

12. NATURAL ANTINUTRITIVE AND TOXIC COMPOUNDS

antinutritive compounds

interference with nutrients

toxic compounds

natural toxic compounds

toxins

products of anthropogenic activity

xenobiotics

toxic effects

acute, late (chronic)

legislation

feeding experiments → NOAEL (No Observed Adverse Effect Level) → ADI (Acceptable Daily Intake) = NOAEL/100 (mg/kg), safety factor (100 or more)

MLR = ADI * 60, food basket, consumed amount

anti-nutritive substances

plant origin, potential risk

- enzyme inhibitors, anti-enzymes
- substances interfering with metabolism of vitamins, anti-vitamins, antagonists of vitamins
- substances interfering with metabolism of metals
- phenol compounds (tannins) reaction with proteins
- galactooligosaccharides (α -galactosides) causing flatulence

anti-enzymes

inhibitors of proteases (anti-proteases), inhibitors of serine proteases (trypsin, chymotrypsin, elastase)

weight loss of domestic animals, inactivation by heat (proteins)

anti-vitamins

structure analogues (oxythiamine, linatin)

enzymes (ascorbase, thiaminase, lipoxygenase)

formation of non-utilisable complexes (avidin)

mineral binding compounds

phytic acid and phytine

Fe, Zn

oxalic acid

Ca

glucosinolates and their degradation products

I

tannins

slow growth of domestic animals

decrease of protein digestibility and of minerals absorption

α -galactosides

raffinose, higher homologues, gastrointestinal problems

toxic compounds plant and animal origin, real risk

- developing food intolerance, toxic to certain individuals
- developing intoxication, toxic to all individuals

food developing food intolerance

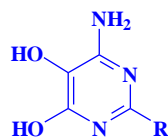
allergy (immunological reaction), allergenes (immunogenes), non developing formation of IgE
celiac disease, non gluten diet (<100 mg/kg dry matter gliadin)

intolerance (non-immunological manifestation), malfunction of metabolisms, hypersensitiveness (anaphylaxis), adverse effects (idiosyncrasy)

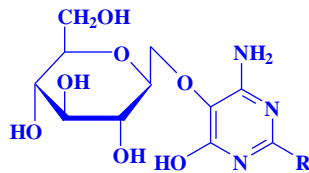
lactose intolerance

phenylketonuria, protein hydrolysates without Phe

favism, fava beans (*Vicia faba*)



divicine, R = NH₂
isouramil, R = OH



vicine, R = NH₂
convicine, R = OH

toxins and other compounds developing intoxication

classification

- according to structure
- according to origin
- according to toxic effects

main groups of toxins

- alkaloids
- saponins
- cyanogens
- glucosinolates
- lectins
- estrogenic substances
- phototoxic substances
- toxic amino acids and their products (biogenic amines)

anti-nutritive and toxic compounds of legumes

- ◆ inhibitors of proteases and amylases
- ◆ α-galactosides
- ◆ substances developing favism
- ◆ lectins
- ◆ cyanogenic glycosides
- ◆ estrogens
- ◆ saponins
- ◆ lathyrogens

toxic compounds of mushrooms

- ◆ proteins
- ◆ peptides
- ◆ amino acids
- ◆ amines
- ◆ hydrazines
- ◆ alkaloids
- ◆ terpenoids

alkaloids

classification (book 3, tab. 10.2)

◆ true alkaloids

(*N*-heterocycles, derived from amino acids)

pyridine (nicotinic)

tobacco a.

piperidine

pepper a.

pyrrolizidine

senecioic (necins) a.

quinolizidine

lupine a.

quinoline

quinine (bark of cinchona tree) a.

◆ pseudoalkaloids

(*N*-heterocyclic, derived from others precursors)

purine

coffee, tee, cocoa a.

terpenoid (glycoalkaloids)

potato, tomato a.

◆ protoalkaloids

(non *N*-heterocycles, derived from amino acids)

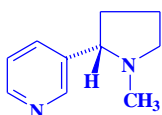
capsaicinoids

bell pepper and chili pepper a.

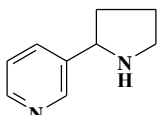
pyridine alkaloids

nicotine and minor alkaloids (~ 20 compounds)

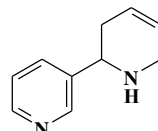
tobacco (obligation to declare their content on tobacco products, warning)



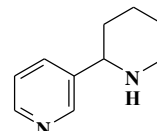
nikotin



nornikotin



anatabin

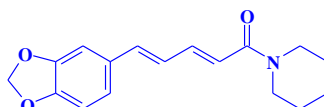


anabasin

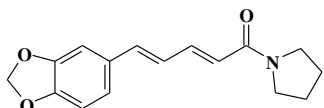
piperidine alkaloids

pepper (burning compounds), piperine,

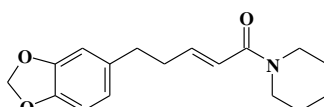
homologues, geometric isomers,



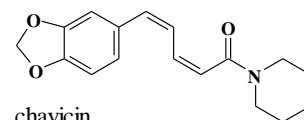
piperin



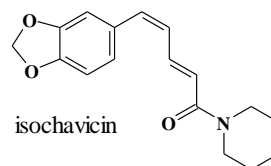
piperilin



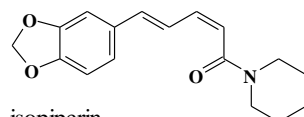
piperanin



chavicin



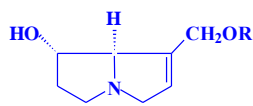
isochavicin



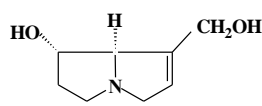
isopiperin

pyrrolizidine alkaloids

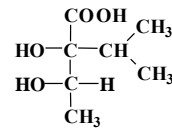
mono-, di-, macrocyclic esters of plants, hepatotoxic compounds



echinatin



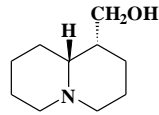
heliotridin



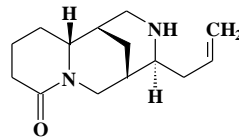
viridiflorová kyselina

quinolizidine alkaloids

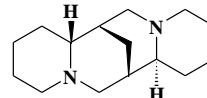
lupine, many similar structures



lupinin



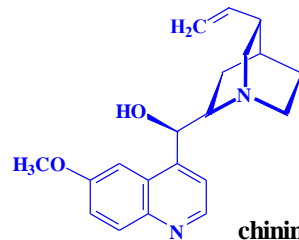
angustifolin



spartein

quinoline alkaloids

cinchona tree

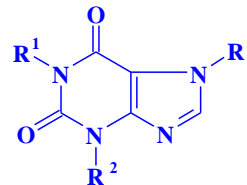


chinin

legislation: food additive, alcoholic beverage: 300 mg/l, non-alcoholic (tonic water): 75 mg/l (teratogenic)

purine alkaloids

row of relative compounds, coffee (book 3, tab. 10.4), tee, cocoa (chocolate), maté, guarana



caffeine
theobromine
theophylline

$R^1 = R^2 = R^3 = \text{CH}_3$
 $R^1 = \text{H}, R^2 = R^3 = \text{CH}_3$
 $R^1 = R^2 = \text{CH}_3, R^3 = \text{H}$

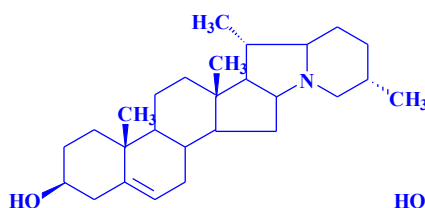
steroid glycoalkaloids

row of relative compounds (book 3, tab. 10.5) potato, tomato, eggplant
heteroglycosides, aglycones, sugars

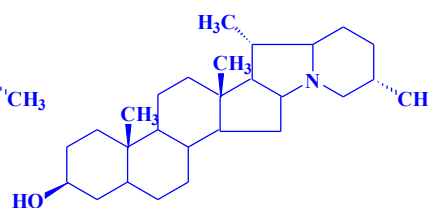
potato:

α -solanine = solanidine + β -solutriose

α -chaconine = solanidine + β -chacotriose



solanidin



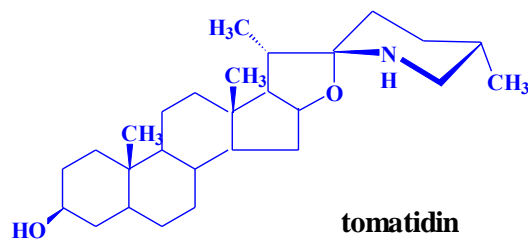
demissidin

distribution (book 3, tab. 10.6)

legislation: 200 mg/kg

tomato:

tomatine = tomatidine + β -lycotetraose



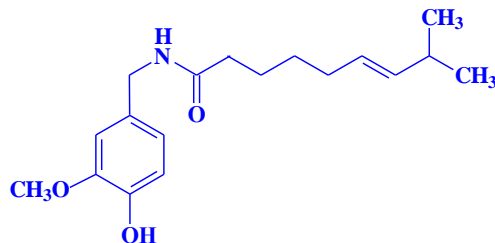
content (book 3, tab. 10.7)

legislation: 200 mg/kg, teratogenic

capsaicinoids

capsaicin, homologues, bell and chili peppers (burning compounds)

influence of technological procedures (book 3, tab. 10.8)



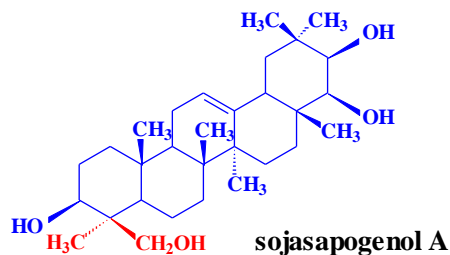
saponins

many similar compounds of plant origin

content (book 3, tab. 10.9)

heteroglycosides, aglycone, sugar, aglycone = sapogenin (sapogenol),

- triterpenic alcohols
- sterols (4-demethylsterols)



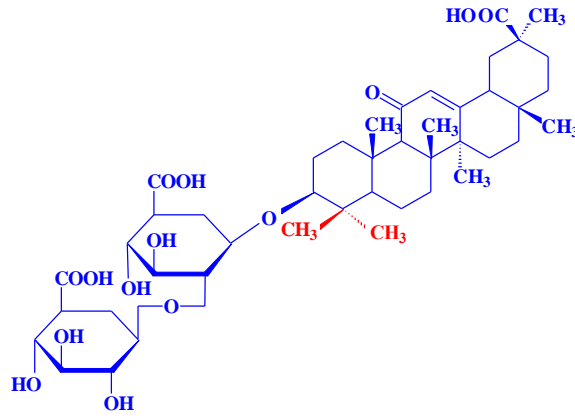
biological effects

erythrocyte hemolysis, damage of intestinal mucose,

- toxic for cold-blooded animals
- bitter taste
- detergents activity, emulsion (o/v)
- fungicide, antioxidant, anti-carcinogenic, anti-cholesterolemic activities

usage

- foaming compounds (cosmetics)
- emulsifiers (cosmetics)
- sweeteners (glycyrrhizin, liquorice: 0,2-5,6 % saponins)

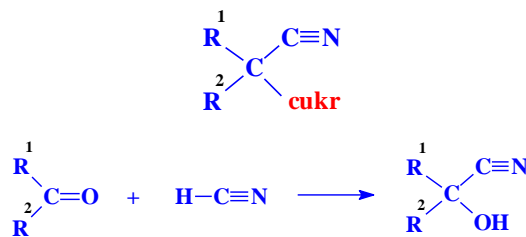


cyanogenic glucosides

many compounds of similar structure, foods of plant origin

content of HCN in cyanogens (book 3, tab. 10.10)

heteroglycosides, aglycone, sugar, aglycone = 2-hydroxynitril (cyanhydrin)



nitril 2-hydroxykyseliny

substituents

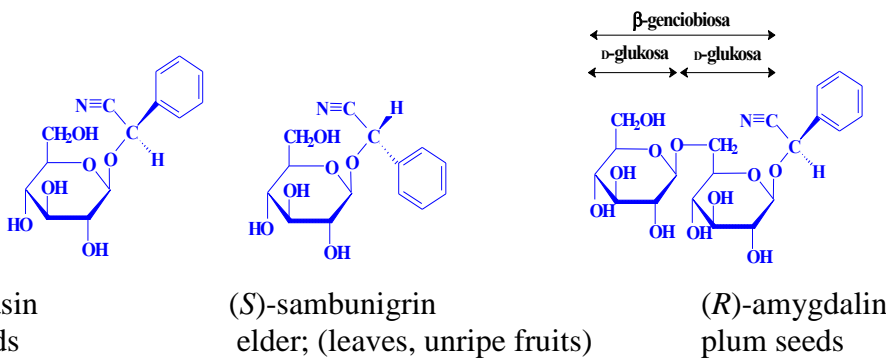
- aliphatic
- aromatic

sugar

- mostly Glu
- disaccharides: genciobiose and others

chirality

acetone, methyl(ethyl) ketone
benzaldehyde



properties

- decomposition (β -glucosidase) \rightarrow HCN, toxicity (inhibition of cytochromoxidase, actual intoxication, chronic intoxication (cassava, manioc))

glucosinolates

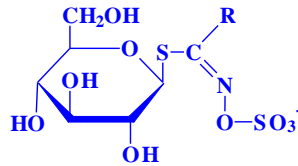
thioglucosides (glucosides of mustard oils), plum seeds, foods of plant origin (*Brassica* plants)

names and structure (book 3, tab. 10.12)

dominant glucosinoles in vegetables (book 3, tab.10.13)

content (book 3, tab. 10.14)

heteroglycosides, sugar, aglycone = thiohydroxamate-*O*-sulphonate, K^+ ion



substituents

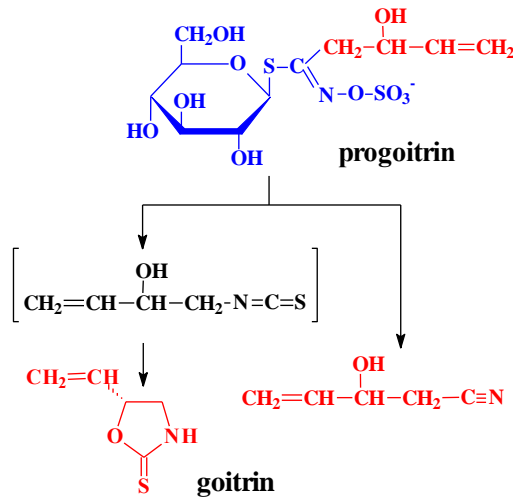
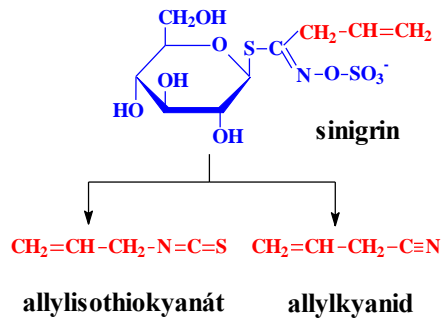
- aliphatic
- aromatic
- heterocyclic

sugar

- exclusively Glc

properties

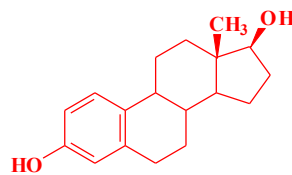
- degradation (myrosinase) → isothiocyanates, nitriles and other products
- toxicity, isothiocyanates and goitrin strumigenic, nitriles hepatotoxic



plant phenols

estrogenic compounds

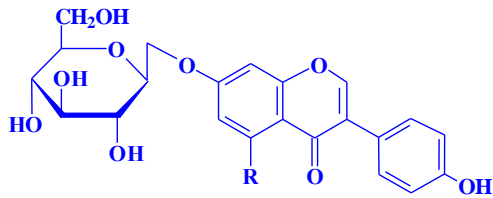
activity (book 3, tab. 10.17)



estradiol

food of plant origin

- phytoestrogens
- isoflavones
- content in soy beans (book 3, tab. 10.15)



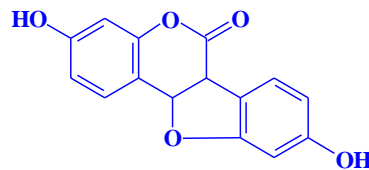
daidzin, R = H
genistin, R = OH

aglycon daidzein
aglycon genistein

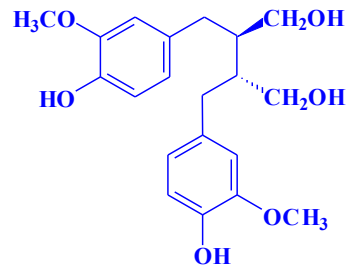
content in soy beans (0,13 - 0,42 %)

pterocarpanes
lignans

content (book 3. tab. 10.16)



coumestrol
germinated soy beans



secoisolariciresinol
linseeds

- mycoestrogens
- xenoestrogens
-

properties: simultaneously useful and harmful

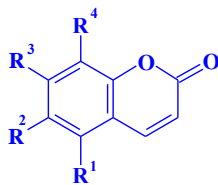
phototoxic compounds

cumarins

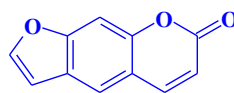
furanocumarins

content in foods (book 3, tab. 10.18)

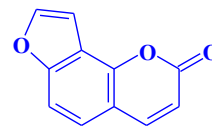
foods of plant origin



cumarine



linear psoralen



angular angelicin

properties

- phototoxicity (sensitivity of non pigmented skin, connection with skin cancer, acute dermatitis)
- phytoalexins (phytoncides, plant antibiotics, pesticides), blastocolines (inhibit germination of seeds)
- antimicrobial and another effects

phototoxic pigments

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

lectins (fytohematoglutinins) (book 3, tab. 10.19)

foods of plant origin (seeds and other parts of plants)

proteins with another centre than catalytic

- merolectins (1 centre, catalytic no)
- hololectins (2 centres, catalytic no)
- chimerolectins (1-2 centres, catalytic yes)

soy lectin (metaloprotein, 120 kDa, bound *N*-acetyl-D-galactosamine)

properties

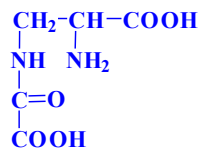
- precipitate of erythrocytes, interaction with sugar in glycoproteins and glycolipids membranes (protection mechanism of plants against predators, parasites)
- toxic intravenously, some orally, some not at all, some probiotics (garlic)

amino acids

lathyrogens

foods of plant origin (seeds of vetch)

amino acids (peptides, nitriles)



3-(*N*-oxalyl)-2,3-diaminopropionic acid

properties

- structure appearance with proteinogenic amino acids, metabolic failure
- deformation of legs (osteolathyrism), injury of blood vessel (angiolathyrism), disorder of neural system (neurolathyrism), human, above all farm animals

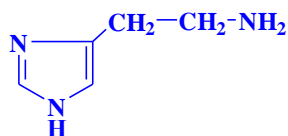
biogenic amines

precursors (book 3, tab. 10.20)

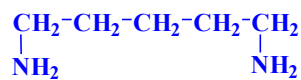
aliphatic, aromatic, heterocyclic bases with biological activity, fermented and microbially adulterated plant and animal foods

formation

from amino acids by **microbial**(book 3, tab. 10.21) carboxylyases and transaminases



histamine (His)



cadaverine (Lys)

properties

hormones (allergic reaction, anaphylactic shock), psychoactive and vasoactive compounds

content (book 3, tab. 10.22, 10.23)

changes in salami and fish (book 3, tab. 10.24)