FOOD CHEMISTY

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ANTINUTRITIONAL FACTORS AND FOOD CONTAMINANTS

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intentional addition / unintentional incorporation of chemicals

food

health hazards

sources of contamination :

- food additives,
- chemicals used in agricultural production,
- accidental contaminants during food processing,
- radioactive fall-out.

ANTINUTRITIONAL FACTORS

Many foods

wide range of anti-nutritional factors

interfere with the assimilation of nutrients contained in them

Important anti-nutritional factors :

trypsin inhibitors, phytates, oxalates,
tannins, lectins and goitrogens

interfere with the utilization of other nutrients like
proteins, minerals like iron, zinc, calcium and iodine.

- Antinutritional factors → reduce digestion and utilization of nutrient and may produce other adverse effects.

- common symptoms exhibited by a large number of antinutrients in the body → nausea, bloating , headaches, rashes, nutritional deficiencies.

Trypsin inhibitors

- proteins → legumes (soybean, lima and kidney bean) and egg white.
- competes with proteins to bind to trypsin
- inhibit the activity of trypsin in the gut and interfere with digestibility of dietary proteins and reduce their utilization.

- heat labile → the extent and ease of heat inactivation varies from one trypsin inhibitor to another.

- autoclaving at 120oC for 15-30 min → inactivates almost all trypsin inhibitors → improves utilization of protein present in these foods.

- Boiling soybeans for 14 minutes inactivates about 80% of the inhibitor, and for 30 minutes, about 90%.

Phytate

- widely distributed→ seeds, grains, nuts and legumes.
- unrefined cereals and millets are richest sources of phytates.
- store phosphorus as phytic acid in their husks in the form of phytate salt.
- Phytate is hexaphosphate of inositol → acts as a source of bound phosphorus → seeds during germination.

- phytates → strong binding affinity → iron, zinc, calcium and magnesium → results in highly insoluble salts → poorly absorbed by the GIT → lower bioavailability of minerals.

- phytate content reduces due to enzymatic breakdown of phytate during germination of grains.

- Improved iron availability in germinated grains can be partly attributed to a reduction in phytate content.

Tannins

- major group of antioxidant polyphenolic compounds
- widely distributed in plant kingdom
- present in high amount in seed coat of most legumes, spices, tamarind, turmeric, green tea, in certain vegetables and fruits- grapes.
- Millets - bajra, ragi, sorghum → a fair amount of tannin.
- bind **iron** irreversibly → interfere with iron absorption.
- also known to bind **proteins** and reduce their availability.

Lectin

- Vegetables - tomatoes, potatoes, peppers, and eggplant, legumes - lentils, beans, and chickpeas, peanuts, peanut-based products - peanut butter and peanut oil
- cause flatulence
- Consuming legumes and grains in their raw form → nausea, diarrhea and vomiting.
- inactivated → heat and fermentation.

Oxalates

- Oxalic acid → form soluble (potassium and sodium) or insoluble (calcium, magnesium, iron) salts or esters called **oxalates.**
- widely distributed → green leafy vegetables , green vegetables and some legumes.
- interfere with **calcium** absorption by forming insoluble salts
- Insoluble salts cannot be processed out of the urinary tract once processed through the digestive system.

- Calcium oxalate can have a deleterious effect on human nutrition and health by accumulating kidney **stones**.

- Stone patients are advised to avoid high oxalate foods.

- Most people can induct normal amounts of oxalate rich foods, while people with certain conditions, such as enteric and primary hyperoxaluria, need to lower their oxalate intake.

- In sensitive people → small amounts of oxalates → burning in the eyes, ears, mouth, and throat
- large amounts → abdominal pain, diarrhea, nausea and muscle weakness.

Goitrogens

- disrupt the production of thyroid hormones by interfering with **iodine uptake** in the thyroid gland.

- triggers **pituitary** to release thyroid-stimulating hormone (TSH) → promotes the growth of thyroid tissue → leading to goiter.

- leaves and vegetables - cabbage, cauliflower, radish, rapeseed, mustard, soybean, peanut, lentils

- Thiocyanate, isothiocyanates and their derivatives.

Antinutrients are found at some level in almost all foods

Traditional methods of food preparation → reduce certain antinutrients → increase the nutritive quality of plant foods.

- ***Soaking*** : in distilled water, 1% $NaHCO_3$ and mixed salt solutions → reduced total phenols, tannins and phytates by 33, 35 and 21 %, respectively.

- ***Fermentation :*** assorted grain flour with *L. acidophilus* at 37°C for 24 h → reduction of phytic acid and polyphenol content.

- ***Germination :*** one of most effective processes → reduction of phytate levels.

- ***Heating :*** Cooking whole grains, beans and vegetables → reduce phytic acid, tannins, oxalic acid and Protease inhibitors.

RADIONUCLIDES

- Radioactive atoms that has excess nuclear energy → unstable.

- emit radiation as they undergo radioactive decay through the emission of alpha particles (α), beta particles (β), or gamma rays (γ) → more stable forms.

- emit radiation at its own specific rate → measured in terms of half-life → time required for half of the radioactive atoms present to decay.

- In living tissues they can lead to development of cancers or genetic abnormalities.

- Examples - Strontium-90, Cesium-137, Iodine-131 and Carbon-14

RADIONUCLIDES

Emission	Nature
a particles	Two protons (positively charged) and two neutrons
β^- particles	Electrons (negatively charged)
γ rays	Electromagnetic radiation (no charge)
Neutrons	Subatomic particles (no charge)

Sources of Radionuclide Contamination:

1. **Naturally occurring radionuclides:**
   40K, 235U, 232 Th, 14C, 7Be, 3H, 87Rb

- burning of coal and oil → lead to the distribution of 40K, 214Bi, 214Rb, 222Rn and 226Ra → into the biosphere in the form of smoke and fly ash.

- Disseminated material (soil) → incorporated into plant → eventually in animal products → finally in man.

2. Testing of nuclear weapons

Nuclear weapons tests release large quantities of plutonium, 90Sr, and 137Cs

3. Operation of reactors of all kinds and the application of atomic energy in medical, industrial and scientific uses.

ground testing of fission or fusion of nuclear testing results in → widespread distribution of many different kinds of artificial radionuclides → 90Sr, 89Sr, 140Ba,137Cs, 131I, 91Ca and other less familiar radioelements.

The actual steps utilized depend upon

- the mode of contamination,
- the chemical and physical characteristics of the radioelements, and
- the dietary patterns of the human population involved.
- Not all of these pathways will be involved in the dissemination of any one particular radionuclides.

Radiological properties of some radionuclides			
Radionuclide	**Half-life**	**g-energy (MeV)***	**b-energy (MeV)***
I-131	8.05 days	0.36	0.61
Cs-137	30 years	0.66	0.52
Cs-134	2.06 years	0.79	0.66
Sr-90	29.1 years	-	0.55

- **MeV = million electric volt**

Strontium-90:

- half-life => 29 years and is b emitter.
- chemically similar to **Ca** → greatest amounts in **Ca rich foods**.
- treated by body in the same way as Ca and ultimately finds its way → **bone structure**.
- grazing animals can ingest Sr-90 → contaminated grass →Sr-90 concentrated in bones and cow's milk → human diet → bones → because of radioactivity → **bone tumors** and **leukemia.**
- **Children** → very sensitive → require large amounts of Ca for bone formation and as a result deposit relatively more Sr-90.
- They also face a longer life span → important because **radiation effects** are **cumulative**.

Caesium-137:

- half-life => 30 years
- Cs-137 is a g-emitter
- alkali metal → similar to **sodium and potassium** and its compounds are absorbed by the body in the same way as sodium compounds.
- absorbed Cs-137 → soft tissues of the body → may cause genetic harm.
- **not retained** in the body for a long time.

Iodine-131:

- b-g-emitter
- accumulates in thyroid gland → attains high concentration radioisotope of I-131 → considered **hazardous** → produces intense radiation → however, for **short period** after a serious fall out.
- soil pathway is almost nonexistent because of the short half life
- major movement is from atmosphere → vegetation → dairy cow → milk → man.

Carbon- 14:

- explosion of nuclear weapons → C_{14} → in the course of time → converted into CO_2 → incorporated into plant tissues by photosynthesis → eaten by man / animals (eaten by man) → finds its way into any organ.

- C_{14} decays very slowly and remains radioactive for thousands of years.

- Modern nuclear bombs → release into the atmosphere a much smaller amount of harmful radioactive isotopes than the original types.

- Nevertheless, contamination of atmosphere still occurs → when such bombs are exploded → testing of nuclear weapons should be avoided.

- While contaminant radionuclides can and do reach man → many different foods and pathways, **milk** is found to be a major contributor to the uptake of the fall out nuclides → considered to be of most hazard to man, ^{90}Sr, ^{137}Cs, and ^{131}I.

Toxic Trace Elements

- **essential trace element** is a dietary element => needed in very minute quantities => growth, development, and physiology of organism.

- required => vital metabolic activities in organisms - Fe (hemoglobin), Cu (respiratory pigments), Co (Vitamin B12), Mn and Zn (enzymes).

- **cobalt, copper, fluorine, iodine, iron, manganese and zinc** => although they are essential, they become toxic at high concentrations.

- Elements such as Pb, Hg, Cd and As have no known biological function => **toxic effects** even at low concentration => are a **"threat"** to our foodstuffs by virtue of industrial usage.

Lead

- used in batteries, paints, alloys and as antiknock in petrol → environmental pollution
- Fruit **juices** kept in lead containing glazed pottery can pick up lead because of acidic nature
- cow => very effective **biological filter** diverting lead from her feed to her **bones** rather than to her milk.
- **crops** grown near busy highways → high lead contents → exceeding 100 ppm in the dry matter.
- estimated that nearly **90 per cent** of the ingested lead is derived from **food → 5 per cent is absorbed.**
- **Clinical Symptoms** → mild anemia, kidney damage, mental deterioration and aggressive behaviour.

Mercury:

- **Industries → Chloralkali** industry (mercury => electrolytic cells), **pulp and paper industry** (mercury compounds => as slimicides) and **agriculture** (seed dressings and sprays) → release → environment.

- converted in **sediments** on river and lake bottoms into highly toxic **methylmercury compounds.**

- cumulative poison → stored mainly in the **liver and kidney**.

- **pure metallic form** is **poorly absorbed**, readily excreted → unlikely to cause poisoning.

- **the inorganic and organic compounds → highly toxic** to humans.

Clinical Symptoms:

- depend upon the type, dose, method and duration of exposure.
- most common cause of **mercury poisoning** → consuming too much **methylmercury** or **organic mercury**(seafood).
- **Methylmercury** accumulates → human brain → neuro-toxic → sensory disturbances in the limbs, the tongue, and around the lips.
- irreversible damage to **central nervous system** → atoxia, tremor, slurred speech, tunnel vision blindness, loss of hearing, and death.
- **Minamata disease** (Japan) → mercury contaminated fish and shell fish (Minamata bay) → causative agent → **organic mercury** compound → used in **chemical industry**

Cadmium:

- **Toxicity** → person breathes in high levels of cadmium from the air or eats food or drinks water → high levels of cadmium.
- present in the envt. as a mineral combined with other elements - oxygen, chlorine, or sulfur.
- cigarette smokers increase their intake by 25-50%.
- Threat to **milk** ← forage and fertilization of feedstuffs with **sewage sludge**.
- Cow acts → effective biological filter → proportion of ingested cadmium finding access to milk is extremely small.

- **Clinical Symptoms:**

- Most of absorbed cadmium → retained in the **kidneys**.

- long term chronic ingestion → serious renal damage and bone disease leading to brittleness and even collapse of skeleton.

- Abnormally high levels → several cancers.

- Cadmium toxicity is the prime cause of Itai-Itai disease (Japan).

Arsenic:

- metalloid → properties of both a metal and a non-metal.
- most toxic inorganic compounds → Arsenic trioxide and arsenic pentoxide .
- major sources of arsenic → copper smelting and low grade coal combustion.
- Herbicides, burning of firewood and cowdung → environmental arsenic.
- Inorganic and organic arsenic compounds → absorbed → blood stream → different organs.
- Chronic arsenic poisoning → general muscular weakness, loss of appetite, nausea and inflammation of the mucous membranes of eyes, nose and lungs.

THANKS