Production of bioethanol from vegetable waste using a small scale reactor as an environment management system

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Introduction

It is very much evident that the combustion of the fossil fuels at the current rate would contribute to the environmental crisis globally (Chandel et al., 2007). Studies have revealed that there are attempts to develop alternative source of energy so as to conserve the dwindling reserves of crude oil and fossil fuels (Akpan et al., 2005;Taherzadeh and Karimi, 2008; Hossain and Fazliny, 2010).Bioethanol is considered as one of the best alternative energy sources since it is an environmental friendly and lower pollutant energy source which can be produced from the lignocelluloses out of the waste vegetables.

Ethanol can be produced by fermentation of any organic materials rich in carbohydrate through microbial activity. Yeast is one of the most important microorganisms in the production of ethanol through the fermentation. Previous study has proven that the use of *Saccharomyces cerevisiae*s train could optimize the fermentation performance using waste materials containing sugar and starch (Arumugam and Manikandan, 2011).The utilization of the waste feedstock for biofuel production does not disturb the food chain as it is a *waste-to-energy* concept based. The massive amount of agricultural waste (fruit and vegetables) generation necessitates the need of technology development to derive economic benefit by turning this waste into a useful product. For instance, one third of the agricultural products (vegetables and fruits) in Sri Lankan market system end in waste due to poor handling and storage practices. (Weerahewa et al., 2004).

Therefore, this study was mainly focused on the production of bioethanol from the rotten vegetables removed from the Sri Lankan market as an alternative energy source. Further, the fabrication of a low cost stirring batch type bioreactor system was highlighted to improve the efficiency of bioethanol production based on the requirement of environmental waste management system.

Methodology

In order to facilitate the bioethanol production from rotten vegetables, a portable small scale low cost bioreactor system was fabricated. The overall implementation and scaling up of the system was based on the waste materials mostly in order to eliminate the unnecessary costs. Further, a low cost solar dryer was fabricated to minimize the electrical energy consumption and to maximize drying process.

Approximately 40-45kgof agriculture waste materials which were not suitable for human consumption, were collected from the local vegetable markets. The selected vegetable waste were washed and cut into small pieces where they were subjected to sun dry for seven days under hot sun using the fabricated solar dryer. Dried waste materials were subjected for acid pre-treatment using Conc.H_2SO_4 (aq) 60 minutes of boiling at 120°C followed by adding distilled water and *Saccharomyces cerevisiae*according to a pre-determined ratio.

Different shaking hour combinations and different fermentation days were evaluated in order to obtain the optimum requirements. The pretreated mixtures with different shaking hours were filtered in to different schott bottles separately and measured pH and Total

Soluble Solids (TSS). Bioethanol concentration was estimated according to the method proposed by Williams and Darwin (1950). Then the statistically significant shaking hour and number of fermentation dayscombination was employed in to the fabricated bio reactor modal. Bioethanol concentration, pH and TSS values of the fermented mixture in the bio reactor was measured while maintaining the all other parameters constant as the laboratory experiment procedure.Chromic acid oxidation test,Ritter test and Lucas tests were carried out with respect to narrow down the justification of ethanol been produced (Pasto *et al*, 1992).AAS (Atomic Absorption Spectrometer) analysis was carried out for further identification of the elements in the produced raw bioethanol. The statistical analysis was carried out according to two factor factorial in Complete Randomized Design (CRD) experimental design using MINITAB 15.0 statistical package.

Results and Discussion

According to the results, the pH value and TSS values of the extracted bioethanol after fifth days of fermentation with six hour shaking time were significantly lower than that of the other shaking times (p=0.000). It is very much evident that the pH of the vegetable slurry tends to decrease with respect to the increment of the anaerobic fermentation process with*Saccharomyces cerevisiae*.

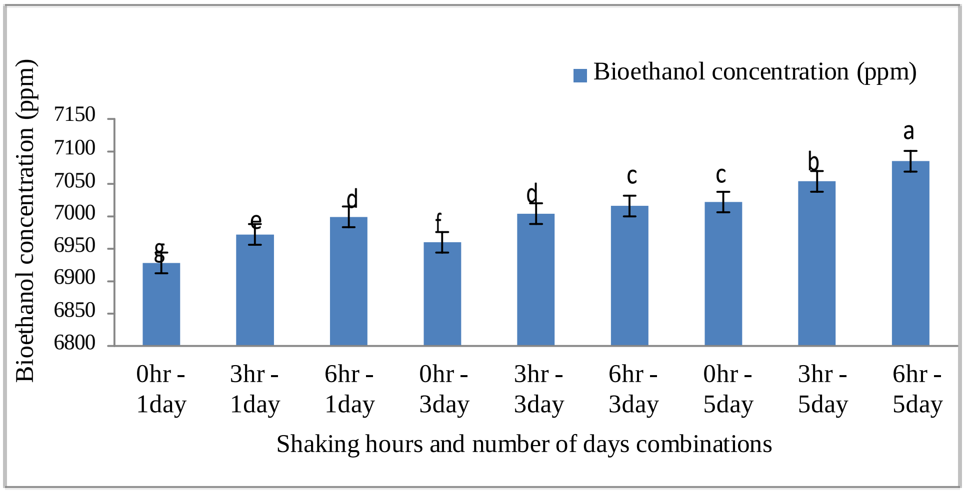

Figure 1. Mean bio ethanol concentrations (ppm) based on different shaking hours and number of fermentation days combinations. Vertical bars show standard errors.

Table 1: Results of ANOVA analysis for number of fermentation days and shaking hours.

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Day	2	0.0000117	0.0000117	0.0000058	151.75	0.000
Shaking	2	0.0000030	0.0000030	0.0000015	39.08	0.000
Day*	4	0.0000006	0.0000006	0.0000002	3.96	0.018

Figure 1 shows that the bioethanol concentration is increasing with the increment of the number of fermentation days. The highest bioethanol concentration was obtained after five days of fermentation with six hours shaking time. The results of ANOVA analysis shows that there is an interaction between shaking hours and the number of fermentation days (pvalue= 0.018).

According to the figure 2 and two sample t test, the mean bioethanol concentration obtained from the bioreactor sample was significantly higher than that of the bioethanol mean concentration value obtained from laboratory sample (p= 0.000).Therefore, it was compromisingly evident that the optimum parameters of shaking hours and number of fermentation days would improve the bio ethanol concentration in Bioreactor modal comparatively to the laboratory test sample.

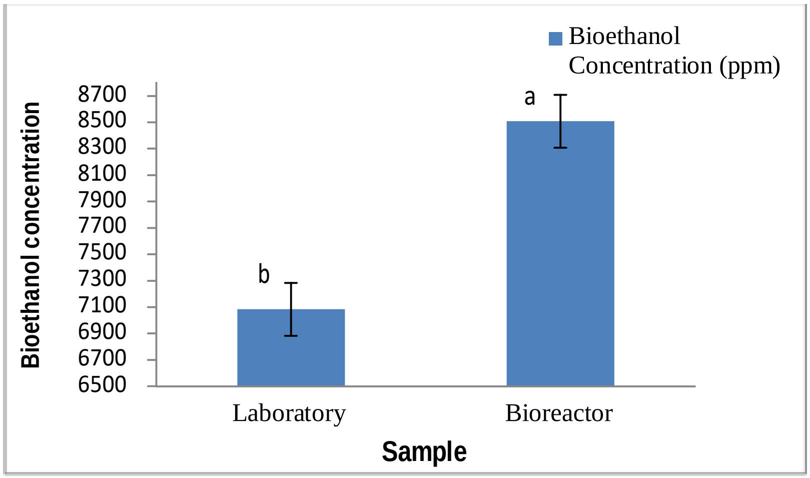

Figure 2. Mean bio ethanol concentrations from fermented vegetable mash at optimum shaking hours of six and number of days of five with relevant to laboratory sample and bioreactor sample.

The results of the AAS test showed that there were several metal elements (Zn, Ca, Mg and Fe) in the raw bioethanol sample. It was confirmed that all these metal elements were within the threshold values of the American Society for Testing and Materials (ASTM) D4806 & (ASTM) D5709 standards.

Conclusions

Production of bio ethanol increases with the increment of fermentation days and shaking hours. The optimum shaking hour ranges between three hours to six hours while the optimum number of fermentation days was five. The bioethanol production can be enhanced using the fabricated bioreactor prototype.

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