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Review Article

Production of Lactic Acid from Various Feed Stocks: A Review on Studies and Research

Sunil J. Kulkarni

Datta Meghe College of Engineering, Airoli, Navi Mumbai, Maharashtra, India.

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ABSTRACT

In the present scenario of increasing population and advancements in technologies, reduction in the production cost has become important to the chemical manufacturing sector. The use of biological methods and application of biotechnology can be very effective way to produce some chemicals. Production of chemicals such as Lactic acid, citric acid, acetic acid, and ethanol can be done by using biological processes such as fermentation. The current review focuses on production of Lactic acid. Various investigators have carried out research by using different raw materials and bacteria. The present review summarizes research carried out by various investigators for production of Lactic acid by using various biological species and raw materials.

Key words: Biomass, concentration, raw material, nutrients, substrates.

INTRODUCTION

In the era of cutting edge technology, production of various chemical by using low cost and environment friendly technology is the need of the society for sustainable development. Process intensification methods such as hydrotropy, extractive distillation solar distillation can be used to optimize and economize the process. [1-3] Two main aspects of environmental friendly process are temperature and effluent emission. The effluent can be treated by various chemical, biological and physical methods. [4-7] Manufacturing of the chemicals by using biological pathways has advantages such as high specificity, moderate temperature and low energy requirement. Biocatalysts have been used effectively for production of various chemicals. [8-11] The production of chemicals such as acetic acid, ethanol and starch has been reported by various investigators. [12-15]

RESEARCH AND STUDIES ON PRODUCTION OF LACTIC ACID

Hosamane et.al carried out research on Lactic acid production from cane sugar molasses. [16] They employed the response surface methodology to make mathematical modeling and optimization of the temperature and shaking time. They observed that two variables had mutually dependent influence on the % of Lactic acid recovered. They also found that maximum % of Lactic acid recovered was 0.65. Goranov et.al investigated the Lactic acid production by encapsulated Lactobacillus casei ssp. rhamnosus ATCC 11979 cells in alginate/chitosan complexes with solid and liquid core. [17] They compared the Lactic acid biosynthesis with immobilized cell. The free and the immobilized cells produced maximal

Lactic acid quantities at pH 6.5. In their investigation they also determined dynamics of substrate uptake, accumulation of Lactic acid, pH and redox potential of the fermentation medium. They observed that the temperature increase above 42°C led to a decrease in the cells' catalytic activity.

Bayitse reviewed prospect for bioresidue utilization in Ghana for Lactic Acid production from biomass. [18] They studied current research in Lactic acid fermentation processes, bio-residue availability in Ghana and potential utilization for Lactic acid production. They found that both starchy and lignocellulosic biomass has been extensively used. Materials such as maize cobs, millet stalk, sorghum stalk and rice straw were found to be excellent feed sticks for Lactic acid production.

Mudaliyar and Kulkarni studied the development of a bioprocess to produce Lactic acid using dry grass, coconut husk, sugarcane waste and wood chips as substrate. [19] They found that by using Rhizopus genus, many renewable resources including refined sugars, molasses, raw starch materials and even lignocellulose can be converted to Lactic acid. Wee et.al carried out a review on Lactic acid-producing microorganisms, raw materials for Lactic acid production, fermentation approaches for Lactic acid production. [20] They also studied various applications of Lactic acid. According to their estimates, the worldwide consumption of Lactic acid is estimated to be 130 000-150 000 (metric) tonnes per year. According to them, there are still several issues that need to be addressed in order to produce Lactic acid biotechnologically within the targeted cost. They concluded that the biotechnological processes for the production of Lactic acid from cheap raw materials should be improved further to make them competitive with the chemically-derived one.

Farooq et.al carried out investigation on production of Lactic acid by Lactobacillus delbrueckii using food wastes as substrates. [21] They observed that the productivity was affected by fermentation time, temperature and the level of substrate. They achieved maximum Lactic acid production after 7 days of fermentation in media containing 18% substrate level. The maximum recovery obtained was 78-80 percent. Corn by-product raw materials were used for production of Lactic acid by Minh et.al [22] They studied various factors affecting Lactic acid and optimized them. They obtained optimum parameter values as 5% glucose concentration, pH value 6, time 84 hours. At these conditions, they obtained highest concentration of Lactic acid 19.07 (g/l).Their research was mainly focused on biotransformation of xenluloza in raw materials. They concluded that it was necessary to perform further studies to not only reduce sugar (calculated by glucose) but also sugar5-carbon and 6-carbon.

Jahromi et.al carried out investigation on Lactic acid fermentation. [23] They used Different Lactobacillus Species using sorghum seed extract as a carbon source. They observed that, among the selected bacterial species, Lactobacillus delbrueckii was having unique characteristics. It could tolerate different physico-chemical conditions. They concluded that hydrolyzed sorghum seed extract has enough nutrients to support the efficient growth of Lactic acid bacteria and production of Lactic acid under favorable conditions.

Munyon and Merchant investigated the relation between glucose utilization and Lactic acid production. [24] They also studied utilization and the growth cycle of l strain fibroblasts. In their research, they attempted to follow carbohydrate metabolism by measurements of glucose and lactate levels at successive periods of growth. They observed that the pH of the medium decreased from 7.3 to 6.8 during the period of linear increase in cell numbers. Also they observed that there was no constant relation between the rate of glucose uptake with growth. Zhang and Jin carried out investigation on alternative method for l (+)-Lactic acid production using sugarcane molasses and waste potato starch. [25] According to them, the main disadvantage of using bacteria is that expensive nutrients such as yeast extract and peptone are required. They examined the production of Lactic acid from sugarcane molasses and waste potato starch by the fungus Rhizopus arrhizus. They found that adding extra nutrients into molasses did not improve Lactic acid yield.

Xue et.al carried out investigation on production of Lactic acid by thermophilic Bacillus sp. strain XZL4 from corn stover hydrolyzate. [26] They obtained the highest Lactic acid concentration (81.0 g L-1) and yield (0.98 g g-1 total reducing sugars) from corn stover hydrolyzate. They also found that that Bacillus sp. XZL4 was a promising polymer-grade L-Lactic-acid producer from cellulosic biomass. Fermentation processes using Lactic acid bacteria (LAB) producing bacteriocins for preservation were carried out by Juodeikiene et.al. [27] According to them, the use of bacteriocins and/or bacteriocin-producing strains of LAB are of great interest. They are generally recognized as safe organisms and their antimicrobial products as biopreservatives. They emphasized that there is a need for practical technology controlled from an economical point of view.

Cell-recycle repeated-batch bioreactor was used for Lactic acid production by Oh et.al. [28] They investigated the effect of various nitrogen sources on cell growth and Lactic acid production. They found that increasing the yeast extract content raises the total production cost of Lactic acid. They tried to find the optimum yeast extract dosage for a repeated-batch operation with cell recycling. Narayanan et.al carried out investigation on L (+) Lactic acid fermentation. [29] They also studied its product polymerization. They reviewed the microorganisms being used for Lactic acid fermentation, the raw materials reported, the various novel fermentation processes and its processing methods. They found that varieties of raw materials can be used for the Lactic acid production.

Sobrun et.al carried out investigation on isolation of Lactic acid bacteria from sugar cane juice. [30] During their studies, they observed that several isolates exhibited a clear zone and growth on de Man, Rogosa, Sharpe (MRS) agar supplemented with sodium azide, bromocresol purple and sucrose. They isolated a total of 112 mutants. Out of these 9 homofermentative isolates were further investigated for their ability to produce Lactic acid. They observed that all mutant isolates produced Lactic acid as the sole fermentation product. Shiphrah et.al carried out research on Lactic acid production from whey water. [31] They used a by-product after the precipitation of cheese as a substrate. They observed that the various milk products and milk itself has the maximum content of Lactic acid bacteria. They concluded that the potential of using this isolate for bioremediation of dairy waste (whey water) could be explored and exploited in future.

Wang et.al carried out studies on corncob molasses containing a high content of xylose for Lactic acid production. [32] They obtained highest Lactic acid concentration when initial corncob molasses concentration was 150 g/l. Thereafter sharp decrease was observed in Lactic acid production. According to them, the production of Lactic acid from various by-products or agricultural residues has gained considerable interest because of the increasing interest in producing biotechnological products from low-cost and renewable biomass. Kivanc et.al isolated a total of 45 Lactic acid bacteria from 10 different boza samples consumed in Turkey. [33] They tested isolates for inhibitory activity against food-borne bacterial pathogens. They determined antimicrobial effects of these Lactic acid bacteria. They observed that Lactic acid bacteria strains examined in this study were rather moderate acid producers.

Hadadji and Bensoltane carried out an investigation on bifidobacterium longum and Lactobacillus acidophilus in goat's milk for growth and Lactic acid production. [34] They compared the production of Lactic acid with pure and mixed cultures. They observed that the maximum rate of Lactic acid production was obtained with mixed culture at 45°C. Maas et.al carried out investigation on Lactic acid production from xylose. [35] They used the fungus Rhizopus oryzae bacteria for the purpose. Their investigation resulted in the conversion of xylose in synthetic media into Lactic acid by ten R. oryzae strains resulting in yields between 0.41 and 0.71 g g^{-1}. Diauxic growth was observed in case of mixed substrates. Afolabi demonstrated a fermentation process, which would economically produce Lactic acid from inexpensive carbon source. [36] First, they inoculated the spores of lactobacillus casei to the growth medium and then changed the medium to production medium. They observed that with glucose concentration, The Lactic acid production increased. Hundred percent conversions could not be achieved as a result of Lactic acid inhibition. They also found that the inhibitory effect can be minimized by using certain additives such as ammonium sulphate and manganese sulphate. Ray et.al carried out research on use of fibrous residue obtained during extraction of starch from cassava for Lactic acid production. [37] They carried out semi-solid state fermentation using Mann Rogassa Sharpe medium in lieu of glucose [2 %(wv^{-1})] as the carbon source. They used response surface methodology (RSM) to evaluate the effect of main variables. The important variable includes incubation period, temperature and pH. The optimum values of these variables were obtained to be 120 hr, 35^0C and 6.5, respectively during their investigation.

CONCLUSION

The review suggests that starchy and lignocellulosic biomass has been extensively used for Lactic acid production. Various researchers have reported Lactic acid production from various feed stocks such as agricultural waste, corncob, dairy industry waste, dry grass, coconut husk, sugarcane waste and wood chips. In order to make the Lactic acid fermentation more attractive more research on affecting parameters, bacteria and feed stocks is required.

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