Environmental Contaminants In food

- Toxic trace elements as cadmium, mercury, arsenic, lead, manganese, nickel, and aluminium.
- Nitrate
- Mycotoxins as ochratoxin A (OTA), deoxynivalenole (DON), T-2 and HT-2
- Chlorinated environmental contaminants as PCBs, dioxins and chlorinated pesticides
- Contaminants formed during preparation as acrylamide, furan, 3-MPCD, and polycyclic aromatic hydrocarbons (PAH)

Mercury

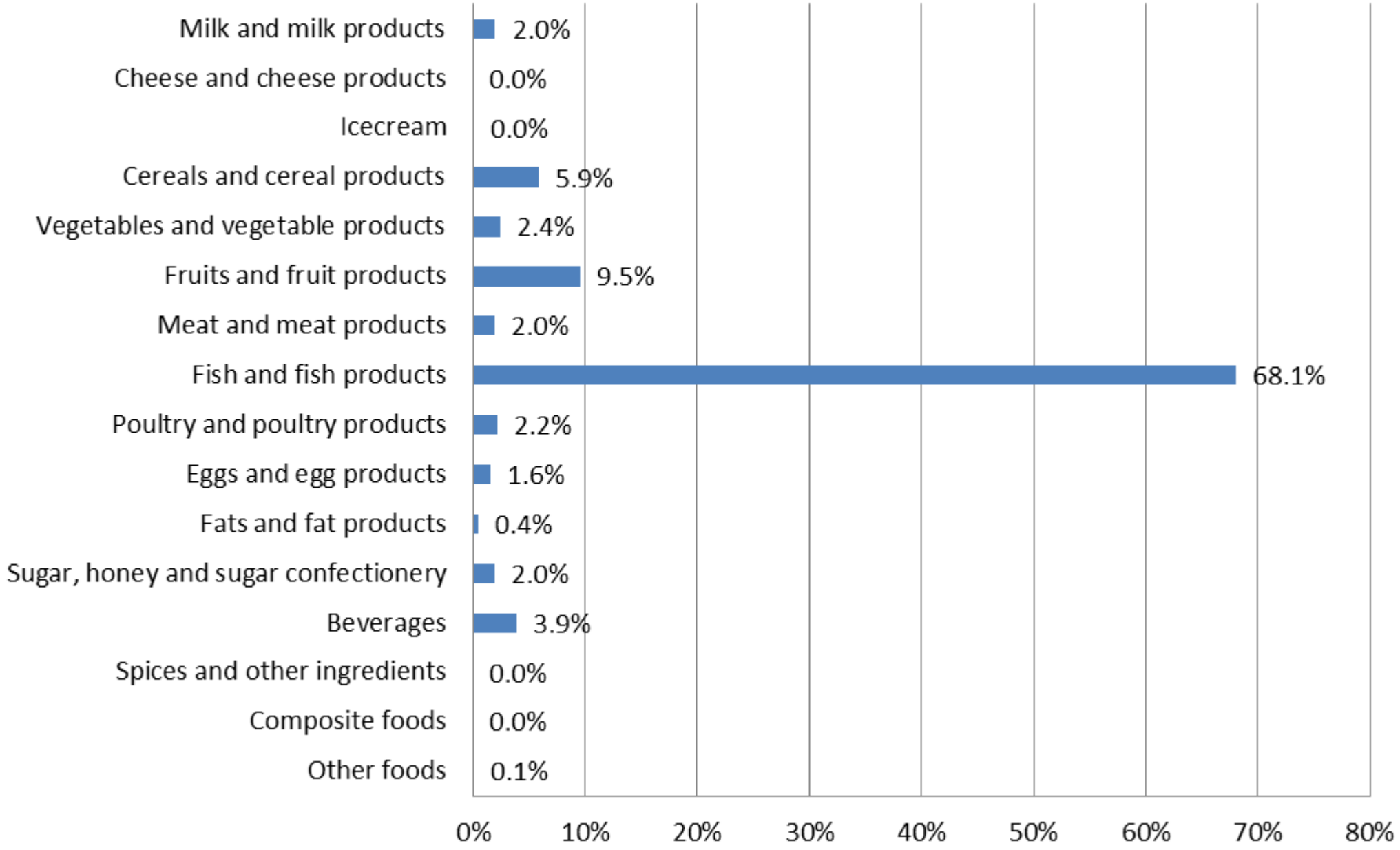
Mercury (Hg) is naturally present in the Earth's crust usually at concentrations around 0.02 mg/kg.

Elemental mercury is liquid at room temperature and in standard pressure conditions. The element can be found in various chemical forms, both inorganic and organic. It is used in various industrial applications, including products such as batteries, cables, electrical switches, dental amalgams and lamps. The main anthropological source of mercury is the incineration of waste.

Ingested mercury accumulates in the body, and the most toxic species is methyl-mercury, which is the predominant chemical form of mercury in marine fish. The central nervous system is the target organ of methyl-mercury, particularly during foetal development, and the toxic effects include alteration of sensory functions, motor coordination, memory, attention and learning ability. For inorganic mercury the adverse effects include renal lesions, neurotoxicity and cardiovascular disorders.

TWI for inorganic mercury at 4 µg/kg bw/week, for methyl-mercury exposure at 1.6 µg/kg bw/week

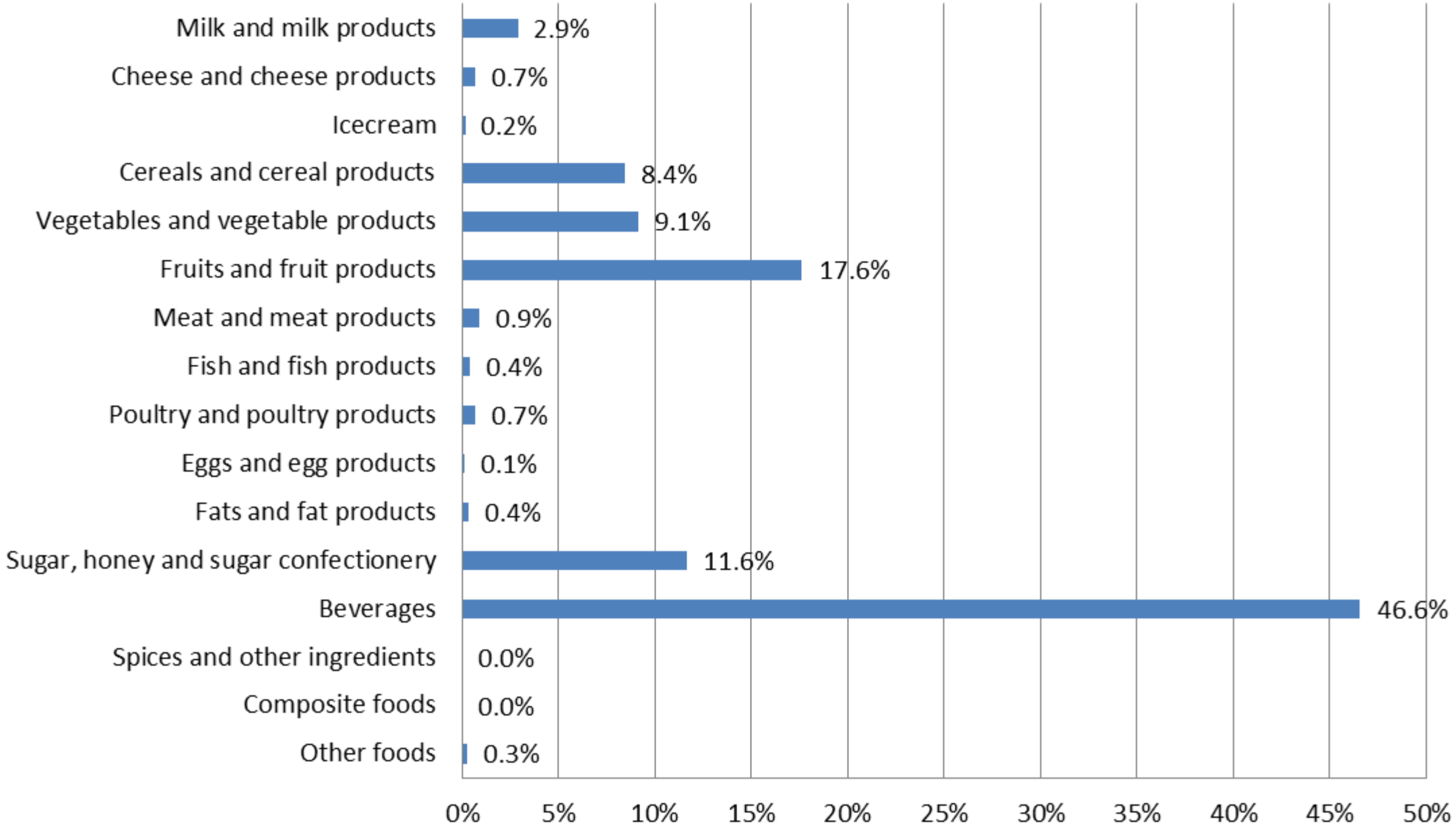
Exposure of mercury from main food groups



Lead

Lead is a ubiquitous element, found naturally in the Earth's crust at an average concentration of 10 mg/kg. It is widespread in the environment due to its use in various applications, including mining and industrial activities, accumulators, pigments, alloys, and ammunition. Exposure levels have decreased since the banning of lead additives to car fuel. Ingested lead accumulates in the body, and its most adverse effect is associated with the development of the central nervous system in children and probably also in the foetus. In adults, lead affects the kidneys (increased prevalence of chronic kidney disease) and the cardiovascular system (high systolic blood pressure).
TWI value at 25 µg/kg bw/week

Exposure of lead from main food groups



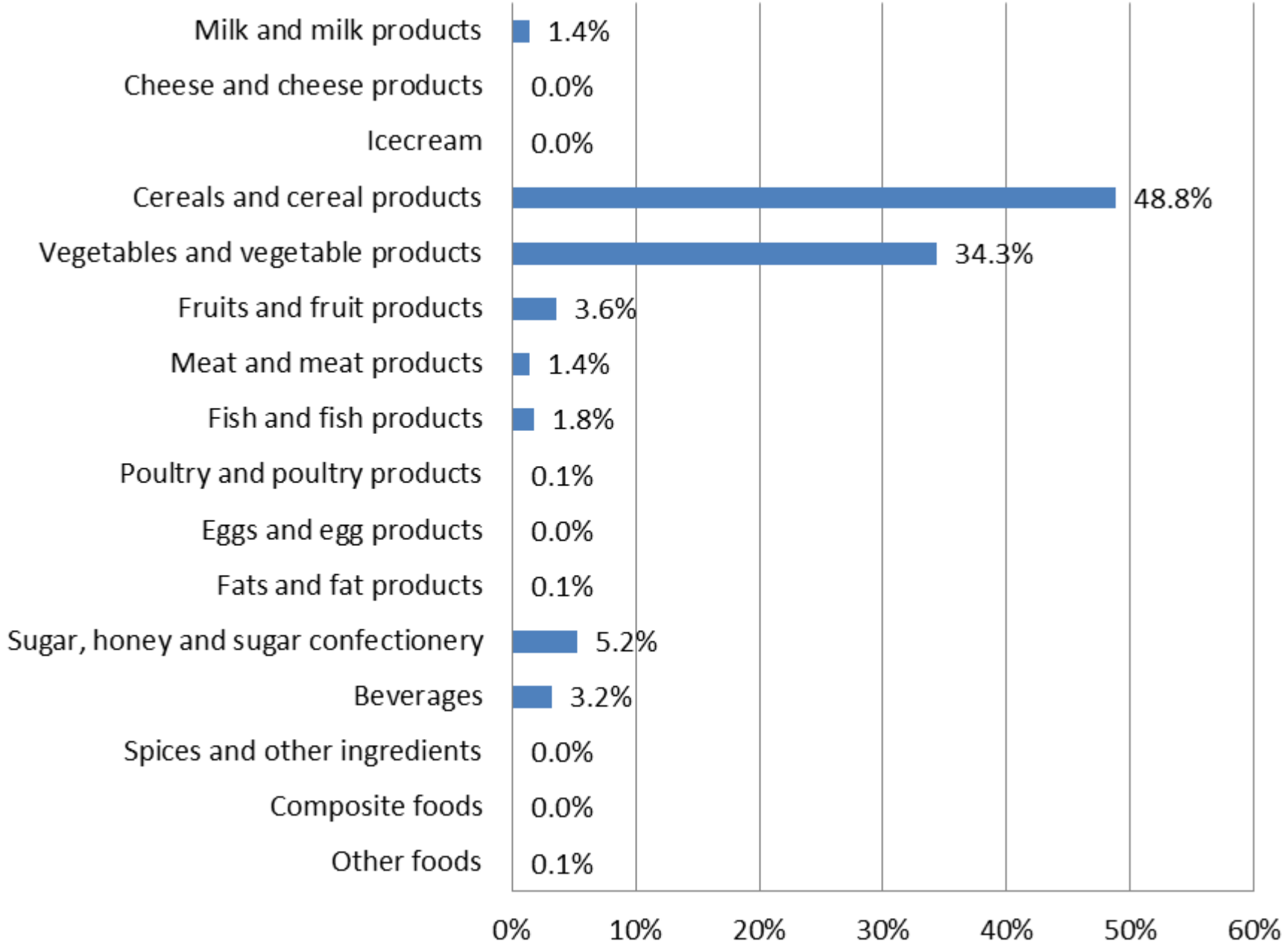
Cadmium

Cadmium (Cd) is a heavy metal found as an environmental contaminant, both through natural occurrence and from industrial and agricultural sources. Foods are the main source of cadmium exposure for the non-smoking population. Tobacco smoking and work place air have also been identified as major contributors to cadmium exposure.

Upon exposure, cadmium is efficiently retained in the kidney and liver in the human body, with a very long biological half-life ranging from 10 to 30 years. Cadmium is primarily toxic to the kidneys and may cause renal dysfunction. Cadmium can also cause bone demineralisation, either through direct bone damage or indirectly as a result of renal dysfunction. There is limited evidence for the carcinogenicity of cadmium following oral administration.

TWI value of 2.5 µg/kg bw/week

Exposure of cadmium from main food groups



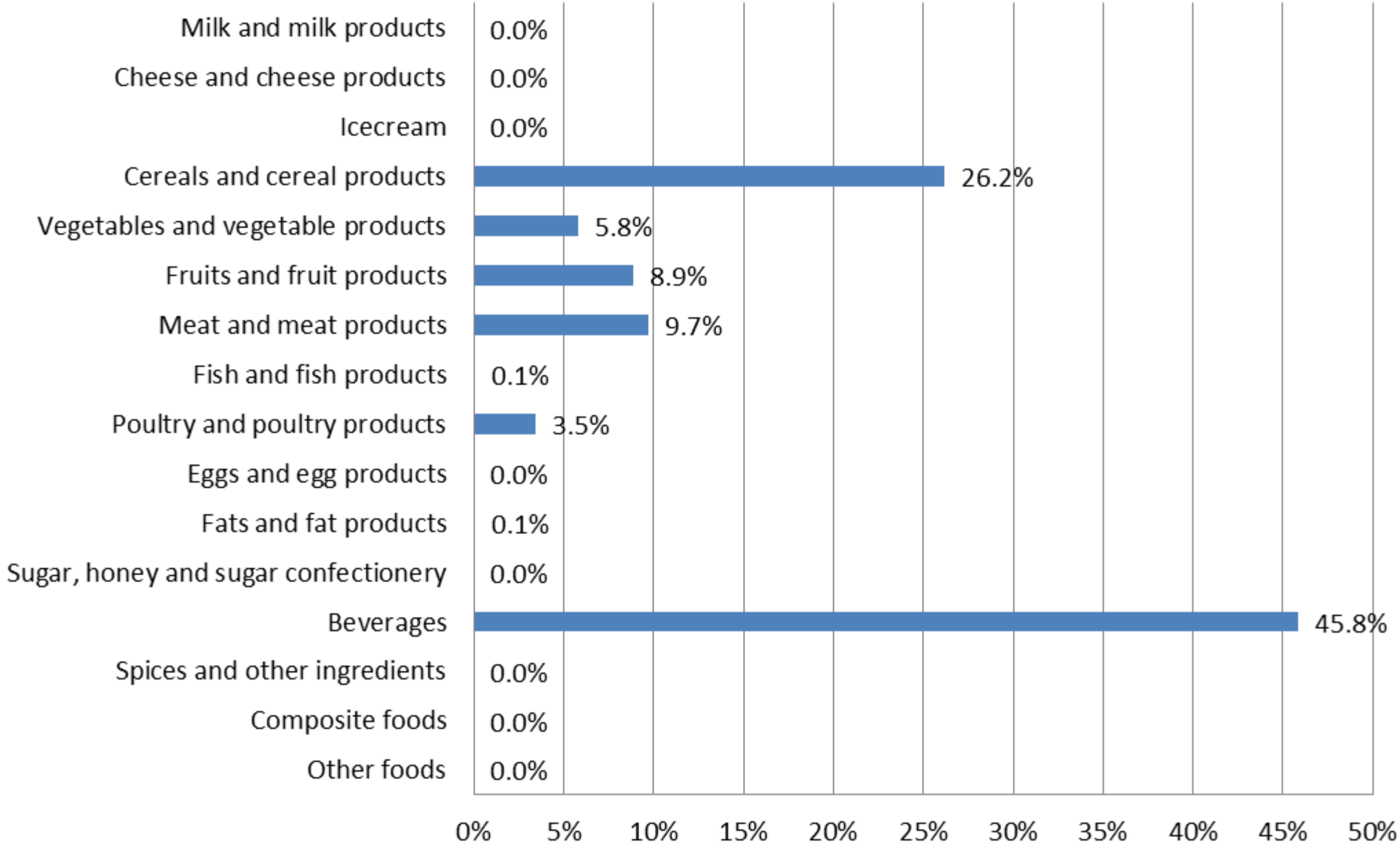
Arsenic

Arsenic is a ubiquitous element, which is introduced to the environment from both natural and anthropogenic sources. The crust of the Earth contains arsenic, which is released through weathering of rocks and volcanic activity. The anthropogenic contribution originates primarily from mining and smelting industry, the burning of fossil fuels and from use of arsenic containing pesticides, growthpromoters and wood-preservation agents. Arsenic has a very complex chemistry and natural metabolic processes in the biosphere have resulted in the existence of a large number of arsenic compounds.

The toxicity of arsenic compounds strongly depends on their chemical forms (speciation). Inorganic arsenic is considered the most toxic of the species present in food. There is good evidence for the carcinogenicity of inorganic arsenic and IARC consider it as carcinogenic to human. Organoarsenic compounds are generally considered to have intermediate to low toxicity.

ADI was calculated to be 7.0 µg/day or 0.12 µg/kg bw/day

Exposure of inorganic arsenic from main food groups



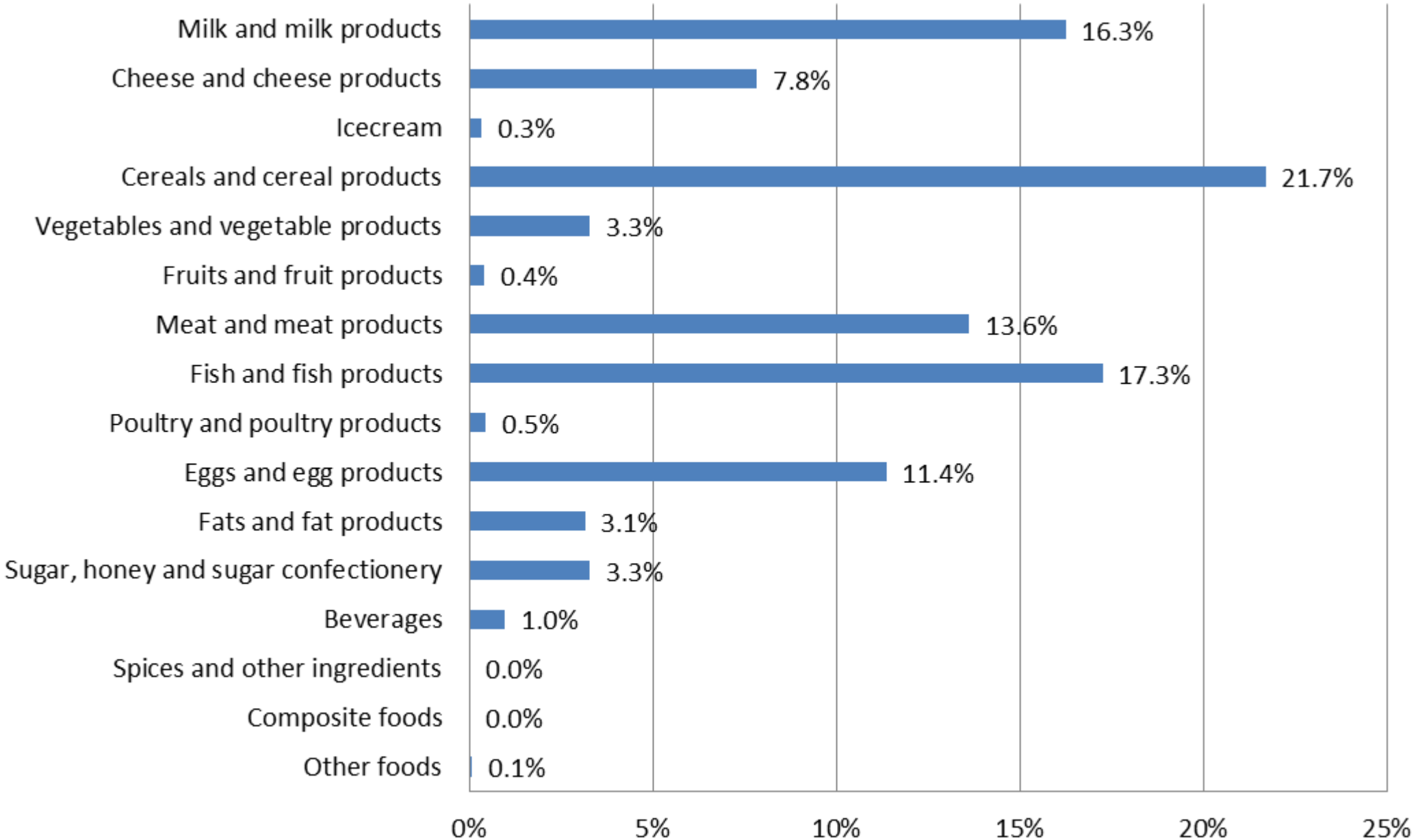
Selenium

Selenium is an element essential to humans and the main functions of selenium are performed through selenoproteins. Several selenoproteins have been identified, including glutathione peroxidases, deiodinases, selenoprotein P and thioredoxin. The deiodinases are involved in the thyroid hormone metabolism, while the other are antioxidant enzymes that act in the body's defence system against oxidative stress and the regulation of the redox status of vitamins C and E. Furthermore, selenium is believed to play an active role in the elimination of certain toxic molecules from the body (e.g. mercury). Selenium exposure is also linked to cancer-preventive effects in humans.

A severely low exposure of selenium may lead to adverse effects like heart disease (Keshan's Disease), muscular degeneration, depigmentation of hair and nails, anaemia and increased occurrence of infections. Excessive exposure of selenium, though very seldom in human diets, may lead to selenosis, which causes gastrointestinal disorders, hair loss, fatigue and irritability.

The Scientific Committee on Food (SCF) has established a tolerable upper exposure level at 300 µg/day for adults and from 90-250 µg/day for children aged between 4 and 17 (SCF, 2006). The Nordic Nutrition Recommendations (NNR) working group estimated the recommended exposure of selenium at 40 µg/day for women and 50 µg/day for men (NNR, 2004).

Exposure of selenium from main food groups



Othertraces element

Nickel

Nickel occurs naturally in the Earth’s crust and is used in many industrial applications, e.g. in alloys (stainless steel), ships and aircraft manufacturing and electrical industries. Humans can be exposed to nickel through inhalation (occupational exposure), food and water and via skin contact. Dermal as well as oral exposure to nickel may cause allergic reactions like dermatitis in sensitized persons. Although it has been linked to the metabolism of methionine in animals, nickel is not considered to be an essential element to humans, so, no requirements or recommended dietary allowances have been established for nickel.
WHO has established a TDI of nickel at 22 µg/kg bw/day (WHO, 2005).

Aluminium

Aluminium is the most abundant element in the Earth’s crust (8%). It is used in numerous industrial applications, including food processing, pharmaceuticals and drinking water treatment. Aluminium may be found in foods and drinking water in various chemical forms; but the chemical analysis only provides data on the total aluminium level. In the present monitoring period a project on baby food included the analysis of aluminium with 59 samples analysed. The level varied in the range from 0.2 to 4.4 mg/kg

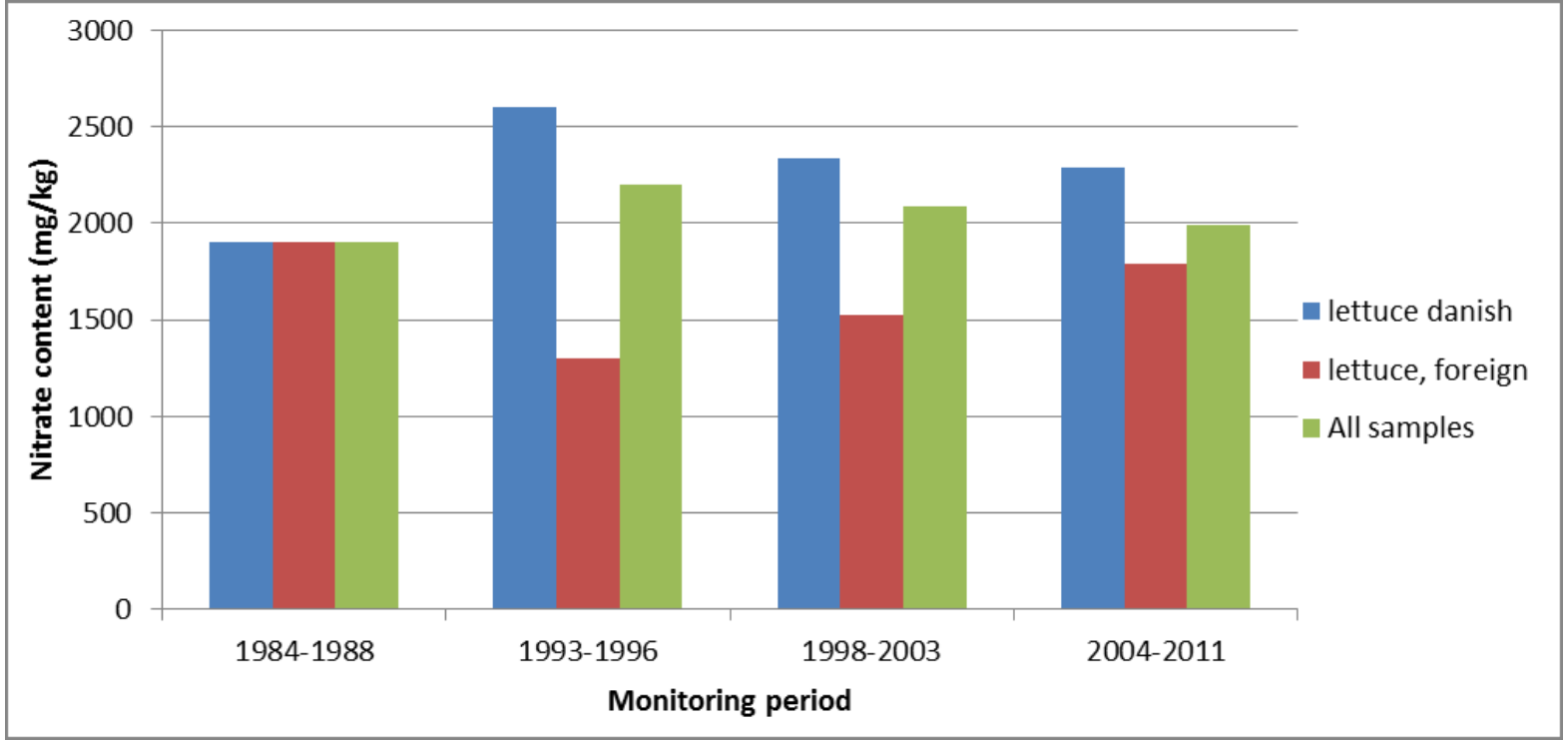
Nitrate in vegetables

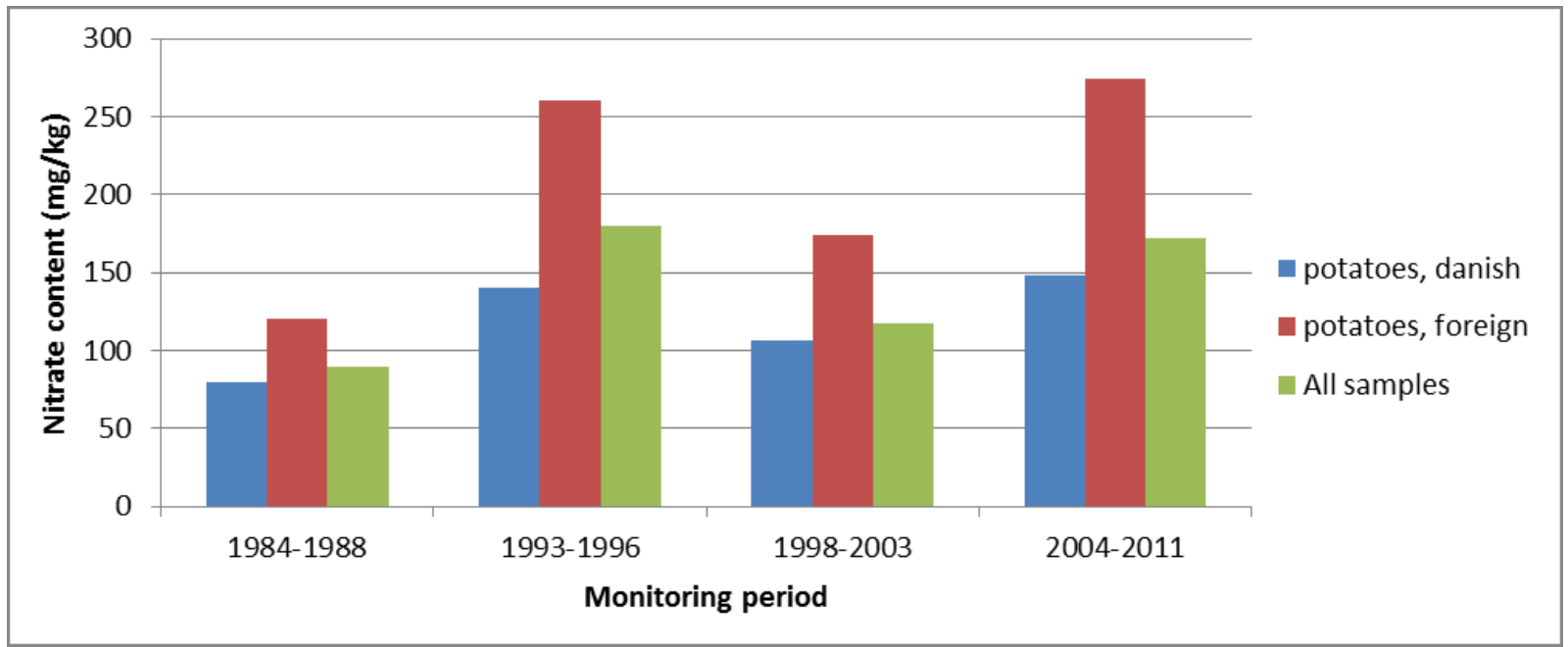
Nitrate is a naturally occurring compound present in plants which may accumulate in different tissues of the plant. Vegetables are the main contributor of nitrate in the human diet, generally providing approximately 80 % of the total daily exposure (SFC, 1997). Some vegetables such as head lettuce, iceberg lettuce, rucola (salad rocket), and spinach have been shown to contain relatively high levels of nitrate.

The level of nitrate varies between plant species, the extent of fertilisers use, humidity, temperature and amount of sunlight.

The acute toxicity of nitrate is low, but in food and in the gastrointestinal tract nitrate can be reduced to nitrite, which has a higher acute toxicity.

The ADI for sodium nitrate is 5 mg per kg body weight (SFC, 1995), which after conversion to the anion gives a value of 3.7 mg nitrate/kg bw/day.


3000
2500
2000
1500
1000
500
0
Nitrate content (mg/kg)
1984-1988
1993-1996
1998-2003
2004-2011
Monitoring period
lettuce danish
lettuce, foreign
All samples


300
250
200
150
100
50
0
Nitrate content (mg/kg)
1984-1988
1993-1996
1998-2003
2004-2011
Monitoring period
potatoes, danish
potatoes, foreign
All samples

Mycotoxins

Mycotoxins are secondary fungal metabolites with diverse structures and toxicological properties that induce a variety of toxic effects in humans and animals. In particular, fungi of the genera *Aspergillus*, *Penicillium* and *Fusarium* are significant in foods and feed all over the world. The Food and Agricultural Organization of the United Nations (FAO) has estimated that up to 25% of the world's food crops are significantly contaminated with mycotoxins.

Many of the *Fusarium* species produce various trichothecenes including deoxynivalenole (DON, vomitoxin), HT-2 toxin (HT-2) and T-2 toxin (T-2) which might be present in cereal grain intended for human consumption. The toxicity of trichothecenes is largely due to their ability to inhibit protein synthesis, and common symptoms in pigs are feed refusal, reduced weight gain, diarrhoea, haemorrhaging, skin lesions and immunosuppression. Generally, T-2 and HT-2 exhibit the strongest activity, whereas DON is considered to be about ten times less toxic.

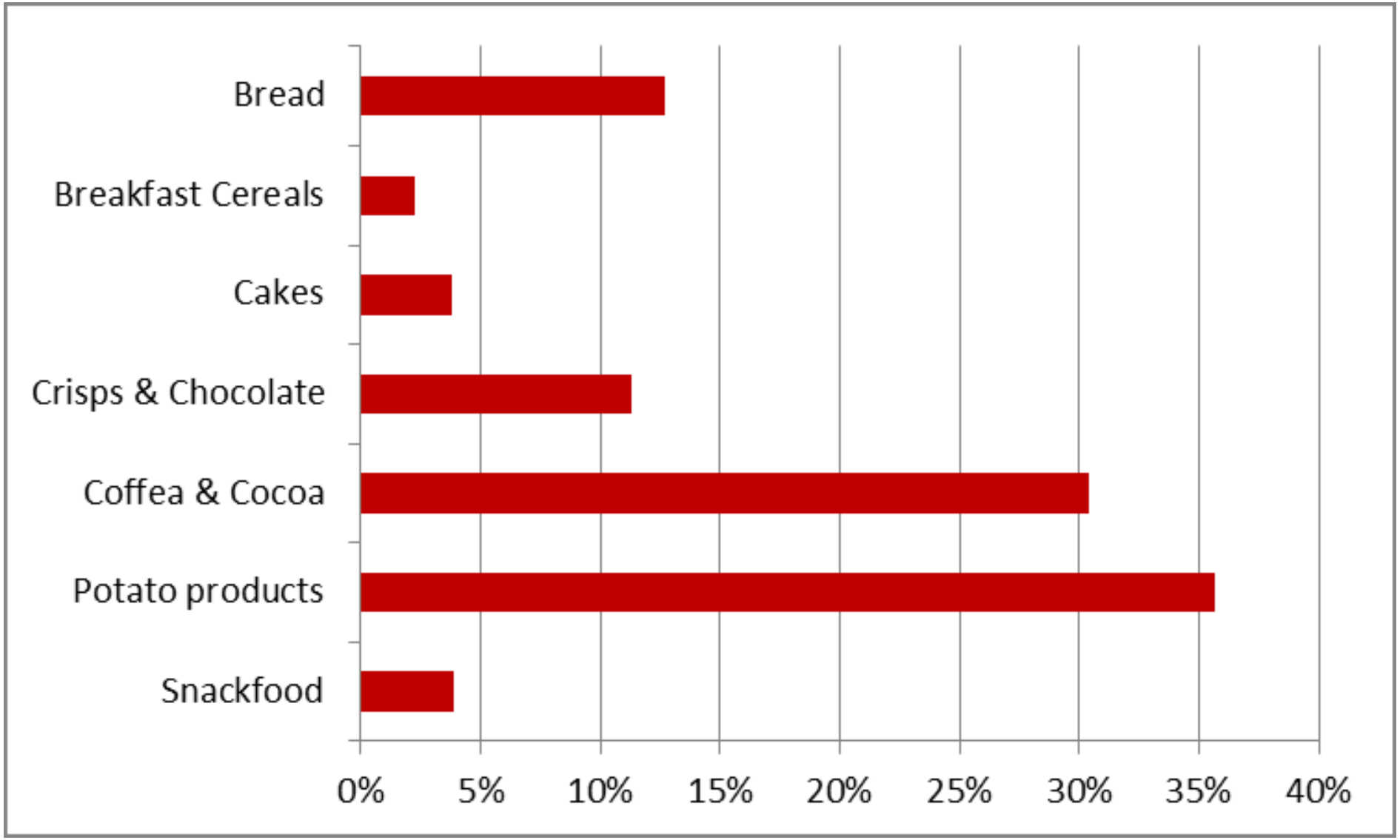
OchratoxinA (OTA) is produced by various *Penicillium* and *Aspergillus* species and represents a well-known hazard to human and animal health. The European Union has set legal limits for OTA levels in grain (5 µg/ kg), flour (3 µg/kg) and cereals to be used for baby food and processed cerealbased food for infants and young children (0.5 µg/kg)

Acrylamide

Acrylamide is a process contaminant which is formed as part of the Maillard reactions when carbohydrate rich food is heat treated. The main precursors of the acrylamide formation is the amino acid asparagine and reducing sugars which form Maillard reaction intermediates resulting in acrylamide forming during food heating processes such as frying, roasting, etc. Even autoclaving of e.g. baby food cereals in glass generates acrylamide.
It should be noted that smoking is an additional source of acrylamide exposure. On average smokers has been shown to be exposed to 3.5 times higher acrylamide levels than non-smokers.

Acrylamide is classified by the International Agency for Research on Cancer (IARC, 1994) as probably carcinogenic to humans.

Exposure of Acrilamide from main food groups



Salmonella sp.....Salmonellosis

The incubation period (the period from infection to manifest symptoms) for food-borne salmonella infections is reported to be ½-3 days in most cases. The infective dose depends on several factors such as age and immunological status. For healthy persons, an infectious dose of 103-106 bacteria has been indicated.

Salmonella has its growth optimum at 37°C and growth interval from 5 to 46°C. *Salmonella* does not survive pasteurization, but is relatively resistant to freezing. The heat resistance of *Salmonella* is highly dependent on environmental factors such as water activity and acidity.

Salmonella is facultatively anaerobic (i.e. capable of growth in the presence as well as absence of oxygen) and is therefore not inhibited by vacuum packing or modified atmosphere packing. *Salmonella* has its pH optimum at 6.5-7.5 with a growth range of 4.5-9.0. At water activities (a^w) below approx. 0.94, growth of *Salmonella* is not possible. The a^w limit of growth depends on factors such as pH and temperature.

The normal habitat of *Salmonella* is the intestinal tract of warm-blooded animals. *Salmonella* is spread from production animals to raw meat, unpasteurized milk, and eggs, which are the main causes of human infection.

CAMPYLOBACTER.....diarrhoea

Bacteria belonging to the genus *Campylobacter* are assumed to be one of the most important causes of diarrhoea in humans all over the world today. The infective dose for food-borne campylobacteriosis has not been established, but analyses indicate that it may be as low as 500 bacteria.

Members of the genus *Campylobacter* are microaerofilic (i.e. growing best in reduced oxygen content in relation to atmospheric air). Oxygen tolerance varies within species and strains. Human-pathogenic *Campylobacter* species do not grow at temperatures below 30°C, with the exception of *C. fetus* subsp. *fetus*, which is able to grow at 25°C. Maximum growth temperature is 42-43°C. This means that *Campylobacter* does not propagate in refrigerated foods. On the other hand, it has been demonstrated that *Campylobacter* survives better at 4°C than at room temperature. *Campylobacter* is more sensitive to heat treatment than most other bacteria. *Campylobacter* is sensitive to desiccation and to salt concentrations above 0.5%. Optimum pH interval for growth is 6.5-7.5. Growth is inhibited at pH values below 5.1.

The natural habitat of the majority of *Campylobacter* species is the intestinal tract in warm-blooded animals, including birds.

Yersinia enterocolitica.....*yersiniosis*

Y. enterocolitica is capable of growth at temperatures close to 0°C, and may thus grow in refrigerated foods. Due to its facultatively anaerobic properties (i.e. growing in the presence as well as absence of oxygen), it is also capable of growing in vacuum packed or modified atmosphere packed foods.
With respect to its salt and pH tolerance, *Y. enterocolitica* does not differ much from other intestinal bacteria. It can grow in foods having a salt concentration up to 5-7% salt in the aqueous phase. It grows in the pH interval of approx. 4-9, with its optimum at 7.2-7.4. *Y. enterocolitica* is rather heat sensitive and will be inactivated by heat treatment at 60°C for a mere 1-3 minutes. It is also quite sensitive to ionizing radiation.
Y. Enterocolitica were found in a study of the natural intestinal flora of pigs.

Escherichia coli .....*diarrhoe*

E. coli grows at temperatures between 8 and 45°C, and survives refrigeration and freezing for months with no substantial reduction. By pasteurization or heating of foods to a core temperature of 75°C, elimination is ensured.
The lower pH limit for growth is stated to be around 4-4.5, but the pH tolerance range is considerably wider. Thus, *E. coli* may survive in standard culture media at pH 2.
The growth of the bacteria is inhibited by 4% NaCl at 10°C, and at a NaCl concentration of 8%, growth at 37°C in standard culture media will cease.
E. coli is an intestinal bacterium of normal occurrence in humans and in most warm-blooded animals.

Listeria monocytogenes.....*Listeriosis*

A number of characteristics enable *L. monocytogenes* to grow in many different environments. Its nutrient demands are very modest, it grows in the presence as well as the absence of oxygen (facultatively anaerobic), has a wide pH range for growth (approx. 4.5-9), grows at temperatures between 0 and 45°C, and is able to multiply at high salt concentrations (10% salt in the aqueous phase, corresponding to an a^w value of 0.92). It does not survive low pasteurizing (72°C for 15 seconds) and is furthermore usually sensitive to most disinfectants.

L. monocytogenes is widely distributed in the nature: in wildlife, plants, and soil, its natural habitat being earth and decaying plant material. Survival and growth of *L. monocytogenes* in the earth depends on soil type, moisture, and temperature.

Staphylococcus aureus

Staphylococcus aureus is an occasionally pathogenic micro-organism which is present as a natural part of the flora on skin and mucous membranes, and which therefore often occurs in low numbers in foods. Some *S. aureus* are capable of producing a toxin which is called staphylococcal enterotoxin.

S. aureus has its growth temperature optimum around 37°C and growth range from approx.10 to 45°C. It is relatively sensitive to heat treatment and will be eliminated by a heat treatment equivalent to low pasteurizing. The toxin, on the other hand, is highly heat stable and will not be inactivated by less than prolonged boiling.

S. aureus is characterized by its ability to grow at very low water activities (a^w), down to 0.86. Thus, it is the most salt tolerant of the known pathogenic bacteria.

S. aureus is highly resistant to desiccation, which is part of the reason for its frequent presence on surfaces such as skin and mucous membranes, as well as in dust. It is so commonly occurring that it must be assumed to be present in low numbers in most raw foods.

S. aureus is capable of growth within the pH interval from approx. 4 to 9.

Clostridium perfringens

Clostridium perfringens is one of the most frequent causes of food-borne disease. The disease in an intoxication caused by a toxin which the bacterium liberates in the small intestine. The incubation period is normally from about 8 to 12 hours. It takes a large number of bacteria, approx. 10^6 per g of food, to bring about intoxication.

C. perfringens has its growth temperature optimum around 37°C and growth range from approx. 10 to 50°C. The bacterium is spore-forming. When present in spore form in foods, it is very resistant to heat treatment; however, the heat resistance of the spores varies considerably. Thus, some spores are readily killed by boiling, whereas others will be able to survive boiling for a long time. The vegetative bacteria are easily inactivated by heat treatment.

C. perfringens is anaerobic (i.e. growing best in the absence of oxygen), but tolerates the presence of oxygen better than most other clostridia.