

Flavour-active compounds

sensory quality
organoleptic properties

perception

◆ olphactoric	smell	odorous compounds
◆ gustative	taste	gustatory compounds
◆ visual	vision	colour compounds (colourants)
◆ auditorial	hearing	
◆ haptic	tactile	

perception of smell + perception of taste = **perception of aroma**

odorous compounds + gustatory compounds = **aroma compounds**

Odorous Compounds

olfactoric perception

~10 000 compounds, 50 – 1000 different compounds in individual foods

properties

- ◆ low polarity or non-polar compounds
- ◆ little soluble and insoluble in water
- ◆ volatile

main groups

hydrocarbons, alcohols, ethers, carbonyl compounds (aldehydes, ketones), acetals (ketals), acids, functional derivatives of acids (esters, lactones), phenols, S- a N-aliphatic compounds, O-, S-, N-heterocycles

food	content in mg / kg
Beef meat	34
Bread (without ethanol)	6-10
Strawberry	2-8
Banana	12-18
Cocoa	100

Commodity	Type of aromatic substance
fruit ,vegetable	terpenes, alcohols, ketones, esters
alcoholic beverage	acids, esters, aldehydes, alcohols, acetals
roasting, frying product	Heterocyclic compounds

formation

- ◆ primary compounds

 - bound as glycosides, esters

 - free

- ◆ secondary compounds

 - enzymatic reactions (damage of tissues on storage and processing)

 - chemical reactions (storage, processing)

 - non-enzymatic browning reactions

 - fermentation processes

 - oxidative reactions

 - thermal reactions (Maillard reaction)

Type of aromatic substance	% of the identified substances in total	
	alcoholic beverage	roasted coffee
hydrocarbons	8	11
alcohols	13	10
aldehydes	6	4
ketones	5	8
acetals	8	0
acids	11	4
esters	24	5
lactones	4	2
O-heterocycles	4	23
N-heterocycles	8	20
S-heterocycles	2	8

factors influencing aroma perception

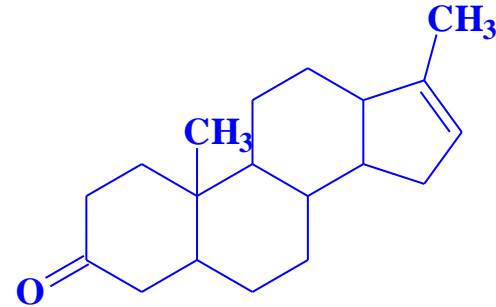
- ◆ thresholds of perception
- ◆ stimuli threshold
- ◆ threshold of recognition

- ◆ concentration
- ◆ synergism, antagonism of compounds
- ◆ sensitivity of individuals

age, sex, physiological and pathological conditions

adaptation

anosmia

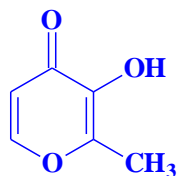


5α-androst-16-en-3-on

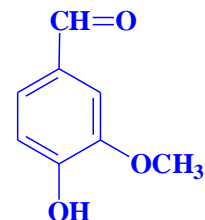
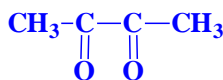
feel 71% of women, 63% of men

Compound	Occurence	Odour detection threshold (mg/l)
Ethanol	Alcoholic beverage	100
Maltol	Caramel	35
Acetic Acid	Vinigar	25
Biacetyl	Butter	2
Trimethylamine	Fish	2
Butyric acid	Rancid butter	0.2
Vanillin	Vanilla	0.02
2-Isobutyl-3-methoxypyrazine	Bell pepper	0.000 002
(+)-(R)-p-Menth-1-en-8-thiol	Grapefruit	0.000 000 02
Bis(2-methyl-3-furyl)disulfide	Thiamine photolytic product	0.000 000 002

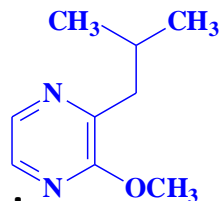
maltol



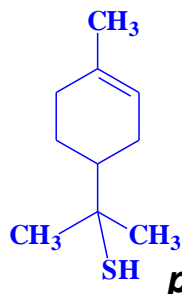
biacetyl



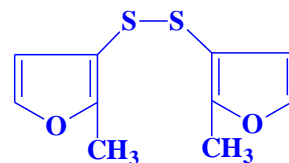
vanillin



2-isobutyl-3-methoxypyrazin



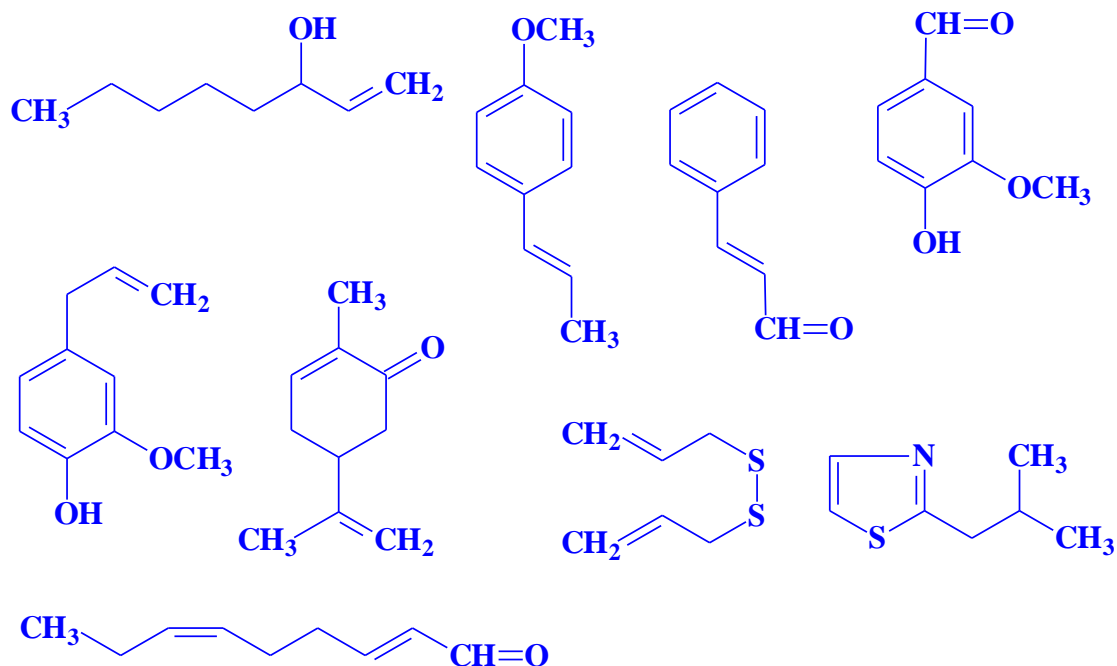
p-menth-1-en-8-thiol



bis(2-methyl-3-furyl)disulfide

Key odor components

Compound	Description	Occurrence
(<i>R</i>)-Oct-1-en-3-ol	Mushroom-like	Mushrooms, molds
Anethole	Anise-like	Anise seeds
Cinnamaldehyde	Cinnamon-like	Cinnamon bark
Vanillin	Vanilla-like	Dry vanilla beans
Eugenol	Clove-like	Clove plant fruits
(+)-(<i>S</i>)-Carvone	Caraway-like	Caraway and dill seeds
Diallyl disulfide	Garlic-like	Garlic
(2 <i>E</i> ,6 <i>Z</i>)-Nona-2,6-dienal	Cucumber-like	Fresh cucumber
2-Isobutylthiazole	Tomato-like	Tomato leaves, fresh fruits

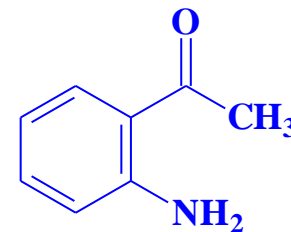
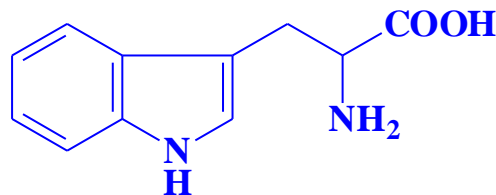
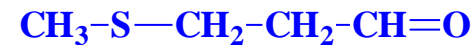
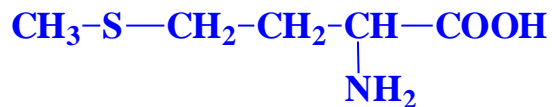


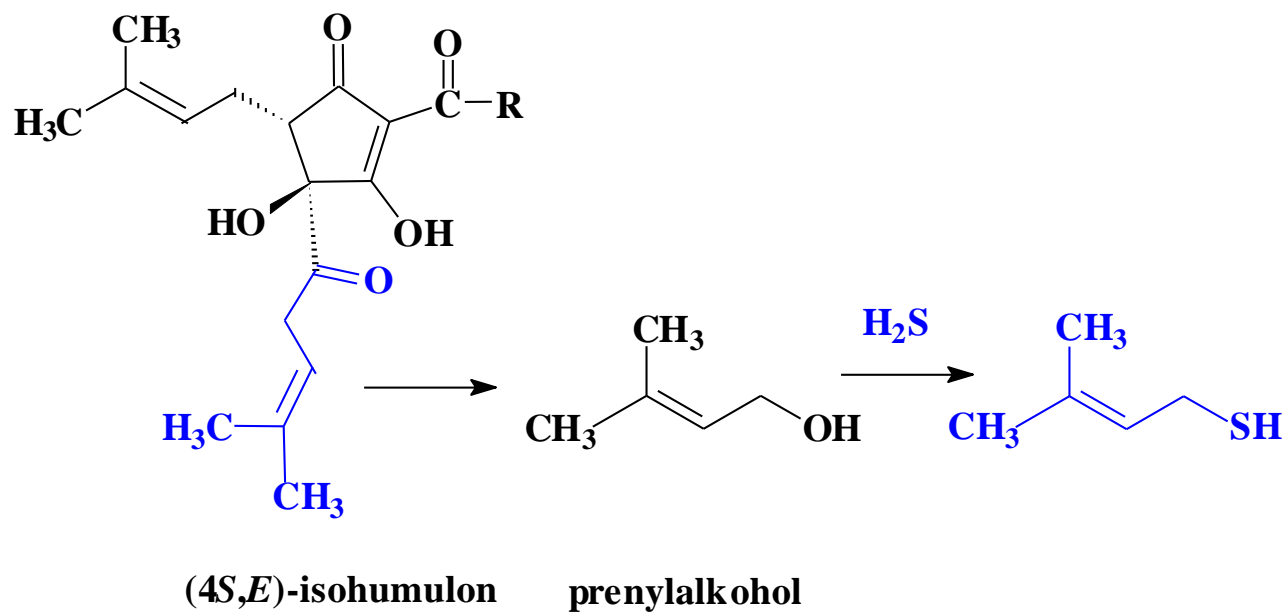
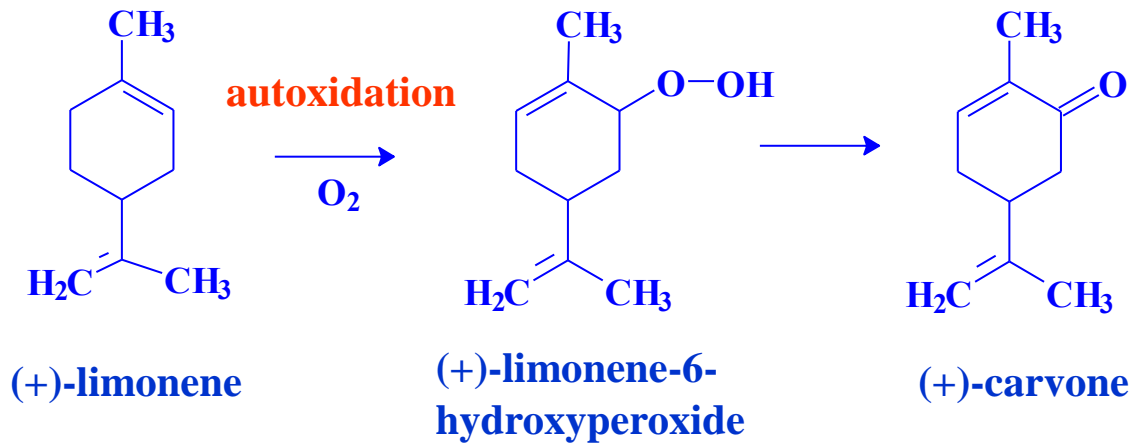
off-flavours

- ◆ processing (undesirable fermentation, preservation, thermal operation)
- ◆ storage (microbial contamination, reaction of components, oxidation, packaging material)
- ◆ animal source foods (feed)
- ◆ foods of Plant Origin (contamination of environment)

example

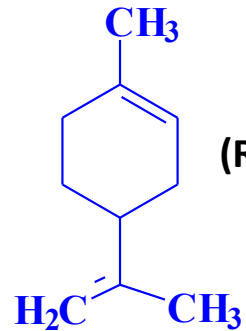
food	defect	source
milk	sun off-flavour	methional (Met, riboflavin)
orange juice	terpenic off-flavour	carvon (oxidation of limonene)
beer	sun off-flavour	Photolysis of isohumulone, reaction with H ₂ S (3-methylbut-2-en-1-thiol)





hydrocarbons

Alicyclic



(R)-limonene

citrus essential oil

aromatic and polycyclic aromatic (PAU)

benzene, toluene, xylene, benzo[a]pyrene

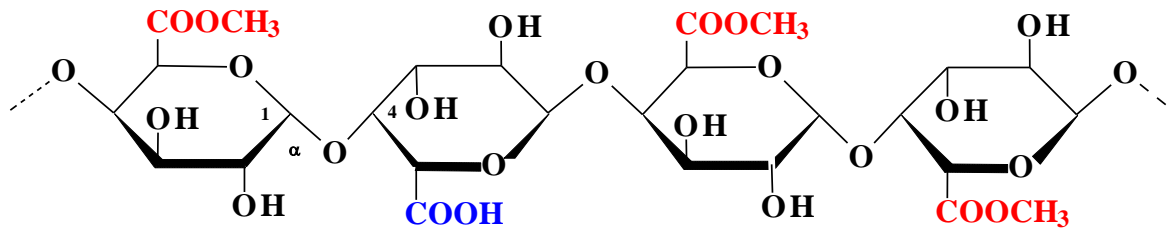
contaminants

Alcohols

aliphatic saturated

Methanol

hydrolysis of pectin



comodity

allowed amount in Czech legislation
(g/l ethanol)

spirit (alcohol)

0.8

destillate

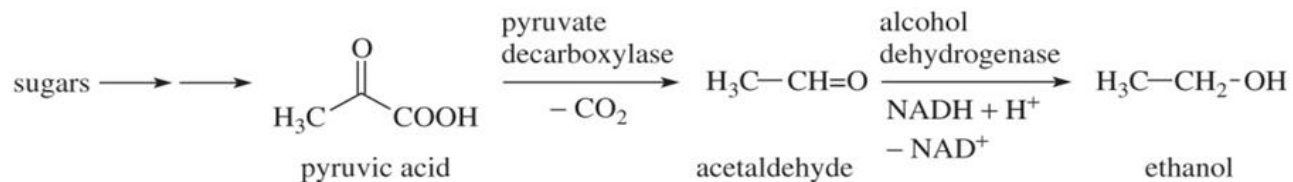
12

pomace brandy

15

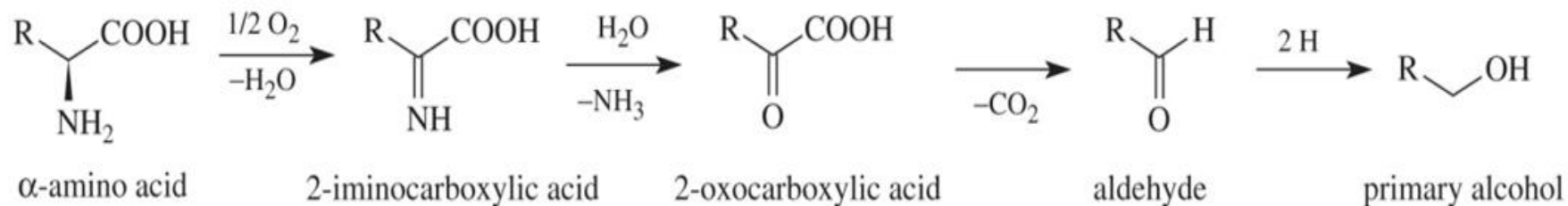
Ethanol

sugar fermentation



higher alcohols

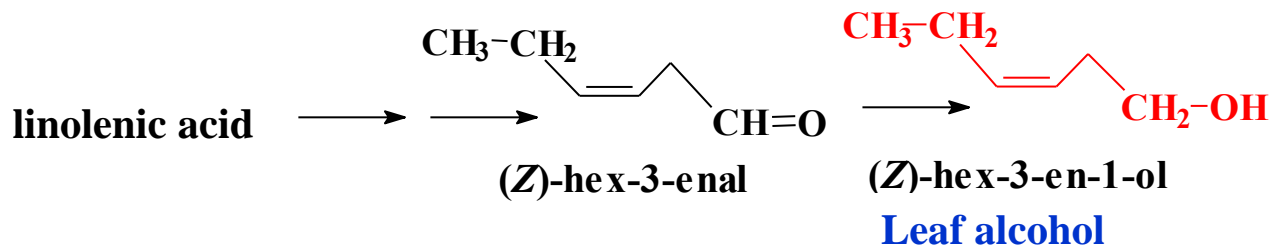
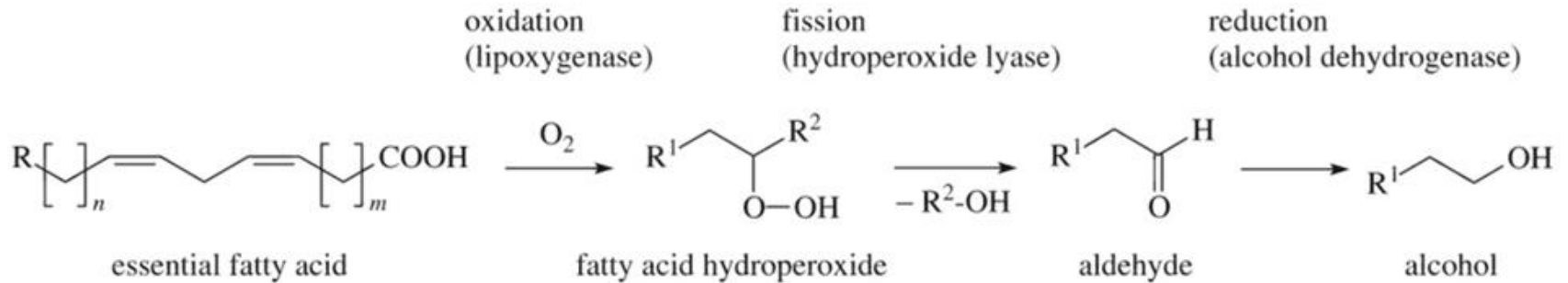
transformation of amino acids



Alcohol	Amino acid
propan-1-ol	Thr
butan-1-ol	Thr
2-methylpropan-1-ol	Val
(S)-2-methylbutan-1-ol	Ile
3-methylbutan-1-ol	Leu
2-phenylethanol	Phe

aliphatic unsaturated

oxidation of higher fatty acids



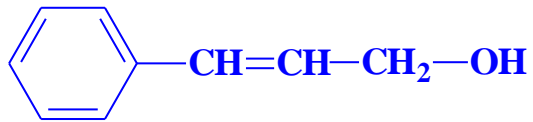
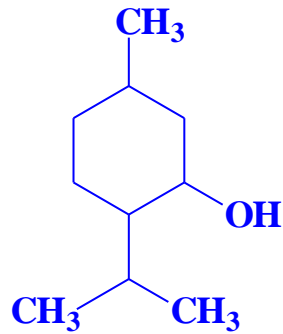
terpenic and aromatic alcohols

menthol

cinnamyl alcohol

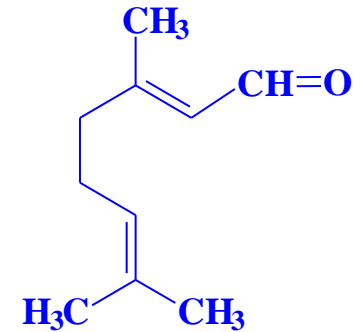
mint, chewing gum

cinnamon

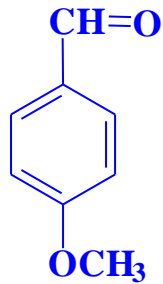


aldehydes

terpenes and aromatics

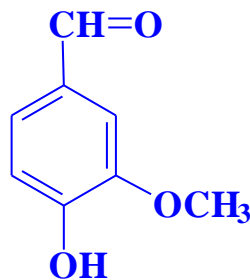


citral and (geranial)
citrus essential oils



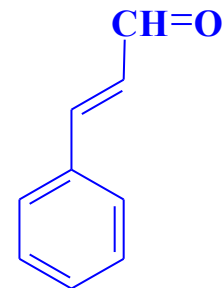
anisaldehyde

anise, star anise, vanilla



vanillin;

vanilla

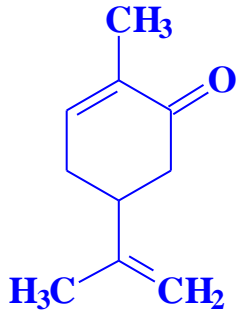


cinnamaldehyde

cinnamon

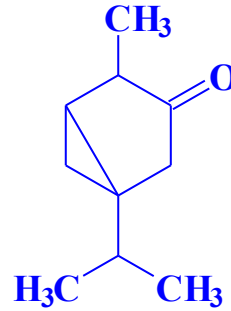
Ketones

terpenes



carvone

caraway



thujone

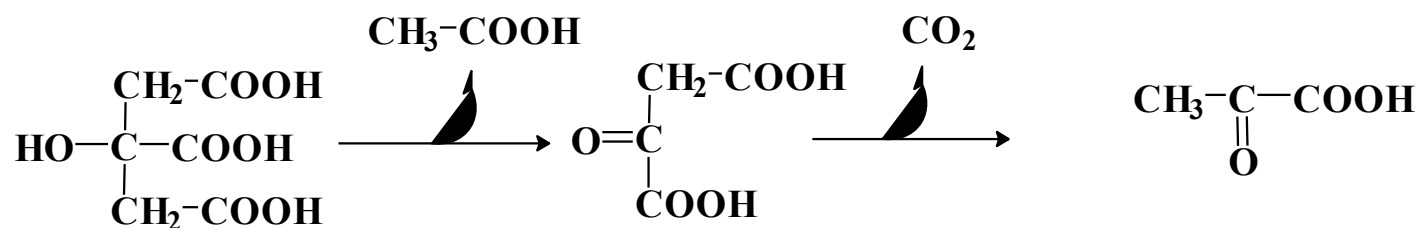
wormwood (absinth)

products fatty acids β -oxidation

methylketones

products of saccharides degradation

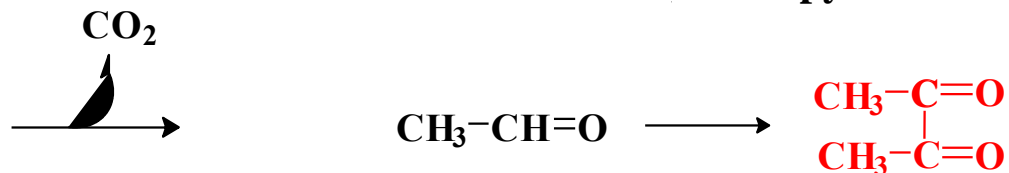
diketones



citric acid

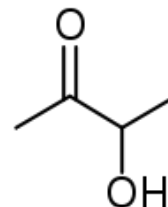
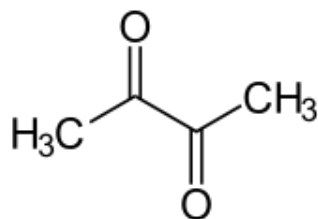
2-oxaloacetic acid

pyruvic acid



acetaldehyde

biacetyl



Butane-2,3-dione (diacetyl, biacetyl) + 3-Hydroxybutanone (acetoin) = aroma of butter

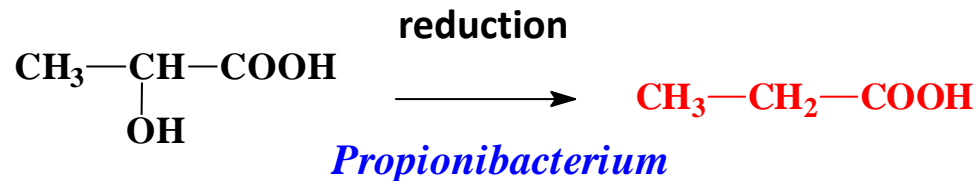
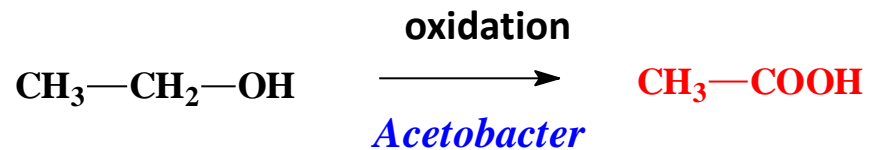
Acids and their functional derivatives

Acids

aliphatic saturated acids

fermentation products

formic, acetic, propionic, higher acids



lactic acid

esters

main compounds:

acetic acid

formic acid

propionic acid

butyric acid

isobutyric acid

ethanol

methanol

butanol

isoamylalkohol

(mono)terpenes

fruity and flower aroma

alcoholic beverages

beer

wine

ethyl acetate

~ 30 mg/l

10-260 mg/l

fruit

apple

banana

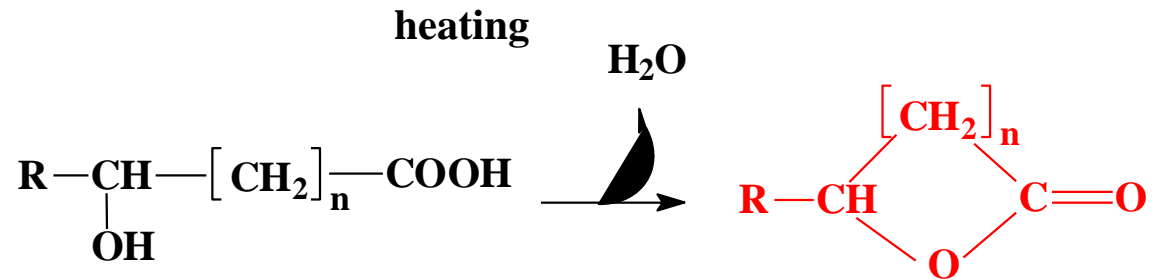
pineapple

acetates, butyrates

isoamylacetate

ethyl-3-(methylthio)propionate

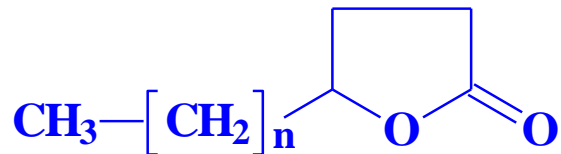
lactones



γ -hydroxyl acids \rightarrow γ -lactones (butano-4-lactones)

δ -hydroxyl acids \rightarrow δ -lactones (pentano-5-lactones)

aromatic hydroxy acids \rightarrow coumarins, phthalides



γ -nonalactone

$n = 4$

coconut aroma

γ -decalactone

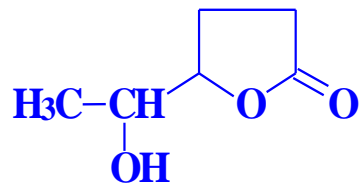
$n = 5$

peaches aroma

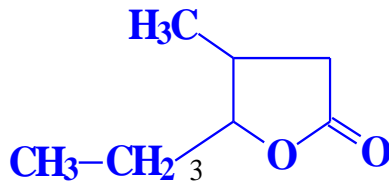
γ -dodecalactone

$n = 7$

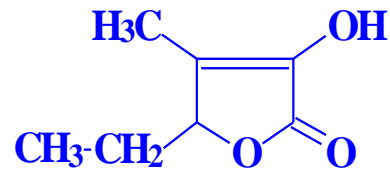
butter aroma



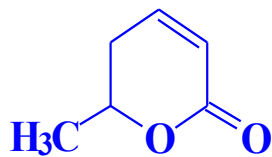
sherry lactone



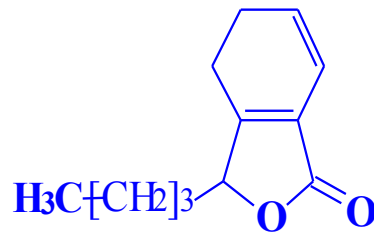
whisky lactone



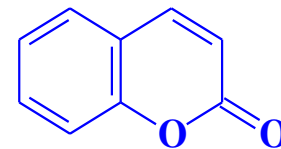
maggi lactone (abhexon)



parasorbic acid

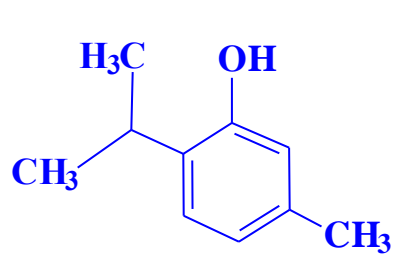


sedanenolid



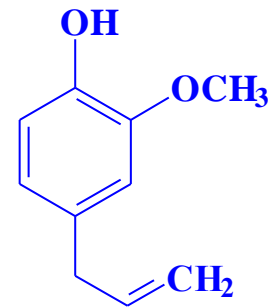
coumarin

phenols



thymol

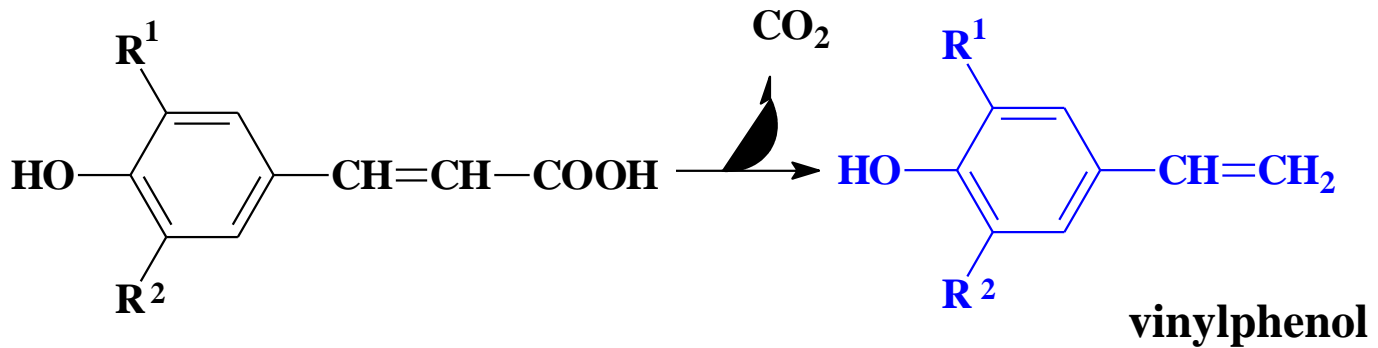
thyme



eugenol

clove

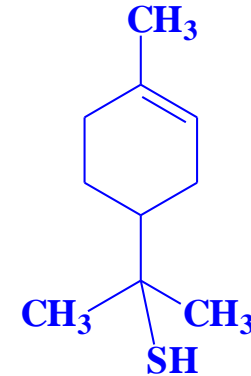
decarboxylation of phenolic acids, lignin degradation



sulphur containing compounds

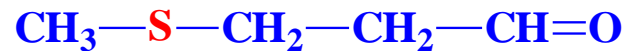
p-meth-1-en-8-thiol

grapefruit



degradation products of sulphur-containing compounds

(sulphur amino acids, glucosinolates)



methional

boiled potato



diallyldisulfide

garlic



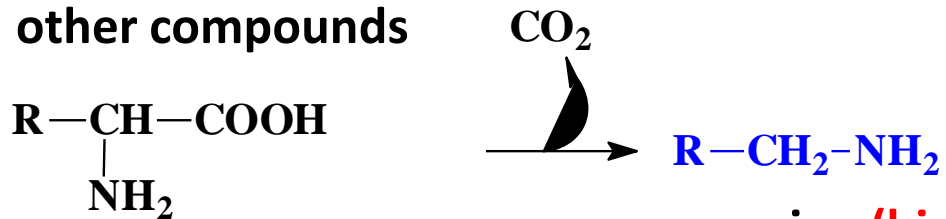
allyl isothiocyanate

mustard, horse radish

nitrogen containing compounds

decarboxylation products of amino acids, transformation products of

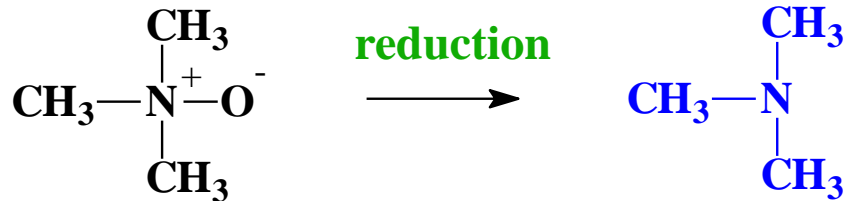
other compounds



amine (**biogenic amine**)

cheeses, meats, fish, fermentation products

post mortem



trimethylaminoxide

trimethylamine

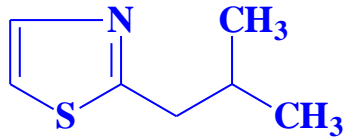
sea fish 40-120 mg/kg

indiferent

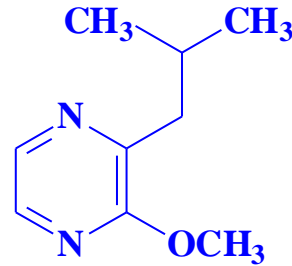
fishy smell

heterocyclic compounds

O-, S-, N-heterocycles

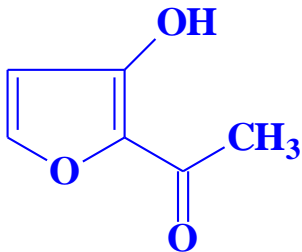


2-isobutylthiazole
tomato

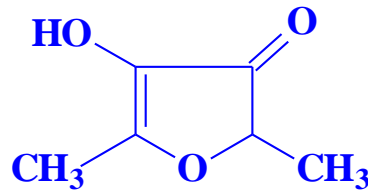


2-isobutyl-3-methoxypyrazine
bell pepper

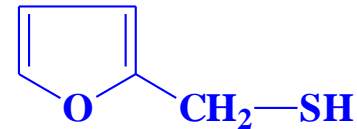
products of Maillard reaction, products of other reactions



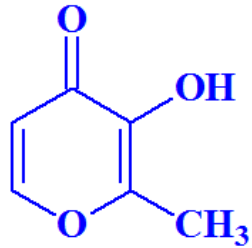
isomaltol
caramel



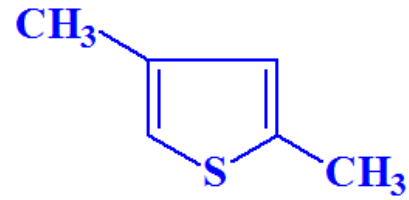
furaneol
strawberry and pineapple
fruit



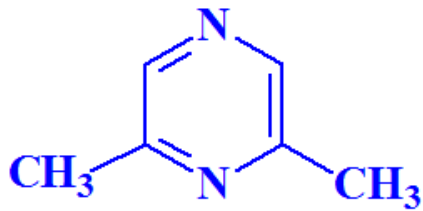
furfurylthiol
coffee



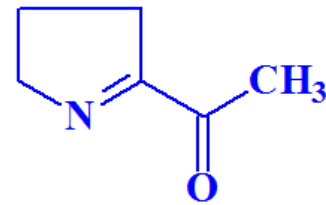
Maltol
caramel



2,4-dimethylthiophene
fried onion



2-acetyl-1-pyrroline
bread



2,6-dimethylpyrazine
chocolate and nuts

obtaining fragrances for flavoring food

75% natural

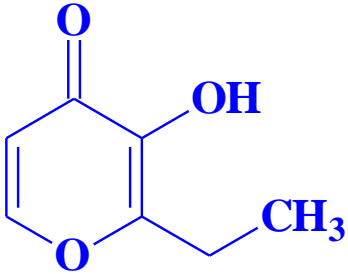
25% syntetic – 99% in nature (naturally identical)

1% not in the nature

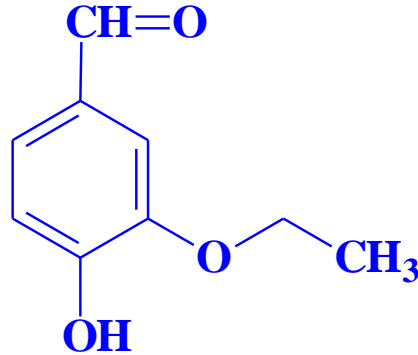
materials essential oils

oleoresins

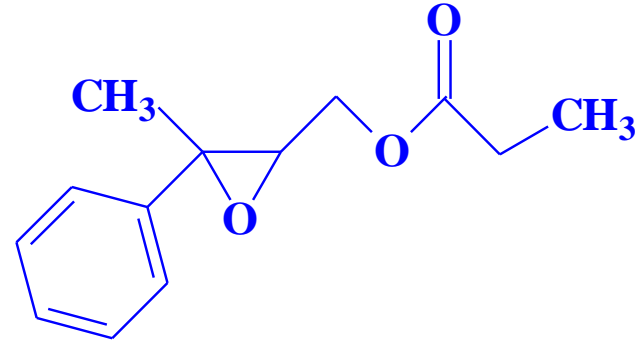
synthetic compounds



ethylmaltol
caramel



ethylvanillin (bourbonal)
vanilla sugar



ethyl-3-phenyl-3-methylglycidate
strawberry (candies)

biological effect

beneficial effects

bactericidal and anti-inflammatory

(borneol, eugenol, pinene, camphor, thymol, menthol)

spasmolytic or cholinolytic effects

(camphor, camphene, α - and β -pinene)

analeptic effects

(camphene)

antioxidant effects

(essential oils of many kinds of spices: marjoram, sage, thyme)

toxic effects

chronic neurotoxicity (convulsions, damage to the cortex)

α and β -thujone= dominant component

wormwood, sage, clove oil

absinthism

Pulegone (essential oils of different varieties of mint)

carcinogenic effects **alkenylbenzenes**

β -asarone (calamus oil)

estragole (tarragon oil)

methyleugenol (clove)

safrole (essential oils of nutmeg, anise, cinnamon)

isosafrole (laurel oil, clove)

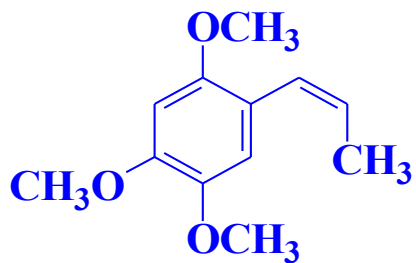
myristicin (oil vegetables: carrots, parsley, celery, caraway)

psychomimetic, hallucinogenic and narcotic effects (comparable to the effects of ethanol)

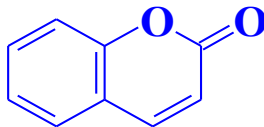
myristicin (nutmeg - flower, hazelnut)

hepatotoxic effects

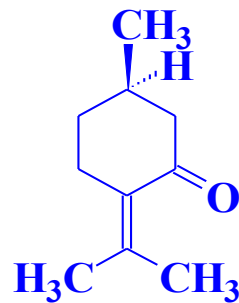
coumarin



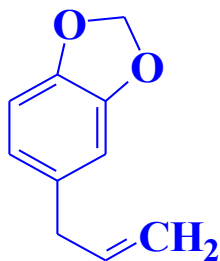
β -asaron



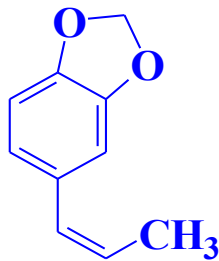
coumarin



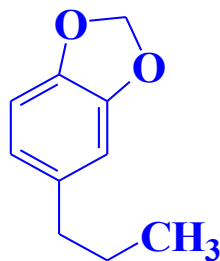
(+)-pulegon



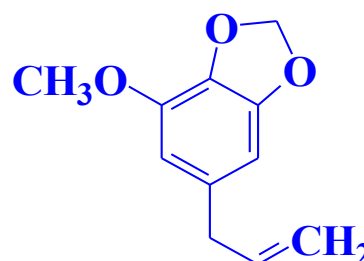
safrole



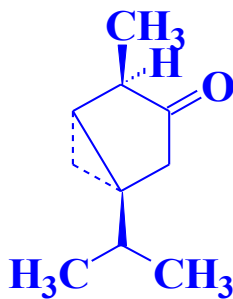
isosafrole



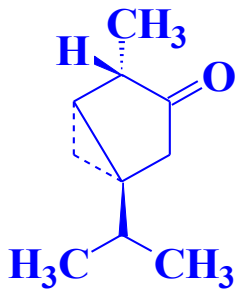
dihydrosafrole



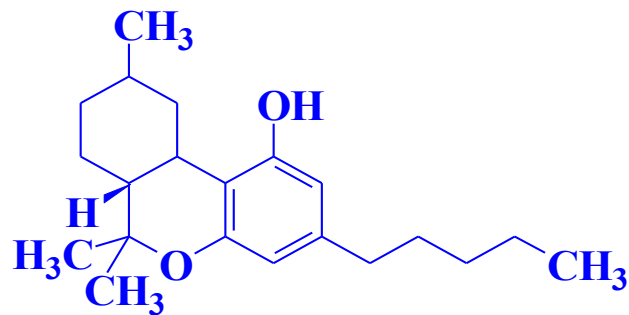
myristicin



**α -thujon
(-)-thujon**



**β -thujon
(+)-isothujon**



tetrahydrocannabinol

Compounds influencing food taste

perception of gustation

4 (5) basic tastes

- | | |
|--------------------------|-----------------------------------|
| ◆ sweet | end of tongue |
| ◆ salty | upper surface of tongue |
| ◆ acid | sides of tongue |
| ◆ bitter | root of tongue, roof of the mouth |
| ◆ umami | whole oral cavity |
| ◆ astringent | whole oral cavity |
| ◆ pungent (burning, hot) | whole oral cavity |
| other sensations | |

Properties

- ◆ polar
- ◆ water-soluble
- ◆ non-volatile

Formation

- ◆ primary compounds
- ◆ secondary compounds
 - enzymatic reactions (damage of tissues on storage and processing)
 - chemical reactions (storage, processing)

factors influencing taste perception

- ◆ thresholds of perception
 - stimuli threshold
 - threshold of recognition

Compound	Stimuli threshold (vol. %)	Compound	Stimuli threshold (vol. %)
sweet		acid	
D-glucose	1.17	acetic	0.011
D-fructose	0.24	lactic	0.020
saccharose	0.36	citric	0.015
salty		bitter	
sodium chloride	0.175	limonin	0.0006
umami		quinine	0.001
Glu (Na-H)	0.012	caffeine	0.014

saccharide	stimuli threshold (vol. %)	threshold of recognition (vol. %)
D-glucose	1.17	1.63
D-fructose	0.24	0.94
saccharose	0.36	0.81

SWEET COMPOUNDS

according to origin

- ◆ **natural**
- ◆ **synthetic, identical with natural**
- ◆ **modified natural and synthetic**

according to importance in nutrition (energy value)

- ◆ **nutrients (source of energy)**
- ◆ **non-nutrients (they are not source of energy)**

according to possibility to influence the blood sugar level

- ◆ **contraindicated to diabetes**
- ◆ **without any influence**

according to influence on caries

- ◆ **cariogenic**
- ◆ **non-cariogenic**

Sweetness

Saccharides

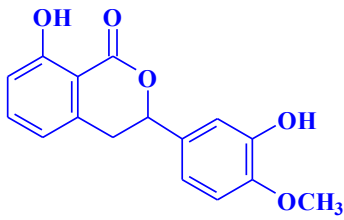
standard = 10% solution of saccharose

compound	Sweetness	compound	Sweetness
D-glucose	0.4-0.8	D-galactose	0.3-0.6
D-fructose	0.9-1.8	maltose	0.3-0.6
saccharose	1.0	lactose	0.2-0.6

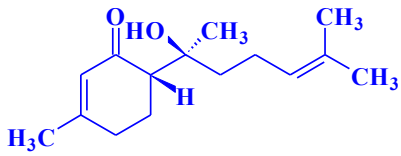
artificial sweeteners – taste quality

natural sweet compounds

Compound	Sweetness	structure	occurrence
phylloducin	200-800	isocoumarin	<i>Hydrangea opuloides</i>
glycyrrhizin	50	saponins	<i>Glycyrrhiza glabra</i>
hernandulcin	1250	aromatic ketone	<i>Lippia dulcis</i>
monellin	1500-3000	protein	<i>Dioscorcophyllum comminsii</i>
osladin	3000	steroidal glycoside	<i>Polypodium vulgare</i>
stevioside	100-300	steroidal glycoside	<i>Stevia rebaudiana</i>
thaumatin (thalin)	2000-3000	protein	<i>Thaumatococcus daniellii</i>

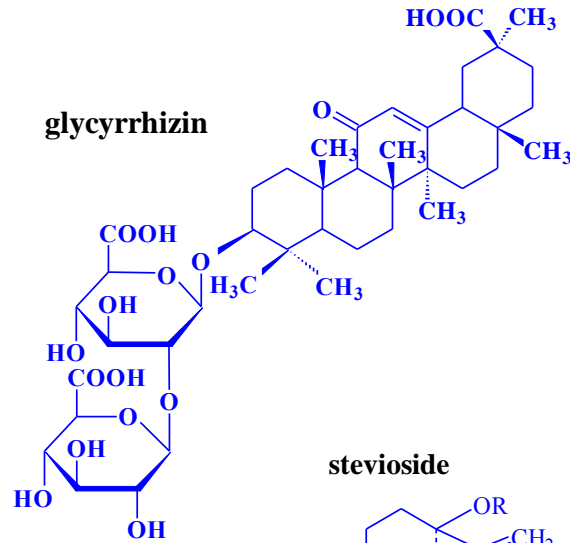


phylloducin

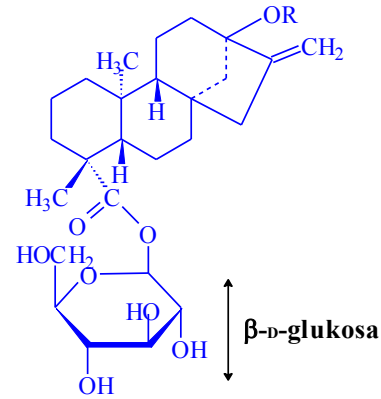


hernandulcin

glycyrrhizin

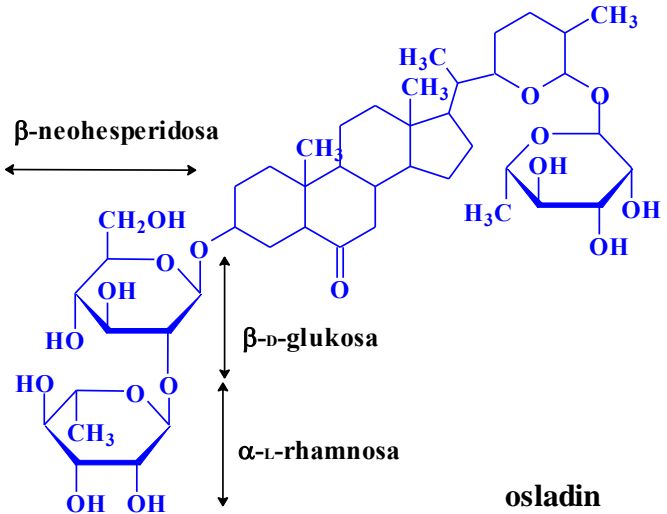


stevioside



β -D-glukosa

R = β -soforosa
 (β -D-Glcp-(1 \rightarrow 2)- β -D-Glcp)



β -neohesperidosa

α -L-rhamnosa

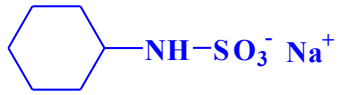
β -D-glukosa

α -L-rhamnosa

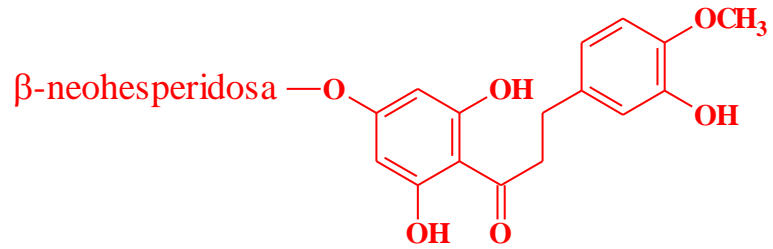
osladin

synthetic compounds

Compound	Sweetness (sucrose = 1)
Cyclamates	30-35
Aspartane	200
Saccharin	300-350
Neohesperidin dihydrochalcon	1100-1500
Acesulfame K	200
Dulcin	110-250

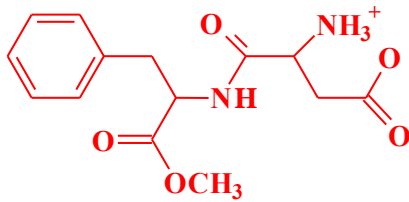


cyclamic salt

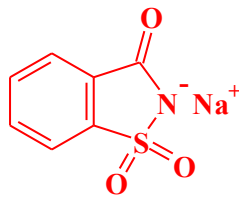


β -neohesperidosa

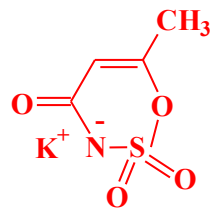
neohesperidin dihydrochalcone



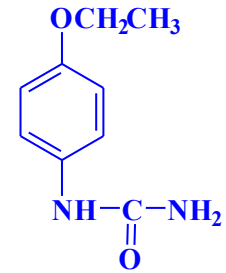
aspartame



saccharin



acesulfame K



dulcin

List of current EU approved sweeteners and their E-codes

E code

E420	Sorbitol and sorbitol syrup
E421	Mannitol
E950	Acesulfame K
E951	Aspartame
E952	Cyclamic acid and its Na and Ca salts
E953	Isomalt
E954	Saccharin and its Na and Ca salts
E955	Sucralose
E957	Thaumatococin
E959	Neohesperidin dihydrochalcone
E960	Steviol glycoside
E961	Neotame
E962	Salt of aspartame-acesulfame
E965	Maltitol and maltitol syrup
E966	Laktitol
E967	Xylitol
E968	Erythritol

SALTY COMPOUNDS

Inorganic salts, **mostly NaCl**

some salts of organic acids

taste quality, further attributes (bitter, metallic)

food classification

- ◆ with very low content < 0.4 g/kg Na ~ < 1 g/kg NaCl
milk, fruits, vegetables
- ◆ with low content 0.4-1.2 g/kg Na
meat, poultry, fish
- ◆ with high content 1.2-4.0 g/kg Na
bread, some bakery products, pickled vegetables
- ◆ with very high content > 4.0 g/kg Na
some meat and fish products, olive, salty condiments

ACIDIC COMPOUNDS

non-dissociated carboxylic acids

◆ aliphatic monocarboxylic	volatile	aroma, taste,
◆ aliphatic dicarboxylic	non-volatile	taste
◆ aliphatic hydroxy acids	non-volatile	taste
◆ alicyclic	non volatile	taste
◆ aromatic	some non-volatile	aroma, taste

mineral acids, H_3O^+ (pH)

taste quality, further attributes (fruity)

food classification

◆ very sour	pH < 4,0	fruits
◆ little sour	pH 4,0-6,5	vegetables (fruits),cereals
◆ neutral	pH > 6,5	meat, milk, egg

	pH
1. Vinegar 8%	2,53
2. 100% juice from sicilian citron - Lemon d'or	2,57
3. Coca Cola	2,87
4. Grapefruit nectar 50%	3,16
5. Sour cabbage	3,59
6. Pickled cucumber	3,80
7. Yogurt	4,12
8. Tomato juice 100%	4,30
9. Mineral water Vincentka	6,75
10. Milk	6,86
11. Mineral water Magnesia	8,05
12. Egg – white	8,70

Lemon	citric acid	4.0-4.4%
Grapefruit	citric acid	1.2-2.1%
Tomato	citric acid	0.9-2.0%
Vinegar	acetic acid	8.0%
Pickled cucumber	acetic acid	1.0%
Sour cabbage	lactic acid	2.0%
Yogurt	lactic acid	1.0%
Coca Cola	phosphoric acid	0.08%

fruits	citric, malic, quinic, ascorbic
vegetables	citric, malic, oxalic
meat	lactic
milk (vegetables) fermented products	lactic

apple unripe	quinic
apple ripe, pulp	malic
apple ripe, skin	citric, malic

aliphatic monocarboxylic acids

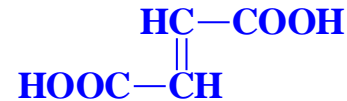
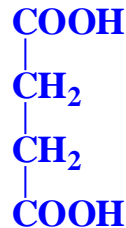
formic	side product of fermentation, degradation of saccharides, preservative compound
acetic	acetic acid fermentation (<i>Acetobacter</i>), vinegar preservative compound
propionic	propionic acid fermentation (<i>Propionibacterium</i>) preservative compound

aliphatic dicarboxylic acids

oxalic metabolisms, antinutritive compound

succinic metabolisms

fumaric, (E)-but-2-enic metabolisms



content in carrot

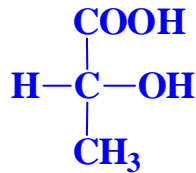
- ◆ Oxalic 0-0,06%
- ◆ Succinic 0,002-0,013%
- ◆ Fumaric 0,0005-0,0008%
- ◆ Quinic 0,004-0,006%
- ◆ Malic 0,4-5,2%
- ◆ Citric 0,034-0,093%

Food	Content of oxalic acid in %
Orange	0.004
Tomato	0.010
Spinach	0.54-0.98
Rhubarb	0.23-0.96
Tea	0.65-0.70

aliphatic hydroxyacids

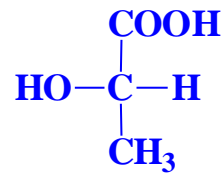
lactic

milk fermented products (Lactobacillus and others), meat



D-(-)-lactic

(R)-2-hydroxypropionic



L-(+)-lactic

(S)-2-hydroxypropanic

milk fermented products

0.5-1.0%

Sour cabbage

1.5-2.5%

sour olive

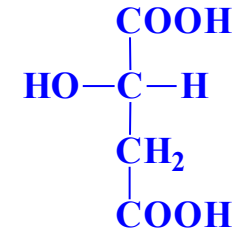
0.8-1.2%

meat

0.2-0.8%

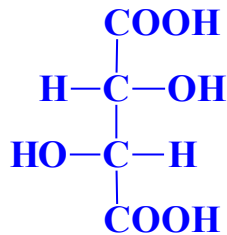
L-malic acid

fruits, vegetables, additives (acidulant)

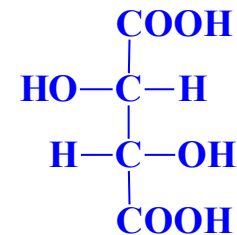


tartaric acid

fruits, vegetables, additives (acidulant)



L-tartaric, (2R,3R)-tartaric, L-threarinic



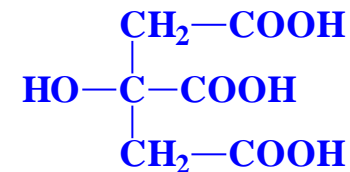
D-tartaric

grapy acid (racemic mixture, racemate, K-H salts = tartar),

mesotartaric (erythrarinic)

citric acid

fruits, vegetables, additives (acidulant)

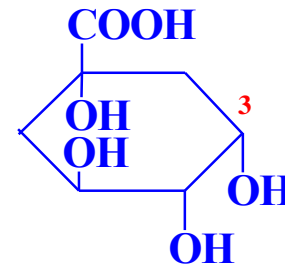


Content of main acid in fruit (%)

Fruit	Malic	Citric	Tartaric
Apple	0.2-1.3	0.0075-0.01	-
Orange	0.06-0.2	0.56-0.98	-
Lemon	0.17-0.30	4.0-4.4	-
Grapes	0.7-1.5	0.03-0.1	0.4-1.4

alicyclic acids

L-quinic fruits, vegetables (free, depsides)



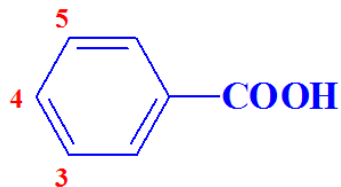
aromatic acids

fruits, vegetables, cereals, (free, esters, glycosides)

seeds germination inhibition, antibacterial properties

sensory properties (phenols, non-enzymatic browning reactions)

benzoic acid, cinnamic acid and derivatives



benzoic

4-OH

3,4-diOH

4-OH, 3-MeO

4-OH, 3,5-diMeO

3,4,5-triOH

p-hydroxybenzoic

protocatechuic

vanillic

syringic

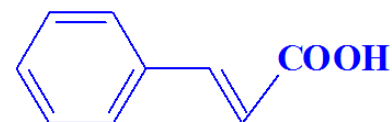
gallic

benzoic, *p*-hydroxybenzoic

caffeic

vanillic

gallic



cinnamic

p-cumarinic

caffeic

ferulic

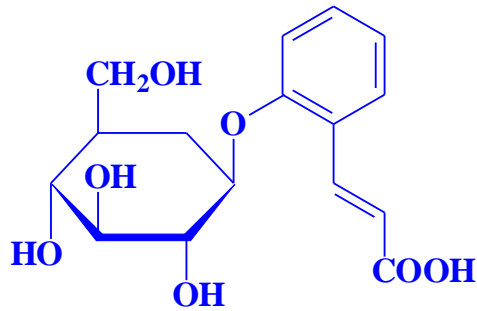
sinapic

food preservative

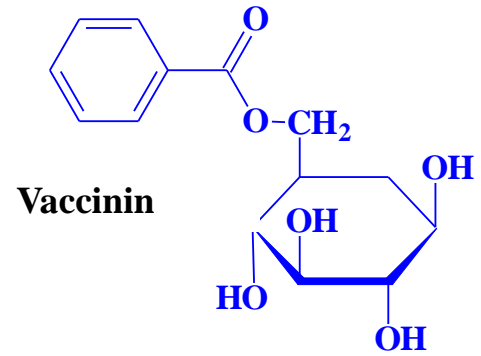
substrate oxidoreductases

component of alkaloids

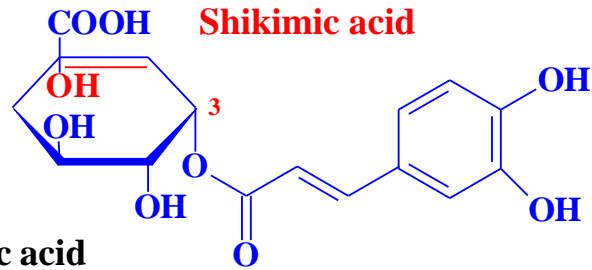
component of tannins



Melilotoside



Vaccinin



Chlorogenic acid

apple, potato, coffee
dates

chlorogenic = caffeic + quinic
dactylipheric = caffeic+ shikimic

BITTER COMPOUNDS

primary compounds

- ◆ characteristic compounds of plants

secondary compounds

- ◆ formation during processing and storage
(reaction products, metabolites of microorganisms)

additives

alkaloids

quinine (true alkaloids, quinolinic alkaloids),

tonic water

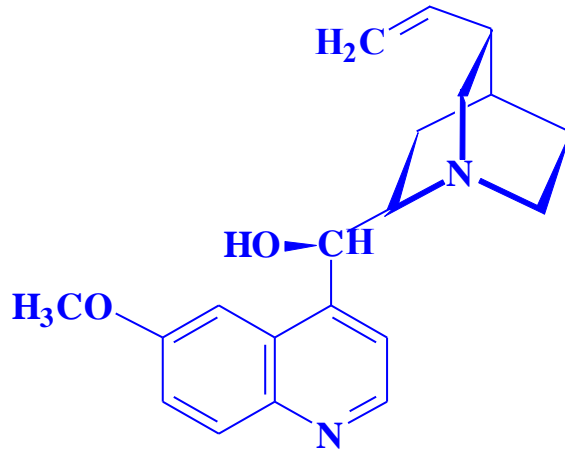
caffeine (protoalkaloids, purine alkaloids)

coffee, tee, cocoa, guarana, cola drinks

mate - prepared by steeping dried leaves of yerba mate (*Ilex paraguariensis*), "national infusion" in Argentina



Ilex



quinine

mg/kg

nonalcoholic beverages

75

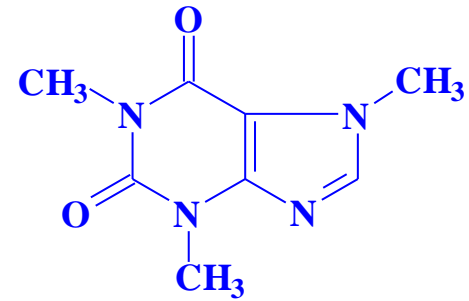
spirits

300

fruits

grapefruits (bitter oranges)

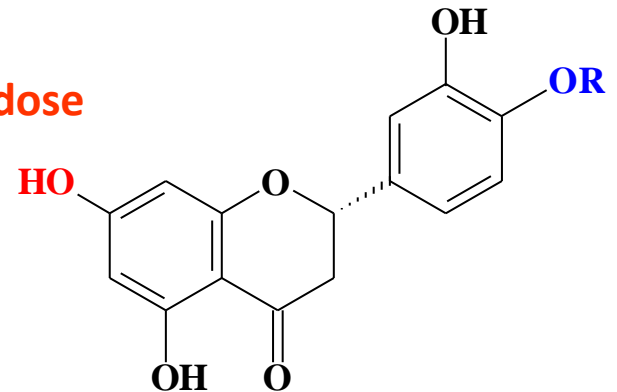
flavonoids (flavanones)



caffeine

250

neohesperidose



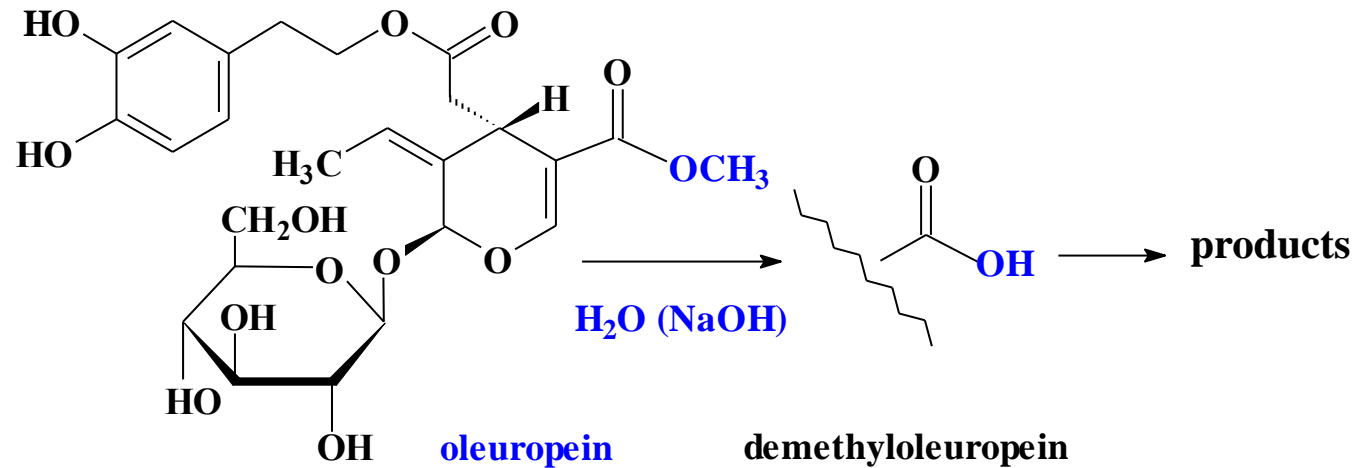
naringin = naringenin (R = H) + neohesperidose, α -L-Rha-(1 \rightarrow 2)- β -D-Glc

neohesperidin = hesperetin (R = CH₃) + neohesperidose

sweet neohesperidin dihydrochalcon

olive

phenols



vegetables

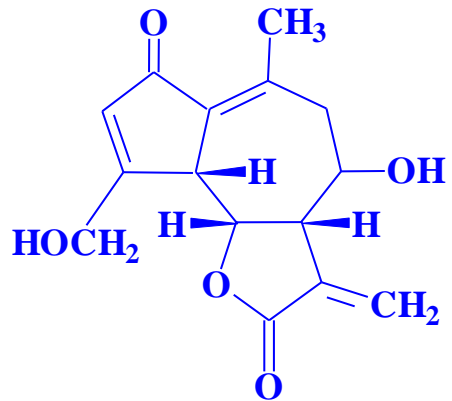
lettuce, endive, chicory (lactucin)

terpenes

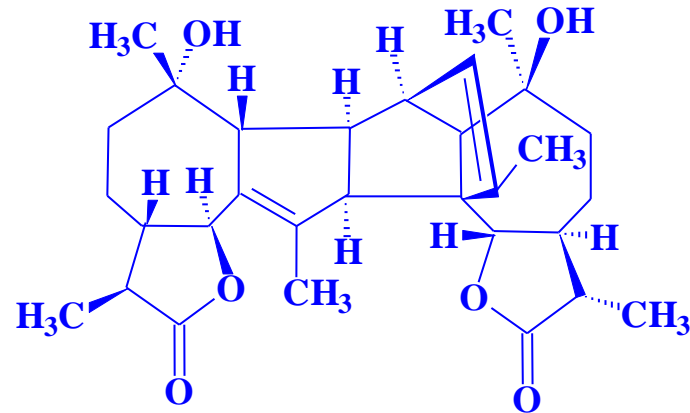
spices and other plant materials

wormwood (absinthin)

terpenes



lactucin



absinthin

hops

derivatives **phloroglucinol** (1,3,5-benzenetriols)

bitter acids (18% dry matter)

- ◆ α -bitter acids (homologues humulone)
- ◆ β - bitter acids (homologues lupulone)

beer

isobitter acids

- ◆ iso- α -bitter acids (isohumulone)
- ◆ iso- β - bitter acids (isolupulone)

ADSTRINGENT COMPOUNDS

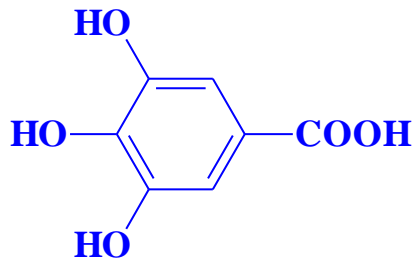
perception = protein interaction of saliva with polyphenolic compounds → denaturation
(loss of protective role)

tannins

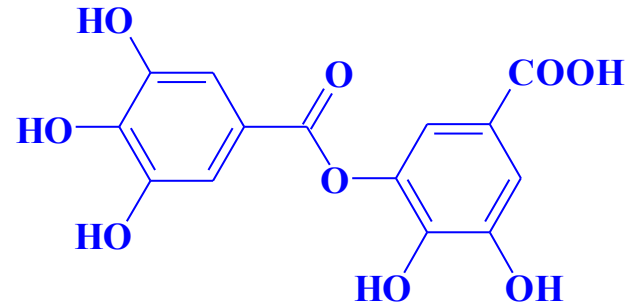
- ◆ hydrolysed polymers of gallic acid esters
 additives, little in food
- ◆ condensed polymers of flavan-3-ols (3,4-diols)
 food (fruits, wine)

hydrolysed tannins

gallotannins

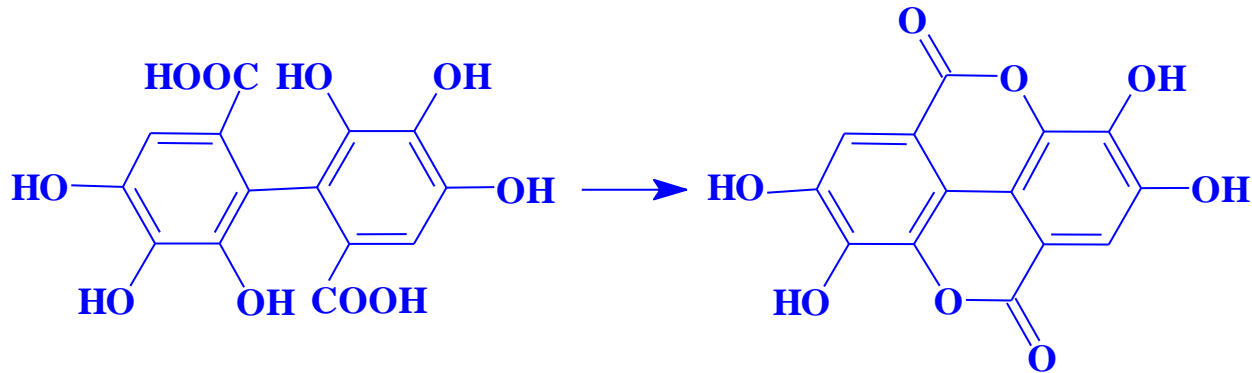


gallic acid



m-digallic acid (depside)

◆ ellagotannins



hexahydroxybiphenylic acid (C-C dimer)

ellagic acid (lactone)

gallotannins

Chinese tannin

mixture of galloylesters and m-digalloylesters D-glucose

elimination of turbidity caused by proteins (vinegar, beer, wine)

Ellagotannins

corilagin

cranberries leaves

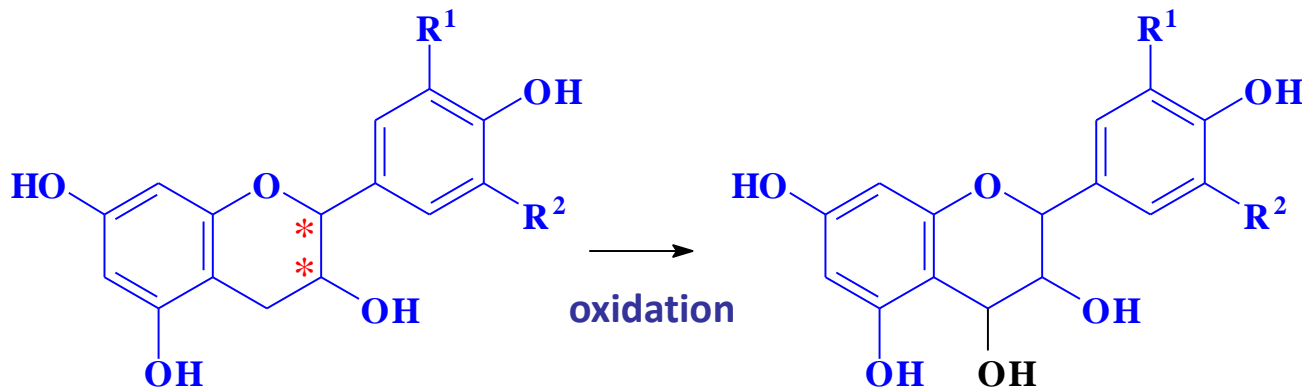
condensed tannins (proanthocyanidins, flavolans)

dimers and higher oligomers (2-10 unites)

- ◆ flavan-3-ols (catechins)
- ◆ flavan-3,4-diols (leucoanthocyanidines)

monomers do not have the properties of tannins

oxidised oligomers are coloured



afzelechins (R1 = R2 = H)

catechins (R1 = H, R2 = OH)

gallocatechins (R1 = R2 = OH)

p-hydroxybenzoic

protocatechuic

gallic

leucopelargonidin

leucocyanidin

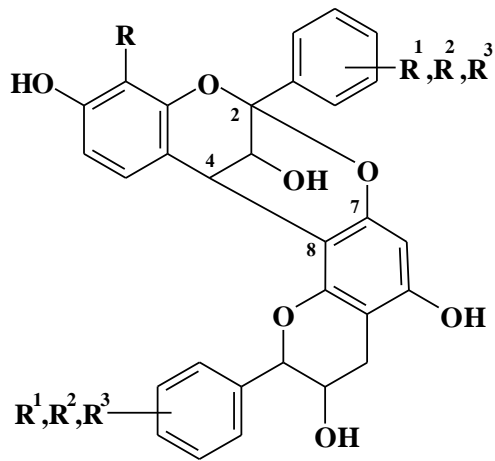
leucodelphinidin

Examples

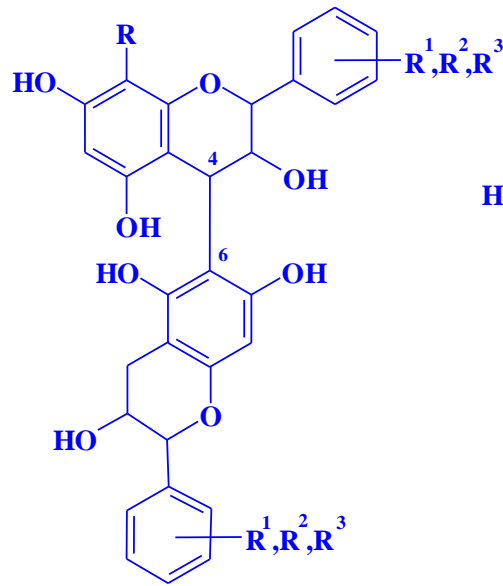
fruit and wine tannins

tea tannins

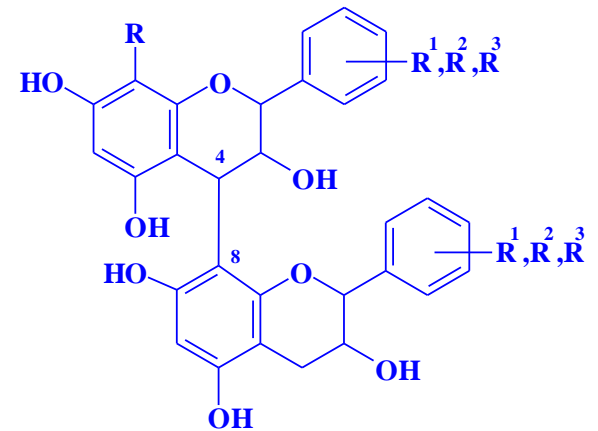
non-enzymatic browning reaction



type A (C-4→C-8, C-2→O → C-8)



type B (C-4 → C-6)



type B (C-4 → C-8)

PUNGENT SUBSTANCES

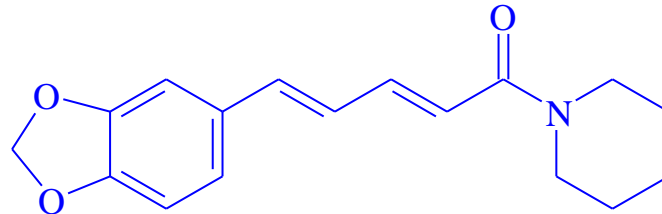
primary compounds

- ◆ characteristic components of plants

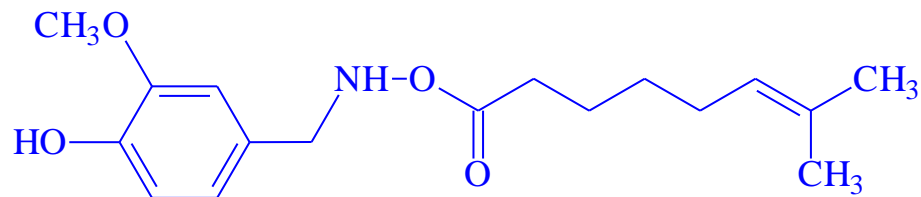
secondary compounds

- ◆ enzymatic reactions

Alkaloids

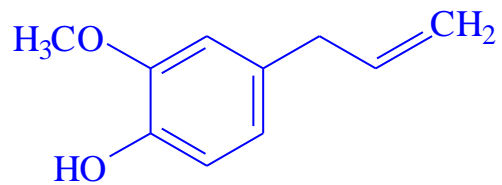


true alkaloids: **piperine** (black pepper)

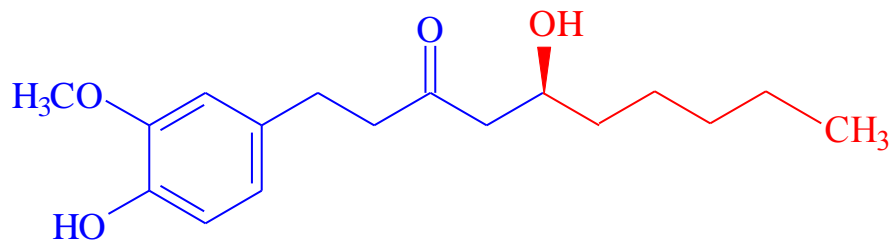


protoalkaloids: **capsaicin** (bell pepper, chilli)

phenols

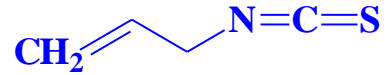


eugenol (clove)



gingerol (ginger)

isothiocyanates



allylisothiocyanate (mustard, horse radish)

formation

