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Utilization of Watermelon Rind (*Citrullus lanatus*) for Bioethanol Production as Waste Treatment or Conversion of Waste into an Energy Source

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ABSTRACT

Watermelon peel (Citrullus lanatus), which has so far been regarded as organic waste or garbage, has great potential to be utilized as a raw material for bioethanol production. The main contents of watermelon peel, namely carbohydrates—especially cellulose, hemicellulose, and simple sugars—allow fermentation processes to produce bioethanol as a renewable energy source. This study aims to explore the utilization of watermelon peel as a basic material for bioethanol through hydrolysis and fermentation stages using ethanol-producing microorganisms. By utilizing watermelon peel, it is expected to reduce organic waste problems while producing sustainable and environmentally friendly alternative energy. The research results show that watermelon peel can be fermented into bioethanol in significant amounts, making it a viable alternative energy source. Thus, the utilization of watermelon peel not only contributes to organic waste management but also supports the development of new renewable energy as a solution to the fossil energy crisis.

Keywords: Watermelon peel, bioethanol, fermentation, organic waste, renewable energy.

1. INTRODUCTION

Bioethanol, a type of alcohol-based biofuel, has long been used as an alternative renewable energy source, especially in the transportation sector. Bioethanol is generally produced from plants rich in carbohydrates, such as corn, sugarcane, or cassava. However, there is great potential in utilizing organic waste, such as fruit peels, to produce bioethanol that can be an environmentally friendly renewable energy solution.

Watermelon peel (Citrullus lanatus), which is usually discarded as waste, contains natural sugars that can be converted into bioethanol through fermentation.

Watermelon is one of the fruits widely consumed around the world, especially in tropical and subtropical regions. The fruit is rich in water, but the watermelon peel is often discarded even though it contains a significant amount of carbohydrates and sugars that can be fermented into bioethanol. Watermelon peel, rich in cellulose, pectin, and sugars like glucose and fructose, can serve as an attractive raw material for bioethanol production. Considering the large amounts of watermelon discarded daily, this peel processing potential is significant as a source of cheaper and environmentally friendly bioethanol raw material.

The production of bioethanol from watermelon peel can be carried out through several stages, including hydrolysis to convert complex carbohydrates into fermentable sugars. This process involves using enzymes or acids to break down cellulose into simpler sugars. Afterward, fermentation is performed using microorganisms such as Saccharomyces cerevisiae (yeast) to convert sugars into ethanol. This process can be done with relatively simple and affordable technology, enabling local bioethanol production from waste raw materials.

With this background, research on the utilization of watermelon peel for bioethanol production not only provides a solution to waste management but also contributes to global efforts in seeking more environmentally friendly and sustainable renewable energy sources. This research can also open opportunities for the development of small and medium enterprises based on bioethanol using agricultural waste as raw materials, while positively impacting the local economy and community welfare.

Bioethanol is a form of renewable energy produced through the fermentation process of biomass rich in sugars or starch. According to Sutrisno (2019), bioethanol is classified as a first-generation biofuel that plays a strategic role in replacing fossil-based energy. The bioethanol production process includes several stages: pretreatment, hydrolysis, fermentation, and purification. Pretreatment and hydrolysis aim to break down cellulose and hemicellulose into simple sugars, while fermentation is carried out with the help of microorganisms such as Saccharomyces cerevisiae that can convert sugars into ethanol.

Watermelon peel, which has so far been considered only as household or fruit processing industry waste, can be processed into alternative energy material. This is in line with Wulandari's (2020) research stating that the utilization of organic waste, especially fruit peels, can reduce environmental pollution while increasing the economic value of the waste. Moreover, bioethanol produced from organic waste is environmentally friendly because it decomposes more easily compared to fossil fuels.

The chemical content of watermelon peel strongly supports the fermentation process. According to Rahman (2021), watermelon peel has a fairly high carbohydrate content with glucose, fructose, and sucrose that are easily broken down. In addition, the lignocellulose content in watermelon peel can be broken down into reducing sugars through acid or enzymatic hydrolysis processes, which are then fermented into ethanol. Thus, the utilization of watermelon peel into bioethanol can be a solution for organic waste management as well as a renewable energy producer.

From an environmental perspective, the processing of watermelon peel waste into bioethanol contributes to the reduction of organic waste volume that has the potential to cause pollution if not properly processed. According to Putri (2022), the processing of organic waste into bioethanol aligns with the circular economy principle, which transforms waste into valuable products. Bioethanol is also more environmentally friendly because it produces lower greenhouse gas emissions compared to fossil fuels.

Furthermore, the utilization of bioethanol from watermelon peel has good economic prospects. Waste that previously had no value can have increased added value through biotechnology processes. This aligns with

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Hidayat's (2020) opinion that energy diversification through the use of biofuels from organic waste can enhance energy independence and reduce dependence on fossil fuels

2. EXPERIMENTAL

2.1. Chemicals and Equipment

The equipment used in this study included Knife, Blender, Erlenmeyer flask, Stirring rod, Spatula, Beaker, Picnometer, Aluminum foil, Oven, Analytical balance, pH meter, Rubber tubing, Filter paper, Evaporator.

The materials used in this study consisted of Watermelon peel, Distilled water, Yeast

2.2. Research Procedure

2.2.1 Pretreatment Stage of Watermelon Peel

The first research procedure is the pretreatment of watermelon peel by cutting the peel into small pieces and then adding distilled water at a ratio of 1:1 by feed weight. The mixture is then blended, and the filtrate is collected. Next, take samples of watermelon peel pulp weighing 200 g each and put them into a 500 ml Erlenmeyer flask.

2.2.2 Fermentation Stage

After that, the fermentation process is carried out. Yeast is added to the watermelon peel pulp at concentrations of 1%, 2%, 3%, 4%, and 5% based on the weight of the pulp. Stir the mixture for 5 minutes until homogeneous. Then, measure and adjust the pH of the solution according to the research variables, which are 2, 3, 4, 5, and 6. The 500 ml Erlenmeyer flask containing the watermelon peel pulp is connected to rubber tubing, with the end of the tubing submerged in water to prevent direct contact with air. The solution is then fermented for 1, 2, 3, 4, and 5 days. After fermentation, the solution and watermelon peel pulp are separated to obtain the alcohol-water liquid. The ethanol-containing liquid is separated from the watermelon pel by filtering with filter paper. Purification is carried out using an evaporator to obtain bioethanol at 79°C.

2.2.3 Density Analysis Stage

Next, ethanol density analysis is performed using a pycnometer. A 5 ml pycnometer is dried in an oven at 80ºC for 15 minutes, then cooled to room temperature, and weighed empty using an analytical balance. Record its weight. The cooled 5 ml pycnometer is then filled with distilled water and weighed using the analytical balance. Record the weight and calculate the volume.

The pycnometer is dried again by heating it in an oven at 100ºC for 15 minutes, then cooled to room temperature. The distilled sample is then placed in the pycnometer, ensuring no air bubbles remain. Finally, weigh the pycnometer containing the distilled sample using an analytical balance. Record the room temperature at the time of weighing.

3. RESULTS AND DISCUSSION

3.1. Bioethanol Content in Yeast

Each sample was formulated with the same amount of raw material, namely 200 grams of watermelon peel pulp with a natural pH of 4.89, and fermented for three days using yeast at 1% of the material weight.

Table 4.1 Bioethanol content by yeast type

Yeast Types	Bioethanol Content (%)

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Tape Yeast	4,328
Bread Yeast	8,127

Based on the data in Table 4.1, it is known that the bioethanol content produced from fermentation using bread yeast is 8.127%, higher than that of tape yeast, which only produces 4.328%. This difference indicates that bread yeast has a more efficient fermentation capability in converting sugars into ethanol. This is due to the main microorganism content in bread yeast, which is Saccharomyces cerevisiae, known for its high fermentative activity and stability under anaerobic conditions. Bread yeast is generally a pure culture that has been industrially developed to produce gas and alcohol in optimal amounts. Additionally, bread yeast contains enzymes such as zimase, which can accelerate the glycolysis process, allowing sugars to be converted into ethanol more quickly. Meanwhile, tape yeast contains a mixture of microorganisms such as yeast, lactic acid bacteria, and molds, which do not all contribute directly to ethanol production; some may even compete to utilize the substrate sugars. Therefore, using bread yeast in fermentation is more advantageous if the primary goal is to produce bioethanol with a higher concentration.

3.2 Effect of Yeast Concentration on Bioethanol Yield

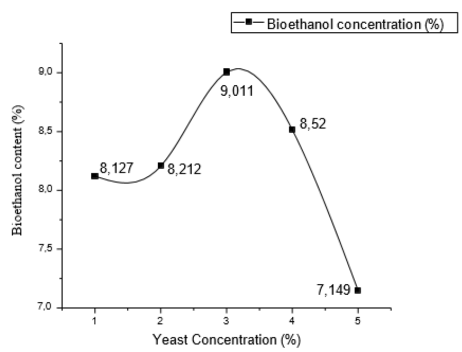

Figure 4.1 Effect of yeast concentration on bioethanol yield

Based on the data in the figure and Figure 4.1, it is evident that yeast concentration significantly affects the bioethanol content produced. At a yeast concentration of 1%, the bioethanol content is 8.127%, which slightly increases to 8.212% at 2% concentration. The peak bioethanol production occurs at a yeast concentration of 3%, with the highest content of 9.011%. Afterward, the bioethanol content begins to decrease to 8.52% at 4%, and a sharp decline occurs at 5% concentration, with bioethanol content dropping to only 7.149%.

The increase in bioethanol content up to a yeast concentration of 3% is caused by the rising number of active yeast cells that accelerate the fermentation of sugars into ethanol. However, the decrease in bioethanol content at yeast concentrations above 3% is due to competition among yeast cells in utilizing the available substrate (sugar) and the accumulation of ethanol, which becomes toxic to the yeast cells themselves. This condition can inhibit enzymatic activity, cause osmotic stress, and reduce fermentation efficiency. Excessive yeast addition also produces more acids while yielding less bioethanol. Additionally, too much yeast increases nutrient consumption without a proportional increase in ethanol yield. Therefore, the optimal yeast concentration for producing the highest bioethanol in this study is 3%.

3.3 Effect of pH on Bioethanol Yield

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In general, the pH for yeast fermentation requires an optimum acidity between 3.0 and 5.0. Outside this range, microbial growth will be disrupted.

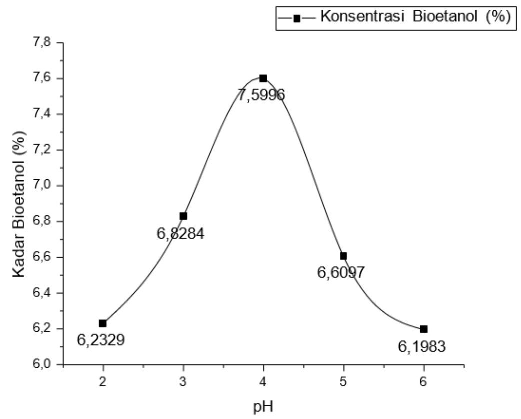

Figure 4.2 Effect of pH on Bioethanol Yield

Based on Figure 4.2, it is evident that pH has a significant effect on the bioethanol yield produced during the fermentation process. At pH 2, the bioethanol content obtained is only 6.2329%, then increases as the pH rises, reaching the highest value of 7.5996% at pH 4. Subsequently, the bioethanol content decreases again to 6.0097% at pH 5 and continues to decline to 6.1983% at pH 6.

The increase in bioethanol content up to pH 4 indicates that a mildly acidic condition is the optimal environment for enzyme activity and yeast growth, especially Saccharomyces cerevisiae, in converting sugar into ethanol. A pH that is too low (such as pH 2) can inhibit enzyme activity and damage the yeast cell structure, whereas a pH that is too high (above 4) can reduce the effectiveness of fermentation enzymes and trigger the growth of unwanted contaminant microorganisms. Therefore, the optimum pH condition that maximizes the bioethanol fermentation process in this study is around pH 4.

3.4 Effect of Fermentation Duration on Bioethanol Yield

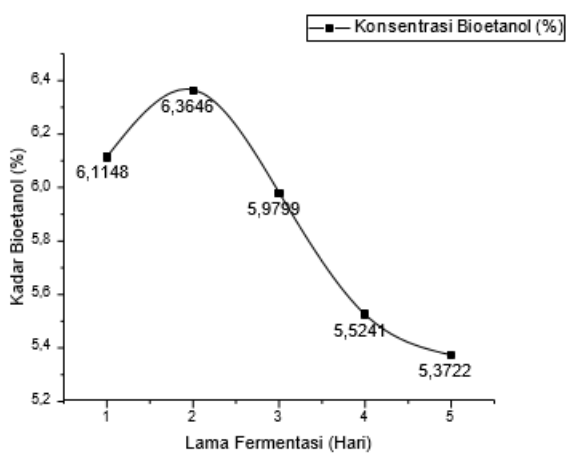

Figure 4.3 Effect of fermentation duration on bioethanol yield

Based on the graph above, it can be seen that the fermentation duration affects the bioethanol content produced. On the first day, the bioethanol content formed was 6.1148%. This value increased on the second day and reached the highest point at 6.3646%. However, after the second day, the bioethanol content gradually decreased to 5.9799% on the third day, 5.5241% on the fourth day, and 5.3722% on the fifth day.

The increase in bioethanol content up to the second day indicates that during this period, the yeast was still active and efficient in converting sugars into ethanol through fermentation. After reaching the peak on the second day, the decrease in bioethanol content was caused by several factors, including the reduced availability of substrate (sugar), accumulation of ethanol which is toxic to yeast, and decreased enzymatic activity due to less optimal environmental conditions. Additionally, prolonged fermentation time can cause ethanol to be hydrolyzed back into other compounds such as acetic acid due to the activity of other microorganisms or oxidation. Thus, based on this graph, it can be concluded that the optimal fermentation time to produce the highest bioethanol content is 2 days.

3.5 Effect of Fermentation Duration on Bioethanol Yield

Table 4.2 Effect of feed boiling on bioethanol yield

Sample	Bioethanol Content (%)
Unboiled	6,3646
Boiled	9,8917

Based on Table 4.2, it is evident that the boiling process of the feed has a significant effect on the bioethanol content produced. The unboiled sample produced bioethanol at 6.3646%, whereas the boiled sample produced a much higher bioethanol content of 9.8917%. This increase can be attributed to the boiling process, which can break down the material's cell wall structure, soften the tissue, and dissolve and release bound sugars, making them more accessible to the yeast during fermentation. Additionally, boiling can inactivate inhibitory enzymes and kill contaminant microorganisms that could compete with yeast in utilizing the substrate. Thus, boiling the feed before fermentation can increase the availability of fermentable sugars and maximize yeast activity, resulting in a higher bioethanol content.

4. CONCLUSION

Based on the research results regarding the influence of various factors on bioethanol content from watermelon peel fermentation, it can be concluded that yeast type, yeast concentration, pH, fermentation duration, and the boiling process of the raw material have significant effects on the amount of bioethanol produced. The best yeast for bioethanol production is bread yeast (Saccharomyces cerevisiae) with the highest bioethanol content of 8.127%, due to its high fermentative activity and enzymatic stability. The optimal yeast concentration is shown to be 3%, producing the highest bioethanol content of 9.011%, where an excess of yeast actually lowers the yield due to substrate competition and ethanol toxicity. The optimum pH condition is at pH 4, with the highest bioethanol content of 7.5996%, as it maximizes enzyme activity and yeast growth. The best fermentation duration is 2 days, producing bioethanol at 6.3646%; after that, ethanol content decreases due to substrate depletion and the toxic effects of ethanol on yeast. Additionally, the boiling process of the raw material has been proven to significantly increase fermentation yield, with bioethanol content rising from 6.3646% to 9.8917%, because boiling helps break down cell walls, dissolve sugars, and reduce microbial contamination. Overall, the optimum fermentation conditions to produce the highest bioethanol from watermelon peel are boiling the raw material, using 3% bread yeast, pH 4, and a fermentation time of 2 days.

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REFERENCES

1. L. Pranata, I. Kurniawan, S. Indaryati, M. T. Rini, K. Suryani, and E. Yuniarti, "Pelatihan Pengolahan Sampah Organik Dengan Metode Eco Enzym," *Indones. J. Community Serv.*, vol. 1, no. 1, pp. 171–179, 2021.
2. I. Aisyah, "Kajian penciptaan „Green Jobs" melalui pengelolaan limbah biomassa menjadi arang dan asap cair dengan teknik pirolisis," *J. Penelit. Pendidik.*, vol. 23, no. 1, pp. 83–91, 2023, [Online]. Available: https://doi.org/10.17509/jpp.v23i1.56991
3. A. T. Kurnia and A. Mustain, "Prediksi Kesetimbangan Uap-Cair Sistem Biner Tert-Butanol + 1-Pentanol Dengan Menggunakan Model Unifac," *DISTILAT J. Teknol. Separasi*, vol. 8, no. 1, pp. 104–110, 2023, doi: 10.33795/distilat.v8i1.297.
4. Herdini, Gobby Rohpanae, and Veriah Hadi, "Pembuatan Bioetanol Dari Kulit Petai (Parkia Speciosa Hassk) Menggunakan Metode Hidrolisis Asam Dan Fermentasi Saccharomyces Cerevisiae," *TEKNOSAINS J. Sains, Teknol. dan Inform.*, vol. 7, no. 2, pp. 119–128, 2020, doi: 10.37373/tekno.v7i2.9.
5. B. Junior, F. S. Pranata, and L. M. E. Purwijantiningsih, "Kualitas Selai Lembaran Kombinasi Pektin Albedo Semangka (Citrullus vulgaris Schard) dan Filtrat Buah Kelengkeng (Dimocarpus longan)," *J. Ilmu Pangan dan Has. Pertan.*, vol. 4, no. 2, pp. 146–162, 2021, doi: 10.26877/jiphp.v4i2.6776.
6. F. Coniwanti, F. Siagian, and Y. Prasetyo, "Pengaruh Konsentrasi Asam Sulfat Dan Variasi Masa Ragi Terhadap Pembuatan Bioetanol Dari Biji Durian," *J. Tek. Kim.*, vol. 22, no. 4, pp. 45–53, 2016, [Online]. Available: http://ejournal.ft.unsri.ac.id/index.php/jtk/article/view/96
7. M. W. Kurniawati, Z. Ulma, P. Alfian, and A. Pratama, "Pemanfaatan Limbah Kulit Pisang Kepok untuk Produksi Bioetanol dengan Proses Hidrolisis Asam Klorida," vol. 16, pp. 187–194, 2023.

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