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Production of Citric Acid: A Review on Research and Studies

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Abstract— **Chemical engineering deals with synthesis of various chemicals in economical and efficient manner. Raw material is important aspect for cost effective manufacturing of chemicals. Biological methods for syntheis consume less energy and are very economical for production of chemicals such as ethanol, acetic acid, citric acid, lactic acid etc. Waste solid materials such as molassis, fruit peels, waste leaves and other waste can be used as a feed stock.The problem of solid waste can thus be solved while manufacturing the required compound. Many investigators have carried out research on manufacturing of different compounds from different feed stocks in order to observe yield and optimiz various parameters affecting the synthesis. The present review summerizes research and studies on manufacturing of citric acid from different waste feed stocks.**

***Index Terms*—Yield, fermentation, concentration, biomass.**

I. INTRODUCTION

In the current era of globalization and financial liberalization, production of various products at lowest possible cost is important. Various chemicals like glucose, ethanol, citric acid, starch, tartaric acid can be produced by using waste feed stocks[1,2,3]. The disposal of biological waste and solid waste is also a key environmental problem[4,5,6]. Use of the solid waste as a feed stock can minimize the solid waste problem also. Ethanol has been produced by various investigators from molassis and other waste feed stocks[7,8,9]. Manufacture of acetic acid is also reported by vatious investigators[10]. The current review summerizes studies and research on manufacturing of citric acid from various feed stocks.

II. RESEARCH AND STUDIES ON CITRIC ACID PRODUCTION

Tongwen and Yang carried out an investigation on citric acid manufacture by electrodialysis[11]. They used bipolar membranes (BP) prepared from poly(phenylene oxide) (PPO) for the production fron sodium citrate. They observed that the membrane potential only shows a slight decrease at high salt concentration.The voltage was not only related with the support electrolyte but also with organic salt concentration. They observed that the current efficiency increases with the concentration of sodium sulfate at low concentration range and then decreases. Citric Acid was produced by yarrowia lipolytica in different crude glycerol concentrations and in different nitrogen sources by Silva et.al.[12].According to them, increased demand for biodiesel leads to an abundant amount of glycerin in the market.They observed that that the addition of ammonium sulfate to the culture medium directs the metabolic pathway for the production of isocitric acid.Their work was aimed at study of citric acid production by Y. lipolytica IMUFRJ 50682 using crude glycerol stemming from biodiesel industries. Igliński et.al. investigated the production of citric acid using electrodialysis[13]. They used electrodialysis with bipolar membrane of sodium citrate solutions.They determined the current efficiencies based on the number of moles of produced acid and on the concentration changes.They found that the mean efficiencies of acid and base were higher at the lowest current densities (52 mA/cm^2). Also, the process efficiency increased with initial sodium citrate concentration in the salt circuit. Kumar and Jain have investigated solid state fermentation for citric acid production[14]. The objective of their work was to observe the effect of bagasse pretreatment and further to compare the kinetic data of flask bioreactor and packed bed bioreactor after optimizing the aeration rate and bed packing density.According to these studies, aeration and packing density of packed bed reactor not only helps in heat and mass transfer but also assists in removal of metabolic heat.Kobomoje et.al. carried out an investigation on the production of citric acid from shea nut shell (Vitellaria paradoxa) using Aspergillus niger[15].They found that maximum yield of anhydrous citric acid was obtained when initial pH of the fermentation medium was kept at 5.0, and decrease in pH further reduced the citric acid production. Kareem and Rahman carried out an investigation on citric acid production by Aspergillus niger by utilization of banana peels[16]. They observed that addition of supplements significantly enhanced the yield of citric acid. They proposed banana peel as an inexpensive medium for the production of citric acid by Aspergillus niger.Kim et.al. carried out an investigation on continuous production of citric acid from dairy wastewater[17]. They used calcium-alginate immobilized Aspergillus niger ATCC 9142. They observed that culture conditions affected the production.They observed that, the optimal pH, temperature, and dilution rate were 3.0, 30^oC, and 0.025 h^{-1}, respectively. Bhattacharjee and Baruah carried out an investigation aimed at isolation and screening

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the ability of citric acid producing Aspergillus spp from soil [18].They isolated fungal samples from soil samples, using serial dilution agar plating method.They found that higher citric acid production was shown by Aspergillus niger S-6.

Femi-Ola and Atere carried out an investigation on citric acid production from brewers spent grain[19]. They also determined the effect of the initial pH and presence of methanol.They observed that the maximum citric acid production was at 4.5 pH value.They also observed that there was no significant difference in the biomass production at different pH ($P \geq 0.05$). They also observed that there were significant differences ($P \leq 0.05$) in the amount of citric acid produced and biomass generated during fermentation with and without methanol.According to Bera et.al.The fermentation method is by far the best adopted method for citric acid production[20].They produced citric acid from non citrus vegetable wastes like rotten fruits and vegetables found in municipal Garbages. They also compared the yield with a standard citric acid in order to find out the viability of this technique in industrial scale.Their studies proved that among all vegetable wastes, brinjal and potato has substantially higher yield of citric acid.

Pawar V and Pawar P investigated effect of various parameters on citric acid production using different substrates[21]. According to them, there is need of commercial production of citric acid using cheap raw materials due to its demand in industries.They studied production of citric acid using different substrates such as molasses, pumpkin.They observed that the decrease in pH indicates production and accumulation of citric acid with an extension in incubation time.They also observed gradual decrease in residual sugar and pH with increase in incubation time and citric acid production. Nica et.al. carried out an investigation on environmental assessment of citric acid production[22]. The purpose of their environmental assessment was to identify the environmental “hot spot” of the process.According to them most of the compounds used in the production, being biological in origin are hazardous.

Iralapati and Kummari used fruit peels for production of citric acid using aspergillus niger[23]. They used fruit peels of mango, banana and orange for the production of citric acid.They carried out solid-substrate fermentation by using Aspergillus niger as the inoculum. They concluded that citric acid production from waste solved the problem of waste management and pollution in the environment.Assadi and Nikkhah carried out an investigation on on production of citric acid from date pulp by solid state fermentation[24]. They obtained poor yield when potassium ferrocyanide treated date pulp was used as substrate. Methanol increased the yield.Within 8 days, they obtained 87 percent yield. Murad et.al. investigated citric acid production from whey with sugars and additives by using Aspergillus niger[25].They studied citric acid (CA) production by Aspergillus niger ATCC9642 from whey with different concentrations of sucrose, glucose, fructose, galactose riboflavin, tricalcium phosphate and methanol in surface culture process. They found that whey with 15% (w/v) sucrose was most efficient medium.Corncobs were used for production of citric acid by Ashour et.al.[26].They carried out culture optimization concerning substrate concentration, culture duration, pH, temperature and substrate hydrolysis for maximum productivity of citric acid. They observed that citric acid has potent melanin inhibitory activity, good inhibition for β-hexosaminidase release and potent stimulatory effect for the production of hyaluronic acid.

Ali et.al. carried out an investigation on the optimization of citric acid production from rice straw[27]. They conducted economical study to show the benefits of optimization during the production of citric acid from rice straw as a substrate by solid-state fermentation (SSF) using Aspergillus niger.They used Plackett-Burman design (PBD) for the screening and central composite design (CCD).They found that about 38 percent additional profit can be earned by using optimization. Fruit Pulp Waste was used for production of citric acid by Bezalwar et.al.[28].According to them, increased demand of citric acid has led to search for high yielding fermentable strains of microorganisms and cheaper fermentation substrate in many countries. Their study suggested that in near future waste fruit pulp could be one of the substrate for citric acid production at industrial scale worldwide. They observed maximum citric acid production by using pineapple pulp waste.Kareem et.al. used pineapple waste for production of citric acid by Aspergillus niger[29].They developed a solid state fermentation for citric acid production from pineapple waste by Aspergillus niger KS-7.They supplimented the medium with glucose, sucrose, ammonium nitrate and ammonium phosphate. According to these studies, pineapple peel were a cheap medium for the production of commercially valuable organic acid by A. niger.

III.CONCLUSION

Citric acid can be manufacred by using various raw materials such as fruit peel, molassis and other waste feed stock.The investigations are reported on use of various feed stock such as molassis, fruit peel waste, corncob and other waste material. The yield obtained by using these raw materials was satisfactory and processes were cost effective.Also culture medium can affect the yield of citric acid. Various parameters such as temperature, pH , substrate concentration, culture duration affects the yield of citric acid. Ferementation is the common process in citric acid production from raw feed stocks. Aspergillus niger is most commonly used for citric acid production. The addition of glucose, sucrose, ammonium nitrate and ammonium phosphate can increase the yield. High yielding fermentable strains of microorganisms and cheaper fermentation substrates are desirable for further reduction in manufacturing cost of citric acid.

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