Energy and Earth Science
Vol. 3, No. 2, 2020
www.scholink.org/ojs/index.php/ees
ISSN 2578-1359 (Print) ISSN 2578-1367 (Online)

Original Paper

Waste-Energy: Feasibility Study of Watermelon (Endocarp) Waste as Raw-Material for Bio-Fuel Prodution

Biose Osadebe[1*], Imhontu U. Maureen[1], Akenzua Oghosa[1], Ehigiamusoe Osaro[1], Okorie Christopher[1], Atsegha Bildad[1], Onabe James[1], Angalapu Daudeigha Jonah[1] & Igbinomwanhia Iyeke[2]

[1] Environmental Pollution and Remediation Unit, National Centre for Energy and Environment, Energy Commission of Nigeria, Benin City, Edo State, Nigeria

[2] Department of Mechanical Engineering, Faculty of Engineering, University of Benin, Benin City, Edo State, Nigeria

[*] Biose, Osadebe, E-mail: bosadebe@yahoo.com

Received: April 30, 2020 Accepted: May 15, 2020 Online Published: July 16, 2020

doi:10.22158/ees.v3n2p11 URL: http://dx.doi.org/10.22158/ees.v3n2p11

Abstract

Waste to energy plays an important role in fulfilling the world's future demands. The continuous climatic change which is primarily caused by the atmospheric concentration of greenhouse gases from the continuous use of fossil fuel due to high demand of energy in our society has affected the human race negatively over the years. Similarly, the improper disposal of agricultural waste (watermelon waste) in markets and environs creates pungent smell overtime and attracts harmful organisms in our environment, destroying the aesthetics of the market, therefore, making it environmentally unsafe for man. This paper therefore describes how feasible it is to produce bio-ethanol from agricultural waste with a focus on water melon. The waste was gotten from the market and processed to get the endocarp after which a locally fabricated juicing machine was utilized for extraction of the juice from the endocarp of watermelon waste. The fermentation pot housed 60 litres of juice for 5 days and laboratory test analysis was carried out during the period of fermentation, this was to monitor the progression of fermentation. The distillate produced 65.25% alcohol content with a volume of 19.5 litres. The utilization of watermelon waste for bio-ethanol production if exploited will lead to environmental sustainability, energy efficiency and waste to wealth.

Keywords

waste to energy, fossil fuel, water melon waste and bio-ethanol

1. Introduction

Nowadays, the high demand for energy has become a thing of concern globally (Prasad et al., 2017), and this is because of the dependence on petroleum-based fossil fuel which is exhausting and depleting very fast in the cause of meeting its continuously increasing demands (Hossain et al., 2014). Moreover, it has been realized that Fossil energy causes greenhouse gas emissions that have negative effects on the environment. The enormous accumulation of Carbon dioxide (CO_2) in the environment is directly responsible for global warming (Naik et al., 2010). Aside the negative effect of CO_2 on the environment and high demand for energy, there has also been issues concerning waste management. Waste is simply any object whose owner does not want to take responsibility for it (Palmer, 1992). Waste management is the application of techniques to ensure an orderly execution of the various functions of collection, transportation, processing, treatment and disposal (www.sciencedirect.com, 2019). Improper disposal of waste causes environmental pollution. This does not affect only the atmosphere but also the populace in that environment by exposing them to health challenges like Dysentery, Diarrhea and Respiratory diseases etc. (Rinkesh, 2020). The advocacy for waste to be converted to a useful resource is necessary in Nigeria. Bio-ethanol derived from waste, which is our focus in this study, is a renewable and environmentally friendly type of fuel produced from a renewable and sustainable energy source called Biomass (Mabee et al., 2005). Biomass is the material derived from plants that use sunlight to grow which include plant and animal material such as wood from forests, material left over from agricultural and forestry processes, organic industrial wastes, human wastes and animal wastes (Salman, 2019). Bio-ethanol's impressive characteristics such as flame speed and wide range of flammability, high octane number (108) and evaporation enthalpy gives it a higher Compression Ratio (CR) with a shorter burning. Besides, Bio-ethanol can be used as transportation fuel in various feasible ways, directly or blend with gasoline called "gasohol" (Balat, 2007). In the United States of America, the most common blended Bio-ethanol used is E-10 containing 10% of ethanol concentration and 90% gasoline (Balat, M. & Balat, H., 2009). This research study is designed not just to solve the challenges of energy demand but to also reduce/eliminate completely the ugly sites of watermelon wastes in our environment (farms, markets and residential) which will bring about a sustainable environment for all.

2. Materials and Methodology

2.1 Area of Study

The study area is Tenboga Market square. It is located along the upper mission road in Benin City of Edo State Nigeria.

2.2 Feedstock Collection

Watermelon waste was collected from tenboga market located at upper mission Road, Benin City of Edo State Nigeria. Personal Protective Equipments (PPE) were employed during field work. It was recorded that 62 balls of water melon waste was collected which weighed 205kg.

Figure 1. Heap of Water Melon Waste

2.3 Sample Preparation

A knife was used to collect the endocarp of the watermelon waste which weighed 108kg and a locally fabricated juicing machine was used to extract juice from the endocarp of the watermelon waste. A cloth sieve was used to further remove the chaff from the juice and a volume of 105 litres of juice was obtained.

Figure 2. Collection of Endocarp

Figure 3. Extracted Juice from Endocarp

2.4 Fermentation Process

Fermentation is an important characteristic of alcohol production. In this regard, the prepared water melon juice was fed into the tightly covered fermentation pot to ensure anaerobic digestion of the feedstock. The fermentation pot had a stirrer which helps for proper stirring of the feedstock to enable enzymes act equally on the feedstock. Brewer's yeast of 17g was added to 105 liters of the water melon juice. Physicochemical analysis (pH, conductivity, sugar content, refractive index, and alcoholic content) of the feedstock was recorded during the fermentation process.

2.5 Alcohol Distillate

The bio-ethanol plant which was fabricated by the Environmental Pollution and Remediation Unit of the National Centre for Energy and Environment as presented in Figure 4 was utilized for the distillation of ethanol from watermelon endocarp waste. Laboratory test of the distillate was also carried out and recorded this was to ascertain the alcoholic content of the feedstock.

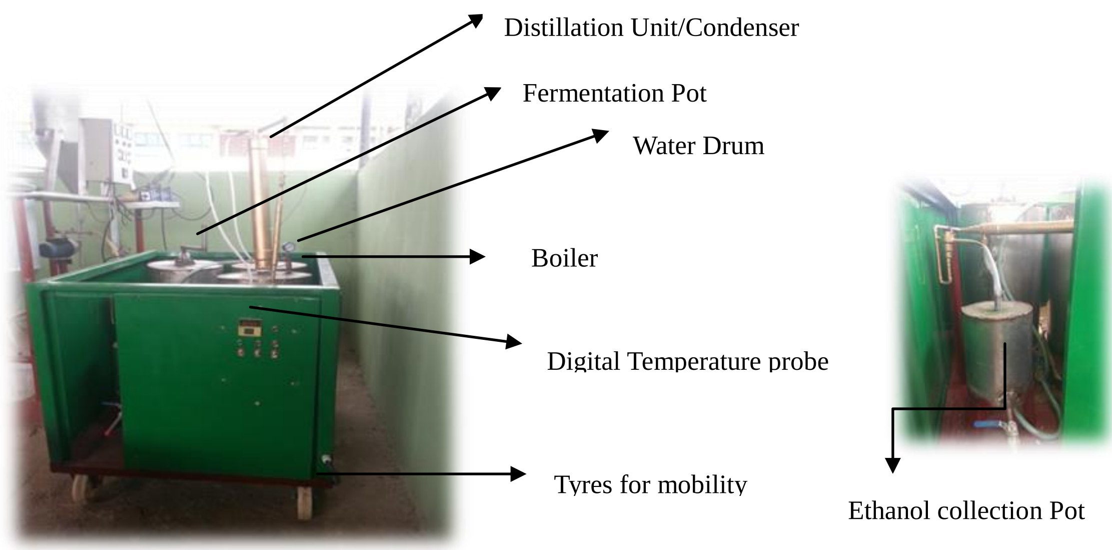

Figure 4. Bioethanol Plant

The result of analysis and graphical representation of the beer (fermenting feedstock) and distillate respectively are presented below.

3. Results and Discussion

3.1 Results

Table 1. Physicochemical Analysis of Beer

Period	pH	Conductivity	Sugar Content	Refractive Index	Alcoholic Content
Day 0	5.30	26.00	8.00	36.00	BDL
Day 1	3.70	34.00	8.00	34.00	BDL
Day 2	3.30	42.00	6.40	28.00	BDL
Day 3	3.20	43.00	5.80	26.00	BDL
Day 4	3.10	44.00	5.20	24.00	BDL

Note. BDL: Below Detectable Limit.

Table 2. Laboratory Test of Alcohol Content of Each Distillate

Distillate	pH	Conductivity	Sugar Content	Refractive Index	Alcoholic Content
1stDISTILLATE	4.70	0.00	20.40	86.00	59.00
2ndDISTILLATE	4.70	0.00	22.60	96.00	58.00
3rdDISTILLATE	5.00	0.00	23.60	100.00	56.00
4thDISTILLATE	4.80	0.00	23.20	98.00	56.00
Average Values	4.80	0.00	22.45	95.00	57.25

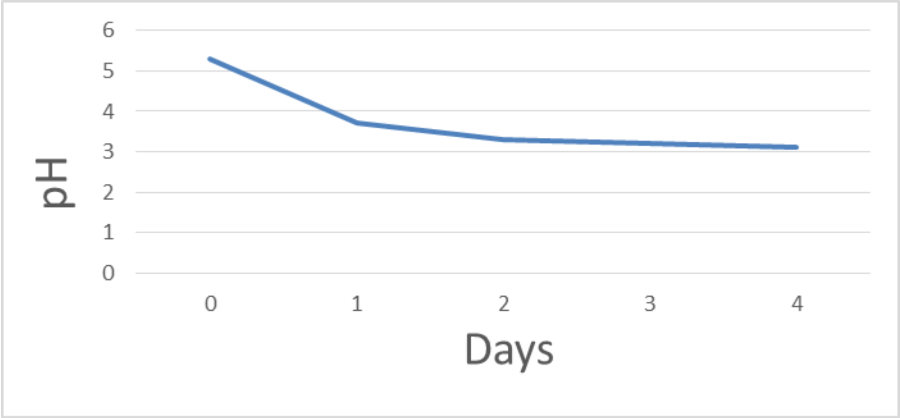

Figure 5. Graphical Representation of the Relationship between PH and Days of Fermentation

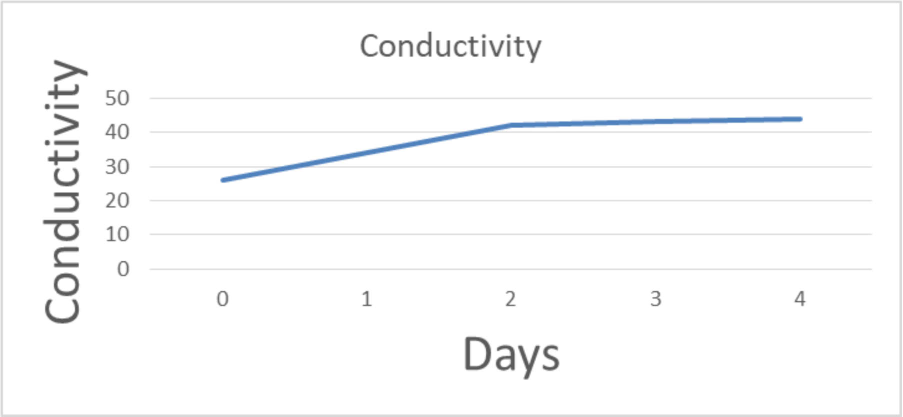

Figure. 6. Graphical Representation of the Relationship between Conductivity and Days of Fermentation

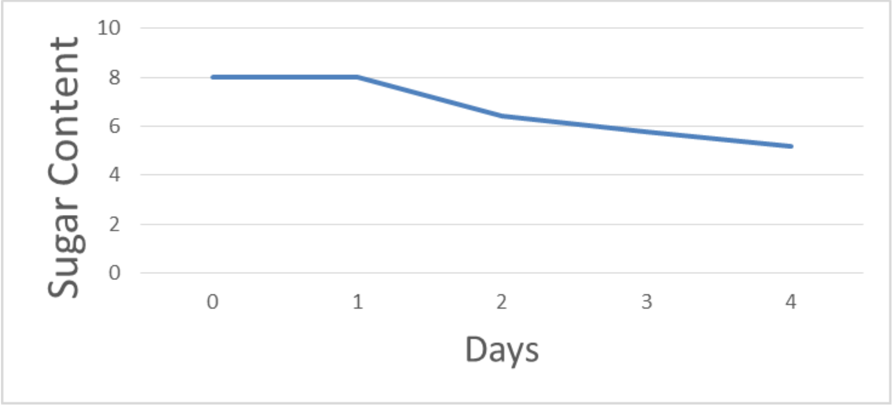

Figure 7. Graphical Representation of the Relationship between Sugar Content and the Fermentation Days

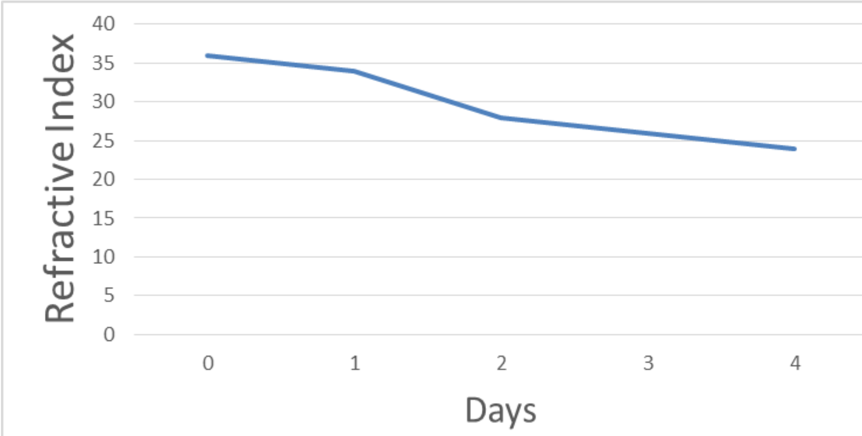

Figure 8. Graphical Representation of the Relationship between Refractive Index and the Fermentation Days

3.2 Discussion

Table 1 represents the fermentation analysis of the feedstock. The PH of the sample decreased from 5.30 to 3.10 (Increasing acidity) from day 0 to day 4.

Similarly, the sugar content and refractive index of the fermenting feedstock decreases from 8.00 to 5.20 and 36.00 to 24.00 respectively from day 0 to day 4 except for the sugar content for day 1 which remained unchanged.

The conductivity of the fermenting feedstock was observed to increase from 26.00 to 44.00.

The inverse relationship between the fermentation days of pH, sugar content and refractive index and the direct relationship between fermentation days and conductivity certified the formation of alcohol. Figures 1-4 clearly represents this direct and inverse relationship between physiochemical parameters and fermentation days.

It was also observed that table 2 represents the analysis of the distillate (ethanol). It revealed the average pH of 4.80, sugar content of 22.45, refractive index of 95.00 and alcoholic content of 65.25% of the yield. This therefore implies that water melon waste is a feasible raw material for ethanol production and if exploited will compliment the energy needs of man and bring about a sustainable environment.

4. Conclusion

The production of Bio-ethanol from water melon waste using a localized Bio-ethanol plant was successful. The sugar content and alcoholic content of the end product was measured 22.45 % Brix and 65.25% respectively. The Environmental Pollution and Remediation Unit, National Centre for Energy and Environment during their recognizance visit to farms and markets in Benin City observed that a lot of agricultural waste materials are generated on a daily basis which destroys the aesthetics of our markets block drainages and also affect man. This wastes which can be a useful resource if employed will help clean up our environment and also provide clean energy for all.

Acknowledgement

We thank the National Centre for Energy and Environment, Energy Commission of Nigeria for the financial support towards the completion of this project.

References

Balat, M. (2007). Global bio-fuel processing and production trends. *Energy, Exploration and Exploitation*, *25*(3), 195-218. https://doi.org/10.1260/014459807782009204

Balat, M., & Balat, H. (2009). Recent trends in global production and utilization of bio-ethanol fuel. *Applied Energy*, *86*(11), 2273-2282. https://doi.org/10.1016/j.apenergy.2009.03.015

Hossain, Z., Golam, F., Jaya, N. S., Mohd, S. A., Rosli H., & Boyce, A. N. (2014). Bio-ethanol Production from Fermentable Sugar Juice. Hindawi Publishing Coporation. *The Scientific World Journal*, *2014*, 1-11. https://doi.org/10.1155/2014/957102

Mabee, W. E., Gregg, D. J., & Saddler, J. N. (2005). Assessing the emerging bio refinery sector in Canada. In *Proceeding of the 26th Symposium on Biotechnology for Fuels and Chemicals* (pp. 765-778). Springer. https://doi.org/10.1007/978-1-59259-991-2_64

Naik, S. N., Goud, V. V., Rout, P. K., & Dalai, A. K. (2010). Production of first and second generation biofuels: A comprehensive review. *Renewable and Sustainable Energy Reviews*, *14*(2), 578-597. https://doi.org/10.1016/j.rser.2009.10.003

Palmer, P. (1992). *Green product by Design 4, U.S*. Congress office technology assessment, Washington D.C.

Prasad, S. A., Singh, & Joshi, H. C. (2007). Ethanol production from sweet sorghum syrup for utilization as automotive fuel in India. *Energy & Fuels*, *21*(4), 2415-2420. https://doi.org/10.1021/ef060328z

Rinkesh, K. (2020). Conserve Energy Future. In *Critical and Grievous Diseases caused by water pollution*. Retrieved from https://www.conserve-energy-future.com/critical-and-grievous-diseases-caused-by-water-pollution.php

Salman, Z. (2019). *An introduction to Bio-energy*. Retrieved from https://www.cleantechloops.com/an-introduction-to-biomass-/energy

Waste to energy: Energy from toxic of juice waste for heat and power generation. (2019). Retrieved from https://www.sciencedirect.com