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Effect of Nutrient on the Bio-Ethanol Production from Pineapple Peel Fermentation

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Abstract
Addressing the problem of increasingly complex urban household waste requires a multi-aspect approach. Bioethanol fermentation from pineapple peel juice is interesting research to carry out because pineapple peel is one of the fruit wastes that has the potential to be used as raw material for bioethanol production. Disposal of pineapple peel waste can cause environmental problems because this waste can become a source of water and air pollution if not managed properly. Therefore, processing pineapple peel waste into useful products such as bioethanol can help reduce the environmental impact of waste disposal. This research discusses the effect of nutrient concentration on bioethanol production in the fermentation process from pineapple peel. The nutrients used include urea and NPK (Nitrogen, Phosphorus, Potassium) which are added during fermentation with varying nutrient concentrations of 11.25 g, 22.50 g, and 33.75 g. This research also considered the initial fermentation conditions, namely the sugar content of pineapple peel juice of around 4 Brix and a pH in the range of 5.5 to 6.0. Fermentation results are measured in the form of bioethanol content, with production targets of 6%, 7.5% and 9%. Higher nutrient concentrations tend to support better yeast growth and higher ethanol production. However, it should be noted that a proper balance between nutrient concentrations needs to be achieved to avoid negative impacts such as overstimulation and the production of undesirable compounds.
Keywords: *Fermentation, Pineapple, Bio-Ethanol, Nutrient, Saccharomyces cerevisiae*

Abstrak
Mengatasi permasalahan sampah rumah tangga perkotaan yang semakin kompleks memerlukan pendekatan multi-aspek. Fermentasi bioetanol dari sari kulit nanas merupakan penelitian yang menarik untuk dilakukan karena kulit nanas merupakan salah satu limbah buah yang berpotensi untuk dijadikan bahan baku produksi bioetanol. Pembuangan limbah kulit nanas dapat menimbulkan permasalahan lingkungan karena limbah tersebut dapat menjadi sumber pencemaran air dan udara apabila tidak dikelola dengan baik. Oleh karena itu, pengolahan limbah kulit nanas menjadi produk bermanfaat seperti bioetanol dapat membantu mengurangi dampak pembuangan limbah terhadap lingkungan. Penelitian ini membahas tentang pengaruh konsentrasi nutrisi terhadap produksi bioetanol pada proses fermentasi dari kulit nanas. Nutrisi yang digunakan antara lain urea dan NPK (Nitrogen, Fosfor, Kalium) yang ditambahkan pada saat fermentasi dengan konsentrasi nutrisi yang bervariasi yaitu 11,25 g, 22,50 g, dan 33,75 g. Penelitian ini juga mempertimbangkan kondisi awal fermentasi yaitu kandungan gula sari kulit nanas sekitar 4 Brix dan pH pada kisaran 5,5 hingga 6,0. Hasil fermentasi diukur berupa kadar bioetanol, dengan target produksi sebesar 6%, 7,5% dan 9%. Konsentrasi nutrisi yang lebih tinggi cenderung mendukung pertumbuhan ragi yang lebih baik dan produksi etanol yang lebih tinggi. Namun, perlu dicatat bahwa keseimbangan yang tepat antara konsentrasi nutrisi perlu dicapai untuk menghindari dampak negatif seperti stimulasi berlebihan dan produksi senyawa yang tidak diinginkan.
Kata Kunci: *Fermentasi, Kulit Nanas, Bio-Etanol, Nutrisi, Saccharomyces cerevisiae*

1. Introduction

Bioethanol is a kind of fuel that is made from plants instead of things like oil. It is better for the environment because it doesn't create as much pollution. Bioethanol has the characteristics of being volatile, flammable, soluble in water, non-carcinogenic, and has no negative impact on the environment. Bioethanol has benefits for human consumption as an alcoholic drink. Apart from that, bioethanol can be used as fuel with a minimum content of 10% ethanol. Scientists are always trying to find better ways to make bioethanol, and one way they are doing this is by using pineapple peels. They use special microorganisms to turn the sugar in the pineapple peels into bioethanol. They also use other plants that have starch, lignocellulose, or sucrose in them. The most common ways to make bioethanol are through a process called fermentation and

a process called distillation [1]. The purpose of distillation is to purify liquids at their boiling point, and separate these liquids from dissolved solids or from other liquids that have different boiling points of pure liquids. In ordinary distillation the vapor pressure above the liquid is atmospheric pressure (normal boiling point). For pure compounds, the temperature recorded on a thermometer placed where the distillation process occurs is the same as the boiling point of the distillate.

Pineapple peel is the part of the pineapple that is usually thrown away. But it has a lot of useful stuff in it. It has things called cellulose, hemicellulose, and sugar, which can be turned into something called bioethanol. Bioethanol is a type of fuel that can be made from plants. Pineapple peel also has nutrients that are important for tiny living things called microorganisms. These microorganisms help with the process of turning pineapple peel into bioethanol. This can be helpful for places that grow a lot of pineapples, because they can make money from the bioethanol. The pineapple peel is made up of mostly water, fiber, carbohydrates, protein, and sugar. It has a lot of carbohydrates and sugar, which are important for making bioethanol. Considering the high sugar content, pineapple peel can be used as a raw material for making bioethanol through a fermentation process [2].

Table 1. Pineapple Peel Nutritional Content

Nutrient content	Amount (%)
Carbohydrate	17.53
Proteins	4.41
Reducing sugar	13.65
Water content	43.54
Crude fiber	20.87
Cellulose	21,98 ± 2,34 %
Hemicellulose	74,96 ± 2,55 %
Lignin	2,68 ± 1,54 %

Source: Nulhakim, et.all (2019) [3]

In addition, the influence of nutrients such as urea (nitrogen) and NPK fertilizer (nitrogen, phosphorus, potassium) in the pineapple peel fermentation process is not fully understood. Proper nutrition can influence the growth of microorganisms, enzyme activity, and ultimately, better bioethanol production in terms of volume and grade.

This research is tended to explore the potential of using pineapple peel as a raw material for bioethanol production and to investigate how the provision of nutrients, especially urea and NPK, affects the volume formation and content of bioethanol during the fermentation process. This research can provide better insight into the nutritional factors that influence the efficiency of bioethanol production from pineapple peel and can support the development of more efficient and sustainable bioethanol production processes.

Fermentation is an anaerobic process of releasing energy without the presence of oxygen. Fermentation is carried out in a fermentation tank with a total sugar content of ± 15%. If the substrate sugar content is low, anaerobic conditions are needed, so that the yeast cells can carry out fermentation which will convert the sugar into ethanol. This fermentation process causes an increase in heat. So that the heat that arises can be absorbed, a cooler is needed to maintain a constant temperature of 30 ^{O}C during the ongoing fermentation process [4] [5]. The fermentation process is carried out by adding yeast to convert glucose into bioethanol which is facultative anaerobic, that is, it does not require oxygen (O_2).

Most yeasts can turn different kinds of sugar into alcohol through a process called glycolysis. But one yeast called Saccharomyces cerevisiae is the most popular for making alcohol because it is strong and can handle different conditions [6]. It can grow with or without air and can handle high amounts of alcohol. When there is no air, this yeast makes a chemical called acetaldehyde, which then turns into alcohol [7].

In principle, the fermentation reaction is as follows:

$$C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2$$
Glucose ethanol carbon-dioxide

The main challenge in using pineapple peel as raw material is how to optimize the fermentation conditions and nutrients needed to maximize bioethanol yield. Controlling nutrient concentration, pH, temperature and the most suitable type of yeast will be key factors in achieving optimal results. The potential use of pineapple peel as a raw material is an abundant and sustainable source of raw materials.

With proper use, pineapple peel can reduce agricultural waste and support more environmentally friendly bioethanol production.

This research will involve laboratory experiments where pineapple peel will be used as a substrate for fermentation. Several variations in nutrient composition will be used to understand their effect on the volume and content of bioethanol produced. Measurements of the volume and content of bioethanol will be carried out periodically during the fermentation period. The data obtained will be analysed to identify significant nutritional influences and optimize bioethanol production conditions.

It is hoped that the results of this research will provide better insight into the potential use of pineapple peel as a raw material for bioethanol and provide a deeper insight into the role of nutrition in the fermentation process. This research has the potential to support the development of a more efficient and sustainable bioethanol industry, as well as reduce agricultural waste that is not fully utilized.

2. Material and Methods

The raw material for pineapple peel is obtained from local markets or a store that sell pineapple juice drinks. Saccharomyces cerevisiae is used as a microorganism that plays a role in the fermentation process in the form of Fermipan and nutrients in the form of urea and NPK fertilizer, all are obtained from local shops. The fermenter which is integrated as a distillation tool is made from 304 stainless steel with a capacity of 20 L along with a distillation column and steam cooler and is equipped with a temperature measuring device on the distillation column. The solid NaOH and HCl used to control the pH in the range of 5.5 to 6.0 were also obtained from local chemical stores.

The process begins with making a starter which is done by dissolving 2-3% Fermipan (Saccharomyces cerevisiae), 0.25% urea, and 0.25% NPK in 500 mL of plain water. Stir until completely dissolved and cover with a cloth. Leave for 60-120 minutes at room temperature and pressure. There is no sterilization treatment at all in this process. Furthermore, the pineapple peel is cut and rinsed then crushed using a blender with the addition of a little plain water to get the extraction liquid from the pineapple peel. Filter the pineapple juice to separate the liquid from the pineapple dregs and get 4,500 mL of pineapple juice.

Carry out an initial analysis of pineapple juice in the form of ethanol content, sugar content (> 3 Brix), and pH (5.5-6.5). Adjust the pH by adding sufficient NaOH or HCl solution. Put the pineapple peel juice into the fermenter tank along with the starter. Add 11.25 g of urea, and 11.25 g of NPK. Close the fermenter tightly (anaerobic conditions) then let it sit for 5 days [8] at room pressure and temperature, although some are recommending for 4 days (96 hours) [9]. There is no effort whatsoever to regulate the fermenter temperature, fermentation temperature conditions are very dependent on environmental temperature. This fermenter is used as a place for the fermentation process to convert glucose into ethanol under anaerobic conditions.

Distillation is carried out after the fermentation process ends. Analyze pH, sugar content and ethanol content. Install the distillation column on the fermenter and install the condenser then connect the cooling water hose, where the fermenter now changes its function to a distillation tool. Heat the reactor using a gas stove at a temperature of 78-89 ^{O}C for around 120 minutes, and the first drop of ethanol will come out at 45 minutes. Carry out a final analysis, namely the volume of ethanol obtained, pH, sugar content and ethanol content.

In this research, variations were made in giving nutrients in the form of urea and NPK added during fermentation that was 11.25, 22.50, and 33.75 gram each. The yeast was given in the amount of 15 g. The sugar content of pineapple peel juice to be fermented is in the range of 4 brix and pH between 5.5-6.0.

3. Results and Discussion

The fermentation process in this research was using microbes, although it has many benefits in various industries such as food, pharmaceuticals and energy, but often faces various challenges that make it difficult to conduct. The suspected factor causing difficulties in the microbial fermentation process is that the microbes used in fermentation are often sensitive to environmental changes such as changes in temperature, pH, or nutrient concentration. Variability in the fermentation environment can make microbes unstable, disrupting the overall fermentation process. In this experiment, no effort was made to keep the temperature, pH or nutrient concentration stable, because it was projected to be easily carried out by the community.

Fermentation is carried out at the optimum temperature, namely 30 ^{O}C [5]. The higher the fermentation temperature actually increases the bioethanol produced, this happens because at high temperatures the formation of ethanol is achieved more quickly because the reaction of the Saccharomyces

cerevisiae bacteria tends to be faster and the concentration decreases due to disruption. growth of Saccharomyces cerevisiae so that ethanol levels decrease over time. It just requires additional heat and control over temperature changes [4].

The time chosen for fermentation was 5 days (120 hours) because at a fermentation time of 3 days to a fermentation time of 9 days, it showed that the formation of bioethanol had increased, but at a fermentation time of 12 days the bioethanol formed had decreased [10] [11]. This means that microbial growth at that time was in the exponential phase, namely the phase of increasing microbial development so that the microbes worked optimally to convert glucose into ethanol. Apart from that, the decrease in glucose levels during the 12 days fermentation period was caused by the number of microbes decreasing and going into the death phase because more bioethanol was produced and the existing nutrients were running low. The increase in bioethanol formed after the sixth day is not very significant, so the economical fermentation time is 5 days.

The nutrients used in this research are urea and NPK which play a key role in bioethanol production because the microorganisms used in the fermentation process, such as yeast, require certain nutrients for efficient growth and conversion of sugar into ethanol. Urea and NPK are nutrients that are important for the growth of microorganisms, including yeast, during the fermentation process. These two nutrients are used as a source of nitrogen (N) and phosphorus (P) needed by Saccharomyces cerevisiae. The respective masses of urea and NPK added during fermentation varied at 11.25, 22.5, and 33.75 grams.

Table 2. Bio-Ethanol product

RUN	Nutrient (g)	*Bio-Ethanol (%)*	*Volume Bio-Ethanol Recovery (mL)*
1	11.25	6	105
2	22.5	7,5	118
3	33.75	9	160

When giving yeast (15 g) at the same fermentation time and treatment during seedlings, it was found that the increase in nutrition also resulted in an increase in the level and volume of Bioethanol obtained. Nutrients, such as urea and NPK, are required by microorganisms, including yeast, during the fermentation process. Variations in nutrient concentration influence yeast growth during fermentation. Higher concentrations will usually support better yeast growth. Sufficient nutrient concentrations support yeast growth and proliferation. The more yeast that grows, the more sugar can be converted into ethanol. Low nutrient concentrations can inhibit yeast growth and reduce fermentation efficiency.

When making things like bread or beer, there are certain things that can make the process not work very well. One of these things is when there is not enough of certain nutrients and substances that help things grow. For example, a type of yeast called S. cerevisiae needs oxygen to make important parts of its body, like fats and acids. When there is not enough oxygen, the yeast can't make these parts properly and it can make the fermentation process does not work very well [12].

Recovering bioethanol after the fermentation process can be done by distillation. The method is by fractional distillation or vacuum distillation. In research on purifying ethanol from pineapple peel fermentation using vacuum distillation, the highest distillate ethanol content value obtained was 21.25% at the most optimal temperature on 50 ^{O}C [13]. In this research, bioethanol recovery was carried out by fractional distillation at a temperature of 78-89 ^{O}C for around 120 minutes.

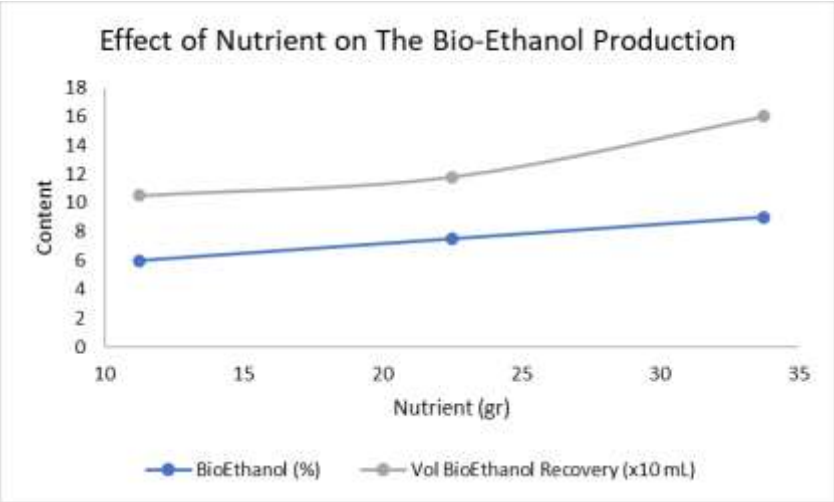

Figure 1. Effect of Nutrient on The Bio-Ethanol Production

In this experiment, the three variations in nutrient concentration, namely 11.25 g, 22.50 g, and 33.75 gs, have the potential to influence bioethanol production. Higher nutrient concentrations can provide more resources for yeast to convert sugar to ethanol. The main effect of varying nutrient concentrations is on the levels of bioethanol produced. Higher nutrient concentrations, in this experiment, would probably result in higher bioethanol levels, such as 7.5% or 9%. It is important to find an optimal balance between nutrient concentration and bioethanol production. Too high a concentration may not always produce better results, and too many nutrients can also interfere with fermentation.

Further research can be done by replacing NPK as nutrients with $(NH_4)_2SO_4$, Na_2HPO_4, $MgSO_4$ or $C_3H_7NO_2$ which can reduce sucrose by around 15% after 6 hours. The addition of the nutrient $MgSO_4$ produces bioethanol yields of up to 81.8% and then $C_3H_7NO_2$ [14]. According to Birch and Walker [15], magnesium helps keep yeast cells safe from stress caused by alcohol and high temperatures by stopping their outer layer from getting too leaky. Adding certain salts, like magnesium, also helps some enzymes in the yeast cells work better and make more alcohol. So, when we give yeast extra magnesium, it helps them make alcohol faster and more efficiently.

4. Conclusion

The influence of nutrient concentrations, such as urea and NPK, in the fermentation process of pineapple peel into bioethanol can be very significant on the results of bioethanol production. In this experiment, these variables can have an impact on the levels of bioethanol produced. To optimize bioethanol production, it is important to carry out further analysis and determine the best combination of conditions to achieve optimal results. Apart from that, it is also necessary to pay attention to the ratio of nutrient concentrations that favor yeast growth without overstimulation thereby disrupting the fermentation process. The fermentation process of bioethanol from pineapple peel is an interesting research area and has the potential to produce ethanol efficiently by taking into account the right nutritional variables. The increase in nutrition also resulted in an increase in the level and volume of Bioethanol obtained. The addition of higher nutrients up to 33.75 grams in 15 grams of yeast with a fermentation time of 5 days resulted in the highest bioethanol production being 9%.

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