7. VITAMINS

definition (attributes)

- organic low molecular weight compounds
- function as biocatalysts (regulation of metabolism)

- autotrophic organisms: biosynthesis
- heterotrophic organisms: partly biosynthesis
  food
  gut microorganisms

terminology and classification

- formerly connection with illnesess

antixerophtalmic factor	A_1 retinol
antiscorbutic factor	C ascorbic acid
antirachitic factor	D calciferols
antiberiberi factor	B_1 thiamine
coagulation factor	K_1 fylloquinone

- letters of alphabet, numbers
- simple trivial names, systematic names

water soluble (hydrophilic)

1. thiamine (aneurin, B_1)
2. riboflavin (lactoflavin, B_2, G)
3. niacin (nicotinic acid, B_3; nicotinamide, PP)
4. pantothenic acid (B_5)
5. pyridoxine (~al, ~ol, ~amine, adermin, B_6)
6. biotin (H)
7. folacin (B_c, B_9)
8. cyanocobalamin (corinoids, B_{12})

1.- 8. = group of vitamins B (B-complex)

9. ascorbic acid (vitamin C)

fat soluble (lipophilic)

10. retinoids (A)
11. calciferols (D)
12. tocopherols (E)
13. phylloquinons (K)

exogenity and essentiality

thiamine	very little by gut microorganisms
niacin	biosynthesis from Trp (1 mg ~ 60 mg)
biotin	gut microorganisms
corrinoids	gut microorganisms
vitamin K	gut microorganisms
vitamin D	vitamin or hormone

- water soluble: excretion by urine, main losses by leaching, cofactors (coenzymes, prosthetic groups)
- fat soluble: storage in liver, main losses by oxidation, possible hypervitaminosis, other function

terminology

hypovitaminosis	insufficient intake
avitaminosis	temporary absolute shortage (malfunction of biochemical functions)
hypervitaminosis	excessive intake (failure of functions), A, D
retention	maintaining of original amounts
restitution	addition over original amounts

fortification	addition at higher amounts than original ones
provitamin	precursor (biologically inactive substance)
antivitamin	substances blocking biochemical usage of vitamin (vitamin antagonists)

amount (content in food) (book 2, tab. 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8)

- biological units
- international units

vitamin A	1 IU = 0.3 μg retinol = 0.6 μg β-carotene
	1 RE = 1 μg retinol = 3.33 IU
vitamin D	1 IU = 0.025 μg vitamin D_3 (or D_2)
vitamin E	1 IU = 1 mg all-rac α-tocopheryl-acetate

- mass units
- rich sources of vitamins
- important sources of vitamins

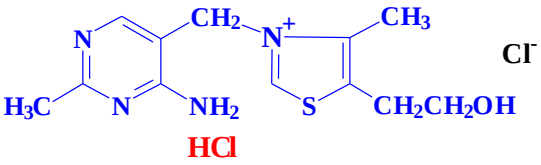
required amount

type of organism, age, physiological state, advisable daily intake

application

- additives for restitution and fortification
  all vitamins
- colouring matters
  riboflavin, provitamins A
- antioxidants
  vitamin C, provitamins A, vitamin E

thiamine



- free
- bound (phosphates: mono-, di-, triphosphate, diphosphate = cofactor of enzymes)
- other forms (thiol, disulfide)

sources (mg / 100 g) (book 2, tab. 5.1)

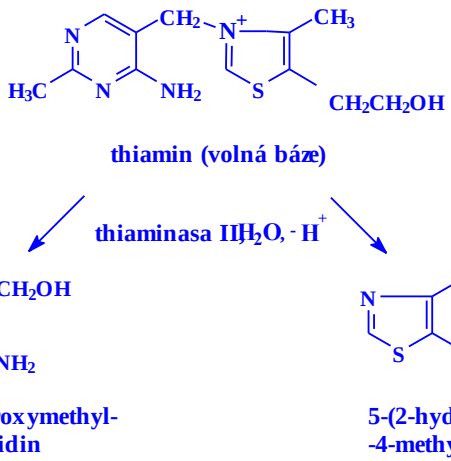
• legumes	0,1-1	mostly free thiamine
• pork	1	mostly diphosphate
• beef	0,04-0,1	
• fruits	0,04-0,1	
• vegetables	0,03-0,15	
• potato	0,05-0,18	

covered by (%)

• cereals products (bread)	43 (20)
• meat and meat products	18-27
• milk and dairy products	8-14
• potato	10
• legumes	5
• vegetables	12

- fruits 4
- eggs 2

reactions

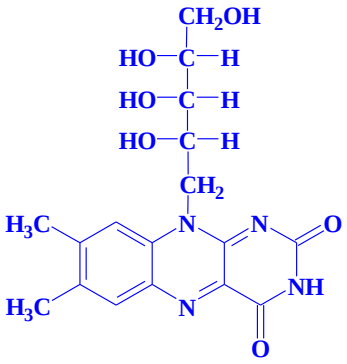


losses

- boiling of pork ~ 40-60 %
- baking of bread ~ 25-30 %
- boiling of potato (by leaching) ~ 25 %
- preservation of non-acid foods by SO_2 100 %

applications
fortification (restitution): wheat flour, breakfast cereals, rice

riboflavin



oxidised form (isoalloxazine, ribitol)

- free, ox. form flavoquinone, red. form flavohydroquinone (leucoflavin)
- bound (proteins), cofactor flavoproteins (FMN, FAD)
- other forms

sources (mg/100g) (book 2, tab. 5.1)

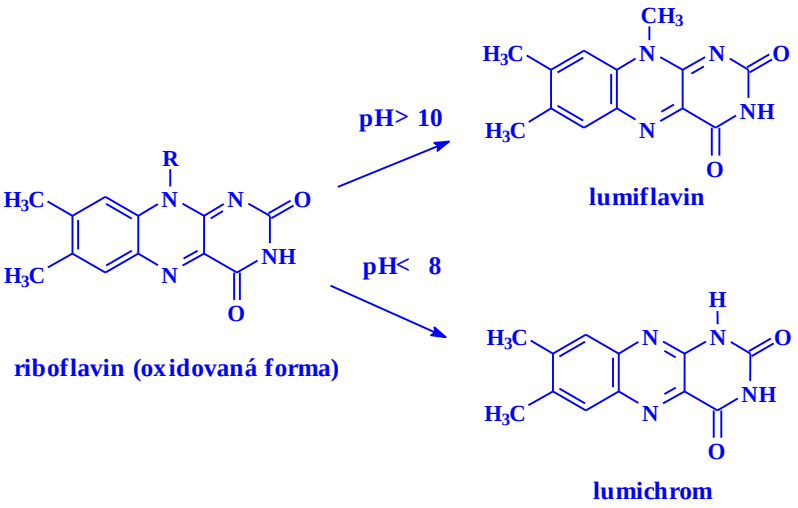
- meat 0,2
- liver 3
- milk 0,2
- cheese 0,5
- beer 0,05 (difference from thiamine)

covered by (%)

- milk, cheeses 36% mostly riboflavin, bound on α- a β-casein

- meat 19% mostly FMN, FAD
- cereals 15%
- eggs 8% mostly riboflavin
- vegetables 8%

reactions
photodegradation



losses
- milk, wine: sun off-flavour
- formation of $^1O_2$ (singlet oxygen)
- destruction of vitamin C, retinol, Met

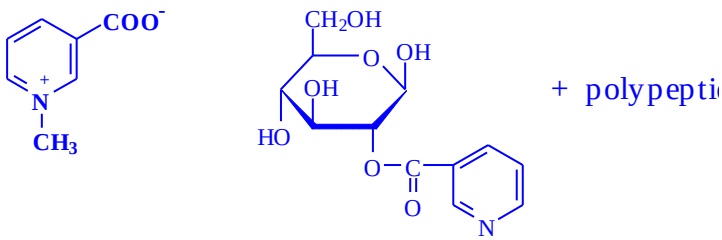
application
- fortification
- colouring matter

niacin

acid amide

- free (low quantity) (acid: plants, amide: animals)
- bound (to proteins): NAD (DPN) and NADP (TPN)
- other forms

trigonelline (coffee, legumes, cereals)
sorghum, corn



trigonelline glycopolypeptide

sources (mg / 100 g) (book 2, tab. 5.1)

- meat 5-15
- legumes, fruits, vegetables 0,7-2
- eggs 0,1
- coffee roasted 50
  green 2

covered by (%)

- meat 33 %
- milk 13 %
- cereals 21 %
- potatoes 9 %

reactions

- limited hydrolyses of amide, acid stable

losses

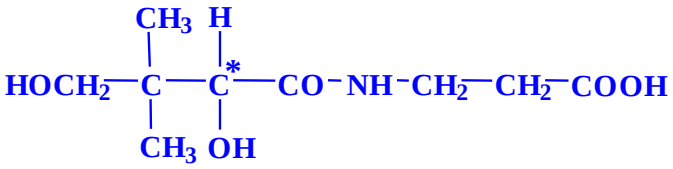
- by leaching

application

fortification

- white flour

pantothenic acid



- free, (*R*)-isomer
- bound (CoA, ACP)

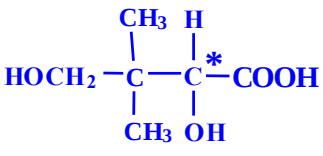
sources (mg / 100 g) (book 2, tab. 5.1)

- meat, fish
- cheeses (milk, little)
- whole cereal products
- legumes
- fruits, vegetables (little)

covered by (%)

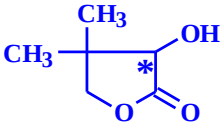
sufficient

reactions



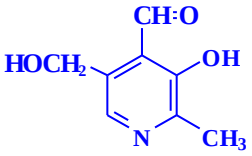
pantoic acid

β-alanine

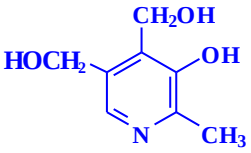


pantolactone

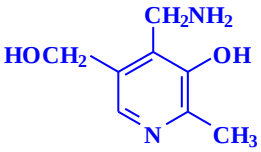
pyridoxine



pyridoxal



pyridoxol



pyridoxamine

- free
- their 5´-phosphates
- 5-*O*-β-D-glucoside of pyridoxol (5-70 % in cereals, fruits, vegetables)

sources (book 2, tab. 5.1)

- animal food: pyridoxal, pyridoxol
  meat, yolk
- plant food: pyridoxal, pyridoxamine
  cereals

covered by (%)

• meat	40
• vegetables	22
• milk	12
• cereals	10
• fruits	8
• legumes	5
• vegetables	2

reactions

- Maillard reaction
- transamination

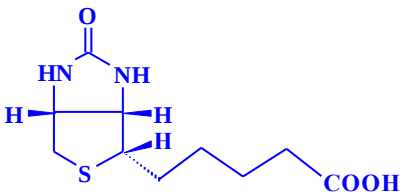
losses

- powder milk 30-70% (reaction with Lys and Cys)

application
fortification

- baby food

biotin

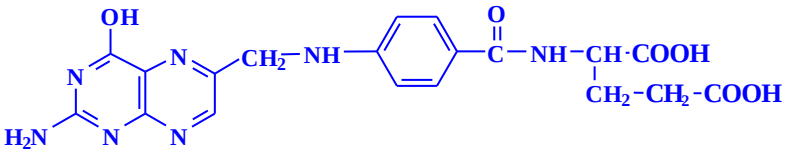


(+)-biotin, *(3aS, 4S*, 6*aR*)-isomer

broadly distributed
deficiency = raw eggs (avidine)

sources (book 2, tab. 5.1)

folacin

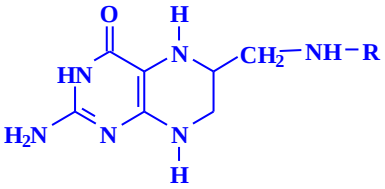


CH=O (10)
CH_3 (5)

3-8 molecules of Glu

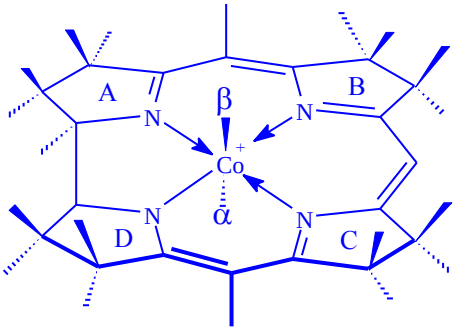
pteroic acid 4-aminobenzoic acid Glu

pteroylglutamic (folic acid)
tetrahydrofolic acid



sources mostly leaf vegetables (book 2, tab. 5.1)

corrinoids
substituted corrin cycles with central Co atom, 4 pyrrols without CH bridge between cycles A-D



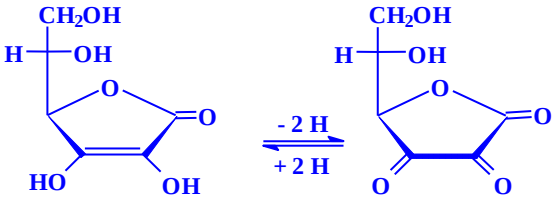
central Co atom: 6 coordination bonds
cobalamins
α = 5,6-dimethylbenzimidazole

β = OH	hydroxocobalamin
H_2O	aquocobalamin
CH_3	methylcobalamin
CN	cyanocobalamin

deoxyadenosylcobalamin coenzym B_{12}

sources (book 2, tab. 5.2), not present in foods of plant origin

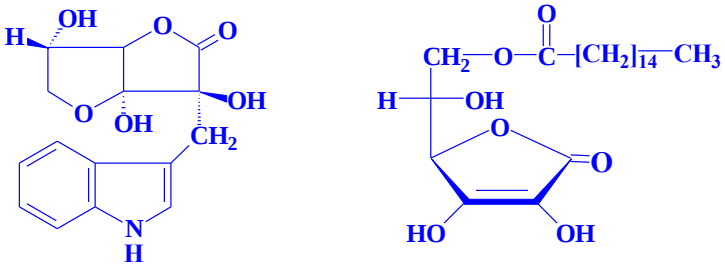
vitamin C (ascorbic and dehydroascorbic acid, redox system)



L-askorbová kyselina **L-dehydroaskorbová kyselina**

4 stereoisomers

- free
- bound
  ascorbigen v brassica vegetables
  ascorbylpalmitate (antioxidant)



sources (mg / 100 g) (book 2, tab. 5.3)

fruits

rose hips	250-1000
blackcurrant	110-300
strawberry	40-70
citrus fruits	24-70
apples	1,5-5

vegetables

parsley	150-270
peppers	62-300
cabbage	17-70
potatoes	8-40

covered by (%)

potatoes	24
leaves vegetables	13
fruits	34
milk	9 (5-20 mg/l)

reactions

- losses by leaching
- presence of O_2: enzymatic oxidation and autoxidation
- absence of O_2: degradation catalysed by acids
  total losses: 20-80 %

enzymatic oxidation

ascorbatoxidase, ascorbase, peroxidase

final reaction:
$2\ H_2A + O_2 \rightarrow 2\ A + 2\ H_2O$

prevention: (precooking), addition of SO_2

autooxidation
catalysed by metals: Fe^{3+}, Cu^{2+}
final reaction:
$2\ H_2A + O_2 \rightarrow 2\ A + 2\ H_2O$

mechanisms:
$H_2A + O_2 \rightarrow A + H_2O_2$
$H_2A + H_2O_2 \rightarrow A + 2\ H_2O$

consequences:
oxidation of others components by H_2O_2 (myoglobin, lipids, anthocyanes)

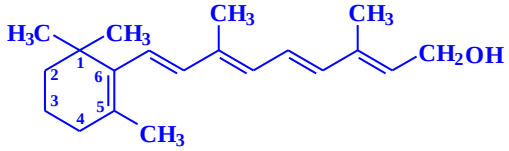
prevention:
- contact with O_2 (air)
  inert atmosphere, deaeration, glucoseoxidase+catalase, HSO_3^-, fermentation
- Fe^{3+}, Cu^{2+}
  complexing agents
- unfavourable conditions (lower a_w, pH)

degradation catalysed by acids
main product: furan-2-carbaldehyde

application
- vitamin
- antioxidant
- complexing agent

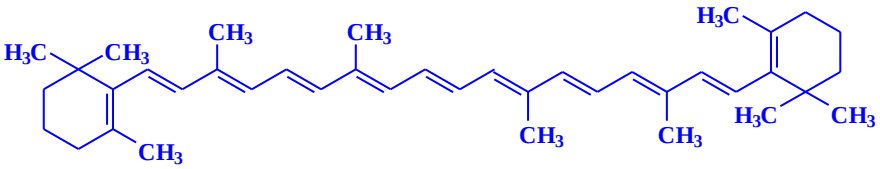
in food technologies
- canning (prevention of aroma, colour, removal of O_2, inhibition of browning)
- fermentation (prevention of turbidity)
- meat (improvement and a acceleration of curing, NO_2^-)
- fats (antioxidant)
- cereals (formation of disulphide bridges in protein dough)

vitamin A
retinol



all-*trans*-retinol, vitamin A_1 (diterpene)

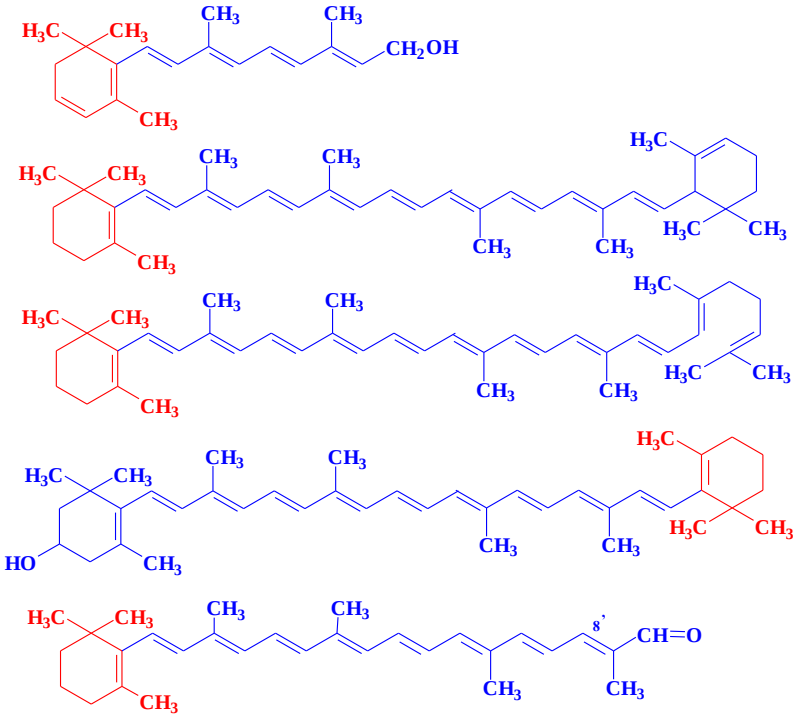
provitamins A (retinoids, isoprenoids)



β-carotene (tetraterpene)

further active substances (β-ionon cycle)

- 3-dehydroretinol (vitamin A_2)
- α-carotene
- γ-carotene
- cryptoxanthin
- β-apo-8´-carotenal



sources (mg/kg) (book 2, tab. 5.4)

- animal materials (retinol / provitamins A)
  - meat 0.1 / 0.4
  - liver 30-400 / 300
  - butter 5-10 / 4-8
  - fish liver oil, margarines
- plant materials (provitamins A)
  - carrot 20-95
  - spinach 50-480
  - apricots 6-20

covered by (%)

- liver 23 esters, mostly $C_{16:0}$
- butter 17
- milk, cream 15
- carrot 14
- margarines 9 retinyl acetate

reactions

isomeration (mostly 13-*cis* a 9-*cis)*, oxidation

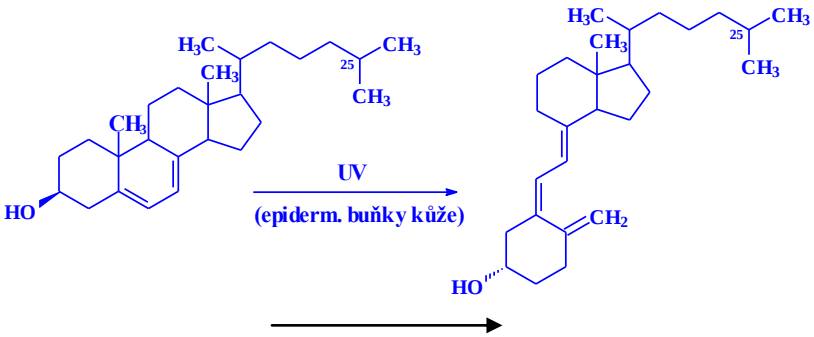
consequences

- flour bleaching
- colour changing of citrus juices
- food aroma

vitamin D (calciferols)

9,10-secosteroids

cholecalciferol (vitamin D_3)



7-dehydrocholesterol (provitamin D_3) → cholecalciferol (vitamin D_3)

ergosterol (provitamin D_2) → ergocalciferol (vitamin D_2)

sources (µg / kg) (kniha2. tab. 5.5)

• sea fish	50-450
• yolk	30-50
• butter	10-20
• liver	2-11
• milk	1
• cream	4
• meat	3
• fish liver oil, margarines	

covered by (%)

margarines	34
fatty fish	17
eggs	16
milk, cream	12
butter, cheeses	9
higher fungi, moulds (cheese)	

reactions

autooxidation (alcohols, ketones)

isomeration

photodegradation (vitamins D from provitamins D, tachysterols, lumisterols and others)

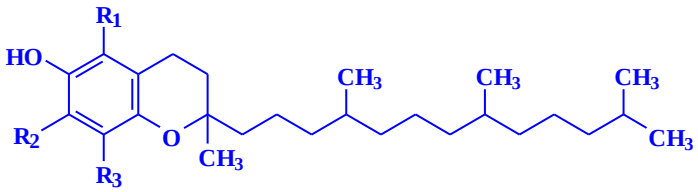
application

fortification

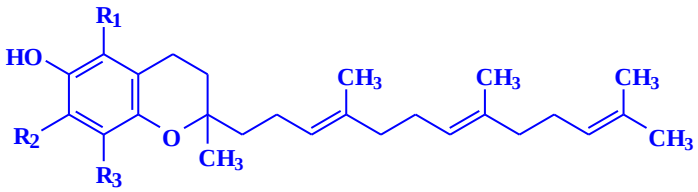
- margarines

- milk
- cereal breakfast

vitamin E (tocopherols and tocotrienols)
6-hydroxychromans, phytol (C_{20}), tocol



tocopherols (*R*,*R*,*R*-isomers)



tocotrienols (*trans*-isomers)

Derivative	R_1	R_2	R_3
α-	CH_3	CH_3	CH_3
β-	CH_3	H	CH_3
γ-	H	CH_3	CH_3
δ-	H	H	CH_3

sources (mg / 100 g) (book 2, tab. 5.6, 5.7)

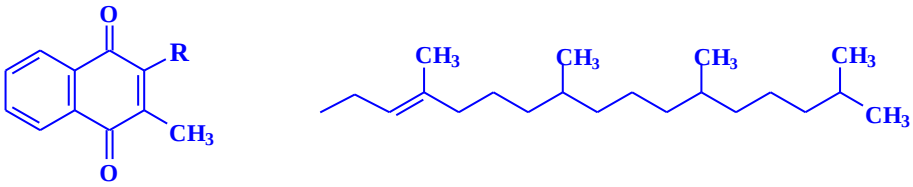
- plant oils 50-200
- plant materials < 0.5
- animal materiala little

vitamin activity: α-T > β-T > γ-T > δ-T α-TT
(1,00-0,27-0,13-0,01-0,30), in dependence on content of unsaturated fatty acids in food

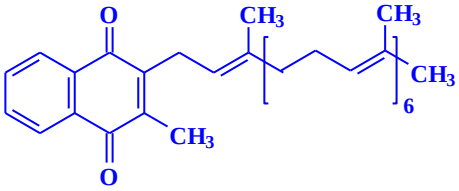
antioxidative activity: δ-T > γ-T > β-T > α-T

reactions
oxidation, quinone, dimers and other products

vitamin K
similar structure of coenzymes Q, 1,4-naftoquinone
terpenoid chain (phytol C_{20}), basic substance: menadione (naphtho-1,4-quinone)



vitamin K_1 (phylloquinone)
R = phytyl C_{20}
4 isoprenoid units (3 reduced)



vitamin K_2 (farnoquinone) bacteria of intestinal tract
7 isoprenoid units (commonly 4-10, even 0-13)
(30 atoms C = dipharnesyl), 3-multiprenyl-

sources (mg / 100 g) (kniha2. tab. 5.8)

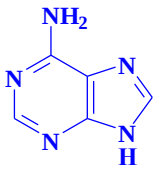
leaf vegetables (cabbage, spinach)	3-4
garden pea, tomato (meat including liver)	0,1-0,4
milk	0,002-0,02
pork liver (forms)	K_1, MK-4, MK 7-10

reactions
photodegradation
oxidation (epoxides, 2,3-epoxides)

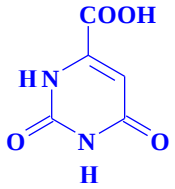
other biologically active compounds

mostly B group vitamins (B-complex)

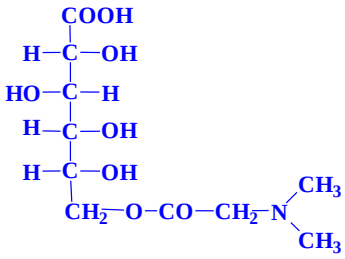
B_8, B_4	adenylic acid (adenine)
B_{13}	orotic acid
B_{15}	pangamic acid
B_t	carnitine
B_x, H_1	4-aminobenzoic acid
	lipoic acid
F	essential fatty acids
P	rutin (bioflavonoids)
U	*S*-methylmethionine
	choline
	myo-inositol
	taurine
	coenzymes Q



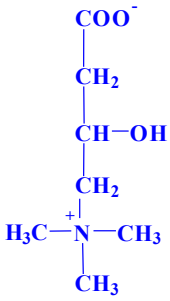
adenylic acid



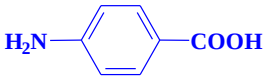
orotic acid



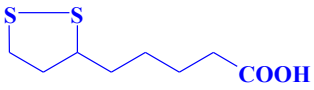
pangamic acid



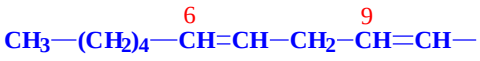
carnitine



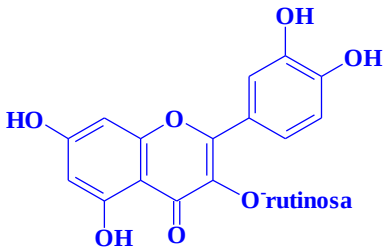
4-aminobenzoic acid (H_1)



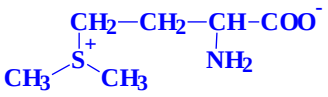
lipoic acid



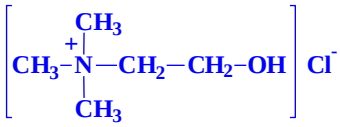
essential fatty acids



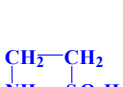
rutin (P) (kvercetin-3-β-rutinosid, rutinose = rhamnose, glucose)



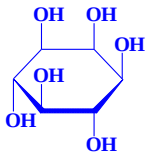
S-methylmethionine



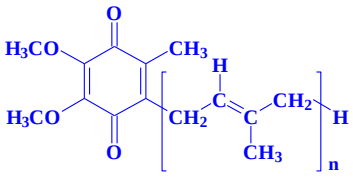
choline



taurine



myo-inositol



coenzymes Q