

FOOD TOXINS

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Definition

- Toxicity can be defined as “the capacity of a substance to cause adverse health effects on a living organism” (Altug, 2002).
- Paracelsus evidence-“All substances are poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy.”
- Generally, food toxins are substances that cause foods to become toxic.

Food toxins

- Food is not only the elementary source of nutrients for humans but may also contain natural chemical substances with toxic properties.
- Some substances which are naturally occurring include cyanogenic glycosides, solanine, industrial pollutants, biogenic amines and mycotoxins. (Dabrowski & Sikorski, 2004).

General classification of food toxins

- **Physical:** glass, stone, metal, wood, etc.
- **Chemical-** natural toxins, residues, pesticides, metals, toxins formed during food processing.
- **Microbiological:** pathogenic microorganisms (bacteria, viruses, parasites, etc).

Further classification of food toxins

- 1) Natural toxins of plant origin
 - 1) Nitrogen containing e.g. alkaloids and glycosides.
 - 2) Nitrogen free e.g. organic acid and phenolic toxins.
- 2) Toxins of Animal origin
 - 1) Animal liver e.g. Bile acids and vitamin A
 - 2) Marine animals e.g. saxitoxin, tetrodotoxin etc.
- 3) Fungal toxins e.g. mycotoxins of ergotism, aflatoxins.
- 4) Food toxins from industrial wastes
 - 1) Chlorinated hydrocarbons e.g. polychlorinated biphenyls
 - 2) Heavy metals e.g. Lead, mercury and cadmium

Further classification of food toxins cntd.

- 5) Bacterial toxins e.g. Cholera toxin and E. coli enterotoxin
- 6) Toxins from pesticide residues e.g. DDT and Chlorinated cyclodiene insecticide
- 7) Toxins from food additives and preservatives e.g. benzoic acid
- 8) Toxins formed during food processing e.g. polycyclic aromatic hydrocarbons, N-nitrosamines

Natural toxins of plant origin

- According to Dabrowski and Sikorski (2004) over 100,000 secondary compounds have been identified and categorized into two major classes:
 - Nitrogen containing compounds that include alkaloids, glycosides, proteins, polypeptides, amines and non protein amino acids.
 - Nitrogen free compounds that include some organic acids, alcohols, polyacetylenes, resinous toxins and mineral toxins.

- Lupine alkaloids are stored in epidermal cells and in seeds (Wink et al., 1995).
- Livestock deaths have generally occurred under conditions in which animals consume large amounts of pods or toxic plants in a brief period of time.



TERATOGENIC EFFECTS OF LUPINES.

Natural toxins of plant origin cntd.

- Cyanogenic glycosides are glycosides from which cyanide is formed by the activity of hydrolytic enzymes. They are widely spread in higher plants.
- Can be found in food plants like cassava, lima beans and the seed of some fruits (e.g. peaches) → cyanide content
- Fresh cassava cortex produces cyanide in quantities ranging from 1.0 to more than 60.0 mg per 100 g, depending on several conditions, including variety, source, time of harvest and field conditions.

Table 2.2 Hydrogen cyanide contents of some foodstuffs

Food	HCN (mg/100 g)
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Lima beans	210–310
Almonds	250
Sorghum sp.	250
Cassava	110
Peas	2.3
Beans	2.0
Chick peas	0.8

Toxins of Animal origin

- The animal liver is a nutritious protein-rich food in which important enzymes are concentrated. In dried bear liver, the bile acid acts as a suppressant on the central nervous system (Shibamoto, Bjeldanes, & Taylor, 2012).
- Vitamin A is necessary for normal growth and vision in animals although it is toxic to humans at the level of 2-5 million IU (one IU corresponds to 0.3mg of pure crystalline vitamin A)

Fungal toxins

- Mushroom toxicity is Caused by the high content of amatoxins in mushrooms.
- Mushrooms identified as containing amatoxin toxins are the species *Amanita bisporigera*, *A. temifolia*, *A. ocreata*, *A. suballiacea*, *Galerina autumnalis*, and *Lipiota brunneolilacea*.
- There are four categories of mushroom toxins:
 1. Neurotoxins
 2. Protoplasmic poisons
 3. Gastrointestinal irritants
 4. Disulfiram-like toxins

Fungal toxins contd.

- Aflatoxins are the most important mycotoxins, which is produced by certain species of *Aspergillus* (*A. flavus* and *A. parasiticus*), which develop at high temperatures and humidity levels.
- Aflatoxins are carcinogenic substances and may be present in a large number of foods. This toxin can cause cancer, cirrhosis of the liver.
- For substances of this type there is no threshold below which no harmful effect is observed.

Fungal toxins contd.

- The most common commodities contaminated are tree nuts, peanuts, and corn and cottonseed oil.
- The major aflatoxins of concern are B1, B2, G1, and G2 → usually found together in various proportions. Aflatoxin B is usually predominant, and it is the most toxic and carcinogenic.
- TLC method can detect aflatoxins.

Bacterial toxins

Organism	Effects	Organism	Toxins and effects
<i>Shigella</i>	Colonization and invasion of epithelial cells in large intestine Replication in cytoplasm	<i>Aeromonas</i> sp.	Endotoxins, exotoxins, invasins, extracellular enzymes, adhesions, siderophores
<i>Salmonella</i>	Colonization of intestinal mucosa, invasion of enterocytes and M cells Replication in vacuoles (diarrhoeogenic enterotoxin, cytotoxin, Vi antigen, LPS, porins)	<i>Escherichia coli</i> EHEC	Shiga family toxins (verotoxins): Stx, Stx1, Stx2, Stxc, Stxe; attachment to cells via fimbriae
<i>Listeria monocytogenes</i>	Proliferation in cytoplasm of different tissues (facultative intracellular pathogen)	<i>Vibrio cholerae</i> 01, 0139, non-01 / non-0139	Cholera toxin – enterotoxin (main dehydrating diarrhea toxin) Zonula occludens toxin (responsible for increase in permeability of intestinal mucosa) Accessory cholera enterotoxin Hemolysin Emetic toxin (vomiting) Enterotoxins (diarrheal illness)
<i>Yersinia enterocolitica</i>	Proliferation in gut associated lymphoid tissue (facultative intracellular pathogen)(heat stable enterotoxin, LPS, invasin, attachment/invasion protein adhesion Ail)	<i>Bacillus cereus</i>	Enterotoxin (type A food poisoning) Beta toxin (necrotic enteritis)
<i>Campylobacter jejuni</i>	May interact and probably invade M cells in the Peyer's patches (cholera like toxin, hepatotoxin, cytolethal distending toxin, heat labile enterotoxin)	<i>Clostridium perfringens</i>	

Foods that have been poisoned with any of the previously mentioned bacteria forms may lead to poisoning and so the above mentioned pathogens are food toxicants. (Dabrowski & Sikorski, 2004)

- Toxic substances such as dioxins, mycotoxins, heavy metals, pesticides, veterinary drugs and polycyclic aromatic hydrocarbons are almost ubiquitous in the environment. Thus, they are also present in ingredients for animal feed.
- Depending on their physico-chemical characteristics, some substances are metabolized into naturally occurring and generally harmless constituents. Most veterinary drugs and feed additives fall into this group.
(Kan & Meijer, 2007)

Food toxins from industrial wastes

- Other substances are persistent and remain in the animal and in animal products, like dioxins. Heavy metals are not metabolized at all. Some metals irreversibly are bound to body tissues, e.g. lead to bone or cadmium to kidneys.
- They result from either agricultural or industrial production or through accidental or deliberate misuse.
- These heavy metals include lead, cadmium, mercury and arsenic.

Toxins from pesticide residues

- For food toxicology the important categories of target organisms are insecticides, fungicides and herbicides.
- Glory years of nobel prize discovery, DDT.

References

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- Wink, M., Meibner, C. and Witte, L.(1995). Patterns of quinolizidine alkaloids in 56 species of the genus *Lupinus*, *Phytochemistry*, 38, 139 – 153.