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Characteristics of bioethanol from coconut water waste fermentation as an alternative fuel

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Abstract: *This paper aims to utilize coconut water waste to produce alternative fuels through a fermentation process so that it can be used as bioethanol fuel. In further research and development of effective and efficient technology for fermentation of coconut water waste into bioethanol is very important to be realized. This not only supports better utilization of natural resources, but also contributes to sustainable development and reducing dependence on fossil fuels. The results of this study showed that there was an effect of fermentation time on the ethanol content of coconut water fermentation results and the optimum time for coconut water fermentation was 6 days from variations in fermentation time of 4 days, 5 days and 6 days with an ethanol content of 4 days of 35%, an ethanol content of 5 days of 40% and an ethanol content of 6 days of 50%. The highest calorific value was obtained at a fermentation time of 6 days with a calorific value of 2295 kcal / g. Variations in fermentation time greatly affect fermentation time, alcohol content, alcohol volume, pure alcohol volume, specific gravity.*

Keywords: *fuel, fermentation, waste coconut water, bioethanol.*

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I. INTRODUCTION

Bioethanol is a compound with the chemical formula C_2H_5OH. Bioethanol is produced from renewable natural raw materials containing sugar, starch, or cellulose through a fermentation process. The conversion of sugar to bioethanol can be carried out by microorganisms such as Saccharomyces cerevisiae (Aspiadi, 2019). Bioethanol can be used as an alternative fuel that has good prospects in the future. According to the Directorate General of Oil and Gas (2012), Indonesia's crude oil reserves are only 3.7 billion barrels with a production rate of 830,000 thousand barrels per day which will run out within twelve years. Given the current energy crisis has entered a very serious stage, alternative solutions to the problem must be sought immediately, namely by finding renewable energy sources (BPS, 2020).

Meanwhile, Indonesia is a fairly large producer of coconuts in the world. Coconut is a natural material that is easy to obtain (Oktavianto et al., 2020; Zely, 2014) and can be processed into materials that have more optimal utility value (Rianto, 2016). Coconut production in tropical areas is very abundant and coconut production in Indonesia averages 15.5 billion grains/year or equivalent to 3.02 million tons of copra, 3.75 million tons of water, 0.75 million tons of coconut shell charcoal, 1.8 million tons of coir fiber, and 3.3 million tons of coir dust (Wulandari and Utami, 2015; Mahendra et al., 2020; Ilangarathna and Kapilan, 2022). Based on the BPS of NTB Province in 2020, the amount of coconut production in NTB Province was recorded at 48,828 tons/year. From these data, it can be seen that the amount of coconut water obtained is around 1,642 tons/year or equivalent to 4.0 tons/day, which is a natural resource potential in the form of coconuts that is very large to be processed into a source of bioethanol fuel.

The amount of water contained in 1 coconut is an average of 300 cc because its utilization is still limited, coconut water is often just thrown away, either into rivers or drainage ditches. As a result of this disposal, black and unpleasant-smelling sediment can form. If large amounts of coconut water enter the rice fields, it can cause abnormal growth in rice plants (Malle et al., 2012). Coconut water is one of the products of the coconut plant that has not been widely utilized, because its utilization is not optimal, this coconut water is often just thrown away. Bioethanol is one of the renewable energy sources that is increasingly being researched and used as an alternative to fossil fuels. The use of bioethanol not only reduces greenhouse gas emissions, but can also increase energy security and support local agriculture and the economy. Raw materials for bioethanol production are usually sources of sugar or starch, such as corn and sugar cane. However, with increasing concerns about competition between the use of food crops for fuel and human consumption, research has shifted to more sustainable and non-competitive sources of raw materials, one of which is coconut water waste. Riyanto (2016) stated that in Indonesia coconut water is available in large quantities, namely 900 million liters per year, a potential that has not been utilized optimally. Coconut water is still waste and is at risk of polluting the environment. Fermentation of coconut water will increase acidity so that it has a negative effect on the surrounding plants.

On the other hand, domestic fossil fuel prices have increased. Indonesia finally adjusted fuel prices by reducing fuel subsidies. As a result, since 2014, domestic fuel prices have continued to increase and the government has issued Presidential Regulation of the Republic of Indonesia Number 5 of 2006 concerning National Energy Policy to develop alternative energy sources as a substitute for fuel and the Policy has determined renewable resources such as biofuels as an alternative to fuel. Biofuels are expected to reduce the occurrence of fuel shortages, so that the need for fuel can be met (Chairul 2013).

Previous research Malle, et al. (2012), studied coconut water waste with a fermentation process of 500 ml put into a fermenter bottle then added 0.875gr/l K_2HPO_4 (Potassium Hydrogen) and added 30gr/l ammonium sulfate stirred until dissolved. Then added 8.7gr/l yeast stirred then incubated by tightly closing the fermenter bottle at a temperature of 30 ºC, taking samples at each variation of the first, second, third time and so on until the fermentation process stops and has an ethanol content of 73% ethanol content of coconut water does not meet the Indonesian National Standard (SNI) bioethanol.

Asip, et al. (2017), based on research conducted from coconut fiber with the highest bioethanol content produced samples with a sulfuric acid concentration during delignification of 5% and fermentation on the fifth day of 5.7768%. The highest bioethanol content is shown by using strong acid with the highest concentration (5%) and the higher the concentration of strong acid (H_2SO_4) the greater the glucose content produced, the highest glucose content is produced at a concentration of 5% sulfuric acid. The longer the fermentation time, the greater the bioethanol content produced, the optimum time for bioethanol formation is on the fifth day. After passing the fifth day, the bioethanol content produced decreased. Coconut water waste is a by-product of the coconut processing industry, especially in the production of coconut oil, coconut milk, and other coconut products (Wijaya et al., 2012). Usually, coconut water is considered waste and is discarded, which can cause environmental problems if not managed properly. In fact, coconut water contains sugar and nutrients that can be utilized by microorganisms in the fermentation process to produce bioethanol. With its great potential, further research and development of effective and efficient technology for the fermentation of coconut water waste into bioethanol is essential to be realized. This not only supports better utilization of natural resources, but also contributes to sustainable development and reduced dependence on fossil fuels.

II. EXPERIMENTAL PROCEDURE

In this study, the method used is an experimental method, namely conducting direct testing of the test equipment in order to obtain the desired data to solve the problem. The material used in this study is coconut water waste which is generally discarded or not utilized. Where the first step is to filter the coconut water, after that the water that has been filtered to be clean from dirt, then the coconut water is cooked until boiling and then waited until it cools and the cooled coconut water is put into a container and tightly closed. Coconut water is heated using a stove until a brix of 14% is obtained. A refractometer is used to determine that the cooked coconut water has reached a brix of 14%. In addition to increasing the brix, this heating also aims to kill bacteria in the coconut water. Furthermore, a starter is made by mixing ingredients in the form of 10gr/l fermipan, 0.5gr/l urea and 0.5gr/l NPK using a prepared container, after the ingredients are evenly mixed, the cooked coconut water is added.

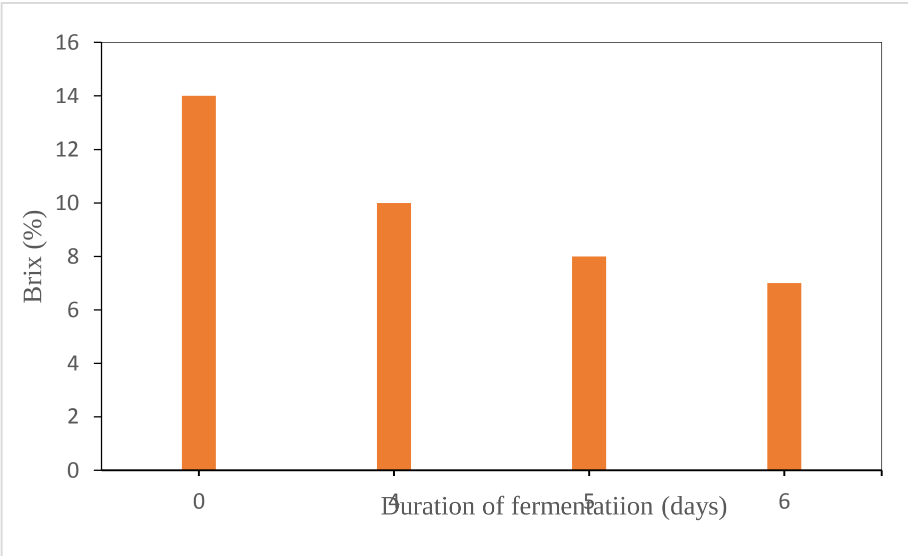
The next stage is the fermentation process at room temperature between 23-33°C, where this fermentation process will last for 4 days, 5 days, and 6 days and in anaerobic conditions. Brix measurements are carried out on days 4, 5, and 6 to see how much sugar has been broken down into alcohol. After the fermentation process is complete, the distillation process is carried out. The distillation process uses a temperature of 80 °C with a tolerance of ± 2 °C. After all samples are distilled, observations and data collection are carried out. The data observed are the volume of bioethanol produced, the content of bioethanol and the calorific value of bioethanol.

Figure 1. Testing Process

III. RESULTS AND DISCUSSIONS

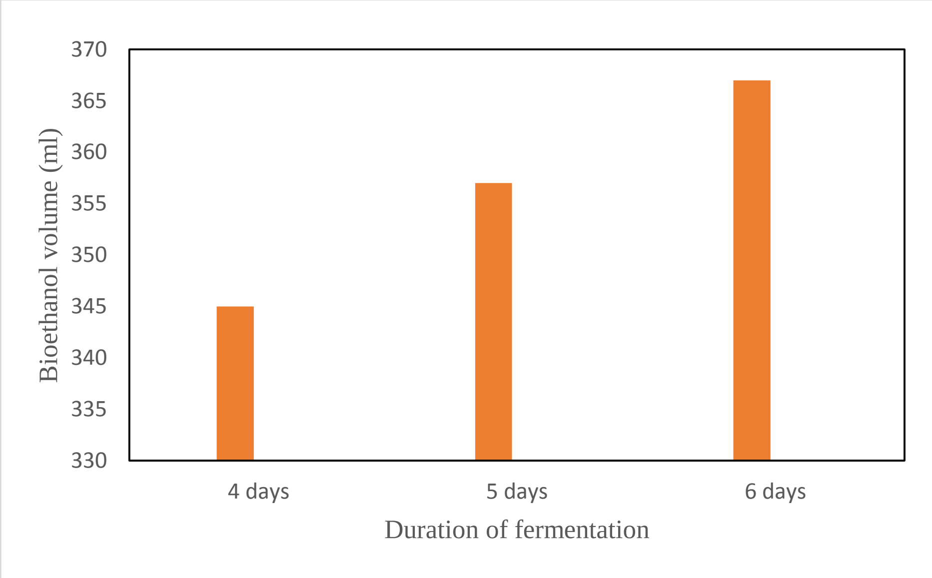
Fermentation is a process to change sucrose molecules into ethanol or better known as bioethanol (alcohol) using yeast microorganisms. This fermentation process lasts for several days, namely 4 days, 5 days and 6 days.

Figure 2. Brix percentage during the fermentation process



From Figure 2, the overall fermentation from day 4 to day 6 for all treatments can be seen. The amount of sugar consumption increases as the fermentation time increases, this can be seen from the decreasing brix levels. Figure 2 shows an increase in the amount of sugar consumed by microbes from day 4 to day 6. This is because the role of NPK as a medium that can support the growth of Saccharomyces cerevisae optimally begins to be seen in consuming sugar, where N functions as a source of nitrogen which is useful for the formation of nucleic acids and amino acids, K functions as an enzyme cofactor and P functions as the synthesis of nucleic acids, ATP, phospholipids and other phosphorus-containing compounds. The Brix content decreases with the length of fermentation because this process involves the conversion of sugar (glucose) into bioethanol, and carbon dioxide gas by microorganisms such as yeast and bacteria. During fermentation, microorganisms decompose reducing sugars into other by-products, so that the sugar concentration in the solution decreases. The rate of Brix decline during fermentation is influenced by various factors (Marlina et al., 2020) such as temperature, type of microorganism used, and initial sugar concentration. Fermentation that takes place under optimal conditions will reduce the Brix value more quickly.

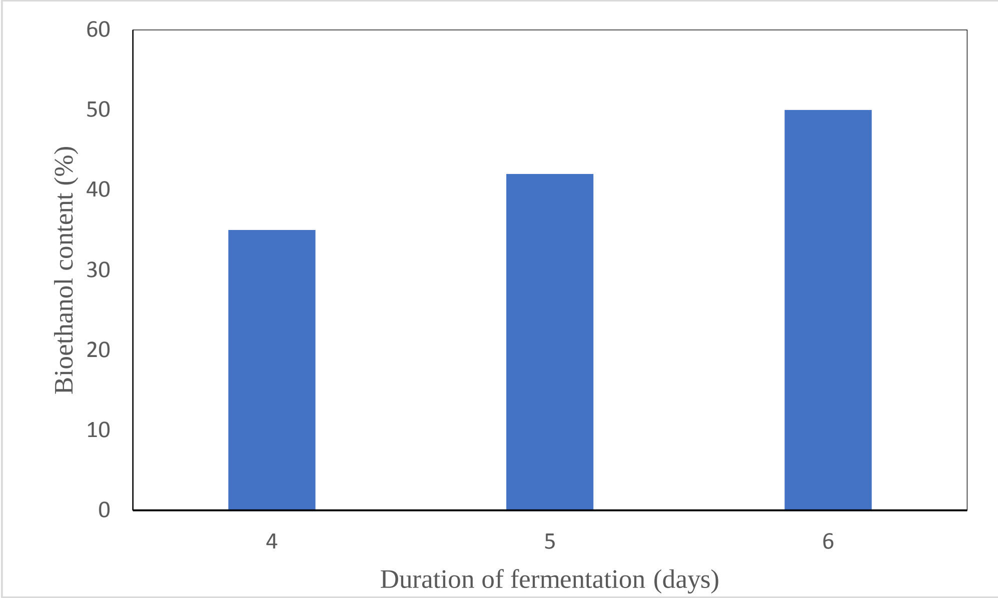
Figure 3. Relationship between the volume of fermented bioethanol and the fermentation time



In Figure 3, the relationship between the influence of fermentation time and the volume of alcohol produced can be seen that the graph trend is increasing with a peak at a fermentation time of 6 days, on the 4th day the volume of alcohol produced is very low because in the life cycle of microorganisms at 1-2 days is the lag phase, the process that occurs is that microorganisms adapt to the environment and the length of time for microorganisms to adapt to each other varies so that within 4 days fermentation continues but the alcohol yield is very little. On the 4th and 5th days there is an increase in the amount of alcohol produced but this amount is not yet optimal, because the microorganisms are still in the exponential phase or growth phase so that it affects the alcohol formation process. The time needed for microorganisms to grow also varies so that it affects the alcohol produced. The 6th day is the maximum fermentation time for microorganisms to produce alcohol, because the microorganisms are already in the static phase of microbes. If seen in Figure 4, it is known that the static phase of microbes/optimum fermentation time is fermentation on the 6th day with an ethanol content of 50%.

From Figure 3, the overall fermentation from the 4th to the 6th day for all treatments can be seen. The amount of sugar consumption increases with increasing fermentation time (Putra and Amran 2009) this can be seen by decreasing brix levels. Figure 3 shows an increase in the amount of sugar consumed by microbes from day 4 to day 6. This is because the role of NPK as a medium that can support the growth of Saccharomyces cerevisae optimally begins to be seen in consuming sugar (Sutanto et al., 2013), where N functions as a source of nitrogen which is useful for the formation of nucleic acids and amino acids, K functions as an enzyme cofactor and P functions as the synthesis of nucleic acids, ATP, phospholipids and other phosphorus-containing compounds (Mahendra et al., 2023).

Figure 4. Relationship between bioethanol content and fermentation duration

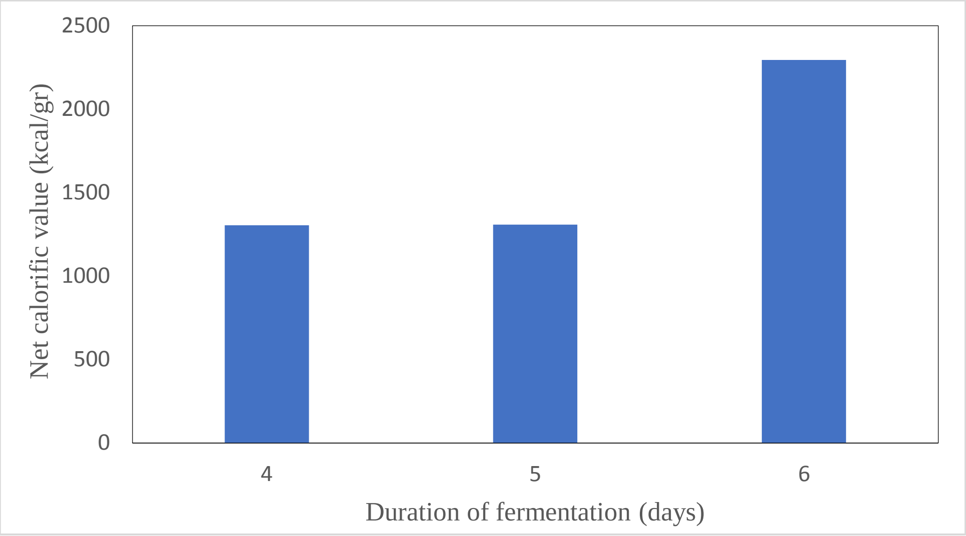


The purpose of this study was to determine the optimum time for coconut water waste fermentation. Determination of the optimum time and duration of fermentation is based on the phase of microbial development during the fermentation process. Initially, microbes experience an adaptation phase, which is a phase where microbes adapt to their environment which can be shown at the beginning of the fermentation process. Fermentation on the 6th day showed the highest optimum ethanol content for fermentation. This is because fermentation on the 4th day is included in the initial phase of fermentation or the adaptation phase so that microbes can still grow. Further fermentation during the 5th and 6th days. In fermentation for 6 days, it is estimated that microbes continue to grow until they reach a static phase, which is a phase where the number of microbes that grow and the number of microbes that die are the same. In this static phase, microbes experience an optimal growth phase before experiencing a death phase. Determination of the optimum fermentation time can be determined by determining the static phase of microbes. If seen in Figure 4, it is known that the static phase of microbes/optimal fermentation time is fermentation on the 6th day with an ethanol content of 50%.

The volume of pure alcohol is the volume value of alcohol, for example 100 ml of alcohol with a content of 60%, meaning 40% of it is water so that the volume of pure alcohol is 60 ml. From figure 4 it can be seen that the longer the fermentation of alcohol content the higher the volume of pure alcohol produced, this is also related to the alcohol content produced because the higher the alcohol content the lower the alcohol volume. In the figure above it can be seen that the highest volume of pure alcohol is 182 ml with a fermentation period of 6 days and an alcohol content of 50% and for the lowest ethanol volume, which is 114.9 ml with a fermentation period of 4 days and an alcohol content of 35%. It can be concluded that in this study the longer the fermentation, the higher the alcohol volume, due to the higher sugar content than other variations, although the alcohol content is low but it will be more efficient because it produces more alcohol, if distilled again it is still possible to get a higher alcohol content and the longer the fermentation is carried out the amount of alcohol content will increase. This is in line with the research of Riyanto (2016) and Hartono and Pagarra 2011).

The higher the alcohol content produced, the lower the specific gravity. This is because the higher the alcohol content, the lower the water content in the alcohol. This affects the calculation of ethanol density (ρ), the lower the water content in the alcohol, the lower the alcohol mass (Noviani et al., 2014). The lower the alcohol mass is what causes the specific gravity to be lower. Specific gravity is a statement that states the density or weight per unit volume of a material, the maximum specific gravity value is 0.99968, and specific gravity is the relative value of the density of a material to water. shows the effect of fermentation time on the specific gravity of bioethanol, obtained on the 4th day 0.9451 where the specific gravity is not yet in accordance with the absolute specific gravity of bioethanol, which is a maximum of 0.99968. The ethanol produced is still not pure because it is mixed with water because the specific gravity value is still too high.

Figure 5. Relationship between calorific value and fermentation duration



Calorific value is a number that states the amount of heat / calories produced from the combustion process of a certain amount of fuel with air / oxygen. The calorific value is inversely proportional to the specific gravity (density). At the same volume, the greater the specific gravity of an oil, the lower the calorific value, and vice versa, the lower the specific gravity, the higher the calorific value. In Figure 5, the highest calorific value is on the 6th day with a fermentation time of 6 days with a calorific value of 2295 kcal / g. In the fermentation process, carbohydrates will be converted into glucose, as well as other compounds. The invertase enzyme produced by Saccharomyces cerevisiae will convert glucose into alcohol. The longer the fermentation process, the more glucose is converted into alcohol and other compounds (Marlina et al., 2020). The alcohol produced from the fermentation process usually still contains gases, including CO2 which arises from the conversion of glucose into ethanol. The calorific value obtained from bioethanol produced from coconut water is still very small compared to bioethanol from different raw materials, including the calorific value of organic waste ranging from 10,000 - 11,000 kcal / g. A higher calorific value will cause it to be more flammable so that the quality of bioethanol is better. This shows that the quality of bioethanol produced in this study still does not meet the standards for stove fuel.

IV. CONCLUSION

Based on the results of the discussion above, it can be concluded that there is an effect of fermentation time on the ethanol content of the fermented coconut water and the optimum time for coconut water fermentation is 6 days from variations in fermentation time of 4 days, 5 days and 6 days with ethanol content of 4 days of 35%, ethanol content of 5 days of 40% and ethanol content of 6 days of 50%. Variations in fermentation time greatly affect fermentation time, alcohol content, alcohol volume, pure alcohol volume, specific gravity. The highest calorific value is obtained at a fermentation time of 6 days with a calorific value of 2295 kcal/g.

Conflict of interest

There is no conflict to disclose.

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REFERENCES

[1]. Asip, F., Febrianti, B., Gibreallah, S., 2017, Pengaruh perlakuan asam dan waktu fermentasi terhadap pembentukan bioetanol dengan bahan baku sabut kelapa, Jurnal Teknik Kimia No. 3, Vol. 23, Jurusan Teknik Kimia, Fakultas Teknik, Universitas Sriwijaya.

[2]. Aspiadi, 2019, Pemanfaatan Nira Batang Sorgum Sebagai Bioetanol Dengan Variasi Massa Ragi dan Temperatur Distilasi, Skripsi, FT-UNRAM.

[3]. Badan Pusat Statistik, 2020, Luas Lahan Menurut penggunaannya di Provinsi NTB, Badan Pusat Statistik Provinsi NTB, NTB.

[4]. Chairul, Yenti,S.R.,2013. Pembuatan Bioetanol dari Nira Nipah Menggunakan Sacharomyces cereviceae, Jurusan Teknik Kimia, Fakultas Teknik, UniversitasRiau.
[5]. Hartono, Pagarra,H., 2011, Analisis Kadar Etanol Hasil Fermentasi Ragi Roti Pada Tepung umbi Gadung (Dioscorea hispida Dennst) terhadap kadar etanol, Jurusan Biologi, Fakultas MIPA, Universitas Negeri Makassar
[6]. Ilangarathna, D. A. and R. Kapilan, 2022., Bioethanol Production from Coconut Fiber Wastes using Saccharomyces Cerevisiae, Vingnanam Journal of Science, Vol.17 (1), June 2022
[7]. Malle,M., Kapelle, I.B.D., 2012, Pembuatan Bioetanol Dari Limbah Air Kelapa Melalui Proses Fermentasi, Universitas Patimura, Ambon.
[8]. Marlina, Lusi., Witri Nur Hainun, 2020, pembuatan bioetanol dari air kelapamelalui fermentasi dan destilasi-dehidrasi dengan zeolite, Jurnal TEDC, Vol. 14 no. 3 PP 255-260
[9]. Mahendra, Kariza Awal, Liliana Liliana, 2023, Potensi Listrik Bioetanol Air Kelapa Tua Serta Analisis Biaya Investasinya di Provinsi Riau, Jurnal Briliant, jurnal riset dan konseptual, Vol. 8 No. 3 (2023): Volume 8 Nomor 3, Agustus 2023
[10]. Noviani, H., Supartono dan K. Siadi. 2014. Pengolahan Limbah Serbuk Gergaji Kayu Sengon Laut menjadi Bioetanol menggunakan Saccharomyces cerevisiae. Indonesian Journal of Chemical Science 3(2):147-151.
[11]. Oktavianto, Putra, Risdiyana Setiawan, Ilhami Ariyanti, Muhammad Fadhil Jamil, 2020, bioethanol production from coconut husk using the wet gamma iradiation method, Jurnal Forum Nuklir Volume 14, Nomor 2, November 2020
[12]. Putra, A.E. dan Amran H. 2009. Pembuatan Bioetanol Dari Nira Siwalan Secara Fermentasi Fase Cair Menggunakan Fermipan. Jurusan Teknik Kimia, Universitas Diponegoro : Semarang.
[13]. Riyanto, Y. 2016 Alanisa Kadar Bioetanol Pencampuran Air Kelapa Dan Air Nira Aren Hasil Proses Destilasi Dengan Variasi Waktu Fermentasi
[14]. Sutanto, R., Jaya, H., & Mulyanto, A. (2013). Analisa Pengaruh Lama Fermentasi Dan Temperatur Distilasi Terhadap Sifat Fisik (Specific Gravity Dan Nilai Kalor) Bioetanol Berbahan Baku Nanas (Ananas Comosus). Dinamika Teknik Mesin, Volume 3 No. 2. p.91-99.
[15]. Wijaya, IMAS, Arthawan, IGKA., 2012, Potensi Nira Kelapa Sebagai Bahan Baku Bioetanol, Universitas Udayana. Bali.
[16]. Wulandari,R.R.A dan Utami,B., 2015, Pembuatan Bioetanol Dari Air kelapa Tua Menggunaka Proses Fermentasi.
[17]. Zely, F.D. 2014. Pengaruh Waktu Dan Kadar Saccharomyces Cerevisiae Terhadap Produksi Etanol Dari Serabut Kelapa Pada Proses Sakarifikasi Dan Fermentasi Simultan Degan Enzim Selulase, Universitas Bengkulu.