Asia Young Scholars Summit (AYSS)
17-18 May 2019, Tianjin, China
Leveraging Region with Economy, Social and Technology Collaboration
ISBN: 978-623-7253-28-0

Utilization of Orange Peel Waste (*Citrus nobilis* Lour.) as Biogas for Electricity Source in Isolated Areas

Anindya Ramadhanti Yufinanda[1], An Nisa Nur Laila[2], Andi Mar'ie Ramadan Nurusalam[3], Yuna Fajar Herdiansyah[4]

Abstract

Orange is one of fruits that have massive productivity in Indonesia. The amount of production has an impact on increasing orange peel waste. Orange peel waste which is often disposed has the potential to be used as biogas. The biogas from the orange peel waste can be used for electricity source. The aim of this paper is to provide innovation in orange peel waste utilization so it can be used for electricity source in isolated area. The processes to make biogas from orange peel waste consist of three process, including depolymerization, acetogenesis and metanogenesis. The depolymerization process is a process of reducing complex organic compounds into simpler compounds by hydrolytic bacteria. The acetogenesis process is a process to convert simple compounds into volatile organic acids. The last process, the methanogenesis process, provides the final product in the form of methane gas that used as biogas. The use of biogas has a smaller negative impact on environment and is more cost-effective than the use of landfill disposal. Some of the advantages possessed by biogas from orange peel waste indicate that this research is one of the innovations for alternative electricity sources in isolated areas for daily life.

Keywords

biogas, electricity source, orange peel waste, waste utilization

1. Introduction

ORANGES are one of the fruits that are included in the annual leading fruit commodity in Indonesia, which ranks second compared to other fruits. Tangerine (*Citrus nobilis* Lour.) is the most produced type of orange in Indonesia. Tangerine production in Indonesia can reach around 1.7 million tons in one year [1].

Corresponding Author: Anindya Ramadhanti Yufinanda (anindya.ramadhanti.yufinanda-2015@ff.unair.ac.id
1 Anindya Ramadhanti Yufinanda, Universitas Airlangga, anindya.ramadhanti.yufinanda-2015@ff.unair.ac.id
2 An Nisa Nur Laila, Universitas Airlangga, an.nisa..nur-2015@ff.unair.ac.id
3 Andi Mar'ie Ramadan Nurussalam, Universitas Airlangga, andi.marie.ramadan-2015@ff.unair.ac.id
4 Yuna Fajar Herdiansyah, Universitas Airlangga, yuna.fajar.herdiansyah-2015@ff.unair.ac.id

Fig. 1. Tangerine Orange

Fruit waste is currently underutilized by society. Usually we can find the waste in the trash, that causes water pollution, disrupts the environment clean and disturbing health. As a solution of the impacts of this fruit waste, this waste can be used as a source of alternative potential raw materials to produce energy [2].

Organic waste generated from human activities such as activities in the market, household waste, industry, etc. can have an impact on the environment such as causing diseases from garbage decay. However, it turns out that organic waste has a high potential to be used as biogas production. This is one solution to prevent various problems, but there are still not many parties who utilize existing waste [3]. It is already known that the energy can be produced by utilizing solid waste as a raw material. Various processes and technologies have been developed for converting waste into energy, their specific characteristics and waste used [4].

One way to utilize waste in creating energy is converting it into biogas (biomethane) through anaerobic digestion [4]. Biogas is a flammable gas produced by anaerobic bacteria (the bacteria that live in airtight conditions) [5]. The advantages of anaerobic digestion include low levels of biological sludge, low nutrient requirements, high efficiency and the production of methane, which can be used as energy sources for on-site heating and electricity [5]. Biogas is environmentally friendly and can be formed like LPG or electricity generators, make it easy to use [6]. In addition, biogas is one form of alternative energy that has high prospects to be developed, because it can reduce dependence on fuel and increase the national energy supply [6].

Based on the results of the latest statistical data by the Ministry of Energy and Mineral Resources regarding the availability of electricity in rural areas, there are still areas that have not been reached by electricity. Among them in the province of West Papua, there are at least 250 villages, and the province of Papua around 2000 villages that have not been reached by electricity [1].

From that statements above, we have an innovation to utilize an tangerine peel waste as biogas for electricity source. This innovation can be used in any places that need electricity, especially isolated areas.

.

2. Method

The method used in this study is literature review from various sources. Sources are obtained through the Google Scholar index using the keywords biogas, orange peel waste, *Citrus nobilis* Lour, biogas production, and electricity. The analysis starts with identifying the problem, analyzing the root of the problem and finding the best solution for the problem.

Materials

The materials used in this research are tangerine peel (*Citrus nobilis* Lour), aquades, inoculum, and buffer (Na_2CO_3 and NH_4HCO_3). The instrument used in this research are water manometer, Erlenmeyer, waterbaths, stop watch, faucet flow regulators, and thermometers. The reactor (digester) consists of: a tub mixer (funnel) for inserting materials, a digesting vessel (having a gas outlet or pipe), a gas washing vessel and a gas reservoir, and a stirrer or mixer.

Experimental procedure

This research is carried out in a few steps including depolymerization, acetogenesis, and metanogenesis. The depolymerization process is the process of reducing complex organic compounds into simpler compounds by hydrolytic bacteria [6]. The process of acetogenesis is the process of converting simple compounds into volatile organic acids [7] The final process, the process of methanogenesis, provides the final product in the form of methane gas used as biogas [7]. Orange peel is collected and disposed of inorganic, then mashed with a blender to get a homogeneous material and the organic material will be easier to degraded. The reactor is filled with a substrate (orange peel) and water with a ratio of substrate: water is 1:1 [3]. The mixture is stirred until homogeneous and 25 ml of inoculum is added inside the mixture [5]. Before the reactor closed, a buffer (Na_2CO_3 and NH_4HCO_3) is added to maintain the pH 7 inside the reactor during the process [5]. The reactor is tightly closed and impermeable so that foreign matter that affects the process does not enter it. The reactor that containing the sample is placed in waterbath with thermophilic temperature (45-60°C) [8]. Biogas production is measured with water manometer two times daily, in morning and afternoon. The measurement are done after the digester did not produce biogas anymore [7].

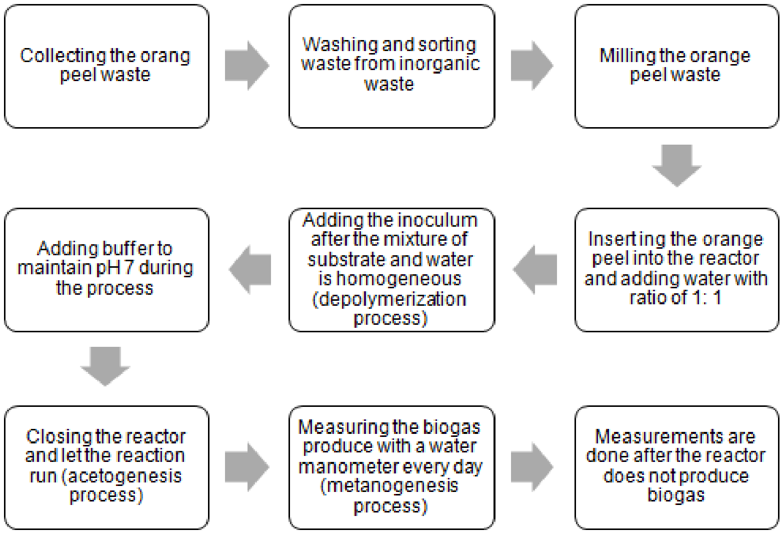

Fig. 2. Procedure to make biogas

Conversion to Electricity

In the previous study, there was mentioned that the generator set is a practical option to converted biogas into electricity than using a fuel cells [9]. Generators commonly use because of it's easy to maintenance, available in all size and in all country. Biogas can convert to mechanical energy by act as fuel for combustion engines and powering electric generator to produce electricity [9]. Theoretically, biogas is compatible to all types of combustion engines like diesel engines and stirrig motors, but the internal combustion engine is more used than an external one because of its advantages [9]. So that, in this paper we prefer to use the Internal combustion engine to convert the biogas into electricity source.

3. Result and Discussion

Oranges are one of the fruits that are included in the annual leading fruit commodity in Indonesia, which ranks second compared to other fruits. Tangerine (*Citrus nobilis* Lour.), is the most produced type of orange in Indonesia. Tangerine production in Indonesia can reach around 2.0 million tons in one year. The region that produce the highest Tangerine come from east java of Indonesia as much as 837.369 tons [1].

Table. 1. Fruits Production in Indonesia 2016 [1]

Commodities	Quantity (ton)
Banana	7.007.117
Citrus	2.014.206
Mango	1.814.540

Fruit waste is currently underutilized by society, included tangerine's peel. Usually we can find the waste in the trash, that causes water pollution, disrupts the environment clean and disturbing health. As a solution of the impacts of this fruit waste, this waste can be used as a source of alternative potential raw materials to produce energy [2]. In 2018, Budiyono *et al*., had utilized lemon's waste for biogas production [5]. It can be concluded that *Citrus nobilis* Lour waste also can utilized to produce biogas like lemons's waste.

Orange peel layer is divided into two parts, epicarp and endocarp. Orange peel is composed of flavedo, albedo, oil gland, and vascular bundle [10]. Orange peel contain a limonene which can inhibit the decomposition process. So, before produce a biogas from orange peel waste, we have to eliminate that limonene first [11].

The results of the literature study show that biogas can be produced from tangerine peel waste [4]. The quality and quantity of biogas produced is influenced by various aspects such as mixture pH, water content and the amount of substrate in the mixture, digester temperature, the presence of an inoculum as a catalyst, the presence or absence of oxygen during the manufacturing process, and bacterial activity during the biogas manufacturing process [5, 8]. These aspects will affect each other so that it is very important to pay attention when producing biogas.

The mixture pH of the initial composition of biogas making greatly influences the process of biogas formation. The optimum pH in making a biogas is neutral pH ranging from 6-7. In fact, this is very difficult to control because every process of making biogas, even from the beginning of the process of acetogenesis, the pH of the mixture will decrease. For this reason, in order to maintain and control the pH of a mixture biogas production, buffers need to be added [5].

The parts of the digester, especially temperature, are also things that need to be controlled when producing biogas [8]. The temperature conditions in the digester not only affect the high biogas production but also affect the speed of time to produce biogas at the optimum value. In thermophilic conditions the optimum gas production is obtained in a shorter time, while the optimum value of gas production pressure in mesophilic and non-heating conditions takes a few days longer than the thermophilic conditions [8]. This figure below shows that the temperature affect biogas production.

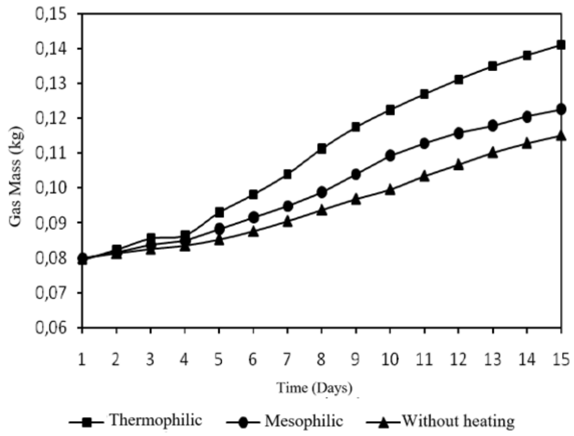

Fig. 3. Comparison of some temperature used in bigoas pr ocess versus accumulation gas production [8]

The high temperature conditions of the digester, which is in the thermophilic temperature will increase the bacterial population which results in the production of enzymes as more catalysts [8]. Higher enzyme concentrations can accelerate the rate of biochemical reactions in the hydrolysis process. This is indicated by higher CO_2 gas production compared to mesophilic conditions. Enzymes and temperatures are one of the keys to speed in biochemical reactions in the process, where high amounts and concentrations of enzymes can accelerate reactions at the hydrolysis stage [8]. While the increase in temperature causes collisions between molecules to occur faster. Because of this condition, the production with termophilic condition will make a higher amount of biogas than other condition. This shown in this graphic below, when the amount of biogas production compared in various temperature.

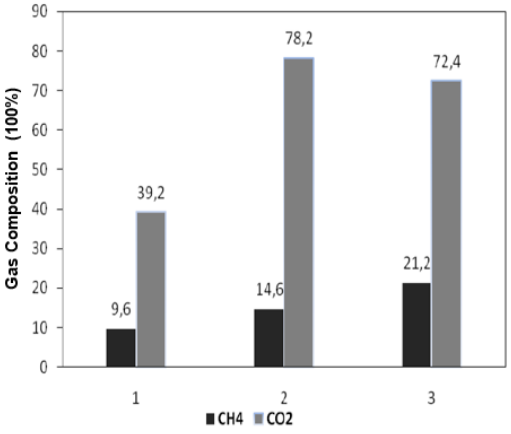

Fig. 4. CO_2 and CH_4 (methane) production with variation of temperature in 15 days of fermentation [8] *1: without heating; 2: mesophilic; 3: thermophilic*

Bacterial activity can affect the process of biogas formation because bacteria are needed to actively work in the process of acetogenesis and metanogenesis, so that the resulting biogas will be more. Based on research by Darmanto et al, it is known that temperatures can affect bacterial activity. At high temperatures bacterial activity is very fast and active. The characteristics of themophilic bacteria have faster growth compared to bacterial growth in mesophilic conditions (20°C to 40°C), cell membrane division in the process of breeding in thermophilic bacteria is shorter [8]. In a relatively short period of time the bacteria can multiply more and finally at this hydrolysis stage (Days 1 to 4) of chemical reactions at this stage, the enzymes produced by the bacteria hydrolyze more and can change the substrate (and other elements contained in the inside is further transformed into compounds that are simpler such as organic acids, amino acids and glucose [8].

Biogas can convert to mechanical energy by act as fuel for combustion engines and powering electric generator to produce electricity [9]. In this paper we prefer to use the internal combustion engine to convert the biogas into electricity source. Biogas can be use alone to operate gas motors with spark ignition (Otto system) [9]. A small amount of gasoline usually useto start the engine. This technology can be used from very small generator sets (~ 0.5-10 kW) to large power plants [9]. These engines do not need additional fossil fuels which can affect to lowering feed-in tariffs according to the Renewable Energy Law (EEG) in Germany [9]. This method would be the best method for applications in developing countries.

1 m^3 of biogas can be compared with various artificial resources that have been used for everyday life. In addition, specifically in its role as a source of electrical energy, 1 m^3 of biogas can produce 1.25 kwh of electricity which can be compared with 60 - 100 watt bulb lights for 6 hours [7]. This table shown the increasement of biogas and its accumulation when the process running. It shown that in 600 minutes (10 hours), biogas collected is 0,696 m3.

Table. 2. Accumulation of gas production from cow dung in minutes [12]

Time (minutes)	Biogas Increasement (m^3)	Gas Accumulation (m^3)
0	0	0
60	0,043	0,043
120	0,068	0,111
180	0,052	0,163
240	0,061	0,224
300	0,050	0,274
360	0,065	0,339
420	0,069	0,408
480	0,082	0,490
540	0,086	0,576
600	0,120	0,696

The use of biogas in the village is most often used for cooking and lighting. Based on research conducted by [6], in the use of biogas biogas users issued Rp. 60,000 per month, so they could save Rp. 86,000 compared to using LPG and Rp. 12,000 compared to the use of firewood. Biogas waste, both solid and liquid, can be used as fertilizer for agriculture. In addition, from research conducted by Sinung, the use of biogas can be developed to meet the needs of cooking, lighting, water heaters, power plants or other uses in the countryside [6]. The table below shown how much biogas volume needed compared with daily human activities.

Table. 3. Human activities with biogas volume used [3]

Activities	Gas volume
Cooking for 5-6 people	2 m3 / days
Boiling water with capacity 100 liter	3 m3 / days
Turn on one lamp	0.1 - 0.15 m3 / hour
Operating machine with two horsepower	0.9 m3 / hour

4. Conclusion

Based on the experiment result, it can be conclude that by using oranges waste can produce biogas for daily electricity resource. Temperature and pH is the important factor that affect the production of biogas, so that we have to keep it stable. Na2CO3 is the optimum buffer to control S/W with ratio 1: 1 in the steady state of biogas production. Temperature used in this experiment is termophilic (45-60°C) because it is the best temperature to maintain the process. 1 m3 of biogas can produce 1.25 kwh of electricity which can be compared with 60 - 100 watt bulb lights for 6 hours. For the next experiment, the researcher needs to do an optimation in order to find the exact ratio for inoculum and S/W added in process.

References

[1] Ministry of Agriculture Republic of Indonesia, Agricultural Statistics 2017. Jakarta: Ministry of Agriculture Republic of Indonesia, 2017.

[2] Marjenah, W. Kustiawan, I. Nurhiftiani, K. H. M. Sembiring, dan R. P. Ediyono, "Pemanfaatan Limbah Kulit Buah-Buahan Sebagai Bahan Baku Pembuatan Pupuk Organik Cair," J Hut Trop., vol. 1, no. 2, pp. 120-127, Sept. 2017.

[3] J. Sutrisno, "Pembuatan Biogas dari Bahan Sampah Sayuran (Kubis , Kangkung dan Bayam)," Jurnal Teknik WAKTU., vol. 08, no. 1, pp. 108-120, Jan. 2010.

[4] T. Ariyanto, R. B. Cahyono, A. Vente, S. Mattheij, R. Millati, Sarto, M. J. Taherzadeh5, S. Syamsiah, "Utilization of Fruit Waste as Biogas Plant Feed and its Superiority Compared to Landfill," International Journal of Technology., vol. 8, pp. 1385-1392, Dec. 2017.

[5] Budiyono, F. Manthia, N. Amalin, H. Hawali, A. Matin, dan S. Sumardiono, "Production of Biogas from Organic Fruit Waste in Anaerobic Digester using Ruminant as The Inoculum," MATEC Web of Conferences 156., pp. 1-5, 2018.

[6] W. Febriyanita, "Pengembangan Biogas dalam Rangka Pemanfaatan Energi Terbarukan di Desa Jetak Kecamatan Getasan Kabupaten Semarang," S.Si. skripsi., Universitas Negeri Semarang, 2015.

[7] P. Rukmini, "Produksi Biogas dari Sampah Buah dan Sayur : Pengaruh Volatile Solid dan Limonen," Konversi., vol. 5, no. 2, pp. 26–31, Oct. 2016.

[8] A. Darmanto, S. Soeparman, dan D. Widhiyanuriawan, "Pengaruh Kondisi Temperatur Mesophilic (35°C) dan Thermophilic (55°C) Anaerob Digester Kotoran Kuda Terhadap Produksi Biogas," Jurnal Rekayasa Mesin., vol. 3, no. 2, pp. 317-326, 2012.

[9] A. Joshi, J. Jose, N. Bansiwal, N. Soni, “Study on Electricity Generation Through Biogas on Small Scale,” International Journal of Innovative Research in Science, Engineering and Technology., vol. 6, no. 4, pp. 6663-6669, Apr. 2017.
[10] [X. Ye, Phytochemicals in Citrus. Boca Raton: CRC Press, 2017.
[11] R. Wikandari, R. Millati, M. N. Cahyanto, M. J. Taherzadeh, "Biogas Production from Citrus Waste by Membrane Bioreactor," Membranes., vol. 4, pp. 596-607, 2014.
[12] M. R. Arianto, Yandri, dan A. Hiendro, "Evaluasi Pembangkit Listrik Tenaga Biogas Berbahan Kotoran Sapi (Studi Kasus: Desa Jungkat, Kecamatan Siantan, Kabupaten Mempawah)," vol. 2, no. 1, pp. 1-3, 2017.

AUTHOR BIOGRAPHY

Name	: Anindya Ramadhanti Yufinanda
Date of Birth	: Tulungagung, January 23, 1998
Sex	: Female
Institution	: Universitas Airlangga
Major	: Pharmacist Education (Bachelor)
E-mail	: anindya.ramadhanti.yufinanda-2015@ff.unair.ac.id
Phone Number	: +6281332960340

AUTHOR BIOGRAPHY

Name	: An Nisa Nur Laila
Date of Birth	: Malang, January 20, 1998
Sex	: Female
Institution	: Universitas Airlangga
Major	: Pharmacist Education (Bachelor)
E-mail	: an.nisa.nur-2015@ff.unair.ac.id
Phone Number	: +6283848495805

AUTHOR BIOGRAPHY

Name	: Andi Mar'ie Ramadan Nurussalam
Date of Birth	: Kolaka, January 17, 1997
Sex	: Male
Institution	: Universitas Airlangga
Major	: Pharmacist Education (Bachelor)
E-mail	: andi.marie.ramadan-2015@ff.unair.ac.id
Phone Number	: +6285257375920

AUTHOR BIOGRAPHY

Name	: Yuna Fajar Herdiansyah
Date of Birth	: Trenggalek, July 19, 1996
Sex	: Male
Institution	: Universitas Airlangga
Major	: Pharmacist Education (Bachelor)
E-mail	: yuna.fajar.herdiansyah-2015@ff.unair.ac.id
Phone Number	: +6282257682206