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Mercury, Lead, Cadmium, Tin and Arsenic in Food

The aim of this document is to provide food business operators (FBOs), enforcement officers and other stakeholders with a concise overview of the health hazards of, and sources of exposure to, mercury, lead, cadmium, tin and arsenic in food. It gives information on methods of sampling and analysis for these contaminants and the legislative control measures in place to minimise their presence in food. Finally, it provides a short guidance for FBOs on the risk management measures that they should have in place to control mercury, lead, cadmium, tin and arsenic in food and also a bibliography giving sources of further information. The summary below gives a short synopsis of the information, while the following pages provide more technical detail.

Summary

Metals and other elements can be naturally present in food or can enter food as a result of human activities such as industrial and agricultural processes. The metals of particular concern in relation to harmful effects on health are mercury, lead, cadmium, tin and arsenic. Mercury and lead are often referred to as “heavy metals”. The toxicity of these metals is in part due to the fact that they accumulate in biological tissues, a process known as bioaccumulation. This process of bioaccumulation of metals occurs in all living organisms as a result of exposure to metals in food and the environment, including food animals such as fish and cattle as well as humans.

The main concern in relation to the toxicity of mercury in the general population is the potential effect of organic forms of mercury, e.g. methylmercury, on the brain and intellectual development in young children. Lead also has an effect on brain and intellectual development in young children, while long-term exposure in both children and adults can cause damage to the kidneys, reproductive and immune systems in addition to effects on the nervous system. Cadmium is toxic to the kidney, while exposure to high levels of tin from, e.g. canned food in incorrectly manufactured tins can cause gastrointestinal irritation and upsets. Exposure to inorganic arsenic is of concern because of its cancer-causing properties. Given the wide spectrum of effects on health and the fact that these toxic metals accumulate in the body, it is essential to control levels in foodstuffs in order to protect human health.

Maximum levels for mercury, lead, cadmium and tin in foodstuffs have been set by Commission Regulation No 1881/2006, the framework EU legislation which sets maximum levels for chemical contaminants in foodstuffs. This Regulation establishes maximum levels (MLs) for these metals in a wide range of foodstuffs including milk, meat, fish, cereals, vegetables, fruit and fruit juices, and also sets a maximum level for mercury in fish and fish products.

In order to ensure that these MLs are not exceeded, routine surveillance of food must be carried out, involving the taking of samples of potentially contaminated produce, followed by laboratory analysis to determine the levels of the metal in question in the product. The Food Safety Authority of Ireland (FSAI), in collaboration with its agencies including the Public Analyst Laboratories (PALs) and the Department of Agriculture, Fisheries and Food (DAFF), carries out regular checks on levels of mercury, lead, cadmium, arsenic and tin in the food chain. The results of these checks show that the levels in Irish food and feed are generally very low, and are considered to present little risk to the health of the Irish consumer, although occasional instances of contamination are detected.

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In addition to the overall responsibility placed on FBOs by the General Food Law (Directive 178/2002) to supply safe food, FBOs must also ensure that their products comply with the legislative limits for heavy metals as laid down in Commission Regulation (EC) No 1881/2006. It is important that FBOs identify critical control points (CCPs) in their processes such as lead in the water supply; the identification of appropriate CCPs along their process chain will enable them to develop and apply proper HACCP systems which will ensure that there are no unforeseen sources of metal contamination in their products.

1. Introduction

Food contains a wide range of metallic elements (metals) such as sodium, potassium, iron, calcium, boron, magnesium, selenium, copper and zinc. These elements are essential in trace quantities for maintenance of cellular processes. Other metallic elements have no functional effects in the body and can be harmful to health if foodstuffs containing them are consumed regularly in the diet. The majority of metals are natural components of the earth's crust. Metals and other elements can be naturally present in food or can enter food as a result of human activities such as industrial and agricultural processes. Chemically, metallic elements can exist as the pure metal, e.g. tin or lead, or compounds formed by combination of a metallic element with a non-metallic element such as the combination of sodium with chlorine (giving a salt such as sodium chloride, common salt) or oxygen (giving an oxide).

The metals of particular concern in relation to harmful effects on health are: mercury (Hg), lead (Pb), cadmium (Cd), tin (Sn) and arsenic (As), mercury and lead often being referred to as "heavy metals" because of their high atomic weight. Other potentially toxic metals such as chromium and uranium have been also reported to be present as contaminants in food or water, while a number of metals have been associated with health effects in individuals exposed to them in the workplace, for example beryllium and nickel. The harmful effects of the latter group of metals are associated with the inhalation of metal dusts, causing lung injury, and these elements are not normally found in food at levels that could cause toxicity. This information document will deal with mercury, lead, cadmium, tin and arsenic only.

2. Toxicity of mercury, lead, cadmium, tin and arsenic

The toxicity of these metals has two main aspects: (a) the fact that they have no known metabolic function, but when present in the body they disrupt normal cellular processes, leading to toxicity in a number of organs; (b) the potential, particularly of the so-called heavy metals mercury and lead, to accumulate in biological tissues, a process known as bioaccumulation. This occurs because the metal, once taken up into the body, is stored in particular organs, for example the liver or the kidney, and is excreted at a slow rate compared with its uptake. This process of bioaccumulation of metals occurs in all animals, including food animals such as fish and cattle as well as humans. It is therefore necessary to control the levels of these toxic metals in foodstuffs in order to protect human health.

Excessive exposure to **mercury** is associated with a wide spectrum of adverse health effects including damage to the central nervous system (neurotoxicity) and the kidney. Different forms of mercury (i.e. mercury metal, inorganic mercury salts such as mercuric chloride and organic forms of mercury such as methylmercury) produce different patterns of toxicity. The main concern in relation to the toxicity of **mercury** in the general population exposed to low levels of mercury in their diet relates to the potential neurotoxicity of organic forms of mercury, e.g. methylmercury, in young children. Organic forms of mercury can cross the placental barrier between the mother and the unborn baby, and epidemiological studies in exposed populations of humans and toxicological studies in animals have shown that this can result in a range of neurological disturbances from impaired learning to obvious brain damage. The European Food

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Safety Authority (EFSA) has recently evaluated methylmercury and has stated, in common with other international expert bodies, that the developing brain should be considered the most sensitive target organ for methylmercury toxicity. Exposure during pregnancy is therefore considered to present particular risks.

The toxic effects of **lead**, like those of mercury, have been principally established in studies on people exposed to lead in the course of their work. Short-term exposure to high levels of lead can cause brain damage, paralysis (lead palsy), anaemia and gastrointestinal symptoms. Longer-term exposure can cause damage to the kidneys, reproductive and immune systems in addition to effects on the nervous system. The most critical effect of low-level lead exposure is on intellectual development in young children and, like mercury, lead crosses the placental barrier and accumulates in the foetus. Infants and young children are more vulnerable than adults to the toxic effects of lead, and they also absorb lead more readily. Even short-tem, low-level exposures of young children to lead is considered to have an effect on neurobehavioural development. Consumption of food containing lead is the major source of exposure for the general population (see Section 3, Exposure).

The principal toxic effect of **cadmium** is its toxicity to the kidney, although it has also been associated with lung damage (including induction of lung tumours) and skeletal changes in occupationally exposed populations. Cadmium is relatively poorly absorbed into the body, but once absorbed is slowly excreted, like other metals, and accumulates in the kidney causing renal damage. The kidney of food animals is a major source of cadmium in the diet although lower levels are found in many foods (see section on exposure below).

Tin is relatively less toxic than mercury, cadmium and lead. The principal concern in relation to tin in food is the possibility of high levels potentially present in canned food in incorrectly manufactured tins, where tin present in the can has leached into the food. This has been shown to occur in the case of acidic foodstuffs such as canned tomatoes, and consumption of the affected foodstuff has resulted in gastrointestinal irritation and upsets due to the acute toxic effects of tin. These short-term effects may occur in some individuals at concentrations above 200mg/kg. Only limited data are available on the toxicological effects of inorganic tin present in canned food, resulting from the dissolution of the tin coating.

Arsenic exists both in inorganic and organic forms and also in different valence states. Inorganic arsenic is significantly more toxic than organic arsenic compounds such as dimethylarsinate, and in turn the trivalent forms of arsenic, e.g. arsenic trichloride, are more toxic than the pentavalent arsenates. The latter are considered to be toxic only after metabolic conversion to the trivalent form of arsenic. This pattern of toxicity is also seen for certain other metallic compounds in the body, e.g. chromium compounds. Exposure to inorganic arsenic is primarily of concern because of its cancer-causing properties. Arsenic has been classified by the International Agency for Research into Cancer (IARC) as a human carcinogen on the basis of increased incidence of cancers at several sites in people exposed to arsenic at work, in the environment or through their diet. However, arsenic is also more acutely toxic than other metallic compounds and was used in earlier times as a rodenticide, while continual low level exposure to arsenic is associated with skin, vascular and nervous system disorders.

3. Exposure to mercury, lead, cadmium, tin and arsenic in the diet

Metals such as mercury, cadmium, arsenic and lead enter the environment primarily as a consequence of industrial emissions or via disposal of products containing these metals, including mercury-cadmium or cadmium-nickel batteries, lead-containing ceramics and glass, mercury thermometers, etc. Past uses such as the use of mercury as a seed dressing and as an antibacterial, the use of lead in water pipes and as an anti-knock agent in petrol and the use of arsenic as a rodenticide have been largely phased out because of the toxicity and persistence of the metals. Nevertheless, because of the widespread use of these metals there is a general background level in the environment and they are consequently present in many foodstuffs in low levels, and may also be present in water supplies, although there are strict legal limits pertaining to both (see section on legislative controls below). However the major dietary sources of exposure are those foodstuffs in which, for particular reasons, high levels of the individual metals may be found, as follows.

3.1 Mercury

A recent SCOOP report (EU Scientific Cooperation Task, 2004) on exposure of the European population to heavy metals in their diet showed that mercury is relatively widely distributed in food at very low levels, and primarily in the less toxic inorganic form, but that the most toxic form of mercury, methylmercury, is found at significant levels only in fish and seafood. Individuals consuming a diet containing a high content of predatory fish and/or shellfish may exceed the Provisional Tolerable Weekly Intake for methylmercury established by JECFA in 2003, of 1.6µg/kg body weight and may therefore be at risk. The major potential dietary sources of exposure to methylmercury are fish and shellfish, in particular top predatory fish such as swordfish and marlin, as a consequence of industrial releases of inorganic mercury into marine environments, followed by uptake into marine microorganisms which then convert the less toxic inorganic mercury into the more toxic methyl mercury. This then accumulates through the food chain due to its low rate of breakdown, reaching potentially toxic levels in species at the top of the food chain, such as swordfish and marlin, which may then form part of the human diet. The amount of methylmercury in fish and shellfish correlates with a number of factors including the size and age of the fish, the species and the level of mercury in the waters that form their primary habitat. Larger, older, predatory species such as shark, marlin, swordfish and fresh tuna usually contain higher levels than other marine fish. Canned tuna on average has been found to contain half the amount of mercury of fresh tuna. This is because different species and smaller more immature fish are used for canning. Shellfish, particularly filter feeders such as mussels and scallops can also take up mercury from their environment, accumulating it in their viscera, and hence may contribute significantly to dietary exposure.

EFSA in its recent evaluation of mercury and methylmercury, also looked at exposure of the European population to mercury in their diet. The estimated intakes of mercury in Europe varied by country, depending on the amount and the type of fish consumed. The mean intakes were in most cases below the Provisional Tolerable Weekly Intake (PTWI) for methylmercury established by JECFA, of 1.6µg/kg body weight, but high intakes may exceed the PTWI. EFSA concluded that methylmercury toxicity has been demonstrated at low exposure levels, and exposure to this compound should therefore be minimized, while recognising that fish constitutes an important part of a balanced diet

3.2 Lead

As indicated, lead contamination of food arises as a result of environmental emissions, such as mining and the now diminished use of leaded petrol. Data from the SCOOP report on heavy metals show that levels of lead in most commonly consumed foodstuffs are generally low. However, like mercury, lead can accumulate in fish and shellfish and in addition can be found at higher levels in the offal (liver and kidney) of food animals. Consumers eating diets rich in these foods may therefore be exposed to an unacceptable level of lead. Levels of lead in these particular foods and in fruit and vegetables generally are stringently regulated in the EU, as outlined in Section 5. A further source of lead in the diet is from food containers containing lead, e.g. storage in lead-soldered cans, ceramic vessels with lead glazes and leaded crystal glass. The first of these has now been largely discontinued, at least in the EU, and the second is also strictly regulated under EU legislation related to food contact materials. However, there are repeated instances of food dishes, utensils or other materials manufactured outside the EU that release lead into food at levels above those permitted in the EU. Finally, the past use of lead as a material for water pipes in many older houses may result in unacceptably high levels in water supplies. The 1998 Drinking Water Directive, in line with World Health Organization recommendations, sets a revised limit of 10μg/l for lead in drinking water. As there is still a significant amount of lead piping in premises EU-wide, it was appreciated that some Member States may have difficulty initially in meeting the revised lead limit, and the Directive takes account of this by setting an interim limit of 25 μg/l (which is effective from 1st of January 2004 until the 25th of December 2013) whereupon the standard of 10μg/l must be met (Environmental Protection Agency (EPA) report on drinking water).

3.3 Cadmium

Cadmium is present at low levels in most foods, with commodities such as cereals, fruit, vegetables, meat and fish making the largest contribution to dietary exposure, given the fact that they are also the foodstuffs consumed in largest amounts. Highest levels of cadmium are found in the offal (kidney and liver) of mammals and in mussels, oysters and scallops. Certain wild mushrooms may also contain high levels, as can rice grown in certain geological areas where the soil is rich in cadmium. These foodstuffs are however minor contributors to overall intake of cadmium, as they are eaten in relatively small amounts, and the results of the SCOOP analysis indicated that the EU population is unlikely to exceed the ADI for cadmium.

3.4 Tin

Organotin compounds reach humans primarily through the diet (in particular fish and fish products). These compounds are widely diffused in the aquatic environment as a result of their use as antifouling agents and biocides in agricultural practices. Organotins occur mainly in aquatic organisms and intake of seafood may be an important source of human exposure. Tin is used in canned foods to protect the steel base from corrosion both externally (aerobic conditions) and internally when in contact with foods (anaerobic). The use of lacquers in can linings has enabled different types of food products to be satisfactorily packed. For example, some highly pigmented foods (beetroot, berry fruits) have their colours bleached by tin dissolution and are best protected from contact with tin by use of linings.

The tin in canned food is likely to be in the form of inorganic tin salts rather than tin in covalently bound organometallic compounds. The tin content of canned foods varies according to whether the can is lacquered, the pH of the food in the can, the presence of plant pigments, the storage conditions (i.e. time and temperature) of the canned foods, whether the food is stored in opened cans, and the presence of oxygen, reducible organic compounds, and food additives. The most obvious influence on internal corrosion in plain tinplate cans is the chemistry of the food product. It should be noted that fruits, vegetables and tomatoes will have significant natural variation in, for example, pH and acid type and concentration, dependent on variety, maturity, time/place/conditions of harvest, soil chemistry and agricultural practices. These are difficult for a canner to control and may ultimately impact on the level of tin uptake by the product. Acidic foods are more aggressive to the tin coating in metal cans and canned acidic foods have higher tin contents. Tomato-based products tend to have high levels of tin as nitrate in the food accelerates corrosion of the tin. Tin concentrations of canned foods increase with storage time and temperature. The reported concentration of tin in foods is also affected by the method of sample preparation and the analytical method used. The JECFA PTWI for tin is 14mg/kg bodyweight, equivalent to 120mg/day for a 60kg adult.

3.5 Arsenic

Data on arsenic occurrence in food shows that fish and seafood account for over 90% of total exposure to arsenic in food. Data from the SCOOP report shows that with the exception of seafood and animal offal, the concentration of arsenic is generally less than 250 ug/kg. High levels are frequently found in crab, in which the white meat generally contains more arsenic than the brown meat. However, the majority of this arsenic appears to be in the form of the less toxic organic arsenic species, for example in shellfish, molluscs and seaweeds the predominant species are arsenosugars (dimethylarsinyl riboside derivatives), while in fish and crustaceans the predominant arsenic compound is arsenobetaine, a form of arsenic which is considered to be virtually non-toxic. The JECFA Provisional Tolerable Daily Intake (PTDI) for inorganic arsenic is 0.002 mg/kg bodyweight, equivalent to 0.12 mg/day for a 60kg adult. As has been stated before, most of the arsenic in the diet is from fish and most of the arsenic in fish is in the less toxic organic forms.

4. Sampling and analysis for mercury, lead, cadmium and tin in food

Commission Regulation 333/2007 lays down the sampling methods and the methods of analysis for mercury, lead, cadmium and tin in foodstuffs in order to meet the requirements of Regulation (EC) No 1881/2006 (see Section 5). As there are no statutory limits for arsenic levels in food at EU level, arsenic does not fall within the scope of this Regulation. The Regulation also lays down requirements for laboratories carrying out analyses, core requirements being accreditation, competence in the specific analyses and ongoing participation in inter-laboratory studies for the determination of the metals in food matrices. Finally, the Regulation lays down sampling procedures which must be followed by Member States in achieving official control of these metals in food and feedstuffs. Sampling has to be carried out by an authorised person, e.g. environmental health officer, and incremental samples taken as specified to give an aggregate sample (at least 300g unless this is not practical) which is representative of the lots or sublots from which it has been taken. Laboratory samples for analysis are then taken from this aggregate sample.

There are usually two major steps to trace element determination, sample digestion and detection method. There are four main methods of sample digestion commonly reported by laboratories: (1) dry ashing of the sample in a conventional oven; (2) microwave digestion of the sample in a strong acid; (3) acid digestion of the sample by heating in a pressure vessel; and (4) dissolving the sample directly into acid. Some laboratories also extract the metals in 2-methylhexan-2-one [isobutyl methyl ketone (IBMK)]. The detection methods most frequently are atomic absorption spectrometry (AAS) and inductively coupled plasma (ICP) techniques. Atomic absorption spectrometry includes flame AAS (CVAAS) for mercury determination and hydride generation (HG), commonly used for arsenic determination. Inductively coupled plasma techniques usually use mass spectrometry (ICP-MS) and ICP-optical emission spectrometry (ICP-OES). Other techniques which are still used by some laboratories include anodic stripping voltammetry, colorimetry, spectrophotometry, ion chromatography, polarography and titration. However, these last few techniques for metal determination have largely been replaced by the methods of AAS and ICP.

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5. Legislative controls for mercury, lead, cadmium, tin and arsenic in food and water

Maximum levels for heavy metals in foodstuffs have been set by Commission Regulation No 1881/2006, the framework EU legislation which sets maximum levels for chemical contaminants in foodstuffs, as amended by Regulation No 629/2008. These Regulations establish maximum levels (MLs) for cadmium and lead in a range of foodstuffs, mercury in fish and fish products and tin in canned foods and beverages including canned foods for infants and young children excluding dried and powdered products. The limits laid down in the Regulations are reproduced in Table 1 in the Appendix. For arsenic no ML is yet established at European level but discussions are ongoing on this topic and it is anticipated that limits will be set for arsenic in the near future as the methodology for the determination of arsenic improves. The levels of arsenic in food are covered at a national level through S.I. No. 44 of 1972 and its amendment S.I. No. 72 of 1992.

No specific limits are laid down for other heavy metals in foodstuffs; however, some maximum limits for metals are specified for drinking water. The EPA is the supervisory authority over public water supplies and has powers of enforcement over local authorities (LA) in this regard. The basic standards governing the quality of drinking water (i.e. potable water) intended for human consumption are set out in EU Directive 98/83/EC, which is implemented in Ireland as S.I. No. 278 of 2007. The legislation sets standards in relation to the quality of water intended for human consumption, cooking, food preparation, other domestic purposes and food production.

Directive 84/500/EEC sets a limit on the levels of lead and cadmium permitted to transfer out of ceramic food contact materials and articles and prescribes the method of testing to be used to establish how much lead and cadmium is being transferred. Directive 2005/31/EC requires a declaration of compliance with these limits and introduces a performance-based approach to the analytical method of establishing the migration levels. For other food contact materials, including those made from metal and alloys, Regulation (EC) No 1935/2004 sets a general requirement that migration of substances should not endanger the health of consumers. This legislation has been transposed in national legislation by S.I. No. 587 of 2007, known as the European Communities (Plastics and other materials) (Contact with food) Regulations, 2007.

6. Control measures for mercury, lead, cadmium, tin and arsenic in food and their application by food business operators

Under the General Food Law (Directive 178/2002), FBOs are responsible for the safety of food and feed which they produce, transport, store or sell. They must also ensure that their products comply with the legislative limits for heavy metals as laid down in Commission Regulations (EC) No 1881/2006 and 629/2008. There is also a need for FBOs to be vigilant in relation to imported ceramic dishes and other food contact materials which may contain lead and cadmium. Codex Alimentarius has adopted a code of practice for the prevention and reduction of inorganic tin contamination in canned foods. It is important that FBOs identify CCPs in their processes such as lead in the water supply; the identification of appropriate CCPs along their process chain will enable them to develop and apply proper HACCP systems which will ensure that there are no unforeseen sources of metal contamination in the food. It is the responsibility of the FBO to test his products for content of mercury, lead, cadmium, tin or arsenic at the point of sale. Sampling and analysis should be carried out in accordance with the principles outlined in Section 4, which refers both to official controls and to sampling and analysis carried out by FBOs. Laboratories selected by the FBO should be accredited and should be able to comply with the requirements of Regulation 333/2007.

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Appendix

Table 1* Maximum levels for mercury, lead, cadmium and tin, Commission Regulations No 1881/2006 and No 629/2008

FOODSTUFFS		MAXIMUM LEVELS (MG/KG WET WEIGHT)
3.1	**Lead**	
3.1.1	Raw milk (6), heat-treated milk and milk for the manufacture of milk-based products	0.02
3.1.2	Infant formulae and follow-on formulae (4) (8)	0.02
3.1.3	Meat (excluding offal) of bovine animals, sheep, pig and poultry (6)	0.1
3.1.4	Edible offal of bovine animals, sheep, pig and poultry (6)	0.5
3.1.5	Muscle meat of fish (24) (25)	0.3
3.1.6	Crustaceans, excluding brown meat of crab and excluding head and thorax meat of lobster and similar large crustaceans (*Nephropidae* and *Palinuridae*) (26)	0.5
3.1.7	Bivalve molluscs (26)	1.5
3.1.8	Cephalopods (without viscera) (26)	1.0
3.1.9	Cereals, legumes and pulses	0.2
3.1.10	Vegetables, excluding brassica vegetables, leaf vegetables, fresh herbs and fungi (27). For potatoes the maximum level applies to peeled potatoes	0.1
3.1.11	Brassica vegetables, leaf vegetables and the following fungi (27): *Agaricus bisporus* (common mushroom), *Pleurotus ostreatus* (Oyster mushroom), *Lentinula edodes* (Shiitake mushroom)	0.3
3.1.12	Fruit, excluding berries and small fruit (27)	0.1
3.1.13	Berries and small fruit (27)	0.2
3.1.14	Fats and oils, including milk fat	0.1
3.1.15	Fruit juices, concentrated fruit juices as reconstituted and fruit nectars (14)	0.05
3.1.16	Wine (including sparkling wine, excluding liqueur wine), cider, perry and fruit wine (11)	0.2 (28)
3.1.17	Aromatized wine, aromatized wine-based drinks and aromatized wine-product cocktails (13)	0.2 (28)
3.1.18	Food supplements (*)	3.0
3.2	**Cadmium**	
3.2.1	Meat (excluding edible offal) of bovine animals, sheep, pig and poultry (6)	0.05
3.2.2	Horsemeat, excluding offal (6)	0.2
3.2.3	Liver of bovine animals, sheep, pig, poultry and horse (6)	0.5
3.2.4	Kidney of bovine animals, sheep, pig, poultry and horse (6)	1.0
3.2.5	Muscle meat of fish (24) (25), excluding species listed in points 3.2.6, 3.2.7 and 3.2.8	0.05

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Food Safety Authority of Ireland

FOODSTUFFS		MAXIMUM LEVELS (MG/KG WET WEIGHT)
3.2.6	Muscle meat of the following fish (24) (25): bonito (*Sarda sarda*) common two-banded seabream (*Diplodus vulgaris*) eel (*Anguilla anguilla*) grey mullet (*Mugil labrosus labrosus*) horse mackerel or scad (*Trachurus species*) louvar or luvar (*Luvarus imperialis*) mackerel (*Scomber species*) sardine (*Sardina pilchardus*) sardinops (*Sardinops species*) tuna (*Thunnus species, Euthynnus species, Katsuwonus pelamis*) wedge sole (*Dicologoglossa cuneata*)	0.1
3.2.7	Muscle meat of the following fish (24) (25): bullet tuna (*Auxis species*)	0.2
3.2.8	Muscle meat of the following fish (24) (25): anchovy (*Engraulis species*) swordfish (*Xiphias gladius*)	0.3
3.2.9	Crustaceans, excluding brown meat of crab and excluding head and thorax meat of lobster and similar large crustaceans (*Nephropidae and Palinuridae)* (26)	0.5
3.2.10	Bivalve molluscs (26)	1.0
3.2.11	Cephalopods (without viscera) (26)	1.0
3.2.12	Cereals excluding bran, germ, wheat and rice	0.1
3.2.13	Bran, germ, wheat and rice	0.2
3.2.14	Soybeans	0.2
3.2.15	Vegetables and fruit, excluding leaf vegetables, fresh herbs, fungi, stem vegetables, root vegetables and potatoes (27)	0.05
3.2.16	Stem vegetables, root vegetables and potatoes, excluding celeriac (27). For potatoes the maximum level applies to peeled potatoes.	0.1
3.2.17	Leaf vegetables, fresh herbs, celeriac and the following fungi (27): *Agaricus bisporus* (common mushroom), *Pleurotus ostreatus* (Oyster mushroom), *Lentinula edodes* (Shiitake mushroom)	0.2
3.2.18	Fungi, excluding those listed in point 3.2.17 (27)	1.0
3.2.19	Food supplements (*) excl. food supplements listed in point 3.2.20	1.0
3.2.20	Food supplements (*) consisting exclusively or mainly of dried seaweed or of products derived from seaweed	3.0

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Mercury, Lead, Cadmium, Tin and Arsenic in Food

FOODSTUFFS		MAXIMUM LEVELS (MG/KG WET WEIGHT)
3.3	**Mercury**	
3.3.1	Fishery products (26) and muscle meat of fish (24) (25), excluding species listed in 3.3.2. The maximum level applies to crustaceans, excluding the brown meat of crab and excluding head and thorax meat of lobster and similar large crustaceans (*Nephropidae* and *Palinuridae*)	0.5
3.3.2	Muscle meat of the following fish (24) (25): anglerfish (*Lophius species*) Atlantic catfish (*Anarhichas lupus*) bonito (*Sarda sarda*) eel (*Anguilla species*) emperor, orange roughy, rosy soldierfish (*Hoplostethus species*) grenadier (*Coryphaenoides rupestris*) halibut (*Hippoglossus hippoglossus*) kingklip (*Genypterus capensis*) marlin (*Makaira species*) megrim (*Lepidorhombus species*) mullet (*Mullus species*) pink cusk eel (*Genypterus blacodes*) pike (*Esox lucius*) plain bonito (*Orcynopsis unicolor*) poor cod (*Tricopterus minutes*) Portuguese dogfish (*Centroscymnus coelolepis*) rays (*Raja species*) redfish (*Sebastes marinus, S. mentella, S. viviparus*) sail fish (*Istiophorus platypterus*) scabbard fish (*Lepidopus caudatus, Aphanopus carbo*) seabream, pandora (*Pagellus species*) shark (all species) snake mackerel or butterfish (*Lepidocybium flavobrunneum, Ruvettus pretiosus, Gempylus serpens*) sturgeon (*Acipenser species*) swordfish (*Xiphias gladius*) tuna (*Thunnus species, Euthynnus species, Katsuwonus pelamis*)	1.0
3.3.3	Food supplements **	0.1

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FOODSTUFFS		MAXIMUM LEVELS (MG/KG WET WEIGHT)
3.4	**Tin**	
3.4.1	Canned foods other than beverages	200
3.4.2	Canned beverages, including fruit juices and vegetable juices	100
3.4.3	Canned baby foods and processed cereal-based foods for infants and young children, excluding dried and powdered products (3) (29)	50
3.4.4	Canned infant formulae and follow-on formulae (including infant milk and follow-on milk), excluding dried and powdered products (8) (29)	50
3.4.5	Canned dietary foods for special medical purposes (9) (29) intended specifically for infants, excluding dried and powdered products	50

* Table 1 is reproduced from Commission Regulations (EC) No. 1881/2006 and No 629/2008. The references ( ) in the table refer to footnotes in this Regulation and persons intending to use the MLs should refer to the Regulation for further details.

** The maximum level applies to the food supplements as sold.