Food waste conversion to Galactaric acid

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Introduction

Galactaric acid (GA), also known as mucic acid, is a symmetrical six carbon diacid. GA is used as a chelator and in skin care products and has the potential application in polymer synthesis as a platform chemical. Its market is limited to the pharmaceutical and cosmetic industry. Currently, GA is commercially produced by oxidation of galactose with nitric acid or from D-galacturonic acid (D-galUA) by electrolytic oxidation. An alternative source of D-galUA is pectin, an abundant component in non-woody plant biomass such as in fruit peels. Citrus Processing Waste (CPW) is mainly generated from the industry of juice production which generates 10 million tonnes of wet CPW. Thus, it represents an available and inexpensive source for production of GA.

The present project suggests an alternative route for production of GA through extraction of pectin from dry citrus peel, and its hydrolysis releasing D-galUA which is later oxidized to GA. An innovative, sustainable and environment-friendly solution is sought and analyzed through an economical and environmental assessment based on calculations done with simple derived models. The aim is to produce 2000 tonnes per year of GA.

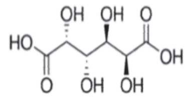
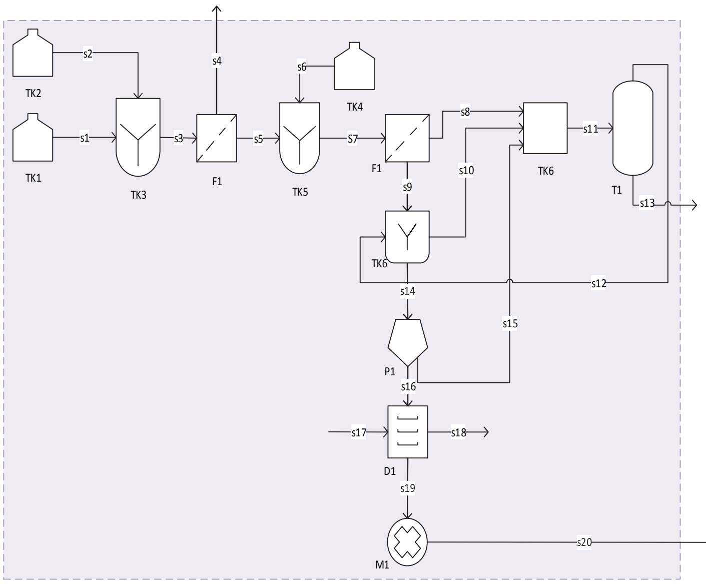


Figure 1. Chemical structure of Galactaric acid.

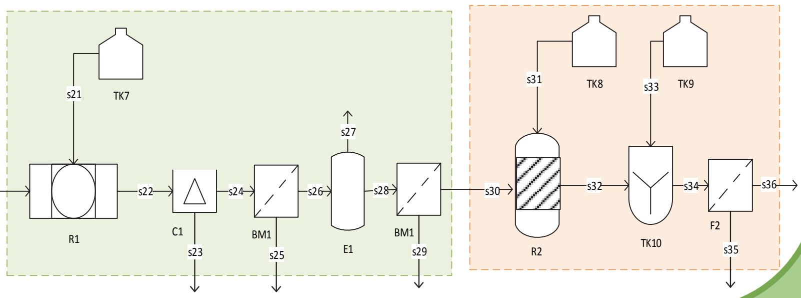
Process flowsheet



For the **extraction of pectin** from dry citrus peel (TK1), citric acid and water are used as solvents (TK2) and the operation runs for 60 min at the solution's boiling point (around 100 ºC) and pH 2.3. The resulting solution is filtrated and non-soluble solids are used as cattle feed (s4). The pectin in the supernatant is precipitated with ethanol (TK4) and filtrated (F1). The filtrate is then washed with an ethanol solution (TK6), pressed (P1), dried with air (D1) and crushed (M1). The ethanol solution is recovered in a distillation column (T1). Extraction yields between 15% - 33% of pectin (dry weight)[1,2].

Continuous **hydrolysis of pectin** happens in a membrane bioreactor (R1) – Figure 2. Polygalacturonase enzyme from *Aspergillus niger* is used with citrate buffer pH 4.1 at 50 ºC. The hydrolysate (s22) is then centrifuged and D-galUA is recovered along with citric acid and water (s26) using a bipolar electrodialysis (BM1) – Figure 3. Experimental results for hydrolysis show that specific productivity is 9.7 g product/h g enzyme[3] while recovery of the monomer reached 47%[4]. D-galUA is separated from citric acid by removal of water (E1) and consequence precipitation.

D-galUA is **oxidized to GA** with catalytic resting cells of recombinant *Escherichia coli*(R2). The pH is neutralized with NaOH and the reaction happens at 37 °C. GA is later precipitated with acid (TK10). Experimental results reveal 95.4% conversion of D-galUA after 24h[5].



Objectives

- Conclude if the process is economically feasible.
- Conclude if it is environmental friendly.
- Understand which changes can be done to the conventional extraction of pectin in order to reduce costs without compromising the effectiveness of the process.
- To find out what are the main impurities in the final product and how does that influence the price of the final product.
- To conclude how to improve the process.

Main advantages

- In this process, an organic acid is used instead of the conventional extraction process in which pectin is extracted with mineral acids (nitric, hydrochloric, and sulfuric).
- Hydrolysis of pectin happens in a membrane bioreactor which is considered an environmentally friendly technology. Moreover, the reaction productivity in a continuous process is higher than in batch system.
- Galactaric acid is produced from a biological source.
- Innovative process.

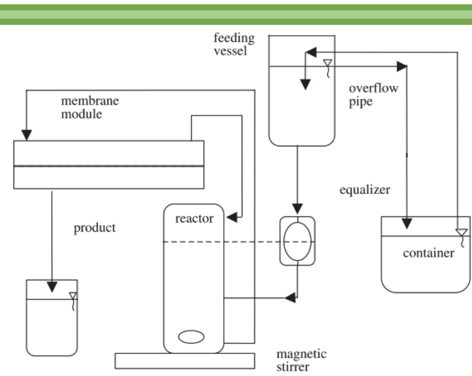


Figure 2. Experimental set-up of the membrane bioreactor for continuous pectin hydrolysis. The membrane was regenerated cellulose and was able to retain the enzyme[3].

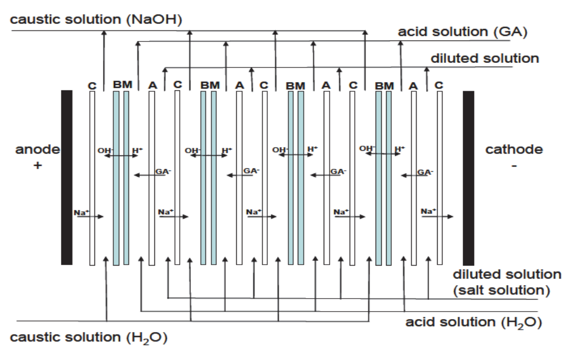


Figure 3. Principals of the bipolar membrane used to recover D-galUA along with citric acid[4].

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