RAMA UNIVERSITY

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FACULTY OF ENGINEERING SCIENCES

Topic -2nd

Production of Gluconic Acid

Mrs. Vandana Yadav

Introduction

- Gluconic acid is a non-corrosive, non-toxic, biodegradable, weak organic acid formed by the oxidation of carbon of glucose.

- Gluconic acid, found abundantly in plant, honey and wine, can be prepared by fungal fermentation process commercially.

- Its used for leavening and acidity properties in food, chelating and perfuming agents in cosmetics products, also it can be used in industrial uses for chelating heavy metals.

- Gluconic acid is a member of Alpha-hydroxy acids (AHAs) family of acids. It's main action is as a frictionless exfoliator- it helps to loosen the top layer of dead skin.

- Glycolic acid is the most popular alpha-hydroxy acid (AHA) used in skin care. It comes from sugar cane, and is the smallest AHA, so it's the most effective at getting into the skin.

(Ramachandran et al., 2006)

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- Gluconic acid was discovered by Hlasiwetz and Habermann in 1870, when glucose was oxidized with chlorine.

- In 1922 it was isolated from a strain of *A. niger*. Later, other filamentous fungi, such as *Penicillium*, *Scopulariopsis*, *Gonatobotrys*, and *Gliocladium*, and also oxidative bacteria.

- Glucuronic acid derivative of glucose, is produced in the liver of humans and most animals. It is a highly soluble compound that can bind to substances such as hormones, drugs, and toxins to facilitate their transport around the body.

- D-Glucaric acid, known as saccharic acid, is the product of oxidizing sugars or polysaccharides with nitric acid.

- Due to abundance of hydroxyl groups, sugar molecules can form different types of carbohydrate derivatives, Sugar acids: Oxidation of glucose at carbon 1 produces “onic” acids, such as gluconic acid, and oxidation at carbon 6 produces “uronic” acids, such as glucuronic acid.

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- Gluconic acid also called D-gluconic acid, dextronic acid, maltonic acid.
- Calcium gluconate is the calcium salt of gluconic acid, an intravenous medication used to treat calcium deficiencies such as hypocalcemic tetany, hypocalcemia related to hypoparathyrodism, and hypocalcemia due to rapid growth or pregnancy.
- Gluconic Acid is the carboxylic acid formed by the oxidation of the first carbon of glucose with antiseptic and chelating properties.
- Glucose oxidase is the most widely used enzyme in glucose-sensing as it oxidizes glucose into gluconic acid.

- ✓ The structural formula of gluconic acid **$HOCH_2(CHOH)_4COOH$** and molecular formula **$C_6H_{12}O_7$.**
- ✓ It is one of the 16 stereoisomers of 2,3,4,5,6-pentahydroxyhexanoic acid.
- ✓ In aqueous solution at neutral pH, gluconic acid forms the gluconate ion, The salts of gluconic acid are known as **"gluconates".**
- ✓ Gluconic acid (pentahydroxycaproic acid) is produced from glucose through a simple dehydrogena- tion reaction catalysed by glucose oxidase.
- ✓ Oxidation of the aldehyde group on the C-1 of b-D-glucose to a car- boxyl group results in the production of glucono-d-lac- tone (C6H10O6) and hydrogen peroxide.
- ✓ The aldonic acid formed by the oxidation of carbon 1 in glucose is designated gluconic acid.

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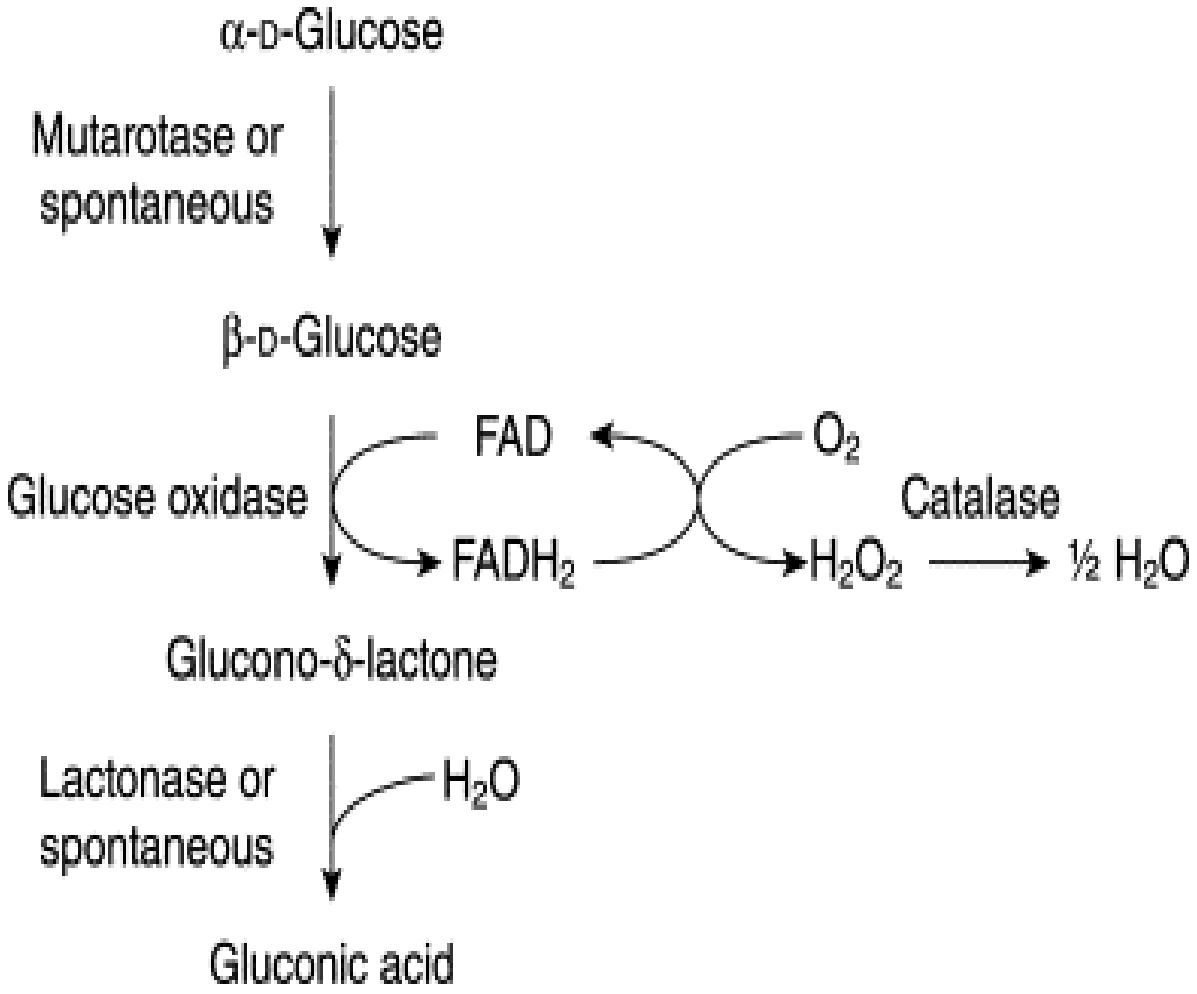

Fungal Gluconic Acid Biosynthetic Pathway

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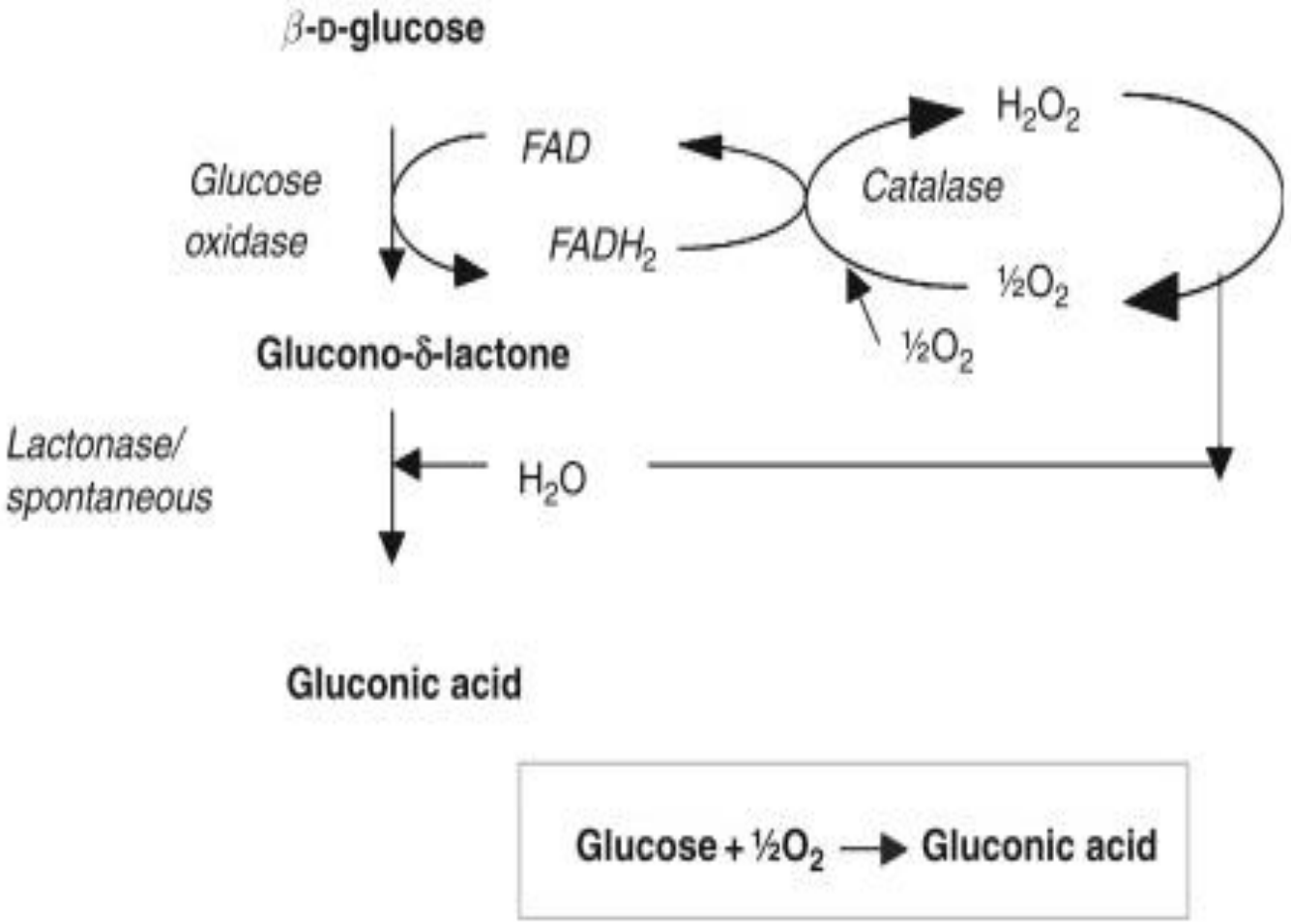
- The main route of gluconic acid production has been by fermentation, mainly using *A. niger* in submerged fermentations with a high oxygen demand, used directly in the biosynthesis, and keeping pH 4.5–6.5, traditionally achieved by addition of calcium carbonate as the neutralizing agent.

- The process resembles more an enzymatic conversion rather than a microbial process. The key enzyme is glucose oxidase, a homodimeric flavoprotein, localized in the mycelial cell wall.

- Consequently, the conversion takes place entirely extracellularly with a net reaction:

$$\text{Glucose} + \tfrac{1}{2}\, O_2 \rightarrow \text{Gluconic acid}$$



Biosynthesis of Gluconic acid

(Ramachandran S, et al., 2006)

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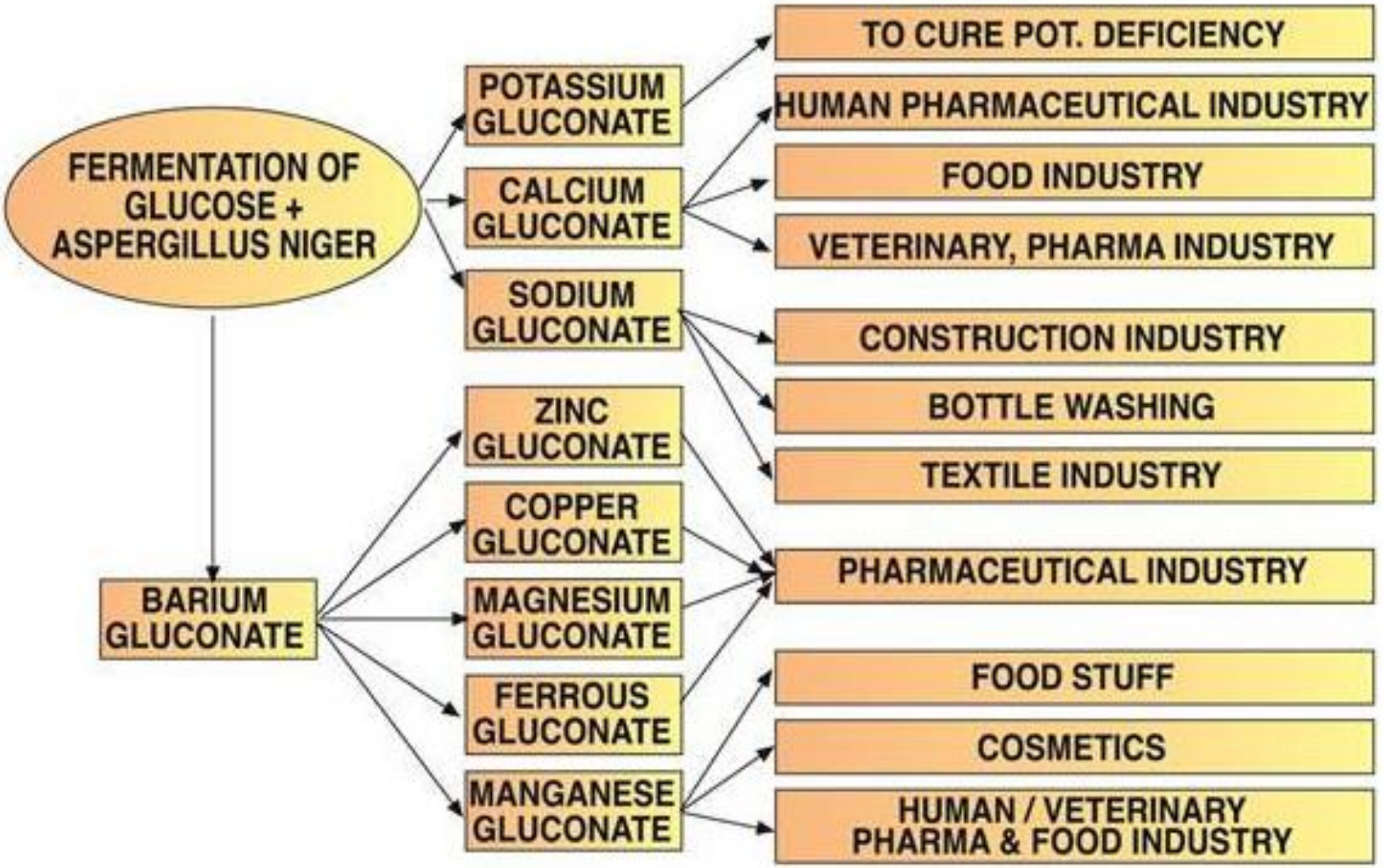
- ✓ d-Glucono-1,5-lactone is unstable in aqueous solution at around neutral pH and hydrolyses spontaneously.
- ✓ The net reaction is a transfer of reduction equivalents from glucose to fructose mediated by enzyme-bound NADP(H), and the cofactor cycles between its oxidized and reduced form.
- ✓ Different sugars (aldose) and other glucose such as xylose, galactose and even lactose can be oxidized into the corresponding aldonolactone, subsequently hydrolysing into aldonic acid.

1. d-glucose + E-NADP ↔ d-glucono-1,5-lactone + E-NADPH

2. d-glucono-1,5-lactone + H_2O ↔ d-gluconic acid

(B. Nidetzky et al., 1998)

Different Salts of Gluconic acid



Applications of Gluconic acid

- ✓ Its use in food industry, as in meat and dairy products, baked goods, flavoring agent, and reducing fat.
- ✓ Gluconic acid is used in the manufacture of metal, leather, and food.
- ✓ It has been accredited with the capability of inhibiting bitterness in foods.
- ✓ This salt is also utilized as a sequestering agent in many detergents, and added to cement to improve the hardening process.
- ✓ Used as a raw material for the manufacturing of gluconate salts with minerals like Calcium, Sodium, Potassium, and Manganese etc.
- ✓ It is widely used in food, pharmaceuticals, cosmetics, electroplating, polishing, metal cleaning, plastics and resin modifying as well as a commodity chemical.
- ✓ Although with a market smaller than that of citric acid, gluconic acid finds its place, as well as its derivatives, such as sodium, calcium, and iron gluconate, which is used for dietary supplements.

(Ramachandran et al., 2006)

Cont...

- ✓ Gluconic acid is a multifunction carbonic acid and it is used extensively in various applications with its physiological and chemical characteristics.

  - As a food additive, it acts as an acidity regulator.
  - In metal cleaning formulations for rust and stains (mineral deposits) removal on metal surfaces.
  - Used in metal finishing baths for aluminum etching and in metal plating processing baths.
  - In high-performance metal degreasers.
  - In textile industries as stabilizers for dye baths and bleach baths.
  - In leather tanning and dyeing processes.

- ✓ Glucono Delta-Lactone is a multifunctional food additive with following applications;

  - Acts as a protein coagulant
  - Sour agent
  - Swelling agent
  - Preservative
  - Flavoring agent
  - Chelating agent
  - Colour retention agent etc.

THANK YOU