Lecture Material - Food Safety
Inneke Hantoro

Food Contaminants, Residues, & Indirect Additivites

Introduction

- Food contaminants are substances that are included unintentionally in foods.
- Contamination can occur at every step on the way from raw material to consumer.
- Raw material of plant origin can be contaminated with environmental pollutants, such as heavy metals, pesticide residues, industrial chemicals, and products from fossil fuels.

- In animal products also, residues of veterinary drugs and growth promoting substances may be present.
- During processing, food can be contaminated with processing aids, such as filtering and cleaning agents, and with metals coming from the equipment.
- Finally, contaminants can be included in foods during packaging and storage. These can originate from plastics, coatings, and tins.

Lecture Material - Food Safety
Inneke Hantoro

Contaminants

Metals

Introduction

- About 80 of the 103 elements listed in periodic table of the elements are metals.
- Some metals are required for human health, but some of them pose an adverse effect for health (toxic metals).
- Metals can enter foods through environment or food processing.
- In the past have been found adulteration cases which involved some toxic metals.

Susceptibility to Metals

- **Age –** young or old?
- **Nutrition** (completion with essential metals)
- **Allergic response** (immune system)
- **Form of metal** (organic or inorganic)
- **Lifestyle –** smoking or alcohol
- **Occupation**
- **Home environment** (lead paint?)

Toxic Metals

- Al ➢ **Aluminum (Al)**
- As ➢ **Arsenic (As)**
- Cd ➢ **Cadmium (Cd)**
- Co ➢ **Cobalt (Co)**
- Pb ➢ **Lead (Pb)**
- Hg ➢ **Mercury – Inorganic (Hg)**
- $Hg\text{-}CH_3$ ➢ **Mercury – Organic ($Hg\text{-}CH_3$)**
- Ni ➢ **Nickel (Ni)**
- Sn ➢ **Tin (Sn)**

Heavy Metals

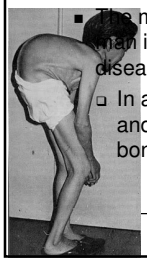
- Cd, Pb and Hg are known as heavy metals.
- Heavy metal: a metal or alloy with a density higher than 4.5–5.0 kg dm^{-3}.
- Chromium (Cr) and nickel (Ni) are also grouped as heavy metals, which are not toxic in the concentrations normally found in food but are used in vast quantities, not least in equipment coming into contact with food.

Cadmium (Cd)

- **Use : alloy in metal, paint**
- **Source : shellfish, cigarette smoke, workplace – welding, paints**
- **Absorption : intestine, lungs**
- **Toxicity : lung, emphysema, kidney, calcium metabolism, possible lung carcinogen**

Cadmium (Cd)

- Cadmium may accumulate in the human body and may induce kidney dysfunction, skeletal damage and reproductive deficiencies.
  - The most well known event of toxic effects of Cd on man is probably the 'Itai-itai' disease ('ouch-ouch' disease).
    - In a district of Japan, after the Second World War and up to the early 1970s → resulted in severe bone deformation and, in many cases, death.



Cadmium (Cd)

- It was found to be the result of river water being polluted by Cd-containing waste from mining activities.
- The river water was used for irrigation of rice fields, which resulted in Cd-contaminated rice, often with Cd levels between 0.5 and 1 mg/kg.
- The consumers, women in particular, then suffered osteomalacia, which led to skeletal deformation and frequent bone fractures. Even the slightest exertion, such as coughing, could result in, for example, broken ribs

Cadmium (Cd)

- The Cd content can vary drastically between different food products, from less than 0.001 to 100 mg/kg. Most of the more commonly consumed products contain low levels of Cd.
- Muscle tissues from most animals, including fish, contain levels below 0.01 mg/kg. Levels approaching 100 mg/kg have been detected in crab hepatopancreas.
- The Cd uptake by adults is in the order of 5%, and is stored primarily in the kidneys.

Concentrations (μg/g dw) of metals in several seafood species from the coast of Semarang

Seafood	Cd	Cu	Zn	Fe
Milkfish[b,1]	0.06 ± 0.01	1.09 ± 0.15	27.79 ± 10.86	23.35 ± 17.56
Milkfish[b]	0.08 ± 0.02	1.38 ± 0.38	49.22 ± 13.68	91.18 ± 51.50
Tilapia[c,1]	0.076 ± 0.048	1.24 ± 0.53	28.75 ± 8.87	23.69 ± 22.50
Tilapia[c]	0.059 ± 0.026	0.75 ± 0.39	37.55 ± 6.33	19.85 ± 8.26
Tiger shrimp[a]	0.66 ± 0.36	26.17 ± 4.98	35.11 ± 5.57	NA

Sources: Tjahjono (2002)[a], Karyoke (2003)[b], (Wulaningsih, 2003)[c]

(NA = not available, [1]pond is located next to the municipal sewage treatment plant)

Lead (Pb)

- **Use : batteries, old paint and previously gasoline**
- **Source : home, paint, dust, kids-hands to mouth, workplace**
- **Absorption : intestine (50% kids, 10% adults)**
- **Toxicity : developmental and nervous system**
- **Facts : developing nervous system very sensitive to low levels of exposure**

Lead (Pb)

- Lead absorption may constitute a serious risk to public health.
- The uptake of Pb from food by adults is in the order of 10%, whereas children may have an uptake of up to 50%.
- Most of the Pb is accumulated in the skeleton. Pb can pass the placenta barrier and the blood–brain barrier in children.
- Lead may induce reduced cognitive development and intellectual performance in children and increased blood pressure and cardiovascular diseases in adults.

Lead (Pb)

- Pb can be detected in most foods, but there are only a few foods that naturally contain high levels
- Intake of Pb via food should be kept as low as possible. A PTWI for Pb (0.025 mg/kg BW) has been decided by an international expert group. This is equal to 1.75 mg of Pb/ week for a person weighing 70 kg

Metal content (ppm, dw) in meat (*bicep femoris*) and viscera (lever, rumen, abomasums, jejenum) of cattle cultivated in the final waste disposal site of Semarang

Tissue	Cr	Cd	Co	Fe	Zn	Pb
Meat	0.838	1.165	0.168	119.72	155.76	10.64
Lever	0.855	1.741	0.287	581.623	144.743	-
Rumen, Abomasum	3.120	1.705	0.291	616.965	119.941	-
Jejenum	0.034	-	0.186	196.553	34.738	-
MRL (UK)	0.02-0.56	0.01-0.09	1.94	3-4	33.0	-

Source: Poswandari (2003) & Wibowo (2003)

(MRL = the maximum residue limit)

Livestock (Cows) in the final sewage disposal site of Semarang

Table 1. Metal Contents in Honey from Different Migratory Beekeeping Areas

Samples	Metal Concentration (µg/g wet matter)				
	Zn	Fe	Cu	Cd	Pb
TR	0.676 ± 0.086[a] (0.588-0.798)	2.187 ± 0.449[a] (1.961-2.991)	0.157 ± 0.008[a] (0.149-0.169)	0.215 ± 0.007[a] (0.206-0.219)	1.987 ± 0.015[a] (1.961-1.998)
TK	1.151 ± 0.055[c] (1.089-1.200)	3.378 ± 0.549[b] (2.967-4.000)	0.383 ± 0.012[c] (0.366-0.396)	0.249 ± 0.022[b] (0.227-0.277)	2.776 ± 0.434[b] (2.000-2.982)
AR	0.814 ± 0.044[b] (0.793-0.894)	1.788 ± 0.445[a] (0.992-1.996)	0.296 ± 0.010[d] (0.288-0.307)	0.254 ± 0.005[b] (0.248-0.258)	2.781 ± 0.008[b] (2.773-2.994)
AK	1.072 ± 0.088[c] (0.983-1.199)	2.977 ± 0.017[b] (2.949-2.997)	0.256 ± 0.019[c] (0.228-0.277)	0.246 ± 0.005[b] (0.238-0.249)	1.984 ± 0.012[a] (1.966-1.998)
SR	1.070 ± 0.040[c] (0.999-1.094)	4.164 ± 0.454[c] (3.925-4.975)	0.258 ± 0.014[c] (0.245-0.277)	0.244 ± 0.011[b] (0.229-0.255)	2.974 ± 0.020[b] (2.944-2.997)
SK	1.326 ± 0.054[d] (1.281-1.393)	3.959 ± 0.998[c] (2.947-4.995)	0.222 ± 0.011[b] (0.207-0.236)	0.247 ± 0.008[b] (0.237-0.259)	1.979 ± 0.014[a] (1.965-1.998)
MRL (mg/kg)			5		1
MPC (mg/kg)	150		10	0.05	1.5
TA (mg/kg)				0.5	

Purwanti, 2003

Potential for Mercury Toxicity

- Elemental Mercury is “quicksilver”
- Mercury occurs naturally in soil and in the atmosphere from volcanic emissions
- Mercury is extracted and used in industry, then enters air or water from pollution

Elemental Mercury

- Also referred to as “inorganic” mercury along with mercury salts
- Very toxic to the nervous system, also to kidneys
- But….**very poorly absorbed by the GI tract so ingestion poses little risk**
- Inhalation route gives higher exposure
- Mercury in fillings is inorganic

Toxicity of Organic Mercury

- Mercury can be formulated as an organic compound with strong anti-microbial properties
- the form of mercury with the most toxicity concerns
- Methylmercury (organic) is far more toxic than other forms and is well absorbed when ingested

Mercury

- Methylmercury may induce alterations in the normal development of the brain of infants and at higher levels may induce neurological changes in adults.
- Mercury contaminates mostly fish and fishery products.

Organic Mercury Poisoning

- Minimata, Japan, 50 years ago…Seafood from the bay was polluted with mercury from an industrial source, many cases of neurotoxcity were seen, directly related to seafood consumption
- Most striking was the vulnerability of the fetal brain to mercury toxicity shown by the high rate of cerebral palsy in children born during this period

Methylmercury Sources of Exposure

- Elemental mercury is biotransformed by bacteria into methyl mercury and then the bacteria are eaten by mollusks, crustaceans etc.
- Poorly eliminated so it concentrates up the food chain… Biggest and oldest predators at the top of the ecosystem have the highest concentrations
- Methylmercury is distributed evenly throughout the fish and is not changed by cooking

What Fish are Low in Mercury?

- Ocean fish are less likely to have industrial contamination than lake fish
- Fish that are not predators
- Smaller, “Pan-sized” fish
- Salmon – (except large, lake salmon)
- Data is lacking on many species

Mercury- How Much is Toxic?

- To follow US EPA reference dose:
  - Fish with levels of 1 part per million or greater should not be eaten at all
  - Fish with levels greater than 0.2 ppm need to be limited to about once per week

PERSISTENT ORGANIC POLLUTANTS (POPs)

- POPs are very stable compounds and can persist in the environment for years or decades.
- They can circulate globally through a process known as the ‘‘grasshopper effect.’’ → POPs released from one part of the world can, through a repeated (and often seasonal) process of evaporation and deposition, be transported through the atmosphere to the regions far away from the original source.

PERSISTENT ORGANIC POLLUTANTS (POPs)

- POP chemicals bioaccumulate through the food web and concentrate in living organisms through deposition in fatty tissues, where concentration can become magnified.
- They are highly toxic, causing an array of adverse effects, notably death, disease, and birth defects among humans and animals.
- Specific effects can include: cancer, allergies and hypersensitivity, damage to nervous systems, reproductive disorders, disruption of the immune system, and endocrine disruptors.

PERSISTENT ORGANIC POLLUTANTS (POPs)

Pesticides	Industrial toxins/ by-products
▪ Aldrin ▪ Chlordane ▪ Endrin ▪ Dichlorodiphenyltrichloroethane (DDT) ▪ Dieldrin ▪ Heptachlor ▪ Mirex ▪ Toxaphene	▪ Polychlorinated biphenyls (PCBs) ▪ Furans ▪ Dioxins

United Nation Environmental Program (1998)

*** High biomagnification**

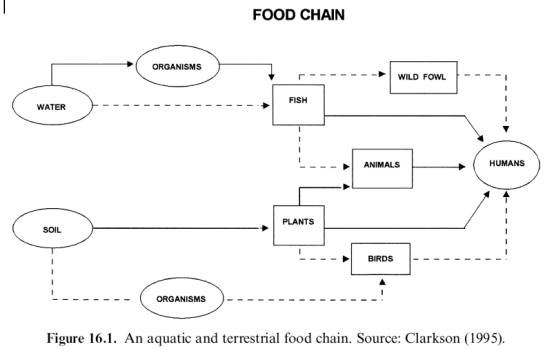


Figure 16.1. An aquatic and terrestrial food chain. Source: Clarkson (1995).

PERSISTENT ORGANIC POLLUTANTS (POPs)

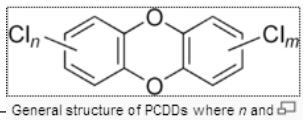
- POPs tend to accumulate in the food chain.
- They are stable in water and other compartments of the aquatic system.
- They are metabolically stable in species involved in the food chain including fish and mammals.
- Their toxicity is usually greater in higher-order mammals than in species of lower phylogenic order.

Major Food Contaminants of Industrial Origin

Chemical	Source	Food Contaminated
Polychlorinated biphenyls	Electric industry[b]	Fish, human milk
Dioxins	Impurities in chlorophenols Incinerator emission	Fish, milk, beef fat
Pentachlorophenol (PCP)	Wood preservative	Various foods
Dibenzofurans	Impurities in PCP and PCB	Fish
Hexachlorobenzene	Fungicide, by-product	Animal fat Dairy products Human milk
Mirex	Pesticide	Fish Edible mammals Human milk
DDT[c] and related halogenated hydrocarbons	Pesticides	Fish Human milk

Dioxins

- Dioxins 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.
- Dioxins are a colourless and odourless



General structure of PCDDs where *n* and *m* can range from 0 to 4

Dioxins

- The term dioxin refers to a broad family of chemicals. Of the 210 different dioxin compounds, only 17 are of toxicological concern. The most widely studied and most toxic form of dioxin is 2,3,7,8-tetrachlorodibenzo-p-dioxin, abbreviated as 2,3,7,8- TCDD.
- It is measured in parts per trillion (ppt).

Dioxins

- Dioxins are often man-made contaminants and are formed as unwanted by-products of industrial chemical processes, such as the manufacture of paints, steel, pesticides and other synthetic chemicals, wood pulp and paper bleaching, and also in emissions from vehicle exhausts and incineration.
- Dioxins are also produced naturally during volcanic eruptions and forest fires.
- Most industrial releases of dioxins are strictly controlled under pollution prevention and control regulations. Currently, the major environmental source of dioxins is incineration.

Dioxins

- Dioxins are ubiquitous environmental contaminants, having been found in soil, surface water, sediment, plants, and animal tissue worldwide.
- They are highly persistent in the environment with half-lives ranging from months to years.
- They have low water-solubility and low volatility, meaning that they remain in soil and sediments that serve as environmental reservoirs from which the dioxins may be released over many years.
- Dioxin concentrates in the fatty tissues of beef and dairy cattle, poultry, pork or seafood.

Dioxins

- Dioxins enter the food chain through a variety of routes.
  - Grazing animals and growing vegetables may be exposed directly, or indirectly, to these contaminants in the soil.
  - Leafy vegetables can also become contaminated through airborne transport of dioxins.
  - Dioxins in surface waters and sediments are accumulated by aquatic organisms and bio-accumulated through the food chain. The concentration of dioxins in fish may be hundreds to thousands of times higher than the concentrations found in surrounding water and sediments.

Dioxins

- Because dioxins are not very soluble in water, they tend to accumulate in the fatty tissues of animals and fish.
- Theoretically, the longer the lifespan of the animal, the longer the time it has to accumulate dioxins.
- Foods that are high in animal fat, such as milk, meat, fish, eggs and related products are the main source of dioxins, and contribute about 80% of the overall human exposure, although almost all foods will contain these contaminants at some (generally very low) level owing to their ubiquitous nature.

Dioxins

- Dioxins are highly stable with reportedly long half-lives.
- In animals, they accumulate in fat and in the liver and are only very slowly metabolised by oxidation or reductive dechlorination and conjugation. They are therefore likely to persist in animal tissues, especially fatty tissue, for long periods.
- They are not generally affected significantly by food processing such as heat treatments, or fermentation.

Dioxins

- The main contributors to the average daily human intake of dioxins have been found to be:
  - milk and dairy products, contributing between 16 and 39%;
  - meat and meat products, contributing between 6 and 32%;
  - fish and fish products, contributing between 11 and 63%.
  - Other foods, mainly vegetables and cereals, contributed 6-26% in the countries for which data was available

(Codex Alimentarius Commission, 2001).

Dioxins

- Human milk can contain elevated levels of dioxins, some of which can pass to the infant during lactation.
- It is estimated that the average dietary intake of dioxins has fallen amongst adults in the UK from 1.8 picograms World Health Organization toxic equivalents (WHO-TEQ)/kg* of bodyweight per day in 1997 to 0.9 picograms WHO-TEQ/kg bodyweight per day in 2001. Similar decreases have been reported in other countries.
- In November 2001, the Independent Committee on Toxicity recommended a TDI (tolerable daily intake) of 2 picograms WHO-TEQ/kg of bodyweight per day.

Dioxins

- Humans accumulate dioxins in fatty tissue mostly by eating dioxin-contaminated foods.
- The toxicity of dioxins is related to the amount accumulated in the body during the lifetime. Dioxins have a broad range of toxic and biochemical effects, and some are classified as human carcinogens.
- In animal testing, dioxins have been implicated in causing damage to the immune and reproductive systems, developmental effects and neuro-behavioural effects.
- The most commonly observed adverse health effect in humans following acute over-exposure to dioxins is the skin disease chloracne, a particularly severe and prolonged acne-like skin disorder.

Regulation (EC) 1881/2006 sets maximum levels for certain contaminants, including dioxins in foods.

The limits for dioxins (EC 1881/2006)	
Foodstuff	**Maximum Levels (Sum of dioxins)**
Meat from bovine animals and sheep	3.0 pg/g fat
Meat from poultry	2.0 pg/g fat
Meat from pigs	1.0 pg/g fat
Liver of terrestrial animals above and derived products thereof	6.0 pg/g fat
Muscle meat of fish and fishery products and products thereof, excluding eel. 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)	4.0 pg/g wet weight
Muscle meat of eel (Anguilla anguilla) and products thereof	4.0 pg/g wet weight
Raw milk and dairy products including butterfat	3.0 pg/g fat
Hen eggs and egg products	3.0 pg/g fat
Bovine and sheep fat	3.0 pg/g fat
Poultry fat	2.0 pg/g fat
Pig fat	1.0 pg/g fat
Vegetable oils and fats	0.75 pg/g fat
Marine oils (fish body oil, fish liver oil and oils of other marine organisms intended for human consumption)	2.0 pg/g fat

www.food.gov.uk

FOOD STANDARDS AGENCY

Table 1: Maximum limits and action levels (ng WHO-TEQ/kg) for dioxins in foods

Foods	MAXIMUM LEVELS APPLICABLE UNTIL 31.12.2005 (ng WHO-TEQ/kg fat basis except for fish and other foods)	ACTION LEVELS (ng WHO-TEQ/kg fat basis except for fish and other foods)
Meat and meat products originating from		
- Ruminants (bovine animals, sheep)	3	2
- Poultry and farmed game	2	1.5
- Pigs	1	0.6
Liver	6	4
Fish and fishery products*	4 (fresh weight)	3 (fresh weight)
Milk and milk products, including butter fat	3	2
Eggs and egg products**	3	2
Oils and fats		
- Animal fat		
- From ruminants	3	2
- From poultry and farmed game	2	1.5
- From pigs	1	0.6
- Mixed animal fat	2	1.5
- Vegetable oil	0.75	0.5
- Fish oil intended for human consumption	2	1.5
Fruits, Vegetables and Cereals	-	0.4 (fresh weight)

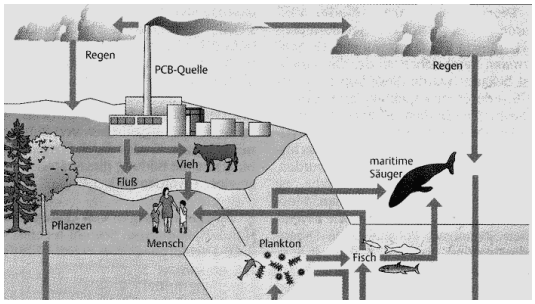
Notes: * excluding brown meat of crab and cephalopods with viscera
** excluding free range and semi-intensive eggs until 31 December 2004

Polychlorinated biphenyls (PCBs)

- PCBs, or polychlorinated biphenyls, are chlorinated aromatic hydrocarbons produced by the direct chlorination of biphenyls.
- There are about 209 related PCBs, known as congeners of PCBs, of which 20 reportedly have toxicological effects.
- Some of the PCBs have toxicological properties similar to those of dioxins and are therefore often referred to as ‘‘dioxin-like PCBs’’.

Polychlorinated biphenyls (PCBs)

- Like dioxins, PCBs are widespread environmental contaminants and are very persistent in soil and sediments.
- PCBs enter the food chain through a variety of routes.
  - Grazing animals and growing vegetables may be exposed directly, or indirectly, to these contaminants in the soil.
  - Leafy vegetables, pasture and roughage can also become contaminated through airborne transport of PCBs.



www.eco-knowhow.eu

Polychlorinated biphenyls (PCBs)

- Foods that are high in animal fat (such as milk, meat, fish, eggs and related products) are the main source of PCBs and contribute about 80% of the overall human exposure.
- In animals, PCBs accumulate in fat & in the liver, and are only very slowly metabolised by oxidation or reductive dechlorination and conjugation → likely to persist in animal fatty tissue, for long periods.
- They are not generally affected significantly by food processing such as heat treatments, or fermentation.
- TDI of PCBs: 2 picograms WHO-TEQ/kg of bw per day.

Polychlorinated biphenyls (PCBs)

- The most commonly observed adverse health effect in humans following acute over-exposure to PCBs is the skin disease chloracne, a particularly severe and prolonged acne-like skin disorder.
- The accidental contamination of edible rice bran oil with PCBs in Japan in 1968 led to a poisoning epidemic amongst those who consumed the oil.
- The poisoning caused chloracne, liver disturbances, abdominal pain, headaches, skin discolouration, and the birth of abnormally small babies to mothers who had consumed the oil.

Polychlorinated biphenyls (PCBs)

- There is very little scope for the removal PCBs from foods once they have entered the food chain.
- It is generally agreed that the best means for preventing PCBs from entering the food chain is to control their release into the environment.
- For example:
  European policy regulates the contamination levels of PCBs in the environment, and in food and feed, and has prohibited the use of most PCBs from 1978 and for certain applications from 1986. A deadline of 2010 has been set for removing all PCB-containing equipment from service.

Furans

- Furan (C4H4O, CAS No. 110-00-9) is a volatile heterocyclic organic chemical often found as an intermediate in industrial processes for producing synthetic polymer materials.
- Concern over furan in foods dates back to 2004, when FDA survey of heat-processed foods in the USA revealed that low levels of furan could be found in an unexpectedly large proportion of products processed in closed containers, such as cans and jars.
- Most of the positive samples recorded levels of furan of less than 100 ug/kg, but the Swiss survey found much higher concentrations (up to 5900 ug/kg) in some ground, roasted coffee samples.

Furans

- Furan is a possible human carcinogen, and therefore, even low levels in foods are undesirable.
- Furan is cytotoxic and the liver is the target organ for acute toxic effects.
- However, it is the effect of prolonged dietary exposure to furan and its possible carcinogenic potential.

Furans

- Furan is a by-product of the high temperatures involved in the heat processing of foods.
- Proposed sources of furan formation include the thermal degradation of reducing sugars alone, or in combination with amino acids, thermal degradation of some amino acids, and thermal oxidation of ascorbic acid, polyunsaturated fatty acids and carotenoids.
- The presence of furan residues in canned foods, and products in sealed jars and other containers, is probably a consequence of the volatile compound being trapped in the container.

Furans

- Furan is a highly volatile compound and is likely to be driven off quite quickly if foods are cooked, or reheated, in open vessels.

CHEMICAL HAZARDS PRODUCED DURING FOOD PROCESSING

3-MCPD

- The chloropropanols are a group of related chemical contaminants that may be produced in certain foods during processing.
- Chloropropanols are potentially carcinogenic and their presence in food, even at low levels is therefore undesirable.
- First became a concern in the late 1970s when small concentrations were found to be generated during the manufacture of acid-hydrolysed vegetable protein (acid-HVP).

3-MCPD

- Several different chloropropanols have been identified in food.
- The most common and the best studied is 3-monochloropropane-1,2-diol (3-MCPD), but other foodborne chloropropanols include 2-monochloro-1,3-propandiol (2-MCPD), 1,3-dichloro-2-propanol (1,3-DCP) and 2,3-dichloro-2-propanol (2,3-DCP).

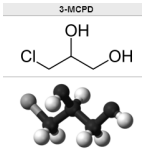
3-MCPD

- Acid-HVP is usually found in savoury foods such as soups, prepared meals, savoury snacks, gravy mixes and bouillon cubes.


3-MCPD

- 3-monochloropropane-1,2-diol (3-MCPD) is created during food processing under certain conditions, particularly during the manufacture of the savoury food ingredient 'hydrolysed vegetable protein' that is produced through the acid hydrolysis method (acid-HVP).





3-MCPD

- 3-MCPD has also been found in bread, biscuits and other baked products, coffee, roasted barley malt, certain cured and fermented-meat products, cheeses, salted fish and smoked foods → generally in low levels (0.01 – 0.5 mg/kg).
- It is thought that it is usually produced during the manufacturing process, especially at high temperatures, but the mechanism is not known in all cases.
- Foodborne chloropropanols may also be derived from migration from food-contact materials, such as sausage casings and teabags, and they can also be produced during domestic cooking of such foods as grilled cheese and meats.

3-MCPD

- **Roasted cereals, dark malts and dark malt extracts**
  - Information from the UK brewing and malting industries indicates that 3-MCPD levels of up to 0.3-0.4 mg/kg can occur in roasted cereals and dark specialty malts which are used to add color and flavor to most dark beers and some lagers.
  - Extracts derived from these ingredients, which are used to flavor certain foods and drinks, may also contain 3-MCPD levels of over 0.1 mg/kg.
  - However, due to the low levels of use of these ingredients, the concentrations of 3-MCPD in the final product are below 0.01 mg/kg.

3-MCPD

- **Fermented sausages**
  - Certain types of fermented sausage such as salami have also been shown to contain levels of 3-MCPD of up to 0.1 mg/kg.
  - This may be due to the formation of 3-MCPD within the meat (due to the interaction between fat and salt in the product, coupled with its long shelf-life) and/or due to the presence of 3-MCPD in the resins used in the sausage casings.
  - The casings industry is carrying out work at European level to determine the contribution of the casings to the 3-MCPD content of salami and, like other users of epichlorohydrin-based wet strength resins, has already started to use higher grade resins with much lower levels of 3-MCPD.

3-MCPD

- **Soy sauces**
  - Following the finding of high levels of 3-MCPD in Chinese soy sauce (6-124 mg/kg) in EU countries, in September 1999, 40 samples of soy sauce and similar products available on the UK market were surveyed.
  - The results showed that around two-thirds of the samples contained 3-MCPD at levels very close to or below the recommended limit of 0.01 mg/kg. However, the remaining one third of the samples contained levels above 0.01 mg/kg, the highest being 30 mg/kg. These products were imported from China and Hong Kong, Taiwan and the Philippines, indicating that higher levels are not restricted to any one country of origin.
  - Several grades of soy sauce are manufactured in the Far East, including the traditional fermented product as well as lower grades which can contain acid-HVP or which may be produced using an acid treatment. It is known that such acid treatments can generate very large amounts of 3-MCPD.

3-MCPD

- **Food contact materials**
  - Information from the packaging industry and others indicates that very low levels of 3-MCPD may migrate into food and beverages due to its presence in certain types of epichlorohydrin-based wet strength resins used in paper (e.g. tea bag paper, coffee filters, absorbent meat padding) and cellulose casings.
  - Work has been carried out by the industry to develop higher grade "third generation" resins which have significantly lower levels of 3-MCPD, and these are increasingly being used in the above applications.
  - With the increase in the availability and use of these resins, 3-MCPD exposure from this source will continue to decrease.

3-MCPD

- 3-MCPD may be formed in foods by the reaction of chloride (for example: chlorinated water or salt) in the food or a food contact material with lipids, the latter often being present only in trace amounts.
- It can occur in foods and food ingredients at low levels as a result of processing, migration from packaging materials during storage, or in domestic cooking.
- This reaction is encouraged during the heat processing of foods, including the roasting of cereals and malts used for brewing.

3-MCPD

- Chloropropanols are relatively non-volatile and may be quite persistent in foods once formed.
- However, degradation does occur during storage, and 3-MCPD has been shown to be lost more rapidly from foods at higher pH values and at higher temperatures.
- How to control the formation of chloroprophanols?
  - replacing acid hydrolysis with an enzymatic process;
  - reducing lipid concentrations in the raw materials;
  - effective control of the acid hydrolysis process;
  - use of an over-neutralisation treatment with NaOH to remove chlorohydrins after acid hydrolysis.

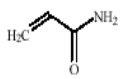
3-MCPD

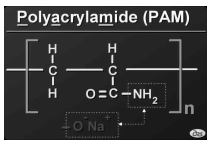
- Although chloropropanols can cause acute toxicity at high concentrations, it is extremely unlikely that this could occur through consumption of contaminated food, and it is the effect of low doses over a long time that is of most concern from a food safety point of view.
- Both 3-MCPD and 1,3-DCP have been shown to be carcinogenic in animal studies and are therefore potential human carcinogens.
- A provisional maximum tolerable daily intake (PMTDI) of 2 mg/kg body weight has thus been set to replace the previous recommendation that levels in foods should be reduced as far as technically possible.

Acrylamide

- What is acrylamide?
- Acrylamide is a chemical that is used to make polyacrylamide materials.
- Polyacrylamide is used in the treatment of drinking-water and waste water where it is used to remove particles and other impurities. It is also used to make glues, paper and cosmetics. Polyacrylamide materials contain very small amounts of acrylamide.

CH_2=CHCONH$_2$





CAS No. 79-06-1

Acrylamide - a versatile molecule

Building block for water-soluble polymers used as additives for:

- water treatment,
- enhanced oil recovery,
- flocculants,
- papermaking aids,
- thickeners,
- soil conditioning agents,
- sewage and waste treatment
- ore processing, and permanent-press fabrics"

What is the problem?

- In April 2002 the Swedish National Food Authority reported the presence of elevated levels of acrylamide in certain types of food processed at high temperatures.
- Acrylamide has been found in a range of cooked and heat-processed foods in other countries, including The Netherlands, Norway, Switzerland, the United Kingdom and the United States.
- Acrylamide is known to cause cancer in animals. Also, certain doses of acrylamide

- Previous studies of food likely to contain acrylamide found wide-ranging concentrations in potato chips, french fries, cookies, breakfast cereals, bread, as well as other foods that are also processed at high temperatures such as coffee, roasted almonds, and grain-based coffee substitutes.
- Of the foods tested by Health Canada, potato chips and french fries tended to contain the most acrylamide, while lower levels were found in soft breads and cereals.

BBC NEWS

Bread and crisps in cancer risk scare

Thursday, 25 April, 2002, 14:21 GMT 15:21 UK

Staple foods including bread, chips and crisps, may contain high levels of a substance believed to cause cancer, a study suggests.

Tests showed they all contain high quantities of acrylamide, a chemical which is classified as a probable human carcinogen.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

FAO cautious on findings of acrylamide in some fried and baked foods

ROME, 26 April 2002 -- It is too early to reach any firm conclusions on the unexpected finding of the toxic chemical acrylamide in fried and baked food by Sweden's National Food Administration, the UN Food and Agriculture Organization (FAO) said today. It added that it welcomed the suggestion by Swedish authorities to study the findings in co-operation with international organizations and has already requested access to the data.

FAO's comments came in the wake of an NFA announcement this week that a scientific group at the University of Stockholm found that acrylamide "probable human carcinogen" is formed during heating of starch-rich foods to high temperatures. The NFA also announced that it has developed a new, rapid method for the analysis of acrylamide in foods. It said the risks

Related links

- Sweden's National Food Administration
- Food and Nutrition Division
- Economic and Social Department

How does cooking produce acrylamide?

- Asparagine is an amino acid that is found in many vegetables, with higher concentrations in some varieties of potatoes.
- When heated to high temperatures in the presence of certain sugars, asparagine can form acrylamide.
- High-temperature cooking methods, such as frying, baking, or broiling, have been found to produce acrylamide, while boiling and microwaving appear less likely to do so.
- Longer cooking times can also increase acrylamide production when the cooking temperature is above 120 degrees Celsius

Is there anything in the cooking process that can be changed to lower dietary acrylamide exposure?

- Decreasing cooking time, blanching potatoes before frying, and postdrying (drying in a hot air oven after frying) have been shown to decrease the acrylamide content of some foods

Main findings

The presence of acrylamide in food is a major concern in humans based on the ability to induce cancer and heritable mutations in laboratory animals.

- Studies in rodent models have found that acrylamide exposure poses a risk for several types of cancer (1988-2003).
- However, the evidence from human studies is still incomplete.
- The National Toxicology Program (NTP) and the International Agency for Research on Cancer consider acrylamide to be a "probable human carcinogen," based on studies in laboratory animals given acrylamide in drinking water.
- However, toxicology studies (2006) have shown differences in acrylamide absorption rates between humans and rodents.

Toxicity of acrylamide

- Quantitative risk assessment models should be investigated on the basis of scientific merit and uncertainty of estimates.
- The dose-response characteristics of acrylamide and glycidamide relative to toxicity, disposition, and binding to DNA and macromolecules need to be further assessed.

Interim advice

- Food should not be cooked excessively, i.e. for too long or at too high a temperature. However, all food, particularly meat and meat products, should be cooked thoroughly to destroy foodborne pathogens.
- The information available on acrylamide so far reinforces general advice on healthy eating. People should eat a balanced and varied diet, which includes plenty of fruit and vegetables, and should moderate their consumption of fried and fatty foods.

THANK YOU…