African Journal of Biotechnology Vol. 10(50), pp. 10157-10165, 5 September, 2011
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB11.790
ISSN 1684–5315 © 2011 Academic Journals

Full Length Research Paper

Bioethanol fuel production from rambutan fruit biomass as reducing agent of global warming and greenhouse gases

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Accepted 15 June, 2011

The depletion of fossil fuels impacts on the increase of petroleum price and has triggered the finding of alternative and renewable energy. Biofuel has attracted the attention of researchers all over the world due to reducing the environmental impacts of elevated carbon monoxide. Abundant of fruits waste can be reused in the bioethanol production. Hence, it can reduce pollution and waste material, thus, helps in waste disposal management and reducing global warming. The aim of the study of producing bioethanol from rotten rambutan was to manage rambutan wastes, cleaning the environment and reduction of greenhouse gases and global warming. This study was conducted from rambutan fruit waste biomass in different parameters using yeast (*Saccharomyces cerevisiae*) fermentation. The optimum condition of bioethanol yield was having 3 g of yeast at 30°C by following pH 6 for two days of incubation. Glucose content, total soluble solid (TSS) and pH values reduced after fermentation due to the conversion of glucose to ethanol and carbon dioxide in case of all parameters. The chemical content, viscosity and acid values of the bioethanol produced were within ASTM (American Society for Testing and Materials) standard specifications with less hazardous chemical content in produced bioethanol. Furthermore, the engine test result showed that greenhouse gas emission like hydrocarbon (HC), NOx and SO_2 content in E5 and E10 were significantly lower in bioethanol than in 100% gasoline tested in (proton Gen 2 multicylinder) car. Thus, it can potentially be used as good biofuel for petrol engine purposes.

Key words: Bioethanol, fruit waste, emission, renewable energy, global warming.

INTRODUCTION

Alternative fuel is currently an important issue all over the world due to the efforts on reducing global warming which is contributed by the combustion of petroleum or petrol diesel. Biodiesel is non-toxic, biodegradable, produced from renewable sources and contributes a minimal amount of net green house gases, such as CO_2, SO_2 and NO emissions to the atmosphere. (Hossain et al., 2008, 2010; Hossain and Boyce, 2009). To run the engine, gasoline was burnt to produce enough energy to work. When burning gasoline, there are some emissions produced like carbon dioxide and toxic substances, and they have a high reaction with sunlight. This results in pollution in the atmosphere (greenhouse gas) and high potential for forming the damage in ozone layer. With the emissions of CO_2 and nitrous oxide (Nox) taken into account, rambutan fruit is rich in the following components: fat, calcium, iron, protein, nitrogen, ash, sodium, zinc, magnesium, manganese, potassium, phosphorus, pH, vitamin C, vitamin A, thiamin, riboflavin and fiber. Eating five fruit in a day can seriously decrease the chance of cancer. “Rambutan fruit is also very effective in lowering blood pressure”. Rambutan is one of the most famous and highly grown fruits in the tropical areas of many countries such as Malaysia and has been very popular (wikipedia.org, 2009). That is why this fruit has been chosen for this study; currently there is little

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Table 1. Viscosity and acid value readings obtained were well within the ASTM standards.

Feedstock (pH)	Viscosity (cst)	Acid value (mgKOH/g)
4	2.23[a]	0.38[a]
5	1.58[b]	0.48[a]
6	1.62[b]	0.36[b]

information relating to the production of bioethanol from rambutan. Thus, this study was undertaken to investigate the production of bioethanol fuel from waste rambutan fruit biomass. The objectives of this study were: (1) to produce bioethanol energy from waste rambutan fruits via fermentation; (2) to determine the percentage of bioethanol produced; (3) to contribute in saving the climate of the environment through a reduction of the emission of environmental greenhouse gases: CO_2, NOx, HC, CO and SO_2; (4) to determine the composition of trace elements in the bioethanol produced appropriately for a petrol engine.

MATERIALS AND METHODS

Sample preparation

All experiments were conducted using rotten fruit to produce ethanol and compared with the unpublished data to each other regarding rambutan, mango, banana and pineapple for the ethanol production under same conditions. The fruits were washed, cut into small pieces together with their skin and blended in a Philips household juice blender for 3 min. The skin and the juice obtained were mixed together before dispensing them into 1 L schott bottles and experiments were done in triplicates. Each bottle contained 100 ml of the mixture. The fresh weight was measured. The total soluble solids (TSS) and the pH of the mixture before fermentation were also measured. The initial pH for rambutan juices were measured and tabulated properly.

Fermentation

The general process of fermentation is described as a reaction in a schott bottle containing fruit contents and yeast. The optimum ethanol production as a result of fermentation which was investigated by using different parameters as following: the optimum yeast concentration for maximum ethanol production was determined with the addition of 4 g/l of yeast in the mixture containing fruit contents and the bottles were shaken so that the yeast was mixed together with the samples. The samples were then placed in the incubator at 30℃ and left there for 3 days. Parameters studied were fermentation incubation time, fermentation temperature and fermentation different pH. Fermentation incubation time was conducted at 1, 2 and 5 days. The skin, pulp and mixture of the fruits separated to be used for the fermentation involving different components of fruits have been blended to activate the yeast. Fermentation was followed after the enzymatic digestion of the pH was adjusted using 5 M atrium hydroxide (NaOH) to increase the pH and 1 M acid hydrochloride (HCl) to decrease the pH whenever needed.

Enzymatic hydrolysis

The enzymatic hydrolysis was performed to facilitate the fermentation by yeast releasing sugars from cellulosic fruit's biomass. Enzymatic hydrolysis was carried out at the temperature recommended by the manufacturer. The reaction was emanated by boiling the reaction.

Fermentation of different pH parameter

The fermentation method of pH was the same as previously stated. The pH of samples was adjusted to 4, 5 and 6.

Fermentation of different temperatures

The fermentation method was the same as stated earlier, instead of change in the temperatures to 28, 30 and 35℃.

Fermentation in different period

The fermentation method of different period was the same as stated earlier. The different period used was 24, 48 and 72 h.

Filtration

After a specific reaction time, the mixtures in the bottles were then filtrated using a beaker covered with a piece of folded cheese cloth. The liquid obtained was the raw bioethanol. The volume of the raw bioethanol was measured using the measuring cylinder and it was then transferred into a plastic bottle and labelled. The pH and TSS of the raw bioethanol were measured, and weight of the residues was also checked.

Chemical and viscosity test

Samples from fermentation pH parameter were tested for chemical components and viscosity test. Chemical analysis by using multi element oil analyzer (MOA) II was conducted to measure various chemical components that can be found in the bioethanol. Samples for parameter time were also analyzed for the viscosity of the bioethanol produced (Table 1).

Engine test

Samples that have been tested for chemical and viscosity analysis were tested to run the multicylinder engine of Proton Gen2.

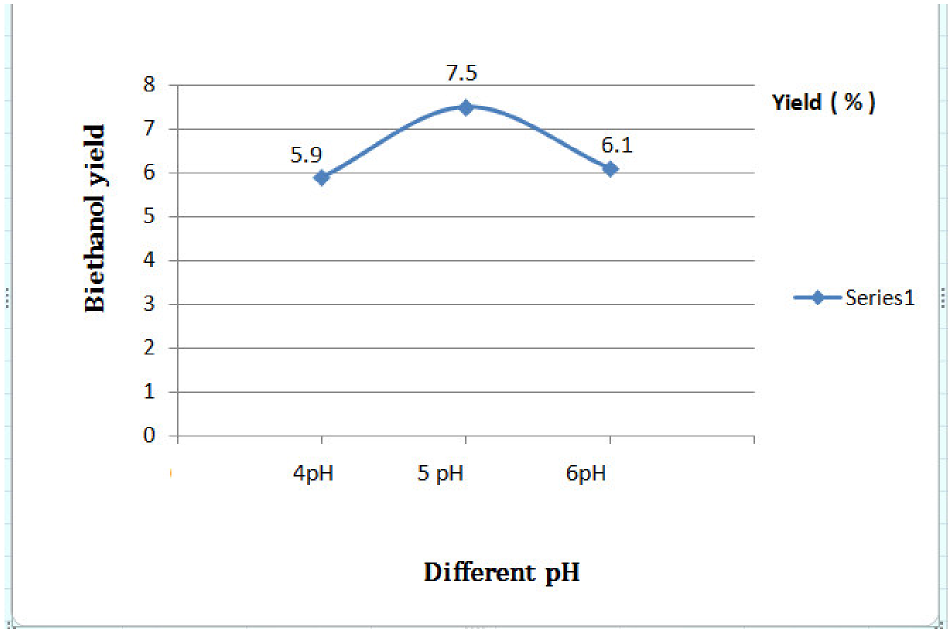

Figure 1. The bioethanol yield in different pH parameters.

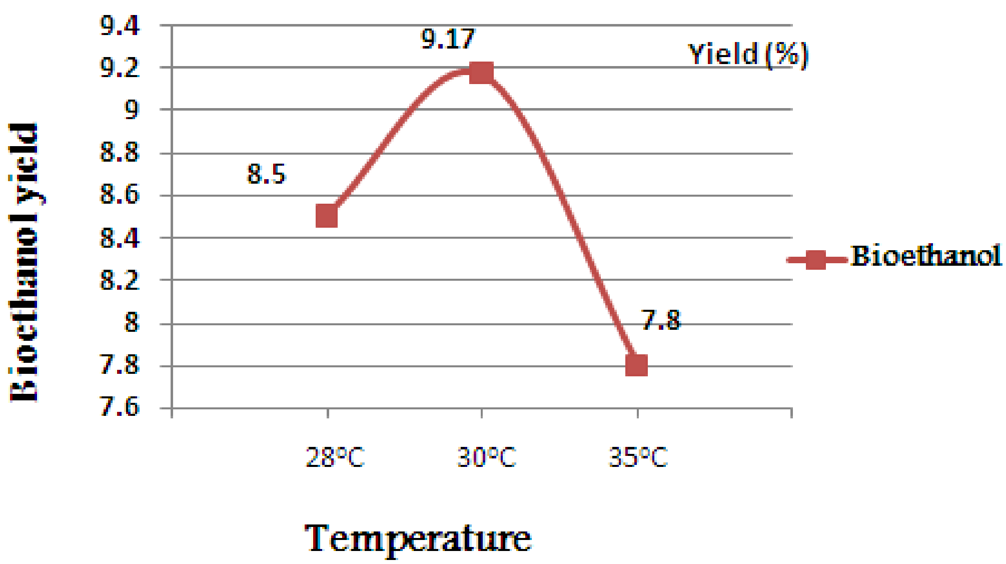

Figure 2. The bioethanol yield in different temperature.

RESULTS

Fermentation of different pH parameter

Bioethanol yield was investigated at different pH using rambutan fruits (Figure 1). The bioethanol production at pH 5 showed the highest with 7.5%, followed by pH 6 and pH 4 in which bioethanol was decreased to be 4.16 and 3.17%, respectively. The range of the percentage of bioethanol production between pH 4 to 6 showed a significant difference.

Fermentation of different temperatures

The percentages of bioethanol production were shown at different temperatures for 28, 30 and 35°C using rotten rambutan wastes and yeast, *Saccharomyces cerevisiae* (Figure 2). It was observed that the maximum ethanol production was at temperature 30°C with 9.17%, followed

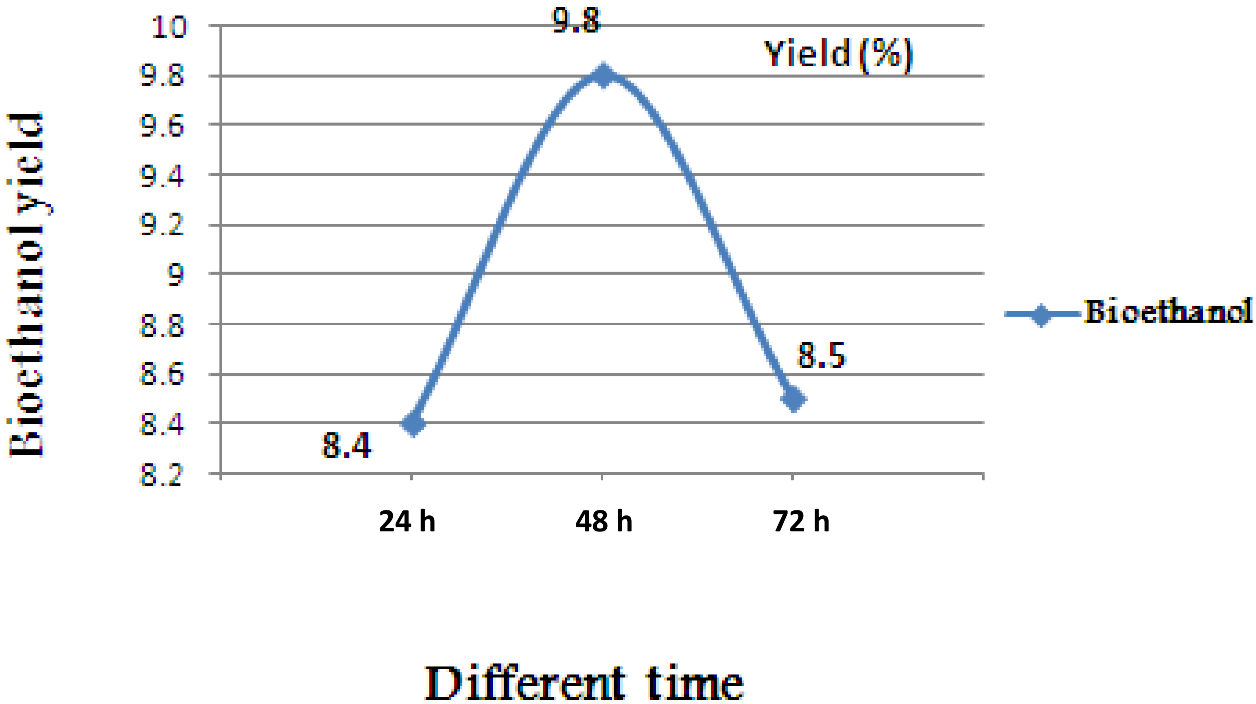

Figure 3. The bioethanol yield in different period.

by 32°C with 8.5% and at room temperature of 28°C, it produced 7.8% of ethanol that was the lowest among of the parameters.

Fermentation in different period

Fermentation was conducted at different time duration to produce ethanol from rotten rambutan fruits (Figure 3). Time duration was set from 1 to 4 days and the products were analyzed to determine the percentage of bioethanol different factors including change in pH, TSS and glucose contents. Ethanol production from one to four days was 8.4, 9.4, 8.5 and 7.4, respectively.

DISCUSSION

Fermentation of different pH parameter

Bioethanol yield was investigated at different pH using rambutan fruits (Figure 1). The bioethanol production at pH 5 showed the highest with 7.5%, followed by pH 6 and 4 in which bioethanol was decreased to 4.16 and 3.17%, respectively. The range percentage of bioethanol production between pH 4 to 6 showed significant difference. The maximum consumption of the total suspended solids (TSS) was noticed at pH 5 and then a gradual decrease in consumption was recorded on pH 4 and 6. Glucose content was observed at pH 5 minimum. In case of pH 5, the glucose content was reduced remarkably. All biological processes were affected by the pH because all biological processes are catalyzed by enzymes which are by definition proteins and tertiary structure that can be broken by extremes in hydrogen and hydroxyl ion concentration which is what pH mea-sures. The suitable pH found for fermentation of fruit was pH 5 to facilitate the enzymatic catalysis of the available sugars into ethanol. Chon xiaoGao and Fleetn (1988) has reported the survival and growth of *S. cerevisiae*, according to the authors, this yeast can tole-rate the ethanol concentration up to 15% but the sensi-tivity of yeast cells to ethanol was marginally increased on decreasing the pH from 6 to 0 to 3 to 0. It showed that the pH had an important impact on ethanol production and yeast cell concentration. Ogunya et al. (2006) reported that when the experiment was conducted at pH 3.4 and 4.1 ethanol production was enhanced from pineapples juices. It was also reported that the pH did not affect the ethanol's yield in the range of 3.5 to 6.0 when pineapple effluent was need as substrates (Muttamara et al., 1982).

Fermentation of different temperatures

The percentages of bioethanol production are shown at different temperatures for 28, 30 and 35°C using rotten rambutan wastes and yeast, *S. cerevisiae* (Figure 2). It was observed that the maximum ethanol production was at temperature 30°C with 9.17%, followed by 32°C with x

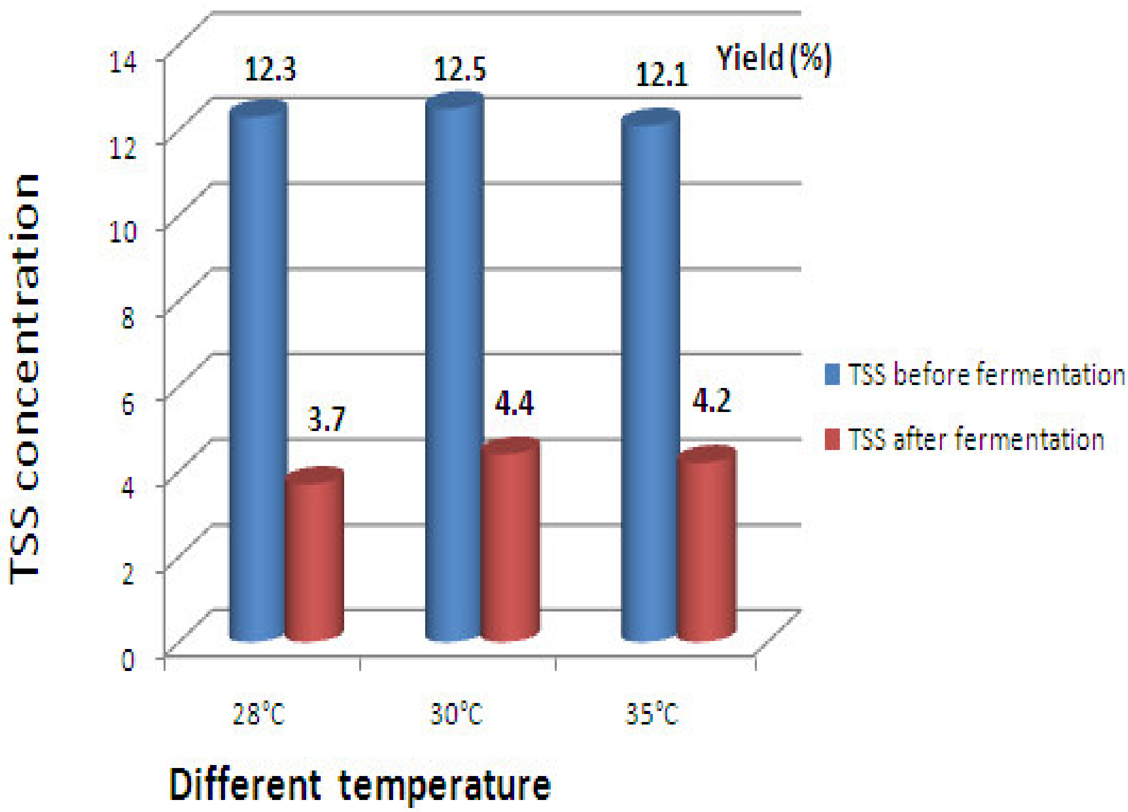

Figure 4. Total soluble solid (TSS) in different temperatures (TSS and glucose).

consumed during the fermentation reaction than it will be after fermentation.

Viscosity

The result for viscosity was found that there was no dangerous element in its acceptability as a transportation parameters. Hence, the strain of yeast, *S. cerevisiae* has performed better at 30℃ than other temperatures. The experiment at 28℃ produced the lowest yield compared with the others parameters which is 30 and 32℃. This is because at low temperatures, the reaction rates of all metabolic functions was slowed down and it reduced the substrate and product diffusion rates for higher ethanol yields. William and Munnecke (1979) reported that the immobilized cells of *S. cerevisiae* could resist the adverse conditions of temperature and pH, but the free cells had usually a range of moderate temperature, in this case the optimum temperature was found at 30℃ for maximum ethanol yield, reduction of the TSS and glucose contents.

Fermentation in different period

Fermentation was conducted at different time duration to produce ethanol from rambutan fruits (Figure 3). Time duration was set from 1 to 4 days and the products were analyzed for different factors including change in pH, TSS, glucose contents and ethanol. Ethanol production from one to four days was 8.4, 9.4, 8.5 and 7.4, respectively. Two days or 48 h fermentation retention time was chosen best for ethanol production which is 9.4%. Initial pH was recorded as 5.2 in all cases, but the lowering in pH was found different as 4.22, 4.19, 3.81 and 3.91, respectively in the cultures grown for 1 to 4 days. Sharma et al. (2007) has reported that maximum ethanol can be produced within 48 h of incubation time. Measurement of TSS revealed that the maximum clarity was observed in experimental vessel carrying fermentation for one day, as it was reducing the TSS from 12 to 3.0. In case of fermentation with 2 to 4 days, the final TSS values were found to be 3.5, 3.17 and 3.17, respectively. The residual glucose concentration was measured and it was found that glucose content was 3.5, 3.8, 3.6 and 3.6 in 1, 2, 3 and 4 days cultures, respectively.

TSS and glucose

The TSS and glucose also decreased during the fermentation period (Figures 4 and 5), of which the initial TSS was (12.3, 12.5 and 12.1) for temperatures of 28, 30 and 32℃ and reduced to 3.7, 4.4 and 4.2, respectively.

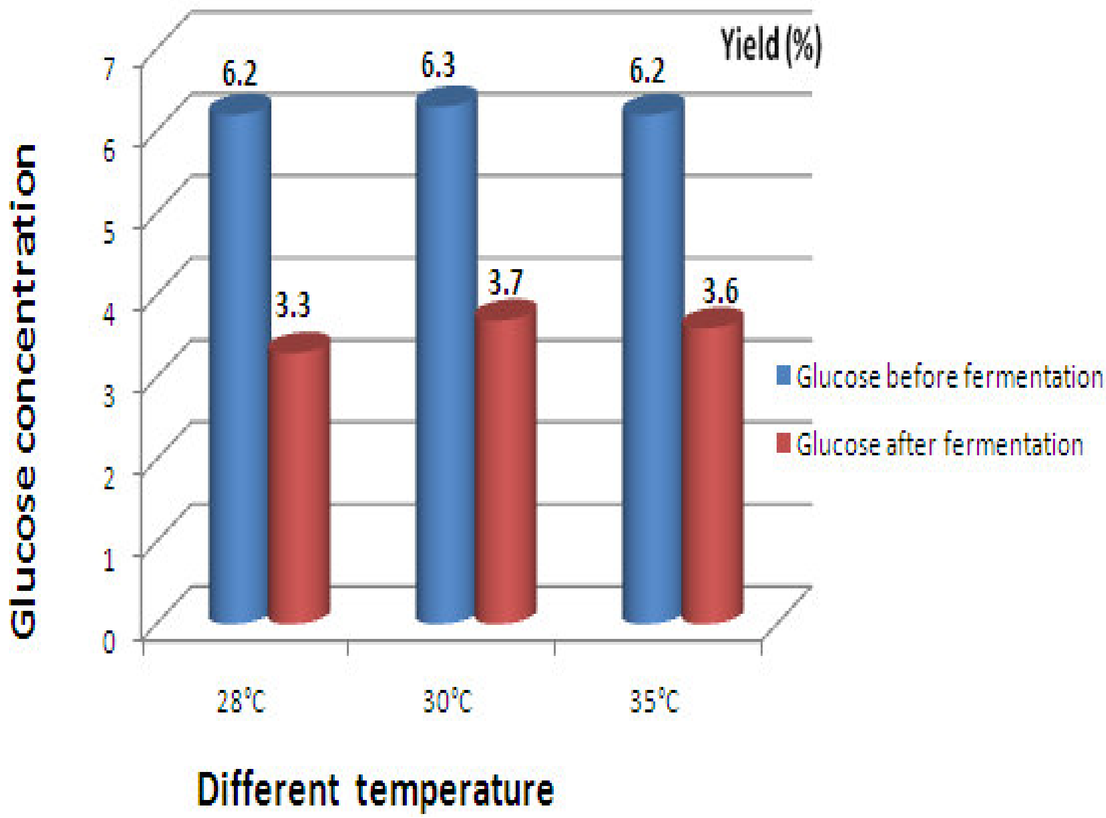

Figure 5. Glucose concentration in different temperatures.

And the initial glucose was (6.2, 6.3 and 6.2) for all temperatures and then, reduced respectively to 3.3, 3.7 and 3.6. This means that the reaction works in the correct way, because the total soluble solid and glucose will be consumed during the fermentation reaction than it will be after fermentation.

Viscosity

The result for viscosity was found that there was no dangerous element in its acceptability as a transportation fuel based on ASTM standard (under American Society for Testing Materials) standard in different ph (Table 1).

Chemical analysis

The anhydrous ethanol was analyzed and it was found that these elements were mostly contained (Fe, Al, Cu, Sn, Mn, Ag, Mo, Zn, P, Ca, Mg, Si, Na, B and V) in the samples of ethanol production from rambutan wastes and there was no significant difference among all the elements (Figure 6). The anhydrous ethanol samples that have been produced from rotten rambutan wastes are very suitable to be used as one of the sources of fuel and it is very safe because they do not contain any dangerous elements and some elements are found at the range of limited acceptance based on the ASTM standard.

Engine test

Fuel consumption and greenhouse gas emissions were significantly lower in bioethanol fuel (5 and 10%, E5 and E10 fuel) than in natural fuel (100% gasoline) when tested in the Malaysian proton car engine (Figures 7 to 9).

Conclusion

From this study, it can be concluded that ethanol can be produced from waste rambutan as the substrates and the optimum bioethanol yield can be produced at 30°C having pH 5 during 48 h and its use lead to a lower fuel consumption and reduce emissions of environmentally unfriendly gases. From total soluble solid, glucose and viscosity analysis, bioethanol yield from rotten rambutan wastes had the values which could be accepted based on American society for testing and materials standard. Fuel consumption and greenhouse gas emissions were significantly lower when tested in the Malaysian proton car engine. From the chemical analysis results, the raw

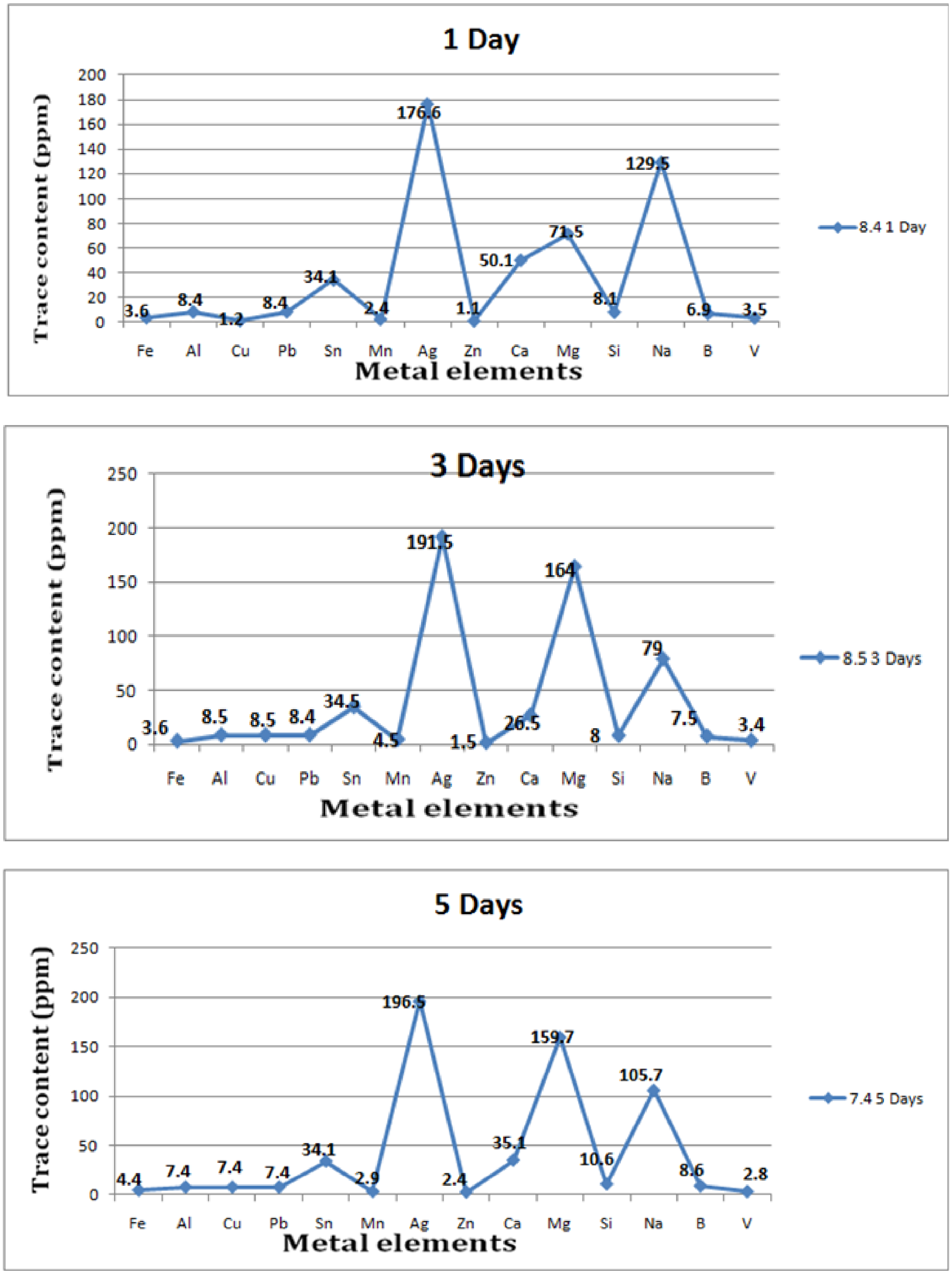

Figure 6. Compositions elements of 1, 3 and 5 days of fermentation.

ethanol yield from rotten rambutan wastes was in acceptable values based on American society for testing and materials standard. This led to the encouragement of the use of bioethanol from rotten rambutan wastes, as it

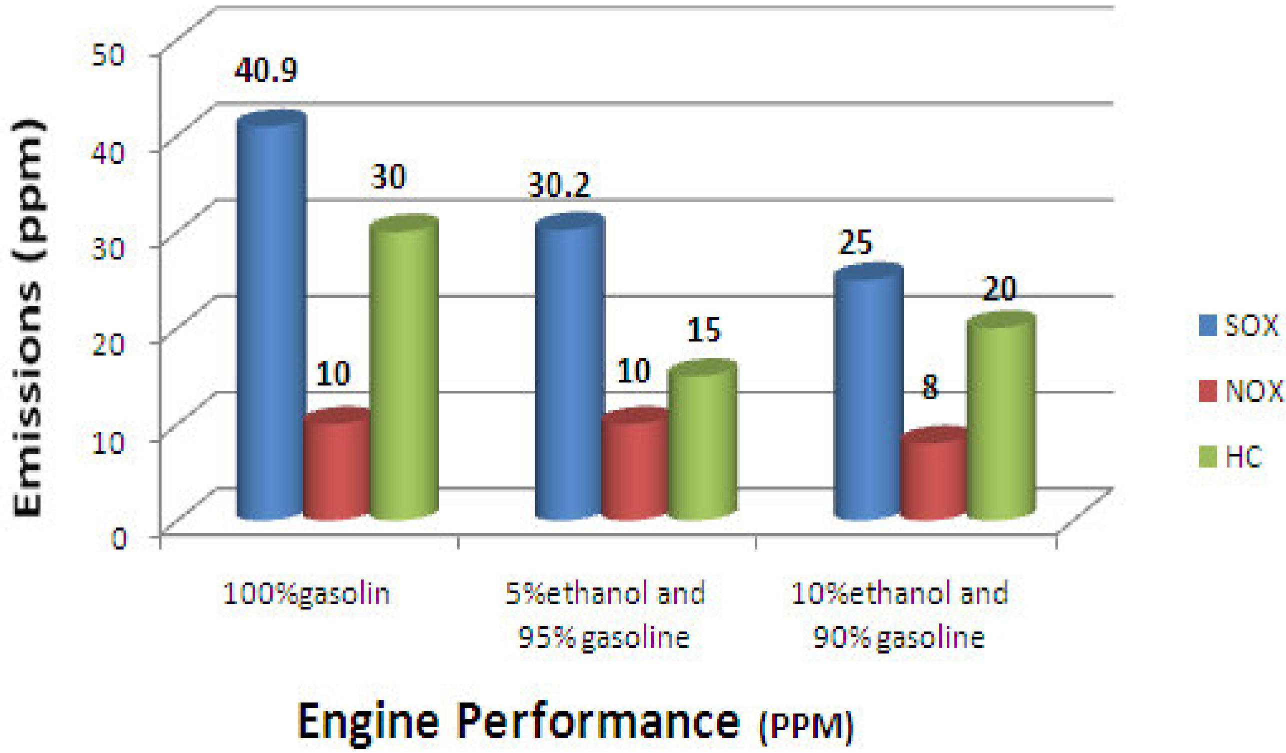

Figure 7. Engine emission of Hc. Nox. Sox.

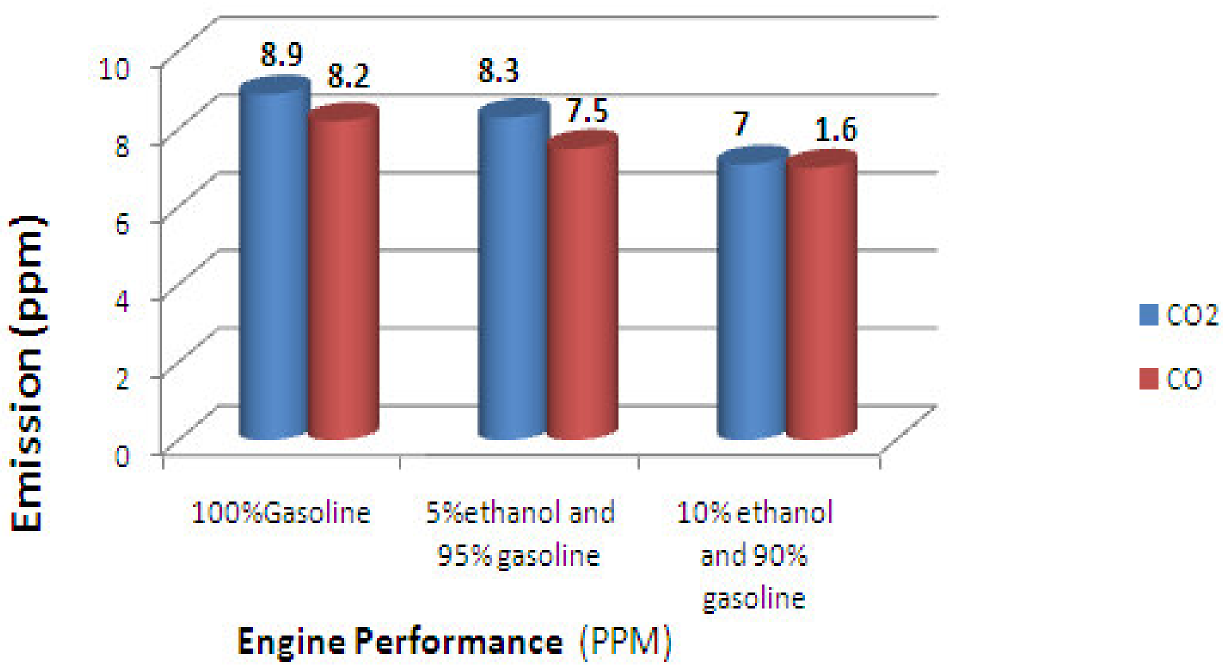

Figure 8. Engine emission of Co. Co_2.

did not pose any danger for the engine, which has low total soluble solid, glucose and viscosity value. Also, high element value was not seen, which makes it suitable for the car engine to work well, thus, the safety and quality of

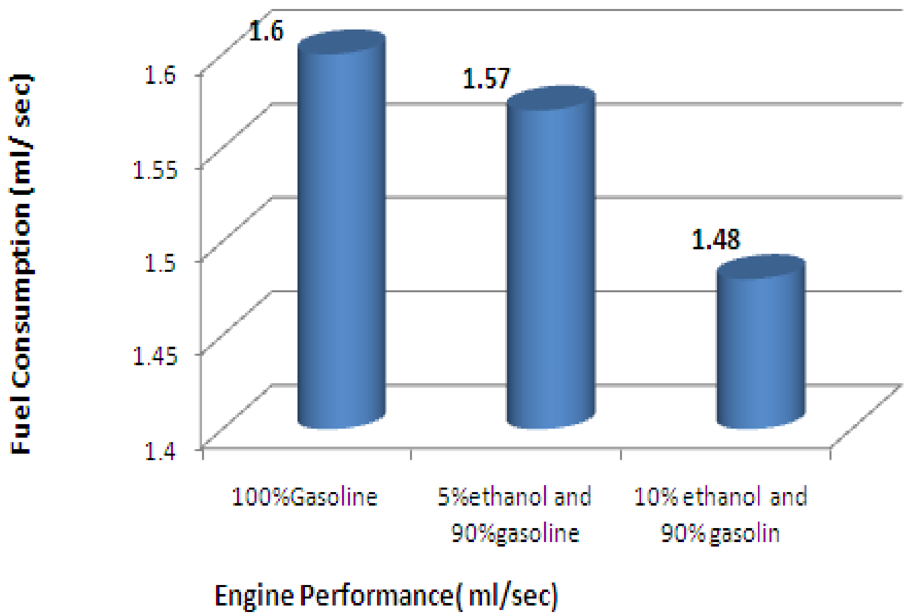

Figure 9. Engine performance.

the engine was preserved. All that spurt using bioethanol from rotten rambutan wastes were safe for the environment, and they contribute to reducing the problem of the ozone layer, decreasing global warming problem and greenhouse gas, and could help to overcome fossil fuel depletion problem with finding a renewable source of bio fuel.

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