Learning outcome

• Describe the possible risks to public health of each of the following chemical contaminants:
  – acrylamide;
  – arsenic in rice;
  – Bisphenol-A (BPA);
  – dioxins; and
  – heavy metals, for example mercury, lead and cadmium.

Acrylamide

Acrylamide is a chemical produced naturally in food as a result of cooking starch rich food at high temperatures, such as when baking or frying. It is also likely to be produced by grilling and roasting food. Food Standards Agency – Acrylamide

Health risks

On 4 June 2015, the European Food Safety Authority (EFSA) released its scientific opinion on acrylamide in food. The conclusion was that, based on evidence from animal studies, dietary exposure to acrylamide potentially increases the risk of developing cancer for consumers in all age groups.

Acrylamide forms particularly in plant-based carbohydrate-rich foods during high temperature cooking (usually above 120 °C) as a consequence of the Maillard reaction. The Maillard reaction is a reaction between a reducing sugar (such as glucose, fructose or lactose) and an amino acid (the building block of protein) that results in the browning and characteristic flavours of certain foods cooked at high temperatures. Besides these sensory changes the Maillard reaction can also result in the formation of undesirable substances, such as acrylamide. Additionally the ingredient’s storage and processing conditions also greatly influence acrylamide formation in food.

Fried potato products, coffee, biscuits, crackers and breads are the main dietary sources of acrylamide.

The panel undertook a rigorous review of available scientific research on acrylamide and glycidamide (one of its breakdown products in the body) provided by animal and human studies. These included original study reports, previous evaluations and information submitted following public calls for
data. Although results from human studies provide limited and inconsistent evidence, EFSA concluded that, based on animal studies, acrylamide and glycidamide are genotoxic (i.e. can damage DNA, our genetic material) and carcinogenic (can cause cancer). Since acrylamide is present in a wide range of everyday foods, this concern applies to all age groups but children may experience more exposure to acrylamide relative to their lower body weights.

EFSA also considered other effects of acrylamide on the nervous system, pre- and post-natal development and male reproduction. These effects were not considered to be a concern at current levels of dietary exposure.

EUFIC – EFSA opinion on acrylamide

Although acrylamide has caused nerve damage in people who have been exposed to very high levels as a result of occupational and accidental exposure through industrial use, it is less clear what the risks are from the acrylamide found in food. Acrylamide is considered to be a genotoxic carcinogen because it has the potential to cause cancer by interacting with cell DNA. Based on independent expert scientific advice, the Food Standards Agency believes that exposure to such chemicals should be as low as reasonably practicable (ALARP).

Given the uncertainties in exposure and the possible exposure to sources other than food, scientists have concluded that it is not possible to draw any definitive conclusions about the cancer risks of acrylamide in food.

Food Standards Agency – Acrylamide

According to the Food and Agricultural Organisation (FAO), arsenic is a naturally occurring element in the earth’s crust. It is present in many foods due to absorption from the soil and water. Rice in particular can take up more arsenic than other foods and due to its high consumption can contribute significantly to arsenic exposure.

The FAO have also stated that long-term exposure to arsenic from drinking-water and food can cause cancer and skin lesions. It has also been associated with developmental effects, heart disease, diabetes, and damage to the nervous system and brain. To protect consumers from excessive exposure the Codex Alimentarius Commission recommends that the level of arsenic in rice should not exceed 0.2 mg/kg.

According to the World Health Organisation (WHO), arsenic occurs in inorganic and organic forms. Inorganic arsenic compounds, such as those found in water, are highly toxic while organic arsenic compounds, such as those found in seafood, are less harmful to health.

Acute effects
The immediate symptoms of acute arsenic poisoning include vomiting, abdominal pain and diarrhoea. These are followed by numbness and tingling of the extremities, muscle cramping and, in extreme cases, death.

Long-term effects
The first symptoms of long-term exposure to high levels of inorganic arsenic (e.g. through drinking-water and food) are usually observed in the skin, and include pigmentation changes, skin lesions and hard patches on the palms and soles of the feet (hyperkeratosis). These occur after a minimum exposure of approximately five years and may be a precursor to skin cancer.

In addition to skin cancer, long-term exposure to arsenic may also cause cancers of the bladder and lungs. The International Agency for Research on Cancer (IARC) has classified arsenic and arsenic compounds as carcinogenic to humans, and has also stated that arsenic in drinking water is carcinogenic to humans.

Other adverse health effects that may be associated with long-term ingestion of inorganic arsenic include developmental effects, neurotoxicity, diabetes and cardiovascular disease. In China (Province of Taiwan), arsenic exposure has been linked to ‘blackfoot disease’, which is a severe disease of blood vessels leading to gangrene. However, this disease has not been observed in other parts of the world, and it is possible that malnutrition contributes to its development.

WHO – Arsenic
Bisphenol-A

Bisphenol-A (BPA) is a chemical used in the manufacturing of polycarbonate plastic or epoxy resins, to confer a unique balance of rigidity, transparency and high heat resistance.

According to the FSA, BPA is a chemical used to make plastics including materials that come into contact with food, such as refillable drinks bottles and food storage containers. It is also used to make protective coatings and linings for food and drinks cans.

Health risks

Very small amounts of BPA can transfer from packaging into food and drinks, but these levels of exposure are not considered to be harmful. Independent experts have worked out how much BPA we can consume every day over a lifetime without coming to any harm, and the amount people actually absorb from all food and drink is significantly below this level.

Independent studies have shown that, even when consumed at high levels, BPA is rapidly absorbed, detoxified and eliminated from humans and, therefore, is not a health concern.

According to EUFIC, BPA belongs to a group of substances which have hormone-like (e.g. estrogenic) effects. In principle, such substances can have effects on any hormone dependent process and therefore have been associated with health effects such as cancer and developmental defects. However, current research indicates that BPA does not accumulate in the body and the small amounts from daily exposure are rapidly excreted from humans and are not a health concern.

While some studies claim to show that BPA causes hormonal changes, even at very low levels of exposure (a so-called ‘low-dose effect’), there is a lot of controversy surrounding its effects because when these studies were repeated in different laboratories, the same changes were not seen. This is important because it is a principle of scientific research that findings should be reproducible to ensure they have not arisen by chance.

Dioxins

Dioxins are a group of chemicals. They are polychlorinated aromatic compounds with similar structures, chemical and physical properties. They are not produced intentionally or deliberately, but are formed as a by-product of chemical processes. These range from natural events such as volcano eruptions and forest fires to man-made processes, such as manufacturing of chemicals, pesticides, steel and paints, pulp and paper bleaching, exhaust emissions and incineration.

Health risks

For most people 90 percent of human dioxin exposure comes from food, particularly meat, fish, poultry, cheese, milk, butter, free range eggs and oily fish have been measured as having high levels. According to the FSA, dioxins have no immediate effect on health, even at the highest levels found in foods. The potential risks to health come from long-term exposure to high levels. Exposure to high levels have been shown to cause a wide range of effects, including cancer, adverse reproductive and developmental effects, birth defects, immune system abnormalities, endometriosis, heart related conditions, skin disease, such as chloracne, and other skin effects such as rashes.
**Heavy Metals**

**Cadmium**
Cadmium (Cd) is a heavy metal found as an environmental contaminant, both through natural occurrence and from industrial and agricultural sources. Foodstuffs are the main source of cadmium exposure for the non-smoking general population. EFSA – Cadmium in food

**Health risks**
The levels of cadmium exposure through food that are consumed by most people are not of major health concern. Cadmium absorption after dietary exposure in humans is relatively low (3–5%) but cadmium is efficiently retained in the kidney and liver in the human body frequently resulting in kidney damage. Cadmium is a cumulative poison, i.e. the danger lies primarily in the regular consumption of foodstuffs with low contamination. Cadmium is primarily toxic to the kidneys, especially to the proximal tubular cells where it accumulates over time and may cause renal dysfunction. Cadmium can also cause bone demineralisation, either through direct bone damage or indirectly as a result of renal dysfunction. After prolonged and/or high exposure the tubular damage may progress to decreased glomerular filtration rate, and eventually to renal failure. The International Agency for Research on Cancer has classified cadmium as a human carcinogen (group 1) on the basis of occupational studies. Newer data on human exposure to cadmium in the general population have been statistically associated with increased risk of cancer such as in the lung, endometrium, bladder, and breast. EFSA – Cadmium in food

**Lead**
Lead is a naturally occurring toxic metal found in the earth’s crust. Its widespread use has resulted in extensive environmental contamination, human exposure and significant public health problems in many parts of the world.

Important sources of environmental contamination include mining, smelting, manufacturing and recycling activities, and in some countries the continued use of leaded paint and leaded petrol. More than three quarters of global lead consumption is for the manufacture of lead-acid batteries for motor vehicles. Lead is, however, also used in many other products, for example pigments, paints, solder, stained glass, crystal vessels, ammunition, ceramic glazes, jewellery, toys and in some cosmetics and traditional medicines. Drinking water delivered through lead pipes or pipes joined with lead solder may contain lead. Much of the lead in global commerce is now obtained from recycling.

**Health risks**
Young children are particularly vulnerable to the toxic effects of lead and can suffer profound and permanent adverse health effects, particularly affecting the development of the brain and nervous system. Lead also causes long-term harm in adults, including increased risk of high blood pressure and kidney damage. Exposure of pregnant women to high levels of lead can cause miscarriage, stillbirth, premature birth and low birth weight, as well as minor malformations.

Once lead enters the body it is distributed to organs such as the brain, kidneys, liver and bones. The body stores lead in the teeth and bones where it accumulates over time. Lead stored in bone may be remobilized into the blood during pregnancy, thus exposing the foetus. Undernourished children are more susceptible to lead because their bodies absorb more lead if other nutrients, such as calcium, are lacking. Children at highest risk are the very young, including the developing foetus, and the impoverished. WHO – Fact Sheet
**Mercury**

Mercury occurs naturally in the earth’s crust. It is released into the environment from volcanic activity, weathering of rocks and as a result of human activity. Human activity is the main cause of mercury releases, particularly coal-fired power stations, residential coal burning for heating and cooking, industrial processes, waste incinerators and as a result of mining for mercury, gold and other metals.

All humans are exposed to some level of mercury. Most people are exposed to low levels of mercury, often through chronic exposure (continuous or intermittent long-term contact). However, some people are exposed to high levels of mercury, including acute exposure (exposure occurring over a short period of time, often less than a day). An example of acute exposure would be mercury exposure due to an industrial accident.

Factors that determine whether health effects occur and their severity include:
- the type of mercury concerned
- the dose
- the age or developmental stage of the person exposed (the foetus is most susceptible)
- the duration of exposure.

**Health risks**

Elemental and methylmercury are toxic to the central and peripheral nervous systems. The inhalation of mercury vapour can produce harmful effects on the nervous, digestive and immune systems, lungs and kidneys, and may be fatal. The inorganic salts of mercury are corrosive to the skin, eyes and gastrointestinal tract, and may induce kidney toxicity if ingested. Neurological and behavioural disorders may be observed after inhalation, ingestion or dermal exposure of different mercury compounds. Symptoms include tremors, insomnia, memory loss, neuromuscular effects, headaches and cognitive and motor dysfunction. [WHO – Mercury and help](#)

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**Revision Questions**

1. Briefly explain how dioxins, mercury and lead can contaminate food.

2. Assess the risks to human health related to the presence of dioxins, mercury and lead.