Galactose

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Galactose (from the Greek stem γάλακτ– *galakt*–, "milk"), sometimes abbreviated **Gal**, is a monosaccharide sugar that is less sweet than glucose. It is a C-4 epimer of glucose.

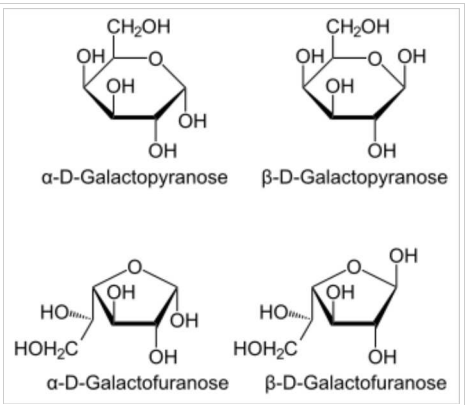
Galactan is a polymer of the sugar galactose found in hemicellulose. Galactan can be converted to galactose by hydrolysis.

Contents

Structure and isomerism

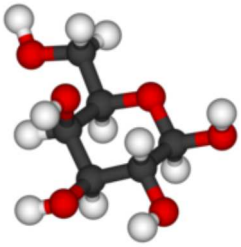
Galactose exists in both open-chain and cyclic form. The open-chain form has a carbonyl at the end of the chain. In the open-chain form D- and L- isomers cannot be separated, but the cyclic forms can be crystallized and isolated.[1]

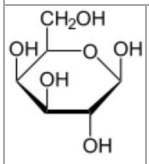
Four isomers are cyclic, two of them with a pyranose (six-membered) ring, two with a furanose (five-membered) ring. Galactofuranose occurs in bacteria, fungi and protozoa. [2] In the cyclic form there are two anomers, named alpha and beta, since the transition from the open-chain form to the cyclic form involves the creation of a new stereocenter at the site of the open-chain carbonyl. In the beta form, the alcohol group is in the equatorial position, whereas in the alpha form, the alcohol group is in the axial position.[1]

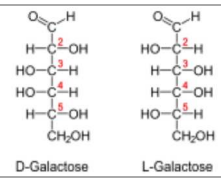


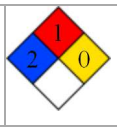
Cyclic forms of galactose

Galactose







Identifiers	
CAS number	59-23-4 ✗
PubChem	439357
ChemSpider	388480 ✓
UNII	X2RN3Q8DNE ✓
KEGG	D04291 ✗
MeSH	Galactose
ChEBI	CHEBI:28061 ✓
ChEMBL	CHEMBL300520 ✗
ATC code	V04CE01 (http://www.whocc.no/atc_ddd_index/?code=V04CE01), V08DA02 (microparticles)
Jmol-3D images	Image 1 (http://chemapps.stolaf.edu/jmol/jmol.php?model=O%5BC%40H%5D1%5BC%40%40H%5D%28O%29%5BC%40H%5D%28O%5BC%40H%5D%28O%29%5BC%40%40H%5D1O%29CO)
SMILES	
InChI	
Properties	
Molecular formula	$C_6H_{12}O_6$
Molar mass	180.156 g mol^{-1}
Density	1.723 g/cm^3
Melting point	167 °C, 440 K, 333 °F
Solubility in water	683.0 g/L
Hazards	
NFPA 704	

✗ (verify) (what is: ✓/✗?)
Except where noted otherwise, data are given for materials in their standard state (at 25 °C, 100 kPa)

Infobox references

Relationship to lactose

Galactose is a monosaccharide. When combined with glucose (monosaccharide), through a condensation reaction, the result is the disaccharide lactose. The hydrolysis of lactose to glucose and galactose is catalyzed by the enzymes lactase and β-galactosidase. The latter is produced by the *lac* operon in *Escherichia coli*.

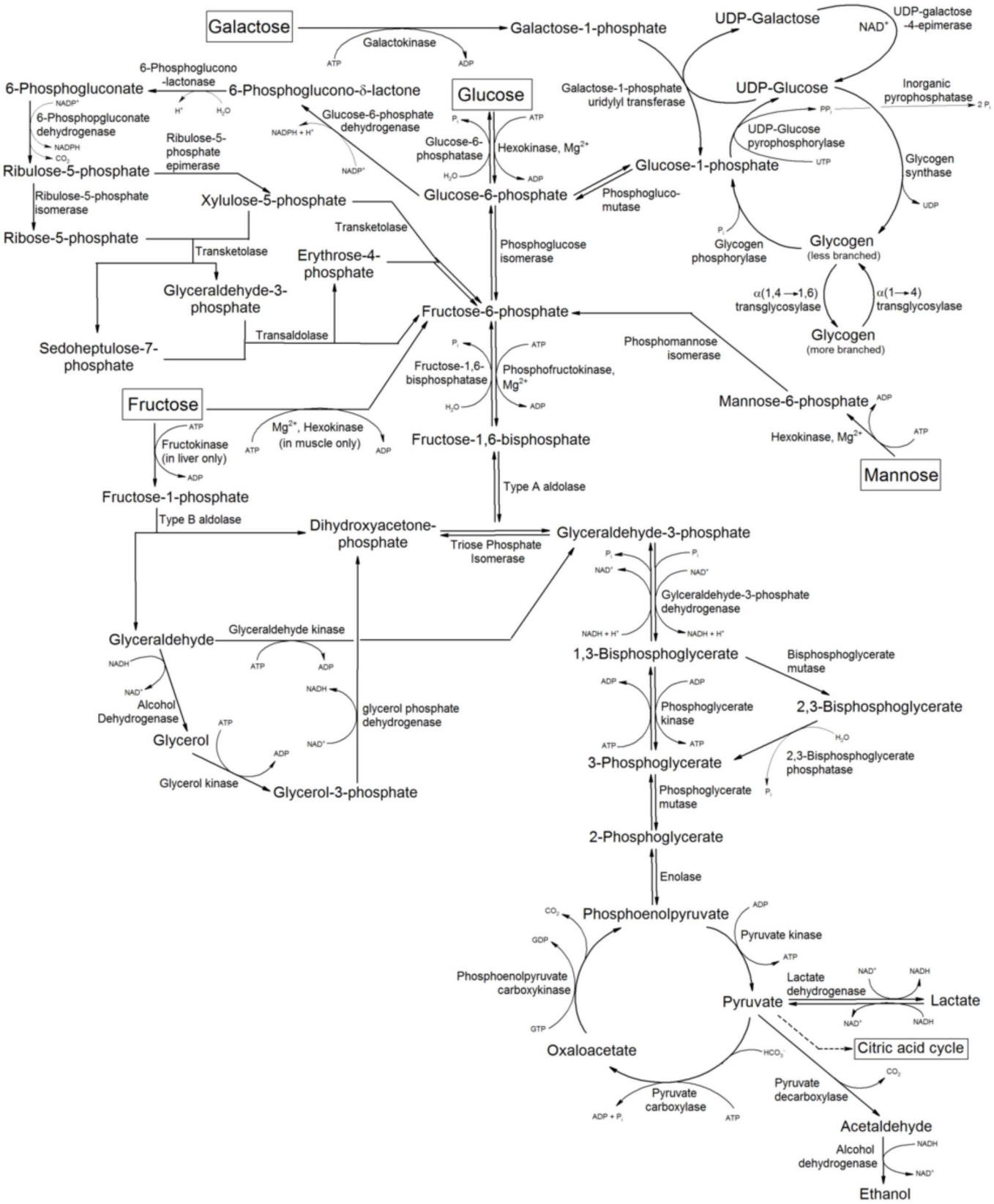
Lactose is found primarily in milk and milk products, although it can also be found in breads and cereals.[3] Galactose metabolism, which converts galactose into glucose, is carried out by the three principal enzymes in a mechanism known as the Leloir pathway. The enzymes are listed in the order of the metabolic

pathway: galactokinase (GALK), galactose-1-phosphate uridyltransferase (GALT), and UDP-galactose-4'-epimerase (GALE).

In the human body, glucose is changed into galactose via hexoneogenesis to enable the mammary glands to secrete lactose. However, most lactose in breast milk is synthesized from galactose taken up from the blood, and only 35±6% is made from galactose from *de novo* synthesis. [4] Glycerol also contributes some to the mammary galactose production.[5]

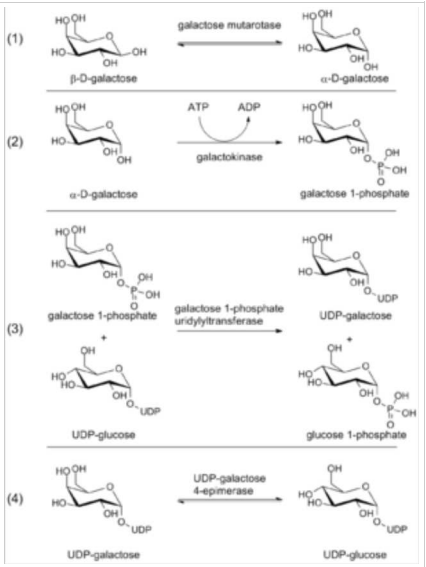
Metabolism

Metabolism of common monosaccharides and some biochemical reactions of glucose



Glucose is the primary metabolic fuel for humans. It is more stable than galactose and is less susceptible to the formation of nonspecific glycoconjugates, molecules with at least one sugar attached to a protein or lipid. Many speculate that it is for this reason that a pathway for rapid conversion from galactose to glucose has been highly conserved among many species.[6]

The main pathway of galactose metabolism is the Leloir pathway; humans and other species, however, have been noted to contain several alternate pathways, such as the De Ley Doudoroff pathway. The Leloir pathway consists of the latter stage of a two-part process that converts β-D-galactose to UDP-glucose. The initial stage is the conversion of β-D-galactose to α-D-galactose by the enzyme, mutarotase (GALM). The Leloir pathway then carries out the conversion of α-D-galactose to UDP-glucose via three principle enzymes. Galactokinase (GALK) phosphorylates α-D-galactose to galactose-1-phosphate, or Gal-1-P. Galactose-1-phosphate uridyltransferase (GALT) then transfers a UMP group from UDP-glucose to Gal-1-P to form UDP-galactose. Finally, UDP galactose-4'-epimerase (GALE) interconverts UDP-galactose and UDP-glucose, thereby completing the pathway.[7]



Galactose metabolism

However, those suffering from galactosemia cannot properly break down galactose as the result of a genetically inherited mutation in one of the enzymes in the Leloir pathway. These individuals cannot break down galactose properly, so the consumption of even small amounts of galactose is harmful to galactosemics.[8]

Sources

Galactose is found in dairy products, sugar beets, other gums and mucilages. It is also synthesized by the body, where it forms part of glycolipids and glycoproteins in several tissues.

Clinical significance

Chronic systemic exposure of mice, rats, and *Drosophila* to D-galactose causes the acceleration of senescence (aging) and has been used as an aging model.[9] Two studies have suggested a possible link between galactose in milk and ovarian cancer.[10][11] Other studies show no correlation, even in the presence of defective galactose metabolism.[12][13] More recently, pooled analysis done by the Harvard School of Public Health showed no specific correlation between lactose-containing foods and ovarian cancer, and showed statistically insignificant increases in risk for consumption of lactose at ≥30 g/d.[14] More research is necessary to ascertain possible risks.

Some ongoing studies suggest galactose may have a role in treatment of focal segmental glomerulosclerosis (a kidney disease resulting in kidney failure and proteinuria).[*citation needed*] This effect is likely to be a result of binding of galactose to FSGS factor.[*citation needed*]

Galactose is a component of the antigens present on blood cells that determine blood type within the ABO blood group system. In O and A antigens, there are two monomers of galactose on the antigens, whereas in the B antigens there are three monomers of glucose.[15]

See also

- Galactolysis

References

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