Report of the Scientific Committee of the Spanish Agency for Food Safety and Nutrition (AESAN) in relation to the risk assessment of dietary exposure to cadmium for the Spanish population

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Working group

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Abstract

In 2011, the Scientific Committee of the Spanish Agency for Food Safety and Nutrition (AESAN) performed a risk assessment of the Spanish population's exposure to cadmium. Since then, there have been updates that include the adoption of new maximum limits of cadmium content in food products and the completion of two new food consumption surveys carried out by AESAN: ENALIA (National Dietary Survey on the Child and Adolescent Population) and ENALIA-2 (National Dietary Survey on Adults, the Elderly and Pregnant Women).

The Scientific Committee has performed a new risk assessment of dietary exposure for the Spanish population to cadmium, taking into account about 3000 new occurrence data on cadmium in different food categories collected between 2014 and 2017 in Spain.

The estimate of the dietary intake of cadmium was performed by means of a deterministic model of calculation based on the mean contamination value for the lower bound (LB) and the upper bound (UB) of the daily consumption of each food product among different age groups (toddlers (12-35 months),

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other children (3-9 years), adolescents (10-17 years), and adults (18-64 years)), and the assumed body weight for each of them.

Considering the contamination scenarios LB and UB, in both cases it has been found that *soluble cocoa powder* (215.3-215.3 µg Cd/kg), molluscs (172.8-178.5 µg Cd/kg) and chocolate and chocolate-based products (114.0-116.7 µg Cd/kg) are the food groups that display the highest mean concentration of cadmium. The main contributor to cadmium intake in adults are molluscs. Although there were fewer samples for analysis, *soluble cocoa powder* was found to be the main contributor to cadmium intake in age groups 3-17 years, whereas the *potato* contributes the highest amount of cadmium to the diet of toddlers aged 12-35 months. Toddlers are especially vulnerable to cadmium exposure, as they consume a greater amount of food in relation to their body weight. Nevertheless, as it is reasonable to assume that real dietary exposure to cadmium would be closer to the estimate derived from the use of the LB rather than the UB of contamination, it may be concluded that cadmium exposure is within the safety margins of safety for all population groups in Spain.

Lower dietary exposure to cadmium has been observed in Spanish adults from 2010 onwards, of 26 % and 42 % in the lower bound and upper bound estimates, respectively, although differences in the quantification limits and in the food consumption data of the studies may influence these results.

For all population groups, the extreme consumption of molluscs is the main dietary source of cadmium. Although unlikely, any scenario of chronic exposure which includes the extreme consumption of any food group constitutes a risk of cadmium exposure over and above the established Tolerable Weekly Intake (TWI).

Key words

Cadmium, foods, exposure, consumption, tolerable weekly intake, risk assessment.

Suggested citation

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1. Introduction

The International Agency for Research on Cancer (IARC, 2012) has classified cadmium (Cd) as carcinogenic to humans (Group 1). Likewise, in Europe, some cadmium compounds are classified as substances that "may cause cancer" (Category 1B) (EU, 2008).

Human exposure to cadmium is primarily (90 %) due to dietary intake of food and drinking water contaminated with this metal. For this reason, the European Food Safety Authority (EFSA) has established a Tolerable Weekly Intake (TWI) of 2.5 µg Cd/kg b.w./week (EFSA, 2011a) and maximum limits for cadmium content in foods have been set by Regulation (EU) No. 488/2014 (EU, 2014).

Concerns relating to the dietary exposure to cadmium have led to several assessments at the European level (Rose et al., 2010) (Vromman et al., 2010) (Millour et al., 2011) (Arnich et al., 2012) (Sand y Becker, 2012) (D'Amato et al., 2013) (Škrbić et al., 2013) (Marzec et al., 2014) (Schwarz et al., 2014) (Barone et al., 2015) (Berglund et al., 2015) (Jean et al., 2015) (Wennberg et al., 2017) (Filippini et al., 2018) (Jean et al., 2018) (Suomi et al., 2018) among others, and also at the national level (Rubio et al., 2006) (Martí-Cid et al., 2008) (AESAN, 2011a) (Martorell et al., 2011) (Domingo et al., 2012) (Perelló et al., 2015) (Marín-Martínez et al., 2016) (Marín et al., 2017) (Marín et al., 2018) (Núñez et al., 2018).

Outside the European Union, it is worth highlighting the recent evaluation by the Food and Drug Administration (FDA) (Spungen, 2019) and studies by (Al-Rmalli et al., 2012) (Chen et al., 2014) (Kim et al., 2014) (Zhong et al., 2015) (Chunhabundit, 2016) (Moon et al., 2016) (Muñoz et al., 2017) (Song et al., 2017) (Chen et al., 2018) (Kawada, 2018) (Huo et al., 2018) (Kim et al., 2018) (Liu et al., 2018) (Wang et al., 2018) (Zhang et al., 2018), among others.

The entry of cadmium into the food chain continues to be a topic of research as its reduction is a priority in preventing human dietary exposure to this metal (Rizwan et al., 2017) (Engbersen et al., 2019) (Hamid et al., 2019) (Wang et al., 2019). In highly industrialised regions, rivers polluted with cadmium enable the metal's entry into irrigation systems and its accumulation in sediment. The high level of water-soil-plant transfer of this metal enables its appearance as contaminant in several foods. The use of phosphate fertilisers has also contributed to the presence of cadmium concentrations in soil (Pan et al., 2010).

Although the gastrointestinal absorption of cadmium is only 5 %, this metal is accumulated mainly in the liver and kidneys, reaching an elimination half-life of up to 10 years in the blood. Cadmium content in the blood is therefore a valid marker of recent exposure (Järup and Akesson, 2009). The urinary excretion of cadmium depends on the concentration of this element in the blood and kidneys. Daily urinary and faecal excretion is estimated to be 0.007-0.009 % of the total amount, respectively (Kjellstrom and Nordberg, 1978) (Nordberg et al., 1985).

With regard to its toxicity, the "itai itai" disease, attributed directly to chronic dietary exposure to cadmium and described in Japan, is characterised by multiple bone fractures and deformities along with osteomalacia, osteoporosis and renal damage (Järup et al., 1998). Although there is evidence that confirms cadmium as a risk factor in the development of osteoporosis (U.S. Department of Health and Human Services, 2004), a recent study (Lavado García et al., 2017) has questioned the impact of the dietary intake of cadmium on bone density.

The chronic toxicity of cadmium is also associated with endocrine disruptions, respiratory and

cardiovascular problems, renal dysfunction, calcium metabolism disorders and neurotoxicity. Cadmium is considered an endocrine disruptor due to its capacity to bind to oestrogen receptors and to mimic oestrogen action (Darbre, 2006) (Buha et al., 2018). Nevertheless, the kidney stands out as being the target organ after cadmium exposure, and renal damage is characterised by the accumulation of cadmium in the cells of the proximal tubular cells, causing a decrease in the glomerular filtration rate, and eventually renal failure. The first sign of cadmium poisoning is a renal tubular lesion followed by glomerular lesions leading to increased urinary excretion of low molecular weight proteins (WHO, 1992) (Järup and Akesson, 2009) (Saturug et al., 2010) (Chen et al., 2018) (Kawada, 2018) (Starug, 2018). Currently, there are concerns regarding cadmium content in some nanomaterials used in biology, medicine, engineering, and consumer products, as greater bioaccumulation in renal tissue and nephrotoxicity have been observed (Werlin et al., 2011). The kidney is the target organ of toxicity for nanoparticles, thus exacerbating the toxicity of nanoparticles that contain cadmium (Rana et al., 2018).

There is evidence that exposure to cadmium may lead to prostate and breast cancer even in the post-menopausal stage (Waalkes, 2003) (Julin et al., 2012). Additionally, cadmium may play a role in the development of other types of cancer such as testicular cancer, bladder, pancreatic and gallbladder cancer (Huff et al., 2007), endometrial and lung cancer (Nawrot et al., 2015) although a recent meta-analysis has questioned the relevance of cadmium in the latter case.

Within Spain, in 2011 the Scientific Committee of the Spanish Agency for Food Safety and Nutrition (AESAN) performed a risk assessment of the Spanish population's exposure to cadmium based on concentrations detected in foods (between 2000 and 2010) and the patterns of consumption of the Spanish population (adults and children aged 7-12 years) (AESAN, 2011a).

Since 2011, there have been a series of updates both at the European and the national level, which include the adoption of new maximum limits on cadmium content in food products, Regulation (EU) No. 488/2014 (EU, 2014), and two new surveys conducted by AESAN on food consumption: ENALIA (National Dietary Survey on the Child and Adolescent Population) and ENALIA 2 (National Food Survey on Adults, the Elderly and Pregnant Women).

Given that AESAN possesses nearly 3000 new data points on the presence of cadmium in different food categories compiled between 2014 and 2017 in Spain, the Scientific Committee has been requested to conduct a new risk assessment of the Spanish population's dietary exposure to cadmium, taking these new data into consideration, in order to provide a more updated perspective on the situation.

2. Risk assessment: background

Within Spain, the AESAN's risk assessment of 2011 examined cadmium concentrations in 5493 food samples collected between 2000 and 2010. The foods were grouped into 15 categories following the FoodEx classification system used in the EFSA's Concise European Food Consumption Database (EFSA, 2008). The number of samples with cadmium concentrations lower than the LOD (limit of detection) was 2156 (39.2 %).

Cadmium exposure in adults was estimated by taking into consideration the mean consumption of

foods revealed by the National Survey of Dietary Intake in Spain (ENIDE) (AESAN, 2011b), whereas in the case of children (7-12 years), the mean consumption obtained from the report on the "Spanish diet model to ascertain consumer exposure to chemical substances" was used (AESAN, 2006).

Given that 9 out of 15 categories of the foods under consideration had a large number of samples (>60 %) with cadmium content lower than the LOD, the upper bound and lower bound were set according to the recommendations of GEMS/Food (Global Environment Monitoring System/Food Contamination Monitoring and Assessment Programme) (WHO, 2003).

The results obtained demonstrated that the mean exposure for adults (total population) in Spain was 1.155-2.85 µg Cd/kg b.w./week for "consumers only" and 2.06-3.95 µg Cd/kg b.w./week for "extreme consumers". Children (7-12 years) displayed a mean weekly exposure of 1.87-4.29 µg Cd/kg b.w. (Table 1). This estimated mean exposure to cadmium for Spain in 2011 was lower than the Tolerable Weekly Intake (TWI) of 2.5 µg Cd/kg b.w./week established by the EFSA (2011a) with regard to the lower bound (LB) but exceeded the upper bound (UB) for both the "total population" and "consumers only". In the case of "extreme consumers", the TWI value could be doubled, likewise in the case of children aged 7-12. There were no appreciable differences between the "total population" and "consumers only" given that the greatest cadmium contribution was from food groups with a very high percentage of "consumers only". The food groups mainly responsible for cadmium dietary exposure were, in descending order "Fish and seafood", "Grains and grain-based products", "Meat and edible offal" and "Vegetables, nuts and legumes".

Table 1. Estimates of cadmium dietary exposure in the Spanish population within the period 2000-2010

Intake (µg Cd/kg b.w./week) Total population		**Intake (µg Cd/kg b.w./week) Consumers only**	**Intake (µg Cd/kg b.w./week) Extreme consumers**
Adults	**Children (7-12 years)**	**Adults**	**Adults**
1.155 (LB) 2.849 (UB)	1.87 (LB) 4.29 (UB)	1.281 (LB) 3.346 (UB)	2.06 (LB) 3.95 (UB)

Source: (AESAN, 2011a).

Likewise, following the European Commission's directives, in 2011, AESAN published a series of "Recommendations regarding the consumption of crustaceans to reduce cadmium exposure" (AESAN, 2011c).

At the European level, in 2012, the EFSA conducted an assessment of the European population's dietary exposure to cadmium. It analysed data on the presence of cadmium in 178 541 samples collected by 22 Member States of the European Union (including Spain) between the years 2003 and 2011 (EFSA, 2012). Results with a limit of detection higher than 100 µg/kg or a limit of quantification higher than 200 µg/kg were excluded and the foods were grouped according to the FoodEx2 classification system (EFSA, 2011b). The mean level of cadmium was higher than 100 µg/kg in 13 out of 144 specific food categories. The results obtained by the EFSA (2012) demonstrated that the mean exposure of the European population (middle bound) was 2.04 µg Cd/kg b.w./week and 3.66 µg Cd/kg b.w./week for the 95th percentile. The highest and lowest levels of cadmium exposure were

detected in toddlers and that of the elderly, respectively (Table 2). The estimates of dietary exposure in children and adults (95th percentile) confirmed that the established TWI of 2.5 µg Cd/kg b.w./week might be exceeded (EFSA, 2012).

Table 2. Estimates of cadmium dietary exposure in the Spanish population for different age groups within the period 2003-2011

Age groups	N*	Dietary exposure to Cd Mean consumption (µg Cd/kg b.w./week)			Dietary exposure to Cd 95th percentile (µg Cd/kg b.w./week)		
		LB	MB	UB	LB	MB	UB
Infants (0-12 months)	876	1.97	2.74	3.50	4.97	6.56	8.42
Toddlers (1-3 years)	1597	3.80	4.85	5.90	6.76	8.19	9.84
Other children (3-10 years)	8468	3.23	3.96	4.69	5.55	6.58	7.66
Adolescents (10-18 years)	6329	1.87	2.20	2.54	3.66	4.17	4.70
Adults (18-65 years)	30 788	1.41	1.70	1.98	2.72	3.09	3.50
Elderly (65-75 years)	4056	1.30	1.56	1.82	2.47	2.82	3.18
Very elderly (>75 years)	1614	1.38	1.63	1.89	2.56	2.87	3.21
Adjusted mean		**1.68**	**2.04**	**2.39**	**3.17**	**3.66**	**4.18**

*N: number of participants in the consumer surveys. **Source**: (EFSA, 2012).

The food groups that had the greatest impact on European dietary exposure to cadmium were "Cereals and cereal products" (26.9 %), "Vegetables and vegetable products" (16.0 %), and "Starchy roots and tubers" (13.2 %). A more detailed look at the food categories reveals *potatoes* (13.2 %), *bread and rolls* (11.7 %), fine bakery wares (5.1 %), chocolate products (4.3 %), leafy vegetables (3.9 %) and molluscs (3.2 %) to be the biggest contributors to cadmium dietary exposure (EFSA, 2012).

3. Risk assessment: the situation in Spain (2014-2017)

The purpose of this report is to assess the Spanish population's exposure to cadmium based on food consumption data published by ENALIA and ENALIA 2, both included in the Comprehensive European Food Consumption Database of the EFSA (2020), and the current data on cadmium content in foods. The total number of data points on cadmium in foods utilised in this study ascends to 2965 and all of them correspond to the official control programme conducted by the autonomous regions and the Sub-Directorate General for Foreign Health, by means of atomic absorption spectrometry and inductively coupled plasma mass spectrometry, for the period 2014-2017.

3.1. Cadmium content in foods

The data to be processed have been distributed into 16 food groups based on the FoodEx2 classification system of the EFSA. This system used by the EFSA's Comprehensive European Food Consumption Database divides foods into 21 main categories (EFSA, 2011b). The most represented food groups in this study are "Fish" and "Seafood" (38.6 % and 16.7 %, respectively), "Meat and

meat products" (12.0 %) and "Vegetables and vegetable products" (11.7 %). The least represented food groups in this study (<1 %) are "Milk and dairy products", "Fats and oils and primary derivatives thereof", "Fruit and vegetable juices and nectars ", "Alcoholic beverages", "Coffee, cocoa, tea and infusions" and "Sugar and similar, confectionery and water-based sweet desserts". Additionally, the study includes 57 samples of "Food products for young population" (Table 3).

Table 3. Food groups and number of samples tested for cadmium

Food groups	N	Representativeness (%)
Grains and grain-based products	221	7.5
Vegetables and vegetable products	346	11.7
Starchy roots or tubers and products thereof	39	1.3
Legumes, nuts, oilseeds and spices	55	1.9
Meat and meat products	357	12.0
Fish	1145	38.6
Seafood	495	16.7
Fruit and fruit products	127	4.3
Milk and dairy products	2	0.1
Fats and oils and primary derivatives thereof	3	0.1
Fruit and vegetable juices and nectars	6	0.2
Water and water-based beverages	64	2.2
Alcoholic beverages	8	0.3
Coffee, cocoa, tea and infusions	7	0.2
Sugar and similar, confectionery and water-based sweet desserts	33	1.1
Food products for young population	57	1.9
Total	**2965**	**100**

As the maximum limits for some foods have been raised in accordance with Regulation (EU) No. 488/2014 (EU, 2014), it is possible that Spanish laboratories for official controls have adjusted their analysis techniques to these new maximum limits (ML) and, therefore, the limit of detection (LOD) and the limit of quantification (LOQ) of this assessment for some foods may be higher than the LOD and LOQ of the techniques used during the period 2000-2010.

For the period 2014-2017, the frequency of quantification is 32.8% (973 samples). The LOQ values for the food samples included in this study range between 0.63 µg/kg (drinking water) and 200 µg/kg (processed and canned fish), although in 89.3 % of the samples, the LOQ value is within the range of 10-20 µg/kg.

The groups of "Coffee, cocoa, tea and infusions", "Seafood" and "Starchy roots or tubers and products thereof" contain the largest percentage of samples with cadmium content higher than the LOQ (100 %, 67.7 % and 64.1 %, respectively), followed by "Sugar and similar, confectionery

and water-based sweet desserts" (57.6 %), "Legumes, nuts, oilseeds and spices" (36.4 %), "Fish" (36.2 %), "Foods products for young population" (22.8 %) and "Vegetables and vegetable products" (24.6 %). In the rest of the food groups, cadmium exceeding the LOQ was detected in less than 10 % of the samples. Specifically, it must be mentioned that some food types display a frequency of quantification of cadmium higher than 60 % (Processed or preserved vegetables, *potatoes* and molluscs), and especially chocolate and chocolate products, *liver* and *cocoa powder* with a frequency of quantification of 73.1, 76.9 and 100 %, respectively (Table 4).

Given that a high percentage of food samples display a cadmium content lower than the LOQ, the mean contamination value corresponding to the lower bound (LB) and upper bond (UB) has been calculated where values lower than the LOQ have been replaced with zero or the LOQ value, respectively (Table 4).

Table 4. Frequency of quantification and mean cadmium content expressed as lower bound (LB) and upper bound (UB) in different food groups for the period 2014-2017

Food groups	N	>LOQ (%)	LOQ (µg/kg)	LB (µg/kg)	UB (µg/kg)
Grains and grain-based products	**221**	**9.0**	**10-25**	**2.9**	**15.0**
Cereals and cereal primary derivatives	192	6.3	10-25	2.2	14.4
Bread and similar products	24	29.2	10-20	6.8	19.3
Breakfast cereals	5	20.0	10-20	8.0	20.0
Vegetables and vegetable products	**346**	**24.6**	**10-40**	**8.7**	**20.9**
Bulb vegetables	14	28.6	10-20	3.6	12.9
Fruiting vegetables	84	4.8	2-20	0.8	13.9
Leafyy vegetables	115	30.4	2-20	10.7	23.0
Stem vegetables	6	0.0	10-20	0.0	15.0
Fungi	84	42.9	10-40	17.0	29.1
Root and tuber vegetables (excluding starchy-)	21	14.3	2-20	4.1	13.2
Legumes with pod	6	0.0	10	0.0	10.0
Flowering brassica	13	7.7	10-20	0.8	16.2
Processed or preserved vegetables	3	66.7	20	44.7	51.3
Starchy roots or tubers and products thereof	**39**	**64.1**	**10-20**	**18.2**	**24.0**
Potatoes	39	64.1	10-20	18.2	24.0
Legumes, nuts, oilseeds and spices	**55**	**36.4**	**10-100**	**39.3**	**76.6**
Legumes and fresh seeds	1	0.0	10	0.0	10.0
Dried legumes seeds	3	0.0	10-25	0.0	20.0

Table 4. Frequency of quantification and mean cadmium content expressed as lower bound (LB) and upper bound (UB) in different food groups for the period 2014-2017

Spices (*paprika*)	50	40.0	20-100	43.2	82.4
Processed legumes, nuts, oilseeds and spices	1	0.0	20	0.0	20.0
Meat and meat products	**357**	**7.8**	**10-60**	**4.1**	**21.5**
Poultry meat	49	0.0	10-60	0.0	14.9
Mammals	282	2.8	10-60	0.5	19.6
Liver	26	76.9	10-50	50.6	55.2
Fish	**1145**	**36.2**	**10-200**	**23.9**	**36.1**
Fish (meat)	876	31.4	10-200	17.1	28.8
Processed and canned fish	269	52.0	10-200	46.3	57.2
Seafood	**495**	**67.7**	**10-200**	**130.9**	**137.8**
Crustaceans	162	53.1	10-100	44.8	53.9
Molluscs	333	74.8	10-200	172.8	178.5
Fruit and fruit products	**127**	**4.7**	**1-40**	**0.3**	**14.4**
Fruit used as fruit	108	5.6	1-20	0.3	13.4
Processed fruit products products	19	0.0	10-40	0.0	20.5
Milk and dairy products	**2**	**0.0**	**12**	**0.0**	**12.0**
Goat's milk	2	0.0	12	0.0	12.0
Fats and oils and primary derivatives thereof	**3**	**0.0**	**10**	**0.0**	**10.0**
Olive oil	3	0.0	10	0.0	10.0
Fruit and vegetable juices and nectars	**6**	**0.0**	**10-20**	**0.0**	**13.0**
Water and water-based beverages	**64**	**0.0**	**0.63-4**	**0.0**	**1.3**
Drinking water	63	0.0	0.63-1.3	0.0	1.2
Water based beverages	1	0.0	4	0.0	4.0
Alcoholic beverages	**8**	**0.0**	**1-30**	**0.0**	**19.5**
Coffee, cocoa, tea and infusions	**7**	**100.0**	**10**	**215.3**	**215.3**
Cocoa powder	7	100.0	10	215.3	215.3
Sugar and similar, confectionery and water-based sweet desserts	**33**	**57.6**	**1-100**	**89.8**	**96.2**
Sugar and other sweetening ingredients	3	0.0	1-100	0.0	34.0
Chocolate and chocolate products	26	73.1	10-12	114.0	116.7
Water-based sweet desserts	4	0.0	10	0.0	10.0

Table 4. Frequency of quantification and mean cadmium content expressed as lower bound (LB) and upper bound (UB) in different food groups for the period 2014-2017

Foods products for young population	**57**	**22.8**	**2-20**	**3.4**	**9.1**
Follow-on formulae	18	5.6	2-10	0.1	3.7
Processed cereal-based food for infants and young children	23	47.8	4-10	7.8	12.7
Ready-to-eat meal for infants and young children	16	6.3	2-20	0.6	10.3
Total	**2965**	**32.8**	**0.63-200**	-	-

In both contamination scenarios (LB and UB) a similar pattern is observed where "Coffee, cocoa, tea and infusions" (215.3-215.3 µg Cd/kg), "Seafood" (130.9-137.8 µg Cd/kg) and "Sugar and similar, confectionery and water-based sweet desserts" (89.8-96.2 µg Cd/kg) are the food groups with the highest levels of cadmium content, followed by "Legumes, nuts, oilseeds and spices" (39.3-76.6 µg Cd/kg).

A detailed analysis by food type reveals four levels of contamination (considering the concentration of cadmium expressed as LB):

- >200 µg/kg (*cocoa powder*).
- 100-200 µg/kg (molluscs, chocolate and chocolate products).
- 10-100 µg/kg (*liver*, processed and canned fish, crustaceans, processed or preserved vegetables, *paprika*, *potatoes*, fish (meat), fungi and leafyy vegetables).
- <10 µg/kg (rest of the foods).

In the most conservative contamination scenario (UB), the mean cadmium content ranges between 1.2 µg Cd/kg (drinking water) and 215.3 µg Cd/kg (*cocoa powder*).

The group of "Foods products for young population" has a mean concentration level of 3.4-9.1 µg Cd/kg. Of note is the mean concentration detected in processed cereal-based food for infants and young children (7.8-12.7 µg Cd/kg), compared with ready-to-eat meal for infants and young children (0.6-10.3 µg/kg) and follow-on formulae (0.1-3.7 µg/kg).

3.2 Assessment of the dietary exposure of cadmium

The dietary exposure to cadmium has been estimated by means of a deterministic calculation based on the mean value of cadmium concentration corresponding to the lower bound (LB) and upper bound (UB) of the daily consumption of each food by different age groups (12-35 months (toddlers), 3-9 years (other children), 10-17 years (adolescents) and 18-64 years (adults)) and the assumed body weight for each (13 kg, 28 kg, 53 kg and 73.2 kg, respectively). The data on the daily consumption of foods has been obtained from the ENALIA survey for population groups between the ages of 1 and 17 years (grouped into intervals of 12-35 months, 3-9 years and 10-17 years), and the ENALIA 2 survey for the 18-64 age group, both included within the Comprehensive European

Food Consumption Database of the EFSA (2020).

When estimating cadmium dietary exposure, two possible scenarios have been considered:

- Mean consumption scenario: calculated on the basis of the mean consumption of each food for the "total population". "Total population" refers to the population included in the sample for each age group (regardless of whether they have consumed a food or a food group).
- Extreme consumption scenario: calculated on the basis of the extreme consumption data (95th Percentile) of "consumers only" (population included in the sample for each age group that has consumed a food or food group) for the two types of foods that are the biggest contributors to the intake and the mean consumption data of the "total population" for the rest of the foods.

Figures 6.1-6.4 (of the Annex) display the contribution of the different food groups analysed to the estimated daily cadmium intake in the Spanish population for each of the four age segments considering the lower bound (LB) of cadmium concentration.

3.2.1 Assessment of cadmium exposure in the adult population (18-64 years)

Table 5.1 (of the Annex) displays the estimated daily cadmium intake values for the lower (LB) and upper bounds (UB) respectively, calculated for the Spanish adult population (18-64 years) considering the mean consumption and extreme consumption (P95) for the "total population" as well as for "consumers only".

3.2.1.1 Mean consumption scenario

In the mean consumption scenario, the cadmium intake for the "total population" of adults aged 18-64 years (73.2 kg body weight according to ENALIA) is estimated at an interval of 0.33 (LB) to 1.18 (UB) µg/kg b.w./week. This intake is the result of the sum of contributions from different food groups without there being a clear and specific dietary source (Table 5.1). Previously in 2011, AESAN had estimated the intake of the Spanish adult population at 1.155 (LB) - 2.849 (UB) µg Cd/kg b.w./week, and in 2012, the EFSA estimated the intake of the European adult population in the mean consumption scenario as 1.68 (LB) - 2.39 (UB) µg Cd/kg b.w./week.

Table 6.1 displays the contribution of each food group to the daily cadmium intake for adults (18-64 years) for the two contamination scenarios (LB and UB).

In the case of the lower bound (LB) of concentration, the food group that is the greatest contributor to the dietary exposure of cadmium is "Fish and Seafood" (31.1 %). "Seafood" constitutes 24.5 % of the intake where molluscs make up 23.1% and within this category, *squid* is responsible for 18.2 % of the estimated intake in the LB.

In second place, we have the "Starchy roots or tubers and products thereof" food group, and more specifically, the *potato* is responsible for 21.6 % of the total cadmium intake.

The group of "Vegetables and vegetable products" is responsible for 18.2 % of the intake, with the main contributors being leafy vegetables (6.6 %); within the food group of "Grains and grain-based products (15.4 %), *white wheat bread* contributes 14.7 % of cadmium intake.

It must be pointed out that those foods that display high concentrations of cadmium do not contribute significantly to the daily cadmium intake in the LB owing to their low consumption within this age group (18-64 years), as in the case of *cocoa powder* (6.6 %), chocolate and chocolate products (3.7 %), fungi (2.0 %), crustaceans (1.4 %), *liver* (0.6 %) and spices (0.0 %).

If we consider the most conservative contamination scenario (upper bound of concentration, UB), then we observe certain differences in the percentage-based contribution of the food groups to the daily cadmium intake in adults, with regard to the results obtained when applying the lower bound (LB) of contamination. Generally, when the UB is applied, a more homogenous contribution to the intake is observed, given the low frequency of quantification in different food groups which means that on many occasions, LOQ values are applied to the cadmium intake estimate. "Vegetables and vegetable products" and "Fruit and fruit products" with contributions of 19.1 % and 15.3 %, respectively, to the intake in the UB, are the two food groups that contribute the most to cadmium dietary exposure in adults, followed by "Fish and Seafood" (13.7 %), "Grains and grain-based products" (13.3 %) and "Meat and meat products" (12.5 %) (Table 6.1).

3.2.1.2 Extreme consumption scenario

Considering extreme consumption values (P95) for all food groups in the "total population" of adults, a cadmium intake of 1.24 (LB) and 5.21 (UB) µg Cd/kg b.w./week is estimated. This maximum intake is logically higher than that estimated in the mean consumption scenario (0.33-1.18 µg Cd/kg b.w./week) and is similar to that estimated by the EFSA in 2012 for adults in the P95 (3.17 (LB) and 4.18 (UB) µg Cd/kg b.w./week) (Table 5.1).

The intake values calculated for adult "consumers only" (P95) have a different profile to that observed in the mean consumption scenario. In this case, the highest intake values are associated with the extreme consumption of "Fish" and "Seafood" (48.05 (LB) - 88.35 (UB) µg Cd/day), followed by "Vegetables and vegetable products" (4.41 (LB) - 36.58 (UB) µg Cd/day) (Table 5.1).

If we assume an extreme consumption (P95) for all food groups in the "total population", this would lead to an estimate of daily intake in a highly improbable scenario. For this reason, the extreme consumption scenario of exposure is based on the maximum intake calculated from the P95 consumption data of "consumers only" for the two food types that are the biggest contributors to the total cadmium intake (molluscs and *potatoes*), and from the mean consumption data for the "total population" for the rest of the foods. This scenario estimates a cadmium intake ranging between 3.07 and 4.12 µg Cd/kg b.w./week (Table 7).

3.2.2 Assessment of cadmium dietary exposure in children and adolescents

Tables 5.2, 5.3 and 5.4 display the intake values calculated for children and adolescents in the age groups of 12-35 months (toddlers), 3-9 years (other children) and 10-17 years (adolescents) respectively, considering mean consumption and extreme consumption (P95) for both the "total population" and "consumers only". According to ENALIA, the body weights considered for each age group are 13 kg for toddlers, 28 kg for other children, and 53 kg for adolescents.

3.2.2.1 Mean consumption scenario

Within the mean consumption scenario, cadmium intake is estimated at 1.37-4.60 µg Cd/kg b.w./week for the "total population" of toddlers (Table 5.2); 1.18-2.96 µg Cd/kg b.w./week for the "total population" of other children (Table 5.3) and 0.76-1.93 µg Cd/kg b.w./week for the "total population" of adolescents (Table 5.4). In its assessment of the dietary exposure of the Spanish population aged 7-12 years between 2000 and 2010, AESAN (2011) estimated the intake in the mean consumption scenario to be 1.87 (LB) - 4.29 (UB) µg Cd/kg b.w./week.

Tables 6.2, 6.3 and 6.4 display the contribution of each food group to the daily cadmium intake for the two contamination scenarios (LB and UB).

3.2.2.1.1 Children aged 12-35 months (toddlers)

For toddlers (Table 6.2), the food group that is the biggest contributor to cadmium dietary exposure in the lower bound (LB) is "Starchy roots or tubers and products thereof" (*potatoes*) which represents 38.8 % of the cadmium dietary intake. Within this age group, *cocoa powder* is also responsible for 20.4 % of the cadmium dietary intake.

Within the "Fish and Seafood" group, molluscs are responsible for 16.5 % of the total intake, and this intake is linked mainly to the consumption of *squid* (12.2 %).

It must be highlighted that "Foods products for young population" which include follow-on formulae, processed cereal-based food for infants and young children and ready-to-eat meal for infants and young children, are not significant contributors to the daily cadmium intake in this population group (6.3 %), owing to their low contamination levels.

In the most conservative contamination scenario (upper bound, UB) the food groups with lower frequency of quantification beyond the LOQ acquire greater importance in the percentage-based contribution to the daily cadmium intake. Thus, in addition to "Starchy roots or tubers and products thereof" (15.3 %), the groups of "Fruit and fruit products" with 16.6 %; "Vegetables and vegetable products" with 12.2 %; and "Meat and meat products" with 11.2 % of the total intake, are the most significant groups. Within the group of "Foods products for young population" (13.2 %), it is worth highlighting the contribution of ready-to-eat meals with 6.3 % of the total cadmium intake in toddlers (Table 6.2).

3.2.2.1.2 Children aged 3 to 9 years (other children)

For other children (Table 6.3) the food types that contribute the most to cadmium dietary exposure in the case of the lower bound (LB) are *cocoa powder* (30.4 %) and molluscs (21.2 %). Likewise, *potatoes* are also a significant contributor to the total intake with 19.3 %. The group of "Grains and grain-based products" provides 11.0 % of the intake, with the most noteworthy being *white wheat bread* at 8.9 %.

In the most conservative contamination scenario (UB), *cocoa powder* is also one of the main food types that contribute to the total cadmium intake, providing 12.1 %, along with "Vegetables and vegetable products" with 13.2 %, "Fruit and fruit products" with 12.9 % and "Grains and grain-based products" with 12.8 %. For this population group and within this contamination scenario, "Starchy

roots or tubers and products thereof" make a lower contribution of up to 10.1 % of the total intake. Molluscs contribute 8.7 %, and Fish (meat) with a contribution of 5.5 % are the highest contributors to cadmium intake in the "Fish and Seafood" group (15.3 %) in this UB scenario (Table 6.3).

3.2.2.1.3 Adolescents (10-17 years)

For adolescents (Table 6.4) the food group that contributes the most to cadmium dietary exposure in the case of the lower bound (LB) is "Fish and Seafood" (27 %), where molluscs (21.2 %) represent a significant amount, especially *squid* (16.7 %). Other foods that contribute significantly to cadmium intake are *cocoa powder* with 25.8 % and *potatoes* with 19 %. In "Grains and grain-based products" *white wheat bread* provides 12.8 % of the total cadmium intake. "Legumes, nuts, oilseeds, spices", "Meat and meat products", "Fats and oils and primary derivatives thereof", "Water and water-based beverages" and "Foods products for young population" do not contribute cadmium in the LB scenario.

In the case of the most conservative contamination scenario (UB), "Grains and grain-based products" is the food group that contributes the greatest amount of cadmium to the diet of adolescents, reaching 16.7 % of the total intake owing to the 13.1 % provided by bread and similar products (Table 6.4)

3.2.2.2 Extreme consumption scenario

3.2.2.2.1 Children 12-35 months (toddlers)

For toddlers, considering extreme consumption values (P95) in the "total population" (Table 5.2), it is observed that mean cadmium intake ranges between 5.38 (LB) and 19.60 (UB) µg Cd/kg b.w./week. Similar to adults, this maximum intake is considerably higher than the intake of 1.37 (LB) - 4.60 (UB) µg Cd/kg b.w./week estimated in the mean consumption scenario (Table 5.2).

The EFSA assessment of 2012 estimated cadmium intake for toddlers with body weight 13 kg in the P95 scenario, to be 6.76 µg Cd/kg b.w./week (12.55 µg/day) in the LB, and 9.84 µg Cd/kg b.w./week (18.27 µg/day) in the UB (EFSA, 2012). Therefore, in the extreme consumption scenario, the Spanish toddlers´ population presents a dietary intake similar to the European intake.

The highest values of cadmium dietary intake in the "total population" of toddlers are those associated with an extreme consumption (P95) of "Starchy roots or tubers and products thereof" (*potatoes*) (2.85 (LB) - 3.76 (UB) µg Cd/day), "Fish and Seafood" (2.77 (LB) - 4.95 (UB) µg Cd/day), and "Coffee, cocoa, tea and infusions (*cocoa powder*)" (2.34 (LB) - 2.34 (UB) µg Cd/day). An extreme consumption of "Vegetables and vegetable products" and "Grains and grain-based products" for the "total population" of this age group entails an intake of 1.05 (LB) - 4.8 (UB) and 0.19 (LB) - 1.27 (UB) µg Cd/day, respectively (Table 5.2).

In toddlers *"*consumers only*"* (P95*),* the highest cadmium intakes (LB-UB) are associated with the extreme consumption of the food groups "Fish and Seafood" (30.16 (LB) - 54.28 (UB) µg Cd/day) and "Vegetables and vegetable products" (4.7 (LB) - 18.38 (UB) µg Cd/día), and by food types to *squid* (7.65 (LB) - 7.75 (UB) µg Cd/day), *cocoa powder* (3.77 (LB) - 3.77 (UB) µg Cd/day) and *potatoes* (2.94 (LB) - 3.87 (UB) µg Cd/day) (Table 5.2).

When estimating the maximum intake in the extreme consumption scenario, the P95 consumption data of "consumers only" for the two food types that are the biggest contributors to cadmium intake in the population group has been used: (*cocoa powder* and *potatoes*) and the mean consumption data of the "total population" of 12-35 months for the rest of the foods. This scenario estimates a cadmium intake ranging between 4.17 and 7.72 µg Cd/kg b.w./week (Table 7).

3.2.2.2.2 Children aged 3-9 years (other children)

Considering extreme consumption values (P95) for the "total population" (Table 5.3), the cadmium intake is estimated at 17.42 (LB) - 49.85 (UB) µg Cd/day or (4.36-12.46 µg Cd/kg b.w./week), once again, this is up to four times of the estimated intake for the mean consumption (4.71-11.85 µg Cd/day or 1.18-2.96 µg Cd/kg b.w./week).

In the case of "consumers only" (P95), the food group "Fish and Seafood" is in first place, contributing 63.65-103 µg Cd/day in the LB and UB scenarios, respectively (Table 5.3).

For intake estimate in the extreme consumption scenario, the P95 consumption data of "consumers only" for *cocoa powder* and molluscs and the mean consumption data of the "total population" of 3-9 years for the rest of the foods has been used. This scenario estimates a cadmium intake ranging between 12.02 and 14.50 µg Cd/kg b.w./week (Table 7).

3.2.2.2.3 Adolescents 10-17 years

Taking extreme consumption values (P95) for the "total population", the cadmium intake is estimated at 20.05 (LB) - 57.82 (UB) µg Cd/day for the adolescent population with an mean body weight of 54 kg, that is to say, 2.65 (LB) - 7.64 (UB) µg Cd/kg b.w./week. In line with what has been observed for the previous population groups, this maximum intake is almost four times the estimated intake of 5.78 (LB) - 14.58 (UB) µg Cd/day for the mean consumption scenario for adolescents (Table 5.4).

Similar to children aged 3-9 years, the extreme consumption of molluscs is also responsible for the most elevated cadmium intake in the case of "consumers only" in adolescents with 36.58 (LB) - 38.58 (UB) µg Cd/day.

To estimate the intake in the extreme consumption scenario, the P95 consumption data of "consumers only" for *cocoa powder* and molluscs has been used, and the mean consumption data of the "total population" of adolescents for the rest of the foods. This scenario estimates a cadmium intake ranging between 5.85 and 7.3 µg Cd/kg b.w./week (Table 7).

3.3 Risk characterisation

The risk characterisation (Table 7) has been performed in relation to the current Tolerable Weekly Intake (TWI) of 2.5 µg Cd/kg b.w./week adopted at the European level (EFSA, 2011a).

Table 7 displays the mean intake values calculated for the entire adult, children and adolescent population, in different scenarios of exposure (mean and extreme consumption), as well as the percentage-based contribution of the food groups to the TWI, both for the LB and the UB of cadmium contamination. Nevertheless, in all the cases and taking into account the frequency of quantification of cadmium beyond the LOQ, it is reasonable to assume in this risk assessment that the real dietary

exposure to cadmium will be closer to the lower bound (LB) estimate of contamination than to the upper bound (UB).

For the adult population (18-64 years), the mean intake value calculated in the most probable contamination scenario (mean consumption) is below the TWI in a percentage that ranges between 14.3 and 48.3 % of the TWI for adults (Table 7). In adolescents (10-17 years), the most probable cadmium dietary exposure (mean consumption) is between 30.5 and 77.0 % of the TWI. However, the most probable dietary intake for other children and toddlers is only below the TWI for the estimate of the lower bound (LB) as, at the upper bound (UB) of contamination, the estimated intake for both groups of children exceeds the TWI, becoming almost double for toddlers in this UB scenario (Table 7).

In the extreme consumption scenario (Table 7) the TWI is exceeded in all age groups and in both contamination scenarios (LB and UB). For adults, the estimated intake with the lower bound (LB) is 1.2 times higher than the TWI and for adolescents, it is double that of the TWI. For younger groups, toddlers and other children, the estimated weekly intake in the extreme consumption scenario is 1.5 and 5 times greater than the TWI, respectively.

3.4 Uncertainties

a) Analytical data:

- The available data is sourced from control programmes conducted by the autonomous regions and the Sub-Directorate General for Foreign Health, therefore the group-based distribution is not homogenous, as these controls are essentially meant to verify compliance with the current legislation.
- Some food groups contain a large number of individual foods or sub-groups, whereas other groups only have the results for a specific food. Additionally, the low number of samples for some foods forces us to estimate the cadmium content in the group from data that is not representative.
- The high number of results lower than the LOD/LOQ, 67.2 % of the total number of samples, has forced us to consider, following EFSA recommendations, a lower bound and upper bound estimate which entails a degree of uncertainty especially when, as in this assessment, the exposure in the upper bound is close to or exceeds the established reference values (TWI).

b) Consumption data:

- It is difficult to adjust consumption data with data on the presence of cadmium for some food groups, as the criteria used to group the foods are not usually the classification employed in the official control. This forces us to discard certain results, reducing the amount of available data for a certain food group.

Conclusions of the Scientific Committee

Cadmium continues to be a prevalent food contaminant, therefore it is necessary to continually monitor and control its levels, as well as assess its dietary exposure. The frequency of cadmium quantification in foods consumed in Spain continues to be high (32.8 %).

Within the concentration range (LB-UB), it is observed that *cocoa powder* (215.3-215.3 µg Cd/kg), molluscs (172.8-178.5 µg Cd/kg), and chocolate and chocolate products (114.0-116.7 µg Cd/kg) are the foods with the highest mean concentrations of cadmium.

In general, the food groups "Fish and Seafood", "Starchy roots or tubers and products thereof", and "Coffee, cocoa, tea and infusions" contain the foods that make the biggest contribution to cadmium intake.

Other foods with significant, though lower, levels of cadmium are *liver*, processed and canned fish, crustaceans, processed or preserved vegetables and spices (*paprika*), which make a less significant contribution to cadmium intake.

In adults, the main contribution to cadmium intake arises from the consumption of molluscs. Nevertheless, although *cocoa powder* has a lower number of analysed samples, it ranks as the food that is the biggest contributor to cadmium intake in the age groups of 3 to 17 years. In toddlers, the *potato* is the food with the highest contribution to cadmium intake.

In the mean consumption scenario, the estimated weekly intake of cadmium between the lower bound (LB) and the upper bound (UB) of the range of concentrations detected in the foods is within the established TWI of 2.5 µg Cd/kg b.w./week. Only in toddlers and other children could the mean exposure exceed the TWI, if the upper bound (UB) is considered.

Toddlers constitute the group that is most vulnerable to cadmium exposure owing to their greater food consumption in relation to their lower body weight. Nevertheless, given that it is reasonable to consider that the real dietary exposure to cadmium shall be closer to the estimate derived from the use of the lower bound (LB) rather than the upper bound (UB), it may be concluded that cadmium exposure is within the safety margins for all population groups in Spain.

There has been a decrease in the dietary exposure to cadmium in the Spanish adult population, with regard to the estimate derived from the assessment of 2011, of 26 % and 42 % in the estimates of the lower and upper bound respectively, although the differences in the limits of quantification and in the consumption data in the two assessments may have an effect on these differences.

For all population groups, the extreme consumption of molluscs is the main dietary source of cadmium. In the case of crustaceans, it must be pointed out that although the estimates display a cadmium contribution to the total intake that is lower than that of other foods, the contribution of this group may increase depending on the mode of consumption of the crustacean. In some countries, including Spain, "other parts" are frequently consumed, specifically those termed "dark meat", in addition to "white meat". The heads of shrimps, prawns, Norway lobsters, among others, and the bodies of crustaceans such as crab among others, which are also ingested/consumed, often have higher cadmium concentrations than the "white" parts. For this reason, this Scientific Committee deems it worthwhile to maintain the recommendation to limit the consumption of dark meat of crustaceans as mentioned by AESAN in its Recommendations regarding the consumption of crustaceans.

Although improbable, any scenario of chronic exposure that includes the extreme consumption of any food group constitutes a risk of exposure above the established TWI limit.

The data on cadmium exposure for the Spanish population that is assessed here as well as the identification of the contributing food groups provide information to set priorities for mitigating exposure and directing risk management and communication.

This Committee reiterates the need to undertake estimates and assessments of the dietary exposure to this and other metals on the basis of the data on their presence in foods and reliable consumption data from different Spanish population groups. This would help to overcome the difficulties and uncertainties involved in making risk assessments based on a limited number of test results and would permit the assessment of trends regarding consumer exposure to different contaminants.

References

AESAN (2006). Agencia Española de Seguridad Alimentaria y Nutrición. Modelo de dieta española para la determinación de la exposición del consumidor a sustancias químicas.

AESAN (2011a). Agencia Española de Seguridad Alimentaria y Nutrición. Informe del Comité Científico de la Agencia Española de Seguridad Alimentaria y Nutrición (AESAN) en relación a la evaluación del riesgo de la exposición de la población española a cadmio por consumo de alimentos. *Revista del Comité Científico de la AESAN*. 15. pp. 57-102.

AESAN (2011b). Agencia Española de Seguridad Alimentaria y Nutrición. Encuesta Nacional de Ingesta Dietética Española (ENIDE).

AESAN (2011c). Agencia Española de Seguridad Alimentaria y Nutrición. Recomendaciones de consumo de crustáceos para reducir la exposición de cadmio. Available at: https://www.aesan.gob.es/AECOSAN/web/para_el_consumidor/ampliacion/consumo_crustaceos.htm [accessed: 8-02-21].

Al-Rmalli, S.W., Jenkins, R.O. and Haris, P.I. (2012). Dietary intake of cadmium from Bangladeshi foods. *Journal of Food Science*, 77 (1), pp: T26-33.

Arnich, N., Sirot, V., Rivière, G., Jean, J., Noël, L., Guérin, T. and Leblanc, J.C. (2012). Dietary exposure to trace elements and health risk assessment in the 2nd French Total Diet Study. *Food and Chemical Toxicology*, 50 (7), pp: 2432-2449.

Barone, G., Storelli, A., Garofalo, R., Busco, V.P., Quaglia, N.C., Centrone, G. and Storelli, M.M. (2015). Assessment of mercury and cadmium via seafood consumption in Italy: estimated dietary intake (EWI) and target hazard quotient (THQ). *Food Additives & Contaminants: Part A,* 32 (8), pp: 1277-1286.

Berglund, M., Larsson, K., Grandér, M., Casteleyn, L., Kolossa-Gehring, M., Schwedler, G., Castaño, A., Esteban, M., Angerer, J., Koch, H.M., Schindler, B.K., Schoeters, G., Smolders, R., Exley, K., Sepai, O., Blumen, L., Horvat, M., Knudsen, L.E., Mørck, T.A., Joas, A., Joas, R., Biot, P., Aerts, D., De Cremer, K., Van Overmeire, I., Katsonouri, A., Hadjipanayis, A., Cerna, M., Krskova, A., Nielsen, J.K., Jensen, J.F., Rudnai, P., Kozepesy, S., Griffin, C., Nesbitt, I., Gutleb, A.C., Fischer, M.E., Ligocka, D., Jakubowski, M., Reis, M.F., Namorado, S., Lupsa, I.R., Gurzau, A.E., Halzlova, K., Jajcaj, M., Mazej, D., Tratnik, J.S., López, A., Cañas, A., Lehmann, A., Crettaz, P., Den Hond, E. and Govarts, E. (2015). Exposure determinants of cadmium in European mothers and their children. *Environmental Research*, 141, pp: 69-76.

Buha, A., Matovic, V., Antonijevic, B., Bulat, Z., Curcic, M., Renieri, E.A., Tsatsakis, A.M., Schweitzer, A. and Wallace, D. (2018). Overview of Cadmium Thyroid Disrupting Effects and Mechanisms. *International Journal of Molecular Sciences,* 19 (5), pp: 1-19.

Chen, M.Y., Chan, B.T., Lam, C.H., Chung, S.W., Ho, Y.Y. and Xiao, Y. (2014). Dietary exposures to eight metallic

contaminants of the Hong Kong adult population from a total diet study. *Food Additives & Contaminants: Part A,* 31 (9), pp: 1539-1549.

Chen, C., Xun, P., Nishijo, M. and He, K. (2016). Cadmium exposure and risk of lung cancer: a meta-analysis of cohort and case-control studies among general and occupational populations. *Journal* of Exposure *Science* & *Environmental Epidemiology*, 26 (5), pp: 437-444.

Chen, X., Wang, Z., Zhu, G., Ding, X. and Jin, T. (2018). The references level of cadmium intake for renal dysfunction in a Chinese population. *Scientific Reports*, 8 (1), pp: 9011.

Chunhabundit, R. (2016). Cadmium Exposure and Potential Health Risk from Foods in Contaminated Area, Thailand. *Toxicological Research*, 32 (1), pp: 65-72.

D'Amato, M., Turrini, A., Aureli, F., Moracci, G., Raggi, A., Chiaravalle, E., Mangiacotti, M., Cenci, T., Orletti, R., Candela, L., di Sandro, A. and Cubadda, F. (2013). Dietary exposure to trace elements and radionuclides: the methodology of the Italian Total Diet Study 2012-2014. *Annali dell'Istituto Superiore di Sanità*, 49 (3), pp: 272-280.

Darbre, P.D. (2006). Metalloestrogens. An emerging class of inorganic xenoestrogens with potential to add to the oestrogenic burden of the human breast. *Journal of Applied Toxicology*, 26, pp: 191-197.

Domingo, J.L., Perelló, G. and Giné Bordonaba, J. (2012). Dietary intake of metals by the population of Tarragona County (Catalonia, Spain): results from a duplicate diet study. *Biological Trace Element Research*, 146 (3), pp: 420-425.

EFSA (2008). European Food Safety Authority. The EFSA Concise European Food Consumption Database.

EFSA (2011a). European Food Safety Authority. Scientific Opinion of the Panel on Contaminants in the Food Chain on a request from the European Commission on tolerable weekly intake for cadmium. *EFSA Journal*, 9 (2): 1975, pp: 1-19.

EFSA (2011b). European Food Safety Authority. Evaluation of the FoodEx, the food classification system applied to the development of the EFSA Comprehensive European Food Consumption Database. *EFSA Journal*, 9 (3): 1970, pp: 1-27.

EFSA (2012). European Food Safety Authority. Cadmium dietary exposure in the European population. *EFSA Journal,* 10 (1): 2551, pp: 1-37.

EFSA (2020). European Food Safety Authority. Comprehensive European The EFSA Food Comsumption Database. Available at: https://www.efsa.europa.eu/en/food-consumption/comprehensive-database [accessed: 8-02-21].

Engbersen, N., Gramlich, A., López, M., Schwarz, G., Hattendorf, B., Gutiérrez, O. and Schulin, R. (2019). Cadmium accumulation and allocation in different cacao cultivars. *Science of the Total Environment,* 678: pp: 660-670.

EU (2008). Regulation (EC) No. 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No. 1907/2006. OJ L 353 of 31 December 2008, pp: 1-1355.

EU (2014). Commission Regulation (EU) No. 488/2014 of 12 May 2014 amending Regulation (EC) No 1881/2006 as regards maximum levels of cadmium in foodstuffs. OJ L 138 of 13 May 2014, pp: 75-79.

Filippini, T., Cilloni, S., Malavolti, M., Violi, F., Malagoli, C., Tesauro, M., Bottecchi, I., Ferrari, A., Vescovi, L. and Vinceti, M. (2018). Dietary intake of cadmium, chromium, copper, manganese, selenium and zinc in a Northern Italy community. *Journal of Trace Elements in Medicine and Biology*, 50, pp: 508-517.

Hamid, Y., Tang, L., Sohail, M.I., Cao, X., Hussain, B., Aziz, M.Z., Usman, M., He, Z.L. and Yang, X. (2019). An explanation of soil amendments to reduce cadmium phytoavailability and transfer to food chain. *Science of the Total Environment*, 660, pp: 80-96.

Huff, J., Lunn, R.M., Waalkes, M.P., Tomatis, L. and Infante, P.F. (2007). Cadmium-induced cancers in animals and in humans. International *Journal Occupational Environmental Health*, 13 (2), pp: 202-212.

Huo, J., Huang, Z., Li, R., Song, Y., Lan, Z., Ma, S., Wu, Y., Chen, J. and Zhang, L. (2018). Dietary cadmium exposure assessment in rural areas of Southwest China. *PLoS One*, 13 (8), pp: e0201454.

IARC (2012). International Agency for Research on Cancer. Arsenic, Metals, Fibres, and Dusts. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans Volume 100C.

Järup, L., Berglund, M., Elinder, C.G., Nordberg, G. and Vahter, M. (1998). Health effects of cadmium exposure - a review of the literature and a risk estimate. *Scandinavian Journal of Work Environment and Health*, 24 (1), pp: 1-51.

Järup, L. and Akesson, A, (2009). Current status of cadmium as an environmental health problem. *Toxicology and Applied Pharmacology*, 238, pp: 201-208.

Jean, J., Sirot, V., Vasseur, P., Narbone, J.F., Leblanc, J.C., Volatier, J.L. and Riviere, G. (2015). Impact of a modification of food regulation on cadmium exposure. *Regulatory Toxicology and Pharmacology*, 73, pp: 478-483.

Jean, J., Sirot, V., Hulin, M., Le Calvez, E., Zinck, J., Noël, L., Vasseur, P., Nesslany, F., Gorecki, S., Guérin, T. and Rivière, G. (2018). Dietary exposure to cadmium and health risk assessment in children - Results of the French infant total diet study. *Food and Chemical Toxicology*, 115, pp: 358-364.

Julin, B., Wolk, A., Bergkvist, L., Bottai, M. and Akesson, A. (2012). Dietary cadmium exposure and risk of postmenopausal breast cancer: a population-based prospective cohort study. *Cancer Research*, 72 (6), pp: 1459-1466.

Kawada, T. (2018). Cadmium intake and chronic kidney disease. *Clinical Nutrition*, 37 (5), pp: 1779.

Kjellström, T. and Nordberg, G.F. (1978). A kinetic model of cadmium metabolism in the human being. *Environmental Research*, 16 (1-3), pp: 248-269.

Kim, D.W., Woo, H.D., Joo, J., Park, K.S., Oh, S.Y., Kwon, H.J., Park, J.D., Hong, Y.S., Sohn, S.J., Yoon, H.J., Hwang, M.S. and Kim, J. (2014). Estimated long-term dietary exposure to lead, cadmium, and mercury in young Korean children. *European Journal of Clinical Nutrition*, 68 (12), pp: 1322-1326.

Kim, D.W., Woo, H.D., Joo, J., Park, K.S., Oh, S.Y., Kwon, H.J., Park, J.D. and Hong, Y.S. (2018). Estimated long-term dietary exposure to lead, cadmium, and mercury in young Korean children. *Environmental Science* and *Pollution Research*, 25 (19), pp: 18762-18771.

Lavado-García, J.M., Puerto-Parejo, L.M., Roncero-Martín, R., Moran, J.M., Pedrera-Zamorano, J.D., Aliaga, I.J., Leal-Hernández, O. and Canal-Macias. M.L. (2017). Dietary Intake of Cadmium, Lead and Mercury and Its Association with Bone Health in Healthy Premenopausal Women. *International Journal of Environmental Research and Public Health,* 14 (12), pp: 1437.

Liu, P., Zhang, Y., Su, J., Bai, Z., Li, T. and Wu, Y. (2018). Maximum cadmium limits establishment strategy based on the dietary exposure estimation: an example from Chinese populations and subgroups. *Environmental Science and Pollution Research*, 25 (19), pp: 18762-18771.

Marín-Martínez, R., Barber, X., Cabrera-Vique, C., Carbonell-Barrachina, Á.A., Vilanova, E., García-Hernández, V.M., Roche, E. and Garcia-Garcia, E. (2016). Aluminium, nickel, cadmium and lead in candy products and assessment of daily intake by children in Spain. *Food Additives & Contaminants: Part B*, 9 (1), pp: 66-71.

Marín, S., Pardo, O., Báguena, R., Font, G. and Yusà, V. (2017). Dietary exposure to trace elements and health risk assessment in the region of Valencia, Spain: a total diet study. *Food Additives & Contaminants: Part A,* 34 (2), pp: 228-240.

Marín, S., Pardo, O., Sánchez, A., Sanchis, Y., Vélez, D., Devesa, V., Font, G. and Yusà, V. (2018). Assessment of metal levels in foodstuffs from the Region of Valencia (Spain). *Toxicology Reports*, 5, pp: 654-670.

Martí-Cid, R., Llobet, J.M., Castell, V. and Domingo, J.L. (2008). Dietary intake of arsenic, cadmium, mercury, and lead by the population of Catalonia, Spain. *Biological Trace Element Research*, 125 (2), pp: 120-132.

Martorell, I., Perelló, G., Martí-Cid, R., Llobet, J.M., Castell, V. and Domingo, J.L. (2011). Human exposure to arsenic, cadmium, mercury, and lead from foods in Catalonia, Spain: temporal trend. *Biological Trace Element Research*, 142 (3), pp: 309-322.

Marzec, Z., Koch, W., Marzec, A. and Żukiewicz-Sobczak, W. (2014). Dietary exposure to cadmium, lead and nickel among students from south-east Poland. *Annals of Agricultural and Environmental Medicine*, 21 (4), pp: 825-828.

Millour, S., Noël, L., Kadar, A., Chekri, R., Vastel, C., Sirot, V., Leblanc, J.C. and Guérin, T. (2011). Pb, Hg, Cd, As, Sb and Al levels in foodstuffs from the 2nd French total diet study. *Food Chemistry*, 126 (4), pp:1787-1799.

Moon, C.S, Yang, H.R., Nakatsuka, H. and Ikeda, M. (2016). Time trend of cadmium intake in Korea. *Environmental Health* and *Preventive Medicine,* 21 (3), pp: 118-128.

Muñoz, O., Zamorano, P., Garcia, O. and Bastías, J.M. (2017). Arsenic, cadmium, mercury, sodium, and potassium concentrations in common foods and estimated daily intake of the population in Valdivia (Chile) using a total diet study. *Food and Chemical Toxicology,* 109 (Pt 2), pp: 1125-1134.

Nawrot, T.S., Martens, D.S., Hara, A., Plusquin, M., Vangronsveld, J., Roels, H.A. and Staessen, J.A. (2015). Association of total cancer and lung cancer with environmental exposure to cadmium: the meta-analytical evidence. *Cancer Causes Control*, 26 (9), pp: 1281-1288.

Nordberg, G.F., Kjellstrom, T. and Nordberg, M. (1985). Kinetics and metabolism. In book: *Cd and health: A toxicological and epidemiological appraisal*. Vol I: Exposure. Dose and Metabolism. CRC Press. Friberg LEC, Kjellstrom T, et al., Boca Raton. FL, pp: 103-178.

Núñez, R., García, M.Á., Alonso, J. and Melgar, M.J. (2018). Arsenic, cadmium and lead in fresh and processed tuna marketed in Galicia (NW Spain): Risk assessment of dietary exposure. *Science of the Total Environment*, 627, pp: 322-331.

Pan, J., Plant, J.A., Voulvoulis, N., Oates, J. and Ihlenfeld, C. (2010). Cadmium levels in Europe: implications for human health. *Environmental Geochemistry and Health*, 32, pp: 1-12.

Perelló, G., Vicente, E., Castell, V., Llobet, J.M., Nadal, M. and Domingo, J.L. (2015). Dietary intake of trace elements by the population of Catalonia (Spain): results from a total diet study. *Food Additives & Contaminants: Part A*, 32 (5), pp: 748-755.

Rana, K., Verma, Y., Rani, V. and Rana, S.V.S. (2018). Renal toxicity of nanoparticles of cadmium sulphide in rat. *Chemosphere*, 193, pp: 142-150.

Rizwan, M., Ali, S., Adrees, M., Ibrahim, M., Tsang, D.C.W., Zia-Ur-Rehman, M., Zahir, Z.A., Rinklebe, J., Tack, F.M.G. and Ok, Y.S. (2017). A critical review on effects, tolerance mechanisms and management of cadmium in vegetables. *Chemosphere*, 182, pp: 90-105.

Rose, M., Baxter, M., Brereton, N. and Baskaran, C. (2010). Dietary exposure to metals and other elements in the 2006 UK Total Diet Study and some trends over the last 30 years. *Food Additives & Contaminants: Part A,* 27 (10), pp: 1380-1404.

Rubio, C., Hardisson, A., Reguera, J.I., Revert, C., Lafuente, M.A. and González-Iglesias, T. (2006). Cadmium dietary intake in the Canary Islands, Spain. *Environmental Research*, 100 (1), pp: 123-129.

Sand, S. and Becker, W. (2012). Assessment of dietary cadmium exposure in Sweden and population health concern including scenario analysis. *Food and Chemical Toxicology*, 50 (3-4), pp: 536-544.

Satarug, S., Garrett, S.H., Sens, M.A. and Sens, D.A. (2010). Cadmium, environmental exposure and health outcomes. *Environmental Health Perspectives*, 118, pp: 182-190.

Satarug, S. (2018). Dietary Cadmium Intake and Its Effects on Kidneys. *Toxics*, 6 (15), pp: 1-23.

Schwarz, M.A., Lindtner, O., Blume, K., Heinemeyer, G. and Schneider, K. (2014). Cadmium exposure from food: the German LExUKon project. *Food Additives & Contaminants: Part A*, 31 (6), pp: 1038-1051.

Škrbić, B., Živančev, J. and Mrmoš, N. (2013). Concentrations of arsenic, cadmium and lead in selected foodstuffs from Serbian market basket: estimated intake by the population from the Serbia. *Food and Chemical Toxicology*, 58, pp: 440-448.

Song, Y., Wang, Y., Mao, W., Sui, H., Yong, L., Yang, D., Jiang, D., Zhang, L. and Gong, Y. (2017). Dietary cadmium exposure assessment among the Chinese population. *PLoS One*, 12 (5), pp: e0177978.

Spungen, J.H. (2019). Children's exposures to lead and cadmium: FDA total diet study 2014-16. *Food Additives & Contaminants: Part A*, 36 (6), pp: 893-903.

Suomi, J., Tuominen, P., Niinistö, S., Virtanen, S.M. and Savela, K. (2018). Dietary heavy metal exposure of Finnish

children of 3 to 6 years. *Food Additives & Contaminants: Part A*, 35 (7), pp: 1305-1315.

U.S. Department of Health and Human Services (2004). Bone Health and Osteoporosis: A Report of the Surgeon General. U.S. Department of Health and Human Services, Office of the Surgeon General, Rockville. MD.

Vromman, V., Waegeneers, N., Cornelis, C., De Boosere, I., Van Holderbeke, M., Vinkx, C., Smolders, E., Huyghebaert, A. and Pussemier, L. (2010). Dietary cadmium intake by the Belgian adult population. *Food Additives & Contaminants: Part A,* 27 (12), pp:1665-1673.

Waalkes, M.P. (2003). Cadmium carcinogenesis. *Mutation Research*, 533, pp: 107-120.

Wang, Z., Pan, L., Liu, G., Zhang, H., Zhang, J., Jiang, J., Xiao, Y., Bai, W., Jiao, R. and Huang, W. (2018). Dietary exposure to cadmium of Shenzhen adult residents from a total diet study. *Food Additives & Contaminants: Part A,* 35 (4), pp: 706-714.

Wang, P., Chen, H., Kopittke, P.M. and Zhao, F.J. (2019). Cadmium contamination in agricultural soils of China and the impact on food safety. *Environmental Pollution*, 249, pp: 1038-1048.

Wennberg, M., Lundh, T., Sommar, J.N. and Bergdahl, I.A. (2017). Time trends and exposure determinants of lead and cadmium in the adult population of northern Sweden 1990-2014. *Environmental Research*, 159, pp: 111-117.

Werlin, R., Priester, J., Mielke, R. et al. (2011). Biomagnification of cadmium selenide quantum dots in a simple experimental microbial food chain. *Nature Nanotech*, 6, pp: 65-71.

WHO (1992). World Health Organization. Renal effects and Low Molecular Weight Proteinuria. Environmental Health Criteria 134: Cadmium. World Health Organisation. Geneva, pp: 136-146.

WHO (2003). World Health Organization. Instructions for electronic submission of data on chemical conta¬minants in food and the diet. Global Environmental Monitoring System-Food Contamination Monitoring and Assessment Program (GEMS/Food).

Zhang, W., Liu, Y., Liu, Y., Liang, B., Zhou, H., Li, Y., Zhang, Y., Huang, J., Yu, C. and Chen, K. (2018). An Assessment of Dietary Exposure to Cadmium in Residents of Guangzhou, China. *International Journal of Environmental Research and Public Health*,15 (3), pp: E556.

Zhong, M.S., Jiang, L., Han, D., Xia, T.X., Yao, J.J., Jia, X.Y. and Peng, C. (2015). Cadmium exposure via diet and its implication on the derivation of health-based soil screening values in China. *Journal of Exposure Science and Environmental Epidemiology*, 25 (4), pp: 433-442.

Annex I

Table 5.1 Estimated daily cadmium intake in the Spanish population (18-64 years). Estimate for lower bound (LB) and upper bound (UB)

Food groups	Estimated Cd intake (µg/day) (Total population)				Estimated Cd intake (µg/day) (Consumers only)			
	Mean consumption		Consumption P95		Mean consumption		Consumption P95	
	LB	UB	LB	UB	LB	UB	LB	UB
Grains and grain-based products (*White wheat bread*)	0.57 *(0.51)*	1.65 *(1.31)*	1.48 *(1.31)*	5.26 *(3.39)*	1.59 *(0.59)*	4.90 *(1.52)*	3.78 *(1.44)*	10.86 *(3.71)*
Vegetables and vegetable products	0.63	2.36	2.73	10.38	5.61	14.02	14.41	36.58
Starchy roots or tubers and products thereof	0.75	0.98	2.48	3.26	1.03	1.35	2.68	3.54
Legumes, nuts, oilseeds and spices	0.00	0.05	0.00	0.21	0.05	1.83	0.10	3.75
Meat and meat products	0.02	1.55	0.01	8.35	8.30	15.53	9.59	24.17
Fish, seafood	1.08	1.69	3.97	6.61	21.92	48.57	48.05	88.35
Fish (meat)	0.14	0.56	0.12	2.19	7.65	29.02	11.79	42.50
Crustaceans	0.05	0.07	0.23	0.29	2.57	2.80	4.72	5.20
Molluscs (*Squid*)	0.80 *(0.63)*	0.82 *(0.64)*	3.39 *(3.17)*	3.43 *(3.22)*	9.68 *(4.49)*	10.42 (*4.55)*	27.50 *(15.95)*	29.03 *(16.16)*
Processed fish and seafood	0.09	0.24	0.23	0.70	2.01	6.33	4.03	11.62
Fruit and fruit products	0.06	1.89	0.42	8.87	0.47	19.45	0.82	37.34
Milk and dairy products	0.00	0.01	0.00	0.00	0.00	2.4	0.00	3.48
Fats and oils and primary derivatives thereof	0.00	0.15	0.00	0.33	0.00	0.16	0.00	0.33
Fruit and vegetable juices and nectars	0.00	0.52	0.00	2.93	0.00	5.98	0.00	8.96
Water and water-based beverages	0.00	0.52	0.00	2.42	0.00	1.96	0.00	4.30
Alcoholic beverages	0.00	0.60	0.00	3.77	0.00	3.04	0.00	7.86
Coffee, cocoa, tea and infusions (*Cocoa powder*)	0.23 *(0.23)*	0.23 *(0.23)*	1.29 *(1.29)*	1.29 *(1.29)*	1.59 *(0.89)*	0.89 *(0.89)*	2.28 *(2.28)*	2.28 *(2.28)*
Sugar and similar, confectionery and water-based sweet desserts (*Dark chocolate*)	0.13 *(0.09)*	0.16 *(0.09)*	0.60 *(0.60)*	0.77 *(0.60)*	2.74 *(1.41)*	3.24 *(1.41)*	5.24 *(2.76)*	6.39 *(2.76)*
Total (µg/day)	**3.47**	**12.63**	**12.98**	**54.45**	**42.59**	**123.32**	**86.94**	**238.19**
Total (µgkg b.w./week)	**0.33**	**1.18**	**1.24**	**5.21**	**4.07**	**11.79**	**8.31**	**22.78**
Mean body weight: 73.2 kg								

Table 5.2 Estimated daily cadmium intake in the Spanish population (toddlers). Estimate for lower bound (LB) and upper bound (UB)

Food groups	Estimated Cd intake (µg/day) (Total population)				Estimated Cd intake (µg/day) (Consumers only)			
	Mean consumption		Consumption P95		Mean consumption		Consumption P95	
	LB	UB	LB	UB	LB	UB	LB	UB
Grains and grain-based products *(Rice)*	0.04 *(0.02)*	0.28 *(0.09)*	0.19 *(0.1)*	1.27 *(0.42)*	0.93 *(0.06)*	3.57 *(0.28)*	1.19 *(0.14)*	5.37 *(0.61)*
Vegetables and vegetable products	0.26	1.04	1.05	4.8	1.41	6.92	4.7	18.38
Starchy roots or tubers and products thereof	0.99	1.31	2.85	3.76	1.21	1.6	2.94	3.87
Legumes, nuts, oilseeds and spices	0.00	0.04	0.00	0.24	0.00	0.52	0.00	1.25
Meat and meat products	0.00	0.96	0.00	4.03	0.08	5.33	0.13	10.53
Fish, seafood	0.52	1.08	2.77	4.95	14.7	28.5	30.16	54.28
Fish (meat)	0.07	0.59	0.08	2.16	6.66	19.37	9.09	29.59
Crustaceans	0.02	0.03	0.15	0.19	0.2	0.25	0.55	0.68
Molluscs *(Squid)*	0.42 *(0.31)*	0.43 *(0.31)*	2.50 *(2.29)*	2.53 *(2.32)*	7.73 *(2.65)*	7.93 *(2.68)*	20.3 *(7.65)*	20.73 *(7.75)*
Processed fish and seafood	0.01	0.03	0.03	0.07	0.10	0.94	0.23	3.28
Fruit and fruit products	0.03	1.42	0.09	5.26	0.38	12.2	0.79	23.53
Milk and dairy products	0.00	0.01	0.00	0.00	0.00	3.72	0.00	3.72
Fats and oils and primary derivatives thereof	0.00	0.07	0.00	0.2	0.00	0.09	0.00	0.2
Fruit and vegetable juices and nectars	0.00	0.45	0.00	3.67	0.00	4.63	0.00	9.56
Water and water-based beverages	0.00	0.19	0.00	0.5	0.00	0.55	0.00	1.01
Alcoholic beverages	-	-	-	-	-	-	-	-
Coffee, cocoa, tea and infusions *(Cocoa powder)*	0.52	0.52	2.34	2.34	1.57	1.57	3.77	3.77
Sugar and similar, confectionery and water-based sweet desserts *(Milk chocolate)*	0.03 *(0.02)*	0.04 *(0.02)*	0.00 *(0.00)*	0.05 *(0.00)*	2.58 *(0.4)*	3.03 *(0.42)*	4.42 *(1.16)*	5.22 *(1.21)*
Foods products for young population	0.16	1.13	0.71	5.33	0.46	7.17	0.9	10.91
Total (µg/day)	**2.55**	**8.54**	**10**	**36.4**	**23.32**	**79.4**	**49**	**151.6**
Total (µgkg b.w./week)	**1.37**	**4.60**	**5.38**	**19.60**	**12.56**	**42.75**	**26.38**	**81.63**
Mean body weight: 13 kg								

Table 5.3 Estimated daily cadmium intake in the Spanish population (other children). Estimate for lower bound (LB) and upper bound (UB)

Food groups	Estimated Cd intake (µg/day) (Total population)				Estimated Cd intake (µg/day) (Consumers only)			
	Mean consumption		Consumption P95		Mean consumption		Consumption P95	
	LB	UB	LB	UB	LB	UB	LB	UB
Grains and grain-based products	0.52	1.52	1.65	5.05	1.06	4.25	2.63	10.71
(White wheat bread)	*(0.42)*	*(1.10)*	*(1.18)*	*(3.04)*	*(0.48)*	*(1.24)*	*(1.25)*	*(3.24)*
Vegetables and vegetable products	0.49	1.57	2.26	7.90	5.74	14.81	14.29	38.20
Starchy roots or tubers and products thereof	0.91	1.20	2.70	3.55	1.15	1.52	2.80	3.70
Legumes, nuts, oilseeds and spices	0.00	0.06	0.00	0.49	0.08	0.89	0.11	1.73
Meat and meat products	0.00	1.38	0.00	5.73	2.12	10.27	2.17	18.91
Fish, seafood	1.21	1.81	6.08	8.00	28.71	53.39	63.65	103.00
Fish (meat)	0.13	0.65	0.09	1.64	7.56	28.96	11.18	43.78
Crustaceans	0.06	0.07	0.26	0.33	4.76	5.26	10.58	11.68
Molluscs	1.00	1.03	5.52	5.59	16.18	17.46	41.48	44.29
(Squid)	*(0.73)*	*(0.74)*	*(4.82)*	*(4.88)*	*(4.78)*	*(4.85)*	*(14.27)*	*(14.46)*
Processed fish and seafood	0.02	0.06	0.21	0.44	0.20	1.71	0.41	3.25
Fruit and fruit products	0.02	1.53	0.13	7.81	0.40	15.57	0.86	30.34
Milk and dairy products	0.00	0.02	0.00	0.00	0.00	3.70	0.00	6.00
Fats and oils and primary derivatives thereof	0.00	0.11	0.00	0.26	0.00	0.12	0.00	0.27
Fruit and vegetable juices and nectars	0.00	0.73	0.00	5.13	0.00	5.90	0.00	10.16
Water and water-based beverages	0.00	0.29	0.00	1.25	0.00	0.91	0.00	1.71
Alcoholic beverages	-	-	-	-	-	-	-	-
Coffee, cocoa, tea and infusions *(Cocoa powder)*	1.43	1.43	4.04	4.04	1.94	1.94	4.31	4.31
Sugar and similar, confectionery and water-based sweet desserts	0.12	0.15	0.54	0.57	3.25	3.79	6.00	7.33
(Milk chocolate)	*(0.08)*	*(0.08)*	*(0.54)*	*(0.57)*	*(0.68)*	*(0.71)*	*(1.63)*	*(1.70)*
Foods products for young population	0.01	0.05	0.02	0.07	0.16	2.87	0.42	5.59
Total (µg/day)	**4.71**	**11.85**	**17.42**	**49.85**	**44.61**	**119.93**	**97.24**	**241.96**
Total (µgkg b.w./week)	**1.18**	**2.96**	**4.36**	**12.46**	**11.15**	**29.98**	**24.31**	**60.49**
Mean body weight: 28 kg								

Table 5.4 Estimated daily cadmium intake in the Spanish population (adolescents). Estimate for lower bound (LB) and upper bound (UB)

Food groups	Estimated Cd intake (µg/day) (Total population)				Estimated Cd intake (µg/day) (Consumers only)			
	Mean consumption		Consumption P95		Mean consumption		Consumption P95	
	LB	UB	LB	UB	LB	UB	LB	UB
Grains and grain-based products *(White wheat bread)*	0.88 *(0.74)*	2.43 *(1.91)*	2.45 *(1.76)*	7.42 *(4.56)*	2.98 *(0.81)*	7.56 *(2.10)*	7.06 *(1.82)*	16.68 *(4.70)*
Vegetables and vegetable products	0.57	1.70	3.08	8.58	8.10	17.80	19.25	43.50
Starchy roots or tubers and products thereof	1.10	1.45	3.18	4.20	1.37	1.81	3.30	4.35
Legumes, nuts, oilseeds and spices	0.00	0.06	0.00	0.25	0.07	0.94	0.10	2.12
Meat and meat products	0.00	1.81	0.01	6.98	0.34	10.44	0.41	21.07
Fish, seafood	1.56	2.25	6.34	8.58	31.99	61.74	60.63	106.80
Fish (meat)	0.21	0.77	0.11	1.97	10.15	35.31	14.39	51.93
Crustaceans	0.06	0.08	0.32	0.40	1.32	1.47	2.16	2.52
Molluscs *(Squid)*	1.23 *(0.97)*	1.26 *(0.98)*	5.69 *(5.00)*	5.76 *(5.06)*	15.44 *(6.33)*	16.57 *(6.42)*	36.36 *(16.83)*	38.58 *(17.05)*
Processed fish and seafood	0.06	0.14	0.22	0.45	5.08	8.39	7.72	13.77
Fruit and fruit products	0.05	1.78	0.41	9.77	0.51	19.38	0.92	37.16
Milk and dairy products	-	-	-	-	-	-	-	-
Fats and oils and primary derivatives thereof	0.00	0.14	0.00	0.34	0.00	0.15	0.00	0.35
Fruit and vegetable juices and nectars	0.00	0.92	0.00	5.13	0.00	7.26	0.00	14.34
Water and water-based beverages	0.00	0.39	0.00	1.81	0.00	1.36	0.00	2.96
Alcoholic beverages	-	-	-	-	-	-	-	-
Coffee, cocoa, tea and infusions *(Cocoa powder)*	1.49	1.49	4.31	4.31	2.16	2.16	4.84	4.84
Sugar and similar, confectionery and water-based sweet desserts *(Dark chocolate)*	0.13 *(0.05)*	0.15 *(0.05)*	0.27 *(0.00)*	0.45 *(0.00)*	4.67 *(2.49)*	5.15 *(2.49)*	12.34 *(6.81)*	13.35 *(6.81)*
Foods products for young population	0.00	0.01	0.00	0.00	0.10	3.98	0.21	4.29
Total (µg/day)	**5.78**	**14.58**	**20.05**	**57.82**	**52.29**	**139.73**	**109.06**	**271.81**
Total (µgkg b.w./week)	**0.76**	**1.93**	**2.65**	**7.64**	**6.91**	**18.45**	**14.40**	**35.90**
Mean body weight: 53 kg								

Table 6.1 Contribution of foods to cadmium intake in the adult population (18-64 years). Estimate for lower bound (LB) and upper bound (UB) based on the mean consumption of the "total population"

Food groups	LB		UB	
	Cd intake (µg/day)	% of the daily intake	Cd intake (µg/day)	% of the daily intake
Grains and grain-based products	**0.57**	**15.4**	**1.65**	**13.3**
Cereals and cereal primary derivatives	0.04	1.2	0.29	2.3
Bread and similar products *(White wheat bread)*	0.51 *(0.51)*	14.7 *(14.7)*	1.31 *(1.31)*	10.6 *(10.6)*
Breakfast cereals	0.02	0.6	0.05	0.4
Vegetables and vegetable products	**0.63**	**18.2**	**2.36**	**19.1**
Bulb vegetables	0.04	1.2	0.18	1.5
Fruiting vegetables	0.06	1.7	0.92	7.4
Leafy vegetables	0.23	6.6	0.70	5.7
Stem vegetables	0.00	0.0	0.03	0.2
Fungi	0.07	2.0	0.10	0.8
Root and tuber vegetables (excluding starchy-)	0.03	0.9	0.10	0.8
Legumes with pods	0.00	0.0	0.06	0.5
Flowering brassica	0.00	0.0	0.04	0.3
Processed or preserved vegetables	0.20	5.8	0.23	1.9
Starchy roots or tubers and products thereof *(Potatoes)*	**0.75**	**21.6**	**0.98**	**7.9**
Legumes, nuts, oilseeds and spices	**0.00**	**0.0**	**0.05**	**0.4**
Legumes and fresh seeds	0.00	0.0	0.01	0.1
Dried legumes seeds	0.00	0.0	0.04	0.3
Spices	0.00	0.0	0.00	0.0
Meat and meat products	**0.02**	**0.6**	**1.55**	**12.5**
Poultry meat	0.00	0.0	0.58	4.7
Mammals	0.00	0.0	0.94	7.6
Liver	0.02	0.6	0.03	0.2
Fish, seafood	**1.08**	**31.1**	**1.69**	**13.7**
Fish (meat)	0.14	4.0	0.56	4.5
Crustaceans	0.05	1.4	0.07	0.6
Molluscs (*Squid*)	0.80 *(0.63)*	23.1 *(18.2)*	0.82 *(0.64)*	6.6 *(5.2)*
Processed and canned fish	0.09	2.6	0.24	1.9
Fruit and fruit products	**0.06**	**1.7**	**1.89**	**15.3**
Fruit used as fruit	0.06	1.7	1.82	14.7
Processed fruit products	0.00	0.0	0.07	0.6

Table 6.1 Contribution of foods to cadmium intake in the adult population (18-64 years). Estimate for lower bound (LB) and upper bound (UB) based on the mean consumption of the "total population"

Food groups	LB		UB	
	Cd intake (µg/day)	% of the daily intake	Cd intake (µg/day)	% of the daily intake
Milk and dairy products	**0.00**	**0.0**	**0.01**	**0.1**
Milk *(goat)*	0.00	0.0	0.01	0.1
Fats and oils and primary derivatives thereof	**0.00**	**0.0**	**0.15**	**1.2**
Fruit and vegetable juices and nectars	**0.00**	**0.0**	**0.52**	**4.2**
Water and water-based beverages	**0.00**	**0.0**	**0.52**	**4.2**
Drinking water	0.00	0.0	0.31	2.5
Water based beverages	0.00	0.0	0.21	1.7
Alcoholic beverages	**0.00**	**0.0**	**0.60**	**4.9**
Coffee, cocoa, tea and infusions *(Cocoa powder)*	**0.23**	**6.6**	**0.23**	**1.9**
Sugar and similar, confectionery and water-based sweet desserts	**0.13**	**3.7**	**0.16**	**1.3**
Sugar and other sweetening ingredients *(Honey)*	0.00	0.0	0.03	0.2
Chocolate and chocolate products	0.13	3.7	0.13	1.1
Water-based sweet desserts	0.00	0.0	0.00	0.0
Total	**3.47**	**100.0**	**12.36**	**100.0**

Table 6.2 Contribution of foods to cadmium intake in toddlers. Estimate for lower bound (LB) and upper bound (UB) based on the mean consumption of the "total population"

Food groups	LB		UB	
	Cd intake (µg/day)	% of the daily intake	Cd intake (µg/day)	% of the daily intake
Grains and grain-based products	**0.04**	**1.6**	**0.28**	**3.3**
Cereals and cereal primary derivatives	0.04	1.6	0.13	1.5
Bread and similar products *(White wheat bread)*	0.00	0.0	0.01	0.1
Breakfast cereals	0.00	0.0	0.14	1.6
Vegetables and vegetable products	**0.26**	**10.2**	**1.04**	**12.2**
Bulb vegetables	0.03	1.2	0.11	1.3
Fruiting vegetables	0.01	0.4	0.37	4.3
Leafy vegetables	0.08	3.1	0.17	2.0
Stem vegetables	0.00	0.0	0.04	0.5
Fungi	0.00	0.0	0.01	0.1

Table 6.2 Contribution of foods to cadmium intake in toddlers. Estimate for lower bound (LB) and upper bound (UB) based on the mean consumption of the "total population"

Food groups	LB		UB	
	Cd intake (µg/day)	% of the daily intake	Cd intake (µg/day)	% of the daily intake
Root and tuber vegetables (excluding starchy-)	0.05	2.0	0.16	1.9
Legumes with pods	0.00	0.0	0.06	0.7
Flowering brassica	0.00	0.0	0.02	0.2
Processed or preserved vegetables	0.09	3.5	0.10	1.2
Starchy roots or tubers and products thereof *(Potatoes)*	**0.99**	**38.8**	**1.31**	**15.3**
Legumes, nuts, oilseeds and spices	**0.00**	**0.0**	**0.04**	**0.5**
Legumes and fresh seeds	0.00	0.0	0.03	0.4
Dried legumes seeds	0.00	0.0	0.01	0.1
Spices	-	-	-	-
Legumes, nuts, seeds and processed products	-	-	-	-
Meat and meat products	**0.00**	**0.0**	**0.96**	**11.2**
Poultry meat	0.00	0.0	0.46	5.4
Mammals	0.00	0.0	0.49	5.7
Liver	0.00	0.0	0.01	0.1
Fish, seafood	**0.52**	**20.4**	**1.08**	**12.5**
Fish (meat)	0.07	2.7	0.59	6w.9
Crustaceans	0.02	0.8	0.03	0.4
Molluscs (*Squid*)	0.42 *(0.31)*	16.5 *(12.2)*	0.43 *(0.31)*	5.0 *(3.6)*
Processed and canned fish	0.01	0.4	0.03	0.4
Fruit and fruit products	**0.03**	**1.2**	**1.42**	**16.6**
Fruit used as fruit	0.03	1.2	1.40	16.4
Processed fruit products	0.00	0.0	0.02	0.2
Milk and dairy products	**0.00**	**0.0**	**0.01**	**0.1**
Milk *(goat)*	0.00	0.0	0.01	0.0
Fats and oils and primary derivatives thereof	**0.00**	**0.0**	**0.07**	**0.8**
Fruit and vegetable juices and nectars	**0.00**	**0.0**	**0.45**	**5.3**
Water and water-based beverages	**0.00**	**0.0**	**0.19**	**2.2**
Drinking water	0.00	0.0	0.19	2.2
Water based beverages	0.00	0.0	0.00	0.0
Alcoholic beverages	-		-	

Table 6.2 Contribution of foods to cadmium intake in toddlers. Estimate for lower bound (LB) and upper bound (UB) based on the mean consumption of the "total population"

Food groups	LB		UB	
	Cd intake (µg/day)	% of the daily intake	Cd intake (µg/day)	% of the daily intake
Coffee, cocoa, tea and infusions *(Cocoa powder)*	**0.52**	**20.4**	**0.52**	**6.1**
Sugar and similar, confectionery and water-based sweet desserts	**0.03**	1.2	**0.04**	**0.5**
Sugar and other sweetening ingredients *(Honey)*	0.00	1.2	0.00	0.0
Chocolate and chocolate products	0.03	0.0	0.03	0.4
Water-based sweet desserts	0.00	0.0	0.01	0.1
Foods products for young population	**0.16**	**6.3**	**1.13**	**13.2**
Follow-on formulae	0.04	1.6	0.44	5.2
Processed cereal-based food for infants and young children	0.09	3.5	0.15	1.8
Ready-to-eat meal for infants and young children	0.03	1.2	0.54	6.3
Total	**2.55**	**100.0**	**8.54**	**100.0**

Table 6.3 Contribution of foods to cadmium intake in other children. Estimate for lower bound (LB) and upper bound (UB) based on the mean consumption of the "total population"

Food groups	LB		UB	
	Cd intake (µg/day)	% of the daily intake	Cd intake (µg/day)	% of the daily intake
Grains and grain-based products	**0.52**	**11.0**	**1.52**	**12.8**
Cereals and cereal primary derivatives	0.10	2.1	0.31	2.6
Bread and similar products *(White wheat bread)*	0.42 *(0.42)*	8.9 *(8.9)*	1.10 *(1.10)*	9.3 *(9.3)*
Breakfast cereals	0.00	0.0	0.11	0.9
Vegetables and vegetable products	**0.49**	**10.4**	**1.57**	**13.2**
Bulb vegetables	0.03	0.6	0.13	1.1
Fruiting vegetables	0.02	0.4	0.55	4.6
Leafy vegetables	0.13	2.8	0.34	2.9
Stem vegetables	0.00	0.0	0.02	0.2
Fungi	0.03	0.6	0.04	0.3
Root and tuber vegetables (excluding starchy-)	0.04	0.8	0.12	1.0
Legumes with pods	0.00	0.0	0.06	0.5
Flowering brassica	0.00	0.0	0.04	0.3

Table 6.3 Contribution of foods to cadmium intake in other children. Estimate for lower bound (LB) and upper bound (UB) based on the mean consumption of the "total population"

Food groups	LB		UB	
	Cd intake (µg/day)	% of the daily intake	Cd intake (µg/day)	% of the daily intake
Processed or preserved vegetables	0.24	5.1	0.27	2.3
Starchy roots or tubers and products thereof *(Potatoes)*	**0.91**	**19.3**	**1.20**	**10.1**
Legumes, nuts, oilseeds and spices	**0.00**	**0.0**	**0.06**	**0.5**
Legumes and fresh seeds	0.00	0.0	0.02	0.2
Dried legumes seeds	0.00	0.0	0.04	0.3
Spices	0.00	0.0	0.00	0.0
Legumes, nuts, seeds and processed products	0.00	0.0	0.00	0.0
Meat and meat products	**0.00**	**0.0**	**1.38**	**11.6**
Poultry meat	0.00	0.0	0.62	5.2
Mammals	0.00	0.0	0.75	6.3
Liver	0.00	0.0	0.01	0.1
Fish, seafood	**1.21**	**25.7**	**1.81**	**15.3**
Fish (meat)	0.13	2.8	0.65	5.5
Crustaceans	0.06	1.3	0.07	0.6
Molluscs (*Squid*)	1.00 *(0.73)*	21.2 *(15.5)*	1.03 *(0.74)*	8.7 *(6.2)*
Processed and canned fish	0.02	0.4	0.06	0.5
Fruit and fruit products	**0.02**	**0.4**	**1.53**	**12.9**
Fruit used as fruit	0.02	0.4	1.47	12.4
Processed fruit products	0.00	0.0	0.06	0.5
Milk and dairy products	**0.00**	**0.0**	**0.02**	**0.2**
Milk *(goat)*	0.00	0.0	0.02	0.2
Fats and oils and primary derivatives thereof	**0.00**	**0.0**	**0.11**	**0.9**
Fruit and vegetable juices and nectars	**0.00**	**0.0**	**0.73**	**6.2**
Water and water-based beverages	**0.00**	**0.00**	**0.29**	**2.4**
Drinking water	0.00	0.0	0.25	2.1
Water based beverages	0.00	0.0	0.04	0.3
Alcoholic beverages	-	-	-	-
Coffee, cocoa, tea and infusions *(Cocoa powder)*	**1.43**	**30.4**	**1.43**	**12.1**
Sugar and similar, confectionery and water-based sweet desserts	**0.12**	**2.5**	**0.15**	**1.3**

Table 6.3 Contribution of foods to cadmium intake in other children. Estimate for lower bound (LB) and upper bound (UB) based on the mean consumption of the "total population"

Food groups	LB		UB	
	Cd intake (µg/day)	% of the daily intake	Cd intake (µg/day)	% of the daily intake
Sugar and other sweetening ingredients *(Honey)*	0.00	0.0	0.02	0.2
Chocolate and chocolate products	0.12	2.5	0.12	1.0
Water-based sweet desserts	0.00	0.0	0.01	0.1
Foods products for young population	**0.01**	**0.2**	**0.05**	**0.4**
Follow-on formulae	0.00	0.0	0.03	0.3
Processed cereal-based food for infants and young children	0.01	0.2	0.01	0.1
Ready-to-eat meal for infants and young children	0.00	0.0	0.01	0.1
Total	**4.71**	**100.0**	**11.85**	**100.0**

Table 6.4 Contribution of foods to cadmium intake in adolescents. Estimate for lower bound (LB) and upper bound (UB) based on the mean consumption of the "total population"

Food groups	LB		UB	
	Cd intake (µg/day)	% of the daily intake	Cd intake (µg/day)	% of the daily intake
Grains and grain-based products	**0.88**	**15.2**	**2.43**	**16.7**
Cereals and cereal primary derivatives	0.13	2.2	0.37	2.5
Bread and similar products *(White wheat bread)*	0.74 *(0.74)*	12.8 *(12.8)*	1.91 *(1.91)*	13.1 *(13.1)*
Breakfast cereals	0.01	0.2	0.15	1.0
Vegetables and vegetable products	**0.57**	**9.9**	**1.70**	**11.7**
Bulb vegetables	0.04	0.7	0.17	1.2
Fruiting vegetables	0.01	0.2	0.36	2.5
Leafy vegetables	0.18	3.1	0.52	3.6
Stem vegetables	0.00	0.0	0.03	0.2
Fungi	0.04	0.7	0.07	0.5
Root and tuber vegetables (excluding starchy-)	0.04	0.7	0.13	0.9
Legumes with pods	0.00	0.0	0.09	0.6
Flowering brassica	0.00	0.0	0.03	0.2
Processed or preserved vegetables	0.26	4.5	0.30	2.1
Starchy roots or tubers and products thereof *(Potatoes)*	**1.10**	**19.0**	**1.45**	**9.9**

Table 6.4 Contribution of foods to cadmium intake in adolescents. Estimate for lower bound (LB) and upper bound (UB) based on the mean consumption of the "total population"

Food groups	LB		UB	
	Cd intake (µg/day)	% of the daily intake	Cd intake (µg/day)	% of the daily intake
Legumes, nuts, oilseeds and spices	**0.00**	**0.0**	**0.06**	**0.4**
Legumes and fresh seeds	0.00	0.0	0.03	0.2
Dried legumes seeds	0.00	0.0	0.03	0.2
Spices	0.00	0.0	0.00	0.0
Legumes, nuts, seeds and processed products	0.00	0.0	0.00	0.0
Meat and meat products	**0.00**	**0.0**	**1.81**	**12.4**
Poultry meat	0.00	0.0	0.66	4.5
Mammals	0.00	0.0	1.13	7.8
Liver	0.00	0.0	0.02	0.1
Fish, seafood	**1.56**	**27.0**	**2.25**	**15.4**
Fish (meat)	0.21	3.6	0.77	5.3
Crustaceans	0.06	1.0	0.08	0.5
Molluscs (*Squid*)	1.23 *(0.97)*	21.3 *(16.8)*	1.26 *(0.98)*	8.6 *(6.7)*
Processed and canned fish	0.06	1.0	0.14	1.0
Fruit and fruit products	**0.05**	**0.9**	**1.78**	**12.2**
Fruit used as fruit	0.05	0.9	1.70	11.7
Processed fruit products	0.00	0.0	0.08	0.5
Milk and dairy products				
Milk *(goat)*	-	-	-	-
Fats and oils and primary derivatives thereof	**0.00**	**0.0**	**0.14**	**1.0**
Fruit and vegetable juices and nectars	**0.00**	**0.0**	**0.92**	**6.3**
Water and water-based beverages	**0.00**	**0.0**	**0.39**	**2.7**
Drinking water	0.00	0.0	0.24	1.6
Water based beverages	0.00	0.0	0.15	1.0
Alcoholic beverages	-	-	-	-
Coffee, cocoa, tea and infusions *(Cocoa powder)*	**1.49**	**25.8**	**1.49**	**10.2**
Sugar and similar, confectionery and water-based sweet desserts	**0.13**	**2.2**	**0.15**	**1.0**
Sugar and other sweetening ingredients *(Honey)*	0.00	0.0	0.02	0.1
Chocolate and chocolate products	0.13	2.2	0.13	0.9
Water-based sweet desserts	0.00	0.0	0.00	0.0

Table 6.4 Contribution of foods to cadmium intake in adolescents. Estimate for lower bound (LB) and upper bound (UB) based on the mean consumption of the "total population"

Food groups	LB		UB	
	Cd intake (µg/day)	% of the daily intake	Cd intake (µg/day)	% of the daily intake
Foods products for young population	**0.00**	**0.0**	**0.01**	**0.1**
Follow-on formulae	0.00	0.0	0.00	0.0
Processed cereal-based food for infants and young children	0.00	0.0	0.00	0.0
Ready-to-eat meal for infants and young children	0.00	0.0	0.01	0.1
Total	**5.78**	**100.0**	**14.58**	**100.0**

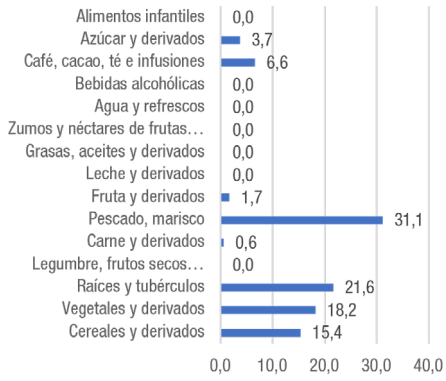

Figure 6.1 Contribution of foods to cadmium intake in the Spanish population (adults, 18-64 years). Estimate for the lower bound (LB)

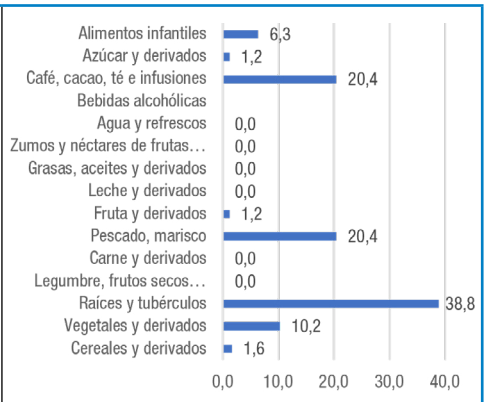

Figure 6.2 Contribution of foods to cadmium intake in the Spanish population (toddlers, 12-35 months). Estimate for the lower bound (LB)

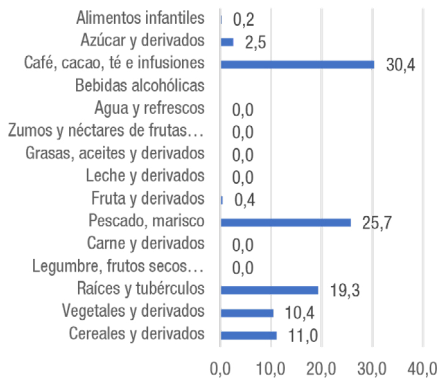

Figure 6.3 Contribution of foods to cadmium intake in the Spanish population (other children, 3-9 years). Estimate for the lower bound (LB)

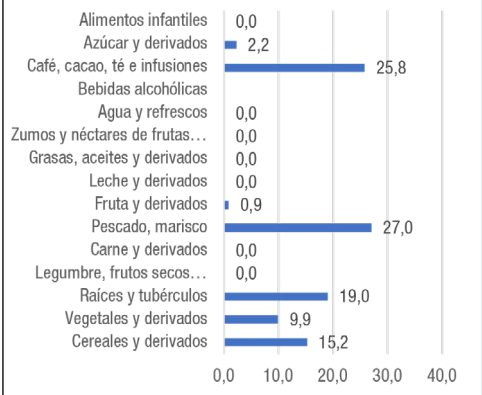

Figure 6.4 Contribution of foods to cadmium intake in the Spanish population (adolescents, 10-17 years). Estimate for the lower bound (LB)

Table 7. Risk characterisation of dietary exposure to cadmium in the Spanish population (mean consumption and extreme consumption scenarios) for different age groups. Estimate for lower bound (LB) and upper bound (UB)

Food groups	Exposure scenario for mean consumption (LB-UB) (µg Cd/kg b.w/week)				Exposure scenario for extreme consumption (LB-UB) (µg Cd/kg b.w/week)			
	Toddlers	Other children	Adolescents	Adults	Toddlers	Other children	Adolescents	Adults
Grains and grain-based products	0.02-0.15	0.13-0.38	0.12-0.32	0.05-0.16	0.02-0.15	0.13-0.38	0.12-0.32	0.05-0.16
Vegetables and vegetable products	0.14-0.56	0.12-0.39	0.08-0.22	0.06-0.23	0.14-0.56	0.12-0.39	0.08-0.22	0.06-0.23
Starchy roots or tubers and products thereof	**0.53-0.71**	0.23-0.30	0.15-0.19	**0.07-0.09**	**1.58-2.08**	0.23-0.30	0.15-0.19	**0.26-0.34**
Legumes, nuts, oilseeds and spices	0.00-0.02	0.00-0.02	0.00-0.01	0.00-0.00	0.00-0.02	0.00-0.02	0.00-0.01	0.00-0.00
Meat and meat products	0.01-0.52	0.00-0.35	0.00-0.24	0.00-0.15	0.01-0.52	0.00-0.35	0.00-0.24	0.00-0.15
Fish (meat)	0.04-0.32	0.03-0.16	0.03-0.10	0.01-0.05	0.04-0.33	0.04-0.18	0.04-0.12	0.02-0.08
Crustaceans	0.01-0.02	0.02-0.02	0.01-0.01	0.00-0.01	0.01-0.02	0.02-0.02	0.01-0.01	0.00-0.01
Molluscs	0.23-0.23	**0.25-0.26**	**0.16-0.17**	**0.08-0.08**	0.23-0.23	**10.37-11.07**	**4.80-5.10**	**2.63-2.78**
Processed fish and seafood	0.01-0.02	0.01-0.02	0.01-0.02	0.01-0.02	0.01-0.02	0.01-0.02	0.01-0.02	0.01-0.02
Fruit and fruit products	0.02-0.76	0.01-0.38	0.01-0.24	0.01-0.18	0.02-0.76	0.01-0.38	0.01-0.24	0.01-0.18
Milk and dairy products	0.00-0.01	0.00-0.01	-	0.00-0.00	0.00-0.01	0.00-0.01	-	0.00-0.00
Fats and oils and primary derivatives thereof	0.00-0.04	0.00-0.03	0.00-0.02	0.00-0.01	0.00-0.04	0.00-0.03	0.00-0.02	0.00-0.01
Fruit and vegetable juices and nectars	0.00-0.24	0.00-0.18	0.00-0.12	0.00-0.05	0.00-0.24	0.00-0.18	0.00-0.12	0.00-0.05
Water and water-based beverages	0.00-0.10	0.00-0.07	0.00-0.05	0.00-0.05	0.00-0.10	0.00-0.07	0.00-0.05	0.00-0.05
Alcoholic beverages	-	-	-	0.00-0.06	-	-	-	0.00-0.06
Coffee, cocoa, tea and infusions (*cocoa powder*)	**0.28-0.28**	**0.36-0.36**	**0.20-0.20**	0.02-0.02	**2.03-2.03**	**1.08-1.08**	**0.64-0.64**	0.02-0.02
Sugar and similar, confectionery and water-based sweet desserts	0.02-0.02	0.03-0.04	0.02-0.02	0.01-0.02	0.02-0.02	0.03-0.04	0.02-0.02	0.01-0.02
Foods products for young population	0.09-0.61	0.00-0.02	0.00-0.00	-	0.09-0.61	0.00-0.02	0.00-0.00	-
Cadmium intake (µg Cd/kg b.w./week)*	**1.37-4.59**	**1.18-2.96**	**0.76-1.93**	**0.33-1.18**	**4.17-7.72**	**12.02-14.50**	**5.85-7.30**	**3.07-4.12**
% TWI (TWI = 2.5 µg Cd/g b.w./week)*	**54.9-183.5**	**47.1-118.6**	**30.5-77.0**	**13.3-47.3**	**166.9-308.6**	**480.7-579.9**	**233.8-291.9**	**122.8-165.0**

*Mean body weight: 13 kg (toddlers); 28 kg (other children); 53 kg (adolescents); 73.2 kg (18-64 adults)