

## SCIENTIFIC REPORT OF EFSA

# Dietary exposure to inorganic arsenic in the European population<sup>1</sup>

European Food Safety Authority<sup>2,3</sup>

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### ABSTRACT

Arsenic is a ubiquitous metalloid present at low concentrations in rocks, soil and natural ground water. A total of 103 773 food samples (including drinking water) were used to calculate dietary exposure to inorganic arsenic (iAs). Of these, 101 020 were based on total arsenic (tAs) and 2 753 on iAs. Among the reported results on tAs, 66.1 % were below the limit of detection or quantification (left-censored); for the reported data on iAs the percentage of left-censored data was 41.9 %. Most of the data (92.5 %) reported as tAs were converted to iAs using different approaches before calculating dietary exposure to iAs. The EFSA Comprehensive European Food Consumption Database was used to estimate chronic dietary exposure to iAs using 28 surveys from 17 European countries. According to the scenarios used for the treatment of left-censored data, mean dietary exposure among infants, toddlers and other children ranged from 0.20 to 1.37 µg/kg b.w. per day, while the 95<sup>th</sup> percentile dietary exposure estimates ranged from 0.36 to 2.09 µg/kg b.w. per day. Mean dietary exposure among the adult population (including adults, elderly and very elderly) ranged from 0.09 to 0.38 µg/kg b.w. per day, and 95<sup>th</sup> percentile dietary exposure estimates ranged from 0.14 to 0.64 µg/kg b.w. per day. For all the age classes except infants and toddlers, the main contributor to dietary exposure to iAs was the food group 'Grain-based processed products (non rice-based)', in particular, wheat bread and rolls. Other food groups that were important contributors to iAs exposure were rice, milk and dairy products (main contributor in infants and toddlers), and drinking water. The most important sources of uncertainty in the present assessment are related to the heterogeneity of the food consumption data, the conversion of tAs into iAs and to the treatment of the left-censored data.

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### KEY WORDS

food, occurrence data, dietary exposure, inorganic arsenic

<sup>1</sup> On request from the European Commission, Question No EFSA-Q-2012-00107, approved on 28 February 2014.

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<sup>3</sup> Acknowledgement: EFSA wishes to thank all the European countries that provided occurrence data on arsenic, the European Commission that supported the consumption data collection for the Comprehensive European Food Consumption Database, EFSA's staff members: José Ángel Gómez Ruiz, for the preparatory work on this scientific output, Davide Arcella, Mary Gilsean and Enikő Varga for the support provided to this scientific output. Special thanks to Michael DiNovi and Peter Fürst for reviewing the final report and providing valuable comments.

Suggested citation: European Food Safety Authority, 2014. Dietary exposure to inorganic arsenic in the European population. EFSA Journal 2014;12(3):3597, 68 pp. doi:10.2903/j.efsa.2014.3597

Available online: [www.efsa.europa.eu/efsajournal](http://www.efsa.europa.eu/efsajournal)

## SUMMARY

The current report provides information on the levels of arsenic (total arsenic (tAs) and inorganic arsenic (iAs)) found in a range of foods on the European market classified according to the FoodEx classification system (EFSA, 2011a). In addition, it provides estimates of chronic dietary exposure to iAs in Europe using individual consumption data from the EFSA Comprehensive European Food Consumption Database (EFSA, 2011b).

Arsenic is a ubiquitous metalloid present at low concentrations in rocks, soil and natural ground water. In natural ground water, arsenic is typically present in inorganic forms (As(III), As(V) or a combination of both); organic forms are rare in water as they are the result of biological activity. Although dermal and inhalation exposure is possible, food and drinking water are the principal routes of exposure to arsenic (WHO, 2011a; IARC, 2012). Organic arsenic species such as arsenobetaine and different arsenosugars are the most common forms in seafood while in foods of terrestrial origin the predominant arsenic forms are iAs (both As(V) and As(III)) and single methylated arsenic species (methylarsonate, methylarsenite and dimethylarsinate (DMA)). Arsenic enters the food chain mainly through contaminated water and soil (Francesconi, 2005).

iAs is more toxic than organic arsenic compounds. Although both forms of iAs are potentially harmful to human health, As(III) is considered more toxic than As(V) (Hughes et al., 2011). The International Agency for Research on Cancer (IARC) classified arsenic and iAs compounds as 'carcinogenic to humans' (Group 1) based on sufficient evidence of carcinogenicity in humans (IARC, 1973, 1980). In 2010 the Joint FAO/WHO Expert Committee on Food Additives (JECFA) withdrew the provisional tolerable weekly intake (PTWI) of 15 µg/kg b.w. Based on epidemiological studies, JECFA identified a benchmark dose lower confidence limit for a 0.5 % increased incidence of lung cancer (BMDL<sub>0.5</sub>) of 3.0 µg/kg b.w. per day (2-7 µg/kg b.w. per day based on the range of estimated total dietary exposure) (WHO, 2011b). Prior to that, in its Scientific Opinion on Arsenic in Food the EFSA Panel on Contaminants in the Food Chain (CONTAM Panel) had concluded that the PTWI of 15 µg/kg b.w. was no longer appropriate as the Panel established a BMDL<sub>01</sub> between 0.3 and 8 µg/kg b.w. per day for an increased risk of cancer of the lung, skin and bladder, as well as skin lesions (EFSA CONTAM Panel, 2009).

Currently, there are no maximum levels (MLs) established for arsenic in food at EU level, although MLs are laid down in national legislation in some Member States (MSs). For water intended for human consumption (Council Directive 98/83/EC) a parametric value of 10 µg/L is established without distinguishing forms of arsenic, while for natural mineral waters (Commission Directive 2003/40/EC) a ML of 10 µg/L is laid down for total arsenic (tAs).

A dataset comprised of 107 646 analytical results collected in 21 European countries was used to calculate the dietary exposure to iAs. Data on arsenic were reported as tAs (103 279), Organic Arsenic (184), iAs (2 561), Methylarsonate (347), DMA (348), As(V) (390), As(III) (358) and Arsenobetaine (179). Those food samples where iAs was reported were used as such, and the rest of analytical results for the same sample were not used for the exposure calculations. In addition, data reported as Organic Arsenic, Methylarsonate, DMA, Arsenobetaine, and samples that reported only As(III) or As(V) were not used to calculate the dietary exposure to iAs. At the end, a total of 103 773 food samples (including drinking water) were used to estimate dietary exposure to iAs. Of these, 101 020 were based on tAs and 2 753 on iAs. Some 92.5 % of the data reported as tAs were converted to iAs using different approaches (in general a conversion factor of 70 % was used) before calculating dietary exposure to iAs. However, for some key food groups (e.g. fish and seafood and some types of rice) only the reported iAs was used in the exposure assessment and tAs data were discarded. At FoodEx level 1 all the food groups were well represented, with a maximum of 23 716 samples in the food group 'Meat and meat products' and a minimum of 492 samples in the food group 'Snacks, desserts and other foods'. Some 24 884 samples of 'Drinking water' were also available. The average consumption level per day was estimated at the individual level for the different food groups that were defined based on the available occurrence data.

The left-censored data were treated by the substitution method (WHO/IPCS, 2009; EFSA, 2010) using the lower-bound (LB) and upper-bound (UB) approach. At the LB, results below the LOD/LOQ were replaced by zero; at the UB the results below the LOD were replaced by the value reported as the LOD and the results below the LOQ and above the LOD were replaced by the value reported as the LOQ.

The EFSA Comprehensive European Food Consumption Database (EFSA, 2011b) was used to estimate chronic dietary exposure to iAs, only considering dietary surveys with more than one day per subject (28 surveys from 17 European countries, 53 728 individuals). In general, dietary exposure to iAs did not differ much among dietary surveys within a specific age class. The main differences were found between the LB and UB estimates, due to the presence of left-censored data. Across the different dietary surveys, the UB estimates of exposure to iAs were, in general, 2-3 times higher than the LB estimations.

The highest dietary exposure to iAs was estimated in the younger population. The mean dietary exposure among infants, toddlers and other children ranged, across the different Member States and surveys, from 0.20 to 0.45 µg/kg b.w. per day (min LB- max LB) and from 0.47 to 1.37 µg/kg b.w. per day (min- max UB), with the maximum value estimated in infants. In the same three age classes, the 95<sup>th</sup> percentile dietary exposure estimates ranged from 0.36 to 1.04 µg/kg b.w. per day (min LB- max LB) and from 0.81 to 2.09 µg/kg b.w. per day (min UB- max UB), with the highest level estimated in toddlers. The mean dietary exposure to iAs among all surveys in the adult population (including adults, elderly and very elderly) ranged from 0.09 to 0.38 µg/kg b.w. per day (min LB- max UB) for the mean dietary exposure, and from 0.14 to 0.64 µg/kg b.w. per day (min LB- max UB) for the 95<sup>th</sup> dietary exposure.

Dietary exposure estimates in this report were considerably lower compared to those in the 2009 EFSA opinion (EFSA CONTAM Panel, 2009). Different factors can explain the different results, the most important being that in this report a more detailed codification to classify the foods (more disaggregated) was used (FoodEx classification), which also avoided the use of sampling adjustment factors (SAF) which were applied in the 2009 EFSA opinion. In addition, in the present report a detailed evaluation of the occurrence data was carried out to identify specific food commodities with high occurrence values that were subsequently linked with the appropriate consumption data (e.g. rice-based and non rice-based products). Other factors that could contribute to the lower dietary exposure to iAs in the present report compared to the 2009 EFSA opinion relate to different occurrence data used (e.g. a total of 2 753 samples with data on iAs were available) and how they were handled (e.g. use of only iAs data in some food categories).

Dietary exposure to iAs was also assessed in the vegetarian population but this assessment was based on a very limited number of subjects. Comparing the five surveys with data on both vegetarians and general population, the range of mean dietary exposure (min LB-max UB) was 0.10-0.42 µg/kg b.w. per day and 0.11-0.34 µg/kg b.w. per day, respectively. The 95<sup>th</sup> percentile dietary exposure (min LB-max UB) ranged from 0.28 to 0.60 µg/kg b.w. per day and from 0.18 to 0.55 µg/kg b.w. per day in the vegetarian and the general population, respectively. These results indicate no remarkable differences between vegetarians and the general population.

In general, with the exception of the youngest population (infants and toddlers), the main contributor to the dietary exposure to iAs was the food group 'Grain-based processed products (non rice-based)'. Other important contributors to the overall intake of iAs in all age classes were 'Rice', 'Milk and dairy products' and 'Drinking water'.

In infants and toddlers, the main contributors were 'Milk and dairy products' followed by 'Drinking water', 'Grain-based processed products (non rice-based)' and 'Food for infants and young children'. The contribution of infant food in these age classes may be underestimated since in most of cases the consumption data in the EFSA Comprehensive European Food Consumption Database did not indicate the potential presence of rice in foods for infants. Consumption of three portions (90 grams/day) of rice-based infant food could represent an important source of iAs (1.59-1.96 µg/kg b.w. per day).

Except for 'Rice', presenting a relatively high level of iAs, the contribution to the dietary exposure of iAs from the other main food groups was mainly due to their relatively high consumption levels. In

particular ‘Grain-based processed products (non rice-based)’ made a large contribution to the overall exposure to iAs. In almost all dietary surveys and age classes in the EFSA Comprehensive European Food Consumption Database, wheat bread and rolls were the most dominant contributor to iAs exposure within ‘Grain-based processed products (non rice-based)’.

The most important sources of uncertainty in the present assessment are related to the heterogeneity of the food consumption data, the conversion of tAs into iAs and to the treatment of the left censored occurrence data. In order to reduce the uncertainty of the exposure assessments to iAs, more analytical data on iAs would be needed, in particular in fish and seafood, and in food groups that provide a significant contribution to the dietary exposure to iAs (e.g. rice and wheat-based products). Analytical data submitted to EFSA should follow the requirements of the EFSA Guidance on Standard Sample Description ver. 2.0 (EFSA, 2013) as well as the specific requirements for the submission of occurrence data on arsenic (e.g. identification of rice as ingredient) described on EFSA’s website (EFSA, 2012). More detailed consumption data would reduce the uncertainties associated with dietary exposure estimates in the overall population, and in particular in certain age classes (young age classes) and specific groups of population (e.g. vegetarians).

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## **BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION<sup>4</sup>**

The European Food Safety Authority (EFSA) has adopted many scientific opinions related to undesirable substances in feed and on nitrates, non-dioxin like PCBs and certain mycotoxins in food, among others. For some of these opinions specific data collection exercises have been launched. In the frame of official control and monitoring more occurrence data are being generated. It is appropriate that these data are collected into one database, collated and analysed. Article 23 (and 33) of Regulation (EC) No 178/2002<sup>5</sup> laying down the general principles and requirements of food law, establishing EFSA and laying down procedures in matters of food safety, entrusts EFSA with this task.

In the framework of Articles 23 and 33 of Regulation (EC) No 178/2002, EFSA has received from the European Commission a mandate to collect on a continuous basis all available data on the occurrence of chemical contaminants in food and feed (Mandates M-2008-0143, M-2009-0130, M-2009-0131, M-2009-0277, M-2009-0318, M-2010-0132, M-2010-0374). In particular, in mandate M-2010-0374 the Commission summarises the scope of the continuous data collection by referring to previous mandates and indicating additional substances.

## **TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION**

The following tasks are related to data collection:

- publication of a report per topic on a regular basis. The report should contain, besides an analysis of the received data, also recommendations for improving data collection on this topic and ensure, in co-operation with the Commission services, the appropriate follow up to these recommendations;
- provide assistance/support/information to the Commission services based on ad hoc requests related to the occurrence data present in the database. Such requests might involve negotiations of timelines should they require the use of significant resources from EFSA.

## **CONTEXT OF THE SCIENTIFIC OUTPUT**

This report presents the available occurrence data on total and inorganic arsenic in food, and estimates the dietary exposure to inorganic arsenic in the European population.

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<sup>4</sup> Request by the European Commission for continued data collection and data analysis for nitrates, mycotoxins and dioxins and PCBs in food and for undesirable substances in feed. <http://registerofquestions.efsa.europa.eu/roqFrontend/questionsListLoader?mandate=M-2010-0374>

<sup>5</sup> Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. OJ L 31, 1.2.2002, p. 1-24.

## ANALYSIS

### 1. Introduction

Arsenic is a ubiquitous metalloid present at low concentrations in rocks, soil and natural water. Agricultural soils and drinking water are exposed to geogenic arsenic as this element naturally occurs in the earth's crust and is a constituent of more than 200 mineral species. In addition, anthropogenic activity has also contributed to increase the levels of arsenic in the environment through industrial emissions (mining, smelting of non-ferrous metals and/or burning of fossil fuels) as well as with the use of arsenic as part of fertilisers, wood preservatives, insecticides or herbicides (Hughes et al., 2011). Nowadays, the application of arsenic containing pesticides is not allowed in the EU (EFSA CONTAM Panel, 2009). In the environment, arsenic generally occurs as pentavalent arsenic (As(V) or arsenate) and trivalent arsenic (As(III) or arsenite), both in inorganic and organic forms. In natural ground water arsenic habitually appears in inorganic forms (As(III), As(V) or a combination of both); organic forms are rare in water as they are the result of biological activity. Organic arsenic species such as arsenobetaine and different arsenosugars are the most common forms in seafoods, while in foods of terrestrial origin the predominant arsenic forms are inorganic arsenic (both As(V) and As(III)) and single methylated arsenic species (methylarsonate, methylarsenite and dimethylarsinate (DMA)). Arsenic enters the food chain mainly through contaminated water and soil (Francesconi, 2005).

Human exposure to arsenic can occur via different routes. Although dermal and inhalation exposure is possible, food and drinking water are the principal routes of exposure to arsenic (WHO, 2011a; IARC, 2012). Arsenic toxicokinetics varies depending on the arsenic form, and different factors such as life stage, gender, nutritional status and genetic polymorphisms. The absorption of inorganic arsenic (iAs) is notably influenced by the solubility of the arsenical compound [As(III) and As(V) in drinking water are almost completely and rapidly absorbed], the presence of other food constituents and nutrients in the gastrointestinal tract and by the food matrix itself (EFSA CONTAM Panel, 2009). Once absorbed, iAs is extensively transformed and excreted via urine mainly as DMA. Although human data are limited, it is recognised that organic arsenic forms are in general efficiently absorbed. While arsenosugars (abundant in seaweed and molluscs) are completely metabolized to DMA before excretion, arsenobetaine (main form in most seafood) is not metabolised in humans and is excreted unchanged (Francesconi, 2010).

Inorganic arsenic is more toxic than organic arsenic compounds. Although both forms of inorganic arsenic are potentially harmful to human health, As(III) is considered more harmful than As(V) (Hughes et al., 2011). The International Agency for Research on Cancer (IARC) classified arsenic and iAs compounds as 'carcinogenic to humans' (Group 1) based on sufficient evidence of carcinogenicity in humans (IARC, 1973, 1980). Recently, the IARC has also classified DMA and methylarsonate as 'possibly carcinogenic to humans' (Group 2B), and arsenobetaine and other organic arsenic compounds not metabolised in humans as 'not classifiable as to their carcinogenicity to humans' (Group 3) (IARC, 2012).

Currently, there are no maximum levels (MLs) established for arsenic in food at EU level, although MLs are laid down in national legislation in some Member States (MSs). For water intended for human consumption (Council Directive 98/83/EC<sup>6</sup>) a parametric value of 10 µg/L is established without distinguishing arsenic forms, while for natural mineral waters (Commission Directive 2003/40/EC<sup>7</sup>) a ML of 10 µg/L is laid down for total arsenic (tAs).

<sup>6</sup> Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption. OJ L 330, 5.12.1998, p. 1-28.

<sup>7</sup> Commission Directive 2003/40/EC of 16 May 2003 establishing the list, concentration limits and labelling requirements for the constituents of natural mineral waters and the conditions for using ozone-enriched air for the treatment of natural mineral waters and spring waters. OJ L126 22.5.2003, p. 34-39.

Regarding the health based guidance values for exposure to iAs, in 2010 the Joint FAO/WHO Expert Committee on Food Additives (JECFA) withdrew the provisional tolerable weekly intake (PTWI) of 15 µg/kg b.w. Based on epidemiological studies, JECFA identified a benchmark dose lower confidence limit for a 0.5 % increased incidence of lung cancer (BMDL<sub>0.5</sub>) of 3.0 µg/kg b.w. per day (2–7 µg/kg b.w. per day based on the range of estimated total dietary exposure) (WHO, 2011b). Prior to that, in its Scientific Opinion on Arsenic in Food (EFSA CONTAM Panel, 2009) the EFSA Panel on Contaminants in the Food Chain (CONTAM Panel) had concluded that the PTWI of 15 µg/kg b.w. was no longer appropriate as the Panel established a BMDL<sub>01</sub> between 0.3 and 8 µg/kg b.w. per day for an increased risk of cancer of the lung, skin and bladder, as well as skin lesions.

The 2009 EFSA Scientific Opinion showed that the estimated dietary exposure to iAs for average and high level consumers in Europe was within the range of the BMDL<sub>01</sub> values identified. Dietary exposure to iAs in the adult population, using lower bound and upper bound concentrations, was estimated to range from 0.13 to 0.56 µg/kg b.w. per day for average consumers, and from 0.37 to 1.22 µg/kg b.w. per day for 95<sup>th</sup> percentile (high level) consumers. The dietary exposure in children under three years of age was, in general, estimated to be 2 to 3-fold higher than that of adults (EFSA CONTAM Panel, 2009). The main contributors to dietary exposure to iAs were the food subclasses of cereal grains and cereal based products, followed by food for special dietary uses, bottled water, coffee and beer, rice grains and rice based products, fish and vegetables (EFSA CONTAM Panel, 2009). A particular concern was raised by the Panel on the role that a staple food such as rice could have on the dietary exposure to iAs. This would be especially relevant to some ethnic population groups with high consumption of rice or to the infant population that may consume rice-based products. The significant contribution of rice to the dietary exposure to iAs has been confirmed in further studies (Xue et al., 2010; Fontcuberta et al., 2011; Wong et al., 2013).

Only few data on iAs were available during the preparation of the 2009 EFSA Scientific Opinion and different assumptions were used in order to estimate the level of iAs present in the different foods. In addition, the food samples were classified according to 15 aggregated food categories specified in the EFSA Concise European Food Consumption Database (EFSA, 2008). Since then, new data on the content of arsenic in different foods have been received in the EFSA chemical occurrence database, including more than 2000 data on iAs in key foods (rice, seafood and crustaceans).

The current report provides updated information on the levels of arsenic (tAs and iAs) found in a range of foods on the European market classified according to the FoodEx classification system (EFSA, 2011a). In addition, it estimates chronic dietary exposure to iAs in Europe using individual consumption data from the EFSA Comprehensive Food Consumption Database (EFSA, 2011b).



## 2. Materials and methods

### 2.1. Occurrence data: data management and validation

#### 2.1.1. Number of analytical results

Most of the occurrence data on arsenic presented in this report were collected through a call for data issued by EFSA in July 2008 in preparation for a Scientific Opinion on Arsenic in Food (EFSA CONTAM Panel, 2009). In addition, this metalloid is included in a continuous annual call for occurrence data launched since July 2010 by the Evidence Management Unit (DATA) (former Dietary and Chemical Monitoring Unit (DCM)) at EFSA.

By the end of August 2013 a total of 114 200 analytical results on arsenic in food were extracted from the EFSA chemical occurrence database, covering the sampling years from 2003 to 2012, of which 26 542 corresponded to 'Drinking water'. Data on arsenic were reported as Arsenic, tAs, Organic Arsenic, iAs, Methylarsonate, DMA, As(V), As(III), Arsenobetaine, and Arsenic and derivatives. Data reported as Arsenic and derivatives and as Arsenic were considered as tAs before carrying out any data transformation.

#### 2.1.2. Data cleaning and validation

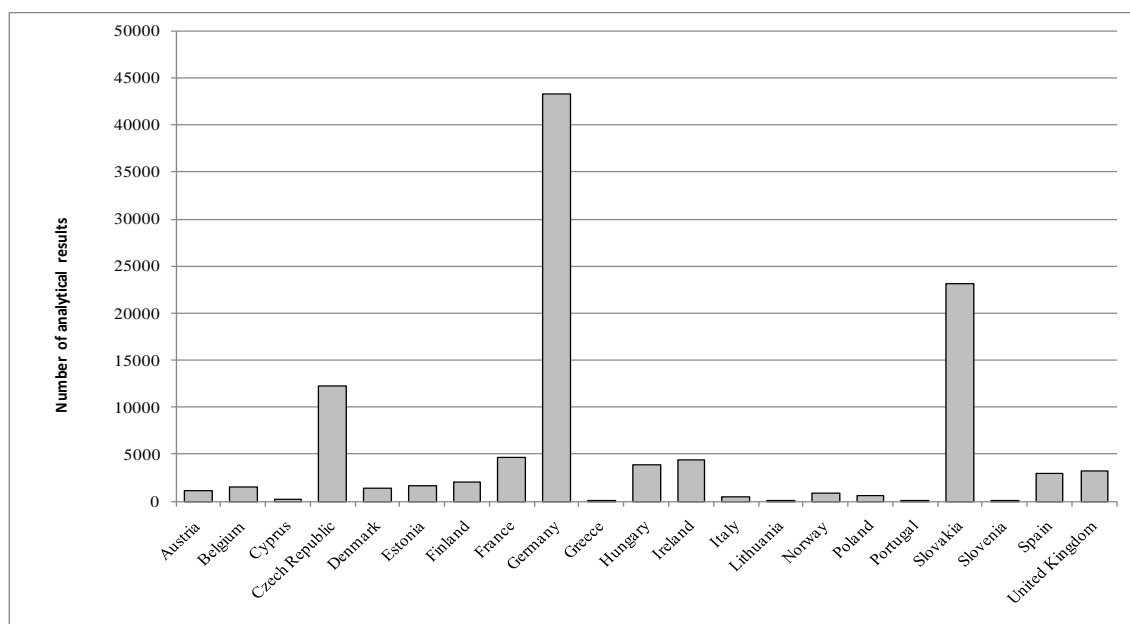
To improve the quality of the data included in the assessment, several data cleaning and data validation steps were applied. Data were also checked for duplicates (same sample transmitted twice or repeated analysis of the same sample), and for wrong food classification. Nine analytical results were excluded from the final dataset as they provided too high occurrence values (2-3 orders of magnitude higher) as compared to the rest of the samples belonging to the same food category, and the information could not be verified with the data providers. Details on these samples are given later in their corresponding food category. Only the most recent occurrence data were used (sampling years 2003-2012), resulting in the exclusion of 700 analytical results. Some 4 325 analytical results were also excluded as they provided neither a limit of detection (LOD) nor a limit of quantification (LOQ), while some 309 analytical results were eliminated since they were reported as 'suspect samples' and their inclusion may lead to an overestimation of the contamination levels. To avoid a bias on the outcome of the exposure assessment and based on the Scientific Opinion on Arsenic in Food (EFSA CONTAM Panel, 2009), it was decided to exclude those data with an LOQ for tAs higher than 200 µg/kg. A total of 931 analytical results were eliminated following this approach. Finally, 172 analytical results classified as 'Grains as crops' for which the final destination is unknown were also discarded.

Most of the analytical results were submitted by MSs to EFSA expressed as whole weight. Results reported as dry matter were converted into whole weight using the data provided on moisture content. Reported food samples were classified according to the FoodEx classification system (EFSA, 2011a). FoodEx is a food classification system developed by the EFSA DCM Unit in 2009 with the objective of simplifying the linkage between occurrence and food consumption data when assessing the exposure to hazardous substances. It contains 20 main food groups (first level), which are further divided into subgroups having 140 items at the second level, 1 261 items at the third level and reaching about 1 800 end-points (food names or generic food names) at the fourth level.

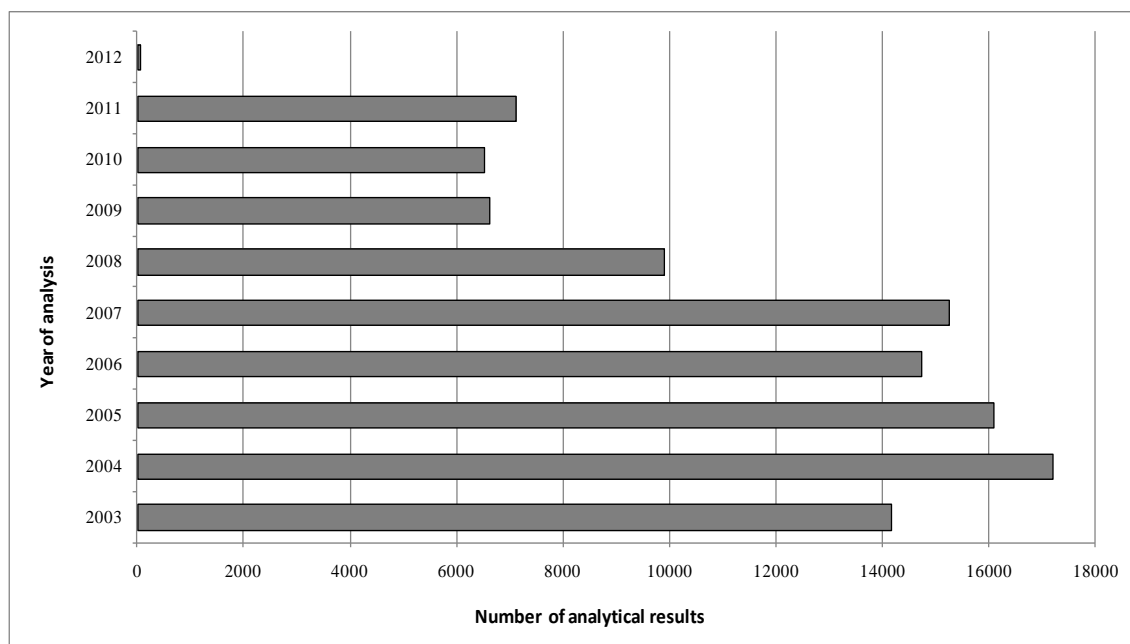
Analytical results on arsenic were collected in 21 different European countries (Figure 1). A few analytical results from samples collected outside Europe (samples collected in Bolivia and Argentina, and reported by Spain) were not included in the exposure calculations (a total of 108 analytical results). Most of the analytical results submitted came from samples collected in Germany, Slovakia

and the Czech Republic. The available dataset covered mainly the sampling years 2003 to 2011, with a few samples also analysed in 2012 (Figure 2).

As a consequence of the data cleaning and validation steps, 6 554 analytical results were excluded. The final dataset comprised a total of 107 646 analytical results. Data on arsenic were reported as tAs (103 279), Organic Arsenic (184), iAs (2 561), Methylarsonate (347), DMA (348), As(V) (390), As(III) (358) and Arsenobetaine (179).



**Figure 1:** Analytical results on arsenic across the different sampling countries in the final dataset.

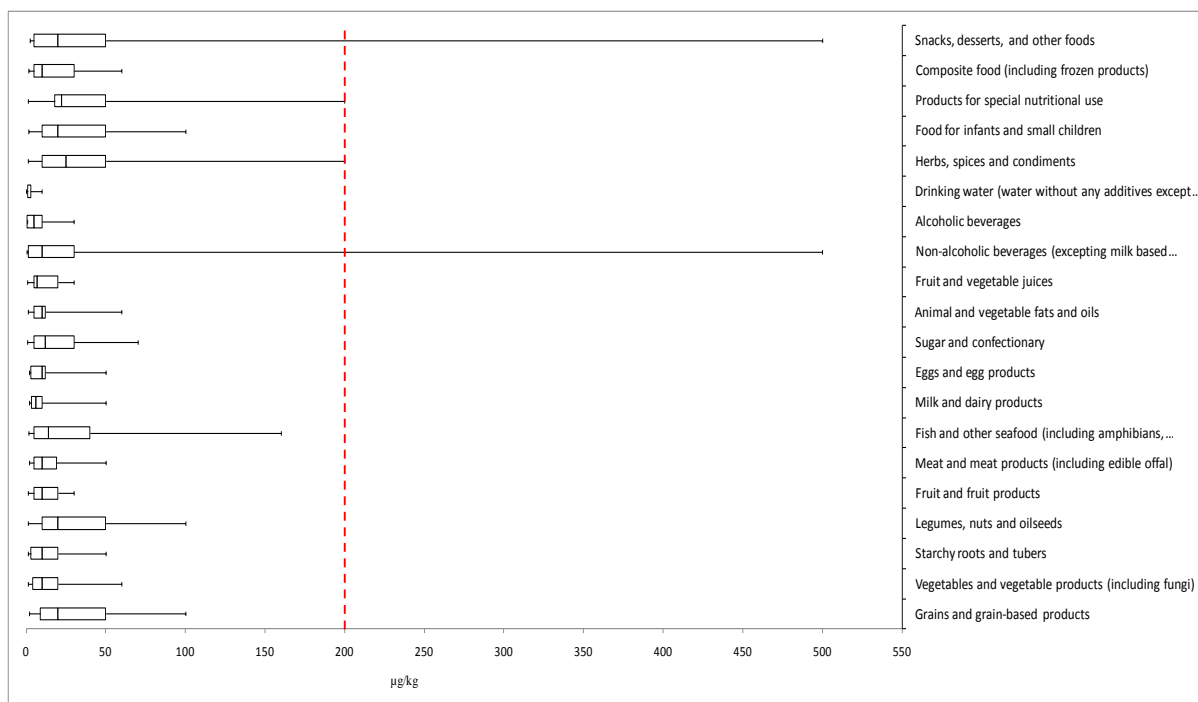


**Figure 2:** Analytical results on arsenic by year of analysis in the final dataset.

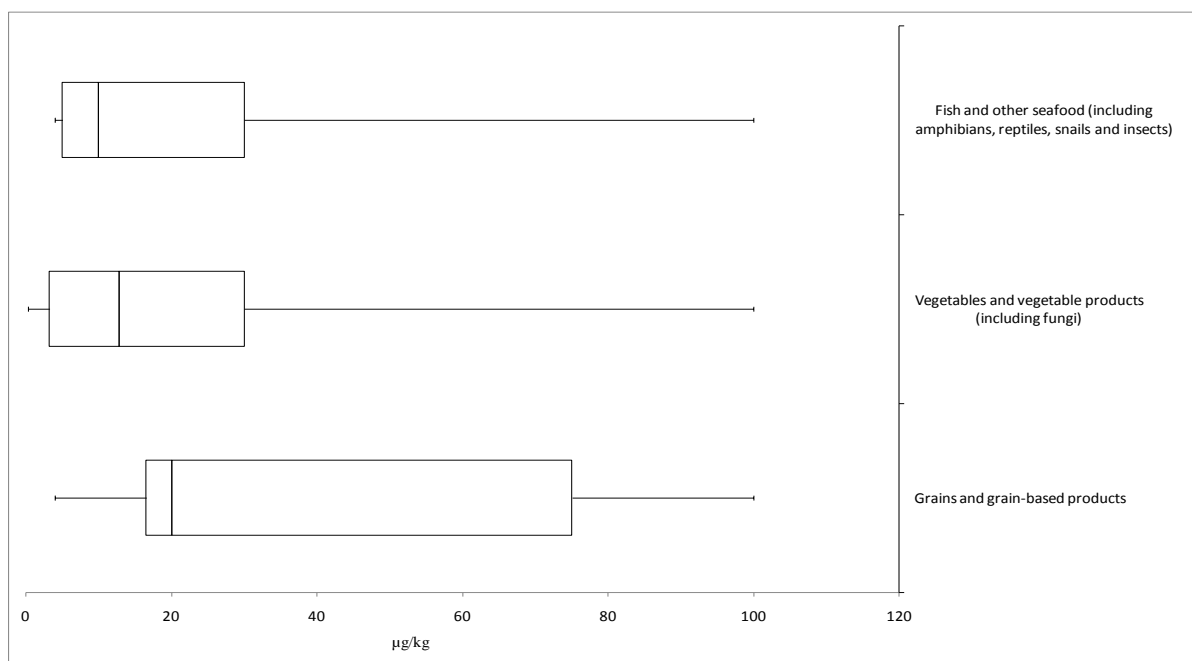
When reporting the analytical results on tAs and iAs in many cases no information on the method of analysis was provided (32.4 %). While for the analysis of tAs the most reported detection method was atomic absorption spectrometry (AAS) (48.3 %) for iAs the most reported detection method was inductively coupled plasma mass spectrometry ICP-MS (66.8 %).

In the final dataset, a total of 66.1 % of the reported results on tAs were below the left-censored limits (LOD/LOQ). Less than half of the reported data on iAs (41.9 %) were left-censored, and among rice samples only 10.5 %. The left-censored data were treated by the substitution method (WHO/IPCS, 2009; EFSA, 2010) using the lower-bound (LB) and upper-bound (UB) approach. At the LB, results below the LOD/LOQ were replaced by zero; at the UB the results below the LOD were replaced by the value reported as the LOD and the results below the LOQ and above the LOD were replaced by the value reported as the LOQ. In addition, the middle-bound (MB) was calculated by assigning a value of LOD/2 or LOQ/2 to the left-censored data.

For tAs the minimum and maximum reported LOQs were 0.001 µg/kg (drinking water) and 9000 µg/kg (tea infusion), respectively. For iAs the minimum and maximum reported LOQs were 0.02 µg/kg (a cucumber sample) and 1000 µg/kg (one unspecified sample belonging to the food group ‘Snacks, desserts and other foods’), respectively. As explained above, an LOQ cut-off of 200 µg/kg was applied to the analytical results on tAs. Since for iAs the influence of LOQs on the UB was negligible it was decided to keep all the analytical results and no LOQ cut-off was applied. The distribution of the reported LOQs at FoodEx level 1 is shown in Figure 3 for tAs (before applying the cut-off). Figure 4 shows the distribution of LOQs for data on iAs in the three most important food categories by number of analytical results reported.



**Figure 3:** Distribution of LOQ values among the analytical results for tAs across the different food categories at FoodEx level 1 (Box-plot: 5<sup>th</sup>, 25<sup>th</sup>, 50<sup>th</sup>, 75<sup>th</sup> and 95<sup>th</sup> percentiles). The dotted line indicates the LOQ cut-off applied to the analytical results for tAs.



**Figure 4:** Distribution of LOQ values across the three food categories with the highest number of analytical results on iAs at FoodEx level 1 (Box-plot: 5<sup>th</sup>, 25<sup>th</sup>, 50<sup>th</sup>, 75<sup>th</sup> and 95<sup>th</sup> percentiles).

### 2.1.3. Estimation of iAs in the food samples

In several cases the same food sample reported arsenic data in different manners (e.g. data on iAs, As(III) and tAs); however, for each food sample only one type of analytical result was used to calculate the dietary exposure to iAs. Those food samples where iAs was reported were used as such, and the rest of analytical results for the same sample were not used for the exposure calculations. When iAs was not reported, the data reported as tAs were converted into iAs using different approaches.

In general, the estimated mean iAs for each selected food group was generated by combining the samples with reported values for iAs with those where iAs was derived from the reported tAs. However, for several key food groups where the number of samples was considered sufficient only the reported iAs was used and the tAs data were discarded (e.g. fish and seafood and some types of rice).

The category ‘Fish and other seafood (including amphibians, reptiles, snails and insects)’ presents a particular problem in trying to derive the amount of iAs from tAs. The available data in the literature show that there is not a consistent relationship between the tAs content (mainly arsenobetaine) and the content of iAs in seafood samples (Francesconi, 2010). One of the reasons is that the relative proportion of iAs tends to decrease as the tAs content increases, and the ratio may vary depending on the seafood type (EFSA CONTAM Panel, 2009). Although different conversion factors have been applied to calculate iAs from tAs (GESAMP, 1986), there is a recommendation that, when possible, the dietary exposure should be based on real data on iAs rather than using generalised conversion factors (FAO/WHO, 2010, 2011). Based on this, it was decided to use only the reported data on iAs for the food category ‘Fish and other seafood (including amphibians, reptiles, snails and insects)’.

For the rest of foods of terrestrial origin, following the approach described in the EFSA Scientific Opinion on arsenic (EFSA CONTAM Panel, 2009), a factor of 70 % was applied to reported tAs to estimate iAs; the corresponding iAs estimates were then combined with the reported iAs if available.

Some specific cases where different approaches were applied are explained below within their corresponding food category.

All data reported for drinking water were on tAs. Although a few studies have reported the presence of methylarsonite and dimethylarsinate in water (Banerjee et al. 1999; Thirunavukkarasu et al., 2002), in general it is well established that almost all arsenic in drinking water is inorganic, either As(III) or As(V) (US EPA, 2001; WHO, 2011a). Therefore, all data reported as tAs for drinking water were assumed to be iAs before calculating dietary exposure.

In a total of 192 food samples reporting As(III) and As(V) [97 of them on rice], the iAs content was derived as the sum of both species. Data reported as Organic Arsenic, Methylarsonate, DMA, Arsenobetaine, and samples that reported only As(III) or As(V) were not used to calculate the dietary exposure to iAs. Following these steps a total of 103 773 samples were available (101 020 with data on tAs and 2 753 with data on iAs), around 6 000 of them corresponding to pooled samples. The number of food samples distributed at FoodEx level 1 for which data on iAs were reported are shown in Table 1.

**Table 1:** Food samples at FoodEx level 1 for which data on iAs were available.

<b>FoodEx level 1</b>	<b>N<sup>(a)</sup></b>
Grains and grain-based products	822
Vegetables and vegetable products (including fungi)	451
Starchy roots and tubers	9
Legumes, nuts and oilseeds	11
Fruit and fruit products	16
Meat and meat products (including edible offal)	223
Fish and other seafood (including amphibians, reptiles, snails and insects)	1012
Milk and dairy products	60
Herbs, spices and condiments	23
Food for infants and young children	38
Products for special nutritional use	10
Composite food (including frozen products)	49
Snacks, desserts, and other foods	29
<b>TOTAL</b>	<b>2753</b>

(a): number of samples

The estimated occurrence values for iAs are initially presented according to the 20 food categories at FoodEx level 1 (EFSA, 2011a). Within each food category and depending on their reported occurrence values, the samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**), level 3 (normal) and level 4 (*italic*) as shown in Tables 4-23 before being linked with the EFSA Comprehensive Food Consumption Database. In general, when less than 10 samples were reported for one specific food group, the average occurrence value of all samples contained in the immediate upper FoodEx level was used. Dilution factors were used to convert the occurrence data reported for solid food groups (e.g. coffee beans) to their respective liquid consumption amounts reported in the consumption database. The dilution factors used were 18 for all types of coffees (except 7 for espresso and 63 for instant coffee), 100 for tea, and 8 for infant formulae.

## 2.2. Consumption data

The EFSA Comprehensive European Food Consumption Database was used to estimate chronic dietary exposure to iAs. This database was built in 2010 based on food consumption information on adults provided by EU MSs and food consumption data for children obtained through an EFSA Article 36 project (Huybrechts et al., 2011). Within the project developing the adult component of the EFSA Comprehensive Food Consumption Database, data providers were asked to codify all foods and beverages present in the national food consumption database according to the preliminary FoodEx classification system developed by EFSA. Recommendations were given to the data providers on how to disaggregate composite dishes to the most detailed level possible. The EFSA Comprehensive Food Consumption Database contains results from a total of 34 different dietary surveys carried out in 22 different MSs covering more than 67 000 individuals (EFSA, 2011b; Merten et al., 2011).

Within the dietary studies, subjects were classified in different age classes as follows: Infants (< 12 months old), Toddlers ( $\geq$  12 months to < 36 months old), Other children ( $\geq$  36 months to < 10 years old), Adolescents ( $\geq$  10 years to < 18 years old), Adults ( $\geq$  18 years to < 65 years old), Elderly ( $\geq$  65 years to < 75 years old) and Very elderly ( $\geq$  75 years old). The EFSA Comprehensive Food Consumption Database includes individual food consumption data concerning infants (2 surveys from 2 countries), toddlers (10 surveys from 8 countries), other children (18 surveys from 14 countries), adolescents (14 surveys from 12 countries), adults (21 surveys from 20 countries), elderly (9 surveys from 9 countries) and very elderly (8 surveys from 8 countries).

Overall, the food consumption data in the EFSA Comprehensive Food Consumption Database are the most complete and detailed data currently available in the EU. However, it should be pointed out that different methodologies were used between surveys to collect the data and thus direct country-to-country comparisons of dietary exposure estimates should be viewed with caution. Similarly to what is described for the occurrence data, consumption records are also codified according to the FoodEx classification system. Further details on how this database is used are published in the Guidance of EFSA on the use of the EFSA Comprehensive Food Consumption Database (EFSA, 2011b).

Since chronic dietary exposure to iAs was calculated and following the recommendations issued by the EFSA Working Group on Food Consumption and Exposure (EFSA, 2011b), only dietary surveys with more than one day per subject were considered. Similarly, subjects who participated only one day in the dietary studies, when the protocol prescribed more reporting days per individual, were also excluded for the chronic exposure assessment. Thus, for the chronic exposure assessment, food consumption data were available from 28 different dietary surveys carried out in 17 different European countries (Table 2).

It is important to highlight that in the dietary surveys the consumed amount of different foods is reported some times as cooked/consumed and some others as raw foods/ingredients. The distinction between raw and cooked/consumed food is not always clear, and the amounts reported were considered as raw when they were linked to the occurrence data. This is particularly important because, when the amount of cooked foods is reported, consumption levels are likely to be overestimated for certain foods such as pasta or rice (the cooked weight of one portion is greater than its raw weight) whereas underestimation may result for other foods such as meat or fish (their weight decrease when cooked due to moisture loss). For example, the weight of cooked pasta or rice is 2-3 times higher compared to the corresponding uncooked product (EFSA, 2011b).

The breakdown of composite foods in the vast majority of the surveys resulted in more accurate intakes of the different components of composite dishes. However, some dietary surveys (e.g. Latvia or Sweden) reported composite foods that were not disaggregated into ingredients, and an underestimation of the foods regularly used as ingredients in respective recipes, e.g. cheese, tomato, etc., can be expected in these data. Furthermore, the breakdown of certain cereal products (e.g. bread, porridges and fine bakery ware) into their basic ingredients, like flour or other milling products and other basic ingredients may result in a shift in apparent consumption of cereal products to basic

milling products. As a consequence, in some countries the consumption of bread and fine bakery ware for instance, may be very low or not seen at all, whereas consumption of basic milling products may be higher than in other countries.

**Table 2:** Dietary surveys from the EFSA Comprehensive Food Consumption Database used for the calculation of chronic dietary exposure to iAs, with the available number of subjects in the different age classes.

Country	Dietary survey <sup>(a)</sup>	Method	Days	Age (years)	Number of subjects						
					Infants	Toddlers	Other children	Adolescents	Adults	Elderly	Very elderly
Belgium	Diet National 2004	24 h dietary	2	15-105				584	1304	518	712
Belgium	Regional Flanders	Food record	3	2-5		36 <sup>(b)</sup>	625				
Bulgaria	NUTRICHILD	24-hour recall	2	0.1-5	860	428	433				
Cyprus	Childhealth	Dietary record	3	11-18				303			
Czech Republic	SISP04	24-hour recall	2	4-64			389	298	1666		
Germany	DONALD 2006	Dietary record	3	1-10		92	211				
Germany	DONALD 2007	Dietary record	3	1-10		85	226				
Germany	DONALD 2008	Dietary record	3	1-10		84	223				
Germany	National Nutrition Survey II	24-hour recall	2	14-80				1011	10419	2006	490
Denmark	Danish Dietary Survey	Food record	7	4-75			490	479	2822	309	20 <sup>(b)</sup>
Greece	Regional Crete	Dietary record	3	4-6							
Spain	AESAN	24-hour recall	2	18-60					410		
Spain	AESAN-FIAB	Food record	3	17-60				86	981		
Spain	NUT INK05	24-hour recall	2	4-18			399	651			
Spain	enKid	24-hour recall	2	1-14		17 <sup>(b)</sup>	156	209			
Finland	DIPP	Food record	3	1-6			497	933			
Finland	FINDIET 2007	48-hour recall	2	25-74					1575	463	
Finland	STRIP	Food record	4	7-8							
France	INCA2	Food record	7	3-79			482	973	2276	264	84
Hungary	National Repr Surv	Food record	3	18-96					1074	206	80
Ireland	NSFC	Food record	7	18-64					958		
Italy	INRAN-SCAI 2005-06	Food record	3	0.1-98	16 <sup>(b)</sup>	36 <sup>(b)</sup>	193	247	2313	290	228
Latvia	EFSA_TEST	24-hour recall	2	7-66			189	470	1306		
Netherlands	DNFCS 2003	24 h dietary	2	19-30					750		
Netherlands	VCP kids	Food record	3	2-6			322	957			
Sweden	RIKSMATEN 1997-98	Food record	7	18-74					1210		
Sweden	NFAn	24-hour recall	4	3-18			1473	1018			
United	NDNS	Food record	7	19-64					1724		

(a): More information on the dietary surveys is given in the Guidance of EFSA ‘Use of the EFSA Comprehensive European Food Consumption Database in Exposure Assessment’ (EFSA, 2011b).

(b): 95<sup>th</sup> percentile calculated with a number of observations lower than 60 are not statistically robust.



## 2.3. Dietary exposure

Dietary chronic exposure to iAs was assessed at individual level by multiplying the average daily consumption for each food with the corresponding mean estimated iAs (LB, MB and UB), summing up the respective intakes throughout the diet, and finally dividing the results by the individual's body weight. For each dietary survey, the mean and 95<sup>th</sup> percentile dietary exposure to iAs were estimated from the distribution of the individual exposure results. In accordance with the specifications of the EFSA Guidance on the use of the EFSA Comprehensive Food Consumption Database, 95<sup>th</sup> percentile estimates for dietary surveys/age classes with less than 60 observations were not calculated since they may not be statistically robust (EFSA, 2011b).

The whole diet was taken into account, except for foods not covered by occurrence data and for which an assumption on their contamination level was not possible. Consumption data and occurrence data were linked at the lowest FoodEx level possible. Some ad-hoc food sub-groups were created when they were not covered by the FoodEx classification and they were identified as playing a significant role on the dietary exposure to iAs [e.g. Fine bakery wares (without rice) and Fine bakery wares (with rice) in Table 4]. The different food commodities were grouped within each FoodEx food category to better explain their contribution to the total dietary exposure to iAs in each age class (Tables 4-23).

## 3. Results

### 3.1. Occurrence data

#### 3.1.1. Grains and grain-based products

A total of 7 998 samples were available for the food category 'Grains and grain-based products', with rice samples being the most represented at FoodEx level 3 (2 211 samples). A total of 822 samples reported data on iAs (706 on rice, see Table 3). Only 17 % of the rice samples with results on iAs were left-censored (121 samples).

**Table 3:** Mean reported iAs concentrations in different types of rice. Mean concentrations ( $\mu\text{g}/\text{kg}$ ) are presented as LB, MB and UB. Values were rounded up to one decimal place.

	N <sup>(b)</sup>	LC % <sup>(c)</sup>	Mean iAs ( $\mu\text{g}/\text{kg}$ )			95 <sup>th</sup> percentile <sup>(a)</sup>		
			LB	MB	UB	LB	MB	UB
<b>Rice (unspecified)</b>	201	27	79.0	93.6	108.1	150.0	150.0	200.0
<b>Rice, brown</b>	94	2	150.7	151.9	153.1	250.0	250.0	250.0
<b>Rice, long-grain</b>	130	24	77.6	88.1	98.6	170.0	170.0	200.0
<b>Rice, mixed</b>	2	0	128.5	128.5	128.5	-	-	-
<b>Rice, parboiled</b>	70	23	92.8	105.1	117.4	234.0	234.0	234.0
<b>Rice, red</b>	12	0	162.4	162.4	162.4	-	-	-
<b>Rice, white</b>	189	8	84.3	88.7	93.0	149.1	150.4	155.4
<b>Rice, wild</b>	8	38	71.5	75.9	80.2	-	-	-
<b>TOTAL</b>	<b>706</b>	<b>17</b>	<b>92.5</b>	<b>101.2</b>	<b>109.9</b>	<b>196.5</b>	<b>196.5</b>	<b>200.0</b>

(a): The 95<sup>th</sup> percentile estimates obtained on samples with less than 60 analytical results reported may not be statistically robust (EFSA, 2011b). Those estimates were not included in this table.

(b): Number of data.

(c): Percentage of left-censored data.

A detailed evaluation of the rice samples with data reported on both iAs and tAs (~ 600 samples) revealed that on average iAs represents approximately 70 % of the tAs content, except for brown rice where on average iAs represents around 80 % of tAs content (data not shown). This compares well with the data described in the literature (Jorhem et al., 2008; Torres-Escribano et al., 2008). For five types of rice samples, namely unspecified, brown, long-grain, parboiled and white, the number of samples was considered adequate to use exclusively the reported data on iAs. For the other grains and grain-based products (including the remaining types of rice) estimated iAs concentrations were generated by combining the samples with reported values for iAs with those where iAs was estimated from the reported tAs after applying a 70 % conversion factor.

Within the different food groups, rice-based products showed the highest levels of estimated iAs (see FoodEx food groups ‘Bread and rolls’, ‘Breakfast cereals’ or ‘Fine bakery wares’ in Table 4). In certain cases since the FoodEx classification does not define rice-based products some ad-hoc food sub-groups were created (e.g. Fine bakery wares (without rice) and Fine bakery wares (with rice) in Table 4). Especially remarkable were the estimated mean levels of iAs in the subgroup ‘Fine bakery wares (with rice)’ (260.6 µg/kg), which mainly consists of rice-based cake. The identification of these rice-based products was mainly based on the additional information supplied by the data providers. These foods were combined with consumption data where the presence of rice in the products was described in the original food descriptors of the dietary surveys.

Among the rice samples the maximum estimated mean value was calculated for red rice (MB= 162.4 µg/kg, n= 12) and brown rice (MB=151.9 µg/kg, n= 94). The 95<sup>th</sup> percentile occurrence values (when n ≥ 60) varied from 150 µg/kg (MB) in unspecified rice to MB values of 250 µg/kg reported for brown rice (Table 3). Higher levels of iAs are usually reported in brown rice as this type of rice retains its outer layers (pericarp and bran) which are removed in the whitening (milling) process (Zavala and Duxbury, 2008). Other estimated 95<sup>th</sup> percentile occurrence values were 234 µg/kg for parboiled rice, 150.4 µg/kg for white rice and 170 µg/kg for long-grain rice, always at the MB assumption (Table 3).

It is also important to mention that out of the 704 samples reported for the food group ‘Bread and rolls’, 337 corresponded to samples of wheat bread and rolls. In these wheat-based samples relatively low mean values of iAs were estimated (9.3-19.2 µg/kg, LB-UB), with a 95<sup>th</sup> percentile occurrence value of 40.9-44.8 µg/kg (LB-UB) (data not shown).

**Table 4:** Estimated iAs in the food category ‘Grain and grain-based products’. Mean concentrations (µg/kg) are presented as LB, MB and UB. Estimates were rounded up to one decimal place. Samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**), level 3 (normal) and level 4 (*italic*).

FOODEX_NAME	N <sup>(a)</sup>	LC % <sup>(i)</sup>	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
<b>GRAIN and GRAIN-BASED PRODUCTS</b>	<b>7998</b>					
<b>Grain milling products</b>	910					
Wheat milling products	536 (1)	72	5.7	13.8	22.0	
Rye milling products	138	80	1.0	10.7	20.5	
Buckwheat milling products <sup>(b)</sup>			5.2	14.0	22.8	
Corn milling products	21	100	0.0	24.7	49.3	Grain milling products
Oat milling products	29	97	1.0	14.2	27.3	
Spelt milling products	53	98	0.8	7.4	14.1	
Other milling products	10	50	9.5	13.5	17.5	
Rice milling products	17	70	64.8	70.7	76.6	
Grain milling products (unspecified)	97	76	2.6	10.6	18.6	
<b>Grains for human consumption</b>	5407					
Wheat grain	1638 (19)	69	9.0	17.1	25.2	Grains for human consumption (not rice)

FOODEX_NAME	Mean estimated iAs (µg/kg)					Groups	
	N <sup>(a)</sup>	LC % <sup>(i)</sup>	LB	MB	UB		
Barley grain	338	73	8.9	18.5	28.0	Grains for human consumption (not rice)	
Corn grain	378	73	12.4	18.7	25.0		
Rye grain	530	82	4.8	14.1	23.5		
Spelt grain	68	94	0.6	10.7	20.7		
Buckwheat grain	115	77	8.6	15.9	23.2		
Millet grain	11	91	0.4	12.9	25.4		
Oats, grain	62	61	22.0	27.8	33.5		
Grains for human consumption (unspecified)	51	49	30.2	38.2	46.3		
Other grains <sup>(b)</sup>			9.1	17.3	25.5		
Rice	2211					Rice	
<i>Rice, brown</i> <sup>(c)</sup>	122 (94)	2	150.7	151.9	153.1		
<i>Rice, long-grain</i> <sup>(c)</sup>	482 (130)	20	77.6	88.1	98.6		
<i>Rice, mixed</i> <sup>(d)</sup>			92.5	101.2	109.9		
<i>Rice, parboiled</i> <sup>(c)</sup>	156 (70)	14	92.8	105.1	117.4		
<i>Rice, red</i>	12 (12)	0	162.4	162.4	162.4		
<i>Rice, white</i> <sup>(c)</sup>	299 (189)	9	84.3	88.7	93.0		
<i>Rice, wild</i>	25 (8)	24	72.2	75.2	78.3		
<i>Rice (unspecified)</i> <sup>(c)</sup>	1112 (201)	10	79.0	93.6	108.1		
<b>Bread and rolls</b>	704						Grain-based processed products (not rice-based)
Wheat bread and rolls	337 (5)	58	9.3	14.3	19.2		
Mixed wheat and rye bread and rolls	124 (1)	44	2.6	6.9	11.1		
Rye bread and rolls	78	24	8.6	9.4	10.3		
Multigrain bread and rolls	26 (5)	73	1.5	8.8	16.1		
Bread products	21	100	0.0	13.0	26.0		
Unleavened bread, crisp bread and rusk (no rice) <sup>(b)</sup>			7.6	12.8	18.0		
Unleavened bread, crisp bread and rusk (with rice) <sup>(c)</sup>			93.1	99.5	105.9		
Bread and rolls (unspecified)	71 (1)	70	8.7	18.5	28.3		
Other bread	36						
<i>Corn bread</i> <sup>(b)</sup>			15.8	19.6	23.3	Grain-based processed products (not rice-based)	
<i>Potato bread</i>	10	20	30.7	31.6	32.4		
<i>Other bread (unspecified)</i>	16	44	11.4	16.0	20.6		
<i>Rice bread</i> <sup>(e)</sup>			93.1	99.5	105.9	Rice-based products	
<b>Breakfast cereals</b>	468					Grain-based processed products (not rice-based)	
Cereal flakes	168						
<i>Corn flakes</i>	15 (3)	73	5.9	12.9	19.9		
<i>Corn flakes with honey and sugar</i> <sup>(b)</sup>			3.3	14.9	26.5		
<i>Mixed cereal flakes</i>	37 (1)	60	4.5	8.9	13.3		
<i>Rye flakes</i> <sup>(b)</sup>			3.3	14.9	26.5		
<i>Spelt flakes</i>	73	96	2.1	20.1	38.2		
<i>Wheat flakes with sugar</i> <sup>(b)</sup>			3.3	14.9	26.5		
<i>Rice flakes</i>	19 (2)	24	73.4	76.5	79.6		
<i>Rice flakes and chocolate</i> <sup>(i)</sup>			61.2	75.4	89.5		
<i>Barley flakes</i> <sup>(b)</sup>			3.3	14.9	26.5	Grain-based processed products (not rice-based)	
<i>Millet flakes</i> <sup>(b)</sup>			3.3	14.9	26.5		
<i>Oat flakes</i> <sup>(b)</sup>			3.3	14.9	26.5		
<i>Wheat flakes</i> <sup>(b)</sup>			3.3	14.9	26.5		
<i>Cereal flakes (unspecified)</i> <sup>(b)</sup>			3.3	14.9	26.5		
Muesli	53 (2)	87	4.0	10.7	17.4		
Cereal bars	162 (1)	69	10.8	17.9	25.0		
Mixed breakfast cereals <sup>(g)</sup>			13.8	22.0	30.2		
Grits <sup>(g)</sup>			13.8	22.0	30.2		
Porridge	23						
<i>Oat porridge</i> <sup>(b)</sup>			9.7	14.2	18.8	Rice-based products	
<i>Wheat semolina porridge</i> <sup>(b)</sup>			9.7	14.2	18.8		
<i>Rice porridge</i> <sup>(d)</sup>			92.5	101.2	109.9		
<i>Rice, popped with sugar</i> <sup>(h)</sup>			108.3	111.5	114.7		
<i>Rice, popped</i> <sup>(h)</sup>			108.3	111.5	114.7		
<i>Wheat, popped</i> <sup>(g)</sup>			13.8	22.0	30.2		
<i>Porridge (unspecified)</i>	16	44	10.6	13.9	17.3		
<i>Breakfast cereals (unspecified)</i>	43	28	16.9	18.8	20.7		
<b>Pasta (Raw)</b>	127						Grain-based processed products (not rice-based)
Pasta, wheat wholemeal, without eggs <sup>(b)</sup>			7.7	14.0	20.3		
Pasta, wheat flour, without eggs	53 (12)	72	5.7	12.5	19.4		
Pasta, wheat flour, with eggs <sup>(b)</sup>			7.7	14.0	20.3		
Noodle, wheat flour, with eggs <sup>(b)</sup>			7.7	14.0	20.3		
Glass noodle <sup>(b)</sup>			7.7	14.0	20.3		

FOODEX_NAME	N <sup>(a)</sup>	LC % <sup>(i)</sup>	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
Noodle, rice	12 (1)	42	42.3	49.6	56.8	Rice-based products
Pasta (Raw) (unspecified)	48 (1)	46	12.2	18.8	25.4	Grain-based processed products (not rice-based)
<b>Fine bakery wares (without rice)</b>	327 (5)	30	6.9	9.9	13.3	
<b>Fine bakery wares (with rice)</b>	41 (31)	0	260.6	260.6	260.6	Rice-based products
<i>Grain and grain-based products (unspecified)</i>	11 (6)	91	3.4	23.4	43.4	Unspecified grain and grain-based products

- (a): In brackets the number of samples available with data on iAs.  
 (b): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the rest of the food commodities at the same FoodEx level except rice-based products.  
 (c): Mean estimates obtained exclusively from the reported iAs.  
 (d): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of all types of rice.  
 (e): Mean estimated value derived from the average concentration reported in five samples of rice bread and six of unleavened bread, crisp bread and rusk (with rice).  
 (f): Mean estimated values derived from the average concentration of three samples of rice flakes with chocolate and the samples of rice flakes.  
 (g): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the rest of the food commodities at the same FoodEx level.  
 (h): Estimated values derived from the average concentration of three samples of rice, popped with sugar and eight samples of rice popped.  
 (i): Percentage of left-censored data.

### 3.1.2. Vegetables and vegetable products

A total of 11 433 samples were available for the food category ‘Vegetables and vegetable products’, with ‘Fruiting vegetables’ at FoodEx level 2 being the most represented food group (2 031 samples). The food group ‘Seaweed’ is included in this category. Seaweed possesses high levels of arsenic, but usually as organic arsenic, concretely arsenosugars (Francesconi and Kuehnelt, 2002). However, the brown seaweed known as Hiziki or Hijiki (*Sargassum fusiforme*, syn. *Hizikia fusiformis*) contains very high amounts of iAs, which led several authorities in the past to advise consumers to avoid its consumption (FSA, 2004; FSANZ, 2004; Almela et al., 2006). Although this brown alga is not included in the FoodEx classification, initially 10 samples of seaweed were identified as Hijiki based on extra information from the data provider, nine of which reported levels of iAs (from 66.7 mg/kg to 96.1 mg/kg, mean= 77.4 mg/kg) (data not shown). In addition another four samples of seaweed, reported as unspecified, were considered as Hijiki based on their reported levels of iAs (> 1 mg/kg). These 14 samples were excluded from the exposure assessment since only one eating occasion on Hijiki is reported in the EFSA Comprehensive Food Consumption Database.

Some 451 samples were available with data reported on iAs. For all food commodities except seaweed the mean estimated iAs level was calculated using the iAs where it was reported and applying a 70 % conversion factor to tAs in those samples where iAs was not reported. Within the seaweed food category, for the group ‘Seaweed, unspecified’ only the reported values of iAs were used in the exposure assessment. For those samples that specified the seaweed type, reported values on iAs were used, and when only tAs was reported iAs was calculated applying a 1 % conversion factor to tAs based on previous reported results (FSA, 2004; FSANZ, 2004; Almela et al., 2006; Llorente-Mirandés et al., 2011).

The maximum estimated mean values of iAs were found in seaweed, in particular in the dark greenish brown seaweed Kombu (MB=352.6 µg/kg) (Table 5).

**Table 5:** Estimated iAs in the food category ‘Vegetables and vegetable products’. Mean concentrations ( $\mu\text{g}/\text{kg}$ ) are presented as LB, MB and UB. Estimates were rounded up to one decimal place. Samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**) and level 3 (normal).

FOODEX_NAME	N <sup>(a)</sup>	LC % <sup>(e)</sup>	Mean estimated iAs ( $\mu\text{g}/\text{kg}$ )			Groups
			LB	MB	UB	
<b>VEGETABLE and VEGETABLE PRODUCTS (including fungi)</b>	<b>11433</b>					
<b>Root vegetables</b>	1564					
Beetroot ( <i>Beta vulgaris</i> subsp. <i>vulgaris</i> )	206	76	0.9	3.9	6.9	
Carrots ( <i>Daucus carota</i> )	724 (39)	70	2.6	5.6	8.7	
Celeriac ( <i>Apium graveolens</i> var. <i>rapaceum</i> )	255	69	2.8	6.3	9.9	
Parsley root ( <i>Petroselinum crispum</i> )	14	36	5.5	7.9	10.4	
Parsnips ( <i>Pastinaca sativa</i> )	48 (15)	29	8.3	9.2	10.2	
Radishes ( <i>Raphanus sativus</i> var. <i>sativus</i> )	197	54	4.3	5.9	7.5	
Salsify ( <i>Tragopogon porrifolius</i> )	11	18	55.1	56.0	56.9	
Swedes ( <i>Brassica napus</i> var. <i>napobrassica</i> )	54	31	4.0	5.2	6.3	
Turnips ( <i>Brassica rapa</i> )	38	66	2.6	5.6	8.6	
Root vegetables (unspecified)	17 (6)	71	0.8	7.7	14.6	
<b>Bulb vegetables</b>	628 (8)	60	5.4	8.3	11.1	
<b>Fruiting vegetables</b>	2031					
Tomatoes ( <i>Lycopersicon esculentum</i> )	484 (19)	87	1.5	4.6	7.7	
Peppers, paprika	535	91	7.4	12.0	16.6	
Chilli pepper ( <i>Capsicum frutescens</i> ) <sup>(b)</sup>			5.6	9.0	12.3	
Aubergines (egg plants)	98 (1)	73	24.1	26.8	29.5	
Cucumbers ( <i>Cucumis sativus</i> )	358 (11)	70	8.6	11.1	13.6	
Courgettes (Zucchini)	322 (18)	83	1.5	4.9	8.3	
Melons ( <i>Cucumis melo</i> )	86	45	4.9	6.3	7.7	
Pumpkins ( <i>Cucurbita maxima</i> )	87 (2)	78	0.7	3.7	6.8	
Watermelons ( <i>Citrullus lanatus</i> )	18	50	0.9	1.5	2.1	
Sweet corn ( <i>Zea mays</i> var. <i>saccharata</i> ) <sup>(b)</sup>			5.6	9.0	12.3	
Gherkins ( <i>Cucumis sativus</i> ) <sup>(b)</sup>			5.6	9.0	12.3	
Okra, lady's fingers ( <i>Hibiscus esculentus</i> ) <sup>(b)</sup>			5.6	9.0	12.3	
Fruiting vegetables (unspecified)	25 (10)	0	8.5	8.5	8.5	
<b>Brassica vegetables</b>	1572 (58)	64	3.3	5.6	7.8	
<b>Leaf vegetables</b>	1903					
Lamb's lettuce ( <i>Valerianella locusta</i> )	239	24	28.2	29.7	31.1	Vegetable and vegetable products (no coffee, no tea)
Lettuce, excluding Iceberg-type lettuce	259 (16)	50	6.9	8.9	10.8	
Iceberg-type lettuce	113	95	2.5	7.4	12.3	
Endive, scarole (broad-leaf endive)	158	84	1.8	6.3	10.8	
Rocket, Rucola	337	50	10.4	12.9	15.5	
Leaves and sprouts of Brassica spp	39 (12)	3	46.2	46.3	46.4	
Spinach (fresh) ( <i>Spinacia oleracea</i> )	73 (3)	36	10.7	11.9	13.2	
Spinach preserved, deep-frozen or frozen	124	61	2.4	5.0	7.6	
Purslane ( <i>Portulaca oleracea</i> ) <sup>(b)</sup>			9.8	12.2	14.7	
Beet leaves ( <i>Beta vulgaris</i> ) <sup>(b)</sup>			9.8	12.2	14.7	
Witloof ( <i>Cichorium intybus</i> var. <i>foliosum</i> ) <sup>(b)</sup>	(4)		9.8	12.2	14.7	
Leaf vegetables (unspecified)	546 (10)	65	5.6	8.0	10.4	
<b>Legumes vegetables</b>	63(7)	40	4.1	5.8	7.4	
<b>Stem vegetables (Fresh)</b>	929					
Asparagus ( <i>Asparagus officinalis</i> )	290 (3)	93	0.3	3.1	5.9	
Celery ( <i>Apium graveolens</i> var. <i>dulce</i> )	42	26	9.2	10.9	12.6	
Fennel ( <i>Foeniculum vulgare</i> ) <sup>(b)</sup>			3.8	6.4	8.9	
Globe artichokes ( <i>Cynara scolymus</i> )	92	74	7.3	10.3	13.4	
Leek ( <i>Allium porrum</i> )	269 (37)	63	3.0	5.4	7.8	
Rhubarb ( <i>Rheum</i> × hybridum)	227	83	6.8	9.1	11.3	
Stem vegetables (Fresh) (unspecified) <sup>(b)</sup>			3.8	6.4	8.9	
<b>Sugar plants</b>	93	75	5.8	12.2	18.6	
<b>Sea weed</b>	367					
Irish moss ( <i>Chondrus crispus</i> )	33 (2)	21	65.2	65.6	66.1	
Kombu ( <i>Laminaria</i> spp.)	11 (7)	64	257.2	352.6	448.1	
Laver ( <i>Porphyra</i> spp.)	15 (8)	53	138.2	208.2	278.2	
Wakame ( <i>Undaria</i> spp)	23 (6)	35	236.7	280.2	323.7	
Sea weed (unspecified) <sup>(c)</sup>	261 (131)		256.3	269.8	283.3	
<b>Vegetable products</b>	84					

FOODEX_NAME	N <sup>(a)</sup>	LC % <sup>(e)</sup>	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
Tomato purée <sup>(b)</sup>			42.3	48.5	54.7	
Mixed vegetable purée <sup>(b)</sup>			42.3	48.5	54.7	
Pickled vegetables	22	27	6.8	8.5	10.3	
Sauerkraut	33	61	0.7	1.5	2.3	
Hops (dried), pellets and unconc. powder <sup>(b)</sup>			42.3	48.5	54.7	
Vegetable products (unspecified)	11	45	65.4	69.7	74.1	
<b>Cocoa beans and cocoa products</b>	215					
Cocoa mass <sup>(b)</sup>			34.8	40.9	47.1	
Cocoa powder	159	36	37.4	43.4	49.5	
Cocoa beverage-preparation, powder	40	60	13.8	16.8	19.9	Vegetable and vegetable products (no coffee, no tea)
Cocoa beans and cocoa products (unspecified) <sup>(b)</sup>			34.8	40.9	47.1	
<b>Fungi, cultivated</b>	597					
Cultivated mushroom	327	69	7.0	11.5	15.9	
Oyster mushroom ( <i>Pleurotus ostreatus</i> )	99	42	21.1	24.6	28.1	
Shiitake mushroom ( <i>Lentinus edodes</i> )	131	9	219.0	219.7	220.5	
Straw mushroom ( <i>Volvaria volvaria</i> ) <sup>(b)</sup>			58.4	62.1	65.9	
Fungi, cultivated (unspecified)	39 (3)	54	45.3	53.8	62.3	
<b>Fungi, wild, edible</b>	338					
Honey mushroom ( <i>Armillaria mellea</i> ) <sup>(b)</sup>			72.7	75.8	78.9	
Boletus ( <i>Boletus</i> (and other) spp.)	129	53	49.8	52.1	54.3	
Truffle ( <i>Tuber spp.</i> ) <sup>(b)</sup>			72.7	75.8	78.9	
Morel ( <i>Morchella esculanta</i> ) <sup>(b)</sup>			72.7	75.8	78.9	
Cantharelle ( <i>Cantharellus cibarius</i> )	129	74	106.4	110.5	114.6	
Orange agaric ( <i>Lactarius deliciosus</i> ) <sup>(b)</sup>			72.7	75.8	78.9	
Fungi, wild, edible (unspecified)	72	38	58.1	60.6	63.2	
<b>Tea and herbs for infusions (Solid)</b>	308	56	39.7	42.3	44.9	Tea and infusions
Tea (dried leaves and stalks)	111	86	6.6	7.9	9.3	
Camomile flowers ( <i>Matricaria recutita</i> )	27	0	74.4	74.4	74.4	
Peppermint ( <i>Mentha × piperita</i> )	53	45	25.0	25.6	26.3	
Hibiscus flowers ( <i>Hibiscus sabdariffa</i> ) <sup>(b)</sup>			33.0	35.1	37.2	
Jasmine flowers ( <i>Jasminum officinale</i> ) <sup>(b)</sup>			33.0	35.1	37.2	
Lime (linden) ( <i>Tillia cordata</i> ) <sup>(b)</sup>			33.0	35.1	37.2	
Maté ( <i>Ilex paraguariensis</i> ) <sup>(b)</sup>			33.0	35.1	37.2	
Ginseng root ( <i>Panax ginseng</i> ) <sup>(b)</sup>			33.0	35.1	37.2	
Tea and herbs for infusions (Solid) (unspecified)	308	56	39.7	42.3	44.9	
<b>Coffee beans and coffee products (Solid)</b>	93					Coffee
Coffee beans, roasted	44	86	1.7	4.5	7.3	
Coffee beans, roasted and ground, decaf. <sup>(d)</sup>			29.0	30.2	31.4	
Coffee beans, roasted and ground	37	30	29.0	30.2	31.4	
Instant coffee, powder	11	0	4.8	4.8	4.8	
Coffee beans and coffee products (Solid) (unspecified) <sup>(b)</sup>			12.9	14.7	16.6	

(a): In brackets the number of samples available with data on iAs.

(b): Since less than 10 samples were available, the mean estimated value were obtained from the average concentration of the food commodities grouped at FoodEx level 2.

(c): Only the reported data on iAs were used. Fourteen samples identified as Hijiki/ Hiziki were excluded from this group as only one eating occasion on Hijiki is reported in the EFSA Comprehensive Food Consumption Database.

(d): Mean occurrence value from samples of Coffee beans, roasted and ground.

(e): Percentage of left-censored data.

### 3.1.3. Starchy roots and tubers

A total of 1 246 samples were available on the food category ‘Starchy roots and tubers’, of which only nine reported values on iAs. The food group with the highest number of samples was ‘Potatoes and potato products’. The mean estimated iAs was calculated using the iAs reported, and applying a 70 % conversion factor to the tAs on those samples where iAs was not reported.

The maximum estimated mean value was calculated for the food group ‘Other starchy roots and tubers’ (MB= 9.2 µg/kg) (Table 6).

**Table 6:** Estimated iAs in the food category ‘Starchy roots and tubers’. Mean concentrations ( $\mu\text{g}/\text{kg}$ ) are presented as LB, MB and UB. Estimates were rounded up to one decimal place. Samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**), level 3 (normal) and level 4 (*italic*).

FOODEX_NAME	N <sup>(a)</sup>	LC % <sup>(b)</sup>	Mean estimated iAs ( $\mu\text{g}/\text{kg}$ )			Groups
			LB	MB	UB	
<b>STARCHY ROOTS and TUBERS</b>	<b>1246</b>					
Potatoes and potato products	1065 (9)	71.1	1.6	4.4	7.2	Starchy roots and tubers
Other starchy roots and tubers	76	65.8	4.0	9.2	14.5	
<b>Starchy roots and tubers (unspecified)</b>	105	76.2	4.9	8.5	12.1	

(a): In brackets the number of samples available with data on iAs.

(b): Percentage of left-censored data.

### 3.1.4. Legumes, nuts and oilseeds

A total of 2 541 samples were available on the food category ‘Legumes, nuts and oilseeds’, with the food ‘Peas, green, without pods (*Pisum sativum*)’ being the most represented with 283 samples. Only eleven samples reported data on iAs within ‘Legumes, nuts and oilseeds’. The mean estimated iAs concentration was calculated using the iAs reported, and applying a 70 % conversion factor to the tAs on those samples where iAs was not reported.

The maximum estimated mean value was found for samples of ‘Pine nuts’ (MB= 37.5  $\mu\text{g}/\text{kg}$ ) (Table 7).

**Table 7:** Estimated iAs in the food category ‘Legumes, nuts and oilseeds’. Mean concentrations ( $\mu\text{g}/\text{kg}$ ) are presented as LB, MB and UB. Estimates were rounded up to one decimal place. Samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**) and level 3 (normal).

FOODEX_NAME	N <sup>(a)</sup>	LC % <sup>(f)</sup>	Mean estimated iAs ( $\mu\text{g}/\text{kg}$ )			Groups
			LB	MB	UB	
<b>LEGUMES, NUTS AND OILSEEDS</b>	<b>2541</b>					
<b>Legumes, beans, green, with pods</b>	18	94	0.1	2.7	5.2	
<b>Legumes, beans, green, without pods (unsp.)</b>	331					
Beans, green, without pods	15	93	0.1	2.1	4.0	
Peas, green, without pods ( <i>Pisum sativum</i> )	283	74	5.6	8.5	11.5	
Lentils, green ( <i>Lens culinaris</i> syn. <i>L. esculenta</i> ) <sup>(c)</sup>			5.9	8.7	11.6	
Legumes, beans, green, without pods (unspecified)	28 (11)	0	12.5	12.5	12.5	
<b>Legumes, beans, dried</b>	591					
Beans ( <i>Phaseolus vulgaris</i> )	202	89	0.6	4.4	8.1	
Lentils ( <i>Lens culinaris</i> syn. <i>L. esculenta</i> )	66	38	8.1	11.3	14.5	
Peas ( <i>Pisum sativum</i> ) <sup>(c)</sup>			4.9	11.5	18.1	
Chick pea ( <i>Cicer arietinum</i> )	12	92	1.3	14.2	27.1	Legumes, nuts and oilseeds
Broad bean ( <i>Vicia faba</i> ) <sup>(c)</sup>			4.9	11.5	18.1	
Soya beans ( <i>Glycine max</i> )	95	57	12.9	16.3	19.7	
Soya beans flour <sup>(c)</sup>			4.9	11.5	18.1	
Scarlet runner bean ( <i>Phaseolus coccineus</i> )	27	11	1.2	3.1	4.9	
Peanut ( <i>Arachis hypogea</i> )	169	81	4.2	18.0	31.7	
Legumes, beans, dried (unspecified) <sup>(c)</sup>			4.9	11.5	18.1	
<b>Tree nuts</b>	726					
Almond, sweet ( <i>Prunus amygdalus dulcis</i> )	208	82	2.0	10.8	19.6	
Almond, bitter ( <i>Prunus amygdalus amara</i> ) <sup>(d)</sup>			2.0	10.8	19.6	
Brazil nuts ( <i>Bertholletia excelsa</i> ) <sup>(c)</sup>			3.7	14.2	24.7	
Cashew nuts ( <i>Anacardium occidentale</i> )	94	96	0.5	10.1	19.7	
Chestnuts ( <i>Castanea sativa</i> )	57	88	0.8	8.4	16.0	

FOODEX_NAME	N <sup>(a)</sup>	LC % <sup>(f)</sup>	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
Coconuts ( <i>Cocos nucifera</i> )	25	100	0.0	5.2	10.5	
Hazelnuts ( <i>Corylus avellana</i> )	77	87	7.3	19.3	31.4	
Macadamia ( <i>Macadamia ternifolia</i> )	106	96	0.6	15.6	30.6	
Pine nuts ( <i>Pinus pinea</i> )	21	43	28.0	37.5	46.9	
Pistachios ( <i>Pistachia vera</i> )	73	73	9.0	20.8	32.7	
Walnuts ( <i>Juglans regia</i> )	46	72	6.8	14.8	22.7	
Tree nuts (unspecified)	14	100	0.0	14.5	29.1	
<b>Oilseeds</b>	<b>867</b>					
Linseed ( <i>Linum usitatissimum</i> )	119	71	13.1	20.8	28.6	Legumes, nuts and oilseeds
Poppy seed ( <i>Papaver somniferum</i> )	90	43	25.6	32.6	39.6	
Sesame seed ( <i>Sesamum indicum</i> )	139	55	13.5	20.1	26.7	
Sunflower seed ( <i>Helianthus annuus</i> )	170	70	15.8	25.1	34.5	
Rape seed ( <i>Brassica napus</i> )	200	32	31.0	33.2	35.5	
Mustard seed ( <i>Brassica nigra</i> )	15	47	22.5	33.7	44.9	
Pumpkin seeds ( <i>Cucurbita pepo</i> var. <i>oleifera</i> )	129	79	3.2	10.5	17.8	
Oilseeds (unspecified) <sup>(c)</sup>			17.8	24.3	30.8	
<b>Other seeds<sup>(e)</sup></b>			17.8	24.3	30.8	
Legumes, nuts and oilseeds (unspecified) <sup>(b)</sup>			9.0	16.2	23.4	

(a): In brackets the number of samples available with data on iAs.

(b): Since less than 10 samples were available, the mean estimated value were obtained from the average concentration of the food commodities grouped at FoodEx level 1.

(c): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the food commodities grouped at FoodEx level 2.

(d): Since only one sample of almond (bitter) was available, the same mean occurrence value as calculated for almond (sweet) was used.

(e): Occurrence value derived from the average occurrence value of all samples of 'Oilseeds' at FoodEx level 2.

(f): Percentage of left-censored data.

### 3.1.5. Fruit and fruit products

A total of 4 330 samples were available on the food category 'Fruit and fruit products'. The food group 'Berries and small fruits (unspecified)' was the most represented with 1 257 samples. Similar to the two previous food categories only very limited data on iAs (sixteen samples) were available. The mean estimated iAs was calculated using the iAs reported, and applying 70 % to the tAs on those samples where iAs was not reported.

The maximum estimated mean values for iAs were calculated for the food category 'Other fruit products (excl. beverages)' at FoodEx level 2 (MB= 24.3 µg/kg) (Table 8).

**Table 7:** Estimated inorganic arsenic in the food category 'Fruit and fruit products'. Mean concentrations (µg/kg) are presented as LB, MB and UB. Estimates were rounded up to one decimal place. Samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**) and level 3 (normal).

FOODEX_NAME	N <sup>(a)</sup>	LC % <sup>(e)</sup>	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
<b>FRUIT and FRUIT PRODUCTS</b>	<b>1257</b>					
<b>Pome fruits</b>	844	82	1.6	5.0	8.4	Fruit and fruit products
<b>Stone fruits</b>	540	90	0.7	4.5	8.2	
<b>Citrus fruits</b>	425	91	0.8	4.3	7.7	
<b>Oilfruits<sup>(c)</sup></b>			1.8	5.5	9.2	
<b>Berries and small fruits</b>	1257 (15)	76	1.7	4.9	8.0	



FOODEX_NAME	N <sup>(a)</sup>	LC % <sup>(e)</sup>	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
<b>Jam, marmalade/other fruit spreads</b>	29	45	2.7	7.2	11.6	
<b>Miscellaneous fruits</b>	869	93	0.7	4.8	8.9	
<b>Jam, marmalade/other fruit spreads</b>	29	45	2.7	7.2	11.6	
<b>Dried fruits</b>	281					
Dried vine fruits (currants, raisins and sultanas)	120	47	13.2	18.7	24.3	
Dried figs ( <i>Ficus carica</i> )	20	100	0.0	5.6	11.1	
Dried prunes ( <i>Prunus domestica</i> )	12	92	1.6	8.4	15.1	
Dried apricots ( <i>Prunus armeniaca</i> )	90	69	8.9	13.8	18.6	
Dried pears ( <i>Pyrus communis</i> ) <sup>(b)</sup>			9.4	14.5	19.6	
Dried apples ( <i>Malus domestica</i> ) <sup>(b)</sup>			9.4	14.5	19.6	
Dried dates ( <i>Phoenix dactylifera</i> ) <sup>(b)</sup>			9.4	14.5	19.6	
Dried bananas ( <i>Musa × paradisiaca</i> ) <sup>(b)</sup>			9.4	14.5	19.6	Fruit and fruit products
Dried fruits (unspecified)	12	42	11.0	13.0	14.9	
<b>Other fruit products (excl. beverages)</b>	63					
Mixed dried fruits <sup>(b)</sup>			17.8	24.3	30.8	
Fruit, purée	17	59	3.1	16.7	30.3	
Fruit, canned	21	81	1.4	4.6	7.8	
Fruit compote	13	85	1.2	3.2	5.2	
Fruit, chocolate coated <sup>(b)</sup>			17.8	24.3	30.8	
Other fruit products (excl. beverages) (unsp.)			17.8	24.3	30.8	
Fruit and fruit products (unspecified)	20	50	1.6	12.5	23.4	

- (a): In brackets the number of samples available with data on iAs.  
 (b): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the food commodities grouped at FoodEx level 2.  
 (c): Since the available samples were less than 10 and all left-censored data, the mean estimated value was obtained from the average concentration of the food commodities grouped at FoodEx level 1.  
 (e): Percentage of left-censored data.

### 3.1.6. Meat and meat products (including edible offal)

A total of 23 716 samples were available in the food category ‘Meat and meat products (including edible offal)’, being the food category with the highest number of samples together with drinking water. Edible offal samples from farmed animals were the most represented (n= 9 556). Some 223 samples reported data on iAs, with the data mainly concentrated in the food groups ‘Edible offal, farmed animals’ and ‘Livestock meat’ in both cases with 105 samples reported. The mean estimated iAs was calculated using the iAs reported, and applying 70 % to the tAs on those samples where iAs was not reported.

The generic food group ‘Meat and meat products’ possessed the highest levels of estimated iAs (MB= 14.4 µg/kg). In addition, relatively high values of iAs for this food category were estimated in the samples of pastes, pâtés and terrines (MB= 12.3 µg/kg) (Table 9).

**Table 9:** Estimated iAs in the food category ‘Meat and meat products (including edible offal)’. Mean concentrations (µg/kg) are presented as LB, MB and UB. Estimates were rounded up to one decimal place. Samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**) and level 3 (normal).

FOODEX_NAME	N <sup>(a)</sup>	LC %	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
<b>MEAT and MEAT PRODUCTS</b>	<b>23716</b>					
<b>Poultry</b>	2720					
Chicken meat ( <i>Gallus domesticus</i> )	1306 (1)	69	4.7	7.9	11.2	Meat and meat products
Turkey meat ( <i>Meleagris gallopavo</i> )	465 (2)	57	5.0	7.5	9.9	

FOODEX_NAME	N <sup>(a)</sup>	LC %	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
Duck meat ( <i>Anas</i> spp.)	325	85	1.3	4.4	7.4	
Goose meat ( <i>Anser</i> , <i>Branta</i> , <i>Chen</i> )	287	89	0.9	3.7	6.4	
Ostrich meat ( <i>Struthio camelus</i> ) <sup>(b)</sup>			3.8	6.8	9.9	
Poultry (unspecified)	329 (1)	79	2.9	6.7	10.4	
<b>Livestock meat</b>	6492 (109)	74	3.3	6.2	9.2	
<b>Game mammals</b>	2140	64	6.4	9.6	12.8	
<b>Game birds</b>	113	69	5.0	6.5	8.0	
<b>Mixed beef and pork meat</b> <sup>(c)</sup>			4.1	7.4	10.7	
<b>Edible offal, farmed animals</b>	9556 (106)	77	3.7	7.4	11.0	
<b>Edible offal, game animals</b>	322	70	7.1	11.5	15.9	
<b>Preserved meat</b>	527 (2)	45	8.5	10.8	13.1	Meat and meat products
<b>Sausages</b>	1556 (2)	61	4.3	7.6	11.0	
<b>Meat specialities</b>	45	38	3.3	3.7	4.2	
<b>Pastes, pâtés and terrines</b>	85					
Meat paste <sup>(b)</sup>			11.0	12.3	13.6	
Pate, goose liver <sup>(b)</sup>			11.0	12.3	13.6	
Pate, pork liver	12	67	1.3	2.0	2.8	
Pastes, pâtés and terrines (unspecified)	64	38	10.4	11.6	12.8	
Textured soy protein <sup>(d)(e)</sup>			12.9	16.3	19.7	
Meat and meat products (unspecified)	152	63	11.5	14.4	17.3	

- (a): In brackets the number of samples available with data on iAs.  
(b): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the food commodities grouped at FoodEx level 2.  
(c): Since the available samples were less than 10 and all left-censored data, the mean estimated value was obtained from the average concentration of the food commodities grouped at FoodEx level 1.  
(d): Since only four samples were available, the mean estimated value for 'Soya beans' (Table 5) was used here.  
(e): Reported samples of 'Textured soy protein' are included under this food category since soy protein is used as meat imitate.  
(f): Percentage of left-censored data.

### 3.1.7. Fish and other seafood

A total of 6 922 samples were available in the food category 'Fish and other seafood (including amphibians, reptiles, snails and insects)', among which 1 012 reported data on iAs especially in the food groups 'Fish meat' (n= 617), 'Water molluscs' (n= 313) and 'Crustaceans' (n= 71) (Table 10).

As explained in section 2.1.3., for this food category only the data on iAs were used. For the food groups, 'Fish and other seafood (unsp.)', 'Fish products' and 'Fish offal', since very few data on iAs were available (only eleven samples), the estimated iAs concentration was calculated from the average iAs concentration of the 1 012 samples that reported data on iAs.

**Table 10:** Mean iAs in the food category 'Fish and other seafood (including amphibians, reptiles, snails and insects)'. Mean concentrations (µg/kg) are presented as LB, MB and UB. Values were rounded up to one decimal place. Samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**) and level 3 (normal).

FOODEX_NAME	N <sup>(a)</sup>	LC %	Mean iAs (µg/kg)			Groups
			LB	MB	UB	
<b>FISH and OTHER SEAFOOD</b>	<b>1012</b>					
<b>Fish meat</b>	<b>617</b>					
Cod and whiting ( <i>Gadus</i> spp.)	199	89	1.4	5.0	8.6	
Sole ( <i>Limanda</i> ; <i>Solea</i> )	12	67	11.8	29.3	46.8	Fish and other seafood
Herring ( <i>Clupea</i> )	60	98	0.7	5.4	10.2	
Mackerel ( <i>Scomber</i> )	89	90	1.8	7.7	13.7	

FOODEX_NAME	N <sup>(a)</sup>	LC %	Mean iAs (µg/kg)			Groups
			LB	MB	UB	
Salmon and trout ( <i>Salmo</i> spp.)	27	78	4.4	10.8	17.3	
Tuna ( <i>Thunnus</i> )	22	91	1.2	12.6	23.9	
Hake ( <i>Merluccius</i> )	14	64	6.9	24.9	42.9	
Halibut ( <i>Hippoglossus</i> spp.)	19	84	2.3	4.0	5.6	
Sardine and pilchard ( <i>Sardina</i> )	20	60	20.4	34.6	48.7	
Grey mullet ( <i>Mugil</i> ) <sup>(b)</sup>			4.5	11.3	18.1	
Plaice ( <i>Pleuronectes</i> ) <sup>(b)</sup>			4.5	11.3	18.1	
Anchovy ( <i>Engraulis</i> ) <sup>(b)</sup>			4.5	11.3	18.1	
Bass ( <i>Marone</i> ) <sup>(b)</sup>			4.5	11.3	18.1	
Eels ( <i>Apodes</i> ) <sup>(b)</sup>			4.5	11.3	18.1	
Carp ( <i>Cyprinus</i> ) <sup>(b)</sup>			4.5	11.3	18.1	
Rays ( <i>Hypotremata</i> ) <sup>(b)</sup>			4.5	11.3	18.1	
Bream ( <i>Charax</i> ) <sup>(b)</sup>			4.5	11.3	18.1	
Sprat ( <i>Sprattus sprattus</i> ) <sup>(b)</sup>			4.5	11.3	18.1	
Lophiiformes ( <i>Pediculati</i> ) <sup>(b)</sup>			4.5	11.3	18.1	
Fish meat (unspecified)	115	84	5.1	14.4	23.6	
<b>Fish products</b> <sup>(c)</sup>			19.6	25.6	31.6	
<b>Fish offal</b> <sup>(c)</sup>			19.6	25.6	31.6	
<b>Crustaceans (unspecified)</b> <sup>(b)</sup>	71					
Crab ( <i>Cancer</i> spp.)	21	24	70.3	74.3	78.3	
Shrimps ( <i>Crangon crangon</i> )	29	38	16.6	22.0	27.4	
Lobster ( <i>Homarus vulgaris</i> ) <sup>(b)</sup>			31.0	36.2	41.3	Fish and other seafood
Norway lobster ( <i>Nephrops norvegicus</i> ) <sup>(b)</sup>			31.0	36.2	41.3	
Prawns ( <i>Palaemon serratus</i> ) <sup>(b)</sup>			31.0	36.2	41.3	
Crawfish ( <i>Panulirus</i> spp.) <sup>(b)</sup>			31.0	36.2	41.3	
Crayfish ( <i>Astacus</i> spp.) <sup>(b)</sup>			31.0	36.2	41.3	
Crustaceans (unspecified) <sup>(b)</sup>			31.0	36.2	41.3	
<b>Water molluscs</b> <sup>(b)</sup>	313					
Squid ( <i>Loligo vulgaris</i> )	10	90	1.1	16.5	31.9	
Octopus ( <i>Octopus vulgaris</i> )	17	94	13.3	35.1	56.9	
Cockle ( <i>Cardium edule</i> )	11	0	128.8	129.7	130.6	
Mussel ( <i>Mytilus edulis</i> )	186	15	39.6	41.6	43.6	
Oyster ( <i>Ostrea edulis</i> )	40	15	64.5	67.3	70.0	
Winkle ( <i>Littorina littorea</i> )	10	0	80.8	82.3	83.8	
Snail ( <i>Helix</i> spp.)	47	38	0.5	0.5	0.5	
Cuttlefish ( <i>Sepia officinalis</i> ) <sup>(b)</sup>			46.6	50.9	55.1	
Clam ( <i>Mya arenaria</i> ) <sup>(b)</sup>			46.6	50.9	55.1	
Queen scallop ( <i>Chlamys opercularis</i> ) <sup>(b)</sup>			46.6	50.9	55.1	
Scallop ( <i>Pecten</i> spp.) <sup>(b)</sup>			46.6	50.9	55.1	
Razor clam ( <i>Solen marginatus</i> ) <sup>(b)</sup>			46.6	50.9	55.1	
Whelk ( <i>Buccinum undatum</i> , <i>Fusus antiquus</i> ) <sup>(b)</sup>			46.6	50.9	55.1	
Water molluscs (unspecified) <sup>(b)</sup>			46.6	50.9	55.1	
Fish and other seafood (unspecified) <sup>(c)</sup>			19.6	25.6	31.6	

(a): N refers to samples with data reported on iAs.

(b): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the food commodities grouped at FoodEx level 2.

(c): Mean estimated value calculated using the 1012 samples for which data on iAs were reported.

(d): Percentage of left-censored data.

### 3.1.8. Milk and dairy products

A total of 5 291 samples were available in the food category ‘Milk and dairy products’, with more than half (3 056) that belonged to the food group ‘Liquid milk’. Sixty samples reported data on iAs, all of which were samples of ‘Rice drink’. For these sixty samples only the reported data on iAs were used. For the rest of the samples the mean estimated iAs was calculated applying 70 % to the tAs reported (see Table 11).

Seven samples were excluded from the final dataset as they reported unusually high values as compared to the rest of the available data in the same food category. Since no plausible explanation for this high concentration was found and the data could not be confirmed by the data provider, the data were eliminated. The eliminated data refer to four samples of cow milk with reported values of tAs equal to 166 µg/kg and three samples of yoghurt that reported values between 350-660 µg/kg.

Relatively low values of estimated iAs were found in this food category; the food ‘Dried milk’ showed the highest mean estimated values at the MB, 18.2 µg/kg (Table 11). In the food group with the highest number of reported samples (‘Liquid milk’), the mean estimated iAs was between 1.6 and 6.6 µg/kg (LB-UB), while the estimated 95<sup>th</sup> percentile was between 10.5 and 21.0 µg/kg (LB-UB) (data not shown).

**Table 11:** Estimated iAs in the food category ‘Milk and dairy products’. Mean concentrations (µg/kg) are presented as LB, MB and UB. Estimates were rounded up to one decimal place. Samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**) and level 3 (normal).

FOODEX_NAME	N <sup>(a)</sup>	LC % <sup>(e)</sup>	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
<b>MILK and DAIRY PRODUCTS</b>	5291					
<b>Liquid milk</b>	3056	81	1.6	4.1	6.6	
<b>Milk-based beverages <sup>(b)</sup></b>			2.7	5.9	9.0	
<b>Concentrated milk</b>	111					
Condensed milk	15	80	0.5	2.6	4.6	
Dried milk	92	57	11.4	18.2	25.0	
Concentrated milk (unspecified) <sup>(c)</sup>			9.6	15.5	21.4	
<b>Whey and whey products (excl. whey cheese) <sup>(b)</sup></b>			2.7	5.9	9.0	
<b>Cream and cream products</b>	183	72	4.4	6.2	8.0	
<b>Fermented milk products</b>	482					
Yoghurt, cow milk, plain	402	76	2.6	6.4	10.2	Milk and dairy products
Yoghurt, cow milk, with fruit <sup>(c)</sup>			2.6	6.4	10.2	
Yoghurt, sheep milk	17	100	0.0	13.5	27.1	
Skyr <sup>(d)</sup>			2.8	6.6	10.5	
Sour milk <sup>(d)</sup>			2.8	6.6	10.5	
Kefir <sup>(d)</sup>			2.8	6.6	10.5	
Buttermilk <sup>(d)</sup>			2.8	6.6	10.5	
Fermented milk products (unspecified)	53	55	5.1	6.0	6.8	
<b>Cheese</b>	1278	75	4.2	8.6	13.0	
<b>Milk and milk products imitates<sup>(e)</sup></b>	150					
Soya drink <sup>(f)</sup>			1.7	6.3	11.0	
Soya yoghurt	12	67	2.9	4.7	6.4	
Tofu	15	73	3.0	10.4	17.9	
Rice drink <sup>(g)</sup>	66 (60)	27	11.0	11.7	12.4	Rice drink
Milk and milk product imitates (unspecified)	52	94	0.8	5.6	10.4	Milk and dairy products
Milk and dairy products (unspecified)	16	75	1.9	4.7	7.5	products

(a): In brackets the number of samples available with data on iAs.

(b): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the food commodities grouped at FoodEx level 1.

(c): Mean occurrence values from the food ‘Yoghurt, cow milk, plain’.

(d): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the food commodities grouped at FoodEx level 2.

(e): Different milk and milk product imitates are included in the FoodEx classification under this food category since they are sometimes used as substitutes of milk and milk products

(f): Since less than 10 samples were available, the mean estimated value was obtained from the average concentration of all food commodities grouped at the corresponding FoodEx level 2 excluding the ‘Rice drink’ samples.

(g): Mean occurrence values calculated using only the reported iAs.

(e): Percentage of left-censored data.

### 3.1.9. Eggs and egg products

A total of 1 768 samples were available in the food category ‘Eggs and egg products’ (Table 12). No samples reported data on iAs. The mean estimated iAs was calculated applying 70 % to the tAs reported.

**Table 12:** Estimated iAs in the food category ‘Eggs and egg products’. Mean concentrations ( $\mu\text{g}/\text{kg}$ ) are presented as LB, MB and UB. Estimates were rounded up to one decimal place. N= number of samples; LC %= percentage of left-censored data. Samples were grouped at FoodEx level 1 (**CAPITALS**).

FOODEX_NAME	N <sup>(a)</sup>	LC % <sup>(b)</sup>	Mean estimated iAs ( $\mu\text{g}/\text{kg}$ )			Groups
			LB	MB	UB	
<b>EGGS and EGG PRODUCTS</b>	1768	76	3.0	5.84	8.68	Eggs and egg products

(a): In brackets the number of samples available with data on iAs.

(b): Percentage of left-censored data.

### 3.1.10. Sugar and confectionery

A total of 2 579 samples were available in the food category ‘Sugar and confectionery’. No data on iAs were reported. The most represented food groups were ‘Honey (unspecified)’ with 893 samples and ‘Chocolate (cocoa) products’ with 804 samples. The mean estimated iAs was calculated applying 70 % to the tAs reported.

The highest mean estimated iAs was calculated for samples of ‘Toffee’ (MB= 64.7  $\mu\text{g}/\text{kg}$ , n= 11) although this estimate should be viewed with caution since only three samples reported quantified values (Table 13).

**Table 13:** Estimated iAs in the food category ‘Sugar and confectionery’. Mean concentrations ( $\mu\text{g}/\text{kg}$ ) are presented as LB, MB and UB. Samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**) and level 3 (normal).

FOODEX_NAME	N <sup>(c)</sup>	LC % <sup>(d)</sup>	Mean estimated iAs ( $\mu\text{g}/\text{kg}$ )			Groups
			LB	MB	UB	
<b>SUGAR and CONFECTIONERY</b>	<b>2579</b>					
<b>Sugars</b>	135	85	2.2	14.4	26.6	
<b>Sugar substitutes</b>	74					
Nutritive sweeteners (e.g., sorbitol, manitol)	51	100	0.0	8.7	17.3	
Non-nutritive sweeteners (e.g., aspartam, saccharine)	16	63	13.0	17.2	21.4	
Sugar substitutes (unspecified) <sup>(a)</sup>			8.1	15.0	21.9	
<b>Confectionery (non-chocolate)</b>	297					Sugar and confectionery
Marzipan	44	98	0.2	10.5	20.8	
Toffee	11	73	62.6	64.7	66.7	
Liquorice candies	80	80	15.6	32.5	49.4	
Gum drops	54	28	21.1	21.3	21.5	
Jelly candies	21	52	8.9	12.9	16.8	
Candies, with sugar <sup>(a)</sup>			12.3	20.9	29.5	
Dragée, sugar coated <sup>(a)</sup>			12.3	20.9	29.5	
Caramel, hard <sup>(a)</sup>			12.3	20.9	29.5	

FOODEX_NAME	N <sup>(c)</sup>	LC % <sup>(d)</sup>	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
Nougat <sup>(a)</sup>			12.3	20.9	29.5	
Chewing gum with added sugar <sup>(a)</sup>			12.3	20.9	29.5	
Chewing gum without added sugar <sup>(a)</sup>			12.3	20.9	29.5	
Foamed sugar products (marshmallows) <sup>(a)</sup>			12.3	20.9	29.5	
Confectionery (non-chocolate)(unspecified)	56	79	3.9	12.8	21.6	
<b>Dessert sauces <sup>(b)</sup></b>			10.3	16.0	21.7	
<b>Chocolate (Cocoa) products</b>	804	61	10.4	15.8	21.2	
<b>Molasses and other syrups (unspecified)</b>	50	78	1.6	3.5	5.3	
Sugar beet syrup	39	67	15.1	17.8	20.6	Sugar and confectionery
Treacle <sup>(a)</sup>			7.2	9.9	12.5	
<b>Honey</b>	995					
Honey, monofloral	54	83	1.7	6.4	11.1	
Honey, polyfloral	28	61	28.9	30.4	31.9	
Honey, blended	15	100	0.0	8.4	16.8	
Honeydew honey <sup>(a)</sup>			12.1	16.1	20.1	
Comb honey <sup>(a)</sup>			12.1	16.1	20.1	
Honey (unspecified)	893	78	12.5	16.4	20.4	
Sugar and confectionary (unspecified)	182	85	4.6	12.3	19.9	

- (a): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the food commodities grouped at FoodEx level 2.
- (b): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the food commodities grouped at FoodEx level 1.
- (c): In brackets the number of samples available with data on iAs.
- (d): Percentage of left-censored data.

### 3.1.11. Animal and vegetable fats and oils

A total of 1 039 samples were available in the food category ‘Animal and vegetable fats and oils’ with the food group ‘Animal fat’ being the most represented (n= 564). No samples reported data on iAs. The mean estimated iAs was calculated applying 70 % to the tAs reported.

Samples of olive oil contained the highest mean estimated concentration of iAs at the MB (23.2 µg/kg, n= 38), clearly influenced by the left-censored data since only five samples were quantified, followed by samples of ‘Vegetable oil, unspecified’ (MB= 16.9 µg/kg) (Table 14).

**Table 14:** Estimated iAs in the food category ‘Animal and vegetable fats and oils’. Mean concentrations (µg/kg) are presented as LB, MB and UB. Estimates were rounded up to one decimal place. N= number of samples; LC %= percentage of left-censored data. Samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**) and level 3 (normal).

FOODEX_NAME	N <sup>(c)</sup>	LC % <sup>(d)</sup>	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
<b>ANIMAL and VEGETABLE FATS/OILS</b>	<b>1039</b>					
<b>Animal fat</b>	564	69	5.0	7.1	9.2	
<b>Fish oil <sup>(a)</sup></b>			5.2	9.5	13.7	
<b>Vegetable fat <sup>(a)</sup></b>			5.2	9.5	13.7	
<b>Vegetable oil</b>	275					Animal and vegetable fats and oils
Olive oil	38	87	1.6	23.2	44.8	
Rapeseed oil	49	61	6.2	8.3	10.4	
Soybean oil			5.4	14.9	22.4	
Sunflower oil	101	62	4.3	13.5	22.7	
Corn oil <sup>(b)</sup>			5.4	14.9	24.4	
Pumpkinseed oil <sup>(b)</sup>			5.4	14.9	24.4	

FOODEX_NAME	N <sup>(c)</sup>	LC % <sup>(d)</sup>	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
Vegetable oil (unspecified)	80	50	8.1	16.9	25.6	
<b>Margarine and similar products</b>	42	52	7.1	8.2	9.3	
Animal and vegetables fat and oils (unspecified)	146	82	4.5	8.6	12.6	Animal and vegetable fats and oils

- (a): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the food commodities grouped at FoodEx level 1.  
 (b): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the food commodities grouped at the corresponding FoodEx level 2.  
 (c): In brackets the number of samples available with data on iAs.  
 (d): Percentage of left-censored data.

### 3.1.12. Fruit and vegetable juices

A total of 1 789 samples were available in the food category ‘Fruit and vegetable juices’, with the food group ‘Fruit juice’ represented with 1 261 samples, of which 473 were apple juice. No data on iAs were available. The mean estimated iAs was calculated applying 70 % to the tAs reported.

One sample of grape juice was excluded from the final dataset as it reported unusual high values as compared to the rest of the available data at the same food category (382 µg/kg vs. 3.8 µg/kg). Since no plausible explanation for this high concentration was found, and the data could not be confirmed by the providers, the sample was eliminated.

In this food category, together with the generic group ‘Fruit and vegetable juices’ (MB= 7.6 µg/kg), the highest mean estimated iAs was found for grape juices with 7.3 µg/kg at the MB (n= 111) (Table 15).

**Table 15:** Estimated iAs in the food category ‘Fruit and vegetable juices’. Mean concentrations (µg/kg) are presented as LB, MB and UB. Samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**) and level 3 (normal).

FOODEX_NAME	N <sup>(c)</sup>	LC % <sup>(d)</sup>	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
<b>FRUIT and VEGETABLE JUICES</b>	<b>1789</b>					
<b>Fruit juice</b>	1261					
Juice, Apple	474	84	1.2	3.6	6.0	
Juice, Orange	290	98	0.4	3.7	7.0	
Juice, Grapefruit	114	89	0.5	3.8	7.2	
Juice, Pineapple	122	94	0.2	3.0	5.7	
Juice, Mango <sup>(a)</sup>			1.2	4.2	7.2	
Juice, Grape	111	70	3.8	7.3	10.7	
Juice, Cranberry <sup>(a)</sup>			1.2	4.2	7.2	
Juice, Pomegranate <sup>(a)</sup>			1.2	4.2	7.2	
Juice, Lemon <sup>(a)</sup>			1.2	4.2	7.2	Fruit and vegetable juices
Juice, Pear	10	70	0.9	4.1	7.3	
Juice, Apricot <sup>(a)</sup>			1.2	4.2	7.2	
Juice, Blackcurrant <sup>(a)</sup>			1.2	4.2	7.2	
Juice, Redcurrant <sup>(a)</sup>			1.2	4.2	7.2	
Juice, Elderberry <sup>(a)</sup>			1.2	4.2	7.2	
Juice, Mixed fruit <sup>(a)</sup>			1.2	4.2	7.2	
Fruit juice (unspecified)	120	76	2.6	5.6	8.6	
<b>Fruit nectar</b>	174	80	1.5	3.7	6.0	
<b>Mixed fruit juice</b>	46	70	2.5	4.7	7.0	

FOODEX_NAME	N <sup>(c)</sup>	LC % <sup>(d)</sup>	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
<b>Dehydrated/powdered fruit juice</b>	12	75	3.6	5.3	7.0	
<b>Vegetable juice</b>	196	82	1.5	4.4	7.2	Fruit and vegetable juices
<b>Mixed fruit and vegetable juice</b> <sup>(b)</sup>			1.3	4.2	4.2	
Fruit and vegetable juices (unspecified)	75	63	5.3	7.6	9.9	

- (a): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the food commodities grouped at the corresponding FoodEx level 2.  
 (b): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of all available samples of fruit juice and vegetable juice.  
 (c): In brackets the number of samples available with data on iAs.  
 (d): Percentage of left-censored data.

### 3.1.13. Non-alcoholic beverages (except milk based beverages)

A total of 695 samples were available in the food category ‘Non-alcoholic beverages’, with no samples reporting data on iAs. The mean estimated iAs was calculated applying 70 % to the tAs reported. The food group ‘Soft drinks’ was the most represented with 519 samples. Samples of tea (infusions) reported the highest values at the MB (8.6 µg/kg) together with samples of ‘Coffee drink, espresso’ (MB= 8.5 µg/kg) (Table 16).

**Table 16:** Estimated iAs in the food category ‘Non-alcoholic beverages (except milk based beverages)’. Mean concentrations (µg/kg) are presented as LB, MB and UB. Estimates were rounded up to one decimal place. N= number of samples; LC %= percentage of left-censored data. Samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**) and level 3 (normal).

FOODEX_NAME	N <sup>(d)</sup>	LC % <sup>(e)</sup>	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
<b>NON-ALCOHOLIC BEVERAGES (except milk based beverages)</b>	<b>695</b>					Other non-alcoholic beverages (not coffee, milk or tea)
<b>Soft drinks</b>	519	77	2.6	6.9	11.2	Soft drinks
<b>Tea (Infusion)</b>	66					Tea and infusions
Instant tea powder, infusion <sup>(a)</sup>			0.1	0.1	0.1	
Instant tea, liquid <sup>(a)</sup>			0.1	0.1	0.1	
Tea (Infusion)	66	64	3.4	8.6	13.8	
<b>Coffee (Beverage)</b>	72					Coffee
Coffee drink, espresso	30	40	7.4	8.5	9.5	
Instant coffee, liquid	31	72	2.5	4.2	6.0	
Coffee drink, café americano (liquid) <sup>(b)</sup>			1.6	1.7	1.7	
Coffee drink, cappuccino (liquid) <sup>(b)</sup>			1.6	1.7	1.7	
Coffee drink, café macchiato (liquid) <sup>(b)</sup>			1.6	1.7	1.7	
Iced coffee (liquid) <sup>(b)</sup>			1.6	1.7	1.7	
Coffee with milk (liquid) <sup>(b)</sup>			1.6	1.7	1.7	
Coffee (Beverage) (unspecified)	10	30	0.4	0.6	0.7	
Hot chocolate	32	50	5.9	7.0	8.2	Other non-alcoholic beverages (not coffee, milk, chocolate)
Non-alcoholic beverages (except milk based beverages)(unspecified) <sup>(c)</sup>			3.0	7.0	11.0	

- (a): Mean occurrence values were obtained by applying a dilution factor of 100 to the value reported for ‘Tea (dried leaves and stalks)’ in Table 5.  
 (b): Mean values calculated using a dilution factor of 18 applied to the food group ‘Coffee beans, roasted and ground’ in Table 5.



- (c): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the food commodities grouped at FoodEx level 1.  
 (d): In brackets the number of samples available with data on iAs.  
 (e): Percentage of left-censored data.

### 3.1.14. Alcoholic beverages

A total of 2 005 samples were available in the food category ‘Alcoholic beverages’, with all samples reporting data only on tAs. The mean estimated iAs was calculated applying 70 % to the tAs reported. The highest number of results (1 047) was reported in the food group ‘Wine’. The food group ‘Wine-like drinks, unspecified’ reported the highest estimated iAs values (MB= 10.4 µg/kg) (Table 17).

**Table 17:** Estimated iAs in the food category ‘Alcoholic beverages’. Mean concentrations (µg/kg) are presented as LB, MB and UB. Estimates were rounded up to one decimal place. Samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**) and level 3 (normal).

FOODEX_NAME	N <sup>(a)</sup>	LC % <sup>(b)</sup>	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
<b>ALCOHOLIC BEVERAGES</b>	<b>2005</b>					
<b>Beer and beer-like beverage</b>	656	72	3.1	6.8	10.5	
<b>Wine</b>	1047	53	3.9	5.8	7.6	
<b>Fortified and liqueur wines</b>	24	13	8.1	8.2	8.4	
<b>Spirits</b>	36	78	0.2	1.1	1.9	
<b>Alcoholic mixed drinks</b>	96	55	3.9	5.3	6.7	Alcoholic beverages
<b>Liqueur</b>	16	88	2.6	5.5	8.3	
<b>Wine-like drinks (e.g. Cider, Perry)</b>	119					
Cider	40	48	2.7	3.1	3.6	
Wine-like drinks (e.g. Cider, Perry) (unspecified)	79	29	10.1	10.4	10.8	
Alcoholic beverages (unspecified)	11	100	0.0	4.6	9.2	

(a): In brackets the number of samples available with data on iAs.

(b): Percentage of left-censored data.

### 3.1.15. Drinking water

A total of 24 884 samples were available in the food category ‘Drinking water (water with nothing added except carbon dioxide; includes water ice for consumption)’. All the data reported for drinking water were on tAs. As explained in section 2.1.3., all data reported as tAs for drinking water were assumed to be iAs when calculating dietary exposure.

Most of the data were left-censored, with an average proportion of 78.2 % among all drinking water samples. Most of the samples were reported as ‘Tap water’ (15 383 results), which was also the most reported type of water in the Comprehensive Food Consumption Database. For ‘Tap water’ the mean estimated iAs ranged between 1.1 and 2.0 µg/kg (LB-UB), and between 5.7 and 5.8 µg/kg for the 95<sup>th</sup> percentile estimate (LB-UB) (Table 18).

The highest mean occurrence values were reported for ‘Still mineral water’ with MB values of 5.8 µg/kg. In general, very low concentrations of arsenic were reported for ‘Still mineral water’, with 93.4 % of the samples reporting ≤ 10 µg/kg as specified in legislation<sup>7</sup> (data not shown). However, for a

few samples values around 200 µg/kg were reported which increased the mean estimates. Relatively high values of arsenic in bottled mineral waters have been reported in the past, with iAs contents in some cases above 500 µg/L (Farmer and Johnson, 1985; FDA, 2007).

**Table 18:** Estimated iAs in the food category ‘Drinking water (water with nothing added except carbon dioxide; includes water ice for consumption)’. Mean concentrations (µg/kg) are presented as LB, MB and UB. Estimates were rounded up to one decimal place. Samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**) and level 3 (normal).

FOODEX_NAME	N <sup>(b)</sup>	LC % <sup>(c)</sup>	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
<b>DRINKING WATER</b>	<b>24884</b>					
<b>Tap water</b>	15383	76	1.1	1.6	2.0	
<b>Bottled water</b>	6969					
Still mineral water	2243	78	3.9	5.8	7.7	Drinking water
Carbonated mineral water	3554	81	0.9	2.2	3.5	
Bottled water (unspecified)	1172	90	0.3	2.2	4.1	
<b>Water ice (for consumption)</b> <sup>(a)</sup>			1.3	2.1	3.0	
<b>Well water</b>	1378	73	1.1	1.8	2.5	
Drinking water (unspecified)	1153	90	1.3	2.6	3.8	

(a): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the food commodities grouped at FoodEx level 1.

(b): In brackets the number of samples available with data on iAs.

(c): Percentage of left-censored data.

### 3.1.16. Herbs, spices and condiments

A total of 1 911 samples were available in the food category ‘Herbs, spices and condiments’, with the food groups ‘Spices’ (n= 704) and ‘Herbs’ (n= 402) the most represented. Apart from 23 samples that reported iAs, all other results were reported as tAs. In these samples, the estimated iAs was calculated applying a 70 % conversion factor to the tAs reported. The highest mean value was estimated in samples of ‘ginger’ (MB= 259.5 µg/kg, n= 20) (Table 19).

**Table 19:** Estimated iAs in the food category ‘Herbs, spices and condiments’. Mean concentrations (µg/kg) are presented as LB, MB and UB. Estimates were rounded up to one decimal place. Samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**) and level 3 (normal).

FOODEX_NAME	N <sup>(a)</sup>	LC % <sup>(c)</sup>	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
<b>HERBS, SPICES and CONDIMENTS</b>	<b>1911</b>					
<b>Herbs</b>	462					
Chives, herb ( <i>Allium schoenoprasum</i> )	68	54	16.7	19.0	21.2	Herbs, spices and condiments
Dill, herb ( <i>Anethum graveolens</i> )	33	76	3.0	5.6	8.3	
Parsley, herb ( <i>Petroselinum crispum</i> )	168	43	20.5	23.5	26.5	
Thyme, herb ( <i>Thymus</i> spp.)	12	17	147.6	154.2	160.8	
Basil, herb ( <i>Ocimum basilicum</i> )	70	30	29.0	31.6	34.1	
Bay leaves (laurel) ( <i>Laurus nobilis</i> ) <sup>(c)</sup>			40.0	43.1	46.2	

FOODEX_NAME	N <sup>(a)</sup>	LC % <sup>(e)</sup>	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
Tarragon, herb ( <i>Artemisia dracunculus</i> ) <sup>(c)</sup>			40.0	43.1	46.2	
Rosemary, herb ( <i>Rosmarinus officinalis</i> ) <sup>(c)</sup>			40.0	43.1	46.2	
Sage, herb ( <i>Salvia officinalis</i> ) <sup>(c)</sup>			40.0	43.1	46.2	
Herbs (unspecified)	93	20	98.0	99.7	101.4	
<b>Spices</b>	704					
Paprika powder	89 (9)	19	107.5	114.8	122.2	
Chilli powder	171 (1)	46	63.6	76.5	89.4	
Cinnamon	28	64	29.2	43.4	57.7	
Coriander seed ( <i>Coriandrum sativum</i> )	14	100	0.0	26.9	53.8	
Cumin seed ( <i>Cuminum cyminum</i> )	17	53	134.8	151.8	168.8	
Ginger ( <i>Zingiber officinale</i> )	20	20	250.7	259.5	268.2	
Nutmeg ( <i>Myristica fragans</i> )	82 (1)	82	4.3	14.8	25.4	
Pepper, black and white ( <i>Piper nigrum</i> )	178 (10)	40	45.9	53.6	61.4	
Turmeric (Curcuma)	18	72	20.1	49.9	79.6	
Allspice ( <i>Pimenta dioica</i> ) <sup>(c)</sup>			58.8	69.9	81.1	
Anise pepper ( <i>Zanthoxylum piperitum</i> ) <sup>(c)</sup>			58.8	69.9	81.1	
Capers ( <i>Capparis spinosa</i> ) <sup>(c)</sup>			58.8	69.9	81.1	
Caraway ( <i>Carum carvi</i> ) <sup>(c)</sup>			58.8	69.9	81.1	
Cloves ( <i>Syzygium aromaticum</i> ) <sup>(c)</sup>			58.8	69.9	81.1	
Fennel seed ( <i>Foeniculum vulgare</i> ) <sup>(c)</sup>			58.8	69.9	81.1	
Mace ( <i>Myristica fragrans</i> ) <sup>(c)</sup>			58.8	69.9	81.1	
Black caraway seed ( <i>Nigella sativa</i> ) <sup>(c)</sup>			58.8	69.9	81.1	
Spices (unspecified)	59 (1)	22	58.6	65.9	73.2	
<b>Herb and spice mixtures</b>	329					
Mixed herbs	19	26	94.7	99.3	103.9	Herbs, spices and condiments
Curry powder	67 (1)	64	33.7	46.9	60.0	
Mixed spices	238	34	81.9	88.0	94.0	
Garam masala			73.4	81.1	88.7	
Herb and spice mixtures (unspecified) <sup>(c)</sup>			73.4	81.1	88.7	
<b>Condiment</b>	83	42	16.9	25.3	33.7	
<b>Dressing</b>	39	67	3.8	5.3	6.7	
<b>Chutney and pickles</b>	13	92	3.8	24.0	44.2	
<b>Flavourings or essences</b>	19	79	21.6	33.1	44.5	
<b>Baking ingredients</b>	174	39	26.7	30.0	33.3	
<b>Savoury sauces</b> <sup>(b)</sup>			5.6	10.7	15.8	
<b>Seasoning or extracts (unspecified)</b>	75					
Salt	37	95	19.5	38.6	57.8	
Salt, low sodium <sup>(d)</sup>			19.5	38.6	57.8	
Salt, iodised <sup>(d)</sup>			19.5	38.6	57.8	
Salt, iodised and fluoridated <sup>(d)</sup>			19.5	38.6	57.8	
Salt, flavoured <sup>(d)</sup>			19.5	38.6	57.8	
Sea salt <sup>(d)</sup>			19.5	38.6	57.8	
Salt, fluoridated <sup>(d)</sup>			19.5	38.6	57.8	
Gravy instant granules <sup>(c)</sup>			26.7	41.9	57.2	
Vegetable extracts <sup>(c)</sup>			26.7	41.9	57.2	
Malt extract <sup>(c)</sup>			26.7	41.9	57.2	
Seasoning or extracts (unspecified)	16	38	79.2	84.2	89.3	
Herbs, spices and condiments (unspecified) <sup>(b)</sup>			5.6	10.7	15.8	

(a): In brackets the number of samples available with data on iAs.

(b): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the food commodities grouped at FoodEx level 1.

(c): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the food commodities grouped at FoodEx level 2.

(d): Mean occurrence values are those calculated for the different samples of 'Salt'.

(e): Percentage of left-censored data.

### 3.1.17. Food for infants and young children

A total of 1 142 samples were available in the food category ‘Food for infants and young children’, many of which were reported as ‘Food for infants and young children, unspecified’ (n= 410). Other food groups with a high number of samples were ‘Fruit purée for children’ (n= 206) and ‘Cereal-based food for infants and young children, unspecified’ (n= 81), among others. A total of 38 samples reported data on iAs (see Table 20). For the rest of the samples, the estimated iAs was calculated by applying a 70 % conversion factor to the tAs content reported.

One sample of unspecified ‘Food for infants and young children’ was excluded from the final dataset as it reported a tAs value of 12 780 µg/kg, which was considered unusually high compared to the rest of the available data for the same food category. Since no plausible explanation for this high concentration was found and the data could not be confirmed by the data provider, the sample was eliminated.

In the FoodEx classification there is no distinction between food for infants and young children with and without rice. However, in this report ad-hoc food categories were created to differentiate some cereal-based foods with and without rice (Table 20). Foods were separated based on extra information supplied by the data providers, and also based on the reported occurrence values. Taking into account the reported values for grains (see Table 3), food for infants and young children with estimates of iAs higher than 50 µg/kg were considered as containing rice. The presence of rice in food for infants and young children is highly plausible since rice and derived products like starch, flour and syrup are normally used to fortify a number of foods for infants and young children (Jackson et al., 2012). Based on this approach, a total of 52 samples were available in the food group ‘Cereal-based food for infants and young children (with rice)’ and 76 samples in the food group ‘Cereal-based food for infants and young children’ (Table 20). In addition, 14 samples of ‘Ready to eat meat meal for children, cereal-based’ were identified as containing rice.

The highest mean estimates of iAs were calculated for these rice-containing foods, ‘Cereal-based food for infants and young children (with rice)’ and ‘Ready-to-eat meal for children, cereal-based (with rice)’ (MB= 133.1 µg/kg and 107.5 µg/kg, respectively) (Table 20). In the food group ‘Cereal-based food for infants and young children (with rice)’ (n≥ 60) the 95<sup>th</sup> percentile was estimated as 224.7 µg/kg (LB=MB=UB) (data not shown).

**Table 20:** Estimated iAs in the food category ‘Food for infants and young children’. Mean concentrations (µg/kg) are presented as LB, MB and UB. Estimates were rounded up to one decimal place. Samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**) and level 3 (normal).

FOODEX_NAME	N <sup>(a)</sup>	LC % <sup>(f)</sup>	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
<b>FOOD for INFANTS and YOUNG CHILDREN</b>	1142					
<b>Ready-to-eat meal for infants and young children</b>	363					
Ready-to-eat meal for children, vegetable-based	44	89	1.3	15.5	29.6	
Ready-to-eat meal for children, cereal-based	20 (3)	55	4.2	8.6	13.0	
Ready-to-eat meal for children, cereal-based (with rice)	14 (6)	0	107.5	107.5	107.5	
Ready-to-eat meal for children, meat/fish-based	35 (5)	77	1.3	4.8	8.4	
Ready-to-eat meal for children, meat and vegetables <sup>(b)</sup>			4.2	8.6	13.0	Food for infants and young children
Fruit purée for children	206	85	1.4	10.2	19.0	
Ready-to-eat meal for infants and young children (unspecified)	35	74	1.6	9.2	16.8	
<b>Infant formulae, powder</b>	123	72	1.8	12.0	22.2	
<b>Infant formulae, liquid <sup>(c)</sup></b>			0.2	1.5	2.9	
<b>Follow-on formulae, powder</b>	89					
Follow-on formula, milk-based	69	68	1.0	9.6	18.1	
Follow-on formula, hypoallergenic <sup>(b)</sup>			5.7	13.8	21.8	
Follow-on formula, soya-based <sup>(b)</sup>			5.7	13.8	21.8	

FOODEX_NAME	N <sup>(a)</sup>	LC % <sup>(f)</sup>	Mean estimated iAs (µg/kg)			Groups
			LB	MB	UB	
Follow-on formulae, powder (unspecified)	17	47	25.7	30.8	35.8	
<b>Follow-on formulae, liquid (unspecified)</b>	89					
Follow-on formula, milk-based, liquid <sup>(d)</sup>			0.1	1.2	2.3	
Follow-on formula, hypoallergenic, liquid <sup>(d)</sup>			0.7	1.7	2.7	
Follow-on formula, soya-based, liquid <sup>(d)</sup>			0.7	1.7	2.7	
Follow-on formulae, liquid (unspecified) <sup>(d)</sup>			3.2	3.8	4.5	
<b>Cereal-based food for infants and young children</b>	76 (4)	62	5.4	15.3	25.1	Food for infants and young children
<b>Cereal-based food for infants and young children (with rice)</b>	52 (20)	0	133.1	133.1	133.1	
<b>Yoghurt, cheese and milk-based dessert for infants and young children</b>	22	86	0.4	11.1	21.8	
<b>Fruit juice and herbal tea for infants and young children <sup>(e)</sup></b>			1.3	4.4	7.5	
Food for infants and small children (unspecified)	410	87	6.2	19.6	33.0	

(a): In brackets the number of samples available with data on iAs.

(b): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the food commodities grouped at FoodEx level 2.

(c): Mean values were calculated using a dilution factor of 8 applied on the samples of 'Infant formulae, powder'.

(d): Mean values were calculated using a dilution factor of 8 applied to the corresponding foods within the food group 'Follow-on formulae, powder'.

(e): Since less than 10 samples were available, the mean estimated values was obtained from the average concentration 1 327 samples of 'Fruit juices' and 'Tea, infusion'.

(f): Percentage of left-censored data.

### 3.1.18. Products for special nutritional use

A total of 1 229 samples were available in the food category 'Products for special nutritional use', with 'Dietary supplements' providing the highest number of results. A total of 10 samples reported data on iAs (see Table 21). For the rest of the samples, the estimated iAs was calculated applying a conversion factor of 70 % to the tAs reported, except for eight samples codified as 'Products presented as a replacement for one or more meals of the daily diet' that contained the brown seaweed Kelp, for which a 1% conversion factor was applied.

A total of fourteen samples of 'Fibre supplements' were reported as based on rice, and due to their relatively high content of arsenic they were treated separately from the rest of fibre supplements (Table 21).

The food group with the highest estimated mean concentration of iAs was 'Algae formula (e.g. Spirulina, Chlorella)' with MB= 6133.8 µg/kg. With this food group a conservative approach was followed as the estimated iAs was calculated applying 70 % to the tAs reported as for the other food groups. This approach was based on the fact that Hijiki seaweed could also be found in food supplements and, as explained previously (section 3.1.2.), this seaweed accumulates high amounts of iAs in contrast to most of the other seaweed.

**Table 21:** Estimated iAs in the food category ‘Products for special nutritional use’. Mean concentrations ( $\mu\text{g}/\text{kg}$ ) are presented as LB, MB and UB. Estimates were rounded up to one decimal place. Samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**).

FOODEX_NAME	N <sup>(a)</sup>	LC % <sup>(c)</sup>	Mean estimated iAs ( $\mu\text{g}/\text{kg}$ )			Groups
			LB	MB	UB	
<b>PRODUCTS for SPECIAL NUTRITIONAL USE</b>	<b>1229</b>					
<b>Dietetic food for diabetics (labelled as such)</b>	52	27	9.1	11.2	13.2	
<b>Food for sports people (labelled as such)</b>	41	83	314.3	326.5	338.6	
<b>Food for weight reduction</b>	39	79	26.7	40.0	53.3	
<b>Dietary supplements</b>	1016					
Vitamin supplements	102	64	15.6	22.0	28.5	
Mineral supplements	126	36	899.8	903.0	906.2	
Combination of vitamins and mineral supplements	113	42	283.1	287.7	292.4	
Supplements containing special fatty acids (e.g. omega-3, essential fatty acids)	97	61	209.6	216.3	223.1	Products for special nutritional use
Fibre supplements	10	40	362.4	369.9	377.3	
Fibre supplements (based on rice)	14 (8)	0	1486.0	1486.0	1486.0	
Plant extract formula	126 (1)	33	182.7	188.2	193.8	
Algae formula (e.g. Spirulina, Chlorella)	134 (1)	6	6132.5	6133.8	6135.0	
Pollen-based supplement <sup>(b)</sup>			371.7	377.1	382.6	
Protein and amino acids supplements <sup>(b)</sup>			371.7	377.1	382.6	
Coenzyme Q10 supplement <sup>(b)</sup>			371.7	377.1	382.6	
Enzyme-based supplement <sup>(b)</sup>			371.7	377.1	382.6	
Yeast based supplement <sup>(b)</sup>			371.7	377.1	382.6	
Dietary supplements (unspecified)	276	41	462.9	468.1	473.3	
<b>Medical food</b>	30	97	0.3	6.7	13.1	
Products for special nutritional use (unspecified)	51	78	45.3	64.1	83.0	

(a): In brackets the number of samples available with data on iAs.

(b): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the food commodities grouped at FoodEx level 2, except ‘Algae formula’ and ‘Fibre supplements based on rice’.

(c): Percentage of left-censored data.

### 3.1.19. Composite food (including frozen products)

A total of 753 samples were available in the food category ‘Composite food (including frozen products)’. The highest number of analytical results was reported for the food group ‘Meat-based meals’ (n= 279). A total of 49 samples reported data on iAs (see Table 22). For the rest of the samples, the estimated iAs was calculated applying 70 % to the tAs reported, with the exception of fish salads, fish soups and fish and seafood based meals where a conversion factor of 1% to the tAs was applied.

In the food group ‘Prepared salads, unspecified’, sixteen samples were excluded from the final dataset as they reported high values of tAs without specifying composition. The high tAs values may derive from the presence of rice and/or fish. Since the conversion from tAs to iAs is different and depends on whether rice or fish is present and, above all, due to the fact that consumption data on rice/fish salads were not available in the consumption database, these sixteen samples were not used for the assessment of the exposure. The mean estimated iAs for this food group was derived from all samples in the food group ‘Prepared salads’ (MB= 15.4  $\mu\text{g}/\text{kg}$ ). The maximum mean estimates of iAs were found for the samples of ‘Rice-based meals’ (MB= 44.8  $\mu\text{g}/\text{kg}$ ) (Table 22).

**Table 22:** Estimated iAs in the food category ‘Composite food (including frozen products)’. Mean concentrations ( $\mu\text{g}/\text{kg}$ ) are presented as LB, MB and UB. Estimates were rounded up to one decimal place. Samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**) and level 3 (normal).

FOODEX_NAME	N <sup>(a)</sup>	LC % <sup>(d)</sup>	Mean estimated iAs ( $\mu\text{g}/\text{kg}$ )			Groups
			LB	MB	UB	
<b>COMPOSITE FOOD</b>	753					
<b>Cereal-based dishes</b>	149					
Sandwich and sandwich-like meal	32	13	25.6	25.9	26.1	
Pizza and pizza-like pies	21	5	11.3	11.7	12.0	
Pasta, cooked	64 (2)	19	13.5	15.2	16.8	
Cereal-based dishes (unspecified)	32	6	17.4	17.5	17.7	
<b>Rice-based meals</b>	12 (1)	33	39.9	44.8	49.6	
<b>Potato based dishes</b>	20	10	19.7	19.9	20.1	
<b>Bean-based meals</b> <sup>(b)</sup>			16.3	18.3	20.2	
<b>Meat-based meals</b>	279					Composite food
Meat burger	32 (2)	16	16.7	17.2	17.8	
Goulash	126	71	4.9	9.4	13.9	
Meat stew	21	14	13.9	15.0	16.0	
Meat-based meals (unspecified)	100 (3)	35	12.2	13.1	14.1	
<b>Fish and seafood based meals</b>	64 (38)	30	9.9	11.1	12.4	
<b>Vegetable-based meals</b>	21 (1)	47	14.3	15.9	17.5	
<b>Egg-based meal</b>	33	27	10.2	11.0	11.8	
<b>Ready to eat soups</b>	113 (2)	51	6.2	8.9	11.7	
<b>Prepared salads (unspecified)</b> <sup>(c)</sup>	30	100	11.8	15.4	19.1	
Composite food (unspecified)	14	14	3.5	3.5	3.6	

(a): In brackets the number of samples available with data on iAs.

(b): Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the food commodities grouped at FoodEx level 1.

(c): Sixteen samples were excluded from ‘Prepared salads (unspecified)’ as they reported high values of tAs without specifying composition, probably from the presence of rice and/or fish, and no consumption data on rice/fish salads were available in the EFSA Comprehensive European Food Consumption Database.

(d): Percentage of left-censored data.

### 3.1.20. Snacks, desserts and other foods

A total of 491 samples were available in the food category ‘Snacks, desserts and other foods’, with ‘Ices and desserts (unspecified)’ (n= 165) and ‘Other foods (foods which cannot be included in any other group)’ (n= 169) providing the highest number of results. A total of 29 samples reported data on iAs (see Table 23). For the rest of the samples, the estimated iAs was calculated applying 70 % to the tAs reported.

The food ‘Starchy pudding’ containing rice showed the highest mean values of estimated iAs (MB= 81.1  $\mu\text{g}/\text{kg}$ ) (Table 23).

**Table 23:** Estimated iAs in the food category ‘Snacks, desserts and other foods’. Mean concentrations ( $\mu\text{g}/\text{kg}$ ) are presented as LB, MB and UB. Mean estimated values were reported to one decimal place. Samples were grouped at FoodEx level 1 (**CAPITALS**), level 2 (**bold**) and level 3 (normal).

FOODEX_NAME	N <sup>(a)</sup>	LC % <sup>(c)</sup>	Mean estimated iAs ( $\mu\text{g}/\text{kg}$ )			Groups
			LB	MB	UB	
<b>SNACKS, DESSERTS and OTHER FOODS</b>	<b>491</b>					
<b>Snack food</b>	102	42	8.7	12.6	16.5	
<b>Ices and desserts</b>	209					
Ice cream, milk-based	24	88	0.9	4.2	7.6	
Ice cream, not milk-based <sup>(b)</sup>			4.4	8.8	13.1	
Sorbet <sup>(b)</sup>			4.4	8.8	13.1	Snacks, desserts and other foods
Custard <sup>(b)</sup>			4.4	8.8	13.1	
Gelatine dessert <sup>(b)</sup>			4.4	8.8	13.1	
Starchy pudding <sup>(b)</sup>			4.4	8.8	13.1	
Starchy pudding (with rice)	14 (11)	36	70.1	81.1	92.2	
Ices and desserts (unspecified)	165 (14)	72	4.3	9.2	14.1	
<b>Other foods (foods which cannot be included in any other group)</b>	169 (4)	60	55.3	69.7	85.0	

(a): In brackets the number of samples available with data on iAs.

(b) Since less than 10 samples were available, the mean estimated values were obtained from the average concentration of the food commodities grouped at FoodEx level 2.

(c): Percentage of left-censored data.



### 3.2. Mean and high dietary exposure to iAs

Mean chronic dietary exposure to iAs across the different dietary surveys and age classes ranged from 0.09-0.45 µg/kg b.w. per day (min LB- max LB) and between 0.24-1.37 µg/kg b.w. per day (min UB- max UB). The 95<sup>th</sup> percentile dietary exposure ranged from 0.14-1.04 µg/kg b.w. per day (min LB- max LB) and between 0.35-2.09 µg/kg b.w. per day (min- max UB) (Table 24).

**Table 24:** Summary statistics of the dietary chronic exposure assessment (µg/kg b.w. per day) to iAs across European dietary surveys. Estimates were rounded up to two decimal places.

	Mean dietary exposure (µg/kg b.w. per day)								
	Lower bound (LB)			Middle bound (UB)			Upper bound (UB)		
	Min	Median	Max	Min	Median	Max	Min	Median	Max
<b>Infants</b> (2 surveys)	0.24	-(a)	0.43	0.56	-(a)	0.87	0.88	-(a)	1.37
<b>Toddlers</b> (9 surveys)	0.32	0.39	0.45	0.59	0.68	0.81	0.91	1.00	1.17
<b>Other children</b> (17 surveys)	0.20	0.30	0.36	0.33	0.51	0.61	0.47	0.71	0.87
<b>Adolescents</b> (12 surveys)	0.12	0.18	0.23	0.22	0.29	0.36	0.31	0.42	0.48
<b>Adults</b> (15 surveys)	0.11	0.13	0.17	0.18	0.23	0.28	0.24	0.33	0.38
<b>Elderly</b> (7 surveys)	0.09	0.11	0.15	0.16	0.20	0.24	0.24	0.29	0.34
<b>Very Elderly</b> (6 surveys)	0.09	0.12	0.16	0.17	0.20	0.26	0.25	0.28	0.36

	95 <sup>th</sup> dietary exposure (µg/kg b.w. per day)								
	Lower bound (LB)			Middle bound (UB)			Upper bound (UB)		
	Min	Median	Max	Min	Median	Max	Min	Median	Max
<b>Infants</b> (2 surveys)	0.54	-(c)	-(c)	1.07	-(c)	-(c)	1.66	-(c)	-(c)
<b>Toddlers</b> (9 surveys)	0.61	0.86	1.04	1.03	1.38	1.42	1.48	1.82	2.09
<b>Other children</b> (17 surveys)	0.36	0.53	0.63	0.59	0.83	1.00	0.81	1.15	1.41
<b>Adolescents</b> (12 surveys)	0.23	0.31	0.43	0.39	0.51	0.61	0.52	0.68	0.84
<b>Adults</b> (15 surveys)	0.18	0.22	0.32	0.31	0.39	0.47	0.44	0.54	0.64
<b>Elderly</b> (7 surveys)	0.14	0.17	0.26	0.25	0.31	0.39	0.35	0.45	0.53
<b>Very Elderly</b> (6 surveys)	0.16	0.24	0.29	0.26	0.35	0.40	0.37	0.47	0.54

(a): Not calculated since estimates were only available from two dietary surveys.

(b): The 95<sup>th</sup> percentile estimates obtained on dietary surveys/age classes with less than 60 observations may not be statistically robust (EFSA, 2011b). Those estimates were not included in this table.

(c): Not calculated since estimates were only available from one dietary survey.

### 3.3. Dietary exposure to iAs by survey and age class. Contribution of different food groups

The contribution of different foods (at the MB) to the dietary exposure to iAs is presented by age class and individual dietary survey. Before calculating the dietary exposure the available foods were appropriately grouped to explain their contribution to the total exposure to iAs. As mentioned in section 2.2., some dietary surveys (DIPP and FINDIET, 2007) reported consumption data at disaggregated level (e.g. reporting the amount of flour instead of the amount of bread), which impacted estimates of the contribution of specific food categories to the dietary exposure to iAs. Therefore, they were not considered when the contribution of the different food groups to iAs exposure was assessed across the different dietary surveys.

### 3.3.1. Infants (< 12 months old) and toddlers (≥ 12 months to < 36 months old)

The dietary exposure estimations for infants should be cautiously interpreted as only two dietary surveys were available, one of which contained data on only 16 participants. Mean dietary exposure to iAs for infants ranged from 0.24 to 0.43 µg/kg b.w. per day (min LB- max LB). The 95<sup>th</sup> percentile dietary exposure based on single qualifying study ranged from 0.54 to 1.66 µg/kg b.w. per day (LB-UB) (Appendix A-1).

Nine dietary surveys were available for toddlers across Europe. This age class showed the highest exposure to iAs. The mean dietary exposure to iAs ranged from 0.32 to 0.45 µg/kg b.w. per day (min LB- max LB) and from 0.98 to 1.17 µg/kg b.w. per day (min UB- max UB). The 95<sup>th</sup> percentile dietary exposure estimates ranged from 0.61-1.04 µg/kg b.w. per day (min LB- max LB) and 1.48-2.09 µg/kg b.w. per day (min LB- max LB) (Appendix A-1).

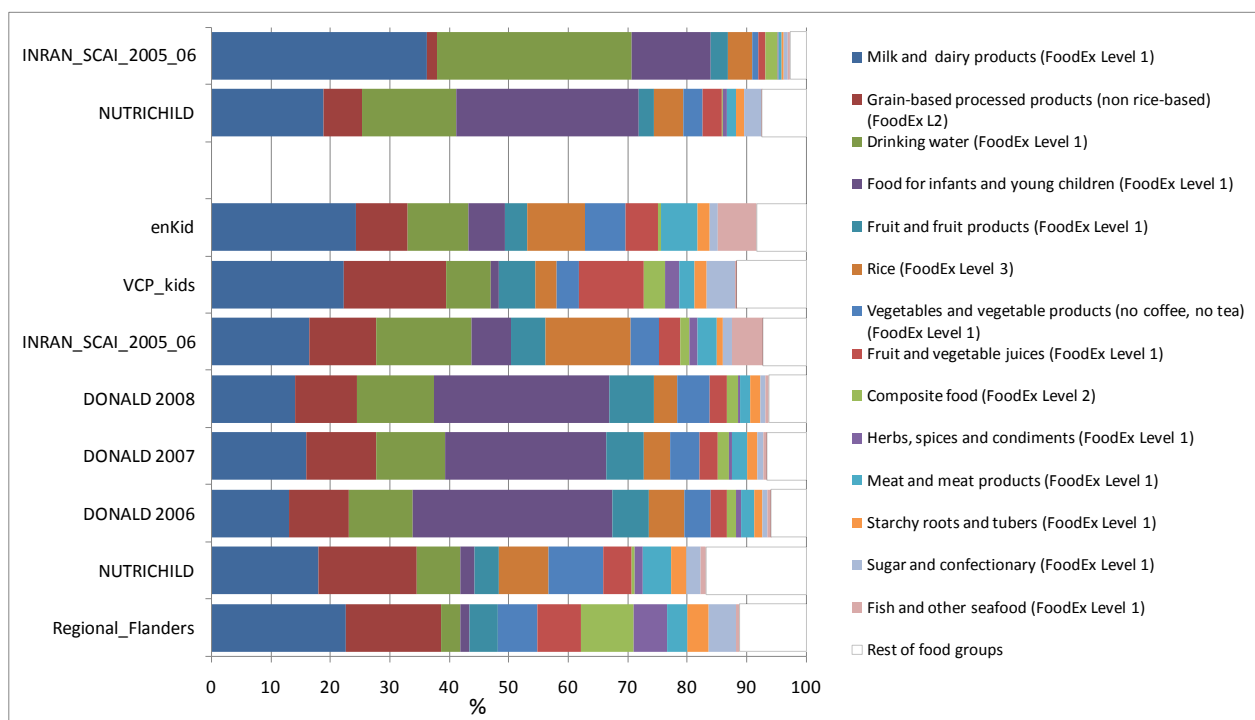
Using the MB exposure calculations, the main food groups contributing to the dietary exposure to iAs in infants were 'Milk and dairy products' (19-36 %), 'Drinking water' (16-33 %) and 'Food for infants and young children' (13-31 %). Milk (in Italy) and fermented foods (in Bulgaria) were the main contributors to iAs from 'Milk and dairy products'. Regarding 'Food for infants and young children', its contribution was mainly driven by the consumption of 'Ready-to-eat meal for infants and young children'. Although rice was not one of the most consumed foods in this age class, it had a significant contribution to the exposure to iAs due to its high occurrence values (see Table 4). Based on MB exposure estimates, the contribution was 4 % and 5 % in the two dietary surveys, although at the LB calculation reached a contribution up to 11 % due to the important amount of left-censored data in the other food categories.

Concerning breast-fed infants, no occurrence data on human milk and only limited data on its consumption were available (less than 4 000 eating occasions, 94% of the data from Bulgaria). There is limited data published on levels of arsenic in breast milk, and in many cases the data pertain to women living in areas with high exposure to arsenic (Sternowsky et al., 2002, Samanta et al., 2007, Fångström et al., 2008). For example, Sternowsky et al. (2002) studied the presence of arsenic samples of breast milk in different German regions contaminated with arsenic from chemical weapons. Arsenic was not detected, i.e. below 0.3 µg/L, in 154 of 187 samples of breast milk. Based on these data, it was decided to assume a concentration of 0.3 µg/L as representative of the levels of iAs in human milk (conservative assumption). As in previous scientific opinions from the CONTAM Panel (EFSA CONTAM Panel, 2011), a mean consumption of human milk of 800 mL per day and a maximum consumption of 1 200 mL per day was considered representative for a breast-fed infant of three months with a body weight of 6.1 kg (IOM, 1991). Considering these consumption and occurrence scenarios, the mean dietary exposure for an infant of 6.1 kg exclusively fed with breast milk would be 0.04 µg/kg b.w. per day; for an infant with high consumption the dietary exposure would be 0.06 µg/kg b.w. per day.

In the 'Toddler' population, the main contributors to iAs exposure were 'Milk and dairy products' (13-24 %, median 17 %) and 'Grain-based processed products (non rice-based)' with an average contribution at the MB in the range of 9-17 % (median 11 %). 'Drinking water' (3-16 %, median 10%) was also an important source of dietary iAs in this population group. In this age class, the contribution to total iAs exposure of the food group 'Food for infants and young children' (1-23 %, median 6 %) was lower compared to infants in most dietary surveys; in three dietary surveys the contribution at the MB ranged from 27-34 % of the overall exposure. As observed in infants, 'milk and fermented foods' were the main contributors to total iAs from the food group 'Milk and dairy products', while 'Wheat bread and rolls' were the main contributors to total iAs exposure from 'Grain-based processed products (non rice-based)'.

Rice was also an important contributor to the total exposure to iAs in the toddler population. A median contribution at the MB among the different surveys of 7 % was observed, although in some cases the contribution was up to 14 % of the total exposure to iAs. This contribution was even higher at the LB

assumption where rice contributed up to 25 % to the exposure (median 12 %). Fish and seafood had, in general, a very low contribution to the total exposure to iAs in toddlers except the two surveys in Spain and Italy where they contributed 5 % and 7 % to the overall exposure to iAs, respectively (Figure 5).



**Figure 5:** Main food groups contributing (%) to the mean chronic dietary exposure to iAs for the age classes ‘Infants’ (the two first surveys from the top) and ‘Toddlers’ (all other surveys). Data are presented by individual dietary surveys using MB mean estimations. Names on the left refer to the names of the different surveys (see Appendix A-1).

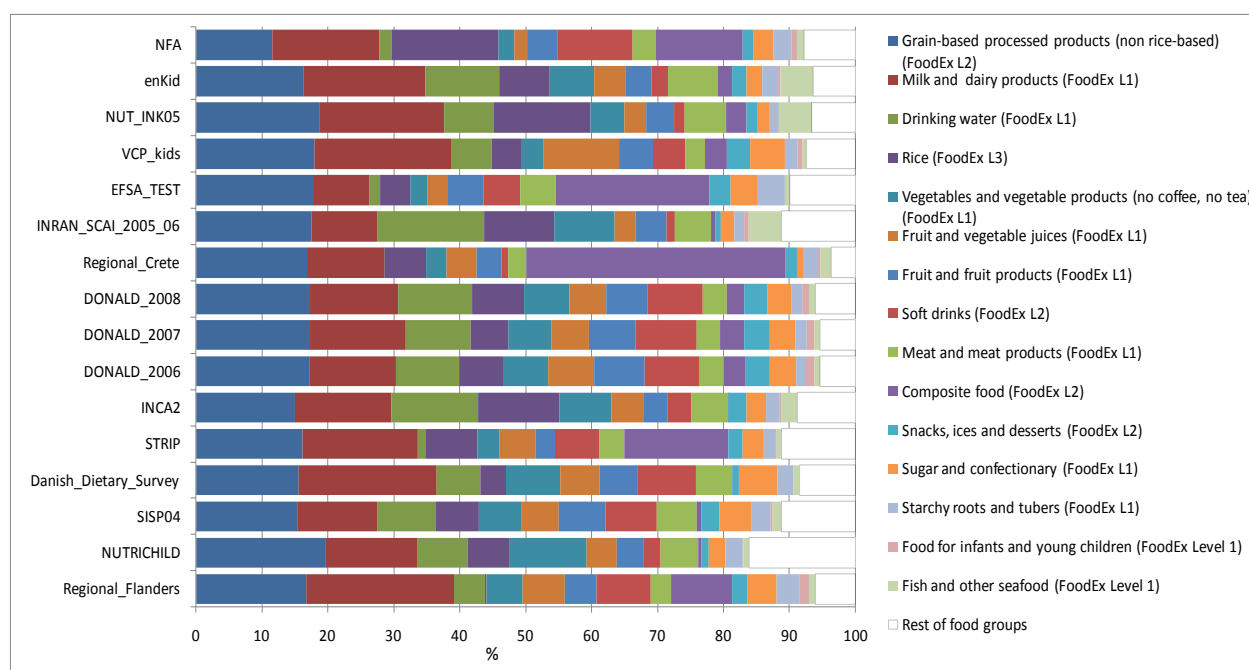
### 3.3.2. Other children ( $\geq 36$ months to $< 10$ years old)

Seventeen dietary surveys from thirteen different countries across Europe were available for the age class ‘Other children’. The mean dietary exposure to iAs ranged from 0.20-0.36  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and from 0.47-0.87  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB). The 95<sup>th</sup> percentile dietary exposure estimates ranged from 0.36-0.63  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and from 0.81-1.41  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB) (Appendix A-2).

The food group ‘Grain-based processed products (non rice-based)’ was the main source of exposure to iAs in almost all dietary surveys, with a range of contribution of 12-20 % (median= 17 %) at the MB (Figure 6). Although different food commodities contributed to this food group, the most prominent was ‘Wheat bread and rolls’. As observed for ‘Toddlers’, the food group ‘Milk and dairy products’ had also a key contribution on the intake of iAs. The contribution at the MB ranged from 9 to 22 % with a median contribution of 15 %, being also important when left-censored data were excluded (LB= 9-22 %, 11 %). Drinking water also contributed to the intake of iAs, with a median contribution of 8% (range= 1-16 %).

Rice was one of the most important sources of dietary exposure to iAs in this age class. Although in some countries its consumption was relatively low, its contribution to the total exposure to iAs ranged

between 0.3 % and 16 % at the MB (median= 6 %), with even higher contributions at the LB (range 0.5-23 %, median= 11 %). In addition to ‘Vegetables and vegetable products (no coffee, no tea)’ (range 2-12 %, median 7 %), other food groups that were significant contributors to the overall exposure to iAs were ‘Fruit and vegetables juices’ (range 2-11 %, median 5 %) and ‘Soft drinks’ (1-11 %, median= 6 %). In a few countries, where the reported consumption data on composite dishes were not disaggregated to the most detailed level possible, composite food made an important contribution to the exposure to iAs (see Figure 6), in particular in Latvia (MB contribution of 23 %) and Greece (MB contribution of 39 %). The contribution of fish and seafood to the total intake of iAs was also very limited in this age class (MB median= 0.97 %), with only important contributions in the two Spanish and the Italian surveys (5 % in the three cases).



**Figure 6:** Main food groups contributing (%) to the mean chronic dietary exposure to iAs for the age class ‘Other children’. Data are presented by individual dietary surveys using MB estimations. Names on the left refer to the names of the different surveys (see Appendix A-2).

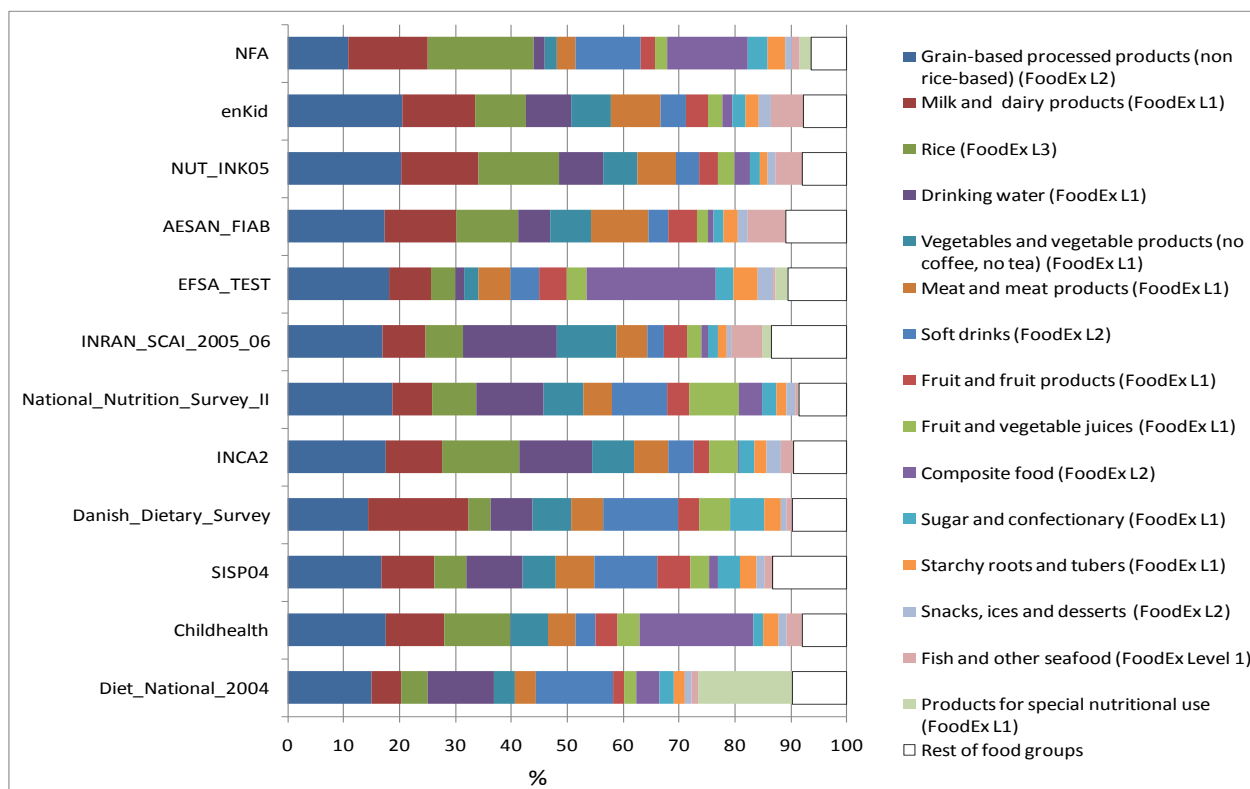
### 3.3.3. Adolescents ( $\geq 10$ years to $< 18$ years old)

A total of 12 dietary surveys across Europe (from 10 countries) were available to estimate the chronic exposure to iAs in adolescents. The mean dietary exposure to iAs ranged from 0.12-0.23  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and from 0.31-0.48  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB). The 95<sup>th</sup> percentile dietary exposure estimates ranged from 0.23-0.43  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and from 0.52-0.84  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB) (Appendix A-3).

Four different foods were identified as the main contributors to the dietary exposure to iAs in European adolescents: ‘Grain-based processed products (non rice-based)’, ‘Milk and dairy products’, ‘Rice’ and ‘Drinking water’ (Figure 7). The group ‘Grain-based processed products (non rice-based)’ was the dominant food group, with a median contribution at the MB of 18 % and a range of 11-21 %. The contribution of ‘Milk and dairy products’ to the dietary exposure to iAs was slightly lower as compared with the age class ‘Other children’ (5-18 %, median= 10%).

The contribution of rice to the exposure to iAs was higher in adolescents compared to younger populations (range 4-19 %, median= 9 %). Apart from contributing up to 19 % of the mean intake of iAs in adolescents, rice made the largest contribution to iAs exposure estimates in Sweden, and the second largest in France and Spain (NUT\_INK05). The contribution of rice to iAs exposure was even higher based on the LB mean estimates, being one of the main contributing foods in four out of the twelve dietary surveys. Together with ‘Vegetable and vegetable products’ (2-11 %, median= 7 %), ‘Meat and meat products’ was one of the main contributors to iAs exposure in adolescents (4-10 %, median= 6 %).

It is also worth mentioning the important contribution to iAs from ‘Soft drinks’ in several countries such as the Czech Republic (mean= 11 %), Sweden (mean= 12 %), Denmark (mean= 13 %) and Belgium (mean= 14 %). Also the contribution of composite food to the intake of iAs was important in those countries that reported data in an aggregated way, for example in Latvia, where composite foods were the highest contributors to iAs exposure (23 %). Fish and seafood had a very low contribution to iAs exposure (median= 2 %), although in those countries with higher consumption, such as Italy and Spain fish and seafood made a larger contribution to iAs exposure (6 % in Italy; 7 % for AESAN\_FIAB, 6 % for enKid, and 5 % for NUT\_INK05) (Figure 7).



**Figure 7:** Main food groups contributing (%) to the mean chronic dietary exposure to iAs for the age class ‘Adolescents’. Data are presented by individual dietary surveys across Europe using MB estimations. Names on the left refer to the names of the different surveys (see Appendix A-3).

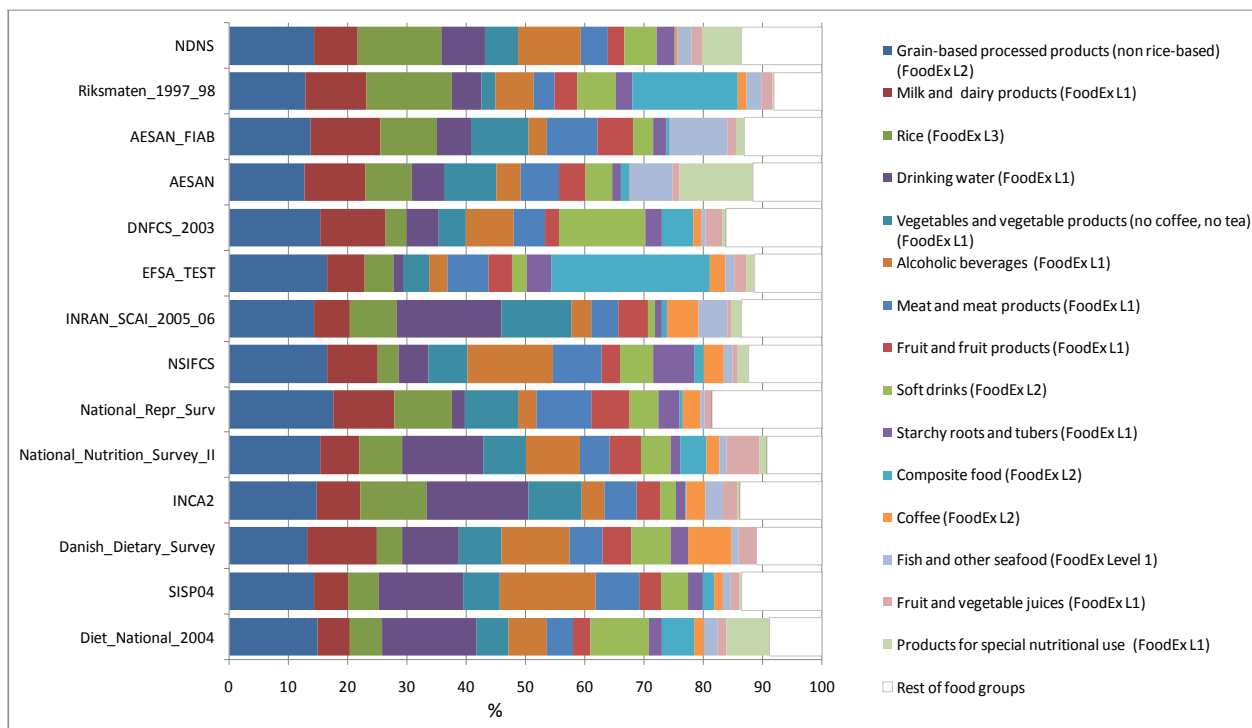
### 3.3.4. Adults ( $\geq 18$ years to $< 65$ years old)

Considering the 15 dietary surveys (from 14 countries) available for this age class, the mean dietary exposure to iAs ranged from 0.11-0.17  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and from 0.24-0.38  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB). The 95<sup>th</sup> percentile dietary exposure estimates ranged from 0.18-0.32  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and from 0.44-0.64  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB) (Appendix A-4).

As observed for adolescents, the main contributing food group to iAs exposure among adults was 'Grain-based processed products (non rice-based)' (MB= 13-18 %, median 15 %), in some dietary surveys the mean contribution from this food group was more than two-fold higher than 'Milk and dairy products' (MB= 5-12 %, median 8 %). After these two food groups, rice made the highest contribution (MB= 3-14 %, median 8 %). In two countries, the United Kingdom and Sweden, the consumption of rice led this food commodity to be the main responsible of the dietary exposure to iAs (in the United Kingdom together with 'Grain-based processed products (non rice-based)'). In both countries the average contribution of rice to iAs exposure was 14 %. The contribution of rice to iAs exposure was even higher when considering the LB, going from 6 to 20 % (median 12 %), being the second largest contributor in most of the countries and the main contributor to iAs in Spain (AESAN\_FIAB), Sweden and the United Kingdom.

The main difference as compared to the younger population was the contribution of the food group 'Alcoholic beverages' (3-16 %, median 7 %). In the Czech Republic 'Alcoholic beverages' was the main contributor to the dietary exposure to iAs (mean= 16%), and one of the highest contributors in the United Kingdom (mean= 11%) and Ireland (mean= 14%). Beer, which represented up to 90 % of the total contribution of the 'Alcoholic beverages', was the main contributor to iAs exposure in this food group.

The food group 'Vegetable and vegetable products' (MB= 2-12 %, median 7 %) was one of the most important contributors to iAs exposure in some countries such as Italy and Spain (AESAN). Across the different dietary surveys, the subgroup 'Fruiting vegetables' provided more than half of the contribution of this group. As observed with the adolescents, soft drinks were an important source of iAs for certain adult populations, in some cases covering 10% of the total exposure (Belgium) and up to 15 % (The Netherlands). The overall contribution of 'Fish and seafood' to iAs exposure was very small in most of the countries. However, in Italy (average contribution of 5 %) and Spain (average contributions of 8 % and 10 %) this food category had a significant contribution to the total exposure. This contribution was especially evident in Spain (AESAN\_FIAB) where 'Fish and seafood' (mean= 10 %) was among the main food contributors to iAs exposure after 'Grain-based processed products (non rice-based)' (Figure 8).



**Figure 8:** Main food groups contributing (%) to the mean chronic dietary exposure to iAs for the age class ‘Adults’. Data are presented by individual dietary surveys across Europe using MB estimations. Names on the left refer to the names of the different surveys (see Appendix A-4).

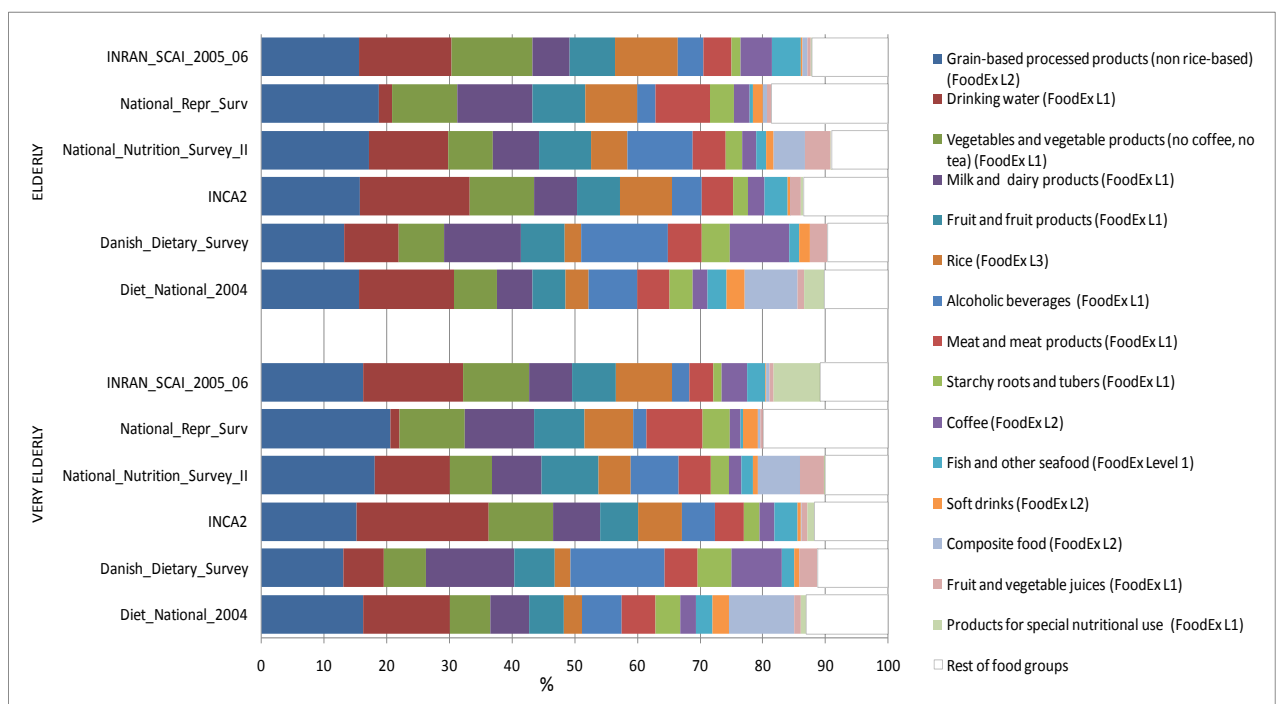
### 3.3.5. Elderly ( $\geq 65$ years to $< 75$ years old) and very elderly ( $\geq 75$ years old)

A total of seven and six dietary surveys across Europe were available for the age classes ‘Elderly’ and ‘Very elderly’, respectively. Seven European surveys covered the two age classes. For those dietary surveys which covered the two age classes, practically the same dietary exposure to iAs was estimated (see Appendix A-5).

For the elderly population, the mean dietary exposure to iAs ranged from 0.09-0.15  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and from 0.24-0.34  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB). The 95<sup>th</sup> percentile dietary exposure estimates ranged from 0.14-0.26  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and from 0.35-0.53  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB) (Table 29). In the ‘Very elderly’ population, the mean dietary exposure to iAs ranged from 0.09-0.16  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and from 0.25-0.36  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB). The 95<sup>th</sup> percentile dietary exposure estimates ranged from 0.16-0.29  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and from 0.37-0.54  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB) (Appendix A-5).

Figure 9 shows that the contribution of the different food groups to the dietary exposure to iAs in each individual survey was the same for the elderly and very elderly population. ‘Drinking water’ gained importance in the intake of iAs in both age classes (median contribution of 14% and 13% at the MB in elderly and very elderly populations, respectively). A plausible explanation for this increasing contribution of drinking water to the iAs exposure might be the reduction of food intake as a consequence of the lower energy requirements in these age classes as compared to younger populations (Jones et al., 2009). In fact, the dietary exposure to iAs in the elderly and very elderly population groups was the lowest compared with other population groups across all dietary surveys.

Similar to the other age classes (except for infants and toddlers), ‘Grain-based processed products (non rice-based)’ contributed the most to the exposure to iAs (MB median of 16% in both age classes). At the same time there was an increasing contribution to iAs exposure of ‘Vegetable and vegetable products’ and ‘Fruit and fruit products’ compared to the other age classes. A median contribution of 9% for ‘Vegetable and vegetable products’ and 7% for ‘Fruit and fruit products’ was estimated in each age class. The contribution of ‘Milk and dairy products’ to iAs exposure was remarkable, in particular in the very elderly population (MB median contribution of 8% vs. 7% in the elderly population). The importance of rice to the overall exposure was slightly lower in these age classes compared to the other age classes, particularly in the very elderly population. While for the elderly population the contribution of rice to iAs exposure ranged from 3 to 10% (median=7%), in the very elderly population was lower (2-9%, median= 6%). It is important to note that ‘Soft drinks’ hardly contributed to the dietary exposure to iAs in these age classes, while ‘Alcoholic beverages’ (with beer as the main contributor), represented the main contributing food in Denmark and one of the most important in Germany in the elderly and very elderly populations (Figure 9).



**Figure 9:** Main food groups contributing (%) to the mean chronic dietary exposure to iAs for the age classes ‘Elderly’ and ‘Very elderly’. Data are presented by individual dietary surveys across Europe using MB estimations. Names on the left refer to the names of the different surveys (see Appendix A-5).



### 3.4. Dietary exposure to iAs from special diets

#### 3.4.1. Vegetarians

Very limited data on food consumption of people who declared to be vegetarian are available in the EFSA Comprehensive Food Consumption Database. Considering the surveys with at least 15 adult vegetarians, the available data were grouped in five dietary surveys [FI/2, 39 individuals; FR, 15 individuals; DE/4, 237 individuals; SE/1, 18 individuals and UK, 77 individuals] (Table 25). Dietary exposure to iAs in the vegetarian population is of interest because this population could potentially have a higher consumption of products with high content of iAs, in particular rice or seaweed (Haddad and Tanzman, 2003).

Table 25 shows the dietary exposure to iAs in the different surveys for which there were available consumption data on vegetarians. Although due to the very limited data one should be very cautious when interpreting these data, the results indicate no remarkable differences between vegetarians and the general population. The range of mean dietary exposure (min LB-max UB) in the vegetarian and the general population were 0.10-0.42  $\mu\text{g}/\text{kg}$  b.w. per day and 0.11-0.34  $\mu\text{g}/\text{kg}$  b.w. per day, respectively. The 95<sup>th</sup> percentile dietary exposure (min LB-max UB) ranged from 0.28 to 0.60  $\mu\text{g}/\text{kg}$  b.w. per day and from 0.18 to 0.55  $\mu\text{g}/\text{kg}$  b.w. per day in the vegetarian and the general population, respectively.

**Table 25:** Comparison of the dietary exposure to iAs ( $\mu\text{g}/\text{kg}$  b.w. per day) between adult vegetarians and the total adult population in those dietary surveys with consumption data on vegetarians.

Country	Dietary survey	N Vegetarians <sup>(a)</sup>	N All <sup>(b)</sup>	$\mu\text{g}/\text{kg}$ b.w. per day			
				Mean exposure		95 <sup>th</sup> percentile exposure	
				Veget.	All	Veget.	All
<b>Lower-bound</b>							
Finland	FI/2	39	1575	0.10	0.11	<sup>(c)</sup>	0.18
France	FR	15	2276	0.19	0.16	<sup>(c)</sup>	0.27
Germany	DE/4	237	10419	0.13	0.11	0.29	0.22
Sweden	SE/1	18	1210	0.20	0.16	<sup>(c)</sup>	0.28
United Kingdom	UK	77	1724	0.16	0.14	0.28	0.28
<b>Upper-bound</b>							
Finland	FI/2	39	1575	0.27	0.28	<sup>(c)</sup>	0.47
France	FR	15	2276	0.42	0.34	<sup>(c)</sup>	0.54
Germany	DE/4	237	10419	0.35	0.31	0.60	0.52
Sweden	SE/1	18	1210	0.41	0.34	<sup>(c)</sup>	0.54
United Kingdom	UK	77	1724	0.34	0.32	0.52	0.55

(a): Number of people who declared to be vegetarian.

(b): Number of total subjects in the dietary surveys.

(c): The 95<sup>th</sup> percentile estimates for dietary surveys/age classes with less than 60 observations may not be statistically robust (EFSA, 2011). Those estimates were not included in this table.

### 3.4.2. High consumers of selected foods

Based on the calculated dietary exposure to iAs, several foods were selected because of their overall contribution to the exposure either because of their relatively high levels of iAs or because their importance in the overall exposure due to their relatively high consumption (Table 26). The exposure to iAs derived from the high consumption of these selected foods is shown in Table 26. In addition, fish, crustaceans and molluscs are also included in this Table due to their importance in the dietary exposure to tAs, although their contribution to the dietary exposure to iAs is rather limited as shown in this report.

Estimated iAs levels were obtained from the reported occurrence data, and are those used to calculate the dietary exposure in the general and vegetarian population, except the iAs concentration for the alga Hijiki that were obtained from the UK FSA report published in 2004 (FSA, 2004). High consumption values were obtained from the EFSA Comprehensive Food Consumption Database using the maximum 95<sup>th</sup> percentile in the adult population for each food group, except for the alga Hijiki that was obtained from literature (Nakumara et al, 2008; Sawada et al., 2013). Although this alga is particularly consumed in the Asian market, it is also commercialised in Europe and can be found in restaurants, supermarkets and as part of food supplements of dietary fibre and/or minerals.

**Table 26:** Estimated dietary exposure to iAs ( $\mu\text{g}/\text{kg}$  b.w. per day) in high consumers of selected food groups. A default value of 70 kg b.w. was used to calculate the dietary exposure.

	Estimated iAs levels <sup>(a)</sup> ( $\mu\text{g}/\text{kg}$ )			95 <sup>th</sup> percentile chronic consumption <sup>(b)</sup> (g/day)	Exposure to iAs ( $\mu\text{g}/\text{kg}$ b.w. day)		
	LB	MB	UB		LB	MB	UB
<b><u>Foods with relatively high consumption</u></b>							
Liquid milk	1.6	4.1	6.6	900	0.02	0.05	0.08
Wheat bread and rolls	9.3	14.3	19.2	290	0.04	0.06	0.08
Soft drinks	2.6	6.9	11.2	1350	0.05	0.13	0.22
Beer	3.1	6.8	10.5	2600	0.12	0.25	0.39
Drinking water	1.3	2.1	3.0	2500	0.05	0.08	0.11
<b><u>Foods with relatively high levels of iAs</u></b>							
White rice	84.3	88.7	93.0	175	0.21	0.22	0.23
Brown rice	150.7	151.9	153.1	175	0.38	0.38	0.38
Tap water used for rice preparation <sup>(c)</sup>	1.1	1.6	2.0	450	0.01	0.01	0.01
Hijiki	11000	11000	11000	10	1.57	1.57	1.57
Fish meat	4.5	11.3	18.1	180	0.01	0.03	0.05
Crustaceans	31.0	36.2	41.3	110	0.05	0.06	0.06
Molluscs	46.6	50.9	55.1	150	0.10	0.11	0.12

(a): For white and brown rice, fish meat, crustaceans and molluscs only reported data on iAs were used. For liquid milk, wheat bread and rolls, and beer it was assumed that 70% of the reported tAs was iAs. For the alga Hijiki occurrence values were obtained from FSA, 2004 and referred to alga as prepared for consumption ( $\mu\text{g}/\text{kg}$  wet weight). For tap water and drinking water it was assumed that all reported tAs was iAs.

(b): Consumption values obtained from the maximum 95<sup>th</sup> percentile consumers only (adults) in the EFSA Comprehensive Food Consumption Database across dietary surveys (with at least two days consumption), except for Hijiki that was obtained from Nakumara et al., (2008) and Sawada et al., (2013). For brown rice as consumption data were only available from one dietary survey, the consumption of white rice was used instead.

(c): Assuming 1 part of rice and 2.5 parts of water during rice preparation.

The impact of the high consumption of these specific foods on the dietary exposure to iAs was especially significant for consumers of the alga Hijiki. Table 26 also illustrates that high dietary exposure to iAs could be achieved by the high consumption of white rice and in particular brown rice. Taking into account the range of mean consumption of white rice in the adult population across the dietary surveys used in this report (10-90 g/day), the dietary exposure to iAs at the MB would be 0.007-0.09 µg/kg b.w. per day for white rice, and 0.013-0.15µg/kg b.w. per day for brown rice (in both cases plus the extra contribution of the cooking water). The dietary intake of iAs through the consumption of rice could be even higher when considering some ethnic populations groups in Europe for which average consumption of 300 g/day has been described (EFSA CONTAM Panel, 2009).

Table 27 shows an estimation of the mean dietary intake of iAs in infants fed with rice-based infant foods. To estimate the exposure, the reported occurrence data in rice-based food were used (assuming iAs= 70% tAs when iAs was not reported) and an infant of six months and 6.1 kg as used above to calculate the exposure in breast-fed infants (IOM, 1991). A consumption of three portions of 30 g per day (90 g/day) was used as representative of the average consumption of infant food (Meharg et al., 2008; EFSA CONTAM Panel, 2009).

**Table 27:** Estimated dietary exposure to iAs (µg/kg b.w. per day) for infants (six months, 6.1 kg b.w.) consuming rice-based infant food.

	Mean estimated iAs levels <sup>(a)</sup> (µg/kg)			Consumption <sup>(b)</sup> (g/day)	Mean exposure to iAs (µg/kg b.w. day)		
	LB	MB	UB		LB	MB	UB
Cereal-based food for infants and young children (with rice)	133.1	133.1	133.1	90	1.96	1.96	1.96
Ready-to-eat meal for children, cereal-based (with rice)	107.5	107.5	107.5		1.59	1.59	1.59

(a): 70% of the reported tAs was considered as iAs when data on iAs were not reported.

(b): Considering 90 g/day consumption as described by EFSA Scientific Opinion on arsenic in food (EFSA CONTAM Panel, 2009) and Meharg et al., (2008).

## 4. Uncertainties

A qualitative evaluation of the inherent uncertainties in the assessment of the dietary exposure to iAs was performed following the guidance of the Opinion of the Scientific Committee related to Uncertainties in Dietary Exposure Assessment (EFSA, 2006). Uncertainties and limitations related to the use of the EFSA Comprehensive Food Consumption Database in view of exposure assessment have already been described in EFSA (EFSA, 2011b) and won't be further detailed. Only those with a particular implication on the dietary exposure to iAs are mentioned here together with those related to the occurrence data and the dietary exposure (Table 28).

**Table 28:** Summary of the qualitative evaluation of the impact of uncertainties on the dietary exposure to iAs.

Sources of uncertainty	Direction <sup>(a)</sup>
<b>Occurrence data</b>	
Measurement uncertainty of analytical results	+/-
Potential presence of suspect/selective sampling as most of the occurrence data are obtained from national official controls	+
Representativity of occurrence data to the whole of Europe	+/-
Inaccurate assignment of food groups due to the lack of information reported and limited number of observations in some food categories	+/-
Assumptions made in the estimation of iAs based on tAs data	+/-
Codification of a few food commodities based on the reported occurrence values	+/-
Use of the substitution method to handle left-censored data (LB-MB-UB)	+/-
<b>Consumption data</b>	
Limited consumption data on infants	+/-
Lack of information on consumption of rice-based products in the whole population, and particularly on rice-based infant/follow-on food in infants and toddlers	-
Limited consumption data on vegetarian populations	+/-
Lack of information of cooking methods of foods that absorb water during cooking	+/-
<b>Dietary exposure</b>	
Linkage between occurrence data on raw foods and consumption data on foods as consumed	+

(a): + = uncertainty with potential to cause over-estimation of exposure; - = uncertainty with potential to cause under-estimation of exposure.

Uncertainties are associated with the occurrence and consumption data as well as to the calculation of the dietary exposure. In most of the cases it is rather difficult to predict in which direction the uncertainty could affect the dietary exposure to iAs, with respect to whether it may cause underestimation or overestimation. An example would be the important uncertainty associated with the food preparation since different factors (e.g. type of water used and/or cooking methods) may cause an increase or decrease of the arsenic levels in rice/vegetables after cooking. It must be mentioned that the limited number of data on iAs and, as a consequence, the need for use of conversion factors is likely one of the most important sources of uncertainty.

In two cases it seems evident that the uncertainty tends to overestimate the dietary exposure. One refers to the fact that most of the reported occurrence data are obtained from national official controls. In general, there is a lack of information on the sampling strategy in the occurrence data. In this report, 65 % of the samples were collected using objective sampling (random sampling). However, for 28 % of the samples included in the final dataset no information on the sampling strategy was provided. It can not be discarded that some analytical results may come from suspect or selective sampling, with high arsenic concentrations and therefore, may overestimate the dietary exposure. The second source of uncertainty that may lead to an overestimation relates to the linkage between occurrence data reported on raw foods (most of the cases) and consumption data on cooked foods in some dietary surveys. This could be especially important for rice, since the weight of cooked rice could be up to 2-3 times higher compared to the corresponding uncooked product.

Regarding the uncertainty associated with the consumption data, in general, as shown in Table 28, it could provoke either an underestimation or overestimation of the dietary exposure to iAs. However, consumption data reported on infant foods most probably may cause an underestimation of the exposure. As shown in Table 20, some foods for infants and young children were separated based on the presence or absence of rice and their high occurrence values. In most of the cases the presence of rice in these foods for infants and young children is not described in the EFSA Comprehensive Food Consumption Database (1% among all eating occasions of 'Cereal-based foods' and 11% among all eating occasions of 'Ready-to-eat meal for children, cereal-based'). Considering that rice is one of the typical cereals used in the preparation of baby-food (Jackson et al., 2012; Llorente-Mirandés et al., 2014), it is reasonable to assume some underestimation of the dietary exposure in infant and toddlers. Table 27 shows that consumption of rice-based food for infants and young children may lead to a high exposure to iAs.

Overall, the dietary exposure to iAs calculated in this report is likely to overestimate the exposure levels of the European population.

## 5. Discussion

A dataset comprised of 107 646 analytical results collected in 21 European countries was used to calculate the dietary exposure to iAs. Data reported as Organic Arsenic, Methylarsonate, DMA, Arsenobetaine, and samples that reported only As(III) or As(V) were not used to calculate the dietary exposure to iAs. In addition, those food samples where iAs was reported were used as such, and the rest of analytical results for the same sample were not used for the exposure calculations. At the end, a total of 103 773 food samples (including drinking water) were used to estimate dietary exposure to iAs. Of these, 101 020 were based on tAs and 2 753 on iAs. Some 92.5% of the data reported as tAs were converted to iAs using different approaches before calculating dietary exposure to iAs, which introduced an important source of uncertainty in the exposure assessment. However, for several key food groups only the reported iAs was used and the tAs data were discarded (e.g. fish and seafood and some types of rice). At FoodEx level 1 all the food groups were well represented, with a maximum of 23 716 samples in the food group 'Meat and meat products' and a minimum of 492 samples in the food group 'Snacks, desserts and other foods'. Some 24 884 samples of 'Drinking water' were also available. The average consumption level per day was estimated at the individual level for the different food groups defined based on the occurrence data available.

In the present report, the 2 753 food samples with analytical results on iAs were used to calculate dietary exposure to iAs. In addition, taking into account the 2009 EFSA opinion and the available scientific literature, different assumptions were made to generate more refined estimates of dietary exposure to iAs in the present report. Unlike the 2009 EFSA opinion where fixed iAs levels were used for 'Fish and seafood', in this report for the food category 'Fish and other seafood' only the reported data on iAs were used, separated in the sub-groups 'Fish meat', 'Crustaceans' and 'Water molluscs'. Typically, iAs represents a very small proportion of the tAs content of 'Fish and other seafood'.

Different studies have shown that there is not a consistent relation between tAs and iAs content in seafood (Francesconi, 2010), and FAO/WHO has advised to use, when possible, existing iAs rather than using conversion factors (FAO/WHO, 2010; FAO/WHO, 2011). Therefore, the data on tAs for the food category 'Fish and other seafood' were discarded to reduce uncertainty in the exposure estimates. Crustaceans and molluscs showed in general a higher concentration of iAs than fish as has been described in the literature (Sloth et al., 2005; Francesconi, 2010; Fontcuberta et al., 2011).

Foods of terrestrial origin contain lower amounts of tAs as compared with fish and seafood, but have a higher proportion of iAs. The percentage of iAs in foods of terrestrial origin varies and is dependent on growing conditions, water used and the geographic area among other factors (Fontcuberta et al., 2011). Different percentages of iAs in foods of terrestrial origin have been described in the literature, with accepted values between 25% and 100% of the tAs (Yost et al., 1998; HKTDS, 2012). Based on the available literature and the 2009 EFSA opinion, for foods of terrestrial origin the mean estimated iAs content was generated by combining the samples with reported values for iAs with those where iAs was derived from the reported tAs by applying a conversion factor of 70%. The exception was for five types of rice samples (unspecified, brown, long-grain, parboiled and white) where reported data on iAs were used exclusively, as they are important contributors to the exposure to iAs and the number of samples was considered sufficient for use in the exposure assessment. The iAs concentrations in rice used in this report are similar to those described in the literature (Williams et al., 2005; Torres-Escribano et al., 2008; Sommella et al., 2013) and to those found in the recent report published by the US Food and Drug Administration on rice and rice-based products (FDA, 2013).

Dietary exposure to iAs across the European surveys was calculated by combining mean iAs occurrence value for foods collected in 21 countries (pooled European occurrence data) with the average daily consumption for each food at individual level in each dietary survey. Therefore, the dietary exposure to iAs across the European countries is linked to the consumption patterns reported in each dietary survey. Chemical concentration data from different countries are often pooled to derive international summary representative concentrations for use in multi-national dietary exposure calculations. By doing this, it is assumed that there is a global European market and that the chemical concentrations found in food commodities sampled in one country are representative of the others. In this particular scientific report, for instance, no particular differences in the concentration of iAs in rice are expected among the three main producers in Europe. Since around two-thirds of the rice consumed by European citizens is grown in the EU, the mean occurrence values selected for rice can be considered representative of the whole Europe.

Although the food consumption data in the EFSA Comprehensive Food Consumption Database are the most complete and detailed data currently available in the EU, it should be pointed out that different methodologies were used between surveys to collect the data and thus direct country-to-country comparisons of exposure estimates should be interpreted with caution. To estimate the chronic exposure assessment to iAs only dietary surveys with more than one day per subject were considered (28 surveys from 17 European countries, 53 728 individuals). In general, dietary exposure to iAs did not differ much among dietary surveys within a specific age class. The main differences were found between the LB and UB estimations, i.e. due to the relatively high presence of left-censored data (66.1 % of the reported data on tAs). Across the different dietary surveys, the UB estimations of exposure to iAs were, in general, 2-3 times higher than the LB estimations.

### *Comparison with the 2009 EFSA Scientific Opinion*

A direct comparison of the estimates of dietary exposure to iAs presented in this report with those published in the 2009 EFSA opinion is not straight forward. At that time, the food samples were classified using the 15 broad food categories, as specified in the EFSA Concise European Food Consumption Database (EFSA, 2008). In addition, sampling adjustment factors (SAF) were applied to the reported occurrence values to correct for the unbalanced proportion of samples analysed in food

subcategories in relation to their dietary contribution (EFSA CONTAM Panel, 2009). The FoodEx classification system used in the present report facilitates a more accurate assessment of the dietary exposure by allowing more exact matching of the datasets on chemical occurrence and food consumption. Another difference, as compared to the 2009 EFSA opinion, is the number of available data on iAs, the most toxic arsenic compound. In the present report, a total of 2 753 food samples with data on iAs were available in contrast with the 919 samples available in the 2009 EFSA opinion. Due to the shortage of iAs data, in the 2009 EFSA opinion it was decided not to use those data, and different conversion factors and scenarios were applied to estimate iAs levels from tAs.

The highest dietary exposure to iAs was estimated in the younger population. In the present report the mean dietary exposure among infants, toddlers and other children ranged, across different Member States and surveys, from 0.20 to 0.45  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and from 0.47 to 1.37  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB), with the maximum exposure value estimated in infants. In the same three age classes, the 95<sup>th</sup> percentile dietary exposure estimates ranged from 0.36 to 1.04  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and from 0.81 to 2.09  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB), with the maximum value estimated in toddlers. A comparison of these dietary exposure estimates in the younger population groups (infants, toddlers and other children) in the present report with the 2009 EFSA opinion is biased by the fact that the 2009 EFSA opinion used 15 different studies covering children aged one to 14 years and the present report groups the individuals in different age classes. In addition, a beta binomial-normal (BBN) model was used to calculate long-term dietary exposure to iAs in the 2009 EFSA opinion, and the results were expressed using different statistics. In the 2009 EFSA opinion the median exposure to iAs among children aged 1 to 10 years ranged from 0.48-1.02  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB), and from 0.62-1.50  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB). The 95<sup>th</sup> percentile dietary exposure estimates ranged from 0.74 to 1.92  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and from 0.95 to 3.21  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB).

The mean dietary exposure to iAs among all surveys in the adult population (including adults, elderly and very elderly) ranged from 0.09-0.38  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max UB) for the mean dietary exposure and from 0.14-0.64  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max UB) for the 95<sup>th</sup> dietary exposure. These dietary exposure estimates are considerably lower than those reported in the 2009 EFSA opinion, where the calculated dietary exposure to iAs in the adult population ranged from 0.13 to 0.56  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max UB) and from 0.37 to 1.22  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max UB) for mean and 95<sup>th</sup> percentile, respectively.

Different factors may be responsible for the lower dietary exposure calculated in this report compared to that in the 2009 EFSA opinion. Different factors can explain the different results, the most important being that in this report a more detailed codification to classify the foods (more disaggregated) was used (FoodEx classification), which also avoided the use of sampling adjustment factors (SAF) which were applied in the 2009 EFSA opinion. In addition, in the present report a detailed evaluation of the occurrence data was carried out to identify specific food commodities with high occurrence values that were subsequently linked with the appropriate consumption data (e.g. rice-based and non rice-based products). Other factors that could contribute to the lower dietary exposure to iAs in the present report compared to the 2009 EFSA opinion relate to different occurrence data used (e.g. a total of 2753 samples with data on iAs were available) and how they were handled (e.g. use of only iAs data in some food categories).

Although the assessment of dietary exposure to iAs in the vegetarian population was based on very limited data, exposure estimates from five surveys with data on both vegetarian and general populations indicate no noteworthy differences between vegetarians and the general population. More food consumption data on this population group are needed before definite conclusions can be drawn.

In general, with the exception of the youngest population (infants and toddlers), the main contributor to dietary exposure to iAs was the food group 'Grain-based processed products (non rice-based)'. Other important contributors to the overall intake of iAs in all age classes were 'Rice', 'Milk and dairy products' and 'Drinking water'. In infants and toddlers the main contributors were 'Milk and dairy

products' followed by 'Drinking water', 'Grain-based processed products (non rice-based)' and 'Food for infants and young children'. It is important to mention that, as explained in section 4, the contribution of infant food in these age classes may be underestimated since in most of the cases the consumption data in the EFSA Comprehensive Food Consumption Database did not mention the potential presence of rice in the infant food. However, as shown in section 3.4.2., the consumption of three portions (90 grams/day) of rice-based infant food represents an important source of iAs. Rice is one of the typical cereals used in the preparation of baby-food and levels of iAs similar to those reported for raw rice have been determined in rice-based infant foods (Meharg et al., 2008; Jackson et al., 2012; Llorente-Mirandés et al., 2013). The conservative scenario used in this report to estimate the exposure to iAs through the consumption of breast milk (see section 3.3.1) indicates that breast-fed infants might be less exposed to iAs than non breast-fed infants as has been previously reported in the literature (Sternowsky et al., 2002; Fångstrom et al., 2008).

Except for 'Rice', in which relatively high levels of iAs were reported, the contribution to the dietary exposure to iAs from other food groups was mainly due to their high consumption. In particular, 'Grain-based processed products (non rice-based)' made a large contribution to the overall exposure to iAs. In almost all dietary surveys and age classes in the EFSA Comprehensive Food Consumption Database, wheat bread and rolls were the most dominant contributor to iAs exposure within 'Grain-based processed products (non rice-based)'. Therefore, in populations with a high consumption of wheat-based products such as bread, this cereal will be an important contributor to the dietary exposure to iAs despite its relatively low iAs concentrations.

As mentioned, the contribution of rice to the dietary exposure to iAs was noteworthy in all age classes. The important role of rice in the overall exposure to iAs is recognized elsewhere (Yost et al., 1998; Fontcuberta et al., 2011; Cheng et al., 2013). Rice is a staple food for nearly one-half of the world's population and is consumed in high amounts by some specific populations. Rice can assimilate the iAs from the soil and irrigating water more efficiently than other staple cereal crops (Meharg et al., 2009). As a result, rice contains one of the highest concentrations of arsenic among the terrestrial foods and has a relatively high proportion of iAs. Together with appropriate cultivation strategies (Banerjee et al., 2013), cooking methods to prepare rice may reduce the dietary exposure to iAs. Assuming low levels of contamination of arsenic in tap water as reported in this report (estimated mean iAs at MB=1.6 µg/L), the use of high volumes of water during the boiling process (e.g. 30:1 water/rice ratio) has been reported to reduce the iAs concentration in diverse types of rice by 35-45% and up to 86% compared to the initial levels in raw rice (Raab et al., 2009; Fontcuberta et al., 2011). The use of additional practices such as rinse washing the rice before cooking are also effective to reduce the levels of iAs in rice (Raab et al., 2009). The recommendation of boiling the rice in an excess of water and discarding the drained water should be also useful even in As-endemic areas since this reduces the arsenic absorbed by the rice from the water (Torres-Escribano et al., 2008).

The importance of 'Milk and dairy products' to the overall exposure to iAs across the different age classes is linked to high consumption since their estimated levels of iAs were, in general, rather low. Among the different subgroups in this food category, the predominant contributors were milk and fermented foods (yoghurt) varying among age classes and dietary surveys. The importance of 'Milk and dairy products' to the dietary exposure to iAs has already been reported in the literature (Yost et al., 1998).

Drinking water was also an important contributor to the exposure to iAs in all age classes. This contribution was, in general, lower than the main food groups represented by 'Grain-based processed products (non rice-based)', 'Milk and dairy products' and 'Rice'. The estimated levels of iAs (all the reported tAs was assumed to be iAs) were quite low (estimated mean iAs at MB= 1.6 µg/L for tap water, the most represented in the consumption database) and the relatively high contribution to iAs exposure is mainly explained the relatively high consumption of water compared to food commodities.



## CONCLUSIONS

- A total of 103 773 food samples (including drinking water) were used to estimate dietary exposure to iAs. Of these, 101 020 were based on tAs and 2 753 on iAs. A total of 66.1% of the reported results on tAs were left-censored; for the reported data on iAs the percentage of left-censored data was 41.9%.
- Most of the data (92.5%) reported as tAs were converted to iAs using different approaches before calculating dietary exposure to iAs. This introduced an important source of uncertainty in the exposure assessment. However, for several key food groups only the reported iAs was used and the tAs data were discarded (e.g. fish and seafood and some types of rice).
- Dietary exposure to iAs was relatively homogeneous among dietary surveys within specific age classes included in the EFSA Comprehensive Food Consumption Database. The main differences were observed between LB and UB estimations due to the relatively high presence of left-censored data.
- The highest dietary exposure was estimated in the younger population (infants and toddlers). Mean dietary exposure to iAs for infants ranged, across different Member States and surveys, from 0.24-0.43  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and from 0.88-1.37  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB). The 95<sup>th</sup> percentile dietary exposure, based on one dietary survey, was 0.54-1.66  $\mu\text{g}/\text{kg}$  b.w. per day (LB-UB). In toddlers, mean dietary exposure to iAs ranged from 0.32-0.45  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and 0.91-1.17  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB). The 95<sup>th</sup> percentile dietary exposure estimates ranged from 0.61-1.04  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and 1.48-2.09  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB).
- In the adult age class mean dietary exposure to iAs ranged from 0.11-0.17  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and from 0.24-0.38  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB). The 95<sup>th</sup> percentile dietary exposure estimates ranged from 0.18-0.32  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and from 0.44-0.64  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB).
- The elderly and very elderly population age classes showed the lowest estimates of dietary exposure to iAs. For the elderly population, the mean dietary exposure ranged from 0.09-0.15  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and from 0.24-0.34  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB). The 95<sup>th</sup> percentile dietary exposure estimates ranged from 0.14-0.26  $\mu\text{g}/\text{kg}$  b.w. per day (min LB- max LB) and from 0.35-0.53  $\mu\text{g}/\text{kg}$  b.w. per day (min UB- max UB). Almost identical dietary exposure to iAs was estimated in the very elderly population.
- Overall, the main contributor to the dietary exposure to iAs was the food group ‘Grain-based processed products (non rice-based)’, in particular wheat bread and rolls. Other food groups that were important contributors to the exposure to iAs were rice, milk and dairy products and drinking water.
- In infants and toddlers ‘Milk and dairy products’ were the predominant contributors to total iAs exposure.
- Consumption of three portions (90 grams/day) of rice-based infant food could represent an important source of iAs (1.59- 1.96  $\mu\text{g}/\text{kg}$  b.w. per day).
- The assessment of the dietary exposure to iAs in vegetarians was based on a limited number of subjects. The results indicated that no remarkable differences were found between vegetarians and the general population.

- Overall, a lower dietary exposure was calculated in this report as compared to that published in the 2009 EFSA opinion. Different factors could explain this fact, in particular the use of a more detailed codification to classify the foods (FoodEx), the exhaustive evaluation of the occurrence data carried out in this report, and the different occurrence data used and how they were handled.

## RECOMMENDATIONS

- In order to reduce the uncertainty of the exposure assessment to iAs more analytical data on iAs are needed. This mainly refers to speciation data in fish and seafood, and on food groups that substantially contribute to the dietary exposure to iAs (e.g. rice, wheat-based products).
- Analytical data submitted to EFSA should follow the requirements of EFSA Guidance on Standard Sample Description ver. 2.0 (EFSA, 2013) as well as specific requirements for the submission of occurrence data on arsenic (e.g. identification of rice as ingredient) as described on EFSA's website (EFSA, 2012).
- Food consumption data from the different European countries are needed to decrease the uncertainties associated to the dietary exposure estimations, in particular in certain age classes (young age classes) and specific groups of population (e.g. vegetarians).

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**Appendix A. Mean and 95<sup>th</sup> chronic dietary exposure to iAs presented by age class and individual dietary survey**

**Appendix A1:** Lower bound (LB), middle bound (MB) and upper bound (UB) estimations for the mean and high dietary exposure (95<sup>th</sup> percentile) to iAs in infants and toddlers (µg/kg b.w. per day).

Ageclass	Country	Dietary survey	N	Mean dietary exposure (µg/kg b.w. per day)			95 <sup>th</sup> percentile (µg/kg b.w. per day)		
				LB	MB	UB	LB	MB	UB
Infants	Bulgaria	NUTRICHILD	860	0.24	0.56	0.88	0.54	1.07	1.66
	Italy	INRAN_SCAI_2005_06	16 <sup>(b)</sup>	0.43	0.87	1.37	-	-	-
<b>Minimum</b>				<i>0.24</i>	<i>0.56</i>	<i>0.88</i>	<i>0.54</i>	<i>1.07</i>	<i>1.66</i>
<b>Median<sup>(a)</sup></b>				-	-	-	-	-	-
<b>Maximum</b>				<i>0.43</i>	<i>0.87</i>	<i>1.37</i>	<i>-(c)</i>	<i>-(c)</i>	<i>-(c)</i>
Toddlers	Belgium	Regional_Flanders	36 <sup>(b)</sup>	0.40	0.75	1.10	-	-	-
	Bulgaria	NUTRICHILD	428	0.41	0.72	1.03	0.67	1.09	1.55
	Finland	DIPP	497	0.32	0.66	1.00	0.73	1.42	2.09
	Germany	DONALD_2006	92	0.39	0.73	1.06	1.04	1.42	1.96
	Germany	DONALD_2007	85	0.35	0.66	0.98	0.98	1.34	1.75
	Germany	DONALD_2008	84	0.34	0.68	1.03	0.98	1.42	1.90
	Italy	INRAN_SCAI_2005_06	36 <sup>(b)</sup>	0.45	0.81	1.17	-	-	-
	Netherlands	VCP_kids	322	0.37	0.68	1.00	0.61	1.03	1.48
	Spain	enKid	17 <sup>(b)</sup>	0.39	0.71	1.03	-	-	-
	<b>Minimum</b>				<i>0.32</i>	<i>0.66</i>	<i>0.98</i>	<i>0.61</i>	<i>1.03</i>
<b>Median</b>				<i>0.39</i>	<i>0.71</i>	<i>1.03</i>	<i>0.86</i>	<i>1.38</i>	<i>1.82</i>
<b>Maximum</b>				<i>0.45</i>	<i>0.81</i>	<i>1.17</i>	<i>1.04</i>	<i>1.42</i>	<i>2.09</i>

(a): Not calculated since estimates were only available from two dietary surveys.

(b): The 95<sup>th</sup> percentile estimates obtained on dietary surveys/age classes with less than 60 observations may not be statistically robust (EFSA, 2011b). Those estimates were not included in this table.

(c): Not calculated since estimates were only available from one dietary survey.

**Appendix A2:** Lower bound (LB), middle bound (MB) and upper bound (UB) estimations for the mean and high dietary exposure (95<sup>th</sup> percentile) to iAs in the age class ‘Other children’ (µg/kg b.w. per day).

Ageclass	Country	Dietary survey	N	Mean dietary exposure (µg/kg b.w. per day)			95 <sup>th</sup> percentile (µg/kg b.w. per day)		
				LB	MB	UB	LB	MB	UB
Other children	Belgium	Regional_Flanders	625	0.31	0.59	0.86	0.48	0.90	1.31
	Bulgaria	NUTRICHILD	433	0.36	0.61	0.87	0.63	1.00	1.41
	Czech Republic	SISP04	389	0.27	0.48	0.69	0.49	0.81	1.15
	Denmark	Danish_Dietary_Survey	490	0.24	0.47	0.70	0.36	0.68	1.01
	Finland	DIPP	933	0.29	0.54	0.80	0.49	0.83	1.17
	Finland	STRIP	250	0.32	0.51	0.70	0.54	0.78	1.05
	France	INCA2	482	0.32	0.52	0.73	0.55	0.84	1.16
	Germany	DONALD_2007	226	0.23	0.44	0.66	0.37	0.65	0.94
	Germany	DONALD_2006	211	0.23	0.44	0.66	0.39	0.69	0.99
	Germany	DONALD_2008	223	0.24	0.45	0.66	0.43	0.67	1.00
	Greece	Regional_Crete	839	0.29	0.45	0.61	0.57	0.78	1.00
	Italy	INRAN_SCAI_2005_06	193	0.32	0.55	0.78	0.61	0.97	1.32
	Latvia	EFSA_TEST	189	0.20	0.33	0.47	0.39	0.59	0.81
	Netherlands	VCP_kids	957	0.31	0.56	0.81	0.53	0.89	1.28
	Spain	NUT_INK05	399	0.30	0.50	0.71	0.59	0.84	1.11
	Spain	enKid	156	0.30	0.52	0.74	0.54	0.89	1.25
	Sweden	NFA	1473	0.35	0.55	0.76	0.62	0.92	1.21
<b>Minimum</b>				<i>0.20</i>	<i>0.33</i>	<i>0.47</i>	<i>0.36</i>	<i>0.59</i>	<i>0.81</i>
<b>Median</b>				<i>0.30</i>	<i>0.51</i>	<i>0.71</i>	<i>0.53</i>	<i>0.83</i>	<i>1.15</i>
<b>Maximum</b>				<i>0.36</i>	<i>0.61</i>	<i>0.87</i>	<i>0.63</i>	<i>1.00</i>	<i>1.41</i>



**Appendix A3:** Lower bound (LB), middle bound (MB) and upper bound (UB) estimations for the mean and high dietary exposure (95<sup>th</sup> percentile) to iAs in the age class ‘Adolescents’ (µg/kg b.w. per day).

Ageclass	Country	Dietary survey	N	Mean dietary exposure (µg/kg b.w. per day)			95 <sup>th</sup> percentile (µg/kg b.w. per day)		
				LB	MB	UB	LB	MB	UB
Adolescents	Belgium	Diet_National_2004	584	0.22	0.33	0.45	0.39	0.57	0.84
	Cyprus	Childhealth	303	0.14	0.22	0.31	0.27	0.40	0.52
	Czech Republic	SISP04	298	0.18	0.33	0.48	0.31	0.56	0.82
	Denmark	Danish_Dietary_Survey	479	0.14	0.28	0.42	0.23	0.45	0.66
	France	INCA2	973	0.18	0.28	0.39	0.32	0.48	0.66
	Germany	National_Nutrition_Survey_II	1011	0.12	0.22	0.33	0.25	0.41	0.61
	Italy	INRAN_SCAI_2005_06	247	0.19	0.33	0.46	0.37	0.58	0.81
	Latvia	EFSA_TEST	470	0.15	0.25	0.34	0.30	0.45	0.62
	Spain	AESAN_FIAB	86	0.13	0.24	0.34	0.23	0.39	0.55
	Spain	enKid	209	0.17	0.30	0.43	0.33	0.54	0.77
	Spain	NUT_INK05	651	0.19	0.31	0.44	0.38	0.54	0.70
	Sweden	NFA	1018	0.23	0.36	0.48	0.43	0.61	0.81
<b>Minimum</b>				<i>0.12</i>	<i>0.22</i>	<i>0.31</i>	<i>0.23</i>	<i>0.39</i>	<i>0.52</i>
<b>Median</b>				<i>0.18</i>	<i>0.29</i>	<i>0.42</i>	<i>0.31</i>	<i>0.51</i>	<i>0.68</i>
<b>Maximum</b>				<i>0.23</i>	<i>0.36</i>	<i>0.48</i>	<i>0.43</i>	<i>0.61</i>	<i>0.84</i>

**Appendix A4:** Lower bound (LB), middle bound (MB) and upper bound (UB) estimations for the mean and high dietary exposure (95<sup>th</sup> percentile) to iAs in the age class ‘Adults’ (µg/kg b.w. per day).

Ageclass	Country	Dietary survey	N	Mean dietary exposure (µg/kg b.w. per day)			95 <sup>th</sup> percentile (µg/kg b.w. per day)		
				LB	MB	UB	LB	MB	UB
Adults	Belgium	Diet_National_2004	1304	0.17	0.28	0.38	0.32	0.47	0.64
	Czech Republic	SISP04	1666	0.12	0.23	0.33	0.22	0.39	0.56
	Denmark	Danish_Dietary_Survey	2822	0.12	0.22	0.32	0.19	0.34	0.49
	Finland	FINDIET_2007	1575	0.11	0.20	0.28	0.18	0.32	0.47
	France	INCA2	2276	0.16	0.25	0.34	0.27	0.40	0.54
	Germany	National_Nutrition_Survey_II	10419	0.11	0.21	0.31	0.22	0.37	0.52
	Hungary	National_Repr_Surv	1074	0.11	0.19	0.28	0.18	0.31	0.45
	Ireland	NSIFCS	958	0.12	0.22	0.32	0.21	0.38	0.56
	Italy	INRAN_SCAI_2005_06	2313	0.16	0.26	0.37	0.28	0.43	0.59
	Latvia	EFSA_TEST	1306	0.11	0.18	0.24	0.22	0.33	0.44
	Netherlands	DNFCS_2003	750	0.14	0.25	0.36	0.24	0.41	0.59
	Spain	AESAN	410	0.13	0.23	0.34	0.22	0.37	0.53
	Spain	AESAN_FIAB	981	0.15	0.25	0.34	0.24	0.41	0.59
	Sweden	Riksmaten_1997_98	1210	0.16	0.25	0.34	0.28	0.41	0.54
	United Kingdom	NDNS	1724	0.14	0.23	0.32	0.28	0.41	0.55
<b>Minimum</b>				<i>0.11</i>	<i>0.18</i>	<i>0.24</i>	<i>0.18</i>	<i>0.31</i>	<i>0.44</i>
<b>Median</b>				<i>0.13</i>	<i>0.23</i>	<i>0.33</i>	<i>0.22</i>	<i>0.39</i>	<i>0.54</i>
<b>Maximum</b>				<i>0.17</i>	<i>0.28</i>	<i>0.38</i>	<i>0.32</i>	<i>0.47</i>	<i>0.64</i>

**Appendix A5:** Lower bound (LB), middle bound (MB) and upper bound (UB) estimations for the mean and high dietary exposure (95<sup>th</sup> percentile) to iAs in the age classes ‘Elderly’ and ‘Very elderly’ ( $\mu\text{g}/\text{kg}$  b.w. per day).

Ageclass	Country	Dietary survey	N	Mean dietary exposure ( $\mu\text{g}/\text{kg}$ b.w. per day)			95 <sup>th</sup> percentile ( $\mu\text{g}/\text{kg}$ b.w. per day)		
				LB	MB	UB	LB	MB	UB
Elderly	Belgium	Diet_National_2004	518	0.13	0.22	0.30	0.24	0.37	0.50
	Denmark	Danish_Dietary_Survey	309	0.11	0.20	0.29	0.17	0.31	0.45
	Finland	FINDIET_2007	463	0.09	0.16	0.24	0.16	0.28	0.40
	France	INCA2	264	0.15	0.24	0.32	0.24	0.38	0.51
	Germany	National_Nutrition_Survey_II	2006	0.09	0.18	0.27	0.17	0.30	0.43
	Hungary	National_Repr_Surv	206	0.09	0.17	0.24	0.14	0.25	0.35
	Italy	INRAN_SCAI_2005_06	290	0.14	0.24	0.34	0.26	0.39	0.53
<b>Minimum</b>				<i>0.09</i>	<i>0.16</i>	<i>0.24</i>	<i>0.14</i>	<i>0.25</i>	<i>0.35</i>
<b>Median</b>				<i>0.11</i>	<i>0.20</i>	<i>0.29</i>	<i>0.17</i>	<i>0.31</i>	<i>0.45</i>
<b>Maximum</b>				<i>0.15</i>	<i>0.24</i>	<i>0.34</i>	<i>0.26</i>	<i>0.39</i>	<i>0.53</i>
Very elderly	Belgium	Diet_National_2004	712	0.13	0.20	0.28	0.25	0.35	0.47
	Denmark	Danish_Dietary_Survey	20 <sup>(a)</sup>	0.11	0.19	0.28	-	-	-
	France	INCA2	84	0.14	0.23	0.32	0.24	0.38	0.53
	Germany	National_Nutrition_Survey_II	490	0.09	0.17	0.26	0.17	0.28	0.41
	Hungary	National_Repr_Surv	80	0.09	0.17	0.25	0.16	0.26	0.37
	Italy	INRAN_SCAI_2005_06	228	0.16	0.26	0.36	0.29	0.40	0.54
	<b>Minimum</b>				<i>0.09</i>	<i>0.17</i>	<i>0.25</i>	<i>0.16</i>	<i>0.26</i>
<b>Median</b>				<i>0.12</i>	<i>0.20</i>	<i>0.28</i>	<i>0.24</i>	<i>0.35</i>	<i>0.47</i>
<b>Maximum</b>				<i>0.16</i>	<i>0.26</i>	<i>0.36</i>	<i>0.29</i>	<i>0.40</i>	<i>0.54</i>

(a): The 95<sup>th</sup> percentile estimates obtained on dietary surveys/age classes with less than 60 observations may not be statistically robust (EFSA, 2011b). Those estimates were not included in this table.

## GLOSSARY AND ABBREVIATIONS

AAS	Atomic absorption spectrometry
AB	Arsenobetaine
AC	Arsenocholine
As(III)	Arsenite/arsenous acid
As(V)	Arsenate/arsenic acid
BBN	Beta binomial-normal
BMDL	Benchmark dose lower confidence limit
BMDS	Benchmark dose software
b.w.	Body weight
CONTAM	Panel on Contaminants in the Food Chain
DMA	Dimethylarsinate/dimethylarsinic acid
EC	European Commission
EFSA	European Food Safety Authority
EU	European Union
FAO/WHO	Food and Agriculture Organization/ World Health Organization
FDA	Food and Drug Administration (United States)
FSA	Food Standards Agency (United Kingdom)
FSANZ	Food Standards Australia New Zealand
iAs	Inorganic arsenic
IARC	International Agency for Research on Cancer
ICP-MS	Inductively coupled plasma mass spectrometry
IOM	Institute of Medicine
LB	Lower bound
LOD	Limit of detection
LOQ	Limit of quantification
MB	Middle bound
ML	Maximum level
MS	Member State
PTWI	Provisional tolerable weekly intake
SAF	Sampling adjustment factor
SSD	Standard Sample Description
tAs	Total arsenic
UB	Upper bound
WHO/ICPS	World Health Organization/International Programme on Chemical Safety