International Journal of Scientific Research & Engineering Trends
Volume 10, Issue 5, Sept-Oct-2024, ISSN (Online): 2395-566X

Bioethanol Production from Potato Peel Waste

Renuka Yadav[1], Shubham Shubhashish[2], Dr. Gurshaminder Singh[3]
UIAS, Chandigarh University, Gharuan, Mohali, Punjab, India

Abstract- Bioethanol is generated by fermenting sugars obtained from biomass such as crops, agricultural waste, and organic refuse, and is a sustainable and eco-friendly energy option. It provides a long-term solution to fossil fuels, which has the capacity to decrease greenhouse gas emissions and combat climate change. Potato peel waste (PPW) is one of the many feedstocks that shows potential for bioethanol production because of its high starch content. PPW is a waste product from the potato processing sector, commonly thrown away or utilized for less valuable purposes. This study investigates the possibility of using PPW as a productive raw material for bioethanol manufacturing, specifically examining its preparation, breakdown, conversion, and purification stages. Even though bioethanol from PPW shows potential, economic and technical limitations arise due to high moisture levels, composition variability, and the requirement for substantial pre-treatment processes. However, the use of PPW for bioethanol production is in line with worldwide initiatives for sustainable energy, waste reduction, and the circular economy.

Index Terms- Bioethanol, Potato Peel Waste, Renewable Energy, Fermentation, Sustainable Fuel Production, Biomass

I. INTRODUCTION

Bioethanol is a type of alcohol made by fermenting sugars sourced from biomass like crops, agricultural leftovers, and organic garbage. It is commonly known as a sustainable energy source, mainly utilized as a fuel or fuel enhancer in the transportation industry. Bioethanol, unlike fossil fuels, comes from sustainable sources, serving as an environmentally friendly option that decreases dependence on finite energy sources such as coal, oil, and natural gas. Bioethanol is becoming increasingly important worldwide due to its ability to lower greenhouse gas (GHG) emissions. The carbon dioxide (CO_2) produced during the combustion of bioethanol when used as fuel or mixed with gasoline is balanced out by the absorption of CO_2 by the feedstocks during their growth stage. This results in a reduced carbon footprint when compared to traditional gasoline. In this way, bioethanol is crucial in reducing climate change and dealing with global warming. Bioethanol stands out as a highly promising substitute for fossil fuels, capable of enhancing energy security and tackling issues related to environmental pollution (Wang et al., 2016).

Globally, there is a growing focus on researching and developing ethanol production as the top biofuel option from renewable resources. Due to the increasing energy needs, environmental concerns, depletion of fossil fuels, and rising oil prices, it is imperative to find a renewable, affordable, environmentally friendly alternative fuel with lower greenhouse gas emissions (Goldemberg, 2007). Sugarcane, maize, wheat, and barley are the primary sources of bioethanol. At present, ethanol production in the commercial sector depends on fermenting sucrose from cane sugar and molasses, or glucose from starch-based crops like corn, wheat, and cassava. There is an increasing demand for the industry to enhance technology and increase output (Wyman, 1999). An abrupt rise in ethanol production through existing corn starch technology is not economically viable as it would create competition for limited agricultural land required for food and feed production. One possible way to produce ethanol at a low cost is by using lignocellulosic materials like crop residues, grasses, sawdust, wood chips, and animal and industrial residues (Prasad et al., 2007). The expense of producing ethanol from lignocellulosic material is quite high using current methods, with the main obstacles being low yield and expensive hydrolysis costs.

The growing need for bioethanol in different industrial applications like energy alternative, solvents, cleaners, and preservatives has led to a higher production requirement. Ethanol is produced by converting carbohydrates found in agricultural products via microbial processes. Saccharomyces cerevisiae, a type of yeast, is crucial in bioethanol production for its high ethanol yield, tolerance to ethanol levels, fast fermentation rate, and substrate concentration tolerance (Muhamud et al., 2009). Various methods have been utilized for producing bioethanol from starchy biomass such as Separate Hydrolysis and Fermentation (SHF) and Simultaneous Saccharification and Fermentation (SSF). SSF, a technology for producing bioethanol using various substrates like sweet sorghum and potato mash, is efficient, affordable, and time-saving (Yu et al., 2008; Srichuwong et al., 2009). It integrates the hydrolysis and fermentation processes in one

© 2024 IJSRET

vessel, reducing substrate inhibition and total reaction time (Neves et al., 2006; Josefin, 2011). Various urban and industrial residues, such as cotton linters, spent sulfite liquor, cheese whey, and wastes from vegetable and fruit industries, are potential feedstocks for bioethanol production. The modern focus on the enhancement of wastes requires converting industrial and municipal waste into products with increased value. PPW (Potato Peel Waste) is primarily composed of lignin, hemicellulose, cellulose, and starch, making it a lignocellulosic substrate.

PPW has a short lifespan because its moisture content makes it highly susceptible to rapid microbial decay. PPW is commonly used for animal feeding and composting purposes, but these approaches can be inefficient in terms of environmental impact due to the loss of valuable materials (Wu, 2016). Given its composition, PPW has the potential to be used as raw material in different industrial fields.

Due to its distinct benefits compared to other sustainable energy sources, bioethanol made from agricultural or industrial waste has garnered particular interest. Using renewable and carbon-neutral bioethanol is seen as a successful method to combat the greenhouse effect (Nigam and Singh, 2011). Biorefineries can create chemical intermediates for bioethanol production (Fernando et al., 2006), and bioethanol works well with existing liquid fuel supplies (Wang et al., 2015). Hence, bioethanol stands out as a highly hopeful substitute for fossil fuels, capable of securing energy and tackling environmental pollution issues (Goldemberg, 2007; Wang et al., 2012).

II. HISTORY OF BIOETHANOL PRODUCTION USING POTATO PEELS

The idea of utilizing agricultural residue for bioethanol manufacturing started to become popular in the late 20th century due to growing worries about the depletion of fossil fuels and environmental sustainability. PPW, a plentiful leftover from potato processing, was recognized as a possible raw material because of its high levels of carbohydrates. Research conducted in the 1980s and 1990s initially concentrated on using enzymes to break down potato peels and transform their starch into sugars that can be fermented, which ultimately paved the way for producing bioethanol from this discarded substance (Nigam, 1999).

Researchers made important progress in bioethanol production from potato peels in the 2000s by improving pre-treatment and fermentation methods. The finding that potato skins have high levels of starch led to research to improve the transformation of this starch into glucose, which can be further fermented into ethanol with the help of yeast. During this period, scientists started investigating the possibility of incorporating PPW into biofuel production processes, prompted by the growing focus on renewable energy sources (Kumar et al., 2009).

In the 2010s, newer research has concentrated on improving the process's effectiveness and financial feasibility through the investigation of different pre-treatment techniques and fermentation technologies, resulting in higher ethanol production. Studies have shown that potato peels are capable of generating bioethanol yields similar to other agricultural residues, proving that PPW is a feasible and sustainable source for bioethanol production (Saha & Roy, 2020). The increasing focus on using PPW supports the worldwide movement towards a circular economy, which seeks to minimize waste and encourage the use of renewable energy sources.

III. POTATO PEEL WASTE AS POTENTIAL FEEDSTOCK

Potato (Solanum tuberosum) is a cost-effective food that serves as an affordable energy source in human diets. It is now one of the most widely grown crops in India and is grown in almost every state. India is second only to China in worldwide potato production, producing around 48 million tons per year. Based on FAO data, the global potato production in 2021 reached 376 million tonnes, with China and India leading as the largest producers at 94 million tonnes and 54 million tonnes, respectively. FAO data shows that the total global harvested area in 2021 was 18,132,694 hectares, with an average yield of approximately 21 tonnes per hectare. As per the CIP (International Potato Centre), there is a global trend towards consuming more value-added food products made from potatoes rather than fresh potatoes.

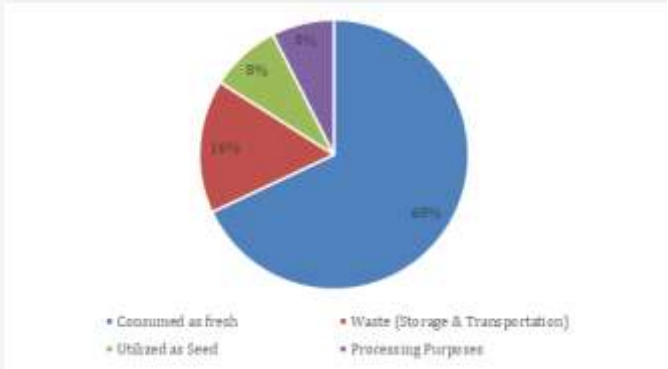

Fig. 1: Distribution of Potato Production Usage

Potatoes are starchy crops that do not need complicated pre-treatments. While a valuable crop, 5% to 20% of potatoes cultivated become waste by-products which can be repurposed for bioethanol production (Adarsha et al., 2010; Minal and Deshpande, 2010). Furthermore, in potato processing,

© 2024 IJSRET

specifically in the potato chips sector, around 18% of the potatoes are produced as waste. Excess potatoes are generated as a secondary product during the cultivation of potatoes. In the potato food industry, there is also a significant amount of solid potato mash that can be used as a raw material for producing bioethanol (Kilpimaa et al., 2009). The potato industry is greatly concerned about managing PPW, highlighting the necessity for finding a comprehensive and environmentally friendly solution. Potato peels are considered a waste product with no economic value that comes from potato processing factories (Duruyurek et al., 2015). The amount of potato peeling losses varies from 15-40%, depending on the method used such as steam, abrasion, or lye peeling (Arapoglou et al., 2010). Hence, the potato industry's waste can serve as growth media (carbon source) for bioethanol fermentation due to its high starch content. Therefore, there is a pressing requirement to discover a different efficient purpose for the potato peels in order to produce biofuel. The PPW has adequate levels of starch, cellulose, hemi-cellulose, and fermentable sugars for yeast growth and can be used as a raw material for bioethanol production (Duhan et al., 2013). Hence, the current research aimed to optimize conditions for bioethanol production from PPW.

Fig. 2: Composition of PPW

The modern focus on the enhancement of wastes requires converting industrial and municipal waste into products that have increased value. PPW is primarily composed of lignin, hemicellulose, cellulose, and starch, making it a lignocellulosic substrate. Because of its makeup, this waste has the potential to be used as raw material in different industrial fields. The main components of PPW are starch, a polysaccharide, along with lignin, hemicellulose, and cellulose. Starch is a beneficial substance for producing bioethanol as it can be changed into sugars that are fermentable with enzymes or microbes. The high starch content in PPW makes it an attractive option for bioethanol production, especially when compared to other agricultural residues. Starch, a complex carbohydrate, must first be broken down into simple sugars before it can be converted into bioethanol. The process of producing bioethanol from starchy biomass includes three stages: 1) breaking down starch with an enzyme like α-amylase, 2) converting the broken-down product into glucose through enzymatic saccharification, and 3) fermenting the glucose into bioethanol with yeast (Chaudhary et al., 2014).

Usually, PPW has been utilized for feeding animals, making compost, or just thrown away, but these methods are frequently ineffective and harmful to the environment. The elevated moisture level in PPW causes quick bacterial decomposition, reducing its storage duration and creating disposal challenges. If not effectively handled, this waste can add to methane emissions and environmental pollution.

The traditional method of producing bioethanol requires a hydrolysis step to produce sugars that can be fermented. Therefore, either acid hydrolysis or enzymatic hydrolysis is necessary (Stichnothe and Azapagic, 2009). Acid hydrolysis processes require severe conditions like elevated temperature and acidic environment. These conditions require the utilization of expensive equipment that is resistant to corrosion.

IV. SCENARIO AND SCOPE OF BIOETHANOL PRODUCTION USING POTATO PEELS

1. Scenario

In recent years, there has been significant interest in using PPW for bioethanol production as a sustainable replacement for fossil fuels. As the need for renewable energy sources increases worldwide, PPW, a byproduct of the food processing industry, is a plentiful and not fully utilized resource. Every year, large amounts of potato peels are produced globally, particularly in countries like China, India, the United States, and European nations with substantial potato cultivation (Chakraborty et al., 2021). The potato peels are frequently thrown away, causing issues with waste management and environmental worries. Researchers are focusing on converting potato peels, which have a high carbohydrate content of 50-60% made up of starch, cellulose, and hemicellulose, into bioethanol. Potato peels, a second-generation bioethanol feedstock, are an appealing choice for sustainable biofuel production as they do not conflict with food crop production (Saha & Roy, 2020). Advances in pre-treatment, hydrolysis, and fermentation techniques have enhanced the effectiveness and output of bioethanol production from potato peels, making it more feasible for commercial use.

2. Scope

Bioethanol production from potato peels shows great potential in helping to increase renewable energy sources worldwide and decrease waste. Potato peels can be gathered from big potato processing facilities, lessening the environmental effects and supporting a circular economy. Moreover, utilizing potato peels for bioethanol production has the potential to bring economic advantages such as developing new sources of income for the potato processing sector and providing employment opportunities in biofuel production plants (Khan & Mubeen, 2020). Studies have demonstrated that bioethanol made from potato peels has the potential to be combined with

© 2024 IJSRET

current energy systems, offering a greener and more eco-friendly option compared to traditional fuels. Additionally, through the improvement of fermentation techniques, pre-treatment approaches, and the utilization of advanced microbial strains, the production of bioethanol from potato peels could be enhanced, leading to its competitiveness in the renewable energy sector (Gupta & Verma, 2015).

V. BIOETHANOL PRODUCTION PROCESS

1. Feedstock Pre-treatment

The pretreatment stage is essential in the process of producing bioethanol from PPW. The goal is to enhance the accessibility of cellulose and hemicellulose in the peel structure, increasing their vulnerability to hydrolysis and fermentation (Ben Atitallah et al., 2019; Zhang et al., 2010).

Physical techniques involve the mechanical breakdown of the PPW arrangement without changing its chemical makeup. Chemical techniques utilize chemicals to break down or eliminate elements that impede hydrolysis. Biological techniques involve using microorganisms or their enzymes to break down the components of lignocellulose.

2. Hydrolysis

Hydrolysis is the breakdown of complex carbohydrates like starch and cellulose into simpler sugars, such as glucose, that can be further converted into ethanol through fermentation. There are two main ways to perform hydrolysis: through enzymatic means or through acid.

Enzymatic hydrolysis is an essential stage in the transformation of PPW into bioethanol. This process includes breaking down complex carbohydrates like starch into simpler sugars such as glucose, which can be fermented by microorganisms to create ethanol (Khawla et al., 2014). Enzymes like amylases are included in the PPW mixture. Amylases are proteins that speed up the decomposition of starch into simpler sugars such as maltose and glucose. The enzymes work on the starch molecules by breaking the glycosidic bonds that bind them. This procedure leads to the production of basic sugars, mainly glucose. The process of hydrolysis is usually performed in a controlled manner, with ideal levels of temperature, pH, and enzyme concentration. These aspects have the potential to greatly impact the effectiveness of the procedure (Ude et al.,2020).

3. Fermentation

Microbial fermentation is when microorganisms help convert organic compounds into desired products using controlled conditions. Microorganisms, such as yeast, are utilized in bioethanol production to transform sugars from plant sources (like potato peel waste) into ethanol (Chohan et al., 2020). Saccharomyces cerevisiae, also called baker's yeast, is among the most commonly utilized microorganisms in the production of ethanol. This yeast has the required metabolic pathways to transform glucose, a basic sugar obtained from starch, into ethanol using the process known as alcoholic fermentation.

PPW contains a significant amount of starch, which is a complex carbohydrate that can be broken down into glucose (Cunha et al., 2019).

S. cerevisiae efficiently converts the glucose from PPW to ethanol, resulting in high ethanol levels.

4. Distillation

The process includes isolating ethanol from the fermented blend, which includes a range of substances like water, different alcohols, and organic acids (Chao et al., 2017).

Distillation is the process of separating components based on their different boiling points.

Heating: The mixture that has undergone fermentation is warmed to a temperature that is lower than the boiling temperature of ethanol but higher than the boiling temperatures of the other substances in the mixture.

Evaporation: When the mixture is heated, the ethanol evaporates because it has a lower boiling point.

Condensation occurs when the ethanol vapor is cooled, leading it to change back to a liquid form.

Collection: The concentrated ethanol is gathered, isolated from the other substances in the mixture (Gomes et al., 2021c).

Gathering of Potato Peel Waste

↓

Pre-processing

- Cleaning and drying to eliminate contaminants
- Reduction in size (grinding/crushing)
- The breakdown of a compound into smaller molecules using water

↓

Hydrolysis

Enzymatic hydrolysis involves adding enzymes like amylase to convert starch into glucose by breaking it down into sugars

↓

© 2024 IJSRET

Fermentation

- Microscopic organism (Yeast): Introduce yeast (such as Saccharomyces cerevisiae) for the conversion of glucose into ethanol.
- Duration: 48 to 72 hours at optimal temperature of 30 - 35°C.

↓

Distillation

- Extract ethanol from the fermentation blend.
- Ethanol level rose (to about 95%)

↓

Dehydration (optional)

- Continued refining **of** ethanol to achieve >99% purity by eliminating water.

↓

Bioethanol Collection

↓

Waste Management

- Solid residues and wastewater that have been processed or repurposed for different uses such as animal feed or compost.

VI. POTENTIAL OF POTATO PEEL WASTE IN BIOETHANOL PRODUCTION

PPW, a significant byproduct of the food processing industry, is typically discarded or used as animal feed. However, its potential as a raw material for bioethanol production has gained attention due to its abundance and high sugar content. Potato peels are rich in carbohydrates, comprising approximately 50-60%, making them an excellent source for bioethanol production. The starch present in potato peels can be converted into fermentable sugars, which yeast can subsequently transform into ethanol (Barampouti et al., 2023). This makes potato peels a cost-effective and sustainable raw material for bioethanol production. Research indicates that bioethanol yields from potato peels can reach between 0.3 and 0.4 grams of ethanol per gram of peel, depending on pre-treatment and fermentation methods (Barampouti et al., 2023). Using PPW for bioethanol production not only provides a sustainable energy source as an alternative to fossil fuels but also reduces the environmental footprint by diverting waste from landfills and lowering disposal costs, thus promoting an eco-friendlier energy landscape (Hossain et al., 2018).

Limitations of Using Potato Peel Waste for Bioethanol Production

PPW presents several challenges in bioethanol production. One major issue is the high moisture content, which can reach up to 80-90%, making the peels bulky, difficult, and costly to transport and store (Soni et al., 2023). This necessitates additional energy for drying before processing. Furthermore, the chemical composition of PPW can be inconsistent, varying with potato type, age, processing methods, and storage conditions, which may affect the uniformity and efficiency of bioethanol production. The complex carbohydrates present in potato peels require pre-treatment—whether physical, chemical, or enzymatic—to convert them into fermentable sugars, but this step can be time-consuming, costly, and require specialized equipment, impacting the overall economic viability (Wang et al., 2016). Additionally, the presence of inhibitory compounds such as phenolics, glycoalkaloids, and lignin can interfere with fermentation and reduce ethanol yield, often necessitating detoxification steps that add complexity to the process (Arapoglou et al., 2010). Logistical challenges also arise from the need to collect and transport PPW from dispersed food processing facilities, potentially increasing operational costs. Lastly, competition for PPW from other applications, such as animal feed, fertilizers, bioplastics, and biogas production, can limit the availability of this raw material for bioethanol production (Djilai et al., 2023).

VII. CONCLUSION

Bioethanol, derived from biomass, is crucial for decreasing reliance on fossil fuels and cutting down on greenhouse gas emissions. PPW is distinguished as a suitable source of raw material for bioethanol production because of its high carbohydrate content, especially in starch. The production of bioethanol from PPW includes different steps like pretreatment, hydrolysis, fermentation, and distillation with the goal of maximizing the transformation of complex carbohydrates into fermentable sugars and, ultimately, ethanol. In the past, the idea of using agricultural waste such as potato peels for making bioethanol arose because of worries about running out of fossil fuels and the need for environmental sustainability. Research conducted in recent years has greatly improved the technologies for converting PPW into ethanol, enhancing pretreatment, fermentation efficiency, and overall yield. These progressions have positioned PPW as a potential feedstock for second-generation bioethanol, without creating competition with food production. There is a significant opportunity for producing bioethanol from PPW, especially in areas with large potato farming and processing sectors like India and China. Using potato peels not only offers a sustainable energy source, but also helps with waste management problems, promoting a circular economy. Although there are advantages, some challenges still exist such as high moisture levels, issues with

© 2024 IJSRET

transportation, and the existence of compounds that hinder fermentation. Furthermore, the competition for PPW from other sectors, like animal feed and biogas production, presents an obstacle to its extensive utilization for bioethanol. To sum up, utilizing PPW for bioethanol production offers a sustainable and environmentally friendly option to traditional fuels, with the ability to decrease environmental harm and support renewable energy sources. Nevertheless, it is crucial to overcome the technological and logistical hurdles in order to increase its production and incorporate it into the wider energy sector.

REFERENCES

1. Adarsha R, Asha DL, Balaji RR. Production of bioethanol from Pectobacterium carotovorum induced soft rotten potatoes. African Journal of Microbiology Research. 2010; 4(12):1340-1342.
2. Anuj KC, Ravinder R, Lakshmi MN, Rao V and Ravindra P (2007). Economic and environmental impact of bio-ethanol production technology. Biotechnology and Molecular Biology Review., 2(1): 1432.
3. Arapoglou D, Varzakas T, Vlyssides A, Israilides C. Ethanol production from potato peel waste (PPW). Waste Management. 2010; 30:1898-1902.
4. Barampouti, E. M., Christofi, A., Malamis, D., & Mai, S. (2023). A sustainable approach to valorize potato peel waste towards biofuel production. Biomass Conversion and Biorefinery, 13(9), 8197-8208.
5. Bekele, A., Fite, A., Alemu, S., Sewhunegn, T., Bogele, E., Simachew, M., & Debele, T. (2015). Production of bio-ethanol from waste potato peel collected from University of Gondar, student's cafeteria. Global Journal of Biochemistry and Biotechnology, 3(3), 132-140.
6. Ben Atitallah, I., Antonopoulou, G., Ntaikou, I., Alexandropoulou, M., Nasri, M., Mechichi, T., Lyberatos, G., 2019. On the evaluation of different saccharification schemes for enhanced bioethanol production from potato peels waste via a newly isolated yeast strain of Wickerhamomyces anomalus. Bioresour. Technol. 289, 121614
7. Brooks AA (2008). Ethanol production potential of local yeast strains isolated from ripe banana peels. Afri. J. Biotechnol., 7 (20) 3749-3752
8. Chakraborty, S., Ahmed, K. M., & Mondal, S. (2021). "Bioethanol production from potato peel waste: A sustainable approach." International Journal of Environmental Science and Technology, 18(5), 1013-1022.
9. Chao, B., Liu, R., Zhang, X., Zhang, X.u., Tan, T., 2017. Tannin extraction pretreatment and very high gravity fermentation of acorn starch for bioethanol production. Bioresour. Technol. 241, 900–907.
10. Chaudhary A, Yadav R, Kumar M. Production of bioethanol from waste potatoes. Journal of Bioscience and Technology. 2014; 5(6):591-596.
11. Chohan, N.A., Aruwajoye, G.S., Sewsynker-Sukai, Y., Gueguim Kana, E.B., 2020. Valorisation of potato peel wastes for bioethanol production using simultaneous saccharification and fermentation: Process optimization and kinetic assessment. Renew. Energy 146, 1031–1040.
12. Cunha, J.T., Soares, P.O., Romaní, A., Thevelein, J.M., Domingues, L., 2019. Xylose fermentation efficiency of industrial Saccharomyces cerevisiae yeast with separate or combined xylose reductase/xylitol dehydrogenase and xylose isomerase pathways. Biotechnol. Biofuels 12, 1–14.
13. Djilali, Bouhadi & Larbi, Khadidja & Belkhodja, Hamza & Belmimoun, Asmaa & Habib, Asmaa & Semmache, Amel & Mohamed, Ouahdi. (2023). Bioethanol production from potato peel waste using Saccharomyces cerevisiae. Acta agriculturae Serbica. 28. 13-21. 10.5937/AASer2355013B.
14. Duhan JS, Kumar S, Tanwar SK. Bioethanol production from starchy part of tuberous plant (potato) using Saccharomyces cerevisiae MTCC-170. African Journal of Microbiology Research. 2013; 7(46):5253-5260.
15. Duruyurek M, Dusgun C, Gulhan MF, Selamoglu Z. Production of bioethanol from waste potato. Journal of Food Science and Technology. 2015; 3(5):331-334.
16. Fernando S, Adhikari S, Chandrapal C, Murali N. Biorefineries: current status, challenges, and future direction. Energ Fuel. 2006; 20:1727–37.
17. Goldemberg J. Ethanol for a sustainable energy future. Science. 2007; 315:808–10.
18. Gomes, D.G., Teixeira, J.A., Domingues, L., 2021c. Economic determinants on the implementation of a Eucalyptus wood biorefinery producing biofuels, energy and high added-value compounds. Appl. Energy 303, 117662.
19. Gupta, R., & Verma, R. (2015). "Bioethanol production from fruit and vegetable wastes: Sustainable approach." Renewable and Sustainable Energy Reviews, 42, 177-185.
20. Hashem, M., & Darwish, S. M. (2010). Production of bioethanol and associated by-products from potato starch residue stream by Saccharomyces cerevisiae. Biomass and bioenergy, 34(7), 953-959.
21. Hossain, T., Miah, A.B., Mahmud, S.A. et al. Enhanced Bioethanol Production from Potato Peel Waste Via Consolidated Bioprocessing with Statistically Optimized Medium. Appl Biochem Biotechnol 186, 425–442 (2018).
22. Josefin A. Separate Hydrolysis and Fermentation of Pretreated spruce. Department of Physics, Chemistry and Biology. Linkoping University. 2011.
23. Khan, A. & Mubeen, M. (2020). "Economic feasibility of bioethanol production from agro-industrial waste."

© 2024 IJSRET

Renewable and Sustainable Energy Reviews, 117, 109500.
24. Khawla, B.J., Sameh, M., Imen, G., Donyes, F., Dhouha, G., Raoudha, E.G., Oum` ema, N. E., 2014. Potato peel as feedstock for bioethanol production: A comparison of acidic and enzymatic hydrolysis. Ind. Crops Prod. 52, 144–149.
25. Kilpimaa S, Kuokkanen T, Lassi U. Bioethanol production from waste potatoes. In: Paukkeri, A.; YiaMella, J. and Pongracz, E. (eds) Energy research at the University of Oulu. Proceedings of the EnePro conference, June 3rd, University of Oulu, Finland. Kalevaprint, Oulu, 2009, 21-23.
26. Kumar, S., Gupta, R., & Singh, J. (2009). "Bioconversion of lignocellulosic fraction of waste potato peel into ethanol by separate hydrolysis and fermentation." Biomass and Bioenergy, 33(3), 326-331.
27. Minal D, Deshpande RS. Bio-fuel from cellulosic agricultural waste. International Journal of Chemical Engineering Research. 2010; 2(2):197-217.
28. Muhamud F and Bin I (2009). Production of Bio-ethanol from Tapioca Starch using Saccharomyces cerevisiae. University of Malaysia Pahang, Malaysia.
29. Neves MA, Kimura T, Shimizu N, Shiiba K. Production of alcohol by simultaneous saccharification and fermentation of low-grade wheat flour. Brazilian Archives of Biology and Technology. 2006; 49:481-490.
30. Nigam PS, Singh A. Production of liquid biofuels from renewable resources. Prog Energ Combust. 2011; 37:52–68.
31. Nigam, P. (1999). "Continuous ethanol production from pineapple cannery waste using immobilized yeast cells." Journal of Biotechnology, 72(3), 197-202.
32. Prasad S, Singh A, Joshi HC. Ethanol as an alternative fuel from agricultural, industrial and urban residues. Resour Conserv Recycl 2007; 50:1–39.
33. Rodríguez-Martínez B, Coelho E, Gullón B, Yáñez R, Domingues L. Potato peels waste as a sustainable source for biotechnological production of biofuels: Process optimization. Waste Manag. 2023 Jan 1; 155:320-328. doi: 10.1016/j.wasman.2022.11.007. Epub 2022 Nov 19. PMID: 36413884.
34. Saha, J., & Roy, R. (2020). "Utilization of Potato Peel Waste for Bioethanol Production." Waste and Biomass Valorization, 11(7), 3401-3409.
35. Soni, S.K.; Sharma, B.; Sharma, A.; Thakur, B.; Soni, R. Exploring the Potential of Potato Peels for Bioethanol Production through Various Pretreatment Strategies and an In-House-Produced Multi-Enzyme System. Sustainability 2023, 15, 9137
36. Srichuwong S, Fujiwara M, Wang X, Seyama T, Shiroma R, Arakane M, Mukojima N et al. Simultaneous saccharification and fermentation of very high gravity potato mash for the production of ethanol. Biomass and Bioenergy. 2009; 33(5):890-898.
37. Stichnothe H, Azapagic A. Bioethanol from waste: Life cycle estimation of the greenhouse gas saving potential. Resour Conserv Recycle. 2009;53(11):624-630.
38. Sujeeta, K. M., Mehta, S., & Sihag, K. (2018). Optimization of conditions for bioethanol production from potato peel waste. Int. J. Chem. Stud, 6(1), 2021-2024.
39. Ude, M.U., Oluka, I., Eze, P.C., 2020. Optimization and kinetics of glucose production via enzymatic hydrolysis of mixed peels. J. Bioresour. Bioprod. 5, 283–290.
40. Wang F, Jiang Y, Guo W, Niu K, Zhang R, Hou S et al. An environmentally friendly and productive process for bioethanol production from potato waste. Biotechnology for Biofuels. 2016; 9:50-57.
41. Wang M, Han L, Liu S, Zhao X, Wang J, Loh SK, et al. A Weibull statisticsbased lignocellulose saccharification model and a built-in parameter accurately predict lignocellulose hydrolysis performance. Biotechnol J. 2015; 10:1424–33.
42. Wang M, Li Z, Fang X, Wang L, Qu Y. Cellulolytic enzyme production and enzymatic hydrolysis for second-generation bioethanol production. Adv Biochem Eng Biot. 2012; 128:1–24.
43. Wu D (2016) Recycle technology for potato peel waste processing: a review. Procedia Environ Sci 31:103–107.
44. Wyman CE. Biomass ethanol: technical progress, opportunities, and commercial challenges. Annu Rev Energy Env 1999; 24:189–226.
45. Yu J, Zhang X, Tan T. Ethanol production by solid state fermentation of sweet sorghum using thermo tolerant yeast strain. Fuel Processing Technology. 2008; 89, 1056-1059.
46. Zhang, L., Chen, Q., Jin, Y., Xue, H., Guan, J., Wang, Z., Zhao, H., 2010. Energy-saving direct ethanol production from viscosity reduction mash of sweet potato at very high gravity (VHG). Fuel Process. Technol. 91, 1845–1850.

© 2024 IJSRET