Chemical contaminants in food- Does the food industry pay adequate attention?

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Chemical Hazards- An Introduction

- Toxic substances and other chemicals that make food unsafe
- Less apparent than biological hazards
- Acute toxicity uncommon; Chronic exposure and resulting aftereffects
- Associated with high profile food safety recalls and withdrawals.

Chemical Hazards and HACCP

- HACCP Principles require identification of chemical hazards during hazard identification and risk assessment stage
- Appropriate controls to be in place to reduce their potential to occur and impact
- Common to overlook or incorrectly assess
- Poor understanding of chemical hazards, science of toxicology and mechanisms behind the effects of chemicals on human body

Toxicology

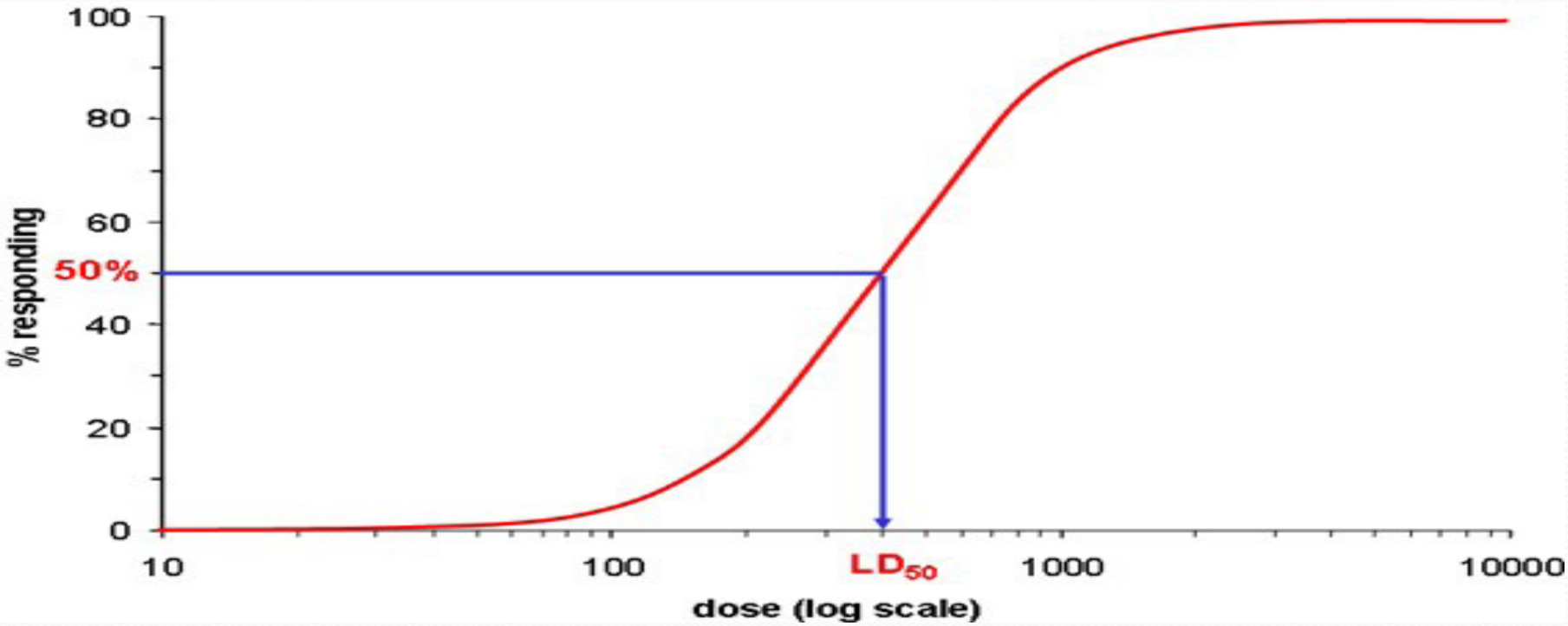
- Deals with interaction between chemicals and biological systems
- Understanding helps in risk assessment and control measures
- Origin- drugs, food additives, natural toxins, industrial chemicals, environmental pollutants

Acute Vs. Chronic Toxicity

- Acute Toxicity- An immediate toxic response
- Chronic Toxicity- Toxic response over a long period of exposure

Dose-Response Relationship

- Relationship between level of toxin and adverse response from dose
- LD 50 (lethal dose that produces death in 50% of exposed organisms)



Examples of LD50 Values

Chemical	LD50 mg/kg; rats, oral administration
Salt	40,000
Ethanol	10,000
Nicotine	1
Dioxin	0.001
Botulinum toxin	0.0001
Ref: Safe Food 360 White Paper (October 2013)	

Routes of Entry of Toxins

Oral- Most important from food safety perspective; Ingested toxins enter liver and then into bloodstream

Lungs-Normally volatile gases or fine dust

Skin- Usually lipophilic toxins; skin is a good protective barrier

Useful websites on Chemical Hazards

1. http://foodrisk.org/database/fshazards/chemical
2. http://www.who.int/foodsafety/chem/en
3. http://ec.Europa.eu/food/food/chemicalsafety/index_en/htm

Risk Assessment of Chemical Contaminants

- Exposure assessment, daily intake
- Dose-response data
- Toxicity testing data from humans or animal data for extrapolation
- ADI data
- Mechanism of action of toxic effects

Categories of Chemical Contaminants

Chemical hazards can thus be divided into five broad categories:

- Inherent ('Natural') toxins
- Natural and environmental contaminants
- Process and storage-derived contaminants
- Intentionally added contaminants, and
- Pesticides and veterinary residues

Inherent Toxins

Occur as regular constituents of food in question

- Lectins-kidney beans, lima beans, lentils; cooking eliminates toxicity
- Glycoalkaloids- Solanine and Chaconine in Potatoes; safety limit 200 mg/kg of fresh potato
- Oxalates- in spinach and rhubarb; high levels found in rhubarb leaves
- Cyanogenic glycosides: Potential to release cyanides; amygdalin in bitter almonds, cassava (linamarin)
- Trypsin Inhibitor-Inhibits proteolytic activity; example,Lima and soy beans

Natural Contaminants

- Mycotoxins: Chemically diverse naturally occurring substances produced by a range of fungi or moulds
    - Example, Aflatoxins, Ochratoxin, Patulin, Zearalenone, Fumonisins, Tricothecenes
- Shellfish toxins: Includes neurotoxic (NSP), diarrhoetic (DSP), paralytic (PSP), amnesic (ASP) fish poisoning;

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Natural Contaminants contd.

- Aflatoxins- B1, B2, G1, G2, M1, M2; in peanuts, tree nuts; A. flavus; A. parasiticus; Liver toxins, carcinogens
- Ochratoxins- A. ochraceus; in green coffee; Teratogenic, carcinogenic
- Patulin- P. expansum; carcinogenic
- Zearalenone- Fusarium species in high moisture corn; endocrine disruptor
- Tricothecenes- Fusarium sp. (aka vomitoxin)
- Fumonisins- F. moniliforme; liver and oesophageal cancer

Environmental contaminants

- **Dioxins / Polychlorinated biphenyls (PCBs):** Found in soil, water, sediment, plants and animal tissue in all parts of the world; present in virtually all foods; highest concentrations are in fatty foods such as oily fish; main sources of dioxins in the diet are meat and milk. Levels accumulate as they move through the food chain.

- Control options are based on prohibiting the use of dioxins and PCBs by industry and hence their release into the environment; No limits exist in the USA although the FDA considers all detectable levels to be of concern.

Environmental contaminants, contd.

- **Polycyclic aromatic hydrocarbons (PAH):** PAHs are genotoxic. Detected in air, water, soil and foods. Foods may become contaminated through direct environmental exposure, migration from packaging material or during thermal processing of food, e.g. baking, grilling, frying and smoking.
- PAHs in fruit, vegetables and cereals is primarily due to soil and air exposure.
- High levels reported in smoked meats and animals farmed on contaminated land.
- Can also be formed during heating and drying processes which allow combustion products to come into contact with food substance.

Environmental contaminants, contd.

- **Heavy metals**: Commonly, Mercury, Cadmium, Arsenic and Lead
- Natural components; originate from earth's crust; found all over the world
- Migration from packaging (e.g. antimony from plastic bottles, and tin in canned food)
- Crop products may contain high levels of lead and cadmium; Raw material control essential to ensure product safety
- Maximum levels established in many countries; important to know legislative limits if exporting

Process Based Contaminants

Production of toxic chemicals in foodstuffs through processing; recently discovered

Acrylamide: Formed in starch-containing foods; Examples are potato products such as crisps and chips, coffee, savory snacks such as cracker type biscuits, and bread

- Acrylamide is a known carcinogen

Process Based Contaminants, contd.

Chloropropanols: Occur in foods and food ingredients as a result of processing, migration from packaging materials during storage, or domestic cooking

- Found in a variety of foods, cooked/cured meats and fish, cheese, bread and toast, malt extracts and baked products, as well as in teabag paper, tissue and sausage casings
- Occurrence in food following reaction between hydrochloric acid and lipids, particularly in foods processed at high temperatures such as soy sauce.
- Carcinogen

Packaging migrants

- Transfer of monomers and additives such as plasticizers in plastic packaging materials are the major area of concern
- A list of approved monomers and additives for use in food contact plastic materials (EU and FDA)
- General limit for containers and sealing devices is 60 mg per kg of food; for other contact materials it is 10 mg/dm2
- Bisphenol A, Semicarbazides, Phthalates

Intentionally Added Contaminants

- **Illegal or unauthorized dyes:** The Sudan dyes are synthetic azo dyes are not permitted food colors; other dyes include Para Red, Rhodamine B, Orange II, Red G, Butter Yellow and Metanil Yellow
- **Melamine:** An industrial chemical found in plastics; a major component in Pigment Yellow 150, a colorant in inks and plastics; fraudulently added to wheat gluten and rice protein from China, which was subsequently used in pet foods; was present in infant milk powder produced in China; Six infants died as a result, and over 300,000 were reported to have been made ill

Pesticides and Veterinary Residues

- **Pesticides:** Include insecticides, fungicides, herbicides, and rodenticides to control pests, weeds and diseases
  - The main insecticide families include organochlorines, organophosphates and carbamates
  - Operate by disrupting the sodium / potassium balance of the nerve fiber, forcing the nerve to transmit continuously
  - National monitoring program exists in many countries

- **Veterinary residues:** The use of medicines used to treat animals raised for food is regulated in a similar manner to that for pesticides used on food crops.

How are maximum limits set?

- Toxicity evidence: How toxic is the contaminant believed to be and how sound is the evidence for this belief?
- Good Manufacturing Practice: What is technologically achievable and how costly is it?
- Analytical capability: What are the limits of detection or quantification?

Codex Limits

Mycotoxins

- Aflatoxins: 15 µg/kg in peanuts; 0.5 µg/kg M1 in milk;
- Patulin: (50µg/kg in apple juice).

Heavy metals

- Arsenic: typically 0.1 mg/kg;
- Cadmium:typically 0.05-0.2 mg/kg;
- Lead: typically 0.1-1 mg/kg;
- Mercury: 0.001 mg/kg in natural mineral water; 0.1 mg/kg in food grade salt;
- Methylmercury: 0.5 mg/kg in fish–1mg/kg in predatory fish;
- Tin: 150 mg/kg in canned beverages; 250 mg/kg in canned fruit and vegetables.

Codex Limits, contd.

Others

- Plastic monomers: typically 60 mg/kg of food or 10 mg/dm2 of package surface;
  Acrylonitrile: 0.02 mg/kg;
  Vinyl chloride monomer: 0.01mg/kg.

Q &A

Questions?