

Natural toxic substances (1. LF UK, NT)

Natural anti-nutritional and toxic substances

Natural anti-nutritional and toxic substances include:

- **antinutritional substances** – interference (nutrients),
- **toxic substances** – poisons (toxins),
 - natural toxic substances – toxins,
 - products of anthropogenic activity – xenobiotics.

The toxic effects of these substances can be acute or late (e.g. chronic).

Amount of risk:

- **contaminants,**
- **toxins,**
- **additive substances,**
- **antinutritional substances.**

Their content in food is subject to legislative measures.

Feeding trials → NOAEL → ADI = NOAEL / 100, (mg/kg), safety factor (100)

- $MLR = ADI * 60$, (NPM, PM, SM), food basket, taking into account the amount of consumption

Antinutritional substances

Antinutritional substances are substances of **plant origin** that cause potential risks. Is part of them:

1. **enzyme inhibitors**, antienzymes,
2. **compounds interfering with vitamin metabolism**, antivitamin, vitamin antagonists,
3. **compounds interfering with the metabolism of mineral substances**,
4. **phenolic compounds (tannins) reacting with proteins**,
5. some **oligosaccharides causing flatulence**.

1. Inhibitors of serine proteases (trypsin, chymotrypsin, elastase):

- lead to a slowdown in the growth of farm animals,
- heat inactivation occurs (they are proteins).

2. Antivitamins:

- structural analogues (oxythiamine, linatin),
- enzymes (ascorbate, thiaminase, lipoxygenase),
- forming unusable complexes (avidin).

3. Compounds binding mineral substances:

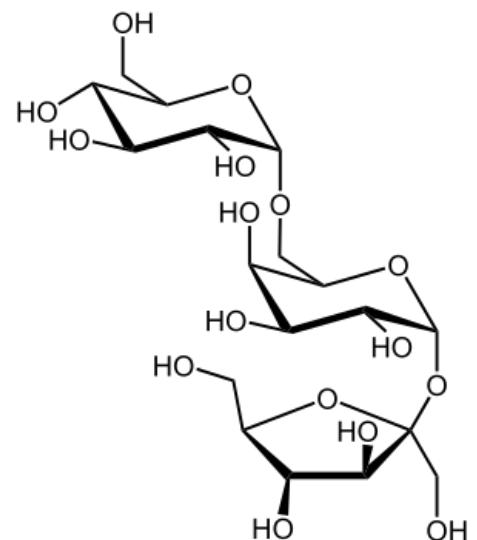
- phytic acid and phytin – Fe, Zn,
- oxalic acid – Ca,
- glucosinolates and their breakdown products – I.

4. Tannins:

- slowing down the growth of farm animals,
- reduction of digestibility of proteins and absorption of mineral substances.

5. α -galactosides:

- raffinose, higher homologues,
- cause gastrointestinal problems.



raffinose

Toxic substances

Toxic substances present real risks:

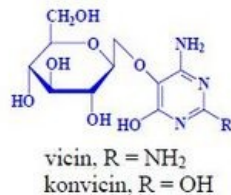
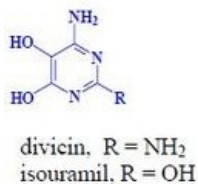
- causing food intolerance (*intolerance*), toxic for certain individuals,
- causing *intoxication* , toxic for all individuals. Substances causing food intolerance:
- allergies (immunological reactions), allergens (immunogens), (do not) induce IgE formation,
 - celiac disease, gluten-free diets (<100 mg/kg gliadin dry weight),

- intolerance (non-immunological manifestations), metabolic disorders, hypersensitivity (anaphylaxis), aversion (idiosyncrasy),
 - lactose intolerance, foods with a low content (<10 g/kg), lactose-free (100 mg/kg),
 - phenylketonuria, hydrolysates without Phe,
 - favism, broad bean (*Vicia faba*).



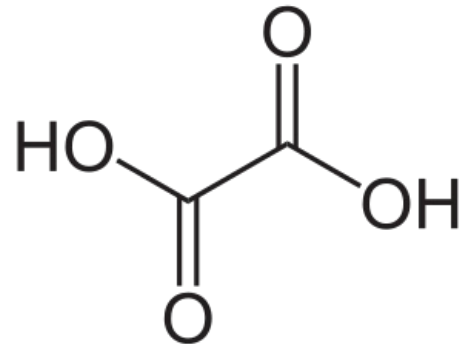
tannin

Toxins and other substances causing intoxication



Classification:

- by structure,
- physical properties,
- by origin (plant, animal),
- by effects,
- main groups of toxins,



oxalic acid

- alkaloids,
- saponins,
- cyanogens,
- glucosinolates,
- lectins,
- estrogenic substances,
- phototoxic substances,
- amino acids,
- biogenic amines.

Antinutritional and toxic substances of legumes:

- protease and amylase inhibitors,
- α-galactosides,
- substances causing favism,
- lectins,
- cyanogenic glycosides,
- estrogens,
- saponins,
- lathrogens.

Toxic substances of higher mushrooms:

- proteins,
- peptides,
- amino acids,
- amines,
- hydrazines,
- alkaloids,
- terpenoids.

Alkaloids

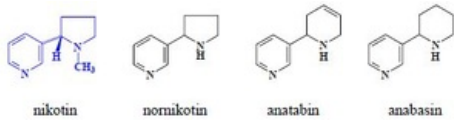
Classification:

- **true alkaloids** (N-heterocycles, derived from amino acids),
 - pyridine (nicotine) and tobacco,
 - piperidine and pepper,
 - pyrrolizidines and senecias (necines),
 - quinolizidine and lupins,
 - quinoline and cinchona bark,
- **pseudoalkaloids** (N-heterocycles, derived from other precursors),
 - purine a. coffee, tea, cocoa,
 - terpenoid (glycoalkaloids) a. potatoes, tomatoes,
- **protoalkaloids** (not N-heterocycles, derived from amino acids),
 - capsaicinoids and peppers.

Pyridine alkaloids

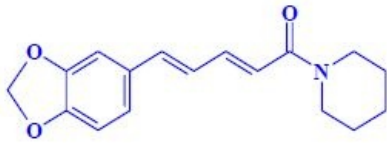
Nicotine and minor alkaloids (~20 compounds):

- tobacco (obligation to indicate content in tobacco products, warnings)



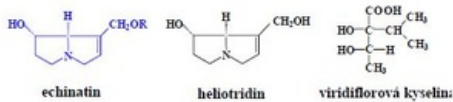
Piperidine alkaloids

Piperine, homologs, geometric isomers, related substances, pepper (hot substances)



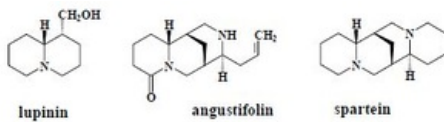
Pyrrrolizidine alkaloids

Many related esters (mono-, di-, macrocyclic), hepatotoxic substances



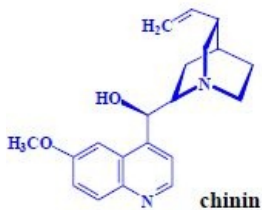
Quinolizidine alkaloids

A number of related compounds, lupine



Quinoline alkaloids

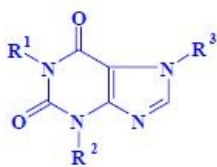
Contents in pod.



Legislation: additive, alcoholic beverages 300 mg/l, non-alcoholic (tonics) 75 mg/l (teratogenicity)

Purine alkaloids

a number of related compounds, coffee, tea, cocoa (chocolate), mate, guarana.



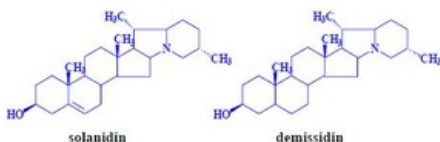
- caffeine $R_1 = R_2 = R_3 = CH_3$
- theobromine $R_1 = H, R_2 = R_3 = CH_3$
- theophylline $R_1 = R_2 = CH_3, R_3 = H$

Steroidal glycoalkaloids

- a number of related compounds, potatoes, tomatoes, eggplant,
- heteroglycosides, aglycone, sugar.

Potatoes

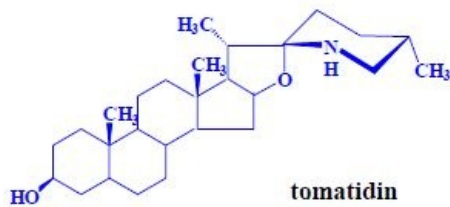
- α -solanine = solanidine + β -solutriose,
- α -chaconine = solanidine + β -chacotriose,



- distribution,
- legislation: 200 mg/kg.

Tomatoes

- tomatine = tomatidine + β -lycotetraose

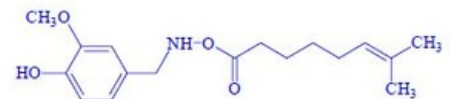


- legislation: 200 mg/kg, teratogenicity

Capsaicinoids

capsaicin, homologues, paprika (hot substances):

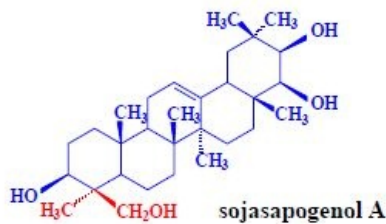
- the effect of technological processing,
- capsaicin, (E)-8-methyl-N-vanillylnon-6-enamide .



Saponins

a number of related compounds, foods of plant origin:

- heteroglycosides, aglycone, sugar,
- aglycon = sapogenin (sapogenol),
 - triterpene alcohols,
 - sterols (4-demethylsterols).



Biological effects:

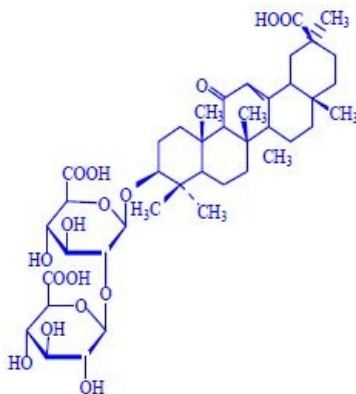
- hemolysis of erythrocytes, other cells, damage to the intestinal mucosa.

Properties

- toxicity to cold-blooded animals,
- bitter taste,
- detergent effects, emulsion (o/w),
- fungicidal, antioxidant, anticarcinogenic, anticholesterolemic effects.

Use

- foaming agents (cosmetics),
- emulsifiers (cosmetics),
- sweeteners (glycyrrhizin, licorice: 0.2–5.6% saponins).



Cyanogenic glycosides

- a number of related compounds, foods of plant origin,
- HCN content in cyanogens,
- heteroglycosides, aglycone, sugar,
- aglycone = 2-hydroxynitrile (cyanohydrin),
- 2-hydroxy acid nitrile.

Substituents - Chirality:

- aliphatic - acetone, methyl (ethyl) ketone,
- aromatic - benzaldehyde.

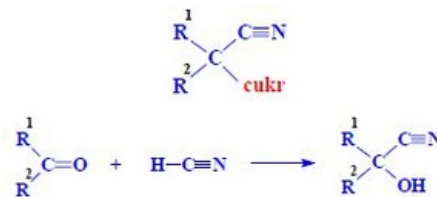
Sugar

- usually Glu,
- gencibiosis disaccharides etc.



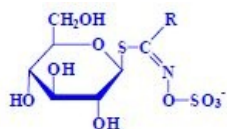
Properties

- decomposition (β -glucosidase) \rightarrow HCN, toxicity (inhibition of cytochrome oxidase in the respiratory chain),
- acute intoxication, chronic intoxication (cassava, cassava).



Glucosinolates

- thioglucosides (glucosides of mustard oils), a number of related compounds, foods of plant origin (cruciferous plants),
- names and structure,
- dominant glucosinolates in vegetables,
 - heteroglycosides, aglycone, sugar, aglycone = thiohydroxamate-O-sulfonate, counterion K⁺



Substituents

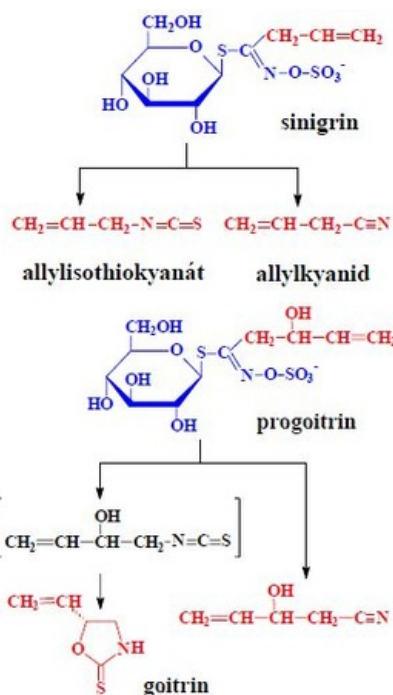
- aliphatic,
- aromatic,
- heterocyclic.

Sugar

- exclusively Glc.

Properties

- decomposition (myrosinase) \rightarrow isothiocyanates, nitriles, etc.,
- toxicity, isothiocyanates and goitrin strumogenic, nitriles hepatotoxic.



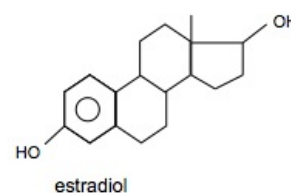
Plant phenols

Estrogenic substances

phytoestrogens - foods of plant origin,

- isoflavones,
- content in soybeans.

daidzin, R = H aglycon daidzein
genistin, R = OH aglycon
genistein
soybeans (0.13–0.42%)

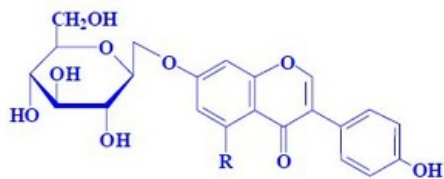


- pterocarps,
- lignans.

content in food

coumestrol – sprouting – soybeans
secoisolariciresinol – flax seeds

▪

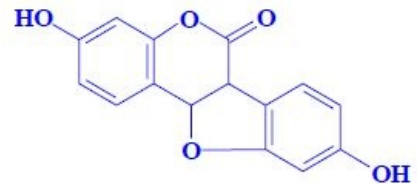


- mycoestrogens,
- xenoestrogens.

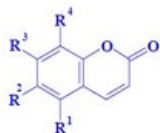
Properties

- simultaneously useful and harmful.

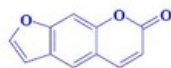
Phototoxic substances



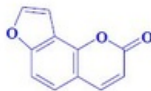
- coumarins,
- furanocoumarins,
- foods of plant origin.



kumariny



lineární psoralen



angulární angelicin

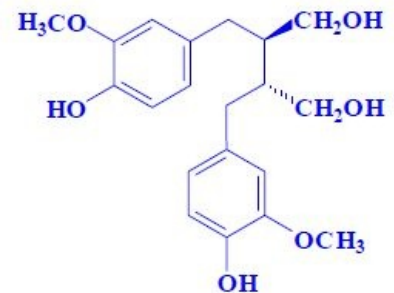
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Properties

- phototoxicity (sensitivity of

non-pigmented skin, association with skin cancer, acute dermatitis),

- phytoalexins (phytonicides, plant antibiotics, pesticides), blastocolins (inhibits seed germination),
- antimicrobial and other effects.



Phototoxic pigments

- hypericin (St. John's wort), fagopyrin (buckwheat).

Lectins (phytohemagglutinins)

foods of plant origin (seeds and other parts)

Proteins with a non-catalytic center:

- merolectins (1 center, catalytic no),
- hololectins (2 centers, no catalytic),
- chimerolectins (1–2 centers, catalytic yes).

Soy lectin

- metalloprotein, 120 kDa, hololectin, N-acetyl-D-galactosamine binding.

Properties

- precipitation of erythrocytes, interaction with sugars in glycoproteins and glycolipids of membranes (plant protection mechanism against predators, parasites),
- toxic intravenously, some orally, some not at all, some probiotics (garlic).

Amino acids

Lathyrogens:

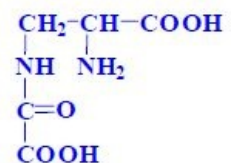
- foods of plant origin (seeds of vetch and peas),
- amino acids (peptides, nitriles) -3-(N-oxalyl)-2,3-diaminopropanoic acid

Properties

- structural form with proteinogenic amino acids, metabolic disorders,
- deformation of the lower limbs (osteolathyrism), damage to blood vessels (angiolathyrism), disorders of the nervous system (neurolathyrism), humans, mainly farm animals.

Biogenic amines:

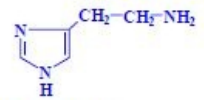
- precursors,
- aliphatic, aromatic, heterocyclic bases with biological activity, fermented and microbially degraded foods of



plant and animal origin

Emergence

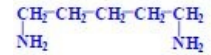
- from amino acids by microorganisms
 - histamine (His) , cadaverine (Lys)



histamin (His)

Properties

- tissue hormones (allergic reactions, anaphylactic shock)
- psychoactive and vasoactive substances



kadaverin (Lys)

Content

- changes in salami

Links

Internal links

- Toxic substances
- Antinutritional substances

Source

- DAVÍDEK, Jiří. 12. *PŘÍRODNÍ ANTINUTRIČNÍ A TOXICKÉ LÁTKY* [online]. [cit. 2012-03-13]. <<https://el.lf1.cuni.cz/p30693038/>>.