



FOOD CHEMISTRY

Course No.-DTC-321, Credit Hours – 3 (2+1)



ANTINUTRITIONAL FACTORS AND FOOD CONTAMINANTS

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intentional addition / unintentional incorporation of chemicals



food



health hazards

sources of contamination :

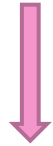
- food additives,
- chemicals used in agricultural production,
- accidental contaminants during food processing,
- radioactive fall-out.

ANTINUTRITIONAL FACTORS

Many foods



wide range of anti-nutritional factors



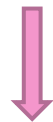
interfere with the assimilation of nutrients contained in them

Important anti-nutritional factors :

trypsin inhibitors,
tannins,

phytates,
lectins and

oxalates,
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 120°C 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% NaHCO₃ 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 |
|---------------------|---|
| α 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:

^{40}K , ^{235}U , ^{232}Th , ^{14}C , ^7Be , ^3H , ^{87}Rb

- burning of coal and oil → lead to the distribution of ^{40}K , ^{214}Bi , ^{214}Rb , ^{222}Rn and ^{226}Ra → 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, ^{90}Sr , and ^{137}Cs

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 \rightarrow widespread distribution of many different kinds of artificial radionuclides \rightarrow ^{90}Sr , ^{89}Sr , ^{140}Ba , ^{137}Cs , ^{131}I , ^{91}Ca 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 β 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 γ -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

The background features abstract, overlapping geometric shapes in various shades of pink and purple, primarily concentrated on the right side of the frame. The shapes are semi-transparent, creating a layered effect. The overall aesthetic is modern and clean.