galactose: friend or foe?

Research studies suggest that lactose and its metabolites such as galactose are essential in human metabolism with an established role in energy delivery and galactosylation of complex molecules.

The facts

- Galactose is a crucial structural element in complex macromolecules and serves as a key source of energy.[2,3,4]
- Galactose forms part of glycolipids and glycoproteins in the brain and nervous system, which suggests a neural and immunological role.[2,3,4,5]
- Sources of galactose are not limited only to lactose-containing food.[6]
- Evidence shows that galactose has prebiotic properties.[7]
- Free galactose is detrimental only for people who suffer from galactosaemia.[8,9]
- Galactose has been shown to have therapeutic potential.[10,11,12]

Dietary galactose is released from complex carbohydrates through hydroxylation by salivary and pancreatic amylase, and from lactose by the action of lactase in the brush border of the small intestine. Once absorbed, dietary galactose can be converted in the liver to either uridine diphosphate glucose (UDP-glucose) for the production of glycogen or glucose-1-phosphate for the release of energy. Alternatively, it can be converted to UDP-galactose and its derivatives, which serve as key substrate donors for the biosynthesis of glycoproteins and glycolipids.[2,13]

– Essential source of energy

As galactose is a precursor to glucose production, it is an essential source of energy. This is particularly important during the early developmental stages of mammalian infants, when they are exclusively dependent on milk.[4]

– Structural role

Galactose has different functional and structural roles from glucose. Apart from its importance for energy production, the Leloir metabolic pathway is crucial for the glycosylation of complex molecules such as myelin (sheath around nerves), in which galactocerebroside is the predominant glycolipid. Galactose is therefore often referred to as 'brain sugar' in lay terms owing to its role in supporting brain structure and development during the neonatal period and early life [4]. Galactose also serves as a substrate for cerebrosides, gangliosides and mucoproteins in the brain and nervous system, which lends further support to its neural and immunological role.[5]

– Therapeutic role of galactose

Galactose has recently been reported to be beneficial in the management of a number of diseases, particularly those affecting brain function.[2] The conversion of galactose to amino acids in the brain requires ammonia equivalents as substrate. This points to the potential use of galactose for removing these neurotoxic compounds from the brain in patients suffering from hepatic encephalopathy or Alzheimer's disease.[10] Dementia as seen in sporadic Alzheimer's disease is associated with dysfunction of the insulin-receptor system, followed by decreased glucose transport to and subsequent metabolism in brain cells. As galactose is transported to the brain by an insulin-independent GLUT3 transporter, it can act as an alternative source of energy owing to its metabolism to glucose via the Leloir pathway.[11] Daily oral galactose administration has also been shown to be a promising new, nontoxic therapy for the treatment of resistant nephrotic syndrome.[12]

– Galactose as a prebiotic

Galactose is present in the so-called raffinose-family oligosaccharides (FOS) and galactose oligosaccharides (GOS).[7,14] These prebiotic oligosaccharides have been found to provide beneficial effects in the gastrointestinal tract of humans not only by stimulating growth of selected members of the intestinal microflora but also through their anti-adhesive activity.
Galactose oligosaccharides specifically were found to inhibit infections by enteric pathogens directly as they are able to act as structural mimics of the pathogen binding sites that coat the surface of gastrointestinal epithelial cells.[14]

Sources of galactose

Galactose is not derived only from lactose-containing food sources. Food items with a high galactose content (>100 mg/100 g) include soy flour, dried figs, cow's milk, yoghurt and legumes (with galactose present in descending order).[6] In light of the importance of galactose for development, it is also not unexpected that the human body is able to synthesise galactose de novo from glucose.
Endogenous galactose production is found to be higher in infants and young children. When plotted against age, the rate of galactose production per body weight follows a typical paediatric developmental growth curve. This re-inforces the suggested importance of galactose for early development.[2,4]

Enzyme deficiencies

The human body is able to metabolise galactose efficiently. Free galactose is toxic only when associated with galactosaemia, a congenital disorder that involves a deficiency in one of the three metabolising enzymes in the Leloir pathway.[8] Galactosaemia is a serious condition, particularly during the neonatal period, and affects a number of organ systems, including the liver and brain. Although dietary restriction of galactose resolves the symptoms of galactosaemia, long-term complications such as cognitive and fertility impairments persist. This confirms the critical structural and functional roles of galactose in the human body.[9]

conclusion

Galactose is crucial in human metabolism, with an established role in energy delivery and galactosylation of complex molecules. Studies confirm that lactose and its metabolites such as galactose are unlikely to be detrimental to health; in fact, potential therapeutic use of galactose has been shown.

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