International Journal of Research in Advent Technology (E-ISSN: 2321-9637) Special Issue National Conference "ACGT 2015", 13-14 February 2015

Utilization of Municipal Food Waste for Production of Lactic Acid- Precursor of Biodegradable Plastic

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Abstract- For treating municipal waste and to sustain the society, an environmentally friendly mode of green technology is required. Large amount of waste from kitchen and food industry readily decompose, generate odour, and sometimes cause illness. Municipal food waste is usually incinerated or land filled which cause problem due to their organic properties. Microbial treatment of biological solid waste reduces the need of incineration and landfill process. Lactic acid is an important commercial product; in addition, it can be polymerized to form biodegradable polyester poly lactic acid, a potential substitute for petroleum manufactured plastic.

In present study, municipal waste was treated with curd, common source of lactic acid bacteria. It was further fermented for 5 days on rotary shaker with continuous monitoring of pH and at the end of fermentation lactic acid was purified with acidification. Titrable acidity noted and was found out to be good.

Index Terms- Lactic acid bacteria; municipal waste; biodegradable plastic

1. INTRODUCTION: Solid waste management is the question of concern in today's world. In rural places biogas production and composting are the solutions obtained to overcome this problem. [1] Biogas and composting from municipal food waste is viable for rural area, due to availability of space and proper discarding and collection infrastructure. But in cities where space and cost problem is important some other solution to the problem of solid waste management is required. Production of lactic acid is possible solution to this problem. [2]. Lactic acid can be used as monomer in synthesis of biodegradable plastic [3].

Lactic acid is widely used in the food, cosmetic, pharmaceutical, and chemical industries and has received increased attention for use as a monomer for the production of biodegradable poly lactic acid. [4]. It can be produced by either biotechnological fermentation or chemical synthesis, but the former route has received considerable interest recently, due to environmental concerns and the limited nature of petrochemical feed stocks [5]. Lactic acid bacteria are among the best studied microorganisms [6,7}

2. MATERIALS - For organic acid fermentation

- Municipal food waste collected from Sarasbaug waste treatment plant in Pune under the municipal corporation of Pune city. Minced kitchen food waste was directly collected from the site in a disposable container weighing 100 gm approximately.
- Household curd
- Diastase (50mg can digest 60g of starch) (Aristozyme® capsules, ARISTO Pharmaceuticals Pvt. Ltd.) a potential source of amylase.
- Calcium carbonate (2g/L)
- Rotary Shaker : Set at 37^0C & 50^0C, 120rpm
- Cooling Centrifuge.

For extraction and purification of organic acid

- Filter paper/Muslin cloth : It is used as a filter press for the separation solid waste and the fermented liquide.
- Methanol
- 70% Sulphuric acid (Reagent grade)
- Oven set at 50^0C.

For Phenol Sulphuric Acid Method [8]

- Phenol 5% reagent grade
- Sulphuric acid reagent grade
- Standard glucose: Stock 100mg/100mL of distilled water
- Working Stock: 0.1mg/mL of std. Glucose

For Glucose oxidase Test

- Test sample + glucose oxidase kit (performed as per manufacturer's instructions).

Quantitative estimation of purified organic acid by volumetric titration method. [9]

- 0.1N Sodium hydroxide
- Standard acid: Lactic acid
- Phenophthalin indicator (1%)

3. METHOD

I) Fermentation-The minced food waste was collected from Sarasbaug municipal waste treatment plant. It consisted majorly of kitchen left-over food. The sample of minced food was weighed 50gm and transferred to 250 ml flasks. To the minced food

equal quantity of distilled water was added. After the addition the mixture was autoclaved at 121^{0}C for 15

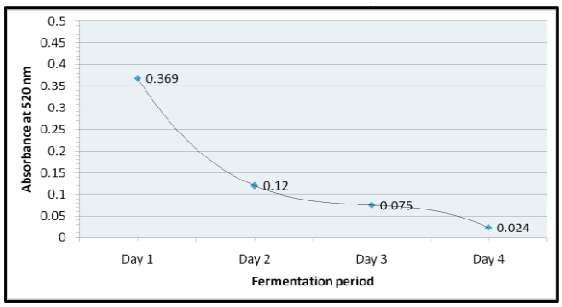


Figure 5: Graph showing gradual decrease in the concentration of glucose.

minutes. Fresh curd which is prepared overnight is inoculated with a concentration of 10% v/v under aseptic conditions as a source of lactic acid bacteria. [10].

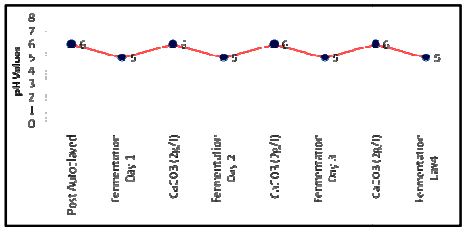


Figure 1: Graph showing change in pH during fermentation

- The pH is adjusted using $CaCO_3$ (calcium carbonate) with a concentration of 2 gm/L. (adjusted daily). (Gunsalus I. C. and Niven C. F.,1942). Flasks containing the suspension are incubated in rotary shaker 37^{0}C for a period of 18 hours at 120 rpm. After a period 18 hours of incubation on shaker the temperature is increased to 50^{0}C and diastase is added simultaneously at a concentration of 0.8gm/gm of food waste in the suspension. The diastase carries out the process of saccharification for 2 hours. The pH adjusted to 6.0 by the addition of $CaCO_3$ at a concentration of 2 g/L, after the addition of CaCO3 the suspension are incubated at 37^{0}C for a period of 4 days to complete the fermentation process.

II)Extraction of Organic acid- The fermented suspension was separated with the help of muslin cloth. The suspension was carefully filter pressed through the muslin cloth and the fermented liquid was transferred into another flask and the solid residue was separated. The fermented liquid was stored at 4^{0}C for further procedures.

III) Purification of organic acid by esterification and hydrolysis method

The fermented suspension is centrifuged to separate of calcium lactate from the fermented liquid. After which of methanol is added to the centrifuged fermented liquid to dissolve the calcium lactate. Subsequently, 70% of H_2SO_4 is added to precipitate the calcium sulphate. Centrifugation of the fermented liquid is carried out at 6000rpm for 5 minutes to separate the calcium sulphate as pellet so as to obtain a calcium free fermented broth. Evaporation is carried out at 50^{0}C and finally the quantitative estimation of the organic acid is done by volumetric titration method.

4. **RESULT -1 pH Maintenance**

The pH of the suspension was check at interval of 24 hours for four fermentation days and adjusted and maintained by addition of calcium lactate ($CaCO_3$) (2g/L).

Table 1. Ph maintenance

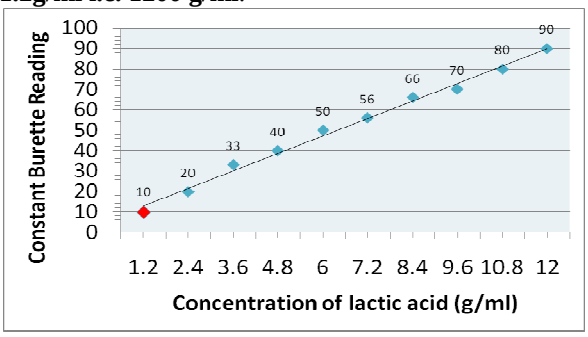
Fermentation day	**pH**	**After Addition of $CaCO_3$ (2g/l)**
1st	5.0	6.0
2nd	5.0	6.0
3rd	5.0	6.0
4th	5.0	6.0

The pH decrease indicates clearly acid formation during fermentation. The calcium carbonate is considered as best neutralizing agent for lactic acid production. The calcium carbonate reacts with lactic acid to yield calcium lactate which neutralizes and maintains the pH conditions during the fermentation.

The gradual decrease in glucose concentration indicates utilization of glucose by microorganisms.

Volumetric analysis by titration method-Graph for titration of standard lactic acid against 0.1N NaOH

Concentration of organic acid in final sample is **1.2g/ml i.e. 1200 g/ml**.



5. Discussion

It was noted that the pH of the fermentation suspension decrease from 6.0 to 5.0 for each fermentation days which was maintained to pH 5.0 by addition of calcium carbonate (2g/L) powder. The calcium carbonate has been the best neutralizing agent for organic acid production. Method for preparation of purified organic esters from crude organic acid obtained from fermentation was adopted from H. G. Joglekar *et al.*,2006, the calcium lactate was dissolved in methanol and equivalent amount of 70% sulphuric acid was added to liberate the organic acid to precipitate and separate calcium sulphate. The lactic acid solution was incubated at 50^0C to evaporate. The organic acid yield determined by volumetric titration method was 1200 g/L (12%), which is higher than reported in paper published by Sakai *et al*., 2004 for lactic acid from municipal food waste.

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