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## A REVIEW ON CITRIC ACID PRODUCTION FROM MICROBIAL SOURCES

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### ABSTRACT

Microorganism-mediated development of commercially useful goods has increased steadily in recent years. Microbial fermentation produces organic acids, which are essential components. Due to many advantages such as high purity, less environmental contamination and cost effectiveness, microbial production of organic acids has been steadily increasing over traditional chemical methods. The substrates as raw materials and fermentation medium should be less expensive, readily available globally and in large quantities for effective processing. Citric acid is a biodegradable and environmentally friendly compound used extensively in the food, pharmaceutical and cosmetic industries. To fulfil the increasing demand of citric acid in industries requires the larger production in an eco-friendly way. In industrial processing, submerged fermentation of starch or sucrose-based media is used for citric acid production. Valuable agro wastes such as wheatbran, rice straw, sugar cane, molasses is suitable, inexpensive and used as starch or sucrose-based media for the production of citric acid. In this review, application, substrate and environmental condition required for citric acid production is discussed along with microorganisms which are highly useful for citric acid production.

**Keywords: citric acid, agricultural waste, submerged fermentation**

## INTRODUCTION

The development of microbial approaches for the production of commodity chemicals for sustainable development on a large scale has been prompted by rising environmental concerns and the depletion of limited resources. It has prompted rapid advancements in microbiology, biotechnology and fermentation technology in order to improve environmentally sustainable green methodologies. Advances in microbiology and fermentation technology have resulted in the production of environmentally sustainable processes that can now replace some of the more traditional chemical methods. The growing body of information about the metabolism and pathway control of industrially appropriate species has already proven invaluable in the production of logical strains with primarily industrial performances [1]. In recent years, the use of microorganisms for production of commercially useful goods has increased. Organic acids have been used as food additives and preservatives to extend the shelf life of food products since ancient times. Organic acids are a key component of the top platform chemicals formed by microbial fermentation. Organic acids are used in a variety of sectors, including food, healthcare, cosmetics, textiles, solvents and construction as well as the production of biodegradable packaging products, either directly or indirectly [1].

Citric acid is the most widely used organic acid. The growing demand for citric acid by industries, combined with the quest for a cost-effective raw material for its production from agricultural waste residue, is a major source of concern. Citric acid is a tribasic organic acid (2-hydroxy-1,2,3-propane tricarboxylic acid). It can be found in a variety of fruit juices, animal bones, muscles and blood. Iron citrate, a citric acid compound is used in the pharmaceutical industry to preserve cosmetic formulations, ointments, preserved blood and tablets as a source of iron and citric acid. Citric acid is obtained as the end-products or as an intermediate portion of a biochemical cycle [2]. In the detergent industry, citric acid is used as a suitable and less expensive substitute for polyphosphates. Polyphosphate's higher cost previously limited their use; however, detergents containing polyphosphates have been banned in some countries and citric acid has completely replaced them. It is the most common food additive, accounting for roughly 70% of total global supply and is used as an acidulant, antioxidant, preservative and flavour enhancer in the food and beverage industry.

It is used as an acidulant, taste enhancer, preservative, antioxidant, emulsifier and chelating agent in the dairy, pharmaceutical and cosmetic industries. It is mass

produced at a rate of 1,000,000 Mt per year due to high demand from the pharmaceutical, chemical, food, beverage and cosmetic industries [3]. Water is used to leach the citric acid from the fermented solid content. The obtained extract contains citric acid, which is recovered using traditional methods after downstream processing. Citric acid extraction has been identified by the US Food and Drug Administration and approved for use in food and pharmaceuticals. Precipitation, extraction and adsorption and absorption using ion-exchange resins are the three main methods for recovering substances from extracts. Precipitation is the traditional process, which involves mixing calcium oxide hydrate (milk of lime) with tricalcium citrate tetrahydrate to form the slightly soluble tricalcium citrate tetrahydrate. Filtration is used to extract the precipitated tri-calcium citrate, which is then washed several times with water. After that, the precipitate is treated with sulphuric acid to produce calcium sulphate, which is then filtered out. The citric acid in the mother liquor is processed with activated carbon before being passed through cation and anion exchangers. Anion-exchange resins are commercially available in a variety of forms. Finally, the liquor is concentrated at 20–25 degrees celsius in vacuum crystallisers, yielding citric acid

monohydrate. Anhydrous citric acid is made by crystallising citric acid at temperatures greater than 25°C. Chemical processes may produce citric acid (CA), but microbiological processes involving *Aspergillus niger* are still favoured over commercially produced citric acid [4]. The effective use of waste and its management have gained a lot of attention. Agricultural waste is a plentiful, low-cost and sustainable source of value-added organic acids like citric acid, allowing for long-term production and sustainability. Citric acid has been produced from a variety of agricultural wastes [5].

#### **Characteristics of Strain To Be Selected For Citric Acid Production**

When it comes to producing bio products like organic acid, strain selection is crucial. The organism's characteristics must be relatively stable and it must be able to develop quickly and vigorously [6]. The chosen microorganism should also be non-pathogenic and appropriate for studies involving parameter optimization. The ability to generate high yields of the desired commodity is the most important economic trait to consider when choosing an organism. Because of its high purity, selectivity, cost effectiveness and environmental friendliness, microorganism-mediated processing of valuable products is favoured over traditional methods [2].

## Microorganism Used For Citric Acid Production

Approximately 99 percent of global output is achieved by microbial processes using surface or submerged cultures. Although a large number of microorganisms have been used for citric acid production, only a few are capable of producing citric acid on an industrial scale [2]. Many other *Aspergillus* species and yeast types are also used in the production of citric acid. In their primary metabolism, some fungal strains may produce citric acid as a metabolite. Several molds, including *Penicillium*, *Aspergillus*, *Mucor*, *Citromyces*, *Paecilomyces*, *Trichoderma* and others, contain citric acid [7]. The explanation for this is that, as compared to *Penicillium* strains, *Aspergillus* strains can produce more citric acid per unit time. Furthermore, harmful side products like oxalic acid, isocitric acid and gluconic acid may be quickly and effectively blocked in *Aspergillus niger* mutants [7].

## Substrates Of Citric Acid Production

Citric acid has been synthesized from agricultural waste residues such as cassava, potato residue, banana peel, bagasse, pineapple waste, apple pomace, soybean, wheat bran, kiwi fruit peel, corncobs and sugar cane [8]. Corn stalk is a suitable and inexpensive substrate for the production of citric acid, it is used as a value-added agro

waste in the production of citric acid. For this reason, a variety of value-added agricultural waste items have been evaluated with the goal of minimizing environmental littering, pollution control and upholding the recycling principle [9]. Using low-cost agricultural waste residues as a carbon source for citric acid production has given stability in the industrial sector, encouraging waste management, cost effectiveness, cost reduction and productive yield and performance [10]. Corn is the world's third most important cereal, after rice and wheat, and has the highest production capacity of all cereals. It is the world's most widely grown cereal crop [11]. The grain, leaves, stem, tassel and cob are all useful parts of the maize plant. These parts are useful to make a wide range of food & non-food products [12]. The ethanol manufacturing co-product wet corn distillers' grains is used as a substrate for commercial citric acid production by *Aspergillus niger* without any treatment [13]. Currently disposal of agricultural waste causes significant economic and environmental issues, necessitating its effective use [14]. This sparks the search for a way to use it in the production of citric acid through submerged fermentation [15].

## Effect of Various Fermenting Parameters On Citric Acid Production

### Impact of carbon source on citric acid production

In comparison to the medium containing only sucrose, the medium containing corn stalk powder and 50% sucrose provides the highest yield of citric acid. In addition, the medium containing corn stalk powder and 50% sucrose has a higher mycelial weight [16].

#### **Effect of pH**

Judy Atabat Adudu & Shefiat O. Arekemase *et al.* discovered the effect of pH by varying different pH levels; as a result, they discovered the following effect on citric acid production: The importance of maintaining a favourable pH for the efficient development of citric acid cannot be overstated. The decrease in citric acid yield is caused by an increase in pH [16].

#### **Effect of temperature**

The temperature of a fermentation medium is a key factor that has a significant impact on citric acid production. Increases in temperature results in a substantial decrease in citric acid production, with the lowest yield occurring at 37°C [17].

#### **Effect of incubation time**

After a substantially high yield of citric acid on the seventh day of fermentation, production drops on the ninth day [17].

#### **Effect of methanol on citric acid production**

The effect of various methanol concentrations on citric acid production is revealed that adding 3% (v/v) methanol

results in a statistically high yield of citric acid. When 4 % (v/v) methanol is applied to the medium, citric acid yield drops significantly [18].

#### **Effects of nitrogen sources**

The action of nitrogen sources on citric acid production such as ammonium nitrate, peptone and yeast extract in various concentrations: When ammonium nitrate is applied to the medium, citric acid intake increases and higher nitrogen source concentrations result in the formation of oxalic acid, which reduces citric acid yield [18].

#### **CONCLUSION**

Agricultural waste is an abundant, low-cost and long-lasting source of citric acid. While chemical methods can produce citric acid, microbiological processes involving various microorganisms are still preferred over commercially produced citric acid. Carbon source, pH, temperature, incubation time, methanol and nitrogen sources are important & affecting factors for citric acid production. Therefore, it can conclude that citric acid is highly used as an emulsifying agent in ice cream as well as preservatives & flavouring agents in foods and its production yield can be improved by the use of various microorganisms.

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