Saccharides

sugars

classification

according number of sugar units

- monosaccharides
- oligosaccharides (2-10 monosacharides)
- polysaccharides (> 10 monosaccharides)
- conjugated (complex) saccharides eg. glycoproteins

free

bound homoglycosides, heteroglycosides, aglycons (non-sugar components)

Monosaccharides

polyhydroxyalkyl substituted aldehydes and ketones

and derived compounds

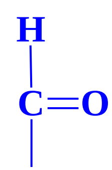
main nutrients

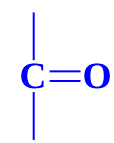
biologically and sensory active compounds

structure and classification

according to type of carbonyl group

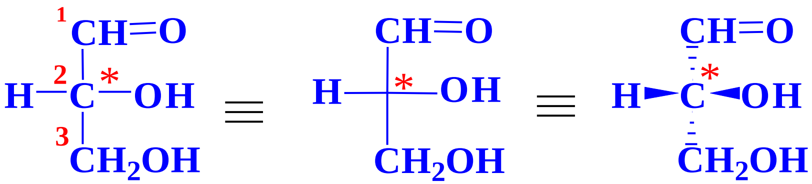
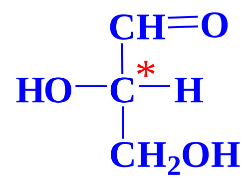
- aldoses
- ketoses





according to number of C atoms (3-8)

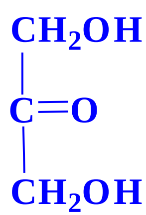
- trioses

D-(+)-glyceraldehyde (D-*glycero*-triose) L-(-)-glyceraldehyde

optical isomers (enantiomers) D/L, *R/S* d/l, +/-

equimolar mixture of D + L = racemate (opt. inactive)

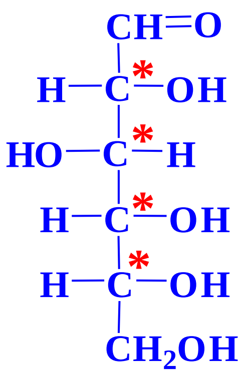


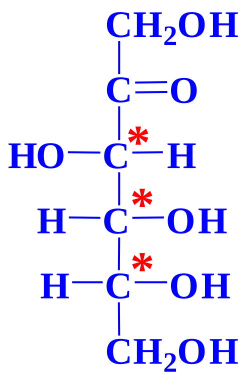
1,3-dihydroxyacetone (1,3-dihydroxypropan-2-one, glycerone)

- tetroses (erythrose, threose, erythrulose)

epimers - aldoses differing only by configuration at C2

- **pentoses** (ribose, arabinose, xylose, lyxose, ribulose, xylulose)
- **hexoses**





D-glucose (D-*gluko*-hexose)

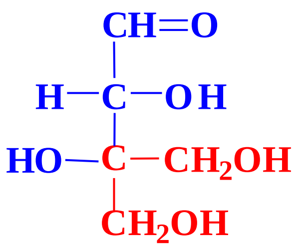
dextrose, grape sugar

D-fructose (D-*arabino*-hex-2-ulose)

levulose, fruit sugar

according to chain

- linear chain
- branched chain

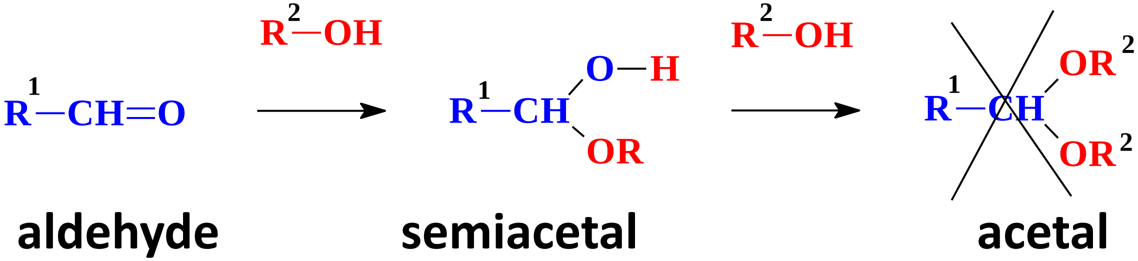


D-apiose (carrot, parsley)

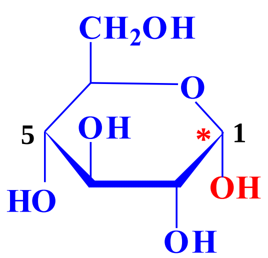
according to type of cyclic structure (lactol)

spontaneous by intramolecular addition

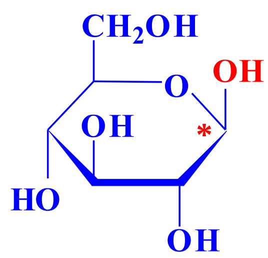
stable hemiacetals (energetically preferable)



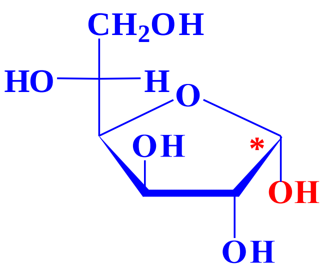
- furanoses
- pyranoses
- septanoses



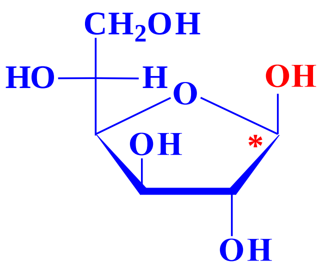
α-D-glukopyranosa



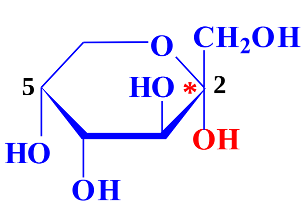
β-D-glukopyranosa



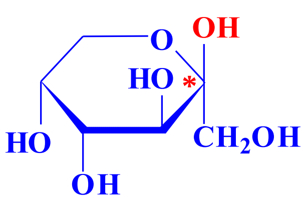
α-D-glukofuranosa



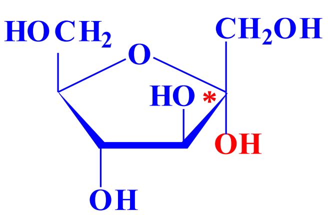
β-D-glukofuranosa



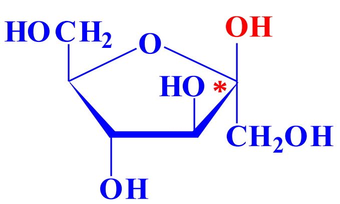
α-D-fruktopyranosa



β-D-fruktopyranosa



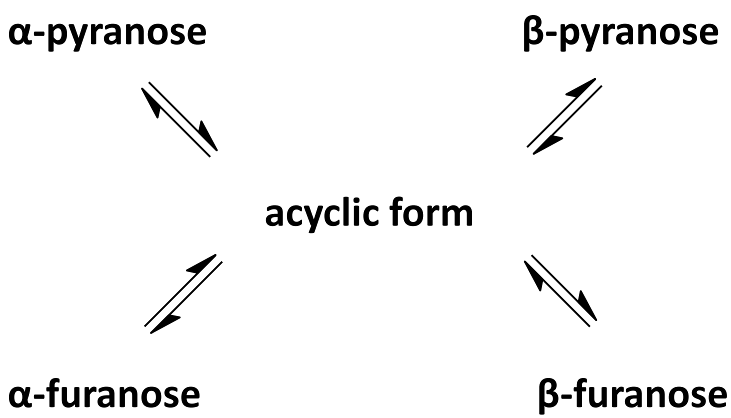
α-D-fruktofuranosa



β-D-fruktofuranosa

mutarotation

anomers - **anomeric C, anomeric OH**



saccharide (40 ^{o}C)	% furanose		% pyranose	
	α	β	α	β
D-glucose	< 1	< 1	36	64
D-fructose	< 1	25	8	67

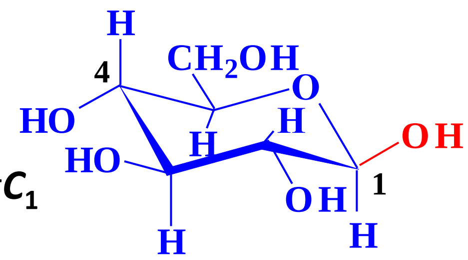
≅ 0,02% acyclic form

Anomer α - the configuration of hydroxyl group agree with the one at chiral C atom with the highest number in the circle

conformation

- **furanoses** (furanoses (envelope *E*, twist *T*)
- **pyranoses** (chair $^{4}C_{1}$, $^{1}C_{4}$)

β-D-glucopyranose-$^{4}C_{1}$



acyclic form

occurence

components of almost all foodstuffs

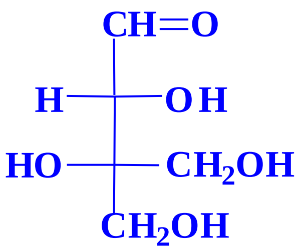
intake from food in %

food	saccharide	%
cereals	starch	48
saccharose	saccharose	22
vegetables	starch, monosaccharides	13
fruits	monosaccharides	5
milk, milk products	lactose	7

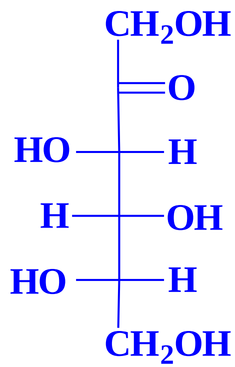
food	saccharide	content in %
meat	glucose, fructose, ribose (phosphates)	0.05-0.20
	glycogen	1-2
milk (cow)	lactose	4-5
	higher galactooligosaccharides	traces
eggs	glucose	0.9-1.0
cereals	polysaccharides (starch)	59-72
	glucose	0.01-0.10
	fructose	0.02-0.1
fruits	glucose	0.5-32
	fructose	0.4-24
	polysaccharides	
vegetables	polysaccharides (starch)	*
	glucose	0.1-2
	fructose	0.1-1
legumes	polysaccharides (starch)	**
	glucose	0.1-1
	fructose	0.1-3
honey	glucose	30
	fructose	40
	other mono- and oligosaccharides	

* potatoes (17-24%) ** beans 46-54%

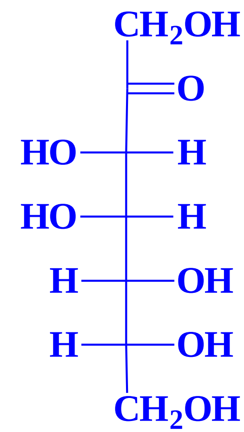
unusual monosaccharides



D-apiose



L-sorbose



D-*manno*-hept-2-ulose

branched chain — sugar of L-configuration — ketoheptose

root vegetables — rowan — avocado

abbreviations

glucose	Glc
fructose	Fru
mannose	Man
apiose	Api

furanose	*f*
pyranose	*p*

β-D-glucopyranose ~ β-D-Glc*p*

% in edible part	glucose	fructose	saccharose
fruits			
apples	1.8	5.0	2.4
pears	2.2	6.0	1.1
cherries	5.5	6.1	0.0
plums	3.5	1.3	1.5
apricots	1.9	0.4	4.4
currannt	2.3	1.0	0.2
grapes	8.2	8.0	0.0
oranges	2.4	2.4	4.7
lemons	0.5	0.9	0.2
pineapples	2.3	1.4	7.9
bananas	5.8	3.8	6.6
dates	32.0	23.7	8.2
figs	5.5	4.0	0.0
vegetables			
broccoli	0.73	0.67	0.42
celery	0.16	0.22	0.02
onion	2.07	1.09	0.89
cauliflower	0.58	0.70	0.15
carrot	0.85	0.85	4.24
cucumber	0.86	0.86	0.06
tomatoes	1.12	1.34	0.01
beetroot	0.18	0.16	6.11
spinach	0.09	0.04	0.06

properties

sweetness

arbitral standard = 10% solution of saccharose

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

DERIVATIVES OF MONOSACCHARIDES

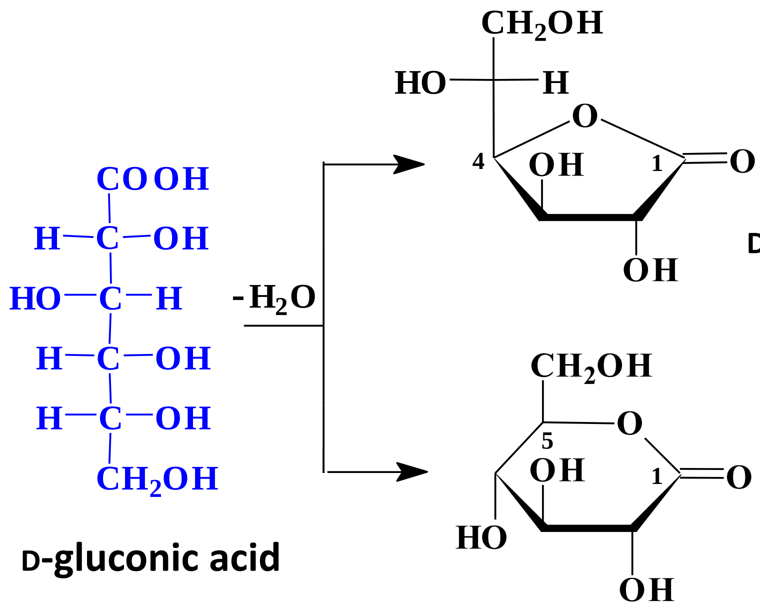
formation

- **oxidation (or rearrangement)** — **sugar acids**; **ketoaldoses, diketoses**
- **reduction** — **sugar alcohols**; **deoxysugars**
- **dehydration** — **anhydrosugars**
- **reaction with other compounds** — **glycosides**; **ethers**; **esters**; **amino sugars**

sugar acids

- **aldonic** (glyconic)

glucosaoxidasa, Ca-gluconan (in pharmaceutical products)
δ-lactone (fermented salami, 0.1%)

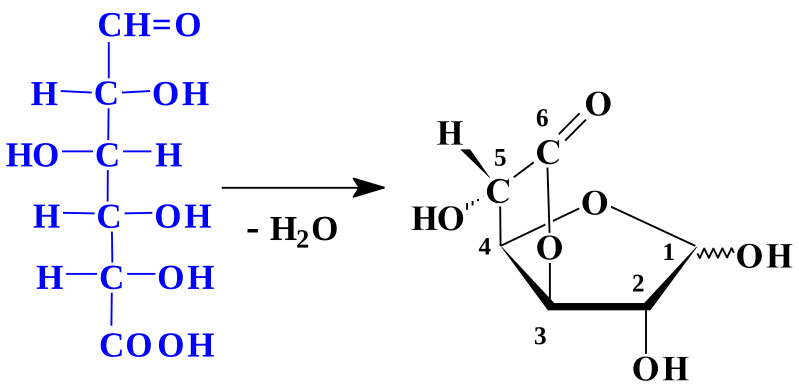


D-gluconic acid

D-glucono-1,4-lactone γ-lactone

D-glucono-1,5-lactone δ-lactone

- **alduronic** (glycuronic)



D-glucuronic acid D-glucurono-6,3-lactone

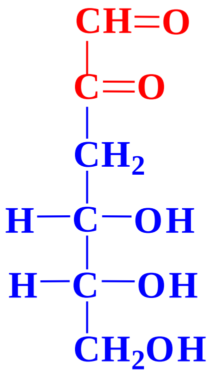
polysaccharides: D-GlcA6 (glycoproteins), D-GalA6 (pectines), D-ManA6, L-GulA6 (alginates)

- **aldaric** (glycaric), for example tartaric and malic acids

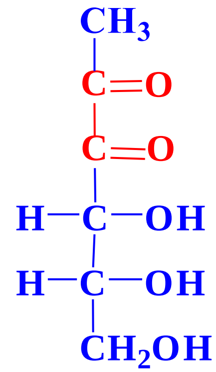
ketoaldoses, diketoses

main products of Maillard reaction and oxidation

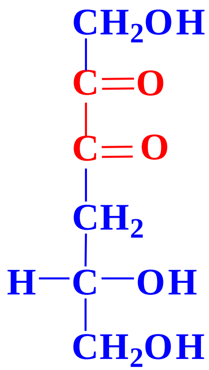
- 3-deoxyglycosuloses
- 1-deoxyglycodiuloses
- 4-deoxyglycodiuloses



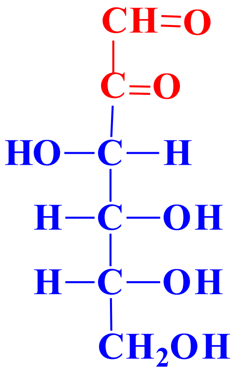
3-deoxy-D-*erythro*-hexos-2-ulosa



1-deoxy-D-*erythro*-hexo-2,3-diulosa



4-deoxy-D-*glycero*-hexo-2,3-diulosa

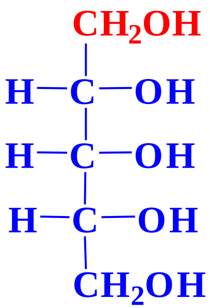


D-*arabino*-hexos-2-ulosa

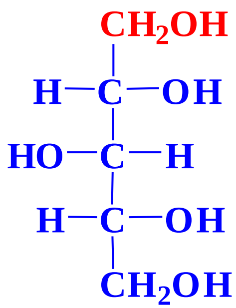
sugar alcohols

alditols, glycitols (homologues of glycerol)

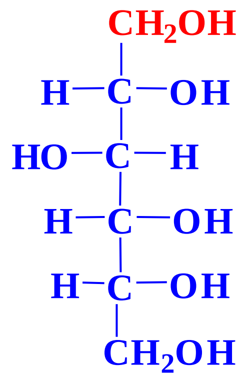
reduction of semiacetal hydroxyl group of mono- and oligosaccharides



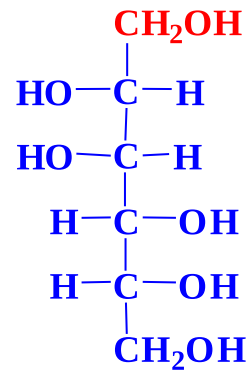
ribitol



xylitol



D-glucitol



D-mannitol

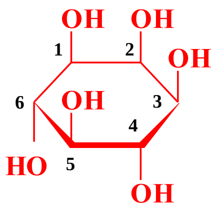
- **přirozené složky potravin**

ribitol	riboflavin
arabinitol	mushrooms
xylitol	mushrooms
D-glucitol	plums, rowan, pears
D-mannitol	mushrooms, rowan, celery, green coffee
galactitol	mushrooms, fermented milk products

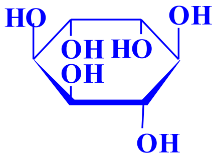
- **synthetic** (reduction H_2/kat., $NaHg_x$, artificial sweeteners)
  - xylitol
  - D-glucitol

cyclitols

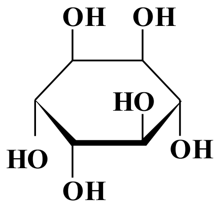
cycohexan-1,2,3,4,5,6-hexols (inositols, cycloses)



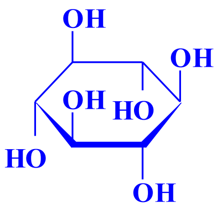
myo-inositol (*meso*-inositol)



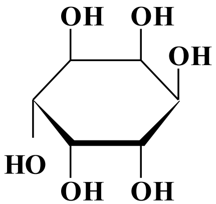
1D-(+)-*chiro*-inositol



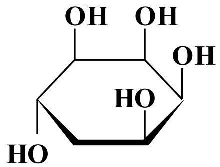
1L-(-)-*chiro*-inositol



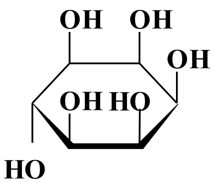
scyllo-inositol (scyllitol)



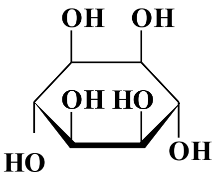
neo-inositol



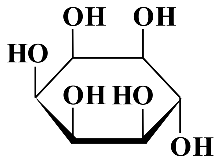
allo-inositol



epi-inositol



muko-inositol



cis-inositol

***myo*-inositol** **widespread, phospholipids, phytates**

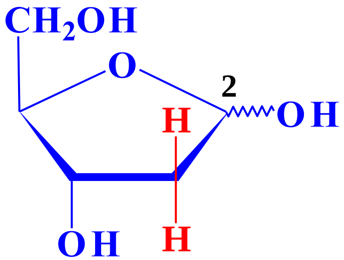
1D-*chiro*-inositol **legumes (soya) D-pinitol (4-*O*-methyl-1D-*chiro*-inositol)**

***scillo*-inositol** **grapes**

deoxysugars

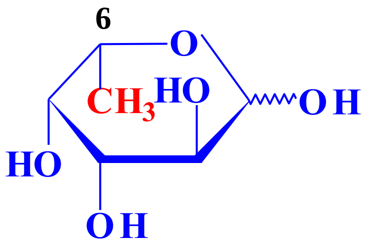
reduction of primary / secondary hydroxyl

- **natural**
- **Maillard reaction**



2-deoxysugars 2-deoxy-D-ribosa (thyminosa) deoxyribonucleic acids

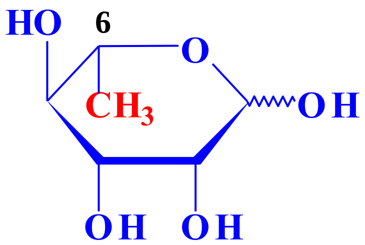
6-deoxysugars (6-deoxyhexoses = methylpentoses)



L-fukose

6-deoxy-L-galactose

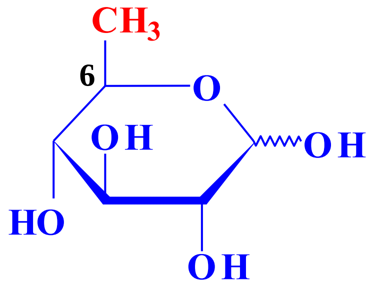
oligosaccharides of milk



L-rhamnose

6-deoxy-L-mannose

heteroglycosides



D-chinovose

6-deoxy-D-glucose

heteroglycosides

natural deoxysugars: lactic acid, acetoin

Maillard r. products: deoxyglycosuloses anhydrosugars

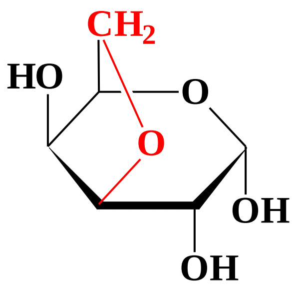
sugar anhydrides, glycosans

water elimination, mostly poloacetal and other OH

- natural components of polysaccharides

  3,6-anhydro-α-D-galactopyranose — carageenan

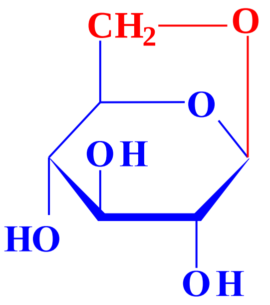
  3,6-anhydro-α-L-galactopyranose — agar



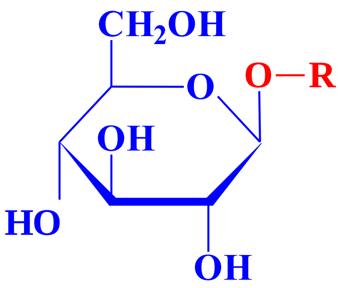
- products of thermal reactions

  1,6-anhydro-β-D-glucopyranose — caramel

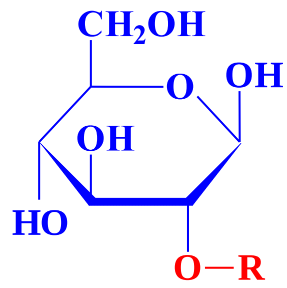
  (β-glucosan, levoglucosan)



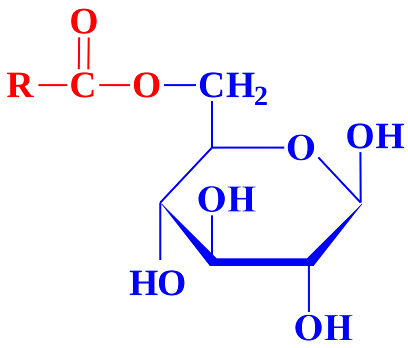
glycosides, ethers, esters and other derivatives



O-glykosid

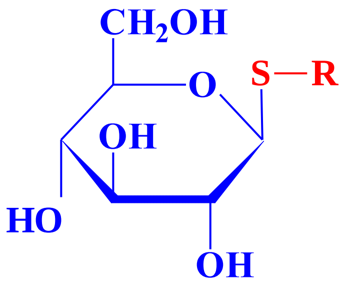


ether

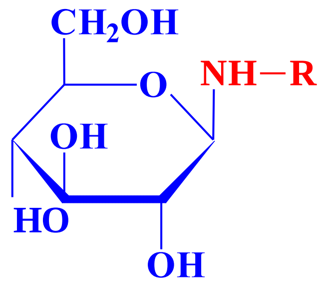


ester

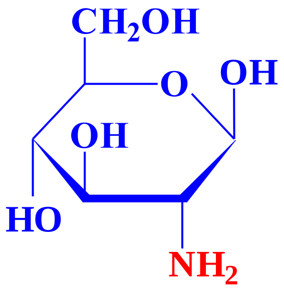
***O*-glycosides**	**widespread**
ethers	**4-O-methyl-D-Glc*p*A (hemiceluloses)**
	2-O-methyl-D-Xyl*p* (pectins)
esters	**natural (phosphates, acetates, benzoates etc.), synthetic (fatty acids, emulsifiers)**



S-glycosides



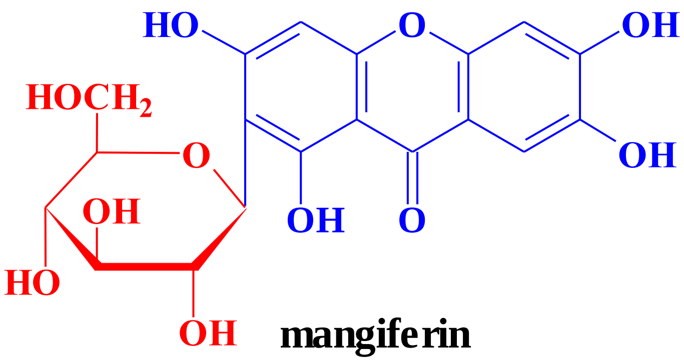
N-glycosides



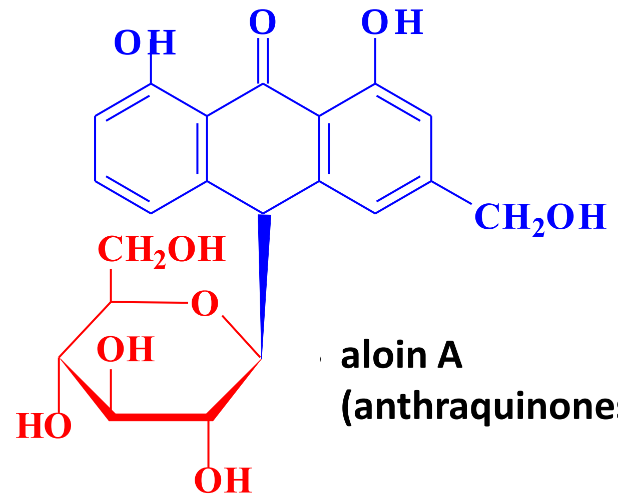
2-amino-2-deoxy sugars

***S*-glycosides**	**glucosinolates in *Brassica* vegetables**
***N*-glycosides**	**natural (ATP, NADH)**
	Maillard reaction (glycosylamines)
aminodeoxysugars	**natural (D-Glc*p*NH_2=chitosamine)**
	Maillard reaction (Amadori products)

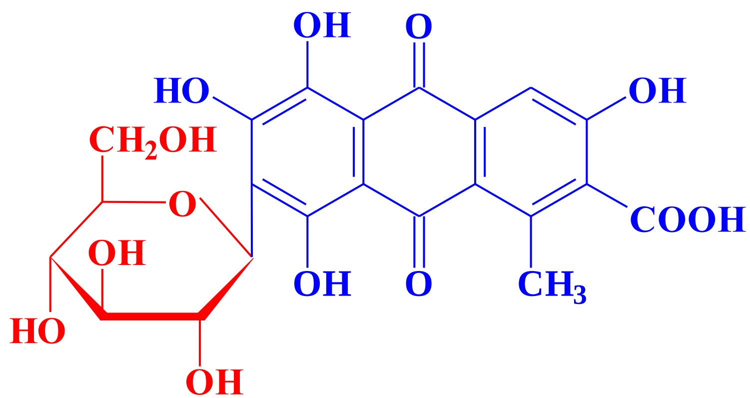
C-glycosides



mangiferin
(xanthony)



aloin A
(anthraquinones)



carminic acid
(anthraquinones)

Cochineal, Carmine, Carminic acid (E120)

The **cochineal** /kɒtʃɨˈniːl/
- scale insect

Carmine is the name of the colour pigment obtained from the insect Dactylopius coccus (old name Coccus cacti), that lives on cacti from the genus Opuntia. The insect is native to tropical South and Central America and produces the pigment as a deterrent against other insects. The pigment can be obtained from the body and eggs of the insect.

Cochineal was already used as a colour by the Aztec and Maya peoples of Central and North America . Cochineal was a commodity of much value, even comparable to gold.

Cities send bags of cochineal to the capital Tenochtitlán as a yearly contribute to the emperor. The Spanish conquerors of Central America saw the value of the dye, which produced a much better colour than the dyes used in Europe at the time. The dye, which at the time was mainly used in cosmetics and textiles and to a lesser extend in foods, became very popular in Europe. Roman Catholic Cardinals robes were coloured with cochineal, as were the jackets of the British military.

Cochineal, Carmine, Carminic acid (E120)

- is one of the few natural and water-soluble colorants that resist degradation with time. It is the most light- and heat-stable and oxidation-resistant of all the natural colorants and is even more stable than some synthetic food colours.

Production

The insects are killed by immersion in hot water (after which they are dried) or by exposure to sunlight, steam, or the heat of an oven. Each method produces a different colour which results in the varied appearance of commercial cochineal. The insects must be dried to about 30 percent of their original body weight before they can be stored without decaying. It takes about 155,000 insects to make one kilogram of cochineal.

There are two principal forms of cochineal dye: cochineal extract (E120(ii)) is a colouring made from the raw dried and pulverised bodies of insects with around 20% carminic acid; and carmine (E120(i)) a more purified colouring made from cochineal.

Cochineal Red

This is the name of an azo dye, E124, which bears no resemblance with cochineal, but produces a similar colour, hence the (confusing) name

http://www.food-info.net/uk/colour/cochineal.htm

Oligosaccharides

homoglycosides

pentoses, hexoses, sugar acids and other derivatives

furanoses, pyranoses

classification

according to number of monosaccharides (2-10)

disaccharides (bioses) – decasacharides (decaoses)

according to semiacetal OH

reducing (glycosides)

non-reducing (glycosylglycosides)

according to major monosaccharids (backbone)

- glucooligosaccharides

  maltose, maltooligosaccharides

- fructooligosaccharides

  saccharose (sucrose)

- galactooligosaccharides

  lactose, α-galactosides

according to digestability

digestible

non-digestible

according to biological effects

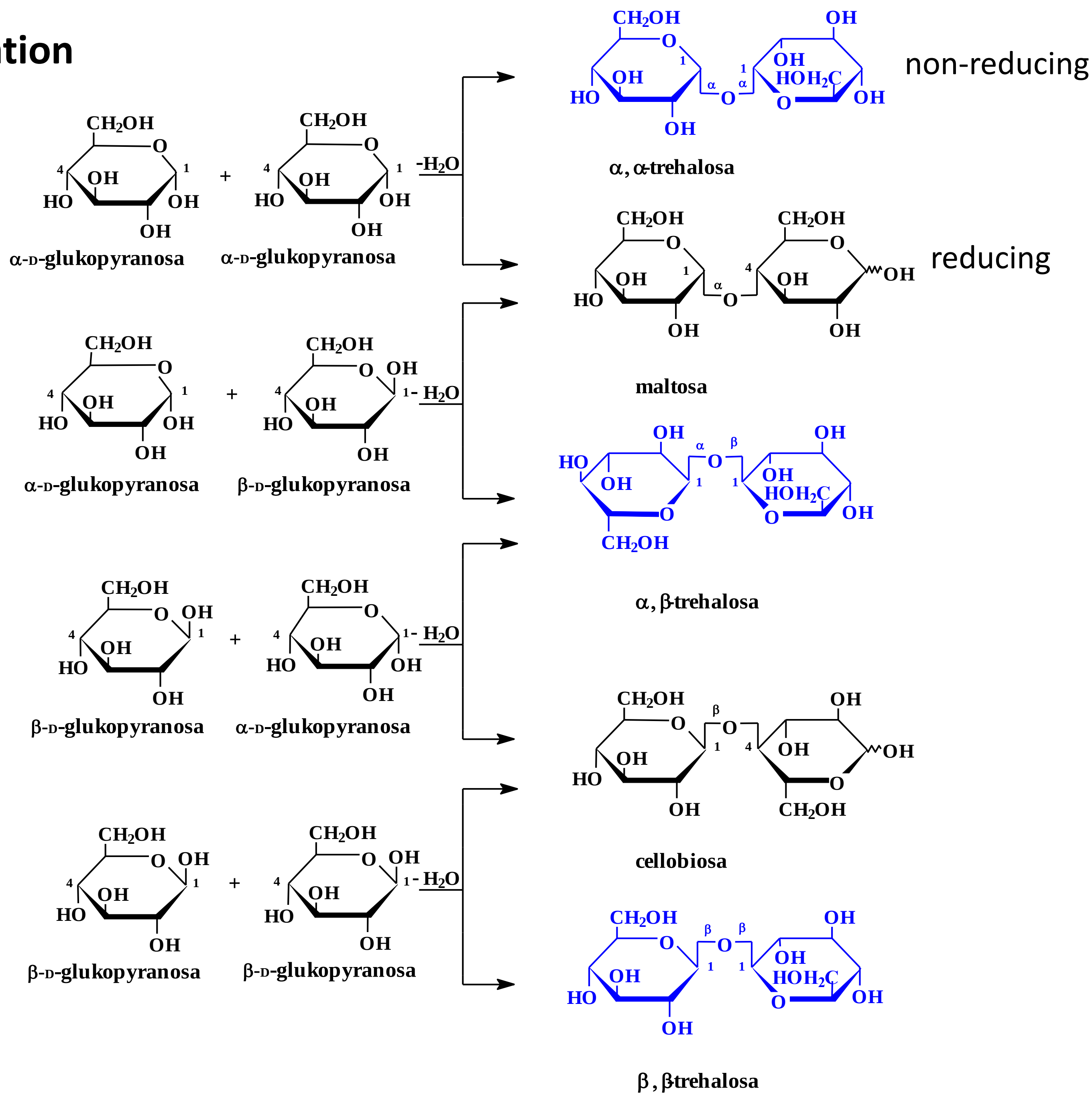
prebiotic - stimulate the growth and/or activity of bacteria in the digestive system in ways claimed to be beneficial to health (eg. fructooligosaccharides)

probiotics - live microorganisms that may confer a health benefit on the host

synbiotic (simultaneously prebiotic and probiotic effects)

Products of condensation

α-D-Glc*p* and β-D-Glc*p*

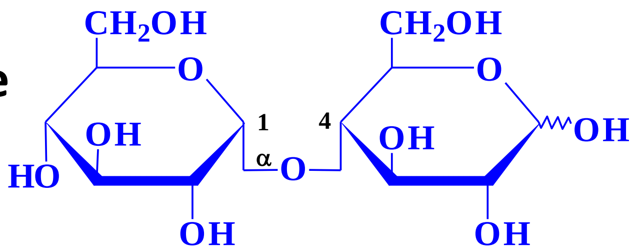


glucooligosaccharides

maltose α-D-Glc*p*-(1→4)-D-Glc*p* malt sugar

occurence

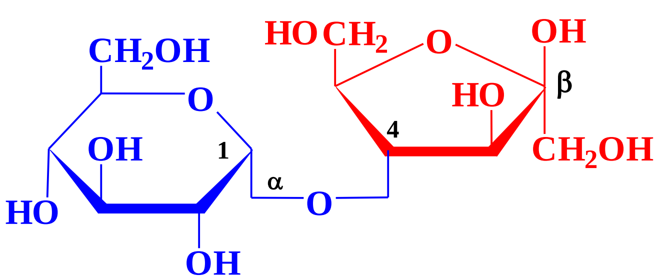
product of starch hydrolysis, reversion of glucose
malt, bread (1.7-4.3%), honey (3-16%)



production

- maltose (85%) and glucose sirups (acids, enzymes)
- maltose
- isomeration on maltulose
- reduction on maltitol

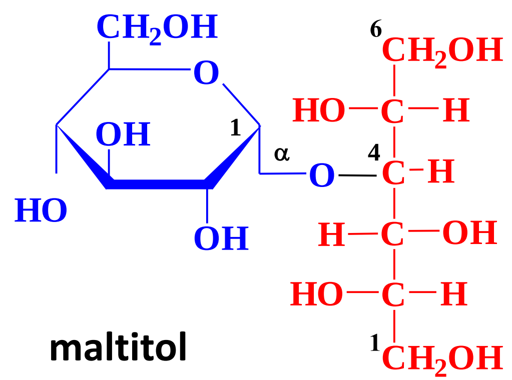
fructose



maltulosa

α-D-Glc*p*-(1→4)-D-Fru*f*

D-glucitol



maltitol

α-D-Glc*p*-(1→4)-D-glucitol

fructooligosaccharides

saccharose (sucrose) α-D-Glc*p*-(1↔4)-β-D-Fru*f* **beet sugar**

cane sugar

occurence

fruits	up to 8%
vegetables	0.1-12%
green coffee (roasted)	6-7% (0.2%)
sugar beet	15-20%
sugar cane	12-26%
maple sirup	5%
dates	81% (dried)

production (from sugar beet)

- extraction of sugar beet slices (diffusion)
- cleaning (epuration) of crude juice, clarification by $Ca(OH)_2$
- saturation by CO_2
- filtration, light juice
- thickening

  heavy juice (61-67% saccharose, 68-72% dry matter)
- crude (brown) sugar

  96 % saccharose, 2-3% non-sugars, 1-2% water

  (1.0-1.2% organic, 0.8-1.0% inorganic matters)
- afinade
- rafinade

Molasses is a viscous by-product of the refining of sugarcane or sugar beets into sugar folder, substrat for fermentation processes

Rum - a distilled alcoholic beverage made from sugarcane byproducts such as molasses, or directly from sugarcane juice, by a process of fermentation and distillation

galactooligosaccharides

lactose β-D-Gal*p*-(1→4)-D-Glc*p* milk sugar

occurence

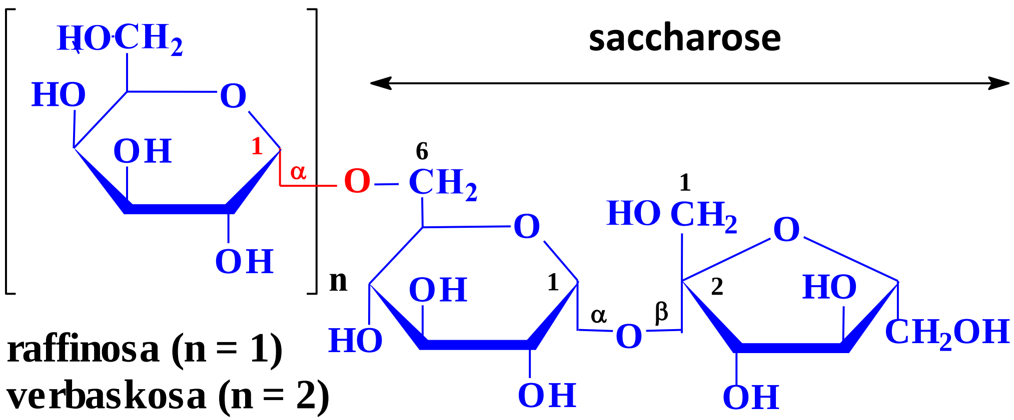
cow´s milk	4-5%
human milk	5.5-7%

production (from whey)

- ultrafiltration
- thickening, crystalisation

production of galactose, galactitol, lactulose, lactitol

α-galactooligosaccharides of legumes



raffinosa (n = 1)
verbaskosa (n = 2)
stachyosa (n = 3)
ajugosa (n = 4)

chickpea

legumes	saccharose	raffinose	stachyose	verbaskose
green beans	2.2-4.9	0.3-1.1	3.5-5.6	0.1-0.3
mungo	1.3	0.3	1.7	2.8
peas	2.3-3.5	0.6-1.0	1.9-2.7	2.5-3.1
lentils	1.3-2.0	0.3-0.5	1.9-3.1	1.2-1.4
soybeans	2.8-7.7	0.2-1.8	0.02-4.8	0.1-1.8
chickpea	2.0-3.5	0.7-0.9	1.5-2.4	0.0

Polysaccharides

glycans

pentoses, hexoses, sugar acids and other derivatives

furanoses, pyranoses

$>$ 10 to 10^3-10^6 monosaccharides

classification

according to origin

natural	plant and animal glycans
food additives	glycans of algae, fungi, microorganisms,
	modified plant glycans

according to basic functions

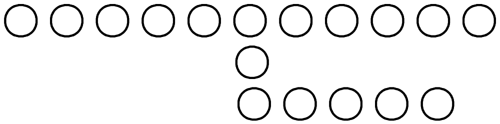
reserved	glycogen, starch, nonstarch glycans
structural	chitin, cellulose and associated glycans
with other functions	arabic gum, ocra

(water management, protection of wounded tissues)

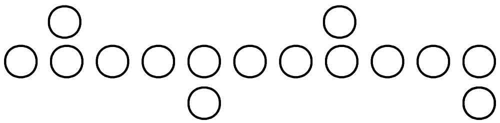
according to type of chain

linear — **unbranched** — **amylose, cellulose**

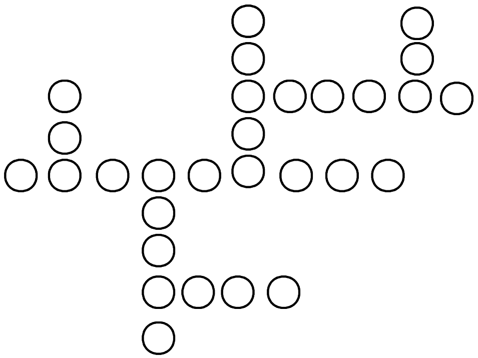
branched one time — **amylopectin**



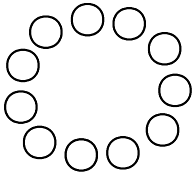
substituted — **dextrane**



branched more times — **guar gum**



cyclic — **cyclodextrins**



according to bound monosaccharide

- homopolysaccharides (homoglycans) from identical monomers
  - glucans
    - α-glucans amylose
    - β-glucans celulose
  - fructans
- heteropolysaccharides (heteroglycans) 2 or more types of monomers

  majority

  - cereals arabinoxylans

    main chain - xyloses, sidechains- arabinoses

according to utilization in nutrition

- utilisable starch, glycogen
- non- utilisable (3 kJ/g vs. 17 kJ/g) fiber

main food polysaccharides

meat	glycogen, complex sugars	
cereals	starch	
	cellulose	
	hemicellulose	
		arabinoxylans
		β-glucans
vegetables, root crops	starch	
	fructans	
	cellulose	
	hemicellulose	
		xyloglucans
		pectin

fruits
- cellulose
- hemicellulose
  - xyloglucans
  - pectin

additive glycans

natural modified	starch, cellulose, chitin, pectin
seaweeds	agars, carageenans, alginates
plant gums	arabic, guar, tragacanth gum
microorganisms	gellan

gels

viscous liquids

content of polysaccharides in wheat flour

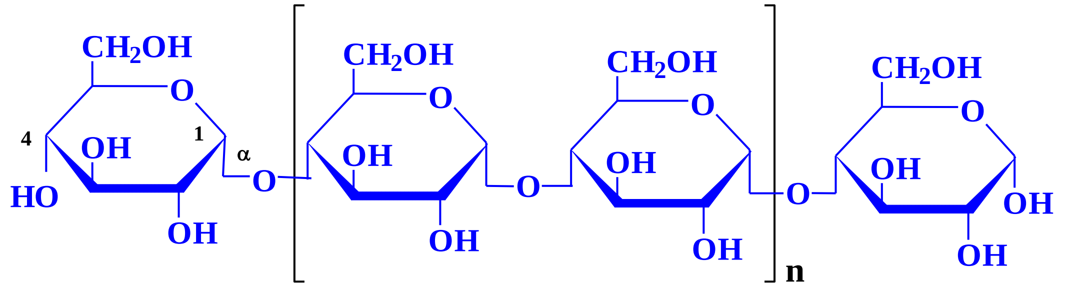
polymer	content in %
starch	59-72
non-starch polysaccharides	3-11
cellulose	0.2-3
hemicellulose	2-7
arabinoxylans	1-3
β-glucans	0.5-2
xyloglucans	0.2-0.4
pectins	0.3-0.5
glucofructans (fructans)	1-4

starch

structure

mixture of 2 glycans: amylose and amylopectin

složka	units	disaccharide	bond	solubility in cold water	behavior by heating
amylose	≅ 10^3	maltose	α-(1→4)	ano	low viscosity
amylopectin	≅ 10^6	maltose isomaltose	α-(1→4) α-(1→6)	ne	very viscous, by cooling gives gel

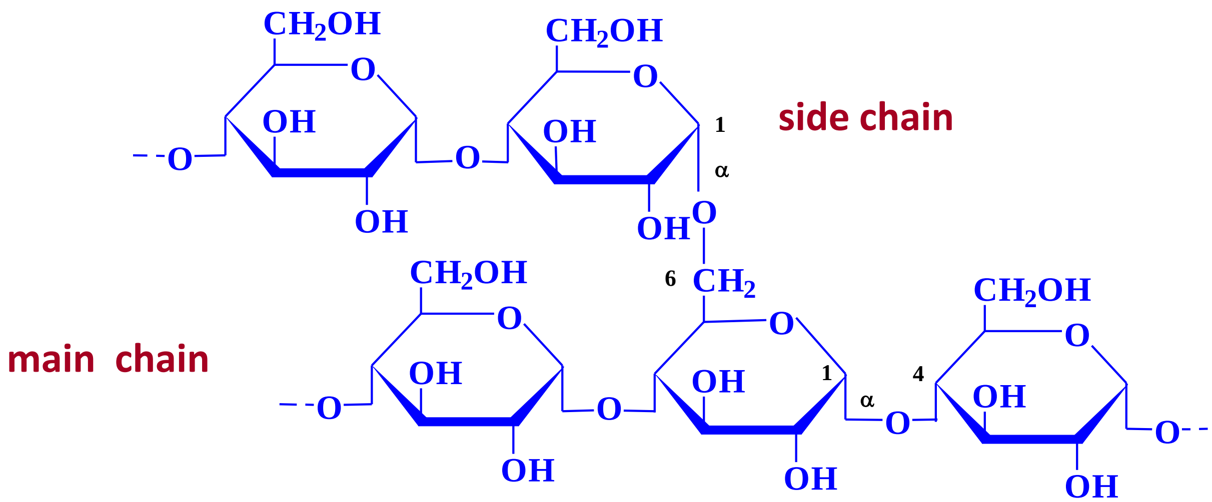


amylose

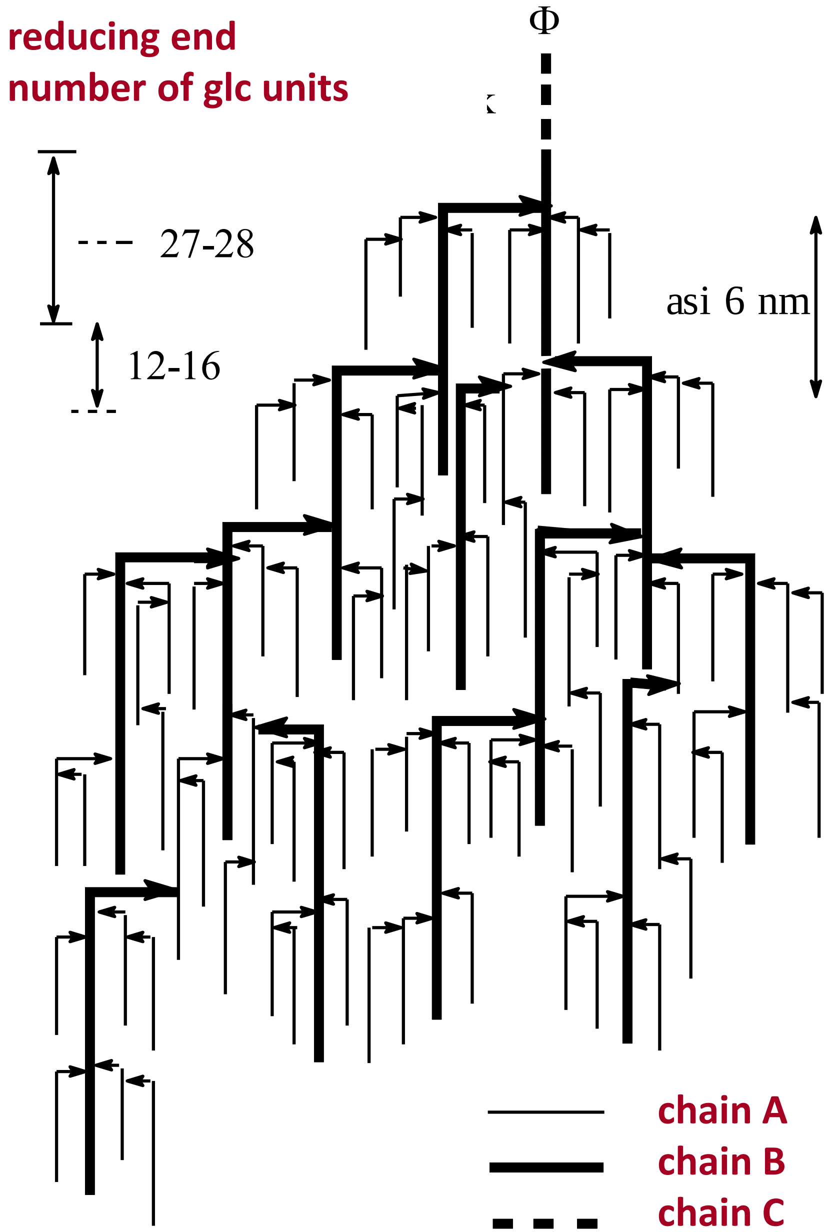
non-reducing end

reducing end

amylopectin

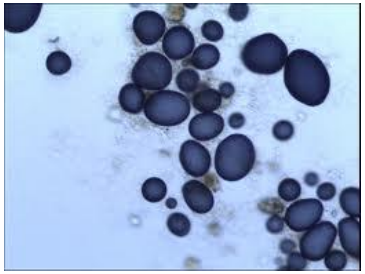


schematic structure of amylopectin



sources

- cereals
- potatoes
- legumes



other – amaranth, Jerusalem artichoke, cassava, sago

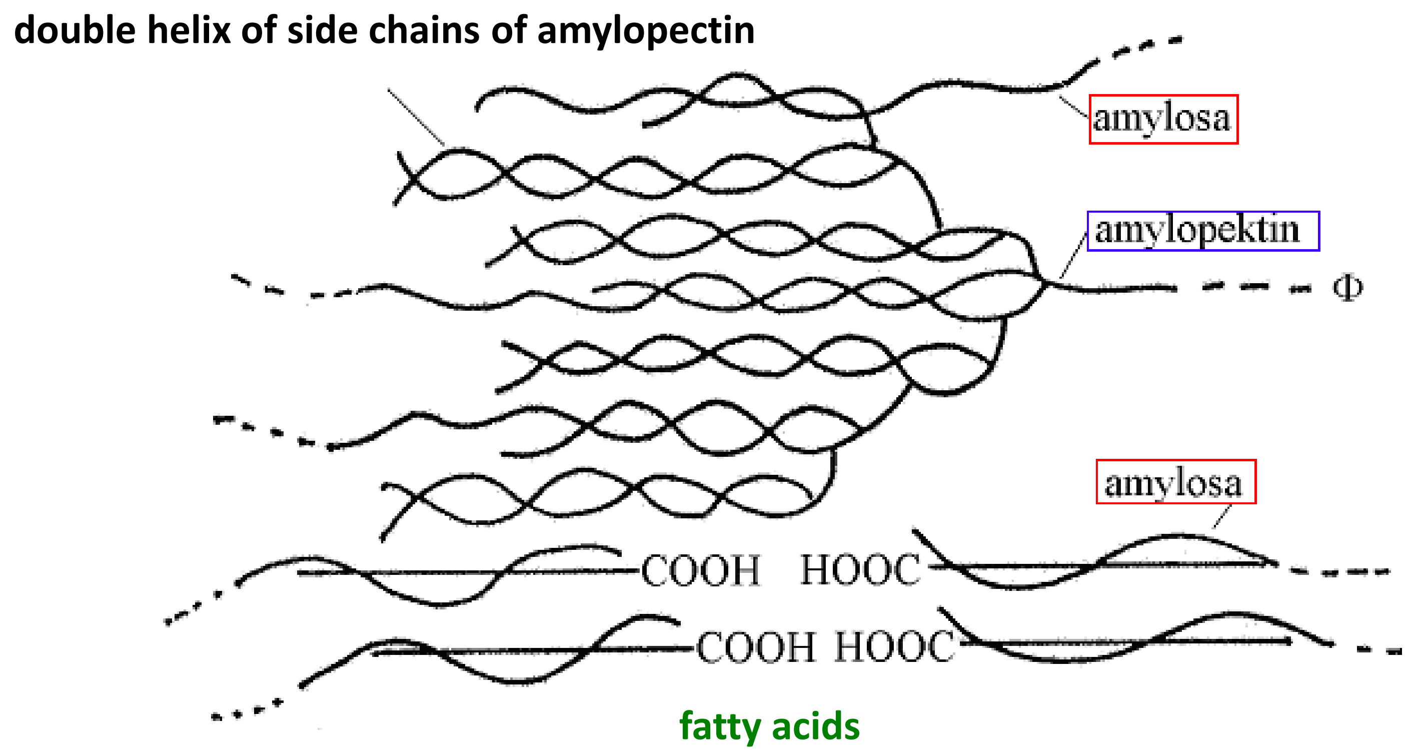
food	% starch	% amylose
wheat	59-72	24-29
potatoes	17-24	20-23
beans	46-54	24-33
cassava	28-35	17-19

fruits: bananas (only 1% in mature)
seeds: chestnuts, cashews

amylocultivars (eg. barley: 60-70% amylose)

waxcultivars (barley: 2-8% amylose)

starch granules in plastides (chloroplasts, amyloplasts)



other components of starch granules

- lipids (in wheat 0.4-0.7%, mostly lysophospholipids)
- proteins (in wheat friabiline, 0.3%)

behaviour in water during heating

- granules - water content 13% (wheat), 18-22% (potato)
- insoluble in cold water - suspension
- income to 30% without changes of shape and size (imbibition)
- during heating to gelatination temperature 50-70 °C (52-64 °C wheaten, 50-68 °C potato)

  ↳ swelling (disconnection of H-bonds)

  ⇩

  hydrated chains move away, amylose is released into solution

  ⇩

  starch sol - viscous

- increasing viscosity during cooling,
  new bindings amylose / amylopectin - new 3D grid - starch gel
- ageing of gel - retrogradation (syneresis) – release of water out of 3D grid

  re-gelatination (association of amylose)

behaviour during bread production

- mechanical damage of granules during grinding (5-10%)
- enzymatic hydrolysis during fermentation by amylases (diastase)

amylose

α-amylase (dextrinogenic) – randomly attacks α-(1→4) bonds
→ Glc, maltose, dextrins

β-amylase (saccharogenic) → cleaves off maltose

amylopectin

α-amylase and β-amylase → limit β-dextrins
pullulanasa, isoamylasa

- gelation of the starch (the effect of water content, fats, emulsifiers)
- pyrodextrins - dextrins produced by heat

α-(1→6), ether bonds (6→6)

- resistant starch

application

- **modified starches (eg. starch esters, ethers, crosslinked phosphates)**
- **dextrins** DE ≤ 20- non-sweet viscous solutions - prevent the formation of crystals (ice cream)
  - flavour carriers
- **starch syrups**
  type I (DE = 20-38), type II (DE = 38-58), type III (DE = 58-73)
  (maltose syrups typ II, typ III)
- **glucose syrups** typ IV (DE > 73)
- **fructose syrups** (glucosaisomerase, *B. circulans*, 55% Fru)

DE (dextrose equivalent) = content of free glucose in %

starch - DE = 0

glucose - DE = 100

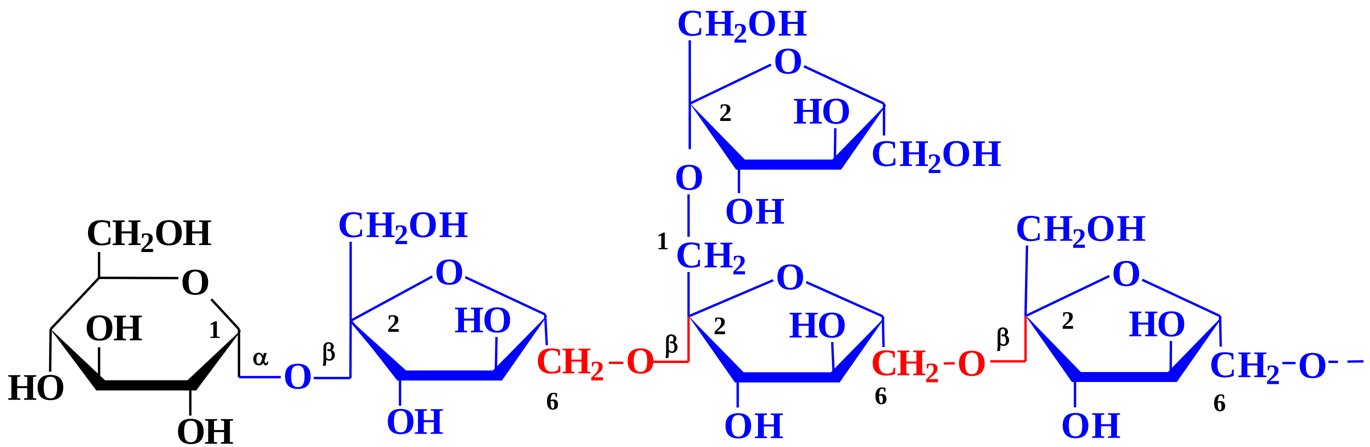
fructosans

fructans, glucofructans (terminal unit is glc)

fructooligosaccharides have a prebiotic effect, meaning they are used by beneficial bacteria that enhance colon health and aid digestion

structure

- **inulins** β-(1→2) chicory, Jerusalem artichokes, dahlias
- **levans (fleins)** β-(1→6) beet juice, *Bacillus subtilis*
- **with mixed bonds** β-(1→2), β-(1→6) cereals, vegetables



sources

food	glucofructans (%)	fructans (%)
Jerusalem artichoke	16-20	12-15
Chicory (root)	15-20	8-11
garlic	9-16	3.5-6.5
wheat	1-4	1-4

wild Cichory (*Cichorium intybus*)
(*Asteraceae*),

Cichory – cultivar
roasted roots – used as coffee surrogates

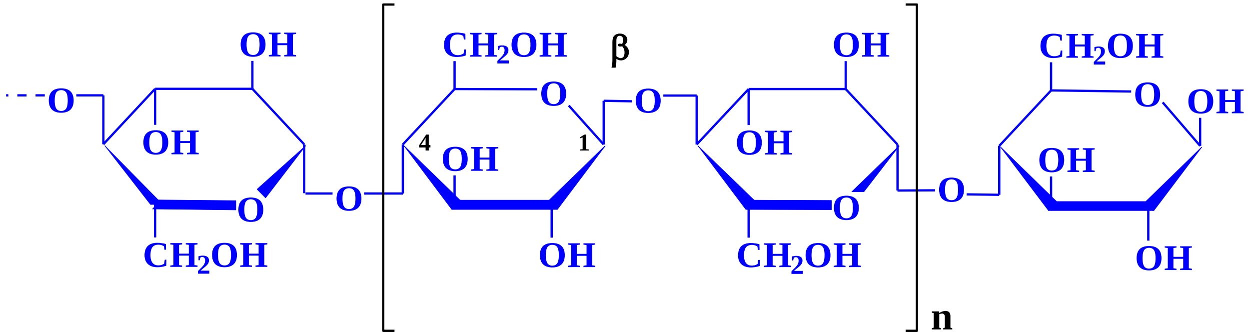
Jerusalem artichoke
(*Helianthus tuberosus*)

The **yacón** (*Smallanthus sonchifolius*) is a traditionally grown in the northern and central Andes from Colombia to northern Argentina for its crisp, sweet-tasting, tuberous roots. Their texture and flavour are very similar to jicama, mainly differing in that yacón has some slightly sweet, resinous, and floral (similar to violet) undertones to its flavour, probably due to the presence of inulin. Another name for yacón is **Peruvian ground apple**, possibly from the French name of potato, *pomme de terre* (ground apple). The tuber is composed mostly of water and fructooligosaccharide.

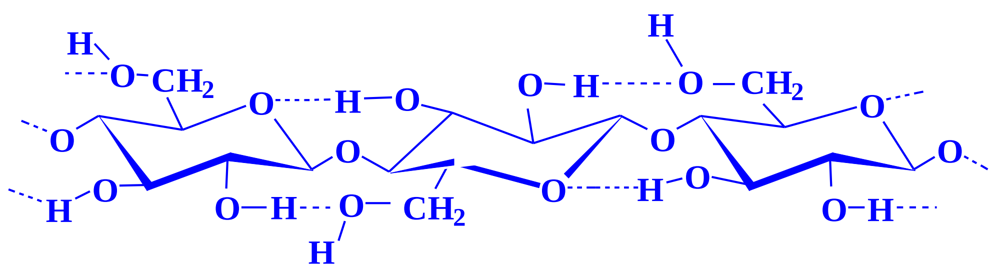



celullose

structure



≅15 000 molecules, β-(1→4)



stabilisation by H-bonds, fibres (microfibriles)

sources

- cell walls of plant cells
- assotiation with hemicelluloses, pectins

fruits, vegetables	1-2%
cereals, legumes	2-4%
wheat flour	0.2-3%
bran	30-35%

use

modified celluloses(hydrolysed, derivatized)

hemicelluloses

non-cellulose polysaccharides – fill the spaces between the cellulose fibers

part of the insoluble components of fiber

- **heteroglucans**
  - **xyloglucans** — **fruits, vegetables, legumes**
  - **β-glucans** — **fruits, vegetables, cereals**
- **heteroxylans**
  - **arabinoxylans (pentosans)** — **cereals**

xyloglucans

→4)-β-D-Glc*p*-(1→4)-β-D-Glc*p*-(1→4)-β-D-Glc*p*-(1→4)-β-D-Glc*p* (1→.....

6 ↑ 1 α-D-Xyl*p* (on the 1st, 2nd and 3rd Glc*p*)

6	6	6
↑	↑	↑
1	1	1
α-D-Xyl*p*	α-D-Xyl*p*	α-D-Xyl*p*

β-glucans

in larger quantities in the seeds of cereals

form partly soluble and partly insoluble fiber

β-(1→3), (1→4)-D-glucans **barley, oat**

→4)-β-D-Glc*p*-(1→4)-β-D-Glc*p*-(1→3)-β-D-Glc*p*-(1→4)-β-D-Glc*p*-(1→

laminaribiose

β-(1→3), (1→6)-D-glucans **mushrooms, microorganisms**

clinical medicine

arabinoxylans

α-L-Ara*f*
1
↓
3
→4)-β-D-Xyl*p*-(1→4)-β-D-Xyl*p*-(1→4)-β-D-Xyl*p*-(1→4)-β-D-Xyl*p*-(1→
2 2 3
↑ ↑ ↑
1 1 1
α-L-Ara*f* α-L-Ara*f* α-L-Ara*f*-(1→3)-α-L-Ara*f*

wheat flour << rye flour

high capacity to bind water ⇒ influence on the viscosity of the dough

dense, sticky texture of rye dough

pectins

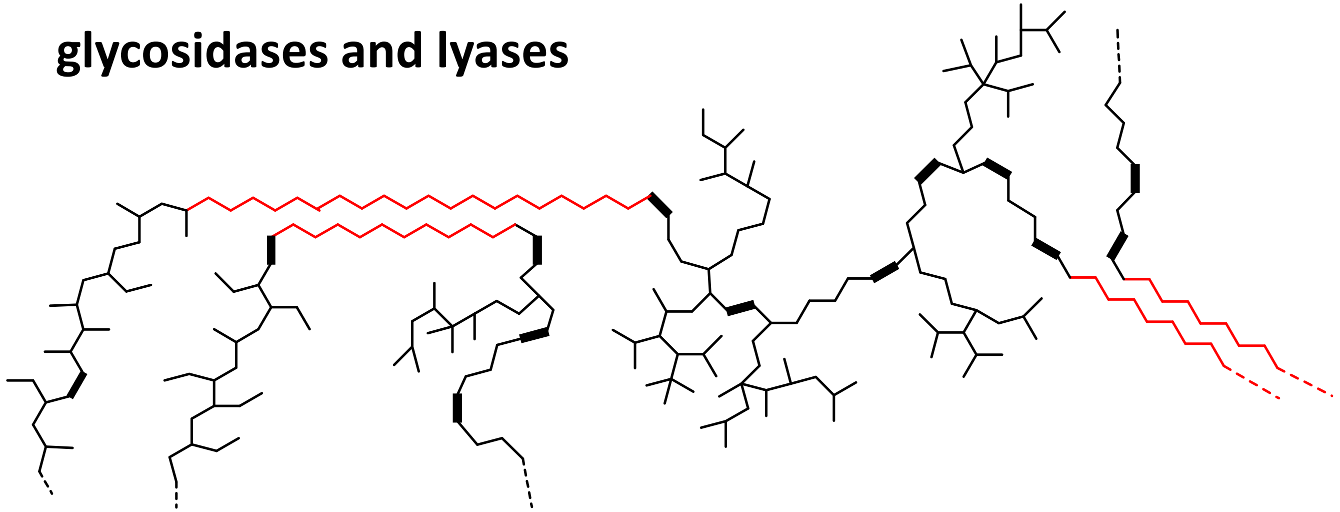
part of the cell wall and intercellular space of higher plants

structure

pectocelluloses → protopectins → pectins (soluble)

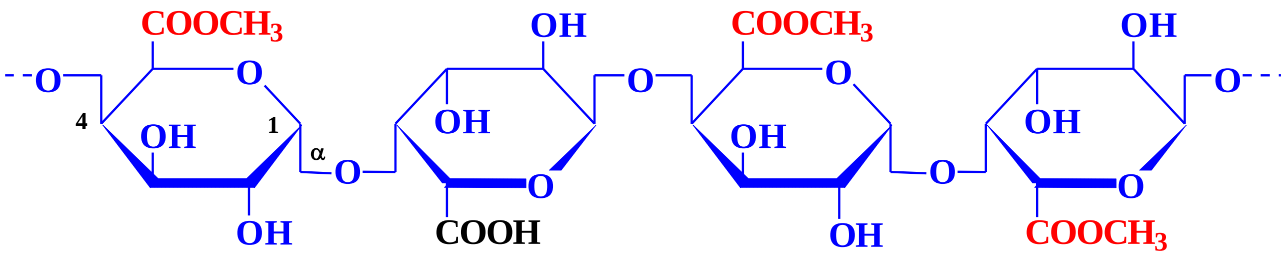
unripe fruit **(pectoses)** **ripe fruit**

glycosidases and lyases



binding region **D-galacturonic acid (methylesters)**

hair region **arabinans, arabinogalactans, L-rhamnose**



polygalacturonic acid

source	pectin (%)
apples	0.5-1.6
pears	0.4-1.3
strawberries	0.6-0.7
gooseberry	0.3-1.4
currant red and black	0.1-1.8
grapes	0.1-0.9
oranges	0.6
oranges peel - albedo	3.5-5.5
carrot	0.2-0.5
tomatoes	0.2-0.6
beans	0.5
onion	0.5

source

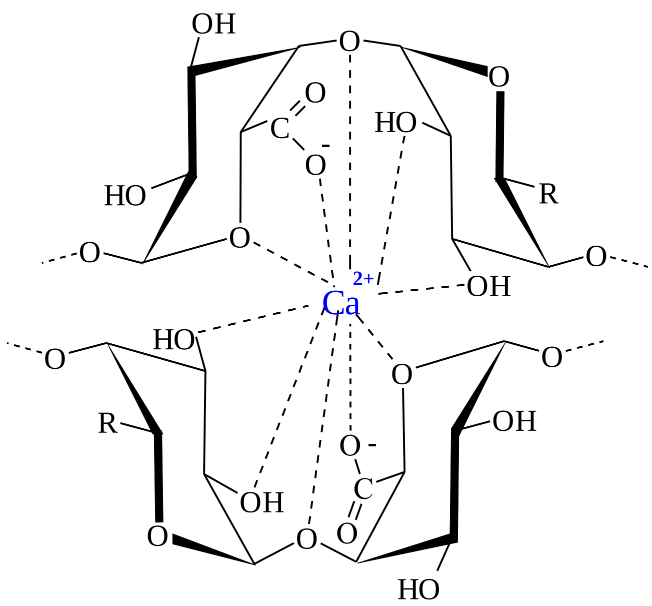
- apple pomace
- albedo of oranges

use

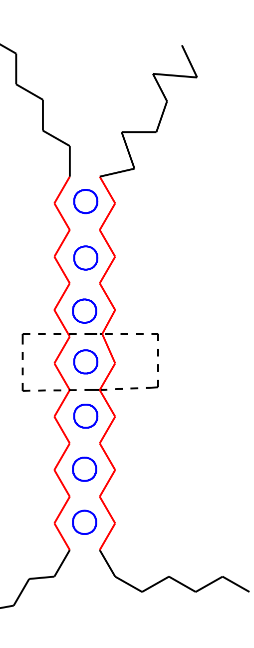
gelling agent

conditions of gels formation

type of pectins	degree of esterification (%)	conditions
highly esterified	(100)	sugar
	≥ 70	sugarcukr (> 50%), pH < 3,5
	50-70	sugar (> 50%), pH < 2,8-3,1
low esterified	< 50	bivalent cations (Ca^{2+})



R = COO$^-$ nebo COOCH$_3$



gums and plant mucilages

gels are not formed, high viscosity liquids

Mucilage is a thick, gluey substance produced by nearly all plants and some microorganisms. It is a polar glycoprotein and an exopolysaccharide. Mucilage in plants plays a role in the storage of water and food, seed germination, and thickening membranes. Cacti (and other succulents) and flax seeds especially are rich sources of mucilage

The following plants are known to contain far greater concentrations of mucilage than is typically found in most plants:

- *Aloe vera*
- *Basella alba* (Malabar spinach)
- Cactus
- *Chondrus crispus* (Irish moss)
- *Dioscorea opposita* (nagaimo, Chinese yam)
- *Drosera* (sundews)
- *Drosophyllum lusitanicum*
- Fenugreek
- Flax seeds
- Kelp
- Liquorice root
- Marshmallow
- Mallow
- Mullein
- Okra
- *Parthenium*
- *Pinguicula* (butterwort)
- *Psyllium* seed husks
- *Salvia hispanica* (chia) seed
- *Ulmus rubra* bark (slippery elm)

vegetable gums and mucilages

gum (mucilage)	plant	
arabic (acacia) gum	*Acacia* sp.	exudate
Locust (carob) bean gum	*Ceratonia siliqua*	endosperm of the seed, legume
tragacanth gum (bassorin)	*Astragalus gummifer*	exudate
okra	*Hibiscus esculentus*	ovary

microbial gums

gum	microorganism
gellan	*Pseudomonas elodea*
xanthan	*Xanthomonas campestris*

mucilage of okra **rhamnogalakturonan**

okra, lady's finger (*Hibiscus esculentus*)

Seaweed polysaccharides

building fuction

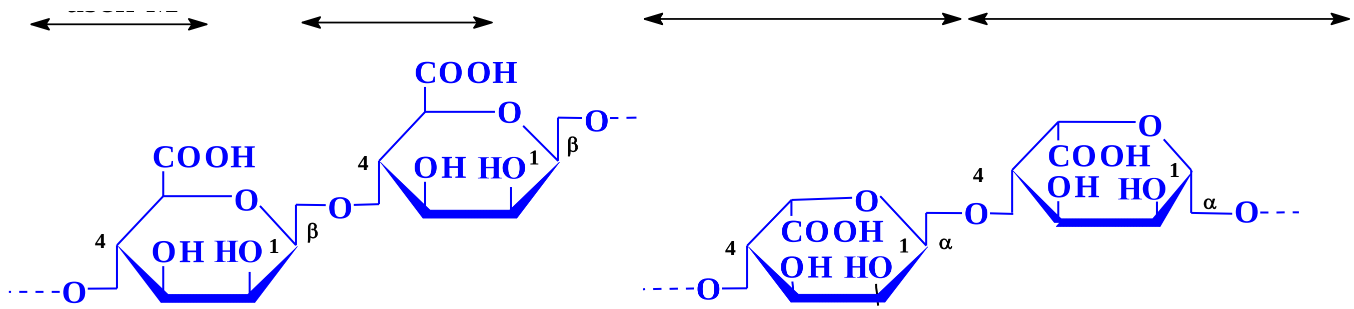
alginates

alginic acid, salts alginates (commercially- Na)

structure

M-M-M-M-G-M-G-G-G-G-G -M-G-M-G-G-G-G-G-G-G-G -M-M-G-M-G-M-G-G-

section M | section G | section G | section M-G



β-D-mannuronic acid **α-L-guluronic acid**

source

brown algae *Pheophycae*

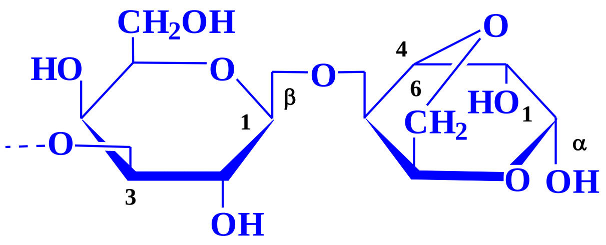
use

gelling agent, stabilizer

essential: presence of Ca^{2+} (like pectins) **modified alginates**

agar- agar, carrageenans

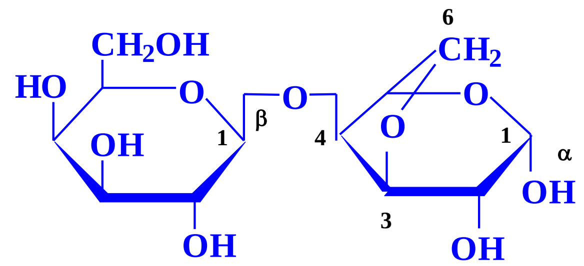
structure



β-D-Gal*p* 3,6-anhydro- α-L-Gal*p*

agarobiose

agarose



β-D-Gal*p* 3,6-anhydro- α-D-Gal*p*

carabiose

carragenans

sources

red algae *Rhodophycae*

application

thickeners, gelling agent

carrageenans (superhelixes) presence of neutralization ions

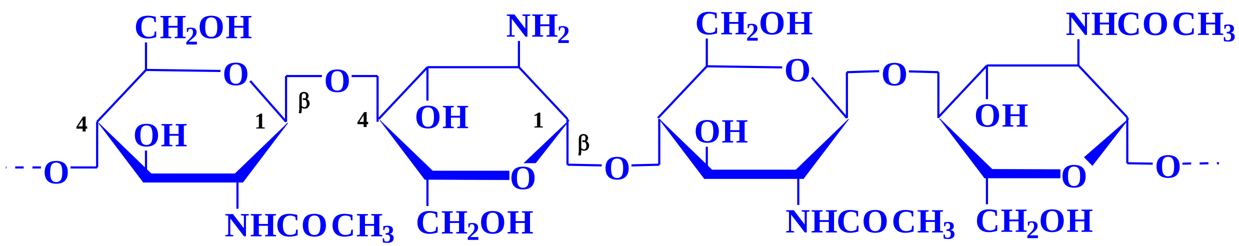
complexes with caseins

chitin

structure

β-D-glukosamin N-acetyl-β-D-glukosamin (chitosamin)

10-30 % 70-90 %



chitobiose

sources

- food: higher fungi (1%), yeasts (2.9%))
- industrially: sea shells

application

modified chitin = chitosan (75-95% glucosamine)

lignin

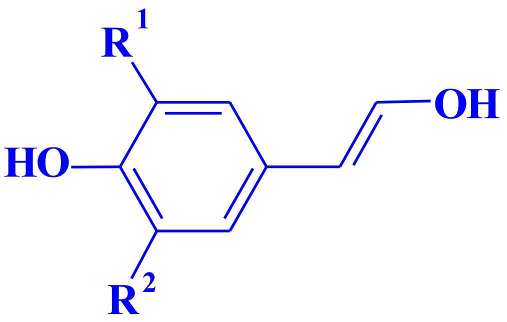
sources

lignified plant cells

- wood 25%
- bran 8%
- fruits, vegetables

structure

polymer of phenylpropane units



p-coumaryl alcohol, $R^1 = R^2 = H$
coniferyl alcohol, $R^1 = OCH_3$, $R^2 = H$
sinapyl alcohol, $R^1 = R^2 = OCH_3$

the basic structure of lignin