PRODUCTION OF GLUCONIC ACID BY FERMENTATION

By

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A C K N O W L E D G E M E N T

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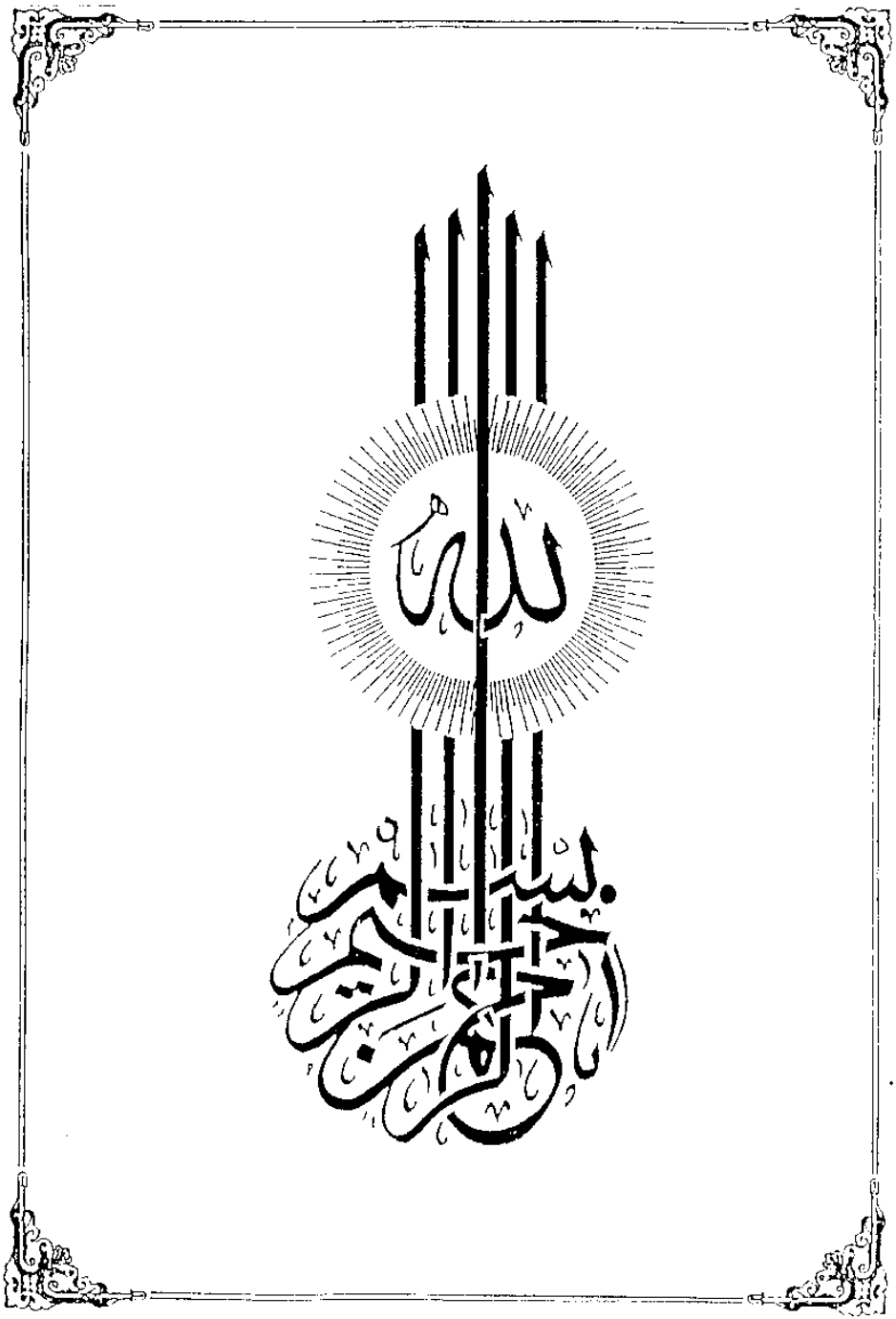


TO MY PARENTS,

MY WIFE

AND MY SON.

C O N T E N T S

INTRODUCTION

Gluconic acid is the simplest oxidation product of glucose. It is produced by various Bacteria, including several Acetobacter species. In addition several fungi, including Penecillium and Aspergillus species, also produce gluconic acid in good yields, and selected strains of A. niger are presently employed in commercial production. Beside the fermentation process, gluconic acid is also produced industrially by direct chemical oxidation of glucose.

Many important applications have been found for gluconic acid and its derivatives in the food, feed, pharmaceutical, and industrial fields. The largest markets for gluconate are in the areas of alkaline bottle-washing machines, used in automatic equipments for cleaning milk bottles, soft drink bottles....etc. The addition of sodium gluconate to water used in these automatic equipments, will prevent scale formation of

calcium and magnesium salts, which result from addition of caustic soda to natural hard water.

Gluconic acid has had its chief importance in the pharmaceutical industry, in the form of its salts, for the purpose of introducing appropriate metallic ions, into the body in a neutral, non-toxic, and easily assimilable form. Calcium and ferrous gluconate has long been a preferred means of treating calcium and iron deficiencies in both humans and animals. Also, gluconates have been incorporated in antibiotic complexes, particularly those of tetracycline.

The latent acidity of δ -gluconalactone has led to several specialized applications. It has been used as the latent acid component of baking powders, in which it is not reactive with sodium bicarbonate until water is added. It is a preferred ingredient of chemically leavened bakery goods and instant bread mixes, because of its latent acid properties.

the possible industrialization of gluconic acid by fermentation in Egypt.

REVIEW OF LITERATURE

I- Historical:

The production of gluconic acid by micro-organisms was first observed by Boutroux (1880), who noticed that Mycoderma aceti (Acetobacter aceti) produced a substance from glucose which was first thought to be lactic acid, but two years later was identified, as gluconic acid.

Molliard (1922) discovered gluconic acid as a product of mould fermentation, along with citric and oxalic acids. The acid was produced in sucrose mashes as a result of the action of Stregmatocystis niger (Aspergillus niger). Molliard later (1924) developed sum optimum conditions for the fermentation.

Bernhauer (1924) discovered a strain of A. niger that would produce gluconic acid in the presence of calcium carbonate. He had shown that thin mats grown

at low temperature, with a low supply of nitrogen, favoured the production of gluconic acid. On the other hand, higher yields of citric acid were obtained when the fermentation temperature and the nitrogen supply were relatively high, and the mats were heavy.

Herrick and May (1928) determined the optimum conditions for the production of gluconic acid by Penecillium luteumpurpurogenum in surface culture, by using shallow pans. Maximum yields of 55 to 65% of theoritical were obtained.

Schreyer (1928) reported the results of a detailed investigation of A. fumaricus which produced mixtures of gluconic and citric acids from glucose. Aeration and agitation of cultures to which calcium carbonate had been added, caused a four-to six - fold increase in gluconic acid production, but had no effect

on citric acid formation. Thies (1930) obtained similar results with the same mould by bubbling oxygen instead of air, through culture solutions containing calcium carbonate.

Currie (1933) obtained high yields of gluconic acid, reaching 90% of the thecritical, in 48-60 hours by acid forming moulds, such as A. niger and Penicillium luteum. In this process, the modern submerged-culture technique was employed, the culture liquid was maintained in a high state of a high-speed stirrer, at the same time, large volume of air was drawn into the solution.

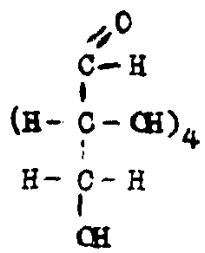
In an attempt to devise an apparatus for culture of moulds in large quantities under increased air pressure, Herrick et al. (1935) designed a rotary drum fermentor. Continued work with the drum by Wells et al. (1937) led to the conclusion that Penicillium chrysogenum would not be a satisfactory organism for commercial-scale operations, because it did not produce the large

quantities of spores necessary for inoculation. Another organism, A. niger, strain 67, was therefore, selected for further work since it produced spores in abundance, and gave a uniform fermentation. These workers made a detailed investigation of the optimum cultural conditions in the laboratory drums and achieved gluconic acid yields of 84% from 15% glucose medium in an 18-hour fermentation period.

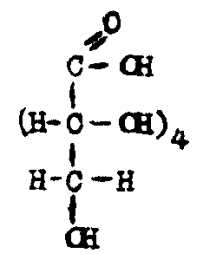
After that time, factors favourable for gluconic acid fermentation had been studied by many investigators such as Elias (1956), Ikeda, Hishimaki, et al. (1959), Carlson (1960), and Taha et.al. (1960). Nowadays glucose oxidase and catalase enzymes are considerd to be important by-products in gluconic acid fermentation industry (Raper and Fennel, 1965).

II- Mechanism of gluconic acid formation:-

Gray (1959) stated that a comparison of the molecular structures of glucose and gluconic acid, reveals that these two compounds are quite chemically similar and that the conversion of glucose tc gluconic acid can be accomplished with only a slightly molecular alteration.



(glucose)



(gluconic acid)

From the structural formulae it is obvious that the conversion of glucose to gluconic acid is chemically simple, involving only the oxidation of the aldehyde group of glucose to the carboxylic group.

The reaction may be written as follows:-

$$C_6H_{12}O_6 + \tfrac{1}{2} O_2 \longrightarrow C_6H_{12}O_7 \qquad (1)$$