, 2005; FAO/WHO, 2010).

The mechanisms of formation, the reduction of acrylamide occurrence in foods, methods suitable for analysis of the levels of acrylamide in food and exposure in different population groups have been studied extensively and reviewed worldwide during the past decade from scientific, regulatory and industry perspectives (Wenzl et al., 2003; Taeymans et al., 2004; Castle & Eriksson, 2005; Dybing et al., 2005; FAO/WHO, 2005; Zhang & Zhang, 2007; FAO/WHO, 2010; Lineback et al., 2012; Health Canada, 2012).

Mitigation of acrylamide levels in foods has been based on voluntary and collaborative actions involving both national authorities and companies producing acrylamide containing foods (Lineback et al., 2012). The EC has been actively involved in these extensive efforts since 2002. The Confederation of the Food and Drink Industry (CIAA)[4] developed and first published in 2005 voluntary measures, the so-called 'toolbox', that can be used selectively by food producers in line with their needs to decrease acrylamide levels in their products (CIAA, 2005). This toolbox covers mitigation actions related to a broad range of foods, including 'French fries', 'potato crisps', 'bread', 'crisp bread', 'breakfast cereals', 'biscuits/bakery wares', 'roast and ground coffee', 'instant coffee', 'coffee substitutes', 'baby biscuits', 'infant cereals' and 'baby foods, other than cereal based foods'. CIAA has, in collaboration with the EC and Member States, since 2007 published pamphlets and their updates to guide producers in mitigation of acrylamide levels in foods (Zhang & Zhang, 2007; CIAA, 2009; FoodDrinkEurope, 2011). In the toolbox advice regarding 13 parameters, and in the most recent update for 14 parameters (e.g. reducing sugars, asparagines, pH, dilution, thermal input and moisture, pre-treatment and consumer guidance), grouped with each product category (agronomy, recipe, processing and final preparation), has been presented (FoodDrinkEurope, 2011).

Acrylamide mitigation and monitoring programmes on acrylamide levels have been carried out in many countries worldwide by official bodies and industry (Lineback et al., 2005; Codex Alimentarius, 2009; Lineback et al., 2012). In addition to earlier reports from Germany and the Netherlands (Kliemant & Göbel, 2007; VWA, 2007), more recent reports on national monitoring programmes have been published e.g. from Belgium and Switzerland, United Kingdom and Canada (Scientific Committee of the FASFC, 2008; Clayes et al., 2010; Biederman et al., 2010; FSA, 2012; Health Canada, 2012). Results from these studies on effects of the mitigation programmes have been inconclusive. In addition, monitoring programmes restricted to certain food categories have been reported (Tsukakoshi et al., 2012).

Systematic collection of acrylamide levels in foodstuffs in Europe has taken place since 2003 (Wenzl and Anklam, 2007). Since 2007 the annual monitoring of European acrylamide levels has been carried out under Commission Recommendation 2007/331/EC of 3 May 2007 (EC, 2007). This monitoring exercise has been extended by Commission Recommendation 2010/307/EU of 3 June 2010 (EC, 2010) with a revised food categorisation. According to Recommendation 2010/307/EU, Member States should carry out acrylamide monitoring annually and provide the monitoring data from the previous year to EFSA by 1 June each year.

Member States should follow the sampling procedures laid down in part B of the Annex to Commission Regulation (EC) No 333/2007 of 28 March 2007 as well as those laid down in

[4] since June 2011 FoodDrinkEurope

Commission Recommendation (2010/307/EU) on the monitoring of acrylamide levels in food (EC, 2007; EC, 2010). As indicated by the Commission, the sampling of products should be carried out at market level, i.e. at supermarkets, small shops, bakeries, French fries outlets and restaurants with good traceability, or at production sites. Products with origin in one of the Member States should be sampled wherever possible. In exceptional cases samples of imported product can be taken. Sampling and analysis should be carried out before the expiry date of the sample.

The requested minimum sample number per product category among the Member States in total is set to be 202 for all main product categories, and 224 for the category 'other products'. The total minimum number of samples to be analysed at Member State level varies between 40 and 230 based on population size. The countries are invited to take more samples when possible (EC, 2010).

So far, EFSA has published three reports on acrylamide levels in foods (EFSA, 2009; EFSA, 2010c; EFSA, 2011). In the most recent report, a decrease in acrylamide levels as seen in three food groups, namely in 'crackers', 'biscuits' and 'ginger bread'. An increase in acrylamide levels was seen both in 'crisp bread' and in 'instant coffee'. The most recent report also included an acrylamide exposure assessment (EFSA, 2011).

In January 2011, the EC published a Recommendation on investigations into the levels of acrylamide in food (EC, 2011). The Recommendation includes indicative acrylamide values in foodstuffs for further investigation (see Table 1).

2. Materials and methods

2.1. Data management

2.1.1. Data cleaning and validation

The acrylamide data included in this report were submitted by 25 European countries between 2008 and 2011 and covered sampling for acrylamide monitoring for the years 2007 to 2010. Data management at EFSA is based on a harmonised data structure described in the document 'Guidance on Standard Sample Description' (EFSA, 2010a) and follows standardised procedures. Moreover, incoming data has to fulfil the 'Specific Requirements for Chemical Contaminants Data Submission' (EFSA, 2012) applied to acrylamide data collection based on the Recommendations by the EC (EC, 2007; EC 2010). In addition, since 2010 data providers have been informed about the successful data upload at the end of the process. In some cases, data providers were contacted at a later stage when further clarification was needed in relation to the acrylamide data submission.

Although data providers did not provide specific information on the conditions of liquid coffee or cocoa beverage preparation (as indicated on the label), for this report, the results reported as liquid coffee beverages (9 samples) and liquid cocoa beverages (8 samples) were transformed to dry coffee and cocoa products, respectively, to facilitate comparison with results of other dry products using standard dilution factors as follows: 7 ml/g for espresso coffee beverage, 18 ml/g for filtered coffee beverage and 60 ml/g for instant coffee beverage and liquid cocoa beverage, respectively.

2.1.2. Food categorisation

A revised acrylamide food categorisation consisting of 10 main food categories (Table 1) was used based on Commission Recommendation 2010/307/EU of 2 June 2010 on the monitoring of acrylamide levels in food. Most of the main categories are further divided into sub-categories. Additional sub-categories covering 'other' and 'unspecified' foods were added to the classification by

Table 1: The revised food categorisation for acrylamide monitoring, LOQ for the analytical method and indicative acrylamide values recommended by the EC for further investigation.

Food category[a]	Number code	Recommended LOQ for the analytical method used[a] (µg/kg)	Indicative value[b] (µg/kg)
French fries, sold as ready-to-eat	1	50	600
French fries from fresh potatoes	1.1	50	600
French fries from potato dough	1.2	50	600
Unspecified French fries	1.3	50	600
Potato crisps	2	50	1 000
Potato crisps from fresh potatoes	2.1	50	1 000
Potato crisps from potato dough[c]	2.2	50	1 000
Unspecified potato crisps	2.3	50	1 000
Pre-cooked French fries/potato products for home cooking[d]	3	50	Not set
Fries baked in the oven (oven fries)	3.1	50	Not set
Deep fried fries	3.2	50	Not set
Unspecified potato products for home cooking	3.3	50	Not set
Soft bread	4	30	150
Unspecified bread	4.1	30	150
Breakfast cereals[e]	5	50	400
Biscuits, crackers, crisp bread and similar[f]		50	500
Crackers	6.1	50	500
Crisp bread	6.2	50	500
Wafers	6.3	50	500
Ginger bread	6.4	50	Not set
Other biscuits, crackers, crisp bread and similar	6.5	50	500
Coffee and coffee substitutes		50	
Roast coffee (dry)	7.1	50	450
Instant (soluble) coffee	7.2	50	900
Coffee substitutes	7.3	50	Not set
Unspecified coffee	7.4	50	Not set
Baby foods[g]	8	30	80
Processed cereal based food for infants and young children		30	
Biscuits and rusks[h]	9.1	30	250
Other processed cereal based foods[h]	9.2	30	100
Other products	10	50	
Muesli and porridge	10.1	50	Not set
Pastries and cakes	10.2	50	Not set
Non-potato savoury snacks	10.3	50	Not set
Unspecified other products	10.4	50	Not set

(a): (EC, 2010), Main food categories are indicated in bold
(b): Indicative acrylamide values since 2011 (EC, 2011)
(c): Formed crisps, stacked crisps
(d): Information about product treatment to be provided with the data submission
(e): Excluding muesli and porridge
(f): Excluding pastries and cakes
(g): Other than processed cereal based foods
(h): For infants and young children

EFSA due to a considerable amount of missing background information in the submitted data and uncertainty in classifying the foods accurately according to the specific sub-categories. The main category 'other products' was divided into four sub-categories as follows: 'muesli and porridge', 'pastries and cakes', 'non-potato savoury snacks' and 'unspecified other products'.

All submitted data (n=13 162) from 2007 to 2010 were checked and reclassified according to the updated food categories, if needed. When the food grouping provided was clearly indicated by the data provider, it was not changed. In case the classification provided was found to be incomplete or conflicting with other food description information, other background information, e.g. food description from the text fields in the submitted dataset, brand name data, ingredients, standard processing information (e.g. to distinguish biscuits from more moist cake type products) and other available information was used to specify the correct food category.

2.1.3. Descriptive statistics

In addition to the 2010 data some new data from previous years were submitted to EFSA. Due to the revised product categorisation and some additional data obtained, descriptive statistics for 2007, 2008 and 2009 are slightly different from those presented in previous reports (EFSA, 2009; EFSA, 2010c; EFSA, 2011). Altogether 192 results from a total diet study (pertaining to one Member State) were excluded from the monitoring data because of different sampling procedures than the ones set by the EC (EC, 2010). In addition, 174 acrylamide results were excluded from the analyses due to high LODs and LOQs for the analytical methods used (see section 3.4.). Potential outlying values were identified by the Tukey's method (Tukey, 1977) which identifies the values greater than the 75th percentile plus 1.5 times the inter quartile distance, or less than the 25th percentile minus 1.5 times the inter quartile distance. For a few suspect outlying values, data providers were asked to check the correctness of the transmitted data. The data provider of the highest values for 'instant coffee' confirmed that the values were not errors. However, the highest five values were excluded from the descriptive statistics and trend analysis as deemed outliers.

The analytical methods used should achieve a LOQ of 30 µg/kg (most intense ion/ion transition) for 'soft bread' and 'foods for infants and young children' and 50 µg/kg for 'potato products', 'other cereal products', 'coffee' and 'other products' (EC, 2007; EC, 2010). In addition, results should be reported corrected for recovery. Results in the dataset that remained after removal of the samples that did not meet the specifications for LOQ given in the Commission Recommendations were included in the final dataset. As the difference between lower and upper bound values (as presented in Tables 4-7) were minor, data with higher LOQs than recommended did not influence the outcome of the data analysis.

Following the recommendations by WHO in 'Principles and Methods for the Risk Assessment of Chemicals in Food' (WHO, 2009) and by EFSA in 'Management of LC data in dietary exposure assessment of chemical substances' (EFSA, 2010b), LC data were treated by the substitution method. Altogether three different scenarios were applied for handling LC data. The 'lower bound' (LB) was obtained by assigning a value of zero to all the samples reported as less than the respective left-censoring limit, the 'middle bound' (MB) was obtained by assigning half of the left-censoring limit and the 'upper bound' (UB) was obtained by assigning the LC limit as the sample result. The MB may be used to represent the occurrence levels when fewer than 60 % of data are LC. As uncertainty increases with an increase in the proportion of LC data, it is recommended to use LB and UB to represent a possible range within which the true value would fall. However, it has also been shown in simulation studies that the MB is a more realistic value to represent the occurrence levels when the range of LB and UB values increases (EFSA, 2010b). Therefore, in this report, all three substitution results (LB, MB and UB) are presented. Descriptive statistics were estimated using the SAS statistical package (SAS Enterprise Guide, version 4.2).

2.1.4. Trend analysis

A trend analysis was carried out by comparing acrylamide results from 2007, 2008, 2009 and 2010 at main food category and sub-category level in order to evaluate their change over time across Europe. The approach was similar to that described in the previous EFSA acrylamide update report (EFSA, 2011). A mixed effect model (Verbeke and Moleberghs, 2000) using log transformed MB and UB mean acrylamide content values was used.

The mixed effect model approach was applied to test whether a 'common European trend' in acrylamide levels could be seen, i.e. similar slopes of log transformed mean acrylamide content values in different European countries over the four year period (assuming a linear trend).

A 'common European trend' was reported when the trend in different countries was towards the same direction and was shown to be statistically significant ($P < 0.05$). In case the analysis did not show a 'common European trend', a 'marginal European trend' was estimated using the whole pool of acrylamide values and testing the overall time-effect for this pool of values. The term 'marginal European trend' implies that there might be countries with an opposite trend to the 'common European trend' and that this kind of deviation is not seen in the pooled 'marginal European trend'.

Altogether three models were fitted to the acrylamide data:

- Model I: It contained two random effects (intercept and slope) and a correlation parameter between the random effects. Model I assumes different starting mean acrylamide levels and different trends per country, and also that for each country the trend is related to the starting acrylamide (i.e. the mean acrylamide value in 2007) level. A positive correlation indicates that a low starting acrylamide level corresponds to a small increase/decrease over the years. In case the correlation between random effects (slope and intercept) in model I was zero, a simplified model without the correlation parameter, i.e. model II was used.

- Model II: It also contained two random effects (intercept and slope) allowing different starting mean acrylamide levels and slopes between countries without being related. If the variance of the random effect of the slope differed from zero, this would indicate that evolution over time could differ between countries regardless of starting acrylamide levels of the countries. Thus, a country with a low starting acrylamide level could have a very steep increasing trend, but another country with low starting acrylamide level could have a very steep decrease in acrylamide levels. In case the variance of the random slope was not different from zero, a further simplified model, i.e. model III, was used.

- Model III: It contained only a random intercept and in this case a 'common European trend' for the food category or sub-category could be reported, having parallel slopes between countries but only a country specific mean acrylamide level for the food category or sub-category in the starting year of evaluation (i.e. in 2007).

In case a 'common European trend' was not found, a 'marginal European trend' was estimated, i.e. an overall intercept (starting acrylamide level in 2007) and an overall slope (change of acrylamide levels over time) averaging out for all countries. This means that an overall change in pooled acrylamide values from all countries in the analysis was evaluated, though the changes of MB mean acrylamide levels did not need to show a consistent pattern across all countries in Europe.

Although MB and UB scenarios were tested, only MB scenario results are presented in this report given that both scenarios introduce similar level of bias, which depends on the magnitude of censoring (EFSA, 2010b). The time effect of the acrylamide values were considered statistically significant when the P-value was <0.05. In case the P-value was between 0.05-0.10, the time effect was considered to be marginally statistically significant.

Fitted acrylamide levels were derived from the model for the years 2007 and 2010 in order to identify any increase or decrease of acrylamide contents over the monitoring period, assuming a linear evolution over time.

In addition, MB median acrylamide levels of acrylamide in respective food categories were compared for the years 2007 and 2010, and distributions of MB acrylamide levels in selected food categories were produced (Figures 5-6).

2.1.5. Seasonal effect analysis of acrylamide levels of potato products

In the three main potato product categories 'French fries', 'Potato crisps' and 'pre-cooked potato product for home cooking' and separately in respective sub-categories, a seasonal effect analysis was carried out. In order to assess differences in MB mean and UB mean acrylamide levels:

- between months from July to December (potato products from freshly harvested potatoes) and from January to June the following year (potato products from stored potatoes) and
- between months from January to June and months from July to December of the same year (seasonal difference seen between the two seasons of one sampling year).

A mixed effect model was used, considering a random intercept and in this case a seasonal random effect, allowing for correlation between both random effects (UB mean results not shown). The difference in acrylamide values between the two seasons was considered significant when the P-value was <0.05 and marginally significant when the P-value was between 0.05-0.10.

3. Results

3.1. Data reported

Twenty-five European countries submitted data covering the monitoring period 2007 to 2010. Data were provided annually from 16 European countries, namely Austria, Belgium, Cyprus, Czech Republic, Estonia, Germany, Greece, Italy, Ireland, Lithuania, Netherlands, Norway, Slovakia, Spain, Sweden and United Kingdom. Some countries submitted data twice or three times in this period. The number of European countries that provided acrylamide data pertaining to 2007, 2008, 2009 and 2010 was 23, 25, 21 and 19, respectively. The number of results during the four year period was highest in 2008 and lowest in the 2010 sampling year. Twenty-five countries provided data pertaining to the 2008 sampling year, while this dropped to 19 in the 2010 sampling year. This can partly explain the decrease in the number of submitted results over the monitoring period.

In total 13 162 samples were submitted to EFSA during period of 2007 to 2010. The number of samples in the final cleaned dataset in the revised food categories specified for acrylamide monitoring is shown in Table 2 (n= 12 716). Most acrylamide results were submitted by Germany followed by United Kingdom, Czech Republic, Belgium and Italy. The total number of samples received exceeded the minimum target set in Commission Recommendation (EC, 2010). However, the set targets were not reached in all food categories. This was the case for 'soft bread', 'breakfast cereals (excluding muesli and porridge)'(hereafter 'breakfast cereals'), 'baby foods other than processed cereal based food' (hereafter 'baby foods') and 'processed cereal based foods for infants and young children' in 2007 to 2010 and for 'pre-cooked French fries/potato products for home cooking' and 'coffee and coffee substitutes' in 2010.

The revised food categorisation set by the EC was applied for the first time in this report. Additional sub-categories were added for 'unspecified' foods due to the fact that in some cases the submitted information lacked specific details necessary to assign a sample to the correct food sub-category. However, special efforts were made to minimise the number of results assigned to 'unspecified' product categories. Due to improved sample description provided by countries as well as to the

attention paid by EFSA to the classification of the foods according to the revised food categorisation, the number of 'unspecified' foods under the different main food categories decreased during the monitoring period, i.e. from 1 326 foods (38 %) in 2007 to 431 foods (20 %) in 2010. (Table 2).

For the 2010 monitoring period, 2 200 analytical results from 19 European countries were obtained of which 2 071 were included in the final dataset. The target for minimum sample numbers was reached by most countries with respect to the main food categories of 'potato crisps', 'coffee and coffee substitutes', 'processed cereal based foods for infants and young children', 'soft bread' and 'biscuits, crackers, crisp bread and similar (excluding pastry and cake)'(hereafter 'biscuits, crackers, crisp bread and similar'). The most under-sampled food category was the main group 'baby foods' (Table 3). On average, only 57 % of the minimum number of samples per food group set by the EC for the annual monitoring programme were received by EFSA in 2010. The number and type of samples per country differed from year to year (Table 3). This affects the comparability of the sampling and also weakens the use of the database for trend analyses.

3.2. Sampling

Sampling information has been reported to EFSA as mandatory since 2010. In the final dataset, the sampling frame for over 95% of the samples collected during 2007 to 2009 was recorded as 'other' meaning 'unknown'. In 2010, 90 % of the samples were reported to be from official EU and national monitoring programmes. Until 2010, the sampling strategy was not defined in more than 95 % of samples. In 2010, 67 % of samples were obtained by selective sampling and 23 % of samples were obtained by objective sampling. Some 4 % of samples in 2010 were obtained by suspect sampling.

Until 2010, the sampling method was reported as 'unknown' in more than 97% of the samples. In 2010, 92 % were individual samples, about 3 % were reported as 'pooled/batched' and in the case of 5 % of the samples, the sampling method was reported as 'unknown'. Since the aggregated pooled samples matched the level of food classification of the individual samples (i.e. only similar matrices were pooled together, e.g. coffee samples from the same sub-category), results on the small number of pooled samples were retained in the dataset.

According to the EC Recommendations on the monitoring of acrylamide level in food (EC, 2007; EC, 2010), the sampling of the products should be carried out at market level or at production sites. During the 2007 to 2009 monitoring period, the sampling point was not specified for more than 90 % of samples, while in 2010 the sampling point was unspecified for approximately half of the samples. The defined sampling point in 2010 was most commonly retail or wholesale (36 %), manufacturing or processing plant (6 %) and catering, restaurant, fast-food outlet or similar (4 %).

Table 2: The number of acrylamide samples in the final dataset from 25 European countries during the monitoring period (2007 to 2010)

Food category	2007	2008	2009	2010	Total
French fries, sold as ready-to-eat	648	563	501	256	1 968
French fries from fresh potatoes	204	301	158	196	871
French fries from potato dough	0	1	0	1	2
Unspecified French fries	444	261	343	59	1 112
Potato crisps	293	532	414	242	1 481
Potato crisps from fresh potatoes	100	104	132	173	515
Potato crisps from potato dough[a]	26	39	23	19	107
Unspecified potato crisps	167	389	259	50	875
Pre-cooked French fries/potato products for home cooking	137	254	249	117	757
Fries baked in the oven (oven fries)[b]	8	121	71	28	228
Deep fried fries	32	34	44	64	177
Unspecified pre-cooked French fries/potato products for home cooking	97	99	134	25	358
Soft bread	176	259	182	150	767
Unspecified bread	4	0	19	0	23
Breakfast cereals[c]	144	166	191	174	675
Biscuits, crackers, crisp bread and similar[d]	938	898	964	462	3 262
Crackers	27	22	39	64	152
Crisp bread	198	93	161	54	515
Wafers	33	48	85	37	203
Ginger bread	458	395	326	207	1 390
Other biscuits, crackers, crisp bread and similar	222	340	353	100	1 038
Coffee and coffee substitutes	312	443	279	151	1 185
Roast coffee (dry)	175	280	187	103	756
Instant (soluble) coffee	52	42[c]	51	15	174
Coffee substitutes	50	76	32	24	182
Unspecified coffee	32	45	9	9	96
Baby foods[e]	93	149	128	55	425
Processed cereal based foods for infants and young children	170	194	153	128	645
Biscuits and rusks[f]	79	106	70	46	307
Other processed cereal based foods[f]	65	69	55	82	284
Unspecified processed cereal based food for infants and young children	26	19	28	0	74
Other foods	432	431	329	336	1 528
Muesli and porridge	47	26	72	14	159
Pasties and cakes	63	98	31	81	273
Non-potato savoury snacks	63	33	66	80	243
Unspecified other products	259	274	160	161	898
Total	**3 347**	**3 889**	**3 409**	**2 071**	**12 716**

(a): Formed crisps, stacked crisps
(b): For home cooking. Between 2007 and 2010 around 45 % of pre-cooked potato products for home cooking were analysed as prepared, 7 % unprepared and preparation was 'unknown' for 48 % of the samples (see footnotes of the Tables 4-7).
(c): Excluding muesli and porridge
(d): Excluding pastries and cakes
(e): Other than processed cereal based foods
(f): For infants and young children

Table 3: The number of samples per food category in the cleaned dataset collected by 19 European countries in 2010 and the number of countries reaching the minimum sampling target set by the EC[a].

Country	Number of samples (n)	French fries as sold	Potato crisps	Precooked French fries/ potato products	Soft bread	Breakfast cereals	Biscuits, crackers etc[b].	Coffee and coffee substitutes	Baby foods	Processed cereal based baby foods	Other products
Austria	93	4	15	7	4	0	17	7	4	6	29
Belgium	159	19	10	0	21	26	2	30	0	15	36
Cyprus	41	1	4	8	11	5	1	5	1	1	4
Czech Republic	45	0	5	4	0	3	7	5	1	6	14
Denmark	120	25	9	7	13	3	12	10	0	6	35
Estonia	30	0	4	6	4	3	0	4	4	3	2
Germany	792	132	60	35	5	49	327	13	0	17	154
Greece	80	8	22	4	8	8	11	6	3	4	6
Hungary	30	2	9	6	2	3	1	3	2	0	2
Ireland	66	12	15	4	4	4	5	8	4	8	2
Italy	165	8	33	5	17	11	26	12	22	22	9
Lithuania	10	0	1	2	1	1	1	1	1	1	1
Netherlands	62	6	6	5	7	7	9	6	5	6	5
Norway	51	0	1	4	7	4	12	6	2	5	10
Slovakia	39	4	5	0	6	0	8	7	0	0	9
Slovenia	41	0	8	4	4	4	8	5	1	7	0
Spain	100	6	17	0	12	19	7	19	1	17	2
Sweden	56	8	8	8	4	4	8	4	4	4	4
United Kingdom	91	21	10	8	20	20	0	0	0	0	12
Total	**2 071**	**256**	**242**	**117**	**150**	**174**	**462**	**151**	**55**	**128**	**336**
Number of countries reaching the EC sampling target[a]	**11**	**10**	**15**	**11**	**12**	**10**	**11**	**13**	**6**	**12**	**8**

(a): (EC, 2010)
(b): Biscuits, crackers, crisp bread and similar (excluding pastry and cake)

3.3. Analytical methods

The analytical methods used for acrylamide analyses during 2007 to 2010 are summarised in Figure 1. The most common methods reported were based on liquid chromatography-mass spectrometry (LC-MS) with over 56% of the results indicating use of such methods. Gas chromatography based methods were used on average for about 37 % of the analyses. The use of liquid chromatography-mass spectrometry for acrylamide analyses has increased during the period of 2007to2010 and was the method of choice for more than two thirds of the samples analysed in 2009 and 2010. Approximately 5 % of the analytical results were reported without an indication of the analytical method used during the period 2007 to 2009 ('classification not possible', Figure 1). In 2010, a description of the analytical methods used was provided for all results. The percentage of accredited laboratories responsible for the submitted data increased from 2% in 2007 and 6% in 2008 to 83% in 2009 and 94 % in 2010.

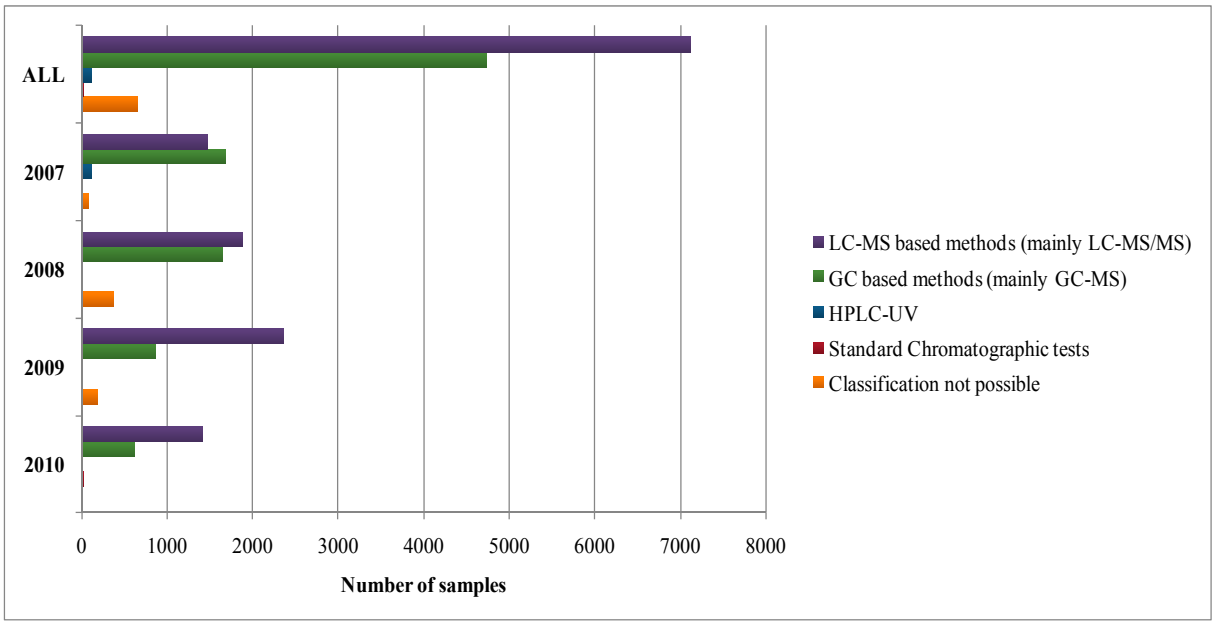


Figure 1: Analytical methods used for acrylamide results reported during 2007 to 2010.

Comparability of analytical methods is still not optimal, due to the fact that the analytical methods were not fully described and their performance may differ even in cases where the same analytical instruments are used (Keramat et al., 2011).

The LOQs set by the EC were in many cases not met by the countries. The situation was most favourable for 'soft bread' and 'baby foods', in which some 75 % and 80 % of the samples analysed used methods compliant with the LOQ of 30 µg/kg (EC, 2007; EC, 2010).

3.4. Reported left-censored data

Minimum and maximum reported LODs and LOQs varied between 0.01 µg/kg to 537 µg/kg and from 0.1 µg/kg to 1 611 µg/kg, respectively. Overall, 174 analytical results with LODs exceeding 75 µg/kg or LOQs exceeding 100 µg/kg were excluded from the analysis to facilitate comparability with the previous EFSA acrylamide update (EFSA, 2011). The distributions of LODs and LOQs for the retained samples after all exclusions, respectively, are presented in Figures 2 and 3. The recommended maximum LOQ of 30 µg/kg (EC, 2010) was exceeded by analytical methods used for analysing about

25 % of the 'soft bread' samples, by methods used for analysing about 20 % of the 'baby food' samples and by methods used for analysing approximately 25-40 % of the samples of 'processed cereal based foods for infants and young children'. Also, the recommended LOQ of 50 µg/kg for methods used for all other food groups was exceeded, except 'instant coffee' (Figure 3).

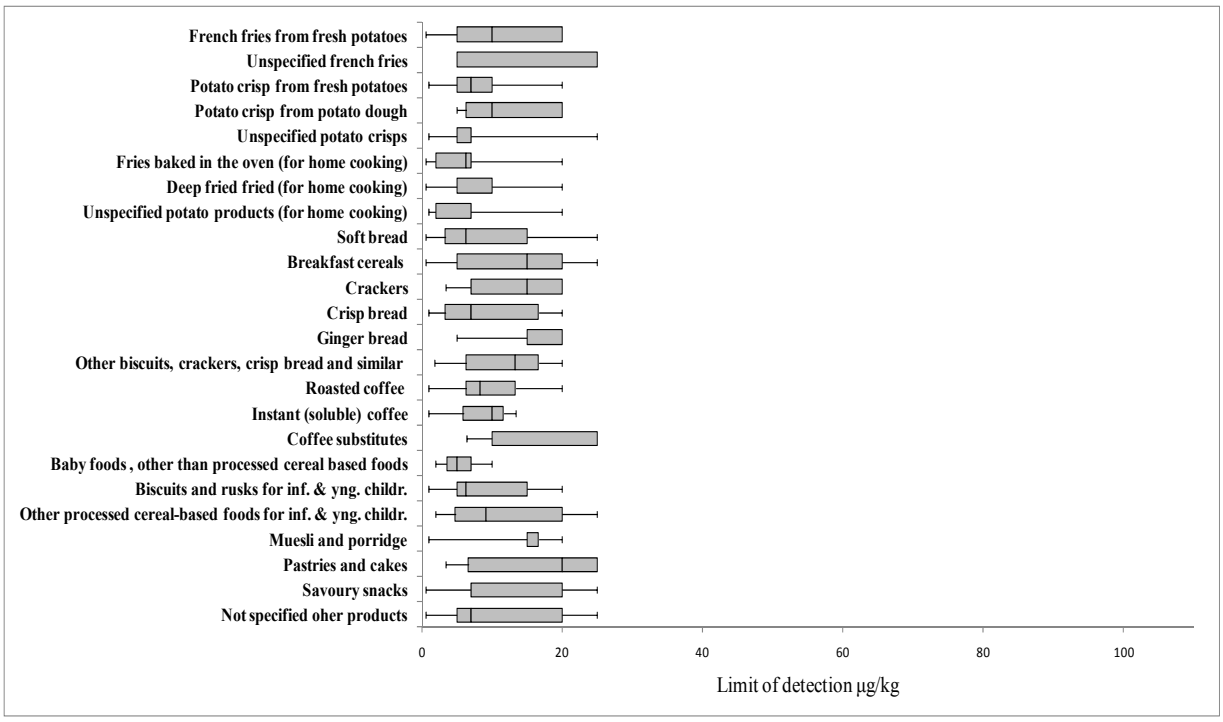


Figure 2: Distribution of the LODs for acrylamide according to the revised acrylamide food categories in the final 2010 dataset. Box-plot: whiskers at P5 and P95, box at P25 and P75 with line at P50.

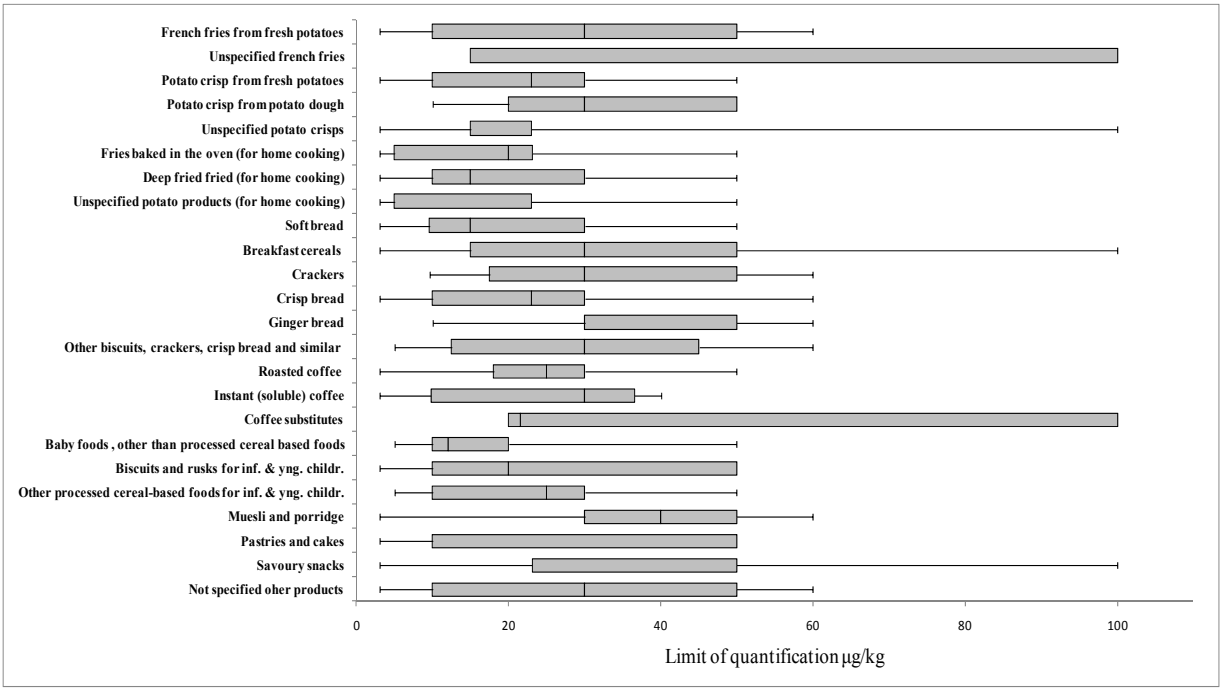


Figure 3: Distribution of the LOQs for acrylamide according to the revised acrylamide food categories in the final 2010 dataset. Box-plot: whiskers at P5 and P95, box at P25 and P75 with line at P50.

The proportion of LC data pertaining to the monitoring period 2007 to 2010 for the different food categories is presented in Figure 4. The highest numbers of data were seen for the food categories 'baby foods' (between 55-65 % of samples), 'soft bread' (between 40-50 % of samples) and 'processed cereal based foods for infants and young children' (between 30-50 % of samples). In 2010 the proportion of LC data was lower than in previous years for all, except foods for infants and young children.

3.5. Occurrence of acrylamide in food

Descriptive statistics of acrylamide levels in the revised food groups for the data collected in 2007, 2008, 2009 and 2010 are presented in Tables 4-7, respectively.

In 2007, MB mean values ranged from 29 to 1 044 µg/kg for 'baby foods' and 'unspecified bread', respectively. The highest reported MB P95 value was 3 025 µg/kg for 'coffee substitutes" (Table 4). In 2008 as well as in 2009 the lowest MB mean values were reported for 'baby foods' (22 µg/kg and 38 µg/kg, respectively). The highest MB mean values in 2008 as well as 2009 were reported for 'coffee substitutes' (1 033 µg/kg and 1 594 µg/kg, respectively). The highest reported MB P95 values in 2008 and in 2009 were reported for 'coffee substitutes' (3 300 µg/kg and 3976 µg/kg), respectively (Tables 5-6). In 2010 MB mean values ranged from 31 µg/kg to 1 350 µg/kg for 'other processed cereal based foods for infants and young children' and 'coffee substitutes', respectively. The highest reported MB P95 value was 8 044 µg/kg for 'coffee substitutes' (Table 7).

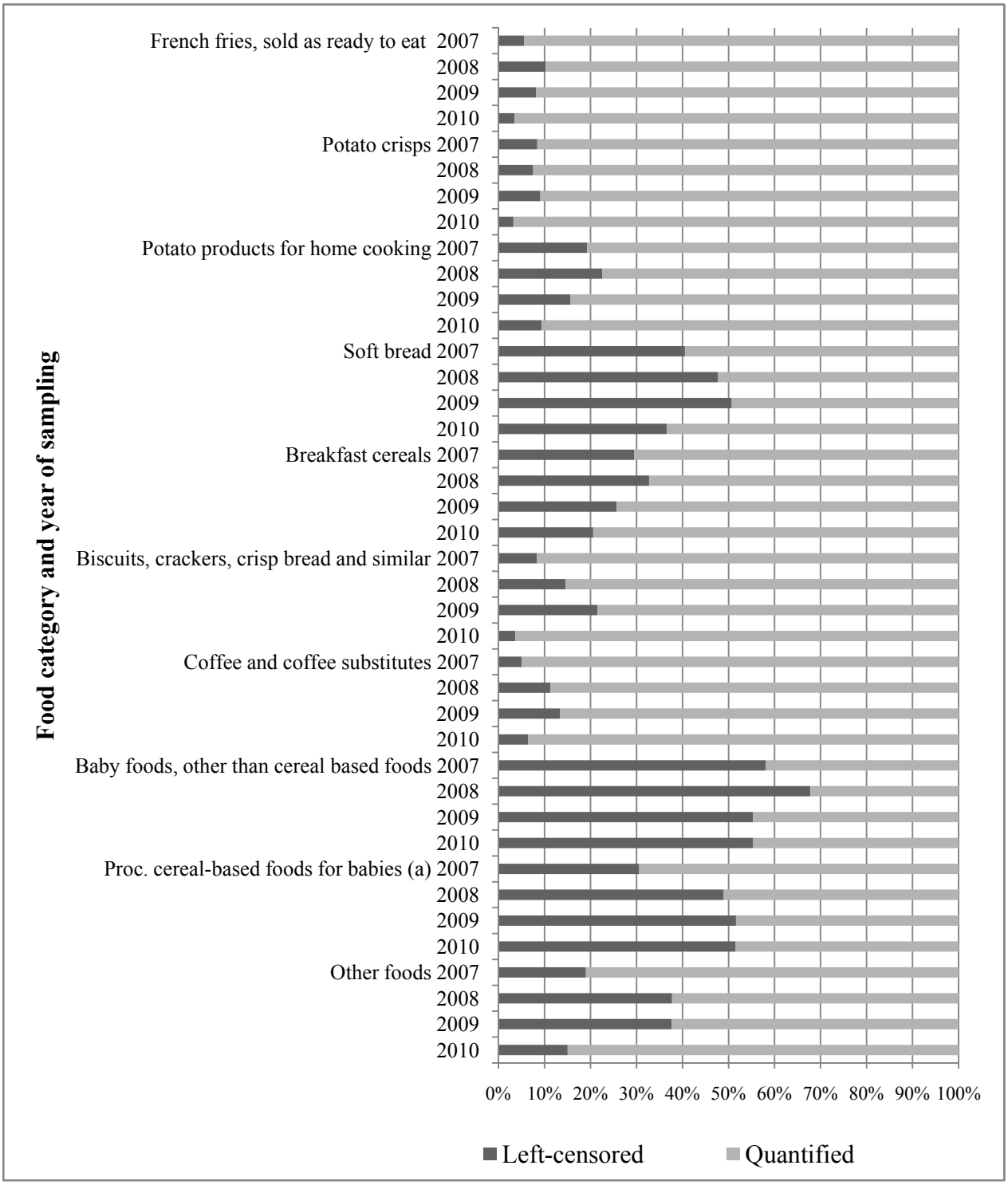


Figure 4: Proportion of left-censored and quantified data per food category for the pooled data from all European countries for each of the years 2007, 2008, 2009 and 2010.

Table 4: Distribution of acrylamide levels[a] in foods in 2007.

Food category	n	Median (µg/kg)	Mean (µg/kg)	P90 (µg/kg)	P95 (µg/kg)	Maximum (µg/kg)
French fries, sold as ready-to-eat	648	245	356 (354-357)	742	1 114	2 668
French fries from fresh potatoes	204	197	237 (236-239)	499	606	1 443
French fries from potato dough	-	-	-		-	
Unspecified French fries	444	274	410 (409-411)	930	1 378	2 668
Potato crisps	293	380	551 (550-553)	1 200	1 589	4 180
Potato crisps from fresh potatoes	100	482	570 (569-570)	1 100	1 395	3 300
Potato crisps from potato dough	26	335	402 (402-403)	851	928	938
Unspecified potato crisps	167	334	564 (562-565)	1430	1 673	4 180
Pre-cooked French fries/potato products for home cooking	137	180	306 (302-310)	794	1 144	2 175
Fries baked in the oven (oven fries)[b]	8	260	365 (362-368)	941	941	941
Deep fried fries[c]	32	239	395 (391-399)	1 140	1 450	1 661
Unspecified potato products for home cooking[d]	97	179	272 (268-275)	623	796	2 175
Soft bread	176	25 (20-41)	75 (68-82)	169	310	1 778
Unspecified bread	4	716	1044	2 565	2 565	2 565
Breakfast cereals	144	84 (84-100)	149 (140-158)	333	420	1 600
Biscuits, crackers, crisp bread and similar	938	183	326(324-328)	837	1 235	4 200
Crackers	27	135	237 (236-238)	755	900	1 526
Crisp bread	198	117	232 (229-235)	480	765	2 430
Wafers	33	128	230 (229-232)	478	694	1 378
Ginger bread	458	209	387 (386-388)	1 074	1 372	3 615
Other biscuits, crackers, crisp bread and similar	222	189	309 (306-311)	672	1 001	4 200
Coffee and coffee substitutes	312	207	373 (372-374)	868	1 084	4 700
Roast coffee	175	200	256 (254-257)	519	872	1 158
Instant (soluble) coffee	52	157	229 (228-230)	530	662	1 047
Coffee substitutes	50	351	890 (890-891)	2 713	3 025	4 700
Unspecified coffee	32	270	455	869	906	1 084
Baby foods (excl. cereal based)	93	15 (0-30)	29 (21-38)	75 (75-85)	94	162
Processed cereal based foods for infants and young children	170	58	119 (113-124)	258	440	1 215
Biscuits and rusks for infants and young children	79	108	174 (171-177)	440	615	1 215
Other processed cereal based foods for infants and young children	65	20 (7-30)	69 (63-75)	220	240	353
Unspecified cereal based foods for infants and young children	26	43 (33-62)	73 (63-82)	121	170	527
Other foods	432	117 (114-1170	232 (222-242)	551(542-551)	825(745-825)	2 529(2529-4020)
Muesli and porridge	47	178	241 (240-243)	551	613	1 315
Pastries and cakes	63	68 (68-70)	140 (136-143)	340	419	910
Non-potato savoury snacks	63	178	275 (271-279)	573	745	2 110
Unspecified other products	259	111 (108-111)	242 (227-257)	608(580-608)	992(953-992)	2 529(2529-4020)

(a): Values indicate middle bound (MB) and ranges in brackets indicate lower bound (LB) and upper bound (UB) values. When LB and UB do not differ from the MB, only the MB value is presented.
(b): 75 % were reported to be analysed as prepared, 12.5 % analysed as unprepared, 12.5 % type of preparation unknown.
(c): 34 % were reported to be analysed as prepared, 19 % analysed as unprepared, 47 % type of preparation unknown.
(d): 56 % were reported to be analysed as prepared, 7 % analysed as unprepared, 37 % type of preparation unknown.

Table 5: Distribution of acrylamide levels[a] in foods in 2008.

Food category	n	Median (µg/kg)	Mean (µg/kg)	P90 (µg/kg)	P95 (µg/kg)	Maximum (µg/kg)
French fries, sold as ready-to-eat	563	215	277 (275-279)	570	767	2 466
French fries from fresh potatoes	301	191	251 (248-254)	538	679	1 276
French fries from potato dough	1	406	406	406	406	406
Unspecified French fries	261	226	306 (305-308)	607	830	2 466
Potato crisps	532	403	580 (578-581)	1 298	1 853	4 382
Potato crisps from fresh potatoes	104	449	541 (541-542)	1 250	1 460	2 449
Potato crisps from potato dough	39	209	361 (360-361)	700	788	2 167
Unspecified potato crisps	389	415	612 (610-614)	1 397	1 900	4 382
Pre-cooked French fries/potato products for home cooking	254	100	223 (219-226)	553	777	3 025
Fries baked in the oven (oven fries)[b]	121	151	256 (255-256)	601	863	1 439
Deep fried fries[c]	34	138	229 (225-234)	588	710	1 220
Unspecified potato products for home cooking[d]	99	40 (40-70)	213 (206-221)	430	763	3 025
Soft bread	259	24 (8-30)	53 (45-60)	110	264	565
Unspecified bread	0	.	.		.	
Breakfast cereals	166	64 (64-100)	155 (145-165)	318	520	2 072
Biscuits, crackers, crisp bread and similar	898	135	272 (269-274)	680	967	3 307
Crackers	22	107	168 (167-169)	365	394	432
Crisp bread	93	105	228 (227-229)	590	770	1 538
Wafers	48	120	256 (255-258)	645	1 230	2 353
Ginger bread	395	185	355 (353-358)	863	1 318	3 307
Other biscuits, crackers, crisp bread and similar	340	114	196 (192-199)	476	679	1 940
Coffee and coffee substitutes	443	205	393 (391-394)	861	1 340	7 095
Roast coffee	280	161	197 (195-199)	346	494	1 524
Instant (soluble) coffee	42[c]	187 (79-129)	298 (295-301)	660	734	2 300[c]
Coffee substitutes	76	786	1 033 (1033-1034)	2392	3300	7 095
Unspecified coffee	45	602	615 (614-616)	898	933	2 520
Baby foods (excl. cereal based)	149	13 (0-25)	22 (13-31)	46(46-75)	62 (62-85)	180
Processed cereal based foods for infants and young children	194	25 (8-41)	69 (62-76)	169	255	1 200
Biscuits and rusks for infants and young children	106	58 (58-62)	94 (87-101)	200	280	1200
Other processed cereal based foods for infants and young children	69	15 (0-25)	31 (23-39)	80	130	410
Unspecified cereal based foods for infants and young children	19	37 (21-37)	66 (60-71)	176	260	260
Other foods	431	30 (30-44)	144 (140-148)	396	618	2 592
Muesli and porridge	26	20 (6-30)	33 (27-40)	81	89	112
Pastries and cakes	98	56 (56-60	163 (159-167)	481	700	2 592
Non-potato savoury snacks	33	170	238 (334-342)	485	1 500	2 120
Unspecified other products	274	25 (17-30)	120 (120-128)	360	608	1 780

(a): Values indicate middle bound (MB) and ranges in brackets indicate lower bound (LB) and upper bound (UB) values. When LB and UB do not differ from the MB, only the MB value is presented.
(b): 85 % were reported to be analysed as prepared, 15 % type of preparation unknown.
(c): 82 % were reported to be analysed as prepared, 3 % analysed as unprepared, 15 % type of preparation unknown.
(d): 43 % were reported to be analysed as prepared, 20 % analysed as unprepared, 37 % type of preparation unknown.

Table 6: Distribution of acrylamide levels[a] in foods in 2009.

Food category	n	Median (µg/kg)	Mean (µg/kg)	P90 (µg/kg)	P95 (µg/kg)	Maximum (µg/kg)
French fries, sold as ready-to-eat	501	248	342 (341-343)	640	900	3 380
French fries from fresh potatoes	158	187	278 (276-279)	668	810	2 030
French fries from potato dough	0					
Unspecified French fries	343	264	371 (370-373)	640	1 226	3 380
Potato crisps	414	375	639 (637-641)	1514	2 125	4 804
Potato crisps from fresh potatoes	132	474	619 (617-622)	1362	1 833	4 686
Potato crisps from potato dough	23	309	409 (403-416)	860	1 350	1 572
Unspecified potato crisps	259	351	670 (669-670)	1763	2 336	4 804
Pre-cooked French fries/potato products for home cooking	249	157	270 (267-273)	670	1 000	2 762
Fries baked in the oven (oven fries)[b]	71	200	333 (332-333)	782	1 152	1 665
Deep fried fries[c]	44	185	220 (216-224)	549	627	1 238
Unspecified potato products for home cooking[d]	134	108	253 (249-257)	612	914	2 762
Soft bread	182	20 (0-30)	46 (38-53)	69(69-75)	140	1 460
Unspecified bread	19	22 (16-22)	104 (101-107)	502	720	720
Breakfast cereals	191	85 (85-100)	139 (131-147)	275	414	1 435
Biscuits, crackers, crisp bread and similar	964	131	247 (243-247)	537	876	4 095
Crackers	39	103	172 (169-175)	504	697	902
Crisp bread	161	176	208 (205-210)	400	460	999
Wafers	85	173	206 (203-209)	491	598	725
Ginger bread	326	120	359 (355-362)	970	1 645	4 095
Other biscuits, crackers, crisp bread and similar	353	104	180 (175-185)	393	545	2 650
Coffee and coffee substitutes	279	245	463 (460-465)	1 009	2 300	4 300
Roast coffee	187	195	235 (232-237)	389	500	2 223
Instant (soluble) coffee	51	579	551 (548-553)	873	1 009	1 470
Coffee substitutes	32	1 223	1 594(1593-1594)	3 400	3 976	4 300
Unspecified coffee	9	252	679	2929	2 929	2 929
Baby foods (excl. cereal based)	128	15 (0-25)	38 (31-45)	65(65-75)	106	677
Processed cereal based foods for infants and young children	153	25(0-48)	72 (64-80)	189	222	710
Biscuits and rusks for infants and young children	70	46 (36-54)	88 (80-96)	203	270	521
Other processed cereal based foods for infants and young children	55	13 (0-25)	41 (30-51)	38(27-75)	162	710
Unspecified cereal based foods for infants and young children	28	67	92 (89-94)	197	206	228
Other foods	329	61(61-70)	185 (174-196)	471	651 (643-651)	4 380
Muesli and porridge	72	25 (12-40)	58 (49-68)	89	351	487
Pastries and cakes	31	25 (0-50)	108 (94-122)	310	370	651
Non-potato savoury snacks	66	132	208 (202-214)	468	500	621
Unspecified other products	160	78 (72-85)	248 (234-261)	663(585-663)	1 161 (1097-1161)	4 380

(a): Values indicate middle bound (MB) and ranges in brackets indicate lower bound (LB) and upper bound (UB) values. When LB and UB do not differ from the MB, only the MB value is presented.
(b): 7 % were reported to be analysed as prepared, 93 % type of preparation unknown.
(c): 100 % type of preparation unknown.
(d): 1 % were reported to be analysed as prepared, 99 % type of preparation unknown.

Table 7: Distribution of acrylamide levels[a] in foods in 2010.

Food category	n	Median (µg/kg)	Mean (µg/kg)	P90 (µg/kg)	P95 (µg/kg)	Maximum (µg/kg)
French fries, sold as ready-to-eat	256	240	338 (336-339)	725	1 024	2 174
French fries from fresh potatoes	196	239	325 (325-326)	692	921	2 174
French fries from potato dough	1	150	150	150	150	150
Unspecified French fries	59	240	382	1 019	1 377	1 800
Potato crisps	242	450	675 (674-676)	1 538	2 080	4 533
Potato crisps from fresh potatoes	173	543	758 (757-758)	1 822	2 193	4 533
Potato crisps from potato dough	19	370	435	980	1 000	1 000
Unspecified potato crisps	50	313	481 (478-484)	890	1 389	4 039
Pre-cooked French fries/potato products for home cooking	117	151	331 (329-333)	873	1 159	3 955
Fries baked in the oven (oven fries)[b]	28	410	690	1 888	1 991	3 955
Deep fried fries[c]	64	115	198 (195-201)	568	681	1 155
Unspecified potato products for home cooking[d]	25	179	270	707	928	1 295
Soft bread	150	18 (9-24)	30 (25-35)	63	94	425
Unspecified bread	0	.	.		.	
Breakfast cereals	174	91 (91-100)	138 (132-144)	293	353	1 290
Biscuits, crackers, crisp bread and similar	462	129	333	833	1 337	5 849
Crackers	64	139	178	303	491	1 062
Crisp bread	54	110	249 (248-250)	665	1 443	1 863
Wafers	37	225	389	880	1 300	1 300
Ginger bread	207	134	415 (414-415)	1 187	1 635	3 191
Other biscuits, crackers, crisp bread and similar	100	99	289 (288-290)	640	1 061	5 849
Coffee and coffee substitutes	151	242	527	1 200	2 000	8 044
Roast coffee	103	200	256 (255-257)	462	641	1 932
Instant (soluble) coffee	15	520	1123	2 629	8 044	8 044
Coffee substitutes	24	870	1 350 (1 349-1 350)	3 300	3 400	4 200
Unspecified coffee	9	300	441	1 800	1800	1 800
Baby foods (excl. cereal based)	55	12 (0-18)	69 (64-74)	116	419	1 107
Processed cereal based foods for infants and young children	128	24(0-30)	51 (45-57)	144	175	578
Biscuits and rusks for infants and young children	46	57	86 (83-90)	175	250	470
Other processed cereal based foods for infants and young children	82	13 (0-24)	31 (23-39)	60	130	578
Unspecified cereal based foods for infants and young children	0	.	.		.	
Other foods	336	82 (82-84)	225 (221-228)	612	811	3 972
Muesli and porridge	14	56	80 (77-83)	104	420	420
Pastries and cakes	81	55	146 (144-148)	420	793	890
Non-potato savoury snacks	80	115	192 (189-194)	389	618	1 910
Unspecified other products	161	81 (81-82)	293 (289-298)	707	1 330	3 972

(a): Values indicate middle bound (MB) and ranges in brackets indicate lower bound (LB) and upper bound (UB) values. When LB and UB do not differ from the MB, only the MB value is presented.
(b): 86 % were reported to be analysed as prepared, 14 % analysed as unprepared.
(c): 73 % were reported to be analysed as prepared, 8 % analysed as unprepared, 19 % type of preparation unknown.
(d): 56 % were reported to be analysed as prepared, 44 % analysed as unprepared.

The whole set of acrylamide results pertaining to the monitoring period 2007 to 2010 was compared with the acrylamide indicative values recommended by the EC in 2011. Some 6 to 17 % of the results in the different food categories exceeded indicative values (Table 8). The proportion of samples exceeding the indicative acrylamide values in the dataset was highest in the sub-category 'potato crisps' and lowest in 'breakfast cereals'. In 2010, the proportion of samples exceeding the indicative acrylamide values ranged from 3 to 20 % in different food categories. The highest proportion was found in the sub-category 'instant coffee' and the lowest in 'soft bread' and 'breakfast cereals'.

Table 8: Proportion of acrylamide values exceeding the indicative acrylamide values recommended by the European Commission in 2011[a].

Food category[a]	Number code[a]	Indicative value[a]	Proportion of MB acrylamide levels exceeding the recommended indicative values			
		(µg/kg)	n	2007-2010 (%)	n	2010 (%)
French fried, sold as ready-to-eat	1	600	1 968	12	256	15
Potato crisps	2	1 000	1 481	17	242	18
Soft bread	4	150	790	7	150	3
Breakfast cereals	5	400	675	6	174	3
Biscuits, crackers, crisp bread and similar[b]	6	500	3 262	8	462	12
Roast coffee (dry)	7.1	450	745	8	103	11
Instant (soluble) coffee	7.2	900	160	10	15	20
Baby foods (excl. cereal based)	8	80	425	7	55	15
Biscuits and rusks for infants and young children	9.1	250	301	9	46	7
Other processed cereal based foods for infants and young children	9.2	100	271	11	82	6

(a): Food categories, number codes and indicative acrylamide values as defined in Commission Recommendation of 10.1.2011 C(2010) 9681 final (EC, 2011)
(b): excluding ginger bread

3.6. Trend analysis of acrylamide levels in foods sampled from 2007 to 2010

The results of the mixed effect model trend analysis of the log transformed MB mean acrylamide content values in different European countries over the four year period are summarised in Table 9. The trend analysis showed only few changes in MB mean acrylamide levels from 2007 to 2010. A significant 'common European trend' was seen in two main food categories and three sub-categories. In addition, in one sub-category a marginally significant (P = 0.08) 'common European trend' was observed. A 'marginal European trend', i.e. a trend not applicable to all countries was seen in three sub-categories of foods.

For the main food categories, a decrease in MB mean acrylamide levels as a 'common European trend' was seen for 'processed cereal based foods for infant and young children' (49 % decrease in the mean acrylamide levels from 2007 to 2010 according to the model) and an increase for 'coffee and coffee substitutes' (41 % increase from 2007 to 2010). At sub-category level, a decrease in MB acrylamide levels was seen for 'biscuits and rusks for infants and young children' (43 % decrease from 2007 to 2010) and for 'non-potato savoury snacks' (35 % decrease from 2007 to 2010). An increase in acrylamide levels was also seen for 'crisp bread' (42 % increase from 2007 to 2010). In addition, as a 'common European trend' an increase in MB mean acrylamide levels was observed for 'wafers' though this was only marginally significant (P = 0.08) (Table 9).

At sub-category level, as a 'marginal European trend' a decrease was observed for 'other processed cereal based foods for infants and young children' (46 % decrease from 2007 to 2010) and an increase was observed for 'French fries from fresh potatoes' (39 % increase from 2007 to 2010) and 'instant coffee' (214 % increase from 2007 to 2010) (Table 9).

In addition to the trend analysis based on the mixed effect model on log transformed MB mean acrylamide values, differences in MB median acrylamide values during the period 2007 to 2010 were also estimated and are presented in table 9. Proportional differences ranged from a 69 % decrease to a 231 % increase. The largest differences between the MB median values during this time period were found in the sub-categories of 'instant coffee' (231 % increase from 2007 to 2010) and 'coffee substitutes' (148 % increase from 2007 to 2010).

Table 9: Trend analysis for log transformed MB mean acrylamide values across revised food categories during the monitoring period 2007 to 2010 and change of median values in the submitted acrylamide data.

Food category	Number of countries	Number of samples	Common European trend[a,b]	Marginal European trend[a,b]	Mean change from 2007 (%)	Median Change from 2007 (%)[f]
French fries, sold as ready-to-eat	24	1 968	n.a.[c]	-	-	
French fries from fresh potatoes	21	859	n.a.	↑	39	21
French fries from potato dough	2	2	n.i.[d]	n.i.[d]	-	
Unspecified French fries	23	1 107	n.a.	-	-	-12
Potato crisps	25	1 481	n.a.	-	-	
Potato crisps from fresh potatoes	21	509	n.a.	-	-	13
Potato crisps from potato dough	14	107	n.a.	-	-	10
Unspecified potato crisps	23	865	n.a.	-	-	-6
Pre-cooked French fries/potato products for home cooking	23	757	n.a.	-	-	
Fries baked in the oven (oven fries)[b]	15	228	n.a.	-	-	58
Deep fried fries[c]	20	174	n.a.	-	-	-52
Unspecified potato products for home cooking[d]	21	355	n.a.	-	-	0
Soft bread	25	767	n.a.	-	-	-28
Unspecified bread	6	23	n.i.[d]	n.i.[d]	-.	
Breakfast cereals	25	675	n.a.	-	-	8
Biscuits, crackers, crisp bread and similar	25	3 262	n.a.	-	-	
Crackers	14	152	n.a.	-	-	3
Crisp bread	20	506	↑	n.a.	42	-6
Wafers	6	203	↑[e]	n.a.	-[e]	76
Ginger bread	11	1 386	–	n.a.	-	-36
Other biscuits, crackers, crisp bread and similar.	25	1 015	n.a.	-	-	-48

Table 9, continued

Food category	Number of countries (n)	Number of samples (n)	Common European trend[a,b]	Marginal European trend[a,b]	Mean change from 2007 (%)	Median change from 2007 (%)[f]
Coffee and coffee substitutes	25	1 185	↑	n.a.	41	
Roast coffee	25	745	_	n.a.	-	0
Instant coffee	15	163	n.a.	↑	214	231
Coffee substitutes	13	182	n.a.	-	-	148
Unspecified coffee	11	95	n.a.	-	-	11
Baby foods (excl. cereal based)	22	425	n.a.	-	-	-20
Processed cereal based foods for infants and young children	24	645	↓	n.a.	-49	8
Biscuits and rusks for infants and young children	17	301	↓	n.a.	-43	-47
Other processed cereal based foods for infants and young children	23	271	n.a.	↓	-46	-35
Unspecified cereal based foods for infants and young children	16	73	-	n.a.	-	
Other foods	25	1 528	n.a.	-	-	
Muesli and porridge	14	159	n.a.	-	-	-69
Pastries and cakes	14	273	n.a.	-	-	-19
Non-potato savoury snacks	16	242	↓	n.a.	-35	-35
Unspecified other products	25	854	n.a.	-	-	-27

(a): 'Common European trend' = slope of the change does not differ significantly from one country to another, 'Marginal European trend' = trend of the whole pool of samples, even if trends differ from one country to another.
(b): - = no change, time effect statistically non-significant, ↑ = Increased trend over the time period 2007 to 2010 ↓ = Decreased trend over the time period 2007 to 2010
(c): n.a. = not applicable. Model I or model II was found to best fit the data, see section 2.1.4. Trend analysis.
(d): n.i. = not enough information to estimate the parameters in the model.
(e): Marginal difference, P-value = 0.08.
(f): Percentage change between MB median acrylamide values from occurrence data presented in Tables 4-7.

3.7. Seasonal differences in acrylamide levels of potato products

Seasonal differences (i.e. second half of a given year vs. first half of the following year as well as first half of a given year vs. second half of the same year) during the reporting period are presented in the Table 10. When the acrylamide levels of potato products sampled in autumn of a given year were compared with levels of similar products sampled in spring of the following year, acrylamide levels were higher in 'potato crisp' samples after the storage period of potatoes. In the two other sub-groups of potato products seasonal differences in acrylamide levels were inconclusive. When seasonal differences were compared during the same sampling year, in most cases, acrylamide levels were lower in the second half of the year (sampled between July to December) compared to the first part of the year. This was most consistently observed in the main food category 'potato crisps' and especially in the sub-category 'potato crisps from fresh potatoes'. Higher acrylamide levels in samples collected between July to December were seen in 'French fries' in 2008 and in 'unspecified potato crisps' as well as 'fries baked in the oven (oven fries)' in 2010, respectively (Table 10).

Table 10: Seasonal differences in MB acrylamide levels[a] per a one year cycle and over the whole monitoring period.

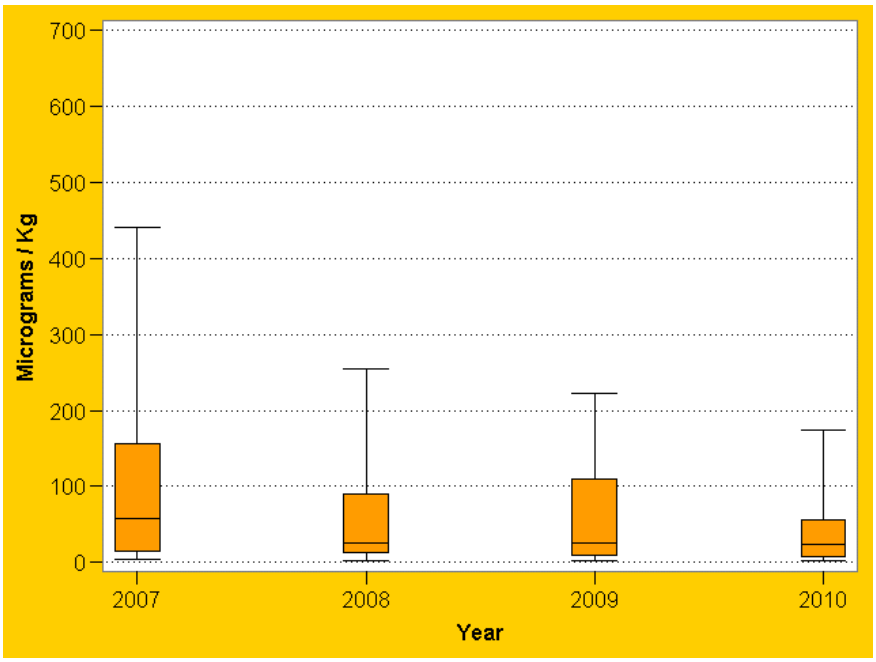
Food category	Season difference from July-December (Season 1) to January- June (Season 2) of the following year				Season difference from January-June (Season 1) to July-December (Season 2) of the same year[b]				
	2007-2008	2008-2009	2009-2010	2007-2010	2007	2008	2009	2010	2007-2010
French fries (all sub-categories included)	↓	–	↑*	–	–	↑	↓	–	–
French fries from fresh potatoes	↓	–	–	–	–	↑	–	–	–
Unspecified French fries	–	↑	–	↑	–	–	↓	–	↓
Potato crisps (all sub-categories included)	↑	↑*	↑	↑	–	↓	↓	–	↓
Potato crisps from fresh potatoes	↑*	–	↑	↑	–	↓	↓	↓	↓
Potato crisps from potato dough	–	–	–	–	–	–	–	–	–
Unspecified potato crisps	↑	↑*	–	↑	–	–	↓	↑	↓
Pre-cooked potato products for home cooking	–	↑*	–	–	–	–	–	–	–
Fries baked in the oven (oven fries)	–	↑*	–	–	–	–	–	↑	–
Deep fried fries	–	–	–	–	–	–	–	–	–
Unspecified pre-cooked French fries, potato products for home cooking	↓	–	–	–	–	–	–	–	–

(a): Pooled samples from sampling months from January to June or pooled samples from July to December.

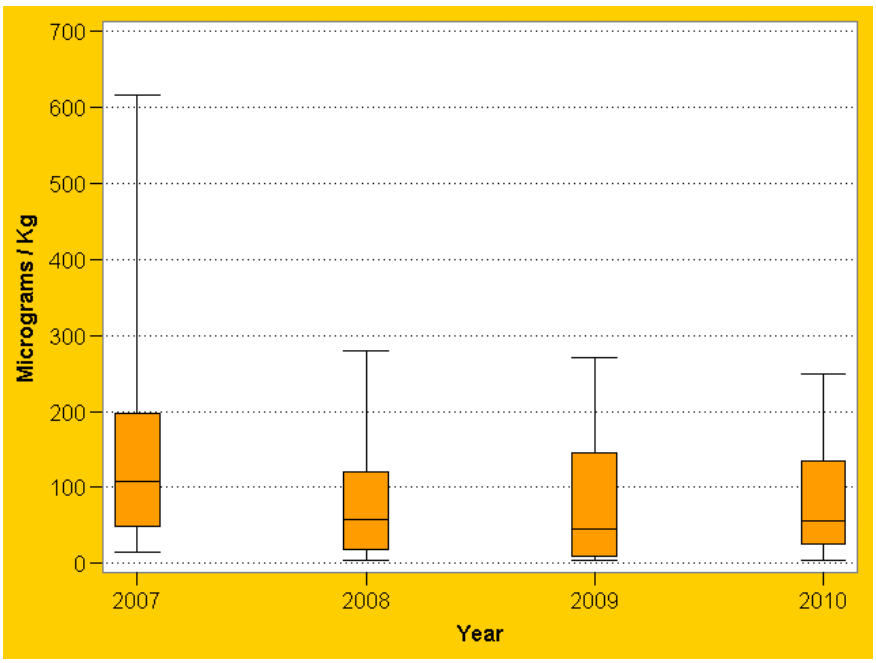
(b): – = no change, season effect not statistically significant, ↑ = significantly higher acrylamide levels in season 1 compared to season 2 (P-value < 0.05), ↓ = significantly lower acrylamide levels in season 1 compared to season 2 (P-value < 0.05), ↑* = marginally higher acrylamide levels in season 1 compared to season 2 (P= 0.05-0.10), ↓* = marginally lower acrylamide levels in season 1 compared to season 2 (P= 0.05-0.10)

.

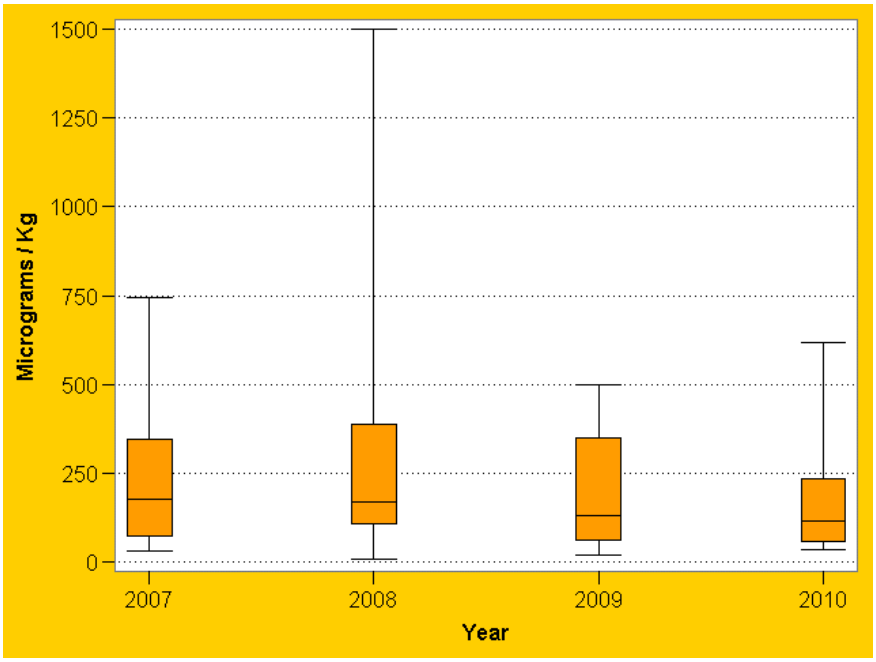
Distributions of MB acrylamide levels in food categories which showed a decreased trend during 2007 to 2010 period are shown in the Figure 5 (A-D) while food categories which showed an increased trend are illustrated in the Figure 6 (A-E).



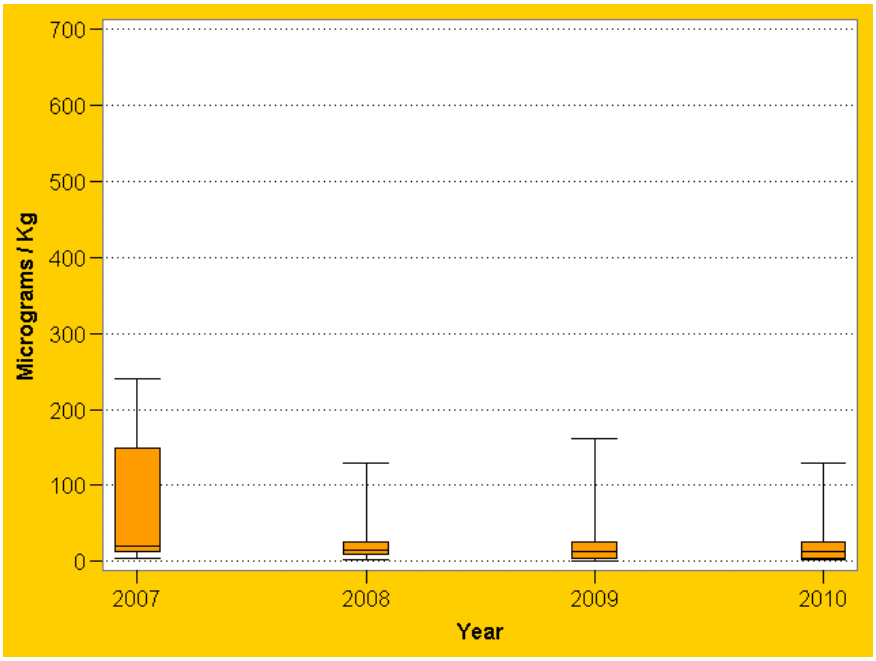
A: 'Processed cereal based food for infants and young children' ('common European trend').



B: Biscuits and rusks for infants and young children ('common European trend')

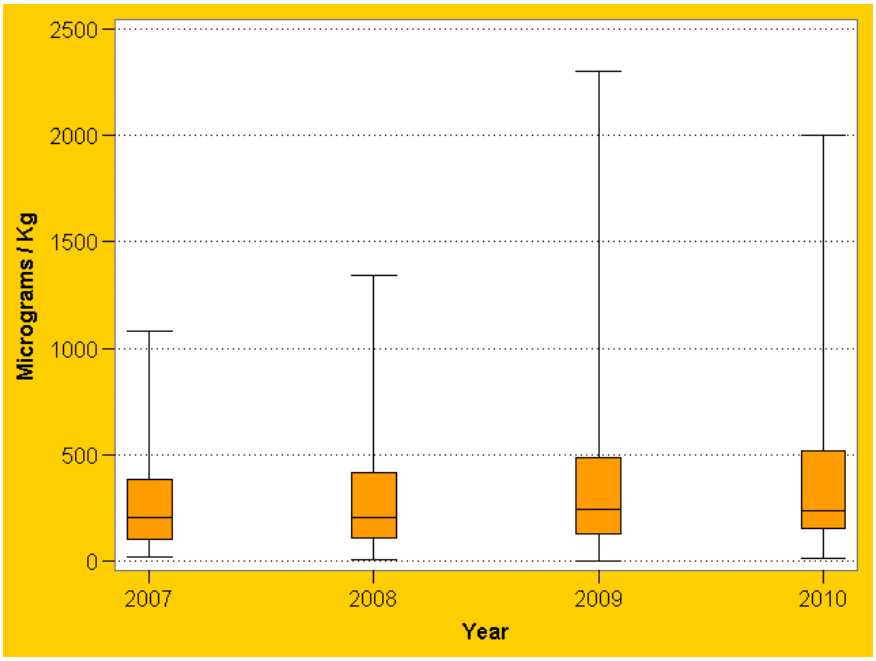


C: Non-potato savoury snacks ('common European trend')

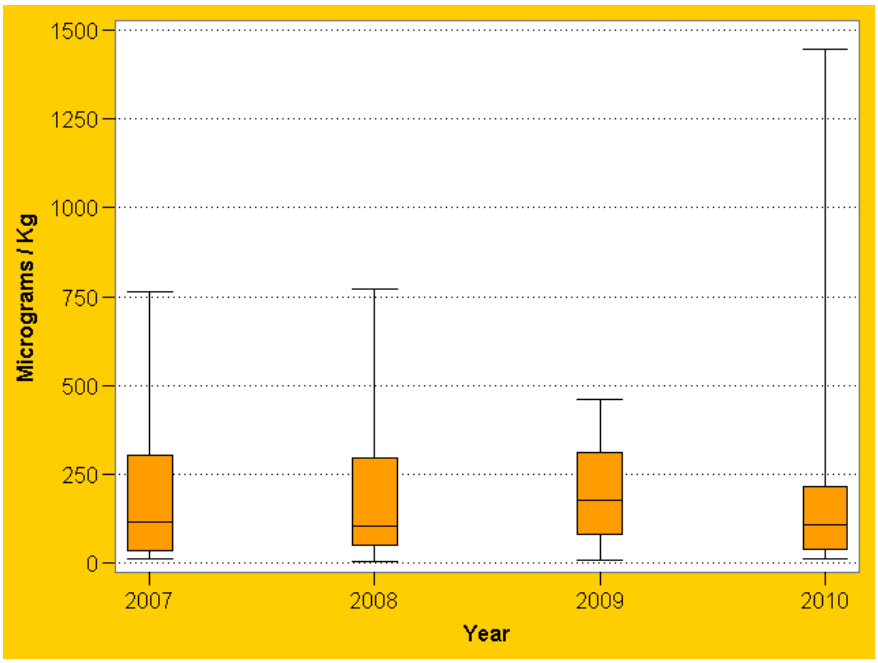


D: Other processed cereal based foods for infants and young children ('marginal European trend')

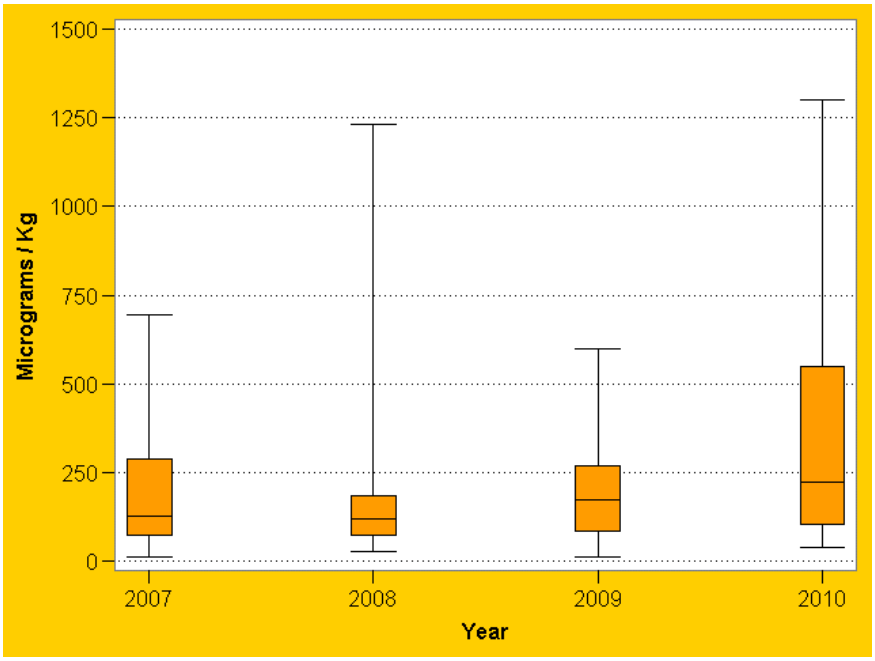
Figure 5: Distribution of MB median acrylamide levels (µg/kg) in food categories which showed a decreased trend in acrylamide levels between 2007 and 2010 (A-D). Box-plot: whiskers at P5 and P95, box at P25 and P75 with line at P50.



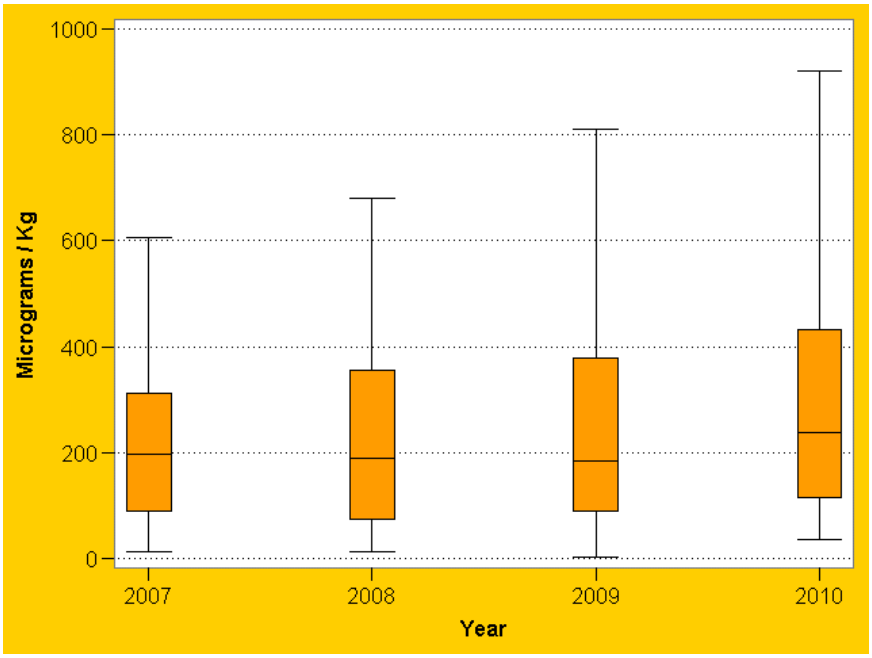
A: **'Coffee and coffee substitutes** ('common European trend')



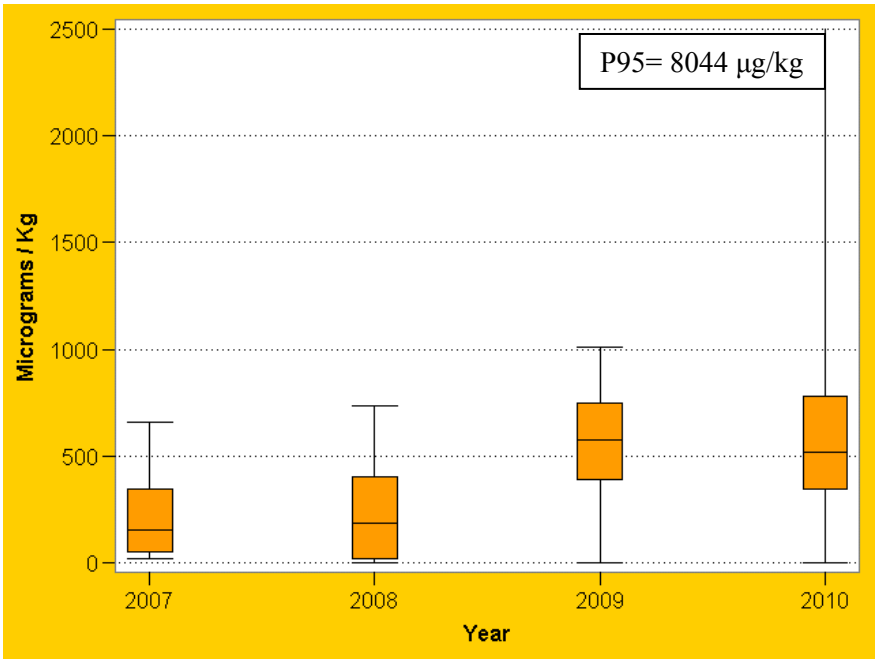
B: **Crisp bread (**'common European trend'**)**



C: **Wafers** (‘common European trend’, marginally significant, P-value = 0.08**)**



D: ‘French fries from fresh potatoes (‘marginal European trend’)



E: Instant coffee ('marginal European trend')

Figure 6: Distribution of MB median acrylamide levels (µg/kg) in food categories with increased European trend between 2007 and 2010 (A-E). Box-plot: whiskers at P5 and P95, box at P25 and P75 with line at P50.

4. Discussion

4.1. Sampling

Information on the sampling programme, strategy and method is an important background when evaluating changes of acrylamide occurrence in food products. Differences in sampling strategies and methods may result in sampling bias that should be controlled for in the statistical model used. This is only possible if accurate information on the sampling is provided. In this monitoring exercise, sampling information was available only from the year 2010, when it became mandatory information, within the EFSA data collection framework, through the harmonised data structure described in the document 'Guidance on Standard Sample Description' (EFSA, 2010a). The proportion of sampling related variables reported as 'unknown/other/not specified' was only 2-9 % in the data pertaining to the 2010 monitoring period. This result is encouraging as it shows that countries are providing sampling information since this became mandatory part of the submissions. On the other hand, only 19 countries submitted data sampled in 2010 compared with 25 countries in 2008 (Table 2). This may reflect the challenges that countries have had in submitting requested acrylamide data in a standardised way. Variability in the number of countries submitting acrylamide data and in the number of results submitted as well as possible sampling bias may have further increased uncertainty e.g. in relation to the proportion of quantified results during the monitoring period (Figure 4). EFSA continues to focus on data quality and Member States are encouraged to submit data in accordance with EFSA requirements: 'Specific Requirements for Chemical Contaminants Data Submission' (EFSA, 2012), including sampling information applied to acrylamide data collection. This will facilitate more robust evaluations of acrylamide occurrence and exposure in Europe.

4.2. Uncertainties in time and seasonal trend analysis

To carry out a reliable trend analysis, an adequate number of samples as well as a sufficiently long monitoring period are essential starting points. In addition, a prerequisite to carry out a robust trend analysis relates to the homogeneity of the data in the time series to be compared. In the case of the analysis of acrylamide levels in different food categories, this would include the number of samples in

annual data collections, accuracy of food categorisation throughout the years, possible preparation of the samples for analysis and documentation of the analytical methods used.

A four-year time period is considered short to distinguish random fluctuations from real trends. This is because variance in acrylamide levels may be found between countries, within countries, between foods in the same food category or sub-category as well as between the same food product from batch to batch of production. In addition, the analytical methods used and the sensitivity of the methods have evolved during the monitoring period which may have influenced the results of the trend analysis. With this short monitoring period, only a linear model could be fitted, although a non-linear model could be more relevant taking into account the fluctuation in the acrylamide values from year to year. To improve the interpretation of results in future years it is important to consistently sample the same type of products in different years and to collect a sufficient number of samples per food group.

The pre-treatment or preparation of foods sampled is also not consistent from year to year in all countries, which lowers the accuracy of the trend analysis. For example, in the case of 'potato products for home cooking', acrylamide results should be reported 'as consumed', i.e. after final preparation (EC, 2007; EC, 2010). During 2007 to 2010 'pre-cooked French fries/potato products for home cooking' were on average in 45 % of the cases prepared before analysis, 7 % were unprepared and for 48 % of the samples the preparation before analysis was reported to be 'unknown'. In 2009, preparation was reported to be 'unknown' in case 93 %-100 % of the samples in this food category. These differences in sample preparations were not included in the model of the trend analysis, but variation that might occur associated to such difference are captured in the model when including 'country' as a proxy for other sources of variations that were not measured and thus it was not possible to adjust for them during the analysis process.

To summarise, more years of monitoring, stable number of samples on each monitoring year and more comparable background information of the sample pool would strengthen the trend analysis.

4.3. Potato products

The percentage of the MB acrylamide results for 'French fries, sold as ready-to-eat' exceeding the indicative acrylamide value by the EC triggering further investigation (EC, 2011) was 12 % in the whole dataset during the period 2007 to 2010 and 15 % in 2010 (Table 8). The slight increase in number of acrylamide values exceeding the respective indicative acrylamide value in the case of 'French fries from fresh potatoes' is in accordance with the increased 'marginal European trend' seen in this evaluation as well as with the 21 % increase of MB median acrylamide values during the four-year monitoring period (Table 9). Also, an increase as a 'marginal European trend' for 'French fries from fresh potatoes' was observed. 'Potato crisps from fresh potatoes' exceeded the indicative values in the case of 18 % of the samples. In the trend analysis, however, no 'common' or 'marginal European trend' for 'potato crisps from fresh potatoes' was observed (P value = 0.11).

A range of mitigation procedures has been developed and an abundant amount of research done on acrylamide mitigation in potato products (Zhang & Zhang 2007; Foot et al., 2007; CIAA, 2009; Vinci et al., 2012). These cover the whole range from raw material production, storage conditions and different processing steps. The discouraging results of mitigation measures concerning potato products have led to a call for more active actions by the authorities (Biedermann, 2010).

Lower levels of acrylamide were seen in potato products that were sampled during July to December of a given year compared with January to June of the following year, especially in the 'potato crisp' food group. This is likely due to seasonal variation in acrylamide precursors or other factors affecting acrylamide formation. The precursors are at lower level in potatoes recently harvested (Vinchi et al., 2012). However, seasonal differences observed during the period 2007 to 2009 in the category 'French fries' were not observed in 2010. With the information available it cannot be concluded whether this is a result of raw material selection, change in storage temperature or time, possibly increasing the sugar

content of the raw material, or active mitigation activities. The results of the comparison of acrylamide levels in potato products between spring season and autumn season in the same sampling year are in accordance with the comparison between autumn and the following spring, but can additionally be affected by the different harvest years e.g. by climatic differences between the years. The former seasonal analysis performed by EFSA showed also that the seasonal variation was mainly seen in the food group 'potato crisps' (EFSA 2011).

4.4. Cereals and cereal products

The number of samples exceeding the indicative acrylamide values set by the EC (EC, 2011) decreased in about half of the food groups (levels in 2010 compared to the whole dataset from 2007 to 2010, Table 8). However, in the other half of the food groups the number of samples exceeding the indicative values increased by up to 20 % (Table 8). The main food category with least samples exceeding the indicative values, i.e. 'processed cereal based products for infants and young children' is the only main food category in which a decreased 'common European trend' was observed in the trend analysis (Table 9) and can be considered as a food category where mitigation actions may have taken place (Figure 5A).

Although the sub-categories of 'soft bread' and 'breakfast cereals' were food categories with least samples exceeding the indicative values recommended by the Commission, no 'common European trend' for the MB mean acrylamide levels was found for these sub-categories. In the case of 'soft bread', a decrease was seen for the UB mean values ('marginal European trend'), indicating that this finding may partly be connected to the sensitivity of analytical methods in relation to the food matrix with low levels of acrylamide, as well as the handling of LC data in the trend analysis. In the case of 'soft bread' the percentage of LC values varied between 40-50 % during the monitoring period. In the MB approach LC result is taken into account at half of the respective analytical limit, i.e. replaced by half of the LC limit (e.g. the LOQ value), while in the case of the UB approach LC results are replaced by the LC limit value. In this way the MB approach may prevent of overestimations compared to the UB approach in case of a high number of LC data and high LC limits. A 28 % decrease was observed between the MB median acrylamide levels of 'soft bread' between 2007 and 2010. Although reasonably low levels of acrylamide were found in 'soft bread', it is an important acrylamide source in European diets. The contribution of 'soft bread' to acrylamide exposure has been shown to be approximately 20 % among children and adolescents and up to 30 % among adults (EFSA, 2011). A decrease in the number of 'soft bread' samples with high acrylamide levels can therefore be considered as a favourable finding.

A 'common European trend' was seen in MB mean acrylamide levels of 'crisp bread' with a 42% increase based on a linear model, although at the same time the difference between MB median values from the year 2007 to 2010 was -6 %. This indicates changes in the acrylamide content distribution. Although not presented in this report, a possibility of a bi-modal distribution, a distribution having two distict peaks, was observed for MB acrylamide values of 'crisp bread' during the monitoring period (2007 to 2010) in some countries. The number of samples in the sub-category 'crisp bread' was, however, small in many countries and especially in 2010. More acrylamide samples from several years would be needed for a more accurate trend analysis concerning the sub-category 'crisp bread'.

A marginally significant increase in MB mean acrylamide values was observed for the sub-category 'wafers' (Table 9, Figure 6C). This was also observed in the comparison of the median MB values between the year 2007 and 2010 showing an increase by 76 %.

In the case of 'ginger bread,' MB median acrylamide levels showed a 36 % decrease during the monitoring period. However, no significant 'common European trend' was observed. This may indicate that the quality of these products vary between European countries providing acrylamide data.

Overall, cereal based food groups showed a decreased trend in acrylamide levels. The proportion of values exceeding the indicative limits triggering further investigation (EC, 2011) were lower in cereal

products compared to other food categories. In 2010, only 3-7 % of the cereal products exceeded the limit, except the food category 'biscuits, crackers, crisp bread and similar', where over 12 % of the samples exceeded the limit.

4.5. Coffee and coffee substitutes

Overall, an increased 'common European trend' was observed for 'coffee and coffee substitutes' with an overall change of 41 % based on the fitted model of the trend analysis. High acrylamide levels of coffee products, especially in product categories 'instant coffee' and 'coffee substitutes' were also seen. The MB median acrylamide levels were more than 200 % and close to 150 % higher in 2010 for 'instant coffee' and 'coffee substitutes', respectively, compared to the results of the year 2007.

The increased 'marginal European trend' of acrylamide levels in 'instant coffee' is in accordance with the results from the previous acrylamide update report covering the years 2007 to 2009 (EFSA, 2011) as well as with the increase in the proportion of samples exceeding the indicative values by the EC. This does not seem to apply, however, to 'roast coffee', which showed a constant level of acrylamide both in the trend analysis and when MB median levels from 2007 were compared with levels in 2010.

It is possible that 'coffee and coffee substitutes' is a food group where substantial reduction of acrylamide content is unlikely without affecting the quality and acceptance of the food or developing additional food safety issues (Lineback et al, 2012). It should also be kept in mind that 'roast coffee' and 'instant coffee' products are not consumed as such in large quantities, but brewed or, in case of powdered products, dissolved in water before consumption. The contribution of coffee to acrylamide exposure has been shown among adults in high coffee consuming countries to be up to about 40 %, but is more commonly around 10 % (EFSA, 2011).

4.6. Other food categories

The proportion of 'baby foods' samples exceeding the indicative values recommended by the Commission by up to 15 % in 2010 was compared with the whole dataset (2007-2010). The finding that during the period of 2007 to 2010 the MB median acrylamide levels in this food category decreased by 20 % shows that the acrylamide distribution in this food group is widening.

4.7. Monitoring the mitigation activities

Monitoring programmes to follow-up the effectiveness of the acrylamide mitigation activities have been in place in many countries since the start of compilation of acrylamide occurrence values to an European database (Lineback et al., 2005; Wenzl &Anklam, 2007). Parallel to the monitoring programme coordinated by the EC (EC, 2007; EC, 2010; EC, 2011) also national monitoring programmes have taken place in several European countries and in other continents (VWA, 2007; Scientific Committee of the FASFC, 2008; Clayes et al., 2010; Biederman et al., 2010; FSA, 2012; Health Canada, 2012; Tsukakoshi et al., 2012). The results of the trend analyses described in these publications have been inconclusive. While some indication of a decreased trend in 'potato crisps' and some 'cereal products' were seen between 2002 and 2007 in the Netherlands (VWA, 2007), no positive effects of the mitigation activities were found between 2002 and 2006 in Belgium (Scientific Committee of the FASFC, 2008). In Germany, the mitigation activities have showed success in some food categories, but in others an increase in acrylamide content was reported (Kliemant & Göbel, 2007). In a Swiss analysis, no improvement in mitigation of acrylamide levels was seen during the period of 2007-2009 (Biedermann et al., 2010). Results from a recent monitoring programme in the UK (FSA, 2012) suggest that there may be an upward trend in acrylamide levels in processed cereal based baby foods (excluding rusks) and a reduction of acrylamide content in some other products such as 'pre-cooked French fries/potato products for home-cooking' and 'bread'.

The present update of acrylamide levels in European foods showed some indications of a favourable 'common European trend' in 'biscuits and rusks for infants and young children' and in 'non-potato savoury snacks'. In addition as 'marginal European trend' a decrease not consistent in all countries, was seen in 'other processed cereal based foods for infants and young children'. A common increase

in acrylamide levels was observed for 'coffee and coffee substitutes' and at sub-category level for 'crisp bread'. An increase, not consistent in all countries, was observed for 'instant coffee ' as well as for 'French fries from fresh potatoes'.

CONCLUSIONS

- Since the 2008 monitoring period, the number of results submitted to EFSA declined.
- The recommended limits of quantification set for the acrylamide monitoring by the EC were not reached by many laboratories.
- Reporting of the analytical methods used has improved since 2007. In 2010 an indication of the analytical method used was obtained for all submitted samples.
- Overall, a decrease in acrylamide levels was shown in only a few food categories.
- The lowest levels of acrylamide and a decreased 'common European trend' were seen for 'cereal based products for infants and young children'. At sub-category level, a common decrease was also seen for 'biscuits and rusks for infants and young children' as well as for 'non-potato savoury snacks'. A decrease, though not consistent in all countries, was also seen for the sub-category 'other processed cereal based food for infants and young children.'
- In certain food groups acrylamide levels have increased during the four-year monitoring period. An common increase was observed for 'coffee and coffee substitutes' and at the sub-category level for 'crisp bread'. An increase, though not consistent in all countries, was found for 'French fries from fresh potatoes' and 'instant coffee'.
- In 2010, indicative acrylamide values recommended by the EC were exceeded in case of 3-20 % of samples in different food categories.
- An extended time period and detailed descriptions of sample sources would be needed for a more accurate trend evaluation.

REFERENCES

Biedemann M, Grundböck F, Fiselier K, Biedemann S, Bürgi C and Grob K, 2010. Acrylamide monitoring in Switzerland, 2007-2009: results and conclusions. Food Additives and Contaminants: Part A, 27, 1352-1362.

Castle L and Eriksson, S, 2005. Analytical methods used to measure Acrylamide concentration in Foods. Journal of AOAC International 88, 274-284.

CIAA (Confederation of the European Food and Drink Industries), 2005. Rev 6. The CIAA crylamide "toolbox". Confederation of the European Food and Drink Industries (CIAA), Brussels, 29 pp.

CIAA (Confederation of the European Food and Drink Industries), 2009. Rev 12. The CIAA acrylamide toolbox. Confederation of the European Food and Drink Industries (CIAA), Brussels, 41 pp.

Claeys W, Baert K, Mestdagh F, Vercammen J, Daenens P, Meulenaer , Maghuin-Rogister G and Huyghebaert A, 2010. Assessment of the acrylamide intake of the Belgian population and the effect of mitigation strategies. Food Additives and Contaminants: Part A, 27:9, 1199-1207.

Codex Alimentarius. 2009, online. Code of Practice for the Reduction of acrylamide in foods. Rome (Italy): codex alimentarius. Available from www.codexalimentarius.org/ input/download standards/ .../CXP_067e.pdf

Dybing E, Farmer PB, Andersen M, Fennell TR, Lalljie SPD, Müller DJG, Olin S, Petersen BJ, Schlatter J, Scholz G, Scimeca JA, Slimani N, Törnqvist M, Tuijtelaars S and Verger P, 2005. Human exposure and internal dose assessments of acrylamide in food. Food and Chemical Toxicology 43, 365-410.

EC (European Commission), 2007. Commission recommendations of 3 May 2017 on the monitoring of acrylamide levels in food. Official Journal of the European Union, L 123, 12.5.2007, pp.33-39.

EC (European Commission), 2010. Commission recommendations of 2 June 2010 on the monitoring of acrylamide levels in food. Official Journal of the European Union, L 137, 3.6.2010, pp.4-10.

EC (European Commission), 2011. Recommendation of 11 January 2011 on investigations into the levels of acrylamide in food, C (2010) 9681 final.

EFSA (European Food Safety Authority), 2005. Statement on summary report on Acrylamide in food of the 64th meeting of the joint FAO/WHO expert committee on food additives by the Scientific Panel on contaminants in the food chain (CONTAM), Parma. Available from http://www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1178620773121.htm

EFSA (European Food Safety Authority), 2009. Results on the monitoring of acrylamide levels in food. Scientific report. 285, 1-26. Available from www.efsa.europa.eu

EFSA (European Food Safety Authority), 2010a. Standard sample description for food and feed. EFSA Journal 2010b;8(1):1457 [54 pp.]. doi:10.2903/j.efsa.2010.1457. Available from: www.efsa.europa.eu

EFSA (European Food Safety Authority), 2010b. Management of left-censored data in dietary exposure assessment of chemical substances. EFSA Journal 2010;1557 8(3): [96 pp.]. doi:10.2903/j.efsa.2010.1557. Available from : www.efsa.europa.eu

EFSA (European Food Safety Authority), 2010c. Results on acrylamide levels in food from monitoring year 2008. Scientific report. EFSA Journal 2010; 8(5):1599. Available from: www.efsa.europa.eu

EFSA (European Food Safety Authority), 2011.Results on acrylamide levels in food from monitoring years 2007-2009. EFSA Journal 2011;9(4):2133. [48 pp.] doi:10.2903/j.efsa.2011.2133. Available from: www.efsa.europa.eu

EFSA (European Food Safety Authority), 2012 Specific Requirements for Chemical Contaminants Data Submission. Available from: http://www.efsa.europa.eu/en/datexdata/docs/dataspecificrequirements.pdf

FAO/WHO (Food and Agricultural Organisation/World Health Organisation), 2005, online. Summary and conclusions of the sixty-forth meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA), pp. 1-17. Available from http://www.who.int/ipcs/food/jecfa/summaries/en/summary_report_64_final.pdf

FAO/WHO (Food and Agricultural Organisation/World Health Organization), 2010, online. Summary and conclusions report of the seventy-second meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA),pp 1-16. Available from http://www.fao.org/ag/agn/agns/ jecfa_output _en.asp

FASFC (Scientific Committee of the Federal Agency for the Safety and the Food Chain), 2008. Advice 25-2008 of the Scientific Committee of the FASFC on acrylamide. Exposure of the Belgian population, contribution of different foodstuff and methodology for defining action limits. 20 pp.

Food Drink Europe, 2011. Acrylamide Toolbox 2011. Confederation of the Food and Drink Industries of the EU (FoodDrinkEurope), Brussels, 47 pp.

Foot RJ, Haase NU, Grob K and Gondé P, 2007. Acrylamide in fried and roasted potato products: A review on progress in mitigation. Food Additives & Contaminants 24, supplement 1: 37-46.

FSA (Food Standard Agency) 2012, online. A Rolling programme of surveys on process contaminants in UK retail foods. Acrylamide & Furan: Survey 4. Food Survey information sheet, Number 2/12, April 2012. 47 pp. Available from: http://www.food.gov.uk/multimedia/pdfs/acrylamide-furan-survey.pdf

Health Canada, 2012, online. Health Canada's Revised Exposure Assessment of Acrylamide in Food. Available from http://www.hc-sc.gc.ca/fn-an/securit/chem-chim/food-aliment/acrylamide/rev-eval-exposure-exposition-eng.php

IARC, 1994. Acrylamide, In IARC monographs on the evaluation of carcinogenic risks to humans, some industrial chemicals, Vol 60, pp. 387-433, WHO, Geneva, Switzerland.

Keramat J, LeBail A, Prost C and Soltanizahed N, 2011. Acrylamide in Foods: Chemistry and Analysis. A Review. Food Bioprocess Technology 4,340-363.

Kliemant A and Göbel A, 2007. The acrylamide minimisation concept: a risk management tool. In Thermal Processing of Food: Potential Health Benefits and Risks, ed., Senate Commission on Food Safety (SKLM) of Deutche Forshungsgemeinscheft, Weinheim: Wiley-VCH. 293 pp.

Lineback D, Wenzl T, Osterman OP, de la Galle B, Anklam E and Taeymans D, 2005. Overview of acrylamide monitoring databases. Journal of AOAC International 88,246-252.

Lineback DR, Goughlin JR and Stadler RH, 2012. Acrylamide in foods: A review of the science and future considerations. Annual Reviews of Food Science and Technology 3,10.1-10.21.

SNFA (Swedish National Food Administration), 2002. Swedish National Food Administration> Analysis of Acrylamide in Food. http://www.slv.se/acrylamide

Taeymans D, Vood J, Ashby P, Blank I, Studer A, Stadler RH, Gondé P, Eijck P, Lalljie S, Lingnert H, Lindblom M, Matissek R, Müller D and Tallmadge D, 2004. A review of acrylamide: An industry perspective on research, analysis, formation, and control. Critical Reviews in Food Science and Nutrition 44,323-347.

Tareke E, Rydberg P, Karlsson P, Eriksson S and Tornqvist M, 2002. Analysis of Acrylamide, a carcinogen formed in heated foodstuffs. Journal of Agricultural and Food Chemistry 50, 4998-5006.

Tsukakoshi Y, Ono H, Kibune N, Isagawa S, Yamazaki K, Watai M and Yoshida M, 2012. Monitoring of acrylamide concentrations in potato chips in Japan between 2006 and 2010. Food Additives & Contaminants 29,1212-1218.

Tukey JW, 1977. Exploratory data analysis. Addison-Wesely, Reading, MA.

Verbeke G and Molenberghs G, 2000. Linear mixed models for longitudinal data. Springer Series in Statistics, Springer-Verlag, New-York, 568 pp.

Vinchi RM, Mestdagh F and de Meuleraer B, 2012. Acrylamide formation in fried potato products – Present and future, a critical review on mitigation strategies. Food Chemistry 133,1138-1154.

VWA (Voedsel en Waren Autoriteit), 2007. Acrylamide in levensmiddelen op de Nederlandse markt (in Dutch). Voedsel en Waren Autoriteit. 18 pp.

Wenzl T, De La Calle MB and Anklam E, 2003. Analytical methods for the determination of acrylamide in food products: A review. Food Addititives & Contaminants 20,885-902.

Wenzl T and Anklam E, 2007. European Union database of acrylamide levels in food: Update and critical review of data collection. Food Additives & Contaminants 24, (supplement 1), 5-12.

World Health Organization (WHO), 2009. Dietary exposure assessment of chemicals in food (Chapter7). Principles and methods for the risk assessment of chemicals in food. Environmental Health Criteria 240. FAO/WHO. International Programme on Chemical Safety (IPCS). Geneva: WHO, 2009. Available from http://www.who.int/ipcs/food/principles/en/index.html

Zhang Y and Zhang Y, 2007. Formation and Reduction of Acrylamide in Maillard Reaction: A Review Based on the Current State of Knowledge, Critical Reviews in Food Science and Nutrition, 47, 521-542.

ABBREVIATIONS

CIAA The Confederation of the Food and Drink Industry (Since June 2011 FoodDrinkEurope)

EC European Commission

EFSA European Food Safety Authority

FAO Food and Agriculture Organization

LB Lower bound – left-censored result entered as zero

LC Left-censored

LOD Limit of detection

LOQ Limit of quantification

MB Middle bound – left-censored result entered at half of the respective analytical limit

P50 50th percentile (Median)

P90 90th percentile

P95 95th percentile

SSD Standard Sample Description

UB Upper bound – left-censored result entered at the respective analytical limit

UK United Kingdom

VWA Voedsel en Waren Autoriteit, Netherlands

WHO World Health Organisation