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Bioethanol Production from Waste Potatoes as a Sustainable Waste-to-energy Resource via Enzymatic Hydrolysis

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Abstract. Ever increasing demand of energy and corresponding looming depletion of fossil fuels have transpired into a burning need of time to vie for alternative energy resources before the traditional energy sources are completely exhausted. Scientists are continuously working on sustainable energy production as an alternate source of energy to meet the present and future requirements. This research deals with conversion of the starch to fermentable carbon source (sugars) by fermentation through liquefaction by using yeast and alpha- amylase. The results show that the significant bioethanol production was achieved while using the parameters like temperature (30 °C) pH (6) and incubation time of 84 hrs. About 90 ml of bioethanol was produced from potato intake of 800 g. Pakistan being an agricultural country is rich in potato crop and this research bodes well to open new vistas to arrest the energy shortage in this part of the world

1. Introduction

Keeping global energy demand pathetic environment quality in view, it is dire need of renewable and sustainable liquid fuel and that can be achieved after the production of bioethanol. It will make future commitment to the energy solution [1].

Potato requirements of the Pakistan are estimated to be around 3 million tons per annum. This year the country is expected to have a record production of over 3.7 million tons. The hoarders have offloaded an estimated 300,000 tons of the last year's stocked potato in the wholesale market. [Source: Ministry of National Food Security and Research]

Pakistan may export 120,000 to 125,000 metric tons of potato to Russia as the demand for potato in Russia is increasing, said Harvest Trading's CEO Ahmad Jawad. Pakistan is making efforts to export the surplus to Sri Lanka, Turkey and Russia. It is important to mention that Pakistan lacked cold storage facilities in the past. The rising exports of citrus have helped develop a good number of storages in the agriculture heartland. The same facility is now being utilized for the storage of vegetables and fruits. <http://www.pakistantoday.com.pk/2016/01/22/pakistan-to-export-500000-tonnes-of-potato>

Globally interest is growing for production of ecological sustainable bio fuels. The target in the European Union is to adjust 5.75% of the fossil fuels which is used by traffic with biomass-based fuel from potatoes and corn as an ecologically sustainable bio-fuels by the year 2010 and 20% by the year



2020 [2]. Ethanol is a significant product of 21st century with its versatile usages and widely consumption across the globe.

The U.S. Energy Information Administration's recently released *International Energy Outlook 2016* (IEO2016) projects that world energy consumption will grow by 48% between 2012 and 2040. Most of this growth will come from countries that are not in the Organization for Economic Cooperation and Development (OECD), including countries where demand is driven by strong economic growth, particularly in Asia. Non-OECD Asia, including China and India, accounts for more than half of the world's total increase in energy consumption over the projection period. OECD-FAO, Agricultural outlook 2011–2020.

Pakistan existing capacity of fuel grade ethanol is 270000 tons per year, while it has a potential of 400000 tons per year. (Environment.gov.pk). Ethanol production from potatoes have enormous potential for industrial production which is environmentally friendly, highly productive, economic with low cost, and can be easily manipulated [3].

There is dire need to investigate the economical ethanol production from waste potato by applying the optimized fermentation process [4].

2. Material and Methods

In order to attain maximum fermentable sugar conversion optimum parameters are applied. Temperature: 30 °C pH: 6 and Incubation Time 84 hrs. Ethanol is mostly produced depends on quality of raw materials and the optimum conditions [5]. Alcohol from potatoes obtained from two enzymatic methods respectively [6]. Using Yeast only 2. Using Alpha amylase and yeast.

First of all raw potatoes of market are being washed properly as contamination along with layers could be removed. After that mash of potatoes were prepared as smooth as silk with the help of grinder or juicer by adding proper amount of distilled water. Homogeneously of solution is made which is afterwards processed to bio chemical or enzymatic reaction.

2.1. Yeast addition

The most common and simple method of forming alcohol from potatoes are yeast reaction to potato mash. First of all mash of potatoes are being prepared via heating the flour along water made up by grinder. Solution of water to potatoes is maintained at ratio of 2:1 (400 ml to 200 g of potatoes). Mash is afterwards heated to 30 to 60 minutes during that time temperature approximately climbs to 50 to 60 °C. After that solution is cooled down when it reaches to 30 to 35 °C. Normally the yeast (Rossmoor Food Product) added is 2 gms in diluted mash prepared [7].

Fermentation is something where microorganism comes in to play to let reaction happens. In that reaction ethanol along with CO₂ is formed. Fermentation includes solution which is yeast added is prepared than fermentation process takes place. Solution is kept at shaker for fermentation cause. Usually retention time for fermentation is 84 hours at room temperature as shown in figure 1 (A).

**A****B**

Figure 1. Shake Flask Fermentation (A), Distilled Ethanol (B)

Distillation could be called as most important step of ethanol formation from potatoes using yeast. Boiling point of ethanol is 78 °C and distillation of fermented shake is maintained at 78 °C along with continuous monitoring as shown in figure 1 (B) as distilled ethanol.

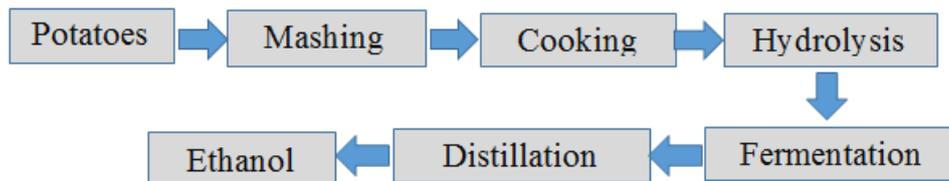


Figure 2. Ethanol Production by Yeast

2.2. Alpha Amylase Addition

This is process as compared to process described above. In this process first of all starch is being extracted from potatoes, which is nothing but the isolation process of starch.

If starch is used as raw material, potato mashing is not needed. Alpha amylase (AVONCHEM limited) enzyme is inserted. About 5 ml for mashing water and potatoes should be in 2:1. Than mash is cooked and stirred well almost for an hour. It is obvious that during that one hour temperature of mash will jump above 80 °C centigrade. Now that mash is cooled down until 60 °C centigrade and at this point remaining alpha amylase is added and mash is allowed to cooled down until 30 °C centigrade where 2 grams of yeast is added and fermentation is followed afterwards [8]. Generally, applied methodology step wise as shown in figure 2.

3. Result & Discussion

The study to produce alcohol from waste potatoes due as an inexpensive and cheap feed stock in Pakistan as an agricultural country is selected and it was first attempt.

Table 1. Survey of Jamshoro City

Area In Jamshoro	Process able Amount(kg)	Spoiled Amount(kg)
Phatak	10000-12000	700-900
Society	2000-3000	300-400
Wapda Colony	1200-1500	100-150

Table 2. Material Balance

SUBSTANCE	WEIGHT
WASTE POTATOES	800 g
MASH SUBSTANCE	200 g
YEAST	2 g
DISTILLED WATER	400 ml
ALCOHOL FORMED	90 ml

The survey has been done by collecting data from different areas of Jamshoro City, Pakistan. It was observed that large amount is left as waste potato shown in table 1, can be recycled for ethanol production.

About 800 g of potatoes were used and significant quantity about 90 ml of alcohol was produced from waste potatoes in Chemical Engineering Department of Mehran University of Engineering and Technology Jamshoro as shown in table 2.

Optimum parameters were selected as pH. 6, temperature 30 °C and incubation time 84 hrs. Finally the produced ethanol was analyzed and obtained satisfactory results as shown in figure 5.

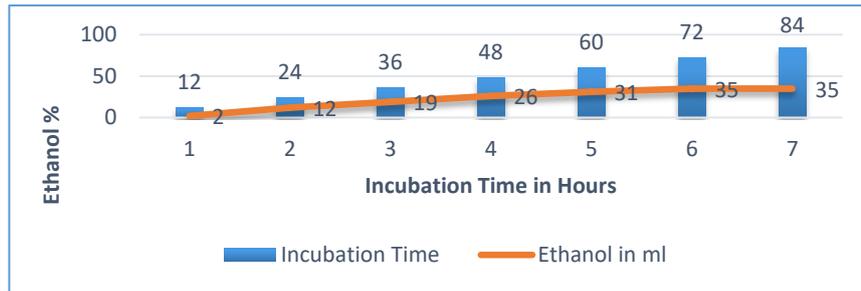


Figure 3. Ethanol % by Yeast

Concentration of alcohol determined from calibration curve, also known as a standard curve.

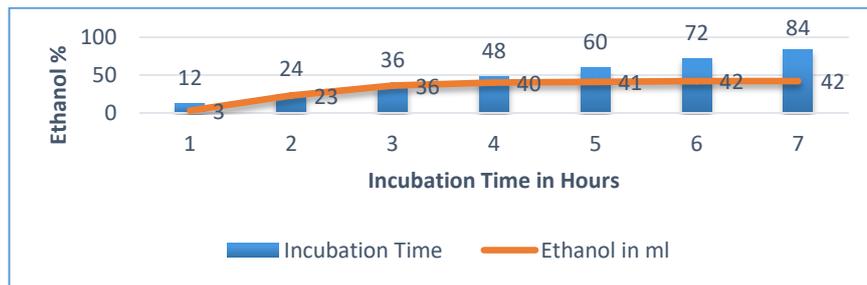


Figure 4. Ethanol % for Alpha Amylase

It has been analyzed that increased quantity around 10% was obtained by using alpha amylase as compared to yeast due to liquification by Alpha Amylase as shown in figure 4 and 5.

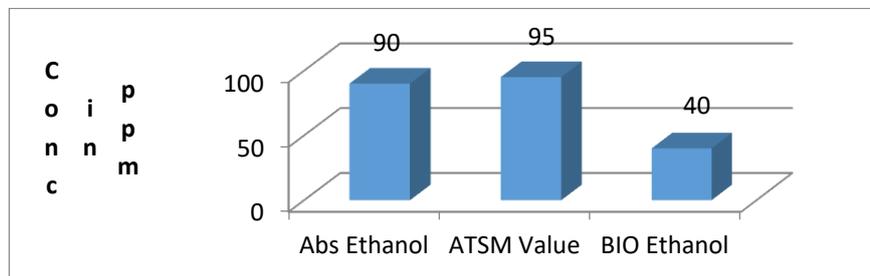


Figure 5. Net Concentration graph

According to ASTM and Absolute standards, the properties of alcohol were compared and found satisfactory as shown in figure 5.

4. Conclusion

Initially liquefaction was performed before fermentation process by adding first yeast then secondly yeast and Alpha Amylase. It was observed that after 72 hrs incubation period by yeast maximum conversion of fermentable sugars to alcohol obtained but in case of Alpha Amylase and yeast, the maximum conversion of fermentable sugars to alcohol is after 48 hrs, so it is concluded that waste potato contain great amount of starch that can produce significant quantity of bioethanol by enzymatic hydrolysis as alternative fuel. By yeast it is very low cost and cheap to produce bioethanol as by alpha amylase enzyme product is expensive. Therefore, it is still need to study/investigate the economical production of ethanol as a common source of energy by achieving optimized fermentation process.

5. Recommendations

It is feasible to establish bio fuel plant and would be economical and contributing to overcome energy crisis we are facing now a days in Pakistan surely address the Global warming issues. Feasibility report for Plant Cost estimation will be calculated.

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