

# Food toxicology

Food production and catering services - increased control by the state.

Basic requirements for food quality and health safety:

- Act No. 110/1997 Coll. on food and tobacco products
- implementing decrees of the Ministry of Agriculture and Health.

Public law protection (Act No. 59/1998 Coll.) - includes sanctions for violation of established obligations - fines. Control by state supervisory authorities.

Injured consumer – can claim compensation for the damage caused (e.g. lost wages during illness; recourse claims of the insurance company for costs associated with treatment, etc.)

The manufacturer also has criminal liability (criminal offense of public endangerment, special criminal offense of endangering health with harmful food and other necessities).

## Health hazards from food and dishes

- the health risk from eating food is almost unlimited
- absolute food safety cannot be guaranteed
- but the risk can be minimized by:
  - compliance with technological procedures
  - elimination of all factors and causes that could negatively affect the safety of food
- Risk factors:
  - biological
  - chemical
  - physical

## Biological hazards

The main and most widespread source of food contamination are microorganisms:

- pathogenic bacteria,
- toxinogenic bacteria and fungi,
- viruses.

Other biological agents: plants and animals.

### Bacteria

- bacterial food poisoning – bacteria multiply in food and a large increase causes illness after eating the food
  - **infectious type** – bacteria continue to grow in the host's body; endotoxin is released after cell breakdown; symptoms of poisoning - acute gastroenteritis (salmonella)
  - **toxic type** – causes "real" poisoning; the toxic substance is released into the food during the growth of bacteria, even before it is ingested; manifestation of poisoning – **acute gastroenteritis**, but ingestion of bacteria is not a necessary condition (*Clostridium perfringens*, *Staphylococcus aureus*)

### Salmonella

- sensitive to higher temperatures, heating to 60 °C for 15–20 min is enough to destroy it
- infectious dose 10<sup>6</sup>–10<sup>10</sup> cells/g food, incubation period 8–36 hours, most often 8–10 hours
- manifestations - vomiting, abdominal pain, diarrhea, fever, severe dehydration of the body; mortality below 1% (small children, debilitated individuals)

### Clostridium perfringens

- spores, very resistant to higher temperatures
- 5 types of clostridia according to the produced toxin AE, intoxication AC
- type A common – manifestation – diarrheal disease; type C rare – acute necrosis ending in bowel perforation, mortality around 50%
- infectious dose 10<sup>6</sup>, incubation period 6–22 h
- are among the most widespread pathogenic bacteria (water, soil)

### Staphylococcus aureus

- produces 6 types of AF toxins, polypeptide nature, the most widespread type A, can be combined with D

- high thermal stability, can withstand boiling for 30 min
- infectious dose >10<sup>6</sup>, incubation period 1-6 hours
- manifestations: nausea, vomiting, abdominal cramps, diarrhea, mortality very low

- bacterial infection caused by food:

- the food has the function of transmitting an infectious organism, the bacteria do not have to multiply in the food

Different types of diseases linked to certain types of food:

- salmonellosis – eggs, egg products, meat, meat products insufficiently heat treated
- listeriosis – dairy products, cheeses made from unpasteurized milk

### **Listeria monocytogenes**

- grows in a wide temperature range of 1-45 °C, a hazard for refrigerated foods
- dangerous only for weakened individuals, possibility of meningitis and septicemia - danger of death; lethality 30-50%!
- incubation around 14 days, range 4-21 days

### **Another bacteria affecting food safety**

#### **Bacillus cereus**

- produces 2 different toxins, one thermolabile (decomposes within 30 min. at 56 °C), symptoms in 10-13 hours, course like *C. perfringens*
- the second resistant (can withstand 126 °C for 90 min.), symptoms in 1-5 hours, course as after *S. aureus*

#### **Clostridium botulinum**

- 8 different types, form spores, type A, B, E toxic to humans, extremely heat resistant; type C, D toxic to animals including birds, lower heat resistance
- botulinum toxins – proteinaceous in nature, they are among the most effective toxins
- symptoms in 6-36 hours, abdominal pain, vomiting, blurred (double) vision, difficulty swallowing, weakness of limb muscles, paralysis of respiratory muscles and heart; if antiserum is not given in time - death

#### **Escherichia coli**

- non-pathogenic and pathogenic - divided into 4 groups
- enteropathogenic - diarrhea in children
- enterotoxigenic - diarrhea in children and adults; cause of "traveler's diarrhea"
- enteroinvasive - causes a number of other diseases - inflammation of the colon, dysentery with bloody stools and fevers
- enterohemorrhagic - cause hemorrhagic appendicitis, hemolytic uremic syndrome ending in death in young and old patients

#### **Shigella**

- the most dangerous *S. dysenteriae*, causes dysentery; other types of diarrheal diseases
- highly pathogenic, 10 cells are enough to cause disease

#### **Toxinogenic fungi**

- form toxic metabolites mycotoxins; the cause not only of mild diseases such as gastroenteritis, but also of malignant tumors
- risky foods: marmalades, jams, nuts, dried fruits and vegetables, dried dairy products, pastries, bread, grains, flour, pasta

The most serious mycotoxins produced by genera:

'- *Aspergillus*, *Penicillium* and *Fusarium*

#### **Aspergillus flavus and oryza**

- aflatoxins, the most toxic aflatoxin B1
- also ochratoxin – mutagenic and carcinogenic effects, death in small children
- aflatoxins are not very lipophilic, they easily pass into the more hydrophilic part of the raw material
- thermal operations lead to partial losses, but ochratoxin is thermostable

#### **Penicillium**

- toxins are cyclopiazonic acid, patulin, citrine



Salmonella

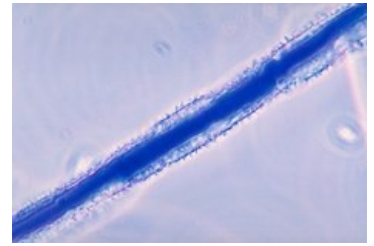


Staphylococcus aureus

- patulin in fruit and vegetable products from overripe and damaged fruits,
- decrease during thermal operations, especially during prolonged microwave heating; also during ethanol fermentation

## Fusarium

- trichothecenes, zearalenone, deoxynvalenone, fumonisins
- frequent contaminants of cereals, deterioration of entire crops
- accumulation in bran (DON), bread production does not lead to their reduction
- risk reduction - careful control and selection of input raw materials



Aspergillus flavus

## Viruses

- a number of viruses transmitted through food and water
- human digestive tract infection
- food can be infected with them, but the viruses do not reproduce in them, they only survive
- some inactivated by short-term heating to 72 °C, others by boiling

resistant hepatitis viruses and oyster enteroviruses

- generally high infectivity, even one virus particle is enough for a sensitive person
- dangerous raw meat, shellfish and molluscs; they can concentrate viruses of human origin from polluted waters

## Parasites

### *Protozoa:*

#### Giardia

- form cysts, found in vegetable salads and fruits, cause intestinal infectious diseases; killed during heat treatment

#### Entamoeba histolytica

- causes dysentery, widespread in places with very poor hygiene

### *Sporozoite protozoa:*

#### Toxoplasmosis gondii

- food infection rare, after ingestion of undercooked meat, course of mild flu, dangerous for pregnant women



Giardia

#### Sarcocystis

- mild disease symptoms, vomiting, diarrhea

#### Cryptosporidium

- an infection with a diarrheal nature, serious for individuals with a compromised immune system

### *Flatworms:*

#### a termatode

- liver fluke in the bile duct of cattle and sheep, intermediate host snail
- symptoms of the disease in humans: fever, fatigue, loss of appetite and abdominal pain

#### Cestidea

- long-limbed tapeworm, intermediate host pig
- the larva settles in the muscle; it remains in this state until it is eaten by a human
- transfer can be prevented by proper heat treatment
- symptoms of the disease - vomiting, abdominal pain, anemia, nervous system disorders, weight loss

## Chemical hazards

- is related to the occurrence of various types of organic and inorganic pollutants
- possibilities of contamination:
  - already in the initial raw materials
  - secondary contamination: in the process of food production or preparation; during transport or storage
- hygienic limits, i.e. maximum permissible quantities, are usually specified in legislative regulations for the following substances

## Environmental contamination

- persistent, difficult-to-degrade substances
  - polychlorinated dibenzodioxins/furans (carcinogenic)
  - polychlorinated biphenyls
  - "classic" chlorinated pesticides (DDT), banned today
  - accumulates in fatty tissues
  - source – contaminated food or feed, atmospheric emissions (e.g. polycyclic aromatic compounds, some such as benzo/a/pyrene – carcinogenic effect)

## Modern pesticides

- several hundred active substances registered
- represent various groups of chemical compounds (organophosphates, carbamates, azoles, pyrethroids, etc.), their residues in raw materials
- mostly not very stable, transformed into relatively non-toxic products by the action of physico-chemical factors and biodegradation
- their residues can be eliminated during input operations (mechanical treatment – peeling, grinding of rice, removal of husks) and further processing (washing, blanching, drying, thickening, pasteurization, sterilization)
- but sometimes the possibility of concentration during the processing of the raw material, mostly removed during further processing; concentration often in the waste products of press during the production of juices, matolina during the production of wine
- the risk of residue findings is higher in the case of post-harvest application (grain protection against pest attack, potato germination retardants) than pre-harvest
- the occurrence of residues above the hygienic limit is rare, usually not exceeding 1-2%

## Veterinary medicines

- occurrence is related to productivity growth in animal production
- application of drugs (antimicrobial, anti-inflammatory, antiparasitic, antibiotics)
- sometimes hormones and various stimulants
- residues in meat, milk, eggs
- danger to consumers (resistance)
- complications in the production of fermented milk products and cheeses
- prevention – consistent compliance with protective deadlines in the production sphere

## Toxic minerals

- commonly observed toxic metals Pb, Cd, As, Hg
- uneven distribution in crops and livestock organisms of higher levels in root parts and leaves; in the liver and kidneys
- in domestic raw materials, exceeding limit findings are rare

nitrates and nitrites: origin - fertilizers and food additives!

- dangerous especially for small children; excess nitrites cause methemoglobinemia
- formation of carcinogenic nitrosamines

## Substances arising during technological processing and storage

- nitrosamines – in smoked meats and cheeses, fish and some drinks (beer); modification of production procedures
- toxic and non-nutritive products during lipid oxidation or non-enzymatic browning reactions – mutagenic heterocyclic primary amines, formed e.g. when frying or grilling meat; hygienic limits have not yet been established;
- toxic chloropropanols – produced during the production of protein hydrolysates (seasoning mixtures and flavorings, e.g. soy sauce) – limits established since 2002 for 3-chloropropane-1,2-diol
- urethane (ethyl carbamate) – carcinogenic effects, high findings were found in stone fruit distillates (plum wine); modification of the production process
- some biogenic amines (histamine, tyramine, cadaverine, putrescine) – fresh fish and meat; the need to strictly observe hygienic conditions

## Natural toxic compounds

- mycotoxins
- toxic plant components – components of commonly used foods, the amount depends on the variety, climatic and soil conditions, storage, technological procedure
- hygienic limits for glycoalkaloids
  - potato –  $\alpha$ -solanine,  $\alpha$ -chaconine
  - tomatoes - tomatin
- normal content 0.002-0.01%. Faulty from 0.2%
- solanine - unripe potatoes (0.06%), old sprouted tubers (up to 0.5% in sprouts), up to 1% in fruits.
- toxic dose 0.3g
- signs of poisoning - scratching and sore throat, nausea, vomiting, diarrhea, colic, fever, reddened face, blue

- lips
- these substances
  - they increase the permeability of membranes
  - cause the risk of developing allergies to natural food components
- cyanogenic glycosides - in stone fruit kernels, bitter almonds and some other crops (cassava) - precursor of hydrogen cyanide;
- it can be released in the initial stage of heat treatment of compotes, where the seeds have not been removed
- problems with natural toxins especially consumers with metabolic disorders – phenylketonuria, lactose intolerance

## Physical danger

- mechanical impurities, sharp and hard objects:
  - endogenous (from raw materials) – stones, clay, sand, shells, bones, feathers
  - exogenous (from the environment) –
    - personal items – paper clips, buttons, cigarette butts, coins, parts of textiles)
    - from technology and the environment – rust, peeling paint, shards of glass, screws, plaster
- The safety and quality of food is related to compliance with good production and hygiene practices.
- A critical point prevention system (HACCP) is in place, which:
  - prevents, identifies and evaluates the risk of endangering the health of the consumer, diner before it can arise
  - indicates what procedures and means are necessary to prevent the danger before it can manifest itself

## Food supplements - additives

- substances added to food in order to improve taste, smell, appearance or durability since ancient times, their number limited until the beginning of the 20th century
- development with increasing knowledge of physical and chemical processes, over 2,500 different substances are added to food in the US
- in our country, the use of additives exploded after 1989, at the same time a new food law was adopted, and the consumer learns about additives from the information on the packaging
- food additives are indicated by the international code E
- additives are classified into groups according to the purpose for which they are used, there are a large number of them

### Examples:

- *antioxidants (E 300 – E 321)*
- *dyes (E 100 – E 182)*
- *preservatives or antimicrobial substances (E 200 – E 290)*
- *acidifying agents and acidity modifiers*
- *melting salts*
- *leavening agents*
- *substitute sweeteners and many others*

## Can additives be harmful?

- some occur naturally in food, others act as vitamins and mineral sources, have been used for years and are considered safe
- various adverse effects associated with others: allergies, asthma attacks, diarrhoea, the formation of tumors, adverse effects on reproduction and fetal development
- an acceptable daily dose is determined, which should not cause health risks during daily consumption; but beware of consuming a number of others - multiple effects
- but the main problem lies in the foods in which they are found - additives often mask cheap substitutes used in the production of the food
- additives tested on animals
- adverse reactions in some people to additives
  - pseudoallergy
  - hypersensitivity to additives;
  - manifestations - skin (hives),
  - problems with the digestive system (abdominal pain, bloating, nausea, diarrhea),
  - neurological (headaches, muscle pains, malaise, visual disturbances, etc.)
- baby food – presence of additives limited to a few time-proven and safe substances; however, this is not taken into account for other foods mainly consumed by children, e.g. synthetic dyes in candies, dyes and artificial sweeteners in sodas, chewing gum and yogurts (especially "light" yogurts); instant soups with a high content of monosodium glutamate and other additives such as dyes, flavorings, modified starches and others are also unsuitable

## Sodium glutamane

- originally isolated from kombu algae in Japan, it adds a distinct flavor to food
- one of the most widely used additives
- adverse effects in sensitive persons: headache, chest pressure, burning of the forearm and back of the neck (Chinese restaurant syndrome); sometimes also perception disorders, hallucinations, nausea, vomiting, shortness of breath and drowsiness
- danger to people on a low-sodium diet
- sometimes they cause asthma attacks - either within 2 hours after a meal, accompanied by Chinese restaurant syndrome, or the attacks themselves with a latency of 10-14 hours
- prohibited in baby food and baby food
- permitted in limited quantities in foodstuffs, except soft drinks

## Nutritional supplements

- nutritional supplement with increased energy, protein and mineral content
- designed for people with increased nutritional requirements
- the exact composition must be indicated on the packaging - the content of fatty acids, vitamins, minerals, trace elements in weight units of µg, mg, g /10g or 100 ml of food, which give the food special nutritional properties specified by decree 336/97 MZ
- protein origin, vegetable or animal
- total content of added vitamins and minerals
- often used by athletes to quickly replenish energy and correct ion balance
- sometimes problems during doping controls (excessive caffeine content, presence of prohibited substances, e.g. ephedrine)

## Links

### Source

- BALÍKOVÁ, Marie. *Potravinářská toxikologie* [online]. [cit. 2012-03-13]. <<https://el.lf1.cuni.cz/p55625531/>>.
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