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VALORIZATION OF FOOD WASTE FOR OPTIMIZED PRODUCTION OF BIO-FUEL

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ABSTRACT

Bio-fuel produced from inexpensive organic waste is a renewable alternative eco-friendly energy source compared to hazardous fossil fuel. Organic wastes contain significant amount of carbohydrates when subjected to acid hydrolysis, yield fermentable sugar wort. Organic waste collected from various source was converted into fermentable sugar by acid hydrolysis carried out using different concentration (2%, 6% and 10%) of sulphuric acid. Sugar wort thus obtained was converted to ethanol by fermentation process using *Saccharomyces cerevisiae.* The maximum yield of 36.2 ml bio-ethanol was obtained from sample hydrolyzed with10% sulphuric acid. The minimum yield of 17.3 ml bio-ethanol was obtained from sample hydrolyzed with 2% sulphuric acid. Considering the quantity of ethanol yield from the biomass, it is concluded that food waste is a potential source for the production of ethanol under optimum preprocess.
***Keywords* :** Bio-fuel, Acid hydrolysis, organic waste, fermentation.

Introduction

Increase in energy consumption due to flourishing industries and population has led to continuous rise in the demand for energy worldwide. This demand for energy is presently fulfilled by the fossil fuel whose consumption had created a vast number of problems as it is responsible for more than 70% of global carbon monoxide and 19% of global carbon dioxide emission (Goldemberg, 2008). This inevitable consumption of fossil fuel accounts for global warming and depletion of the ozone layer. Apart from being hazardous to the environment, fossil fuels were also showing serious health crisis to humans, as continuous exposure to greenhouse gas and related toxic components produced as a residue of burning fossil fuels results in fatal health complications such as chronic asthma, low lung performance, chronic bronchitis and the cardiovascular diseases (Tan *et al*., 2022).

Being the only available energy source for now, relying entirely on fossil fuel may lead to severe shortage of energy in the future. Therefore, it becomes necessary to develop sustainable and renewable alternate energy source that prevents environment and ecosystems from being affected by the usage of energy retrieved from conventional energy sources. Search for alternative and more economical renewable resources in order to meet this demand is increasing in recent times. Efforts to utilize alternative energy sources can be used as a solution in reducing use of fossil fuels (Haryono *et al.,* 2010).

Currently bio-fuels are being considered as an alternative to the fossil fuels. Bio fuel production started to develop in the developing as well as the developed countries (Demirbas, 2008). Any raw material that has sugar and starch can be used to produce bio ethanol with the help of microorganisms. Though sugar cane is the most preferred raw material for the production of ethanol, but it is well known that use of food crop producing land for sugar cane cultivation is under question. For this reason, technological methods that enable the efficient production of bio ethanol have been continuously sought for both economic and environmental reasons (Pereira, 2011).

Due to day today activities of mankind, a large number of wastes is generated in the form of solid waste and municipal waste that may become a source of pollution. It is therefore important to handle them judiciously to avoid health problems (Ledward *et al*., 2003). Food and food related waste produced in large quantity by mankind can also be included as solid waste. In India, it is estimated that the 50 kg per capita per year or 68,760,163 tons of household food waste is dumped in a year. Degradation of food waste if dumped ignorantly produces methane, a greenhouse gas as an end product that is 28 times ill potent than Carbon dioxide. If the food waste is used effectively in the waste management treatment, it will reduce up to 11% of the greenhouse emissions.

Mostly food wastes are made of cellulose and starch. Breaking down of starch in to fermentable sugars require a reaction of starch with water, the process which is known as hydrolysis. Hydrolysis is carried out at high temperature; however, at low temperatures, it is also possible and can contribute to energy savings (Sanchez *et al*., 2008). Starch present in the raw food source can be converted into fermentable sugars by acid hydrolysis or enzymatic hydrolysis. Each has their own set of advantages and disadvantages for use. (Tasić *et al*., 2009).

The ethanol cannot be produced from the waste as such as it is produced from sugarcane, because it requires a specialized pretreatment process such as hydrolysis (Palacios-Bereche *et al*., 2011). Therefore, the objective of this study is to focus on the correlation between the quantities of sugar formed through hydrolysis of food waste for bio ethanol production. The study focuses on the utilization of food waste which will be the basic raw material for the production of the bio-fuels. The result of the study will reflect the simple and eco-friendly methodology for the Bio fuel production. Also, this study paves a new way for the fossil fuel alternate and it will be the future for the next generation in the fuel sector.

Materials and Methods

Collection and processing of samples

Solid vegetable and fruit waste are the main focus of the study. Waste was collected from the nearby restaurants and super markets kept as residues and leftovers in black polythene bag and transported to the laboratory where the experiments were performed. The waste was cleaned with tap water and then rinsed with the distilled water to remove the unwanted debris from the surface. Then cut into small pieces using a pair of scissors and crushed into small particles using mortar and pestle. The final chopped and powdered sample was used for further analysis.

Acid Hydrolysis

Chopped and powdered sample was weighed and 20g was taken in 4 separate conical flasks. Distilled water, 2 %, 6 % and 10 % of sulphuric acid was added to each conical flask respectively. The flasks were sealed and kept in water bath at 98°C for 2 hours, and autoclaved. Then the sample was filtered using Whatman filter paper, and the pH of each collected filtrate was adjusted to 4.5 using 10% Sodium Hydroxide and then subjected to further analysis (Saha *et al.,* 2005).

Estimation of sugar in the filtrate

Sugar content in the filtrate obtained was estimated by Fehling's test. 1ml of Fehling's reagent (A and B) was added to 1ml of each sample taken in a separate test tube. Test tubes were kept in boiling water bath for 5 minutes and observed for the development of colour. 1ml of distilled water in a separate test tube is used as control. The intensity of colour developed is used to calculate the quantity of sugar present in each sample.

Preparation of yeast culture

Yeast Extract Peptone Dextrose (YEPD)is a complete medium for yeast growth. Sterile YEPD medium was used for the preparation of yeast culture. 20g of dried yeast (*Saccharomyces cerevisiae*) was added to the 200 ml of YEPD broth and incubated at 30^{o}C for 48 hr. Growth of yeast can be evidenced from the appearance of turbidity in the broth media. The yeast culture was maintained in the refrigerator at 20^{o}C until required.

Fermentation

The fermentation was carried out along with saccharification (Kroumov *et al*., 2006 and Oghgren *et al*., 2006). Each filtered samples were taken in separate flasks and sterilized using autoclave for 15 min at 121°C. Sterility of the sample was checked by incubating the flask at 30°C for 48 hrs. *Saccharomyces cerevisiae* (yeast) culture was aseptically inoculated into each flask and kept in the incubator at 30°C for 7 days.

Fractional distillation

After 7 days of incubation, the fermented broth was dispensed in to a round-bottom flasks fixed to a distillation column enclosed in a running tap water. A heating mantle with the temperature adjusted to 78°C was used to heat the round-bottomed flask containing the fermented broth (Kroumov *et al*., 2006). A conical flask was fixed to the other end of the distillation column to collect the distillate. The amount of distillate collected from each sample was tabulated. The distillate collected was measured using a measuring cylinder and the results obtained were tabulated.

Confirmatory Test for Ethanol

A pinch of Potassium dichromate was added to 2 ml of distillate from each sample taken in a test tube respectively. The test tube containing mixture was shaken gently. Appearance of green colour will confirm the presence of ethanol in the tested sample mixture.

Results

Percentage sugar content of the filtrate after analysis

Assessment of sugar quantity in four different samples was given in the table–1. The result showed that the maximum sugar content was observed at 10% H_2SO_4 treated food waste sample with 12.3% of sugar, followed by 6 % H_2SO_4 treated food waste sample with 9.9 % of sugar, then 2 % H_2SO_4 treated food waste sample 7.4 % of sugar. Control (distilled water) treated sample formed the least amount of 1.1 % of sugar. The results obtained were used to plot a graph with percentage sugar content of filtrate after analysis at varying H_2SO_4 concentrations.

Table 1: Percentage sugar content of filtrate after analysis at varying H_2SO_4 concentrations.

S. No.	Sample	Sugar content %
1.	Distilled water + Food waste	1.1
2.	2% H_2SO_4 +Food waste	7.4
3.	6% H_2SO_4 +Food waste	9.9
4.	10% H_2SO_4 +Food waste	12.3

Quantity of ethanol produced after analysis

The results obtained from the analysis carried out showed that different amount of ethanol produced from food waste samples treated with different concentration of Sulphuric acid and fermented using *Saccharomyces cerevisiae* (Table – 2). It can be observed that the control (distilled water) treated sample has the minimum quantity of 11.1 ml of ethanol produced by the fermentation, followed by 2 % H_2SO_4 with 17.3 ml and then 6 % H_2SO_4 with 24.7 ml of ethanol. While, 10 % H_2SO_4 treated sample has the maximum quantity 36.2 ml of ethanol. The results obtained was used to plot a graph of quantity of ethanol (ml/g) against acid concentration (%) as presented in figure - 1.Also, from the graph it can be deduced that the quantity of the ethanol produced by the fermentation of food waste is directly proportional to the increase in concentration of H_2SO_4 in hydrolysis process.

Table 2: Quantity of ethanol produced after analysis at varying H_2SO_4 acid concentrations

S. No.	Sample	Quantity of ethanol ml/g
1.	Distilled water + Food waste	11.1
2.	2% H_2SO_4 + Food waste	17.3
3.	6% H_2SO_4 + Food waste	24.7
4.	10% H_2SO_4 + Food waste	36.2

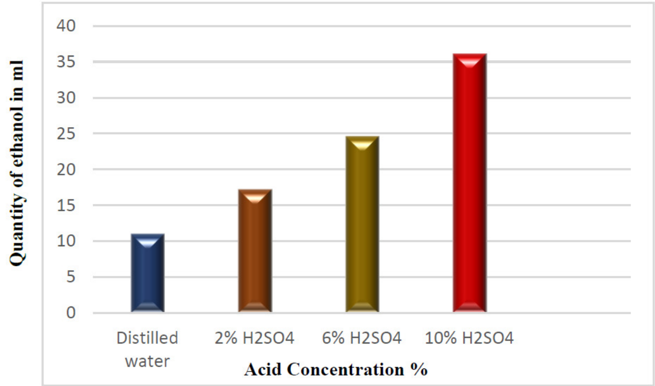

Fig. 1: Graphical representation of ethanol produced after analysis at varying H_2SO_4 acid concentrations

Confirmatory Test for Bio-Ethanol

The result obtained from the confirmatory test showed the formation of green color in the all four tested sample mixture with intensity of color grading from low to high based on the concentration of ethanol present in the different samples.

Discussion

It is evident from the result obtained that the increase in the concentration of acid in the process of hydrolysis resulted with production of substrate with higher amount of sugar molecules compared to other lower concentration of acid used for the analysis, resulting with increased production of ethanol. The experimental results obtained from the current study revealed that under applied conditions and effective hydrolysis of sugars, food wastes can be used as a potential resource for the production of bio ethanol. Optimum condition includes the using appropriate methods for the collection and pretreatment of solid food waste as it is evident that inadequate drying of the food waste samples withholds moist that makes it prone to fungal contamination and spoils the sugar content in the substrate as reported by Patel *et al*. (2006).

Acid pretreatment of food waste was carried out by using different concentrations of the sulphuric acid with the objective of extracting sugar in large quantity from the cellulose content of the organic waste. According to the results obtained from quantity of ethanol produced, percentage sugar content of filtrate was maximum at higher concentration of 10% H_2SO_4 treated food waste sample. The result is in agreement with the study reported by Mustafa *et al.* (2019) where rice husk sample was used as sample that yielded maximum sugar content on treatment with higher concentration of H_2SO_4 in the hydrolysis process. This indicated that the pretreatment of sample with sulphuric acid was very effective in increasing the release of cellulose content from the food waste. Similarly, Abbas *et al.* (2014) reported that acid hydrolysis of millet husk produced increased sugar content with increase in acid concentration whereas 3 % H_2SO_4 proved to be optimum concentration for potential yield.

Concentration of sugar substrate formed by the acid hydrolysis subsequently impacts the quantity of ethanol produced by fermentation process. In the present study ethanol yield quantity was higher with value of 36.2 ml produced by the fermentation of sample obtained by hydrolysis with high concentration of sulphuric acid. Patsalou *et al.* (2019) hydrolysed citrus peel waste through acid hydrolysis to produce bio ethanol revealed that 0.5% sulphuric acid given a higher yield of ethanol. Similarly, Danmaliki *et al.* (2016) observed maximum amount of sugar and ethanol yield were obtained from the acid hydrolysate of banana peel treated with 10% sulphuric acid at a temperature of 120ºC for 6 h to produce bio ethanol. Study hence showed that organic waste can be used as an efficient substrate for ethanol production. Therefore, from the findings of this work, proves that valorization of organic waste contributes simultaneously in waste management as well as ethanol production.

Conclusion

The production of Bio fuel from the food waste is the new trend where the waste can be reused as a useful source. In the current study, ethanol yield from dilute acid hydrolyzed organic waste increased gradually with increase in the concentration of acid used for hydrolysis. Hence it can be concluded that under optimum acid hydrolysis pretreatment conditions, bio ethanol can be produced effectively by microbial fermentation of organic waste.

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Conflict of interest

We declare that we have no conflict of interest.

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