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BIOETHANOL FROM WASTE BIOMAS; A SUSTAINABLE APPROACH IN CIRCULAR ECONOMY

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Abstract: Bioethanol production has recently intensified due to its environment-friendliness, usability, greener output, and its applicability as an alternative solution for fossil fuel depletion. Because of uncontrollable carbon emissions, many researchers have recently focused on reprocessing waste to biofuel, adopting technologies in the circular economy. Waste Biomass generated in larger quantities in agriculture and horticulture sector is freely dumped in open lands or poorly valorized without using these biomaterials in their maximum resource use efficiency. Thus, bioethanol production from agricultural and horticultural waste poses numerous advantages in the long run. This preliminary study, focused on producing bioethanol using three plant species; *Ricinus communis, Impatiens balsamina* and *Lantana camara*. which are fast-growing aggressive plants found on roadsides, abounded lands and freely available as waste biomass. The biomass from selected plants was converted to bioethanol using the cheapest, locally applicable, zero waste and most conventional fermentation method, yeast fermentation. According to obtained results, the bioethanol yields of *Ricinus communis, Impatiens balsamina* and *Lantana camara,* respectively were 7%, 10%, and 12% showing that *Lantana camara* plant achieved the highest when compared with others. These findings demonstrate the potential of these plant species for bioethanol production, contributing to renewable energy generation and highlighting the viability of utilizing agricultural and horticultural waste for sustainable fuel production.

Keywords: Bioethanol; Fermentation; Waste; Biomass

1. Introduction

Bioethanol (C_2H_5OH) recently has emerged as a renewable bio-energy, biodegradable clear-colourless liquid, and eco-friendly potential fuel for petrol substitutes. Usually, bioethanol is synthesized with the help of yeast from the alcoholic fermentation of sucrose of diverse types of biomass, either from feedstock or non-feedstock sources (Hossain, Zaini and Mahlia, 2017). Currently, biomass appears to be an attractive feedstock for bioethanol production due to three main reasons, it is a renewable resource that could be sustainably developed in the future, It appears to be environmentally friendly resulting in no net releases of carbon dioxide, and very low sulfur content and it shows significant economic potential provided that fossil fuel prices increase (Demirbas, 2008)(Haghighi Mood *et al.*, 2013). Bioethanol production from cellulosic and lignocellulosic biomasses especially wastes an alternative solution to existing environmental, economic, and energy problems of the world (Hossain, Zaini and Mahlia, 2017). Especially moving to waste as a raw material in bioethanol production is a novel trend in the circular economy; the utilization of waste breaks the argument of carbon negativity or neutrality associated with traditional biofuel production methods reliant on deforestation and carbon-emitting practices. By repurposing waste streams, this innovative approach not only mitigates environmental concerns but also promotes sustainability by transforming waste into a valuable resource. Some researchers noticed that the waste biomass of sugarcane, Corn, rice straw, beet and wheat straw were used extensively for bioethanol production by different countries as their ready availability worldwide (Hossain, Zaini and Mahlia, 2017)(Lisboa *et al.*, 2011) . The theoretical ethanol yield of wheat straw, rice, corn and sugarcane were 0.9,1.1,1.3 and 3.0 (t/ha) from crop residues yield of 6.9,7.0,10.0 and 17.0 (t/ha) in China respectively(Lisboa *et al.*, 2011). In this preliminary study, we focus on assessing the overall suitability of producing bioethanol using three kinds of plants including *Ricinus communis, Lantana camara,* and *Impatiens balsamina* to provide a sustainable solution for the energy crisis. These plants are known for their rapid growth and aggressive nature, often found in roadside areas, abandoned lands, and other open spaces. Despite being considered waste biomass due to their abundance and invasive tendencies, they present an opportunity for sustainable resource utilization. These plants can potentially provide higher biomass yields within shorter timeframes compared to slower-growing alternatives, making them attractive candidates for biofuel production. Moreover, their availability in various regions, particularly in tropical and subtropical climates, enhances accessibility and reduces challenges associated with feedstock sourcing.

2. Experimental Section/Materials and Methods

2.1 Bioethanol production

The waste biomass was crushed by adding small quantity of water for the physical breakdown. One portion of physically breakdown sample was taken for the non-chemical treatment. Then the other portion of sample was diluted with 0.5M H_2SO_4 and it was autoclaved at 120°C for 60 minutes for the chemical breakdown. It was taken as the chemically treated treatment. After that pH of the sample was measured to ensure the biomass is within the preferred range; 5.5-6.0. Then 1L of tap water was added to 100 g of samples and it was mixed thoroughly. Following that, 15ml from the mixed sample was taken and centrifuged and 10ml of the supernant was taken. Specific gravity of the samples was measured for the calculation (SG1). Then 5g of blended sugar and 10g of yeast (yeast should be dissolved with 20ml water at 40°C) were added to the sample, it was mixed well and kept 7 days for the fermentation. After the fermentation, the specific gravity was measured again (SG2). The approximate ethanol yield was obtained using equation 1.

$$V\% = \frac{(SG1 - SG2)}{0.0074} \tag{1}$$

After 7 days of fermentation, the sample was filtered and 400ml from the sample was taken. Then the sample was filled into the round bottom flask of the distillation unit and small amount of boiling chips (anti-bumping granules) were added to avoid super boiling. The water was filled into distillation apparatus tube and the heater was on (90°C) for the distillation. After that, the ethanol yield was obtained after it reaches to the ethanol boiling point (78.37°C). The same methodology was followed for all the samples and treatments were triplicated.

3. Results and Discussion Section

The approximate bio-ethanol yields obtained from arithmetic method for untreated and treated treatments of *Ricinus communis*, *Lantana camara*, and *Impatiens balsamina* were shown in figure 01; whereas the bio-ethanol yields after distillation process were shown in figure 02.

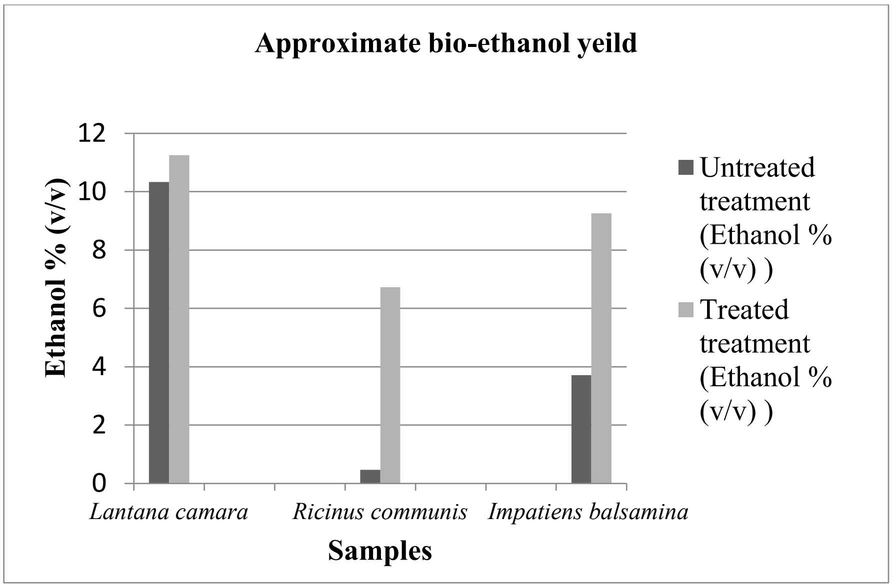

Figure 01: Approximate bio-ethanol yield of control and treated biomass obtained from arithmetic method

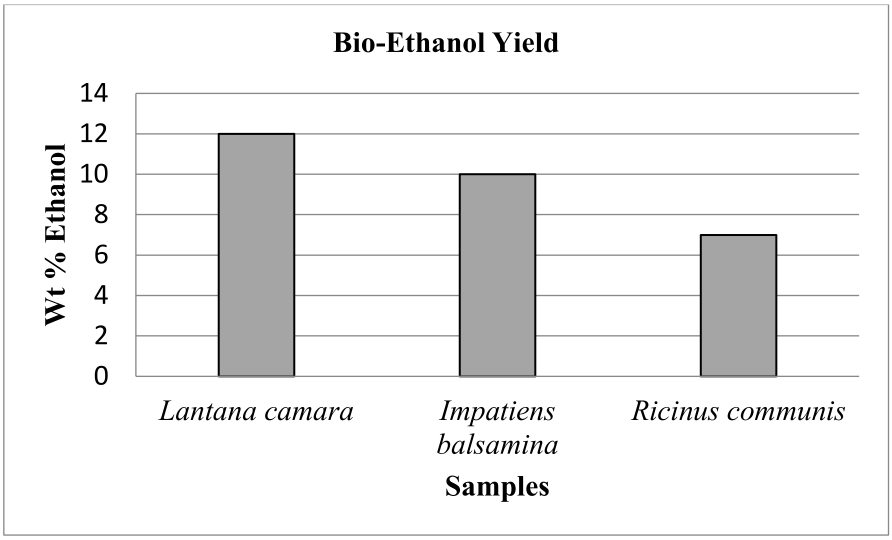

Figure 02: Bio-ethanol yield of *biomass* after distillation

The untreated samples were appeared the reduced yield when compared to the treated samples. Therefore, the treated samples were subjected to distillation process. The result showed that, the ethanol yields of *Ricinus communis, Impatiens balsamina*, and *Lantana camara*, were 7%, 10% and 12% respectively showing that *Lantana camara* plant achieved the highest when compared with others. Studies show that *Lantana camara* contains holocellulose, comprising cellulose and pentosans, lignin, ash, and moisture. The presence of 61.1% of total carbohydrates (holocellulose) makes it a potential and renewable material for bioethanol production (Chander *et al.*, 2010)(Raj *et al.*, 2015). Moreover, the disparity in bioethanol yield between untreated and treated *Lantana camara* biomass is notably smaller compared to the other tested biomasses. This observation underscores the potential for achieving higher yields even without chemical treatment of the biomass prior to production. Such findings accentuate the environmental benefits associated with utilizing *Lantana camara* for bioethanol production. By requiring minimal chemical intervention, *Lantana camara* offers a more sustainable and eco-friendly option for biofuel production, further enhancing its appeal as a viable feedstock. This underscores the importance of exploring and harnessing the inherent qualities of certain plant species, such as *Lantana camara*, to minimize environmental impact and promote sustainable energy solutions.

4. Conclusions

This preliminary study highlights the potential of utilizing fast-growing plant species, namely *Ricinus communis, Impatiens balsamina,* and *Lantana camara,* for bioethanol production. Through yeast fermentation, these plant biomasses were successfully converted into bioethanol, demonstrating their potential as renewable energy sources. The results indicate that *Lantana camara* exhibited the highest bioethanol yield among the tested biomass, with minimal disparity between untreated and treated biomass, emphasizing its environmental advantages. This underscores the feasibility of obtaining significant bioethanol yields without extensive chemical treatment, further promoting the sustainability of biofuel production. Overall, the findings contribute to the growing body of research supporting the utilization of agricultural and horticultural waste for sustainable energy generation, while emphasizing the importance of environmentally friendly approaches in bioethanol production. Future research should focus on optimizing production processes and exploring additional waste biomass to expand bioethanol production possibilities and enhance environmental sustainability.

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References

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Chander, R. *et al.* (2010) 'Bioethanol production from Lantana camara (red sage): Pretreatment , saccharification and fermentation Bioresource Technology Bioethanol production from Lantana camara (red sage): Pretreatment , saccharification and fermentation', *Bioresource Technology*, 101(21), pp. 8348–8354. Available at: https://doi.org/10.1016/j.biortech.2010.06.043.

Demirbas, A. (2008) 'The importance of bioethanol and biodiesel from biomass', *Energy Sources, Part B: Economics, Planning and Policy*, 3(2), pp. 177–185. Available at: https://doi.org/10.1080/15567240600815117.

Haghighi Mood, S. *et al.* (2013) 'Lignocellulosic biomass to bioethanol, a comprehensive review with a focus on pretreatment', *Renewable and Sustainable Energy Reviews*, 27(July 2021), pp. 77–93. Available at: https://doi.org/10.1016/j.rser.2013.06.033.

Hossain, N., Zaini, J.H. and Mahlia, T.M.I. (2017) 'A review of bioethanol production from plant-based waste biomass by yeast fermentation', *International Journal of Technology*, 8(1), pp. 5–18. Available at: https://doi.org/10.14716/ijtech.v8i1.3948.

Lisboa, C.C. *et al.* (2011) 'Bioethanol production from sugarcane and emissions of greenhouse gases - known and unknowns', *GCB Bioenergy*, 3(4), pp. 277–292. Available at: https://doi.org/10.1111/j.1757-1707.2011.01095.x.

Raj, K.S. *et al.* (2015) 'In vitro study on production of bioethanol from Lantana camara leaves', (6), pp. 1–10.