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Bioethanol made from Muskmelon (Cucumis Melo) Peels as an Alternative Fuel

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Abstract*: *In order to decrease the dependency on fossil fuels, bioethanol has been discovered as an alternative fuel source. Bioethanol that is produced from waste sources are one of the promising fuels in the future that will lessen the environmental problems such as to evade the formation of greenhouse gases in atmosphere and controlling the waste disposal system by utilizing the wastes into beneficial product. Therefore, the goal of this study is to determine the ability and efficiency of muskmelon peels in production of bioethanol as an alternative fuel by using Saccharomyces cerevisiae yeast in the fermentation process. Muskmelon peels has a great potential as substrate owing to its wide availability, economical and contains mixture of carbohydrates such as glucose, sucrose, and fructose that can be utilized during fermentation culture. The process for producing bioethanol includes the preparation of muskmelon peels, fermentation, sterilization, distillation and condensation. The produce bioethanol was compared to the characteristic of pure ethanol such as colour of the soot, flame and solution as well as pH value, and odour. The burning test of the bioethanol revealed that the flame had medium size of orange-bluish colour with no smoke. The solution was colorless with pH 7.52 and had a strong fruity smell. The gas chromatography-mass spectrometry analysis confirms the existence of ethanol in the produced bioethanol, showing its potential to be developed as a substitute for fossil fuels.

Keywords*: *Bioethanol, renewable energy, muskmelon peels, fermentation, pure ethanol.

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I. INTRODUCTION

Biofuels are renewable energy mainly in the form of liquid or gaseous fuels that is produced from biodegradable products [1]. Advanced and efficient conversion technology has enabled the extractions of biofuels from natural sources to combat the problem of limited existing sources of fossil fuels which are currently insufficient to support the future demand. Apart from that, the utilization of fossil fuels to meet the world's energy demand will increase CO_2 in the atmosphere and cause global warming by releasing toxic gases into the atmosphere that can contribute to the greenhouse gases formation during combustion. Generally, there are various sources in producing the biofuels such as cellulose, algal oil, corn, sugar cane and many more [2]. These biofuels are known as renewable energy because the production itself is from food crops that grows naturally from plants and fruits. Moreover, the wide availability of plants and fruits has making it variety and unlimited sources for fuels [3].

Ethanol produced from renewable energy sources is one of the most promising biofuels for the future. Bioethanol (CH_3CH_2OH) is a liquid biofuels which can be produced from several different biomass feedstocks and conversion technologies [2]. Bioethanol is a clear, colorless alcohol made from a variety of biomass called feedstocks and mainly produced through fermentation of sugars available from the crops that contain starch [3].

The production of bioethanol liquid requires the usage of large amount of organic waste such as leftover food, fruit peels, plants and many more. All these solid wastes can be a major problem if not properly managed. Factors such as population growth, urbanization and rapid economic growth has contributed to the food waste generation where some of these wastes can be converted into fuel. Malaysians generate waste 15,000 tons of food daily, where about 20% to 50% are fruits and vegetables being dispose [4]. The increasing generation of excessive waste will cause insufficient landfill area for disposal and reduce the lifespan of the landfills. Hence, the utilization of domestic waste as the production for bioethanol is a good way to preserve the environment and generate profits to the gas industry. Since bioethanol is produced from biological products, the combustion of bioethanol results in cleaner emissions. Bioethanol is commonly used in fuels industry as an additive for petrol.

The blending of bioethanol with petrol will oxygenates the fuel mixture so that it burns completely and reduce the emissions of harmful substances into the atmosphere [5]. Bioethanol has many advantages than the conventional fuels as it is more environmental friendly energy sources, has wide availability, and economic.

The utilization of bioethanol as fuel will improve the air quality, operations of vehicles, minimizes harmful gas emissions, and also waste generation [10], [11].

II. MATERIALS AND METHODS

A. Materials

The muskmelon peels were collected from a local fruit stall at Pagoh, Johor, Malaysia. The milk used in this study was fresh milk (Dutch Lady, Malaysia). The yeast was purchased from Mauri-pan Instant Yeast (AB Mauri, Malaysia). Ethanol used was analytical grade with high purity (>99%) purchased from HmbG Chemicals (Hamburg, Germany).

B. Preparation of Muskmelon Peels Sample

The collected muskmelon peels should be in good condition and fresh, in order to produce a good quality extraction. The muskmelon peels chosen was also from the ripe muskmelon fruit and not from the rotten fruit. For about 1 kg of muskmelon peels was used to produce certain amount of bioethanol. The muskmelon peels must be kept carefully in a closed container to avoid any unwanted gas released during decomposition process as shown in Figure 1.

Fig. 1 Muskmelon peels.

C. Preparation of Substrate

Substrate was prepared by mixing muskmelon peels with stale milk to help in producing more glucose and carbohydrates as well as speed up the fermentation process. The muskmelon peels should be clean from any residual as this will affects the quality of the produced bioethanol. The clean muskmelon peels were blended with some distilled water and mixed until smooths. The purchased milk was left open for at least 3-4 days until it become stale and being blended with the muskmelon peels. The ratio used is 250 g of muskmelon peels to 500 g of stale milk. Later the produced substrate was placed in a 1000 mL glass bottle and kept tightly to avoid any spills.

D. Preparation of Starter

Starter is a mixing of glucose and distilled water. The mixture of glucose and distilled water was added into the mixture of muskmelon peels in order to enhance the amount of sugar in the solution and help produce bioethanol. The ratio used is for every 250 g of muskmelon peels: 100 ml of glucose**:** 1000 ml of distilled water. The glucose and distilled water must be dissolved properly before proceeding to the next steps.

E. Sterilization and Fermentation Process

The process of sterilization and fermentation was conducted to produce mixture that contains high content of carbohydrates. During the process of fermentation, the rate of carbohydrates in the substrate will increase and this will help to stabilize the protein and carbohydrates in the muskmelon peels. The starter and substrate was placed in autoclave to obtain sterile condition by preventing decomposition of microorganisms other than yeasts [8]. Next, 50 g of yeast *Saccharomyces cerevisiae* was mixed into the starter solution and stirred until the solution dissolved homogeneously. Microorganisms such as yeasts play an essential role in bioethanol production by fermenting wide range of sugars to ethanol [9]. After that, both substrate and starter were placed inside the incubator for 8 hours, with constant temperature of 30^{o}C. Yeast growth rate and its metabolism increase as the temperature increase until it reaches the optimum value. During the process of fermentation, yeast needed to be at optimum condition to operate efficiently. Therefore, it is important to ensure constant temperature rate of 30^{o}C throughout the fermentation process. After the process of fermentation in incubator is completed, substrate was mixed with the starter. The produced mixture was fermented for 50 hours. The ethanol fermentation from sugar is based on Equation 1 as follows:

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2 \quad (1)$$

F. Distillation Process

Distillation was performed to separate the alcohol from the sample prepared after the fermentation process to get the pure bioethanol without any impurities and residues. The fermented sample was heated using fractional distillation equipment to produce gas that later will be converted to liquid (bioethanol). The process of distillation was conducted at constant temperature of 78.37^{o}C until all the bioethanol was properly separated from the sample.

G. The Physical Test of Bioethanol Compare to Pure Ethanol

The produced bioethanol must be kept carefully to avoid the release of gas. Certain amount of bioethanol was collected in an aluminum weighing dish for burning process and compare to the pure (standard) ethanol by several observations that include the colour of the soot, flame and solution, pH value, and odour of the bioethanol produced. The color of the soot, flame, and solution was observed visually, while the solution pH was determined using a pH meter (HANNA) and the odour of bioethanol was observed by smelling.

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H. GC-MS Analysis

The bioethanol sample was further analyzed by using gas chromatography-mass spectrometer (GC-MS). The compounds present in the bioethanol sample were identified by observing the peak of the chromatogram. The flowchart methodology of this study is shown in Figure 2.

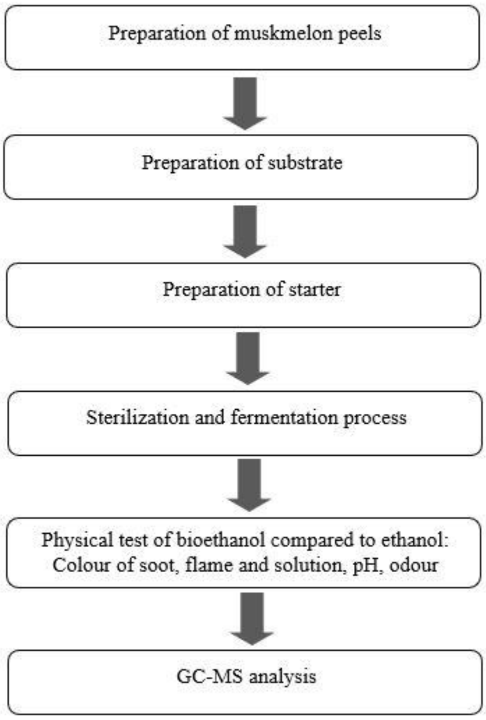


Fig. 2 Flowchart methodology of the study.

III. RESULT AND DISCUSSION

A. Physical Comparison of Bioethanol to Pure Ethanol

The characteristic of the bioethanol and pure ethanol was observed and recorded as shown in Table 1.

Table 1. Comparison between muskmelon peels bioethanol and pure ethanol

Physical test	Muskmelon peels bioethanol	Pure ethanol
Colour of soot	Clear white	Clear white
Colour of flame	Orange-bluish	Orange-bluish
Colour of the solution	Clear	Clear
Odour	Strong smell	Less odour
pH	7.52	7.47

B. Colour of the Soot

The observed colour of the soot was a clear and barely seen by naked eyes in normal light condition. The soot is colorless and clean for both muskmelon peels bioethanol and pure ethanol during the combustion process. Close observation of the bioethanol soot colour was not the same as soot produced from the burning of candlelight or paper. Since the soot is clean and clear, the bioethanol and pure ethanol does not produce any smell during burning.

C. Colour of the Flame

During the burning test, flame is one of the most important factor to be observed since different colour of the flame indicate different solution, such as the flames of burning methanol is completely blue, but for ethanol the flames is orange-bluish. The colour of the flame obtained for both muskmelon peels bioethanol and pure ethanol were orange-bluish. The blue flame was observed on top of the ethanol solution contained in the aluminum weighing dish, then turns orange as the flame getting brighter. Figure 3 and Figure 4 shows the flame produced from pure ethanol and muskmelon peels bioethanol solution, respectively. The pure ethanol can be seen to burns vigorously while the bioethanol burns with medium flame. The size of flame during the burning of the bioethanol is smaller than the pure ethanol. This might be due to the compound inside the solutions that is different from the pure solution as bioethanol was produced from fermented organic waste materials. The ethanol burns well because the molecule contains oxygen during burning process and the oxygen from air will help to burn more completely. Good combustions will lead to less emissions of harmful substances to the environment [10].

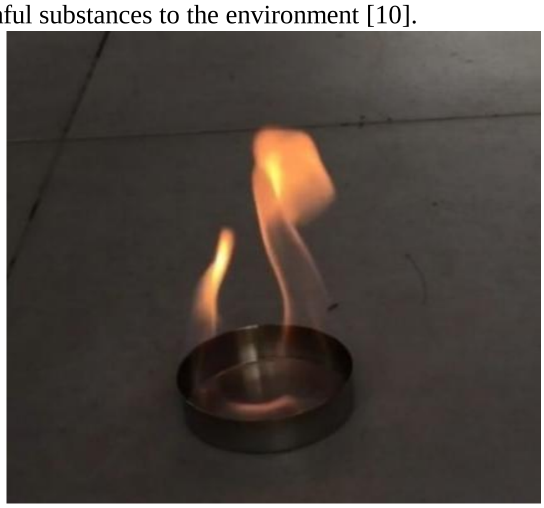


Fig. 3 Flame produced from pure ethanol.

Fig. 4 Flame produced from muskmelon peels bioethanol.

Another test was conducted to record and compare the duration of flames observed during the burning of muskmelon peels bioethanol and pure ethanol.

About 200 µL volume of both liquids were placed in the aluminum weighing dish. Table 2 shows the results of duration of flame observed during the burning of muskmelon peels bioethanol and pure ethanol. The duration of flames observed for both liquids were same, but the size of flame for muskmelon peels bioethanol was smaller than the pure ethanol. This happened due to bioethanol contains lower energy density of 66% than gasoline. Other than that, bioethanol also has low flame luminosity and vapor pressure [10].

Table 2. Duration of flames during the burning of muskmelon bioethanol and pure ethanol

Types of solution	The volume of solution (microliter, µL)	Time (second, s)
Muskmelon peels bioethanol	200	13
Pure ethanol	200	13

D. Colour of the Solution

The muskmelon peels bioethanol and pure ethanol solution appeared to be colorless without any residue or particles observed. It is natural for ethanol to be colorless and clean. Both solutions were viscous, which makes the ethanol and bioethanol does not form any droplets or sticking to the inner walls of the bottle. This is because the hydroxyl group is prone to hydrogen bonding that makes the ethanol more viscous and less polar compared to the organic compound that have similar molecular weight [11]. In order to differentiate either the liquid produce was ethanol or water, the characteristics of steam produced from the distillation process was observed. Figure 5 show that the steam that produced bioethanol will not form any droplets and the liquid is more viscous compared to water. On the other hand, Figure 6 show the steam that produced water and form many droplets on the inner walls of the distillation glass apparatus. Since both water and bioethanol is colorless, so this method is one of the easiest ways to differentiate the resulted liquid from the distillation process other than burning.

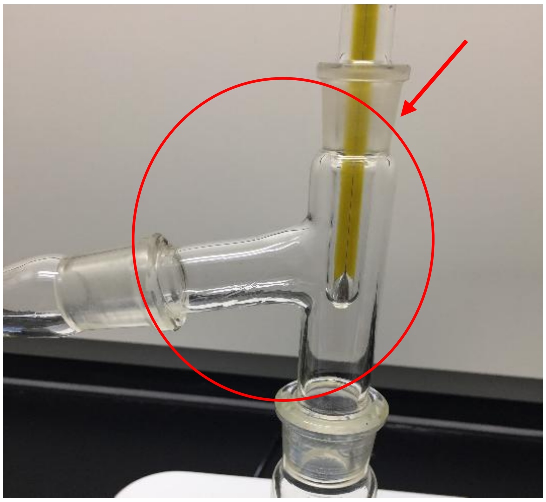


Fig. 5 Steam produced from bioethanol.

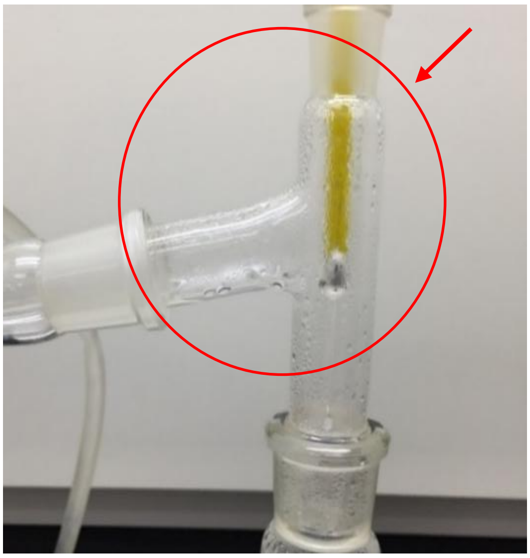


Fig. 6 Steam produced from water.

E. Odour

The muskmelon peels bioethanol had strong fruity smell compared to the pure ethanol. During the burning process, the bioethanol produced a fruity smell due to the strong smell of the fermented fruit (muskmelon peels) liquid. This was not observed during the burning process of pure ethanol, as it does not produce any smell.

F. pH

The pH detected for pure ethanol was 7.47, while for muskmelon peels bioethanol the pH was 7.52. The pH for distilled water was also tested by using pH meter, and the value recorded was 7.53. The pH for ethanol was almost neutral which similar to pure water because ethanol contains the hydroxyl group that causes the solution to be slightly basic and neutral [12].

G. Determination of Bioethanol by Gas Chromatography-Mass Spectrometry (GC-MS) Analysis

The component of ethanol in the muskmelon peels bioethanol solution was determined by using GC-MS analysis. Figure 7 and Figure 8 shows the chromatograms peaks of standard ethanol and bioethanol sample, respectively. The peak of ethanol for both solutions were seen to be same which was at 1-minute retention time and 100% of peak area. Hence, this confirm the component of ethanol in the bioethanol solution extracted from the muskmelon peels. Nonetheless, the compound of ethane was not detected in the bioethanol solution. Instead, the compound of 2-propanol was detected in the graph chromatogram. This can be explained by the ethanol characteristic which have higher volatility compared to propanol due to the existence of fewer hydrogen bonds that hold the volatile compounds in the liquid state. Only less energy is required to break apart the bond and more readily to enter the gas state. As the molecules are getting larger with more electrons, it will increase the boiling point. Consequently, the van der Waals dispersion forces will become greater.

Therefore, the probability for the ethanol to evaporate is high compared to propanol because the boiling point for propanol is higher than the ethanol [13]. Table 3 show the compound of ethanol and propanol.

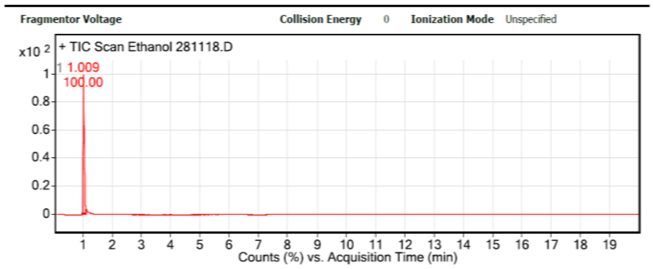


Fig. 7 Chromatograms peak for standard ethanol.

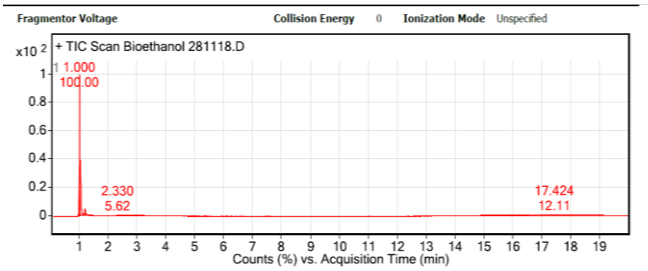
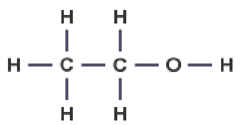
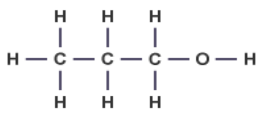


Fig. 8 Chromatograms peak for bioethanol.

Table 3. The compound of ethanol and propanol

Compound	Structural Formula	Displayed Formula
Ethanol	CH_3CH_2OH	
Propanol	$CH_3CH_2CH_2OH$	

IV. CONCLUSION

Bioethanol can be produced from muskmelon peels through the process of sterilization, fermentation and distillation. Muskmelon (*Cucumis melo*) peels have shown great ability to produce bioethanol that is almost identical to pure ethanol by comparing both solutions based on some physical characteristics such as its colour and odour. The GC-MS analysis confirmed the existence of ethanol in the bioethanol solution as shown by the peak that have similar retention time of 1 minute and 100% peak area to the pure ethanol. The overall results obtained in this study conclusively reveal that muskmelon peels could be used as an alternative to fossil fuels which can decrease environmental pollution.

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REFERENCES

1. M. V. Rodionova *et al.*, "Biofuel production: Challenges and opportunities," *Int. J. Hydrogen Energy*, pp. 1–12, 2016.
2. H. Zabed, J. N. Sahu, A. Suely, A. N. Boyce, and G. Faruq, "Bioethanol production from renewable sources : Current perspectives and technological progress," *Renew. Sustain. Energy Rev.*, 2016.
3. S. Mohapatra, R. C. Ray, and S. Ramachandran, "Chapter 1 - Bioethanol From Biorenewable Feedstocks: Technology, Economics, and Challenges," in *Bioethanol Production from Food Crops*, Elsevier Inc., 2019, pp. 3–27.
4. The Star, "Malaysians waste 15,000 tonnes of food daily," *The Star*, no. May, pp. 4–6, 2016. Available: https://www.thestar.com.my/news/nation/2016/05/24/malaysians-waste-15000-tonnes-of-food-daily
5. S. K. Thangavelu, A. S. Ahmed, and F. N. Ani, "Review on bioethanol as alternative fuel for spark ignition engines," *Renew. Sustain. Energy Rev.*, vol. 56, pp. 820–835, 2016.
6. M. Joanna, A. Kupczyk, K. Tucki, H. Pi, B. Anna, and I. Wielewska, "Production and use of biofuels for transport in Poland and Brazil – The case of bioethanol," *Fuel*, vol. 241, pp. 989–996, 2019.
7. A. Mansouri, R. Rihani, A. Nadia, and M. Özkan, "Production of bioethanol from a mixture of agricultural feedstocks : Biofuels characterization," *Fuel*, vol. 185, pp. 612–621, 2016.
8. L. Seguí and P. Fito Maupoey, "An integrated approach for pineapple waste valorisation. Bioethanol production and bromelain extraction from pineapple residues," *J. Clean. Prod.*, vol. 172, pp. 1224–1231, 2018.
9. S. H. Mohd Azhar, R. Abdulla, S.A. Jambo, H. Marbawi, J. A. Gansau, A. A. Mohd Faik and K. F. Rodrigues, "Yeasts in sustainable bioethanol production: A review," *Biochem. Biophys. Reports*, vol. 10, no. November 2016, pp. 52–61, 2017.
10. S. Vallone, H. Sivertsen, GE. Anthon, DM. Barrett, EJ. Mitcham, SE. Ebeler and F. Zakharov, "An integrated approach for flavour quality evaluation in muskmelon (Cucumis melo L. reticulatus group) during ripening," *Food Chem.*, vol. 139, no. 1–4, pp. 171–183, 2013.
11. J. Baeyens, Q. Kang, L. Appels, R. Dewil, Y. Lv, and T. Tan, "Challenges and opportunities in improving the production of bio-ethanol," *Progress in Energy and Combustion Science*, vol. 47. Elsevier Ltd, pp. 60–88, 2015.
12. J. Tech, "Ethanol (C2H5OH)," *JJS Technical Services*, 2018. .
13. H. Fang, K. Ni, J. Wu, J. Li, L. Huang, and D. Reible, "The effects of hydrogen bonding on the shear viscosity of liquid water," *Int. J. Sediment Res.*, 2018.

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