Υδατάνθρακες

$C_x (H_2O)_y$

- Ζώα

  γλυκόζη, γλυκογόνο (αποθήκη ενεργειας)
- Γάλα

  λακτόζη (δισακχαρίτης)
- Φυτά

  άμυλο (αποθήκη ενέργειας)

  90% ξηρού βάρους

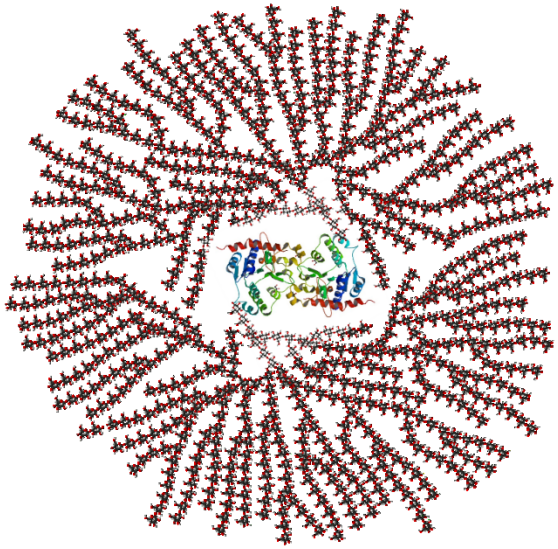
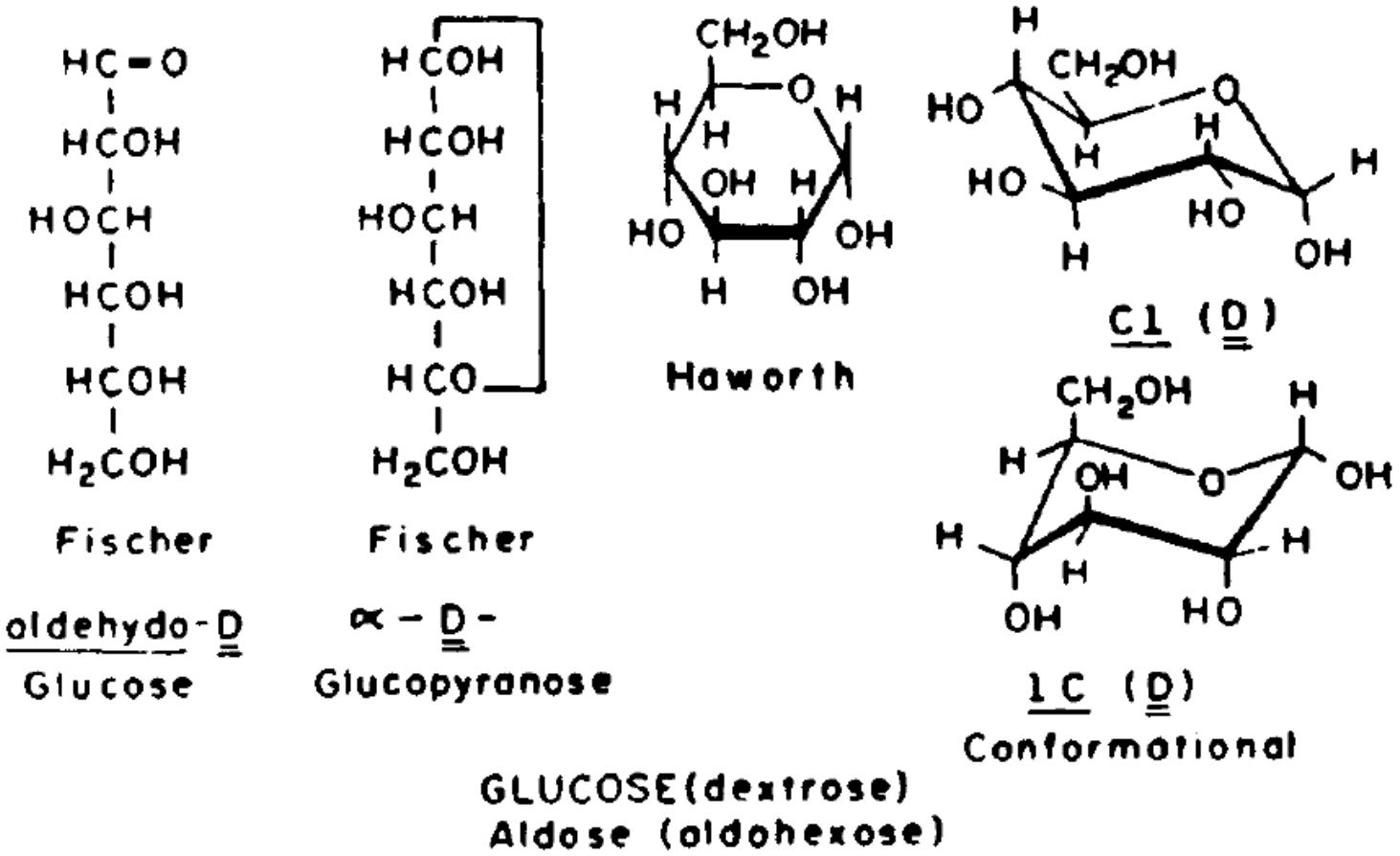


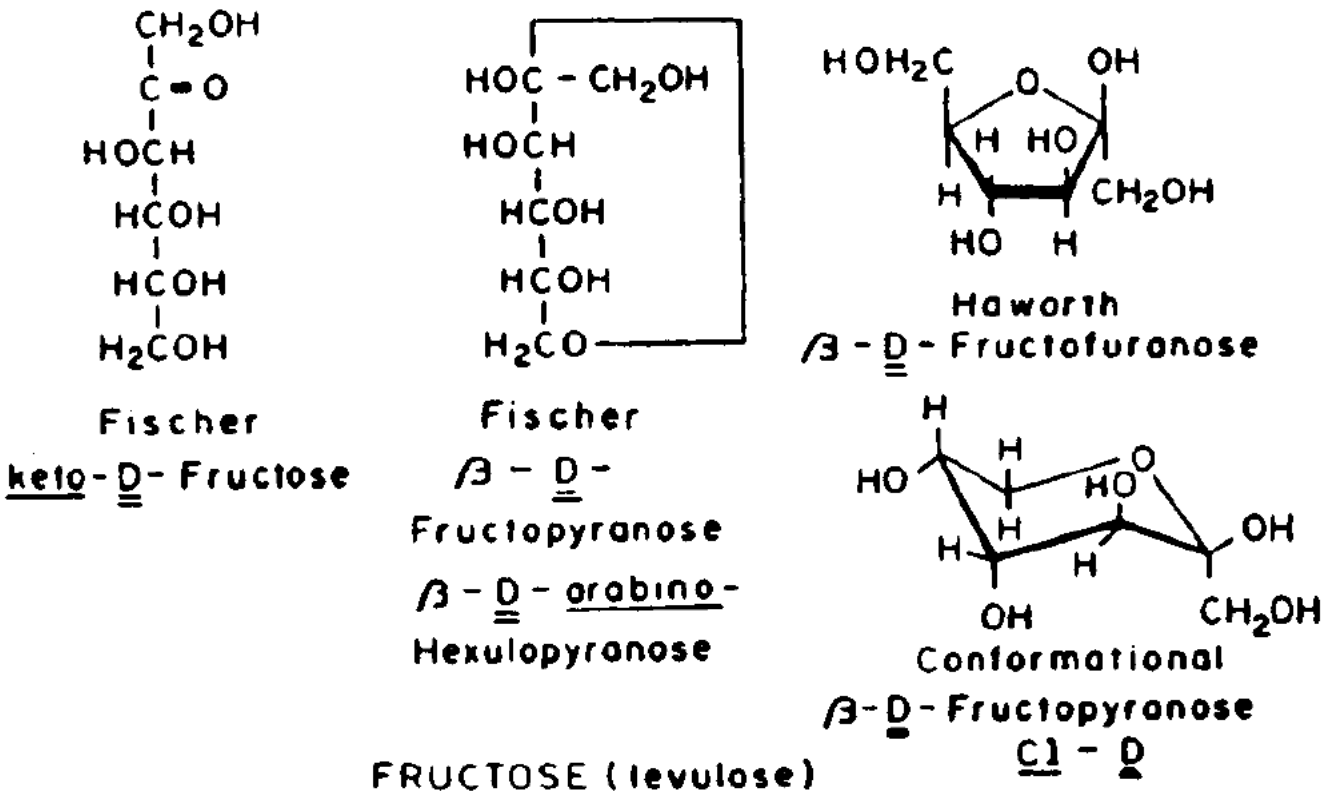
Table 4–1 Carbohydrates in Some Foods and Food Products

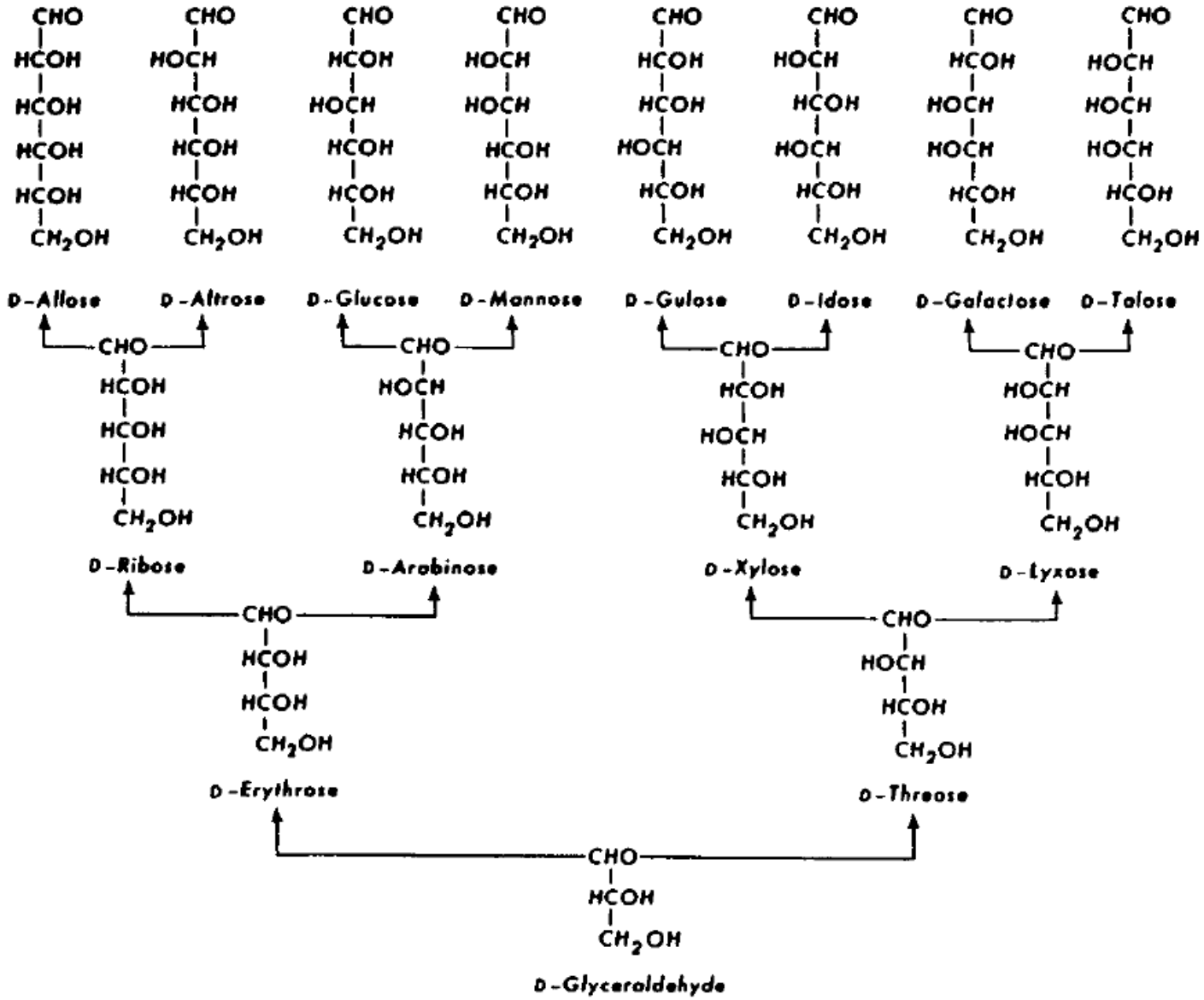
Product	*Total Sugar (%)*	*Mono- and Disaccharides (%)*	*Polysaccharides (%)*
Fruits			
Apple	14.5	glucose 1.17; fructose 6.04; sucrose 3.78; mannose trace	starch 1.5; cellulose 1.0
Grape	17.3	glucose 5.35; fructose 5.33; sucrose 1.32; mannose 2.19	cellulose 0.6
Strawberry	8.4	glucose 2.09; fructose 2.40; sucrose 1.03; mannose 0.07	cellulose 1.3
Vegetables			
Carrot	9.7	glucose 0.85; fructose 0.85; sucrose 4.25	starch 7.8; cellulose 1.0
Onion	8.7	glucose 2.07; fructose 1.09; sucrose 0.89	cellulose 0.71
Peanuts	18.6	sucrose 4–12	cellulose 2.4
Potato	17.1		starch 14; cellulose 0.5
Sweet corn	22.1	sucrose 12–17	cellulose 0.7; cellulose 60
Sweet potato	26.3	glucose 0.87; sucrose 2–3	starch 14.65; cellulose 0.7
Turnip	6.6	glucose 1.5; fructose 1.18; sucrose 0.42	cellulose 0.9
Others			
Honey	82.3	glucose 28–35; fructose 34–41; sucrose 1–5	
Maple syrup	65.5	sucrose 58.2–65.5; hexoses 0.0–7.9	
Meat		glucose 0.01	glycogen 0.10
Milk	4.9	lactose 4.9	
Sugarbeet	18–20	sucrose 18–20	
Sugar cane juice	14–28	glucose + fructose 4–8; sucrose 10–20	

Μονοσακχαρίτες

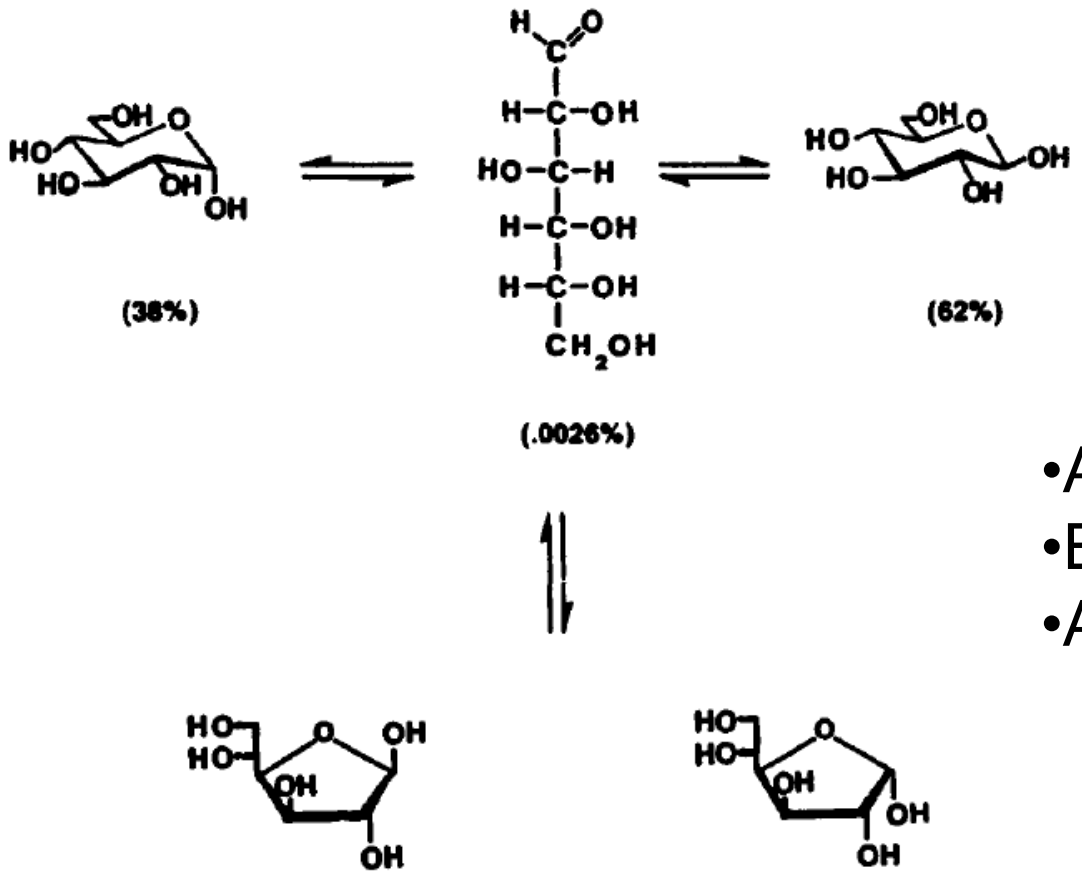


Μονοσακχαρίτες




D-Allose
D-Altrose
D-Glucose
D-Mannose
D-Gulose
D-Idose
D-Galactose
D-Talose
D-Ribose
D-Arabinose
D-Xylose
D-Lyxose
D-Erythrose
D-Threose
D-Glyceraldehyde

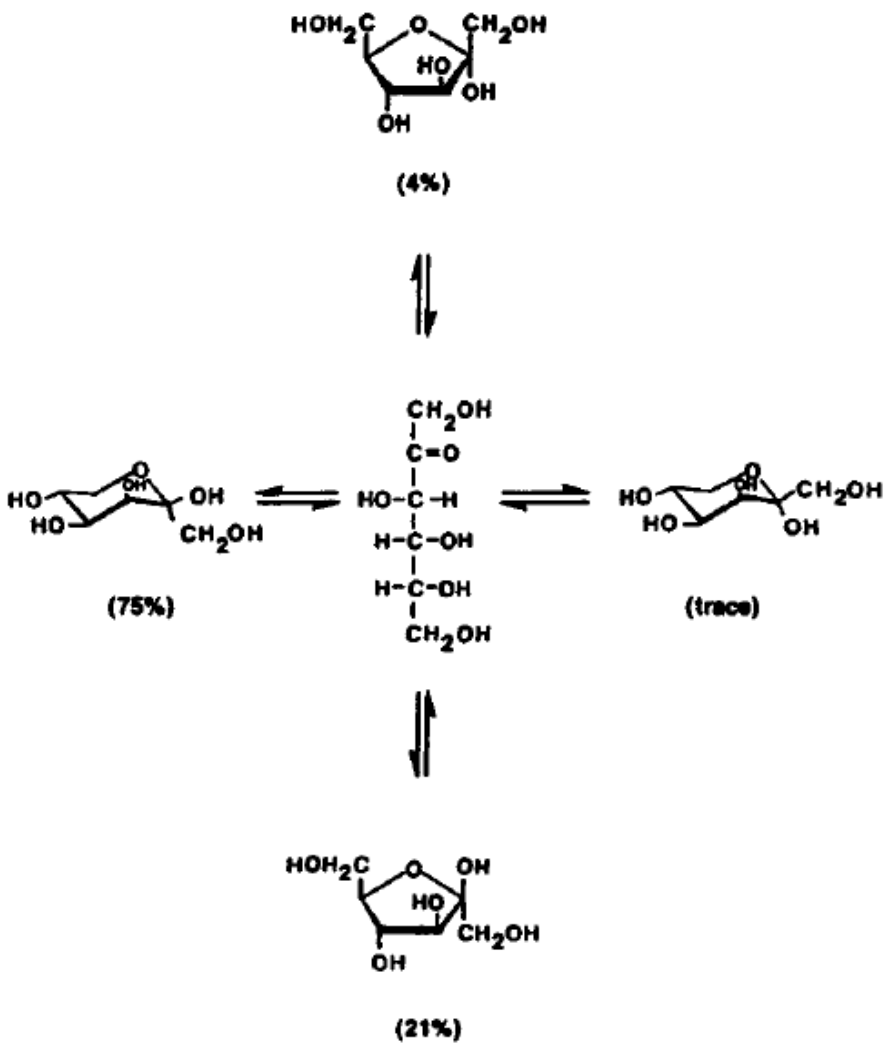
Γλυκόζη



- Αλδόζη
- Εξόζη
- Αλδοεξόζη

Figure 4–3 Tautomeric Forms of Glucose in Aqueous Solution at Room Temperature

Φρουκτόζη



- Κετόζη
- Εξόζη
- Κετοεξόζη

Figure 4–4 Tautomeric Forms of Fructose in Aqueous Solution at Room Temperature

Ολιγοσακχαρίτες

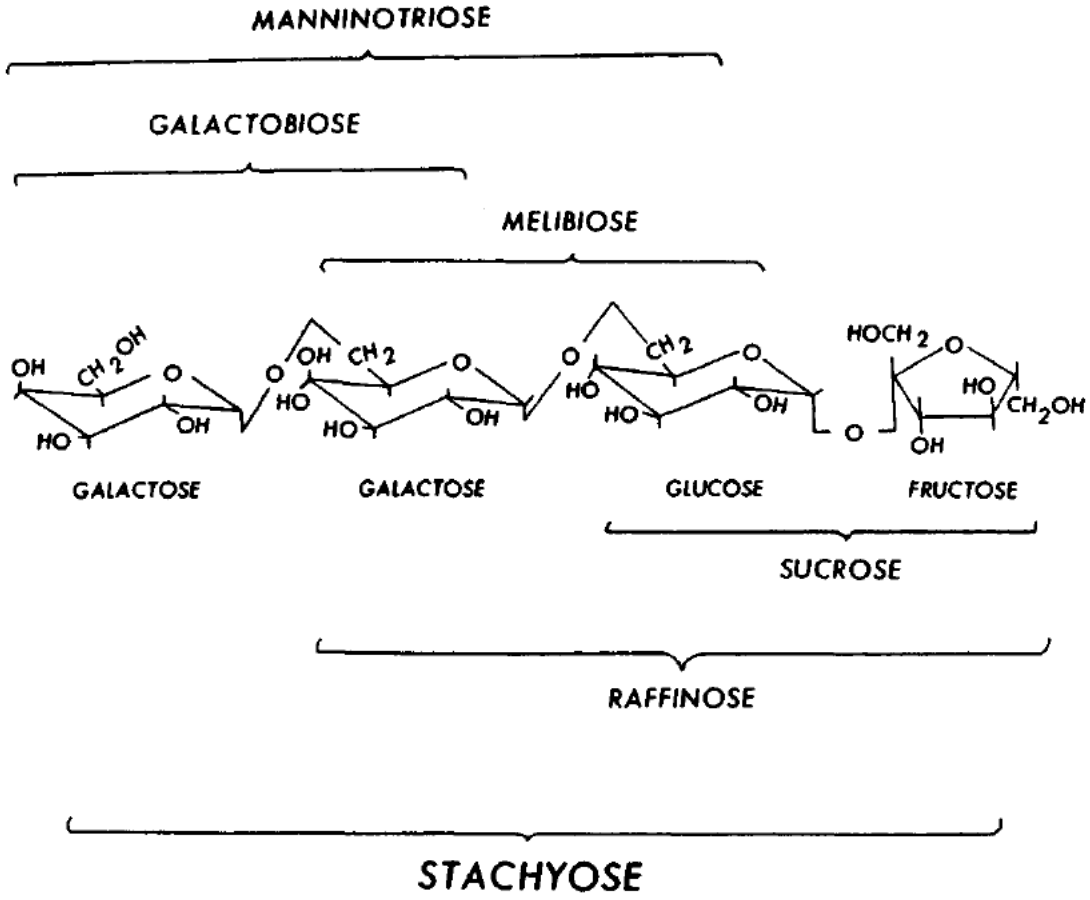
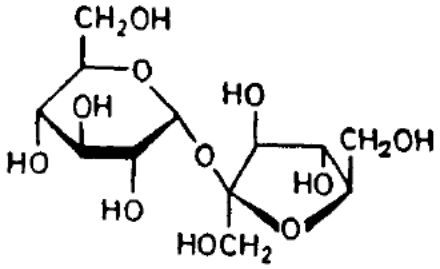
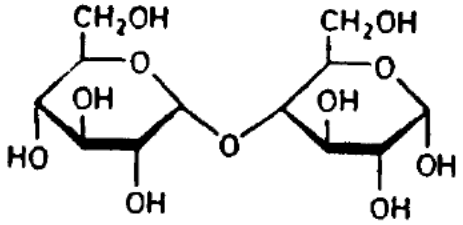


Figure 4–9 Composition of Some Major Oligosaccharides Occurring in Foods. *Source:* From R.S. Shallenberger and G.G. Birch, *Sugar Chemistry*, 1975, AVI Publishing Co.

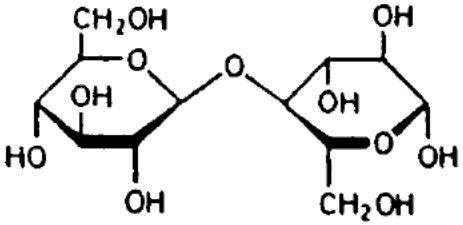
Ολιγοσακχαρίτες



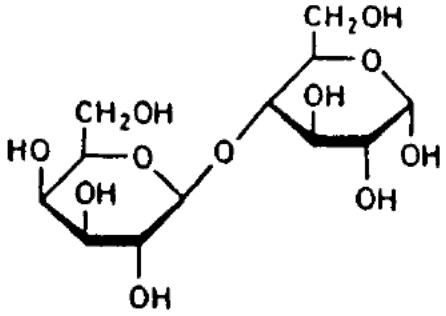
Sucrose



Maltose



Cellobiose



Lactose

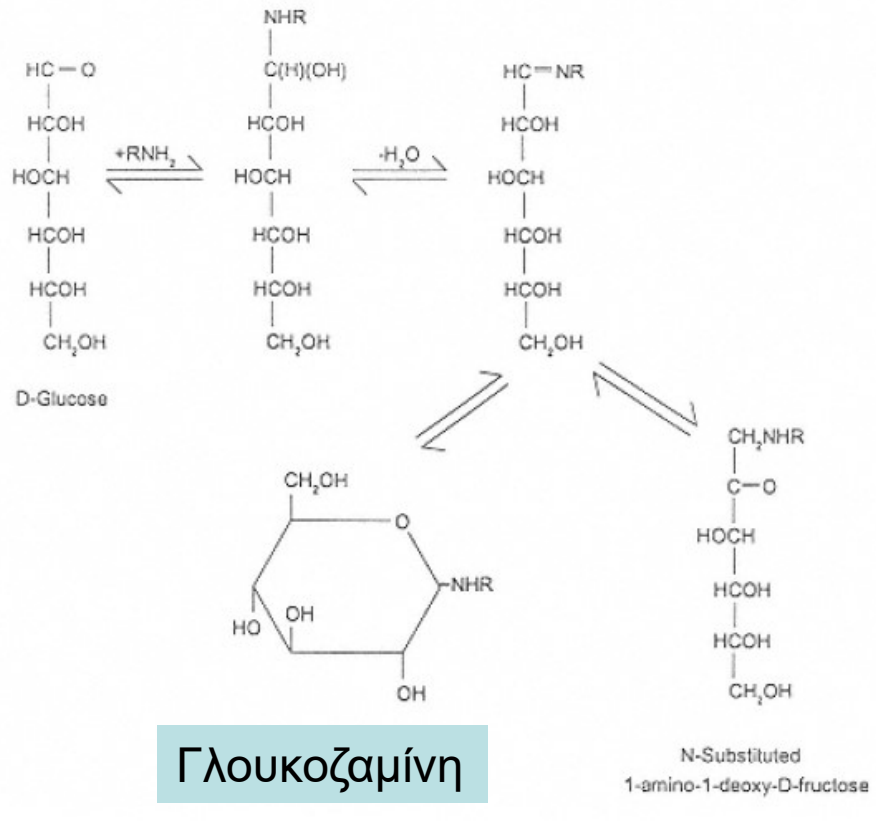
Figure 4–10 Structure of Some Important Disaccharides

Μη ενζυμικό μαύρισμα

- Σάκχαρο + R-NH_2 ή αμινοξύ πρωτεϊνης
  - Αντίδραση Maillard
  - Θέρμανση (ψήσιμο, τηγάνισμα, κλπ)

  Ανάπτυξη καφέ προϊόντων

Μη ενζυμικό μαύρισμα



Γλουκοζαμίνη

FIGURE 22
Products of reaction of D-glucose with an amine (RNH 2).

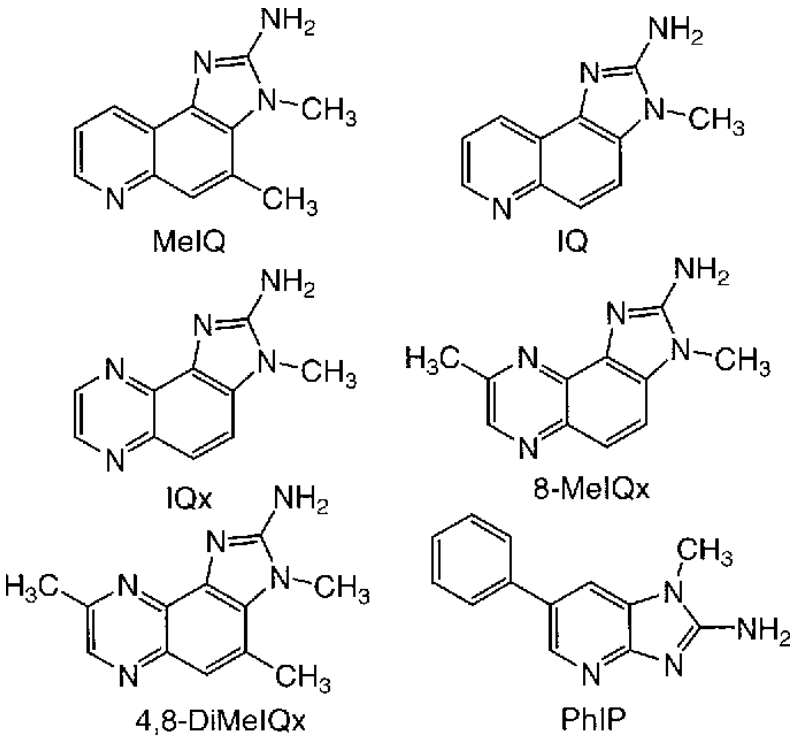


FIG. 1. *Cooked food-derived mutagenic heterocyclic amines.*

Καραμελοποίηση

- Θέρμανση απουσία αζωτούχων ομάδων
- Προκύπτουν σύνθετα πολυμερή

- Caramelans ($C_{24}H_{36}O_{18}$)
- Caramelens ($C_{36}H_{50}O_{25}$)
- Caramelins ($C_{125}H_{188}O_{80}$)

- Cola, παγωτά, γλυκά, κέικ (E150)

Λακτόζη

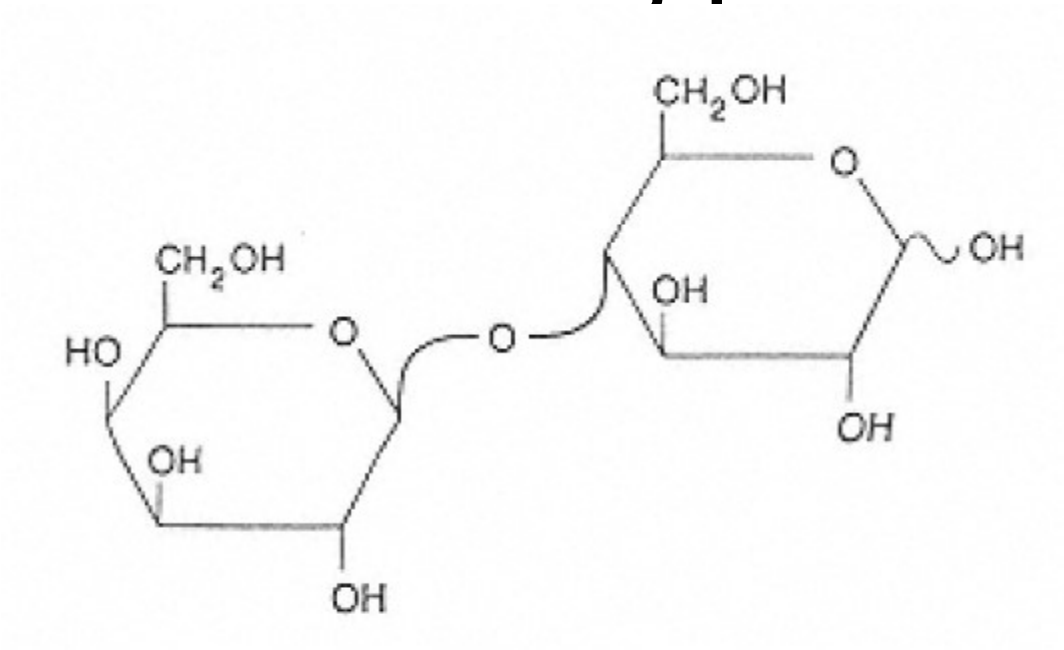


FIGURE 26
Lactose.

Κύρια πηγή ενέργειας για τα αναπτυσσόμενα θηλαστικά

$$\text{lactose} \xrightarrow{\text{lactase}} \text{D-glucose} + \text{D-galactose}$$

Πολυσακχαρίτες

- Πολυμερή μονοσακχαριτών
- Βαθμός πολυμερισμού (DP) = 200-15000
- Ομογλουκάνες
  - Αμυλόζη, αμυλοπηκτίνη
  - Κυτταρίνη
- Ετερογλουκάνες
  - Αλγίνες
  - Κόμμεα

Πολυσακχαρίτες

- Χρησιμοποιούνται για την αύξηση του ιξώδους και τη δημιουργία gel.
- Πολυόλες, απορροφούν νερό.

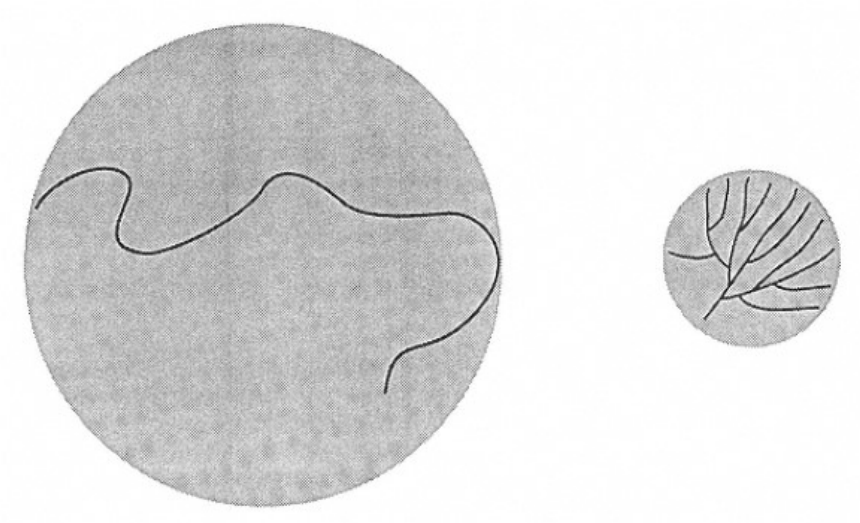
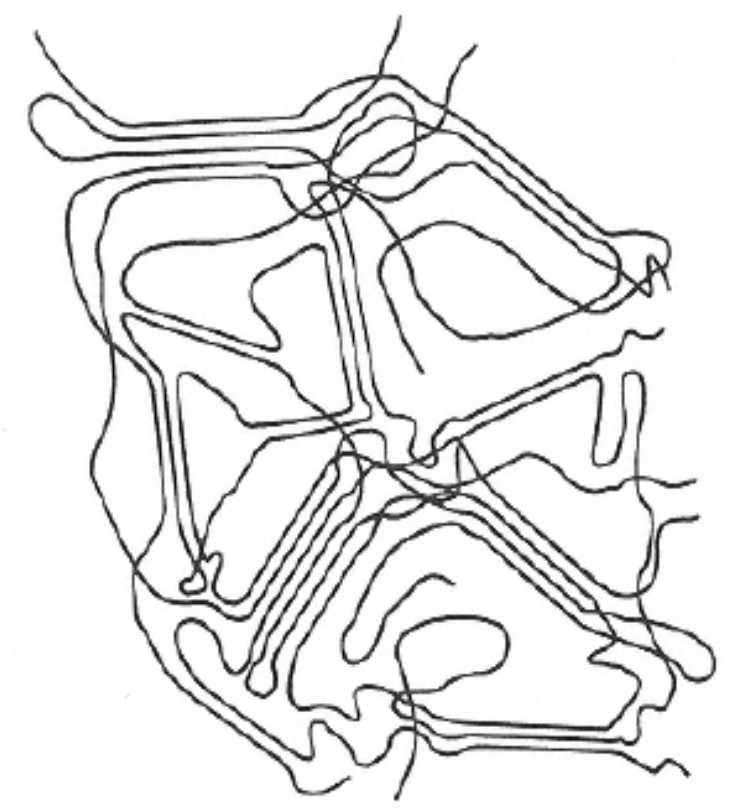


FIGURE 32
Relative volumes occupied by a linear polysaccharide and a highly branched polysaccharide of the same molecular weight.

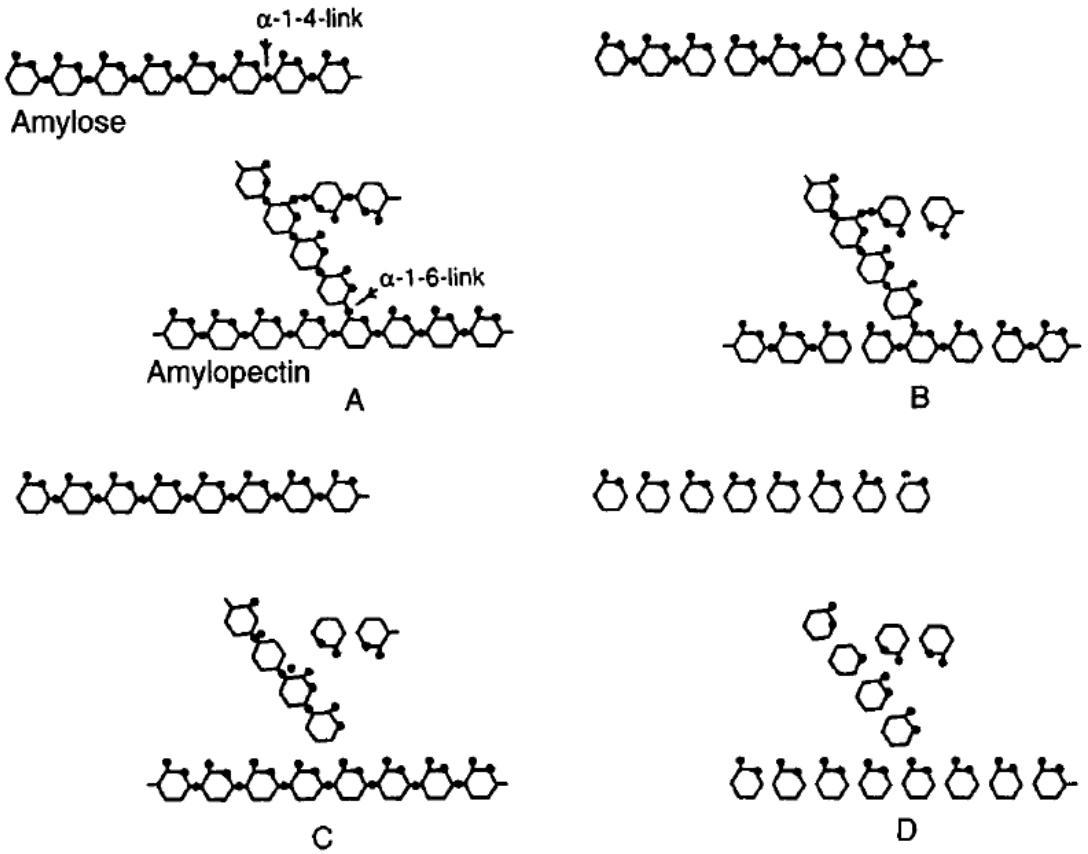
Polysaccharide gels

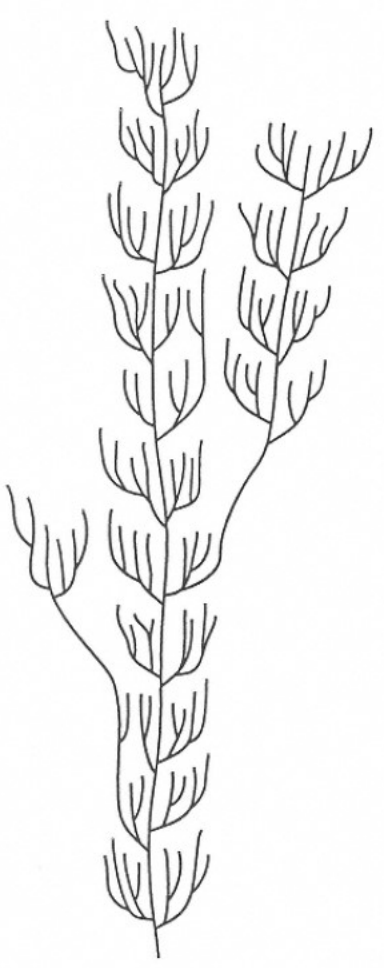


dessert gels, aspics, structured fruit pieces
meat-analog pet foods, and icings

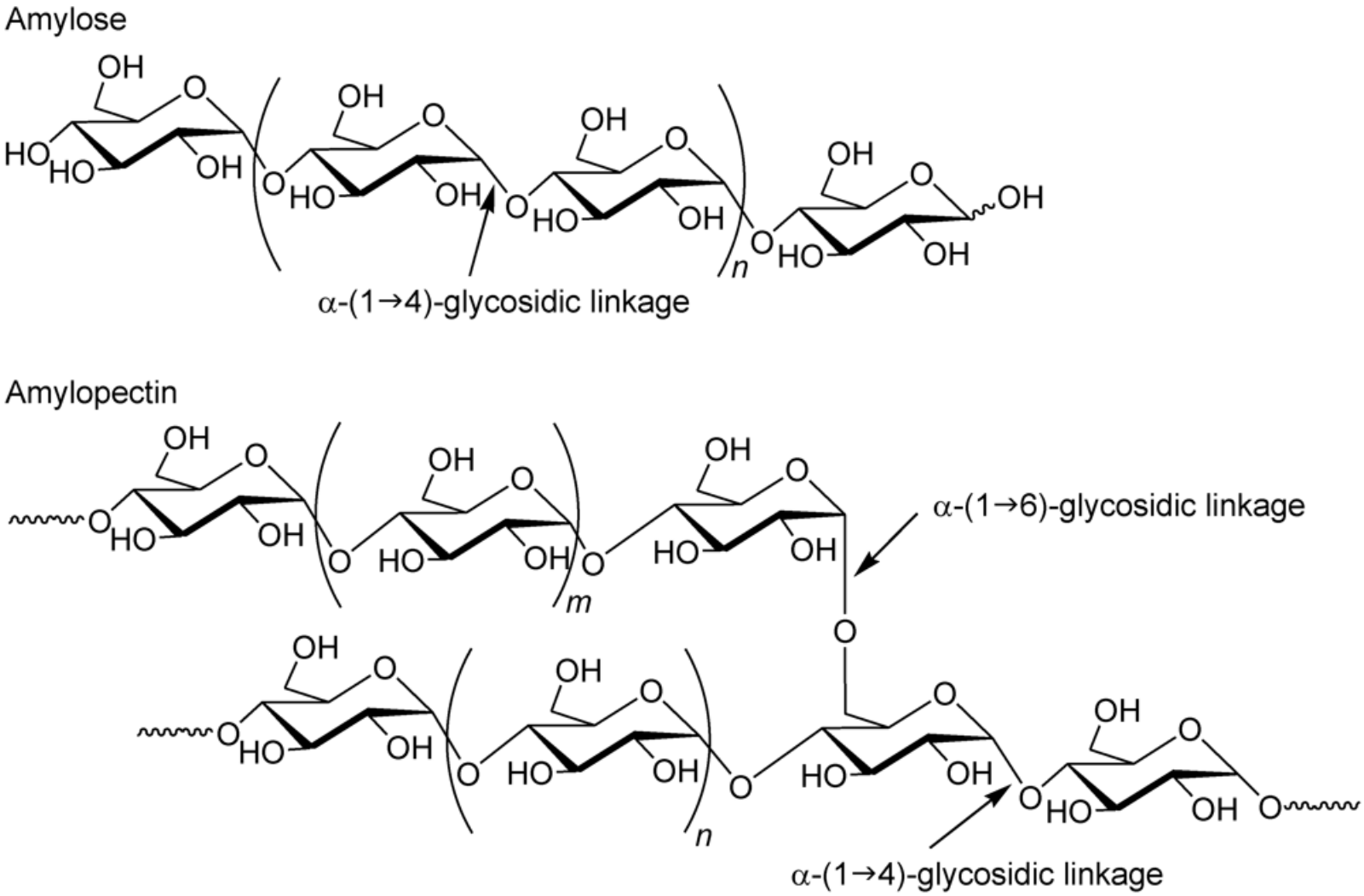
Άμυλο

- Αμυλόζη : γραμμικό πολυμερές της α-D-γλυκόζης
- Αμυλοπηκτίνη : διακλαδισμένο





Αμυλόζη - Αμυλοπηκτίνη



Κόκκοι αμύλου (granules)

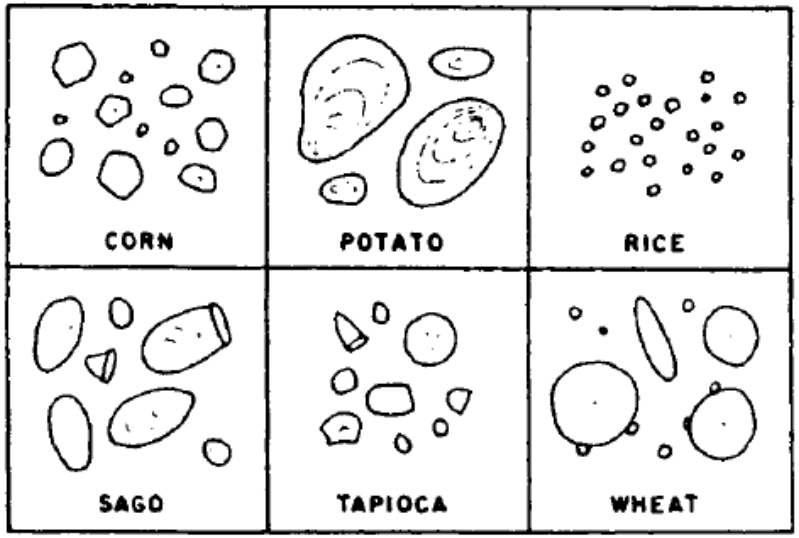
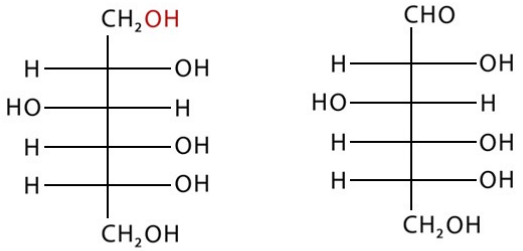


Figure 4–22 Appearance of Starch Granules as Seen in the Microscope



Sorbitol Glucose

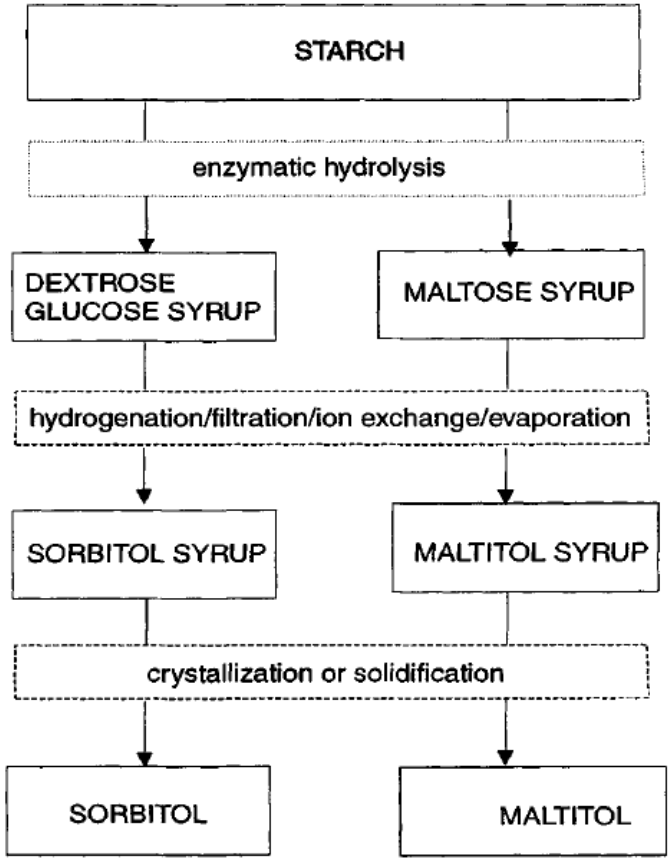
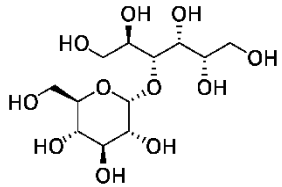


Figure 4–21 Production Process for the Conversion of Starch to Sorbitol and Maltitol. *Source:*



Τροποποιημένο άμυλο

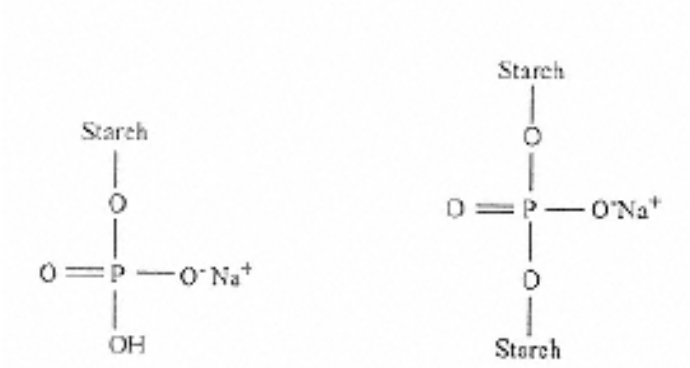
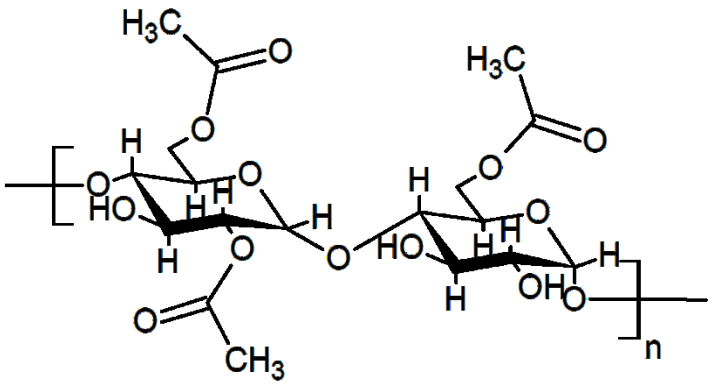
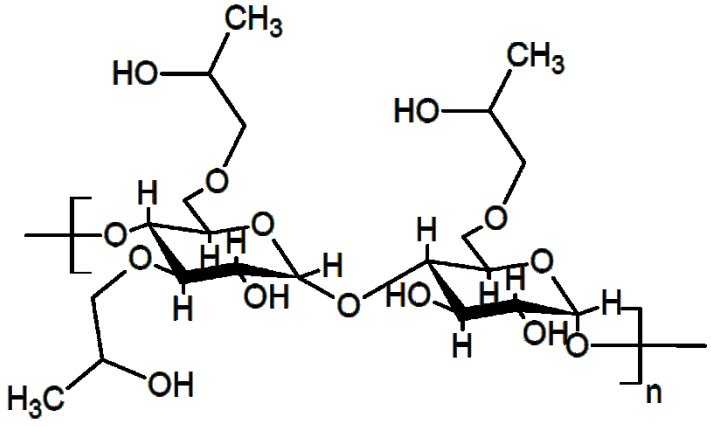


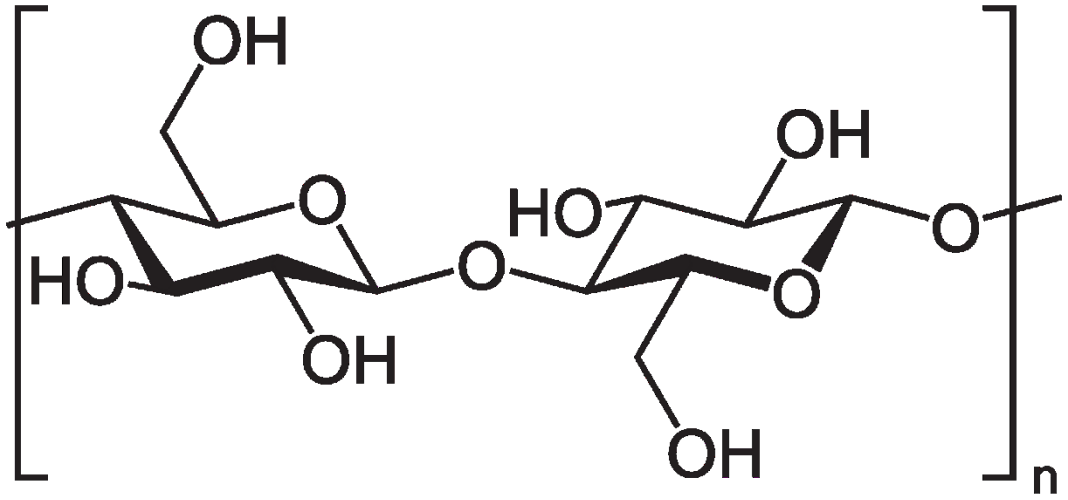
FIGURE 38
Structures of starch monoester phosphate (left) and diester phosphate (right). The diester joins two molecules together, resulting in crosslinked starch granules.



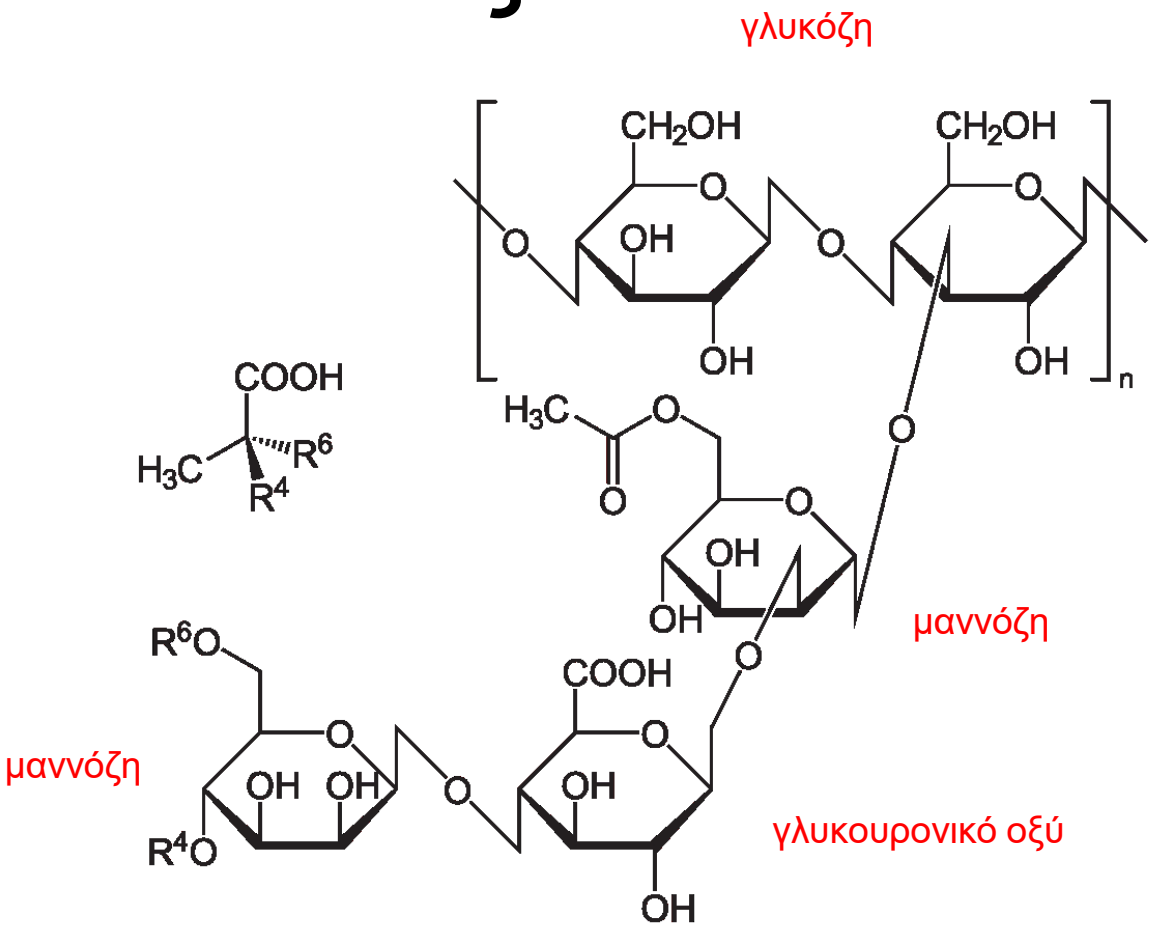


Κυτταρίνη

Γραμμικό πολυμερές της β-D-γλυκόζης
Κύριο συστατικό του κυτταρικού τοιχώματος των φυτών

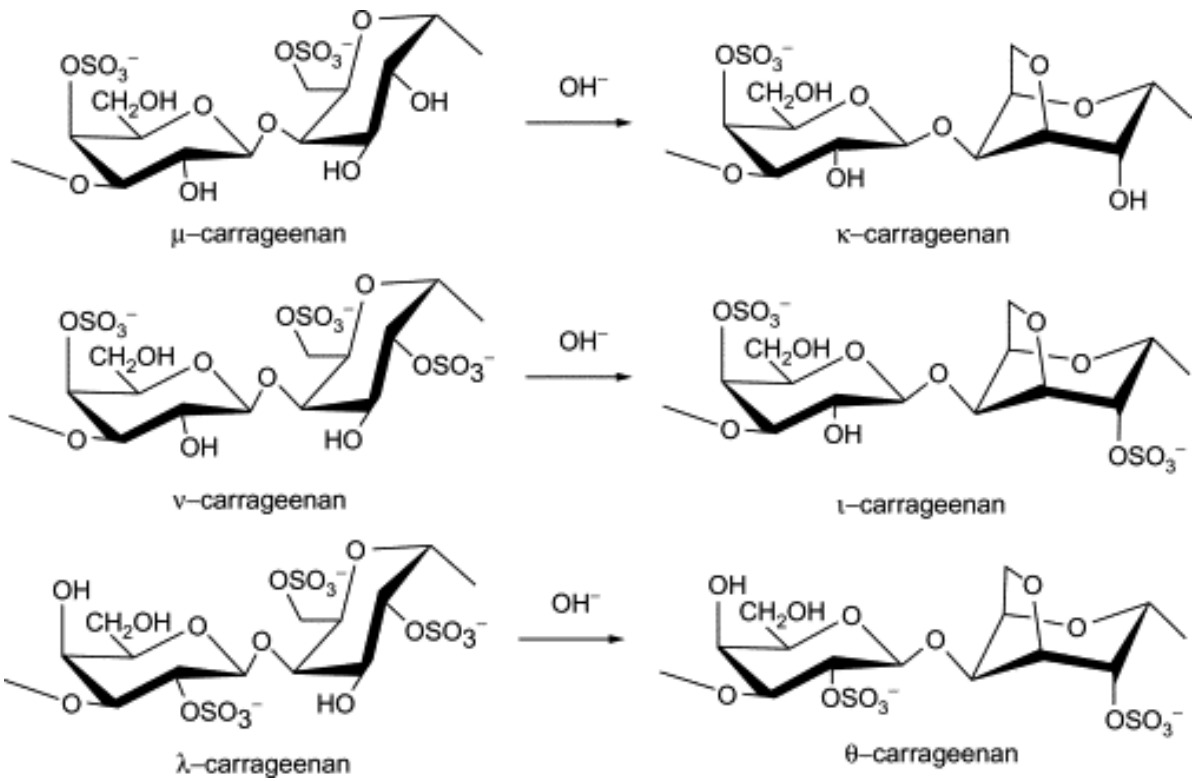


Ξανθάνες



Σταθεροποιητές ιξώδους σε σοκολάτες,
(το ιξώδες τους δεν αλλάζει με τη θερμοκρασία)

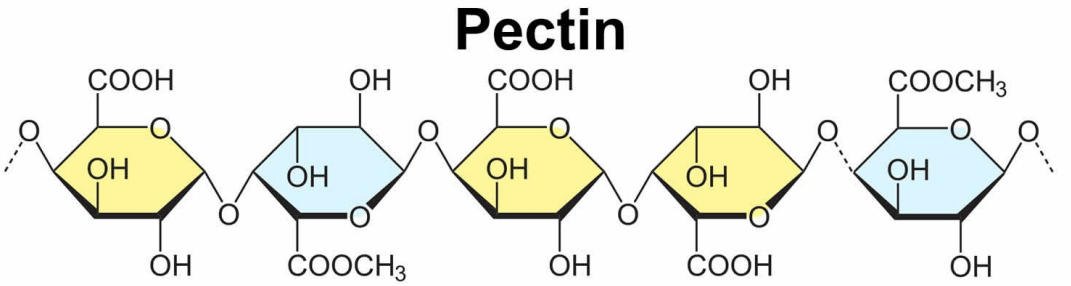
Καραγεννάνες

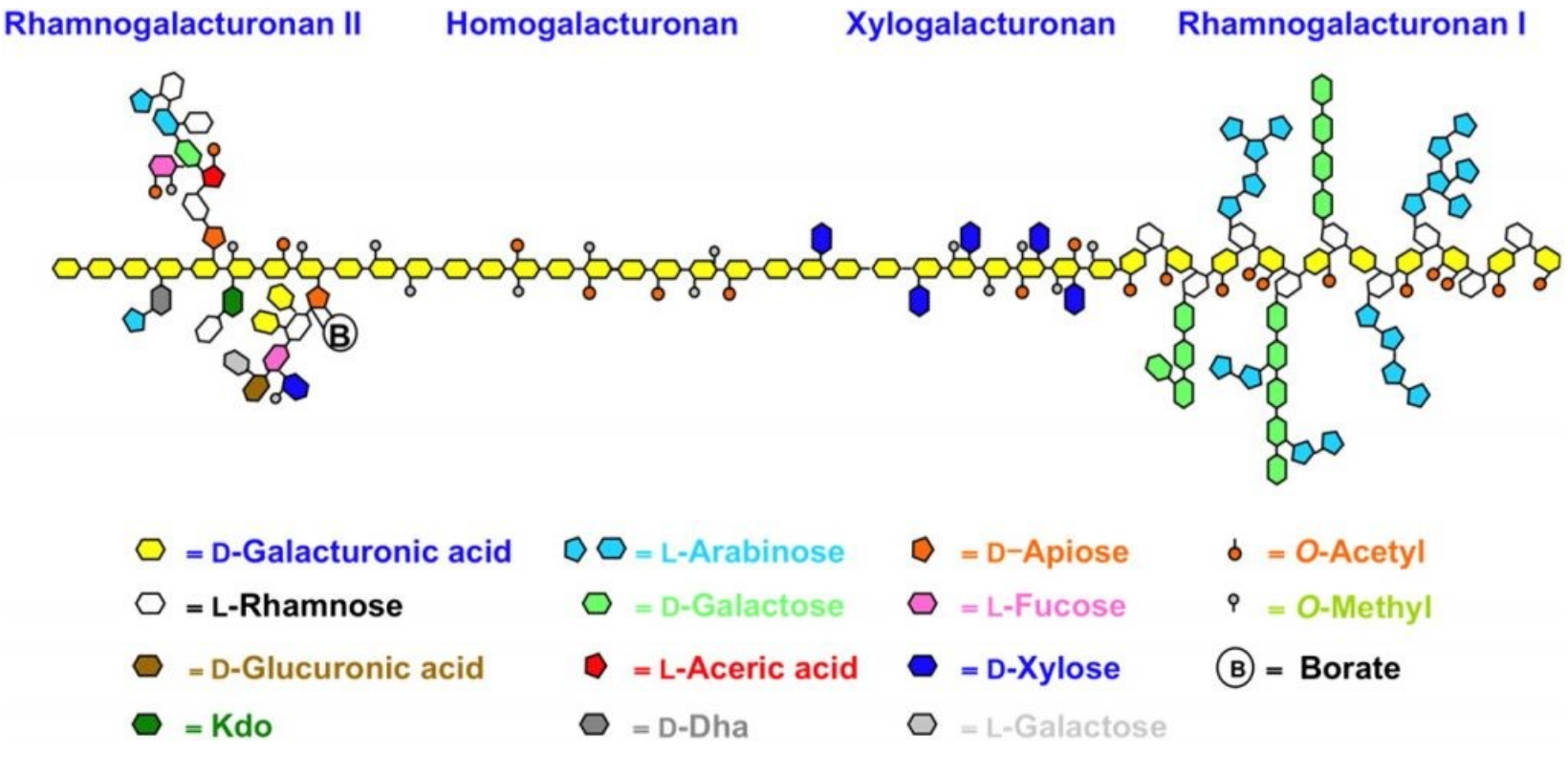


red seaweeds

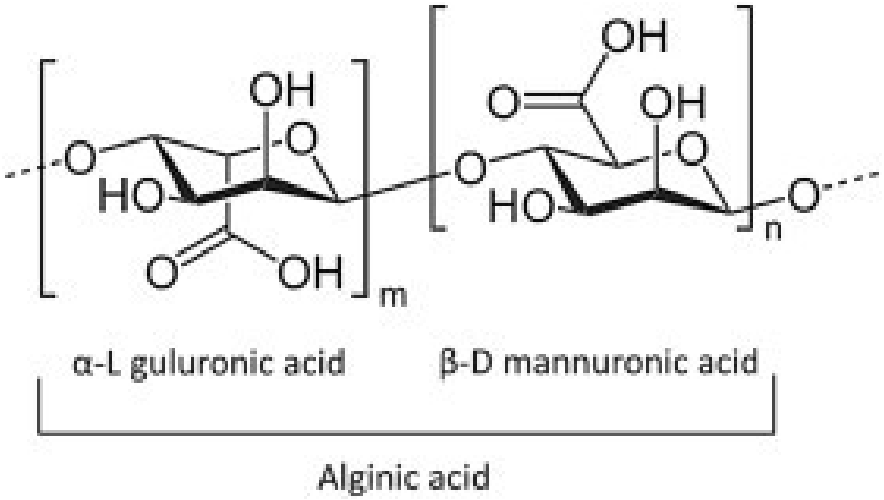
Δημιουργούν gel με το γάλα και το νερό
(σοκολατούχο γάλα και παγωτά)

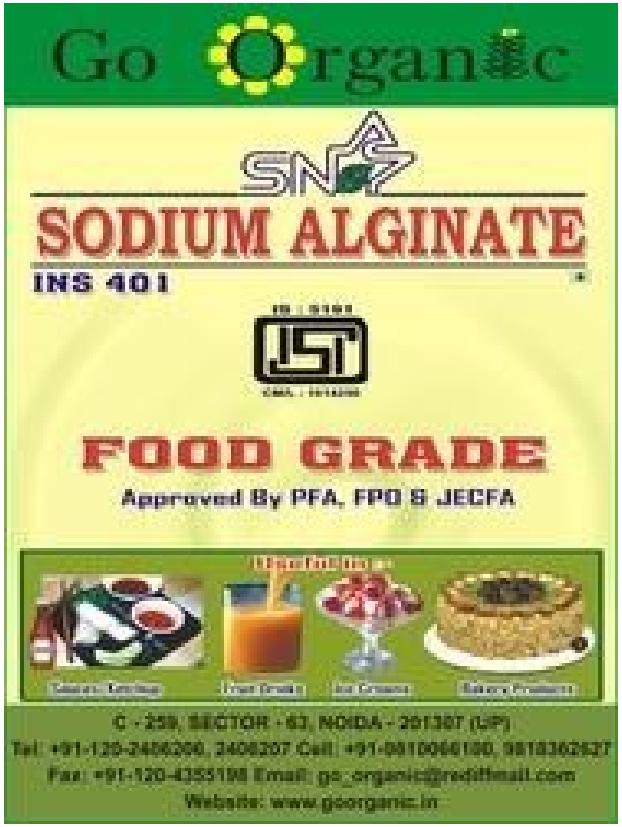
Πηκτίνες


Pectin
COOH
OH
COOH
OH
COOCH3
O
OH
COOCH3
OH
COOH
OH


Rhamnogalacturonan II
Homogalacturonan
Xylogalacturonan
Rhamnogalacturonan I
B
= D-Galacturonic acid
= L-Arabinose
= D-Apiose
= O-Acetyl
= L-Rhamnose
= D-Galactose
= L-Fucose
= O-Methyl
= D-Glucuronic acid
= L-Aceric acid
= D-Xylose
B = Borate
= Kdo
= D-Dha
= L-Galactose

Αλγινικά


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


Go Organic
SNP
SODIUM ALGINATE
INS 401
FOOD GRADE
Approved By PFA, FPO & JECFA
C - 259, SECTOR - 63, NOIDA - 201307 (UP)
Website: www.goorganic.in

Analytical methods for carbohydrates

10-1 table Occurrences of Some Major Carbohydrates in Foods

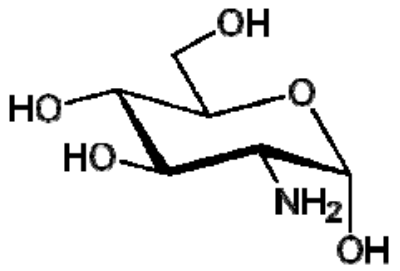
Carbohydrate	*Source*	*Constituent(s)*
Monosaccharides[a]		
D-Glucose (Dextrose)	Naturally occurring in honey, fruits, and fruit juices. Added as a component of corn (glucose) syrups and high-fructose syrups. Produced during processing by hydrolysis (inversion) of sucrose.	
D-Fructose	Naturally occurring in honey, fruits, and fruit juices. Added as a component of high-fructose syrups. Produced during processing by hydrolysis (inversion) of sucrose.	
Sugar alcohol[a]		
Sorbitol (D-Glucitol)	Added to food products, primarily as a humectant	
Disaccharides[a]		
Sucrose	Widely distributed in fruit and vegetable tissues and juices in varying amounts. Added to food and beverage products	D-Fructose D-Glucose
Lactose	In milk and products derived from milk	D-Galactose D-Glucose
Maltose	In malt. In varying amounts in various corn (glucose) syrups and maltodextrins	D-Glucose
Higher oligosaccharides[a]		
Maltooligosaccharides	Maltodextrins. In varying amounts in various glucose (corn) syrups	D-Glucose
Raffinose	Small amounts in beans	D-Glucose D-Fructose D-Galactose
Stachyose	Small amounts in beans	D-Glucose D-Fructose D-Galactose
Polysaccharides		
Starch[b]	Widespread in cereal grains and tubers. Added to processed foods.	D-Glucose
Food gums/hydrocolloids[c]		
Algins Carboxymethylcelluloses Carrageenans Curdlan Gellan Guar gum Gum arabic Hydroxypropylmethyl-celluloses Inulin Konjac glucomannan Locust bean gum Methylcelluloses Pectins Xanthan	Added as ingredients	[d]
Cell-wall polysaccharides[c]		
Pectin (native) Cellulose Hemicelluloses Beta-glucan	Naturally occurring	

Φωτομετρικός προσδιορισμός σακχάρων

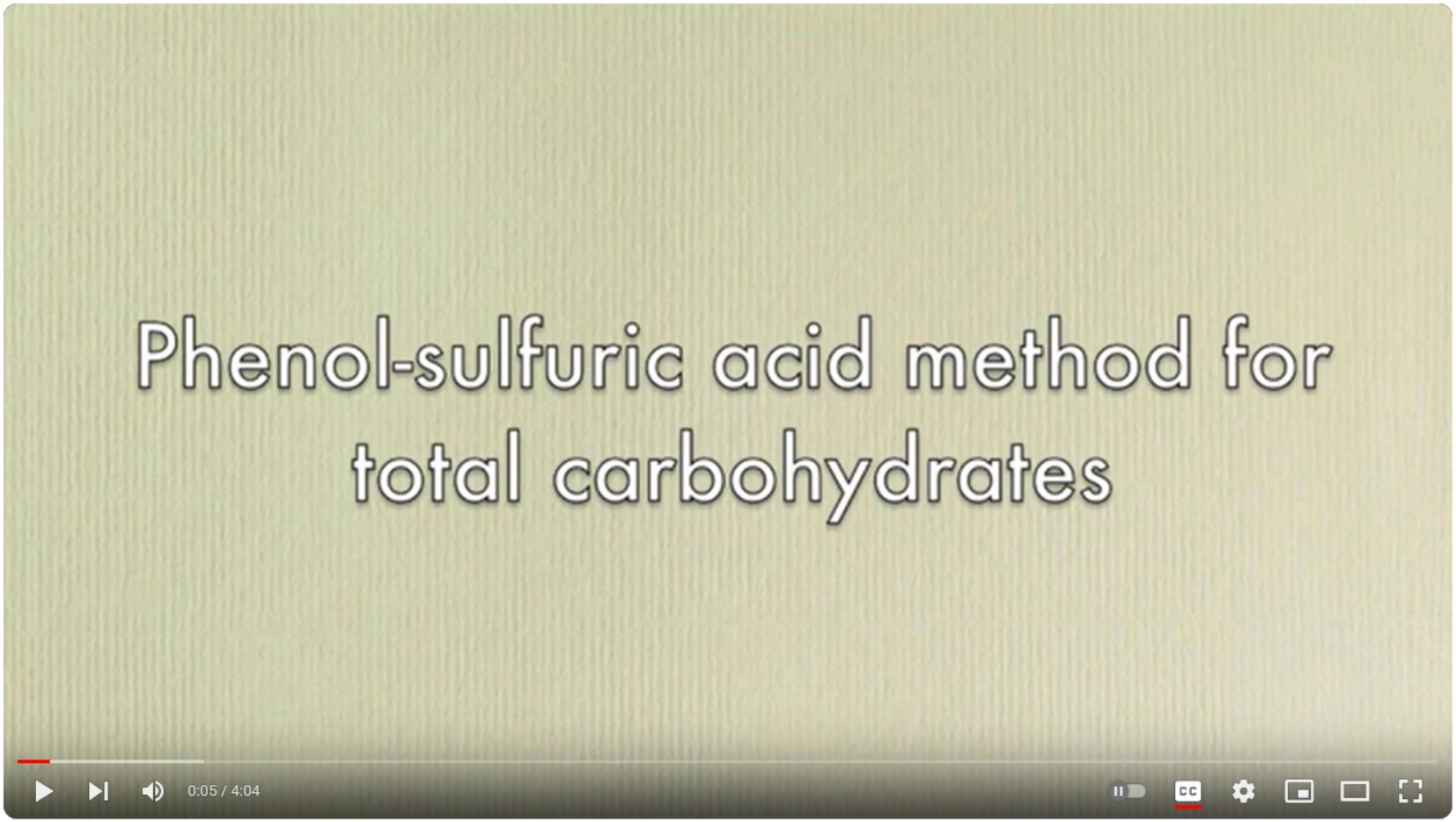
- Αντίδραση με φαινόλη-θειϊκό οξύ : συνολικά σάκχαρα
  - Σύμπλοκο, μέτρηση στα 490 nm

- Μέθοδος Somogyi-Nelson : αναγωγικά σάκχαρα
  - Οξείδωση σακχάρου με Cu^{2+}, σύμπλοκο με αρσενομολυβδενικά
  - Απορρόφηση στα 500 nm

- Μέθοδος Morgan-Elson : άμινο- και *N*-ακετυλο σάκχαρα
  - Αντιδραστήριο Erlich
  - 530 nm αμινοσάκχαρα
  - 544 ή 585 nm *N*-ακετυλοσάκχαρα



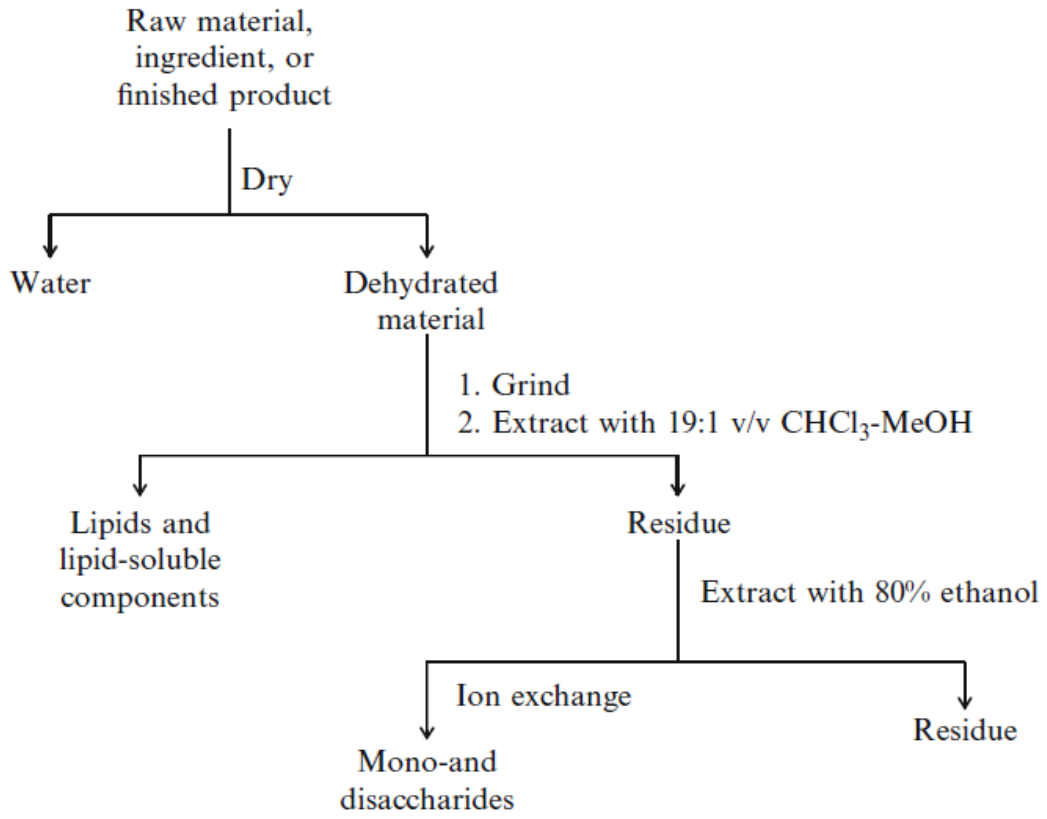
α-D-γλυκοζαμίνη



Phenol-Sulfuric Acid Method for Carbohydrates

https://www.youtube.com/watch?v=So6O62iC8YA

Carbohydrate analysis



10-1 figure Flow diagram for sample preparation and extraction of mono- and disaccharides.

HPLC of Mono- and Disaccharides Using Refractive Index Detection

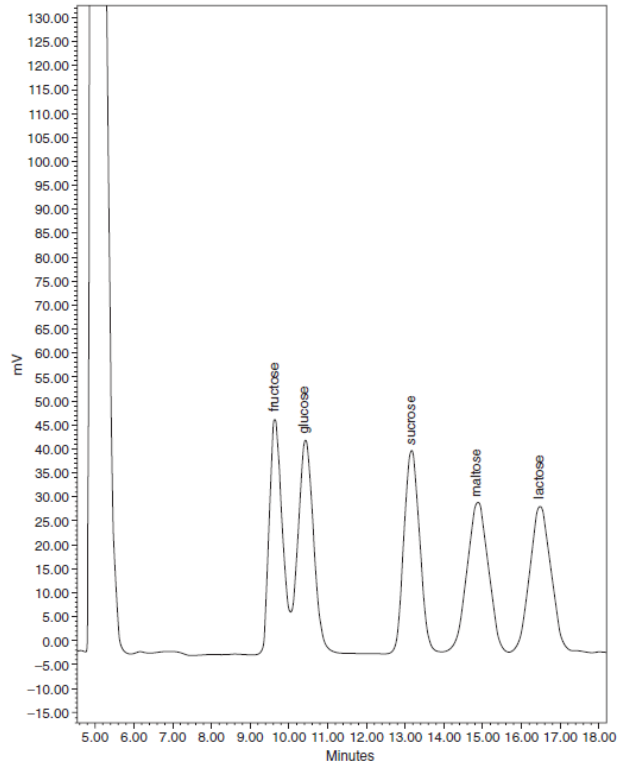


Figure E1.2.1 Chromatogram of a sugar standard analyzed as described (see Basic Protocol).

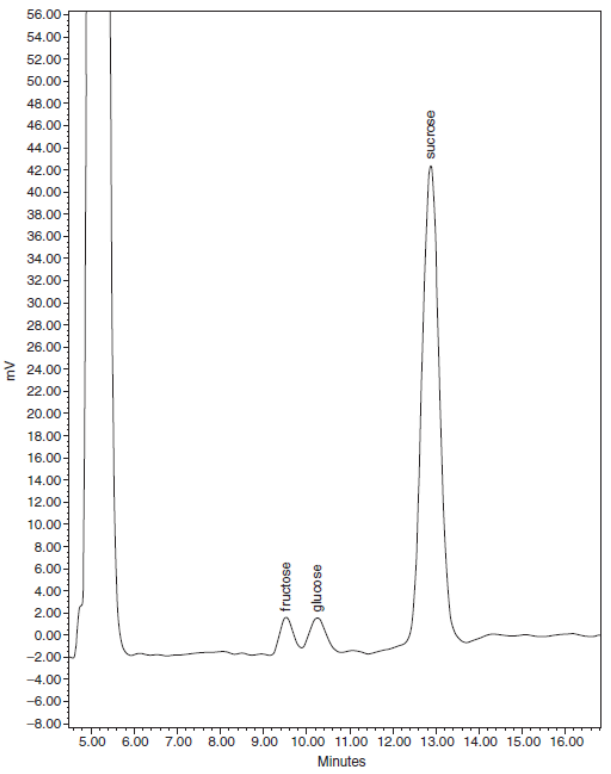


Figure E1.2.2 Chromatogram of a presweetened cereal analyzed as described (see Basic Protocol).

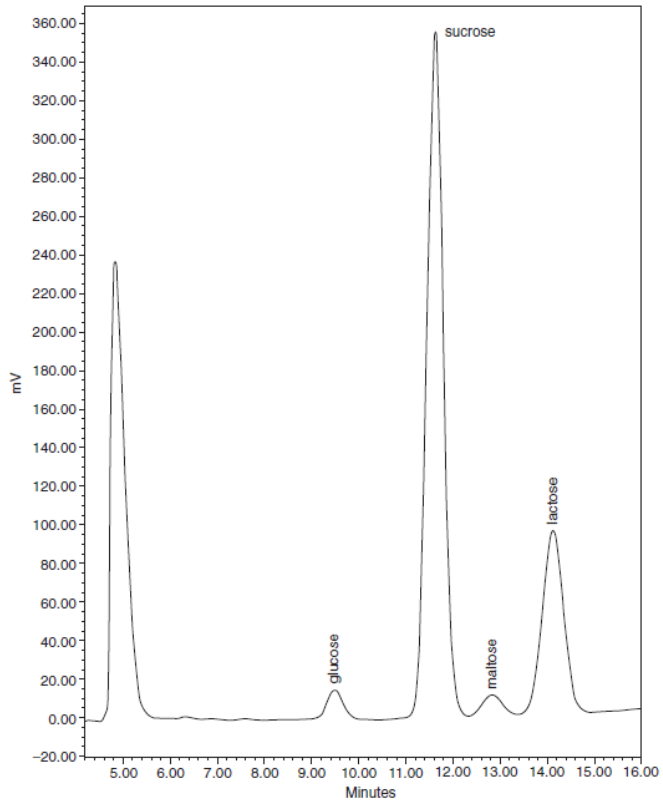


Figure E1.2.3 Chromatogram of an ice cream analyzed as described (see Basic Protocol).

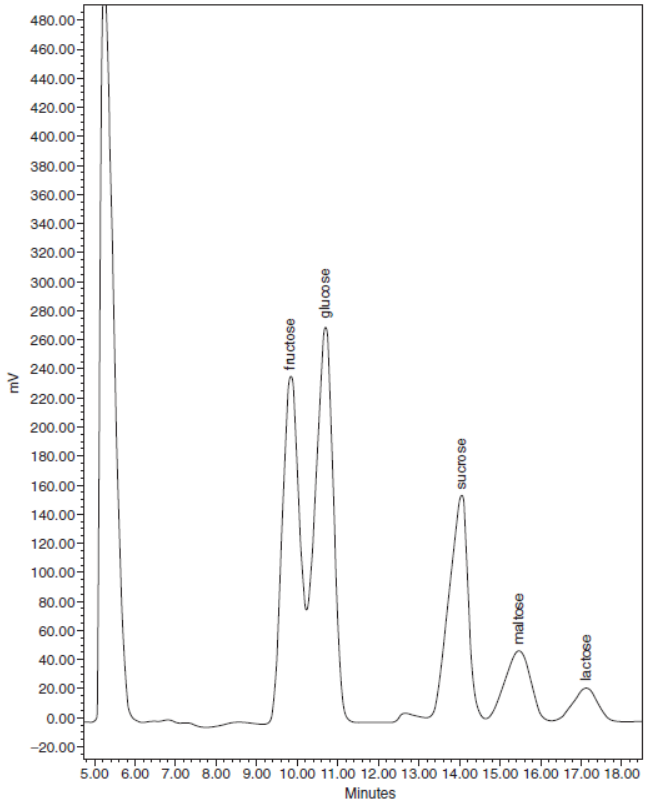


Figure E1.2.4 Chromatogram of a meal replacement bar analyzed as described (see Basic Protocol).

HPLC of Mono- and Disaccharides Using Refractive Index Detection

ALTERNATE PROTOCOL 1

SAMPLE PREPARATION USING ANION-EXCHANGE MINI-COLUMNS

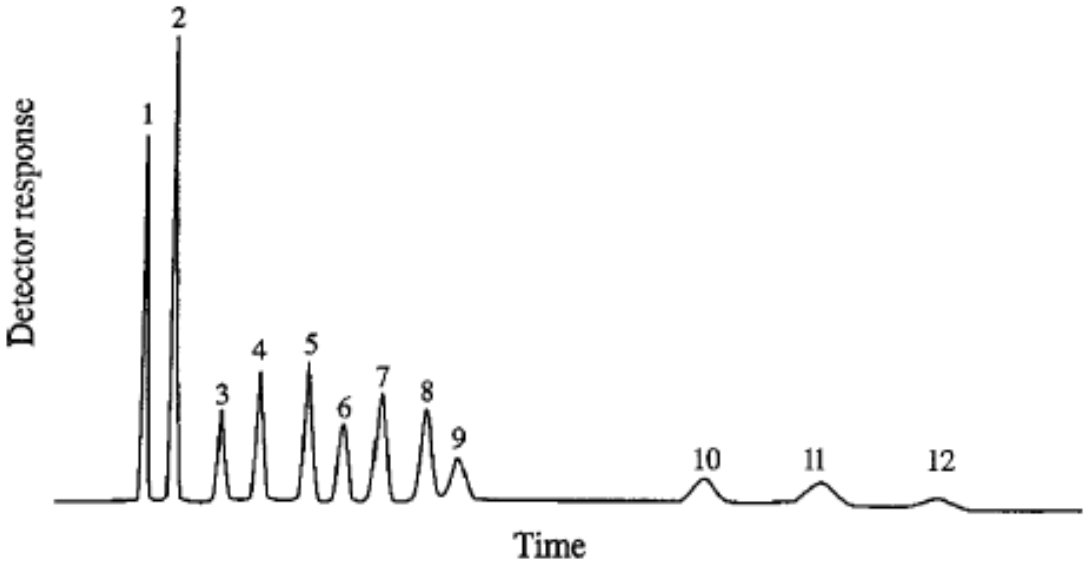
Sample matrices with high levels of citric or other organic acids (e.g., cranberry juice) can result in poor resolution. This method of sample preparation isolates sugars (i.e., neutral compounds) from acids using anion-exchange mini-columns. Development of this protocol is based on research conducted by Hong and Wrolstad (1986). Although the procedure does require additional time (i.e., twelve samples per hour), it does result in improved resolution and a more stable baseline.

ALTERNATE PROTOCOL 2

HPLC OF MONO-AND OLIGOSACCHARIDES IN FRUIT JUICES USING A CALCIUM-LOADED CATION-EXCHANGE COLUMN

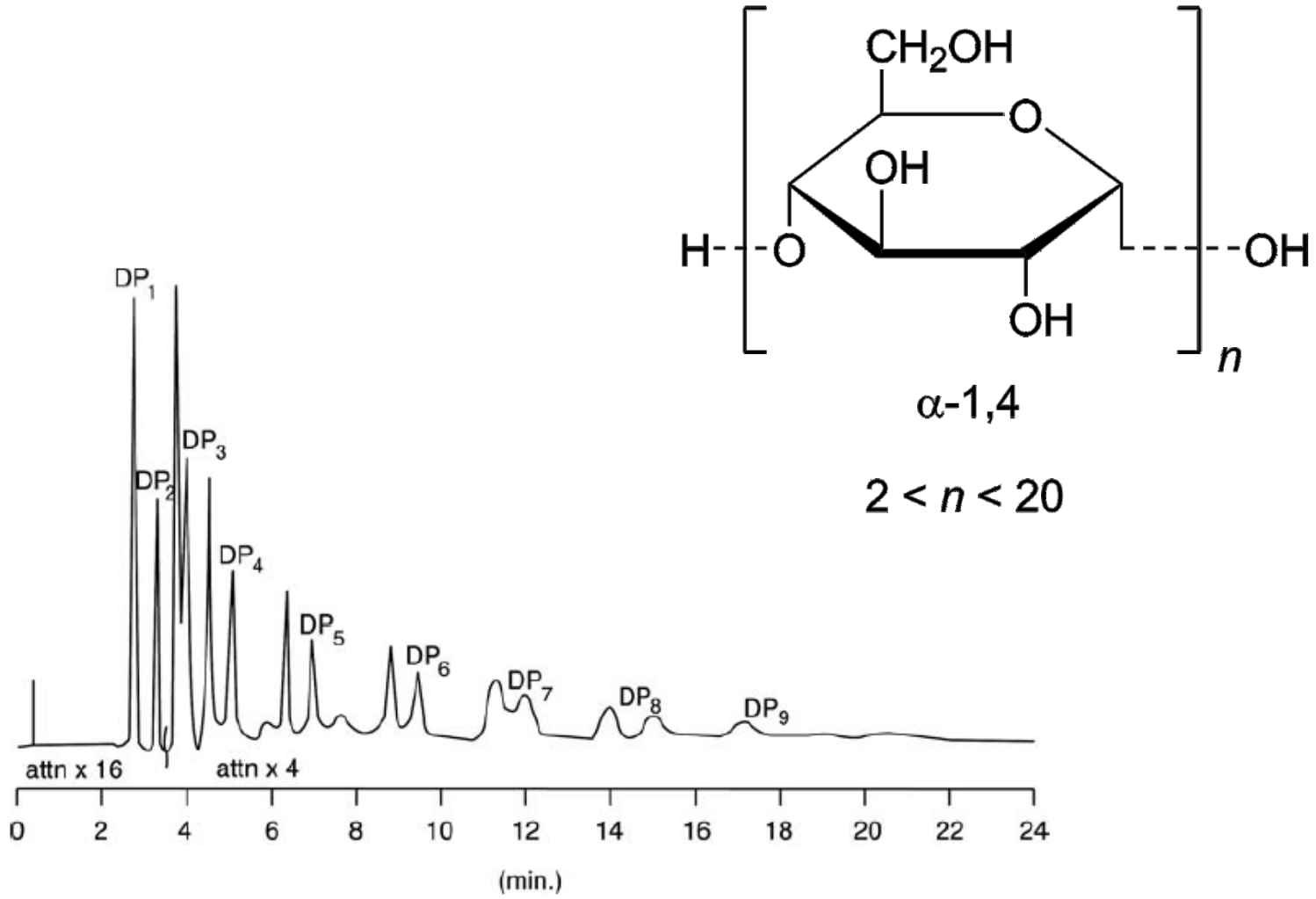
A disadvantage of the amino-bonded column (see Basic Protocol) is its limitation with samples containing small amounts of sorbitol in the presence of large quantities of glucose and the incomplete separation of both sorbitol and galactose from glucose. As an alternative, the use of an HPLC system with a calcium-loaded cation-exchange column can alleviate this constraint. Development of this protocol is based on research conducted by Durst et al. (1995). This application has been found to be useful for the determination of glucose, fructose, sorbitol, and sucrose in processed fruit products, and is commonly

HPLC of Mono- and Disaccharides Using Refractive Index Detection

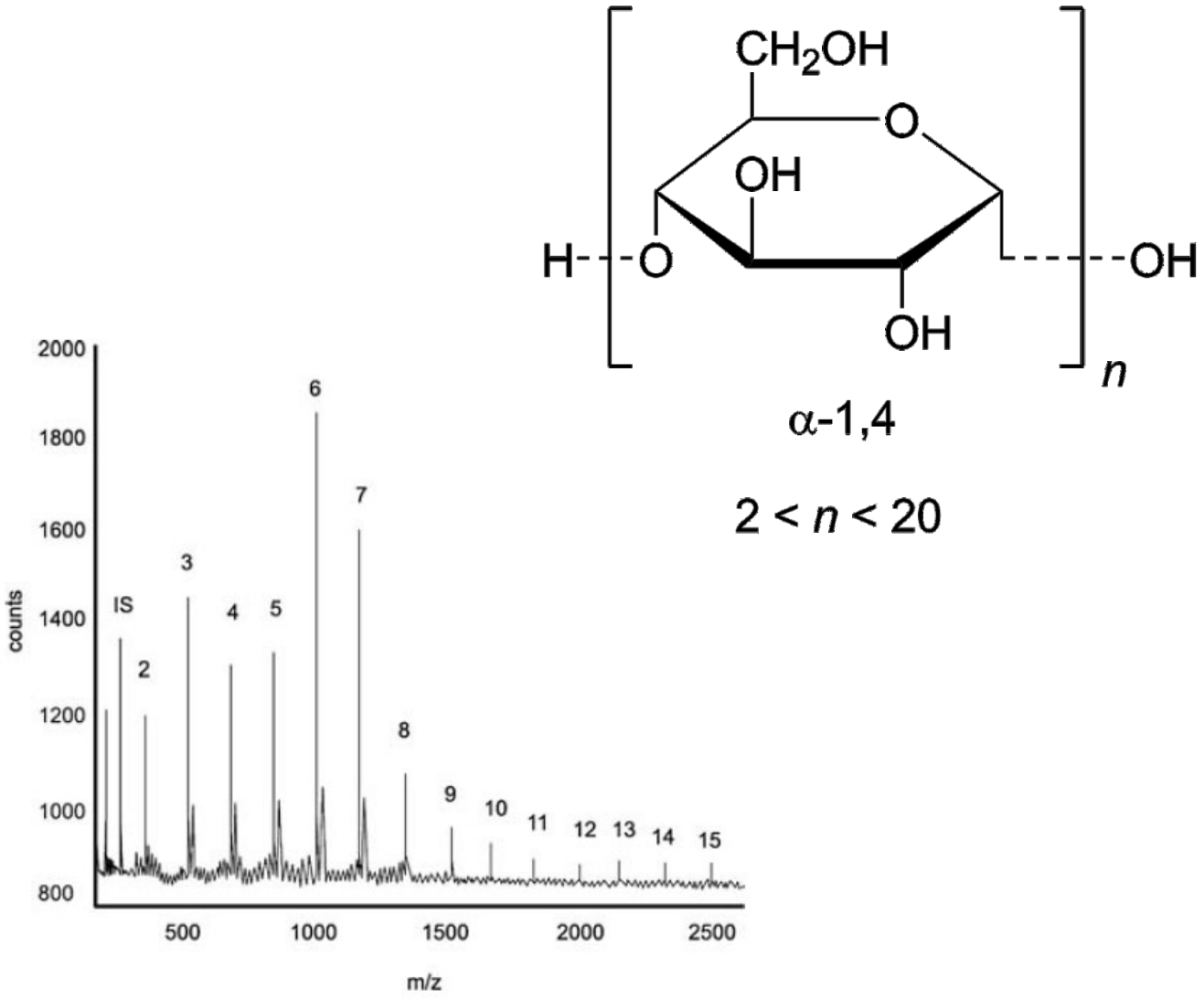


10-4 figure

High-performance liquid chromatogram of some common monosaccharides, disaccharides, alditols, and the trisaccharide raffinose at equal wt/vol concentrations separated by anion-exchange chromatography and detected by pulsed amperometric detection (see Sect. 10.3.4.1.2). Peak *1*, glycerol; *2*, erythritol; *3*, L-rhammose; *4*, D-glucitol (sorbitol); *5*, mannitol; *6*, L-arabinose; *7*, D-glucose; *8*, D-galactose; *9*, lactose; *10*, sucrose; *11*, raffinose; *12*, maltose.



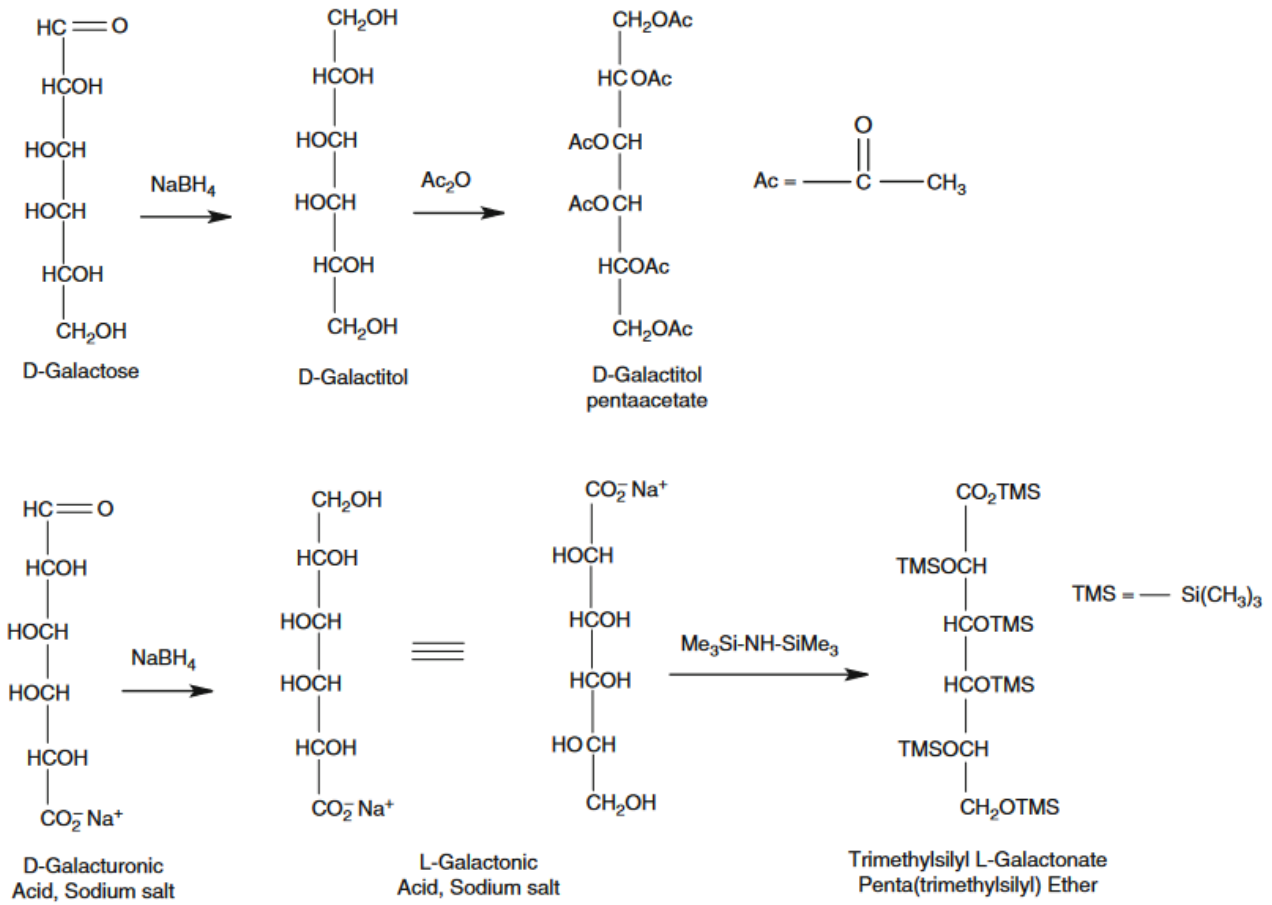
10-5 figure High-performance, reversed-phase liquid chromatogram of maltodextrins (DP 1–9). [From (32), used with permission.]



10-9 figure

MALDI-TOF mass spectrum of maltooligosaccharides produced by hydrolysis of starch. *Numbers* indicate DP. *IS*, internal standard. [From (28), used with permission, Copyright Springer-Verlag, 1998.]

Προσδιορισμός σακχάρων στα φυτικά κυτταρικά τοιχώματα με GC ως οξικοί εστέρες αλδιτολών ή εστέρες TMS

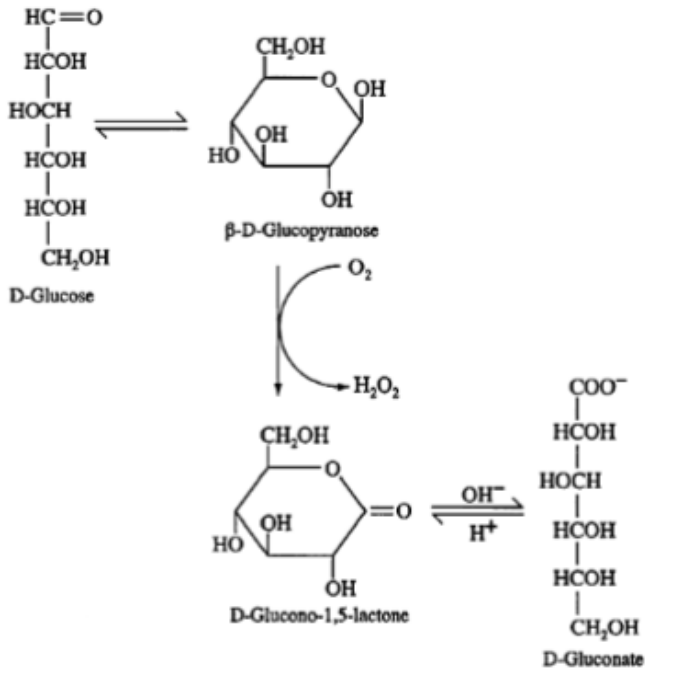


10-6 figure Modification of D-galactose and D-galacturonic acid in preparation for gas chromatography.

10-3 table Selected Enzymic Methods of Carbohydrate Analysis

Carbohydrate	*Reference*	*Kit Form*[a]
Monosaccharides		
Pentoses		
L-Arabinose	(42, 43)	
D-Xylose	(42, 43)	
Hexoses		
D-Fructose	(42, 43)	x
D-Galactose	(42, 43)	x
D-Galacturonic acid	(42)	
D-Glucose		
Using glucose oxidase	(43), Sect. 10.3.4.3.3	x
Using glucose dehydrogenase	(42, 43)	
Using glucokinase (hexokinase)	(42, 43)	x
D-Mannose	(42, 43)	
Monosaccharide derivatives		
D-Gluconate/D-glucono-δ-lactone	(42, 43)	x
D-Glucitol/sorbitol	(42, 43)	x
D-Mannitol	(42, 43)	
Xylitol	(42, 43)	x
Oligosaccharides		
Lactose	(42, 43)	x
Maltose	(42, 43)	x
Sucrose	(42, 43)	x
Raffinose, stachyose, verbascose	(42, 43)	x
Polysaccharides		
Amylose, amylopectin (contents and ratio)		x
Cellulose	(42, 43)	
Galactomannans (guar and locust bean gums)	(42)	
β-Glucan (mixed-linkage)	(42)	x
Glycogen	(42, 43)	
Hemicellulose	(42, 43)	
Inulin	(42, 43)	x
Pectin/poly(D-galacturonic acid)	(42, 43)	
Starch	Sect. 10.4.1.1 (42, 43)	x

[a]Available in kit form from companies such as R-Biopharm, Megazyme, and Sigma-Aldrich.

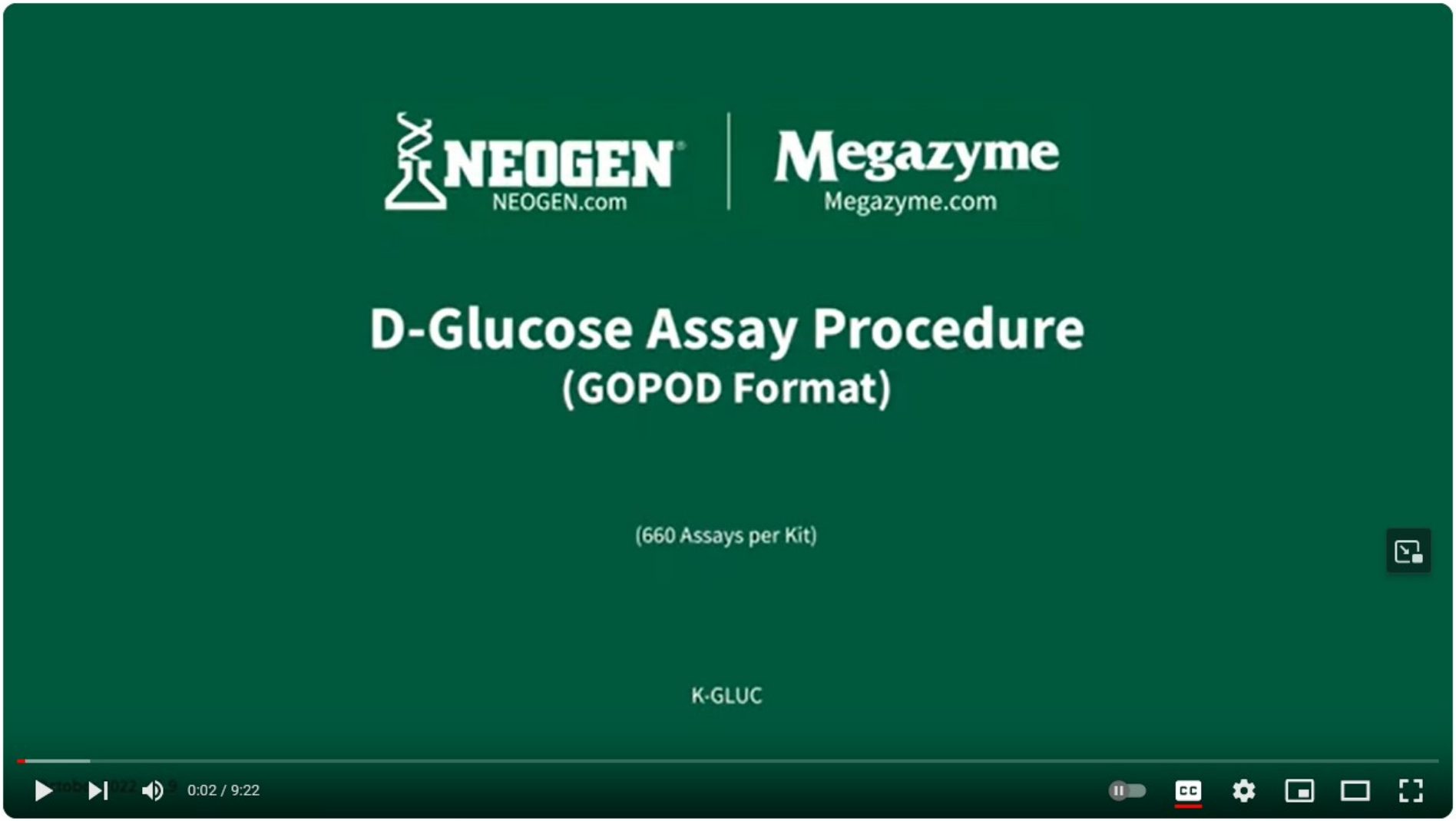


10-8 figure Coupled enzyme-catalyzed reactions for the determination of D-glucose.

Glucose Determination Reagent (glucose oxidase/ peroxidase; GOPOD)

D-Glucose + O_2 + H_2O (glucose oxidase) D-gluconate + H_2O_2

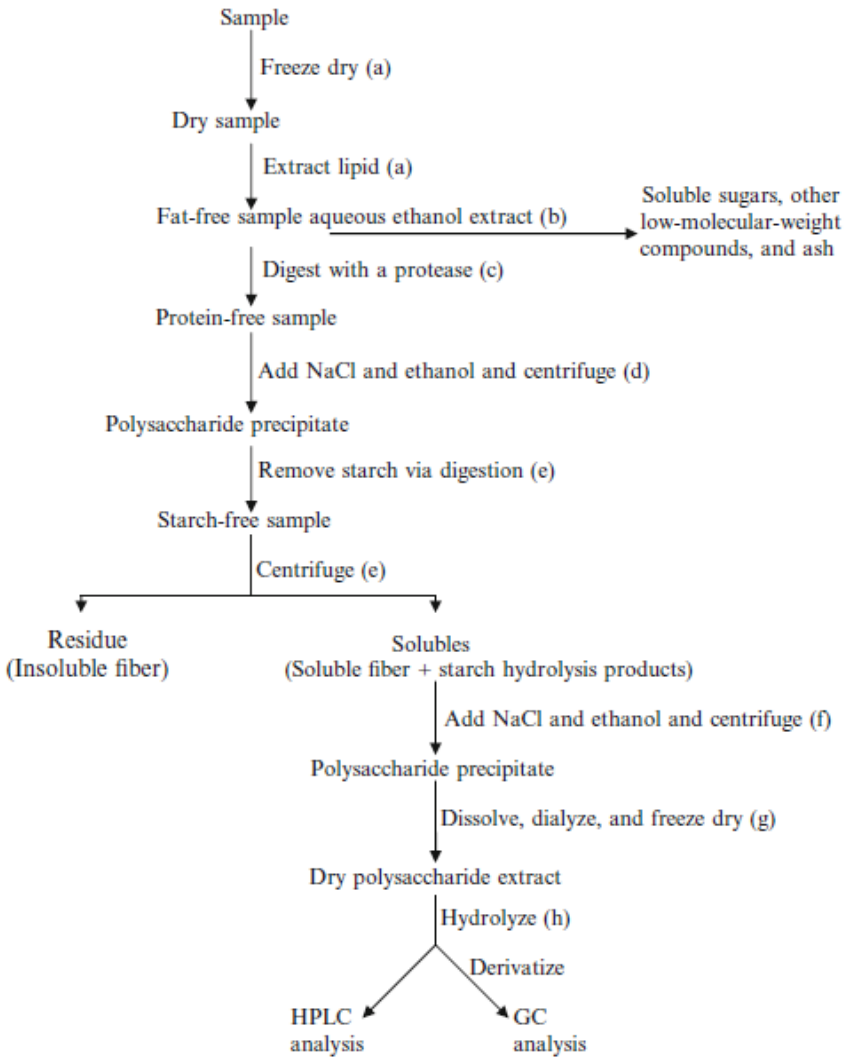
$2H_2O_2$ + *p*-hydroxybenzoic acid + 4-aminoantipyrine (peroxidase) quinoneimine dye + $4H_2O$



D-Glucose Assay Kit (GOPOD Format) K-GLUC

https://www.youtube.com/watch?v=fMbpl6xbNN0

Gums (Κόμμεα) Υδροκολλοειδή



10-11 figure Flow diagram for isolation and analysis of polysaccharides.

10-4 table **Official Methods of Analysis for Dietary Fiber**

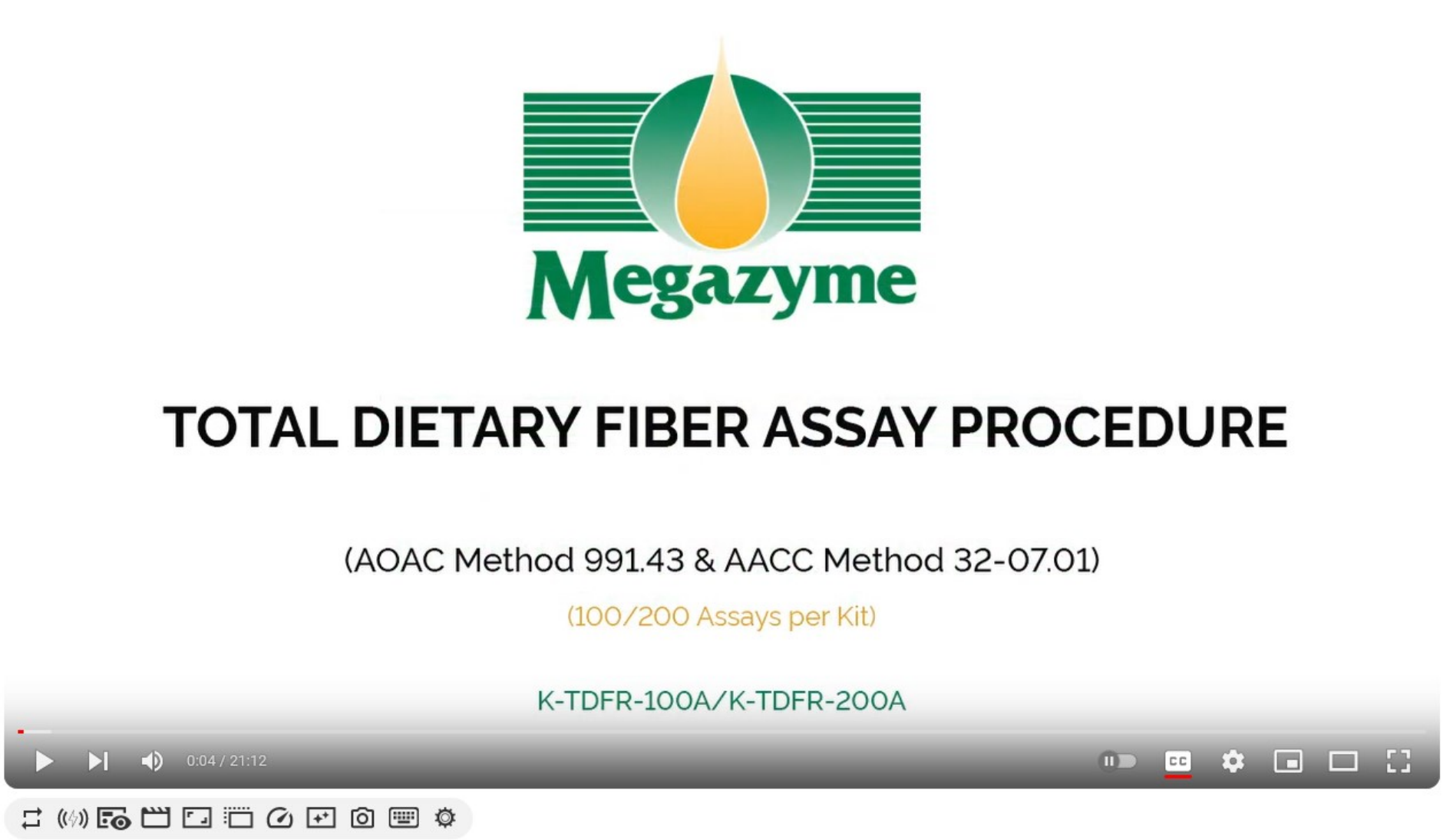
AOAC Method No. (5)	*AACC Method No. (80)*	*Description of Method and Measured Substance*
994.13	32-25.01	Total dietary fiber determined as neutral sugar and uronic acid monomer units and Klason lignin by a gas chromatographic–spectrophotometric–gravimetric method
993.21		Nonenzymic-gravimetric method for total dietary fiber applicable to determination of >10% TDF in foods and food products with <2% starch
985.29	32-05.01	Enzymic-gravimetric method for total dietary fiber in cereal grains and cereal grain-based products
	32-06.01	A rapid gravimetric method for total dietary fiber
991.42		Enzymic-gravimetric method for insoluble dietary fiber in vegetables, fruits, and cereal grains
993.19		Enzymic-gravimetric method for soluble dietary fiber
991.43	32-07.01	Enzymic-gravimetric method for total, soluble, and insoluble dietary fiber in grain and cereal products, processed foods, fruits, and vegetables
2002.02	32-40.01	Enzymic method for RS2 and RS3 in products and plant materials
	32-21.01	Enzymic-gravimetric method for insoluble and soluble dietary fiber in oats and oat products
	32-32.01	Enzymic-spectrophotometric method for total fructan (inulin and fructooligosaccharides) in foods
993.03		Enzymic-spectrophotometric method for fructan (inulin) in foods (not applicable to fructooligosaccharides)
997.08	32-31.01	Anion-exchange chromatographic method for fructan in foods and food products applicable to the determination of added inulin in processed foods
2000.11	32-28.01	Anion-exchange chromatographic method for polydextrose in foods
	32-22.01	Enzymic method for β-glucan in oat fractions and unsweetened oat cereals
	32-23.01	Rapid enzymic procedure for β-glucan content of barley and oats
2001.03	32-41.01	Enzymic-gravimetric and liquid chromatographic method for dietary fiber containing added resistant maltodextrin
2001.02	32-33.01	Anion-exchange chromatographic method for *trans*-galactooligosaccharides (TGOS) applicable to added TGOS in selected food products

10-5 table

Total, Soluble, and Insoluble Dietary Fiber in Foods as Determined by AOAC Method 991.43[a]

Food	*Soluble*[b]	*Insoluble*[b]	*Total*[b]
Barley	5.02	7.05	12.14
High-fiber cereal	2.78	30.52	33.30
Oat bran	7.17	9.73	16.90
Soy bran	6.90	60.53	67.56
Apricots	0.53	0.59	1.12
Prunes	5.07	4.17	9.37
Raisins	0.73	2.37	3.03
Carrots	1.10	2.81	3.92
Green beans	1.02	2.01	3.03
Parsley	0.64	2.37	3.01

[a]Adapted from *Official Methods of Analysis*, 18th edn. Copyright 2005 by AOAC International.
[b]Grams of fiber per 100 g of food on a fresh weight basis.



Total Dietary Fiber Video Method (AOAC Method 991.43/AACC method 32-07.01) with K-TDFR