Novelty Potential of Utilizing Local Betel Nut (*Areca catechu*) of Papua as a Bio-battery to Produce Electricity

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Abstract- Papua is the most eastern Province of Indonesia with the lowest electricity supply. In order to partially reduce the dependence of electrical supply, the betel nut has been utilized to produce electricity. The Betel nut is a local plant or fruit that is initially used for cultural events as a chewing gum. However, due to the less way of recycling the waste of chewing betel nut, caused this plant to become prohibited to be chewed in Public areas. In order to introduce one alternative way of recycling the waste of betel nuts, the study of bio-battery utilizing the betel nut was initiated. Three different pastas prepared were betel nut skin, betel nut liquid waste and betel nut liquid waste and fibers. The pastas have been prepared to generate bio-batter with specific voltages, powers, currents and lifetimes of bio-battery. Results showed that the bio-battery from the local betel nut has the potency to be used as an alternative source of electricity generator. The highest power density and current density produced from the pasta of betel nut liquid waste corresponding to a value of 6.67 μW cm^{-2} and 48 μA cm^{-2}, respectively. While highest initial voltage observed was from 0.98 mV resulted from betel nut skin pasta. The lifetime of bio-battery was performed while increasing of current was observed from time 0 to 56 hours reached maximum peak of 91 μA cm^{-2}. Moreover, acidity measurement level of bio-battery was also performed with pHs ranges from 4.8 to 7.8. Hence, there is a possibility of utilizing the betel nut as a bio-battery.

Keywords Betel nut, pastas, bio-battery, electricity, Papua.

1. Introduction

The need for electricity increases rapidly due to the growing population of human beings. Electricity is required to meet the demand of both public and private sectors. In the most eastern part of Indonesia named Papua, diesel fuel is primarily used to generate electricity. Considering the diverse topography of Papua which consists of highland and lowland, creating the difficulties to transport fuel to fulfil the constant need of electricity in this big island. Therefore, it is wise to conduct study and research with the aim of finding an alternative solution to provide fully or partially electricity in the rural area [1-4]. From several studies reported previously, in order to generate electricity, many sources can be utilized such as coals, wind, hydro, solar cell and diesel fuels, however, due to limitations availability of sources and infrastructures, all these main or alternatives sources cannot be used widely [5-6].

Some sources to be considered to generate electricity are fruits, plants, and agricultural waste [7-8], since those products consist of high sugar, acid and some others ionic sources in which can be converted into superconductive ions through chemical paths. This type of converting materials to produce electricity was then generally known as bio-battery [9]. One model of bio-battery was done before has utilized origami-inspired paper, in which maximum power and current obtained were 20 μW and 25 μA, respectively [9-10]. A bio-battery prototype device from tropical almond paste could produce power of 0.25 mW with a stable current of 4 mA lasting up to 2 days [11], while another set of study utilizing culled papaya fruit has reported maximum power density of 0.7-0.8 $mWcm^{-2}$ [12]. Moreover, this concept of making bio-battery was also done to observe the potency of lemons, potatoes, and almond to generate electricity by attaching each of these sources to metal connectors of Zink and Copper [13-14]. The performance quality of Zn-Cu electrode characterized as cheap but effective material to generate electricity [15], promotes this type of preferred electrodes.

In Papua, there is an abundance of fruits, plants, agricultural wastes that have the potential to produce superconductive ions which is the main source of bio-battery [16]. However, the aimed of this study was to focus on utilizing a widely known local plant called betel nut (*Areca catechu*) from fresh and waste products. This betel nut becomes a raw material for producing electricity because it can grow well in the area in Papua. As chewing this nut is done by people living in the city and rural areas, at many occasions, the waste generated by this activity became a pollutant to the environment. One alternative solution must be considered to reuse this waste. Therefore, by searching in literature findings, the chemical composition of the betel nut is carbohydrates, fats, proteins, crude fibers, polyphenols, and other minerals that can be applied for many uses, such as source of electricity [17]. Furthermore, a study showed that the presence of organic substances in saliva can potentially be utilized as a paper-based microbial fuel cell (MFC) which generated power [18]. Hence there is a potency to generate ions from the betel nut, and its saliva, for electricity by making a simple bio-battery prototype model. It is assumed that when this betel nut-based bio-battery will be able to produce electricity, therefore people living in the rural area of Papua could be able to be partially meet the need for electricity at home.

2. Methodology

2.1. Pasta Production

Fresh betel nuts were collected from a farmer market in Jayapura. Pasta production was divided into three different sets. The first set was the pasta containing the skin of the betel nut and water (1:1), in which skin of this betel nut was removed from the seed and resized into smaller pieces to be used for pasta production by adding the same weight of water. This mix was blended for 5 minutes to ensure size homogenization. The second set of pasta was performed by chewing the betel nut skin all together, with seed betel nut and lime powder, with an assumption that saliva from mouth was responsible for improving the blending process. Pasta from the second set taken consisted of liquid part only, meaning the fibres of mixing skin and seed forms were all removed by applying a strainer to separate them. Lastly, the third set of pasta consisted of betel nut skin, seed and lime powder that were chewed together using saliva from the mouth. All these three different pastas were then transferred into small containers prepared separately and ready to be used as sources of bio-battery. Figures of fresh betel nuts, chewed fibers betel nuts, and betel nuts saliva waste pasta were presented in Fig. 1.

Fig. 1. (a) Fresh betel nuts, (b) chewed fibers betel nuts, and (c) betel nuts saliva waste pasta.

2.2. Prototype of Bio-battery

Three sets of pasta were then transferred into prepared copper metal containers with a size of 4 cm × 3 cm and was used as cathodes while zinc with a size of 4 cm × 3 cm as anode were immersed into pasta containers to perform ions transfer, as simplified presented in Fig. 2.

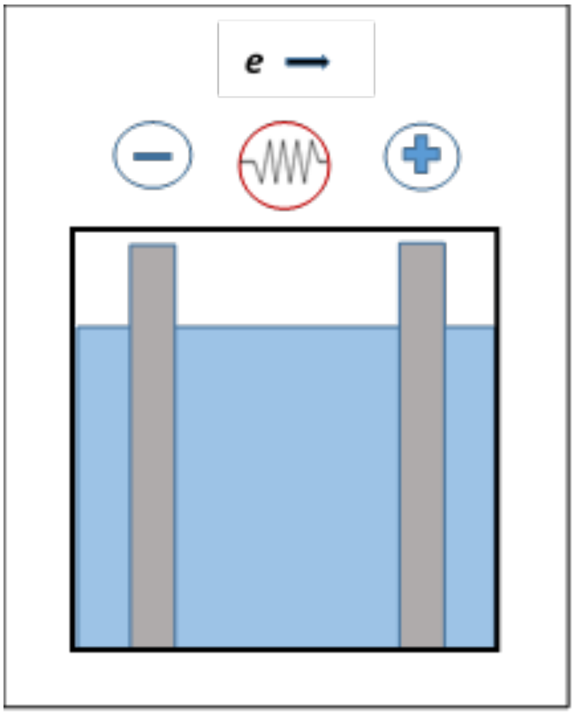

Fig. 2. Simplified bio-battery model.

Initially, before conducting measurements with varied resistance, the maximum voltages reached of all three sets of pasta were measured. Measurements of 40 different resistance values between 100 Ω – 4 M Ω had been conducted. Meanwhile, currents and power were divided into two schemes, where the first scheme was performed by varying resistance applied to generate polarization curves. Second scheme was done by applying constant resistance value of 100 Ω for 200 hours to observe the possibility of power generated while pH of the pastas was also measured using Xplorer GLX pH sensor.

3. Results and Discussion

3.1. Electricity Generated

Polarization performances from three different pastas prepared are presented in Fig. 3. Based on the measurement done, the highest initial voltage was observed from betel nut skin pasta followed by the third pasta of liquid waste and fibers corresponding to values of 0.98 V and 0.74 V, respectively. The highest power density and current density generated were 6.67 μW cm^{-2} and 48 μA cm^{-2} were also found in the betel nut skin pasta. Results from this study are moderately higher compared to paper bio-battery stack that reported maximum power and current generated corresponding to values of 20 μW and 25 μA, respectively [9]. In addition to that, a group of Kannan *et al* was able to obtain bio-battery with power density of > 25 μW cm^{-2} [19]. In other work, the highest bio-battery power density of 0.81 mW cm^{-2} was recorded from pasta or solution with the highest sugar concentration [12]. In which all these comparisons are summarized in table 1. The difference was that, in this study betel nut skin consisted only of water and skin pasta without any additional enzymes, therefore the reaction that took place was a conventional biological reaction where most of carbohydrates of the betel nut was still in the complex form and will take longer time to be converted into simple sugar. Meanwhile, study from Provera *et al*, reported the highest power generated from juice solution, therefore, more simple sugars are found in the system corresponding to value of 91 g L^{-1} [12]. From several findings of the bio-battery reported above, there was an indication that the effect of sugars contained in the raw materials that could be used to produce electricity [9-12, 20-21].

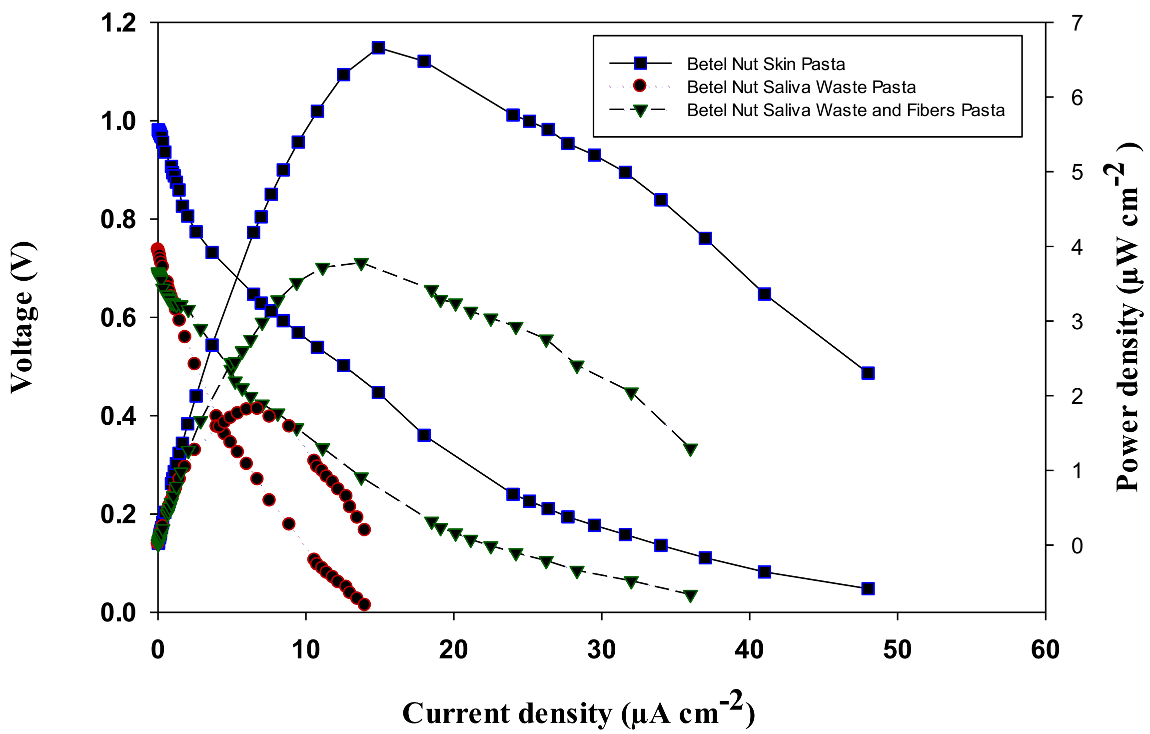

Fig. 3. Polarization and power density curves from three different pastas.

Table 1. Comparison of Currents and Powers Generated

Reference	Current or Current density	Power or Power density	Feedstock
[9-10]	25 μA	20 μW	Origami Inspired Paper
[11]	4 mA	0.25 mW	Tropical Almond Paste
[12]		0.7 -0.8 mW cm^{-2}	Culled Papaya Fruits
[19]		> 25 μW cm^{-2}	Electronic charge transfer protein
Our study	48 μA cm^{-2}	6.67 μW cm^{-2}	Betel Nut

Hence from literature, the skin of the betel nut consisted of carbohydrates, fats, protein, crude fibers, polyphenols, and other minerals [17]. As carbohydrates could be potentially converted into simple sugars such as glucose and has the ability to be used for generating electricity. Thus, from these measurements, it is assumed that carbohydrates from betel nut skin are the main reason of generating voltage, current and power from the betel nut, because carbohydrates are found in the betel nut skin and seed. Meanwhile, the potential of saliva to make pasta also contributed to produce electricity, due to the presence of enzymes in the saliva that could potentially able to break down the complex form of carbohydrates into smaller sugar components that is useful for generating electricity.

The results from this study is favorably easy to be applied to partially supply the electricity needs of local people who consumed betel nuts daily and supported by the existence of betel nut plantations. As the maximum voltage generated was 0.98 mV, thus in order to increase the voltage output this bio-battery system must be arranged in a series line, meanwhile to improve the current production, this bio-battery system will be set in a parallel layout.

3.2. Lifetime of Bio-battery

Lifetime of bio-battery or time period used to observe the possibility of currents generated of bio-battery from three different pastas prepared were presented in Fig. 4. It is clear, that betel nut skin reached the highest current produced at 56 hours of lifetime with maximum current density produced corresponding to 91 μA cm^{-2}. Furthermore, Fig. 4 showed a sharp decreasing of generating current, which is initially assumed to be due to the amount of less sugar found in the pasta system. Another peak observed was assumed to be generated from the second metabolism performed throughout the process because after 3 days (72 hours) of performance, the fermentation process was observed due to the smell produced and increasing of water in the pasta bio-battery system. Hence, current density generated the maximum peak and was assumed to be due to the ions released during the fermentation reaction.

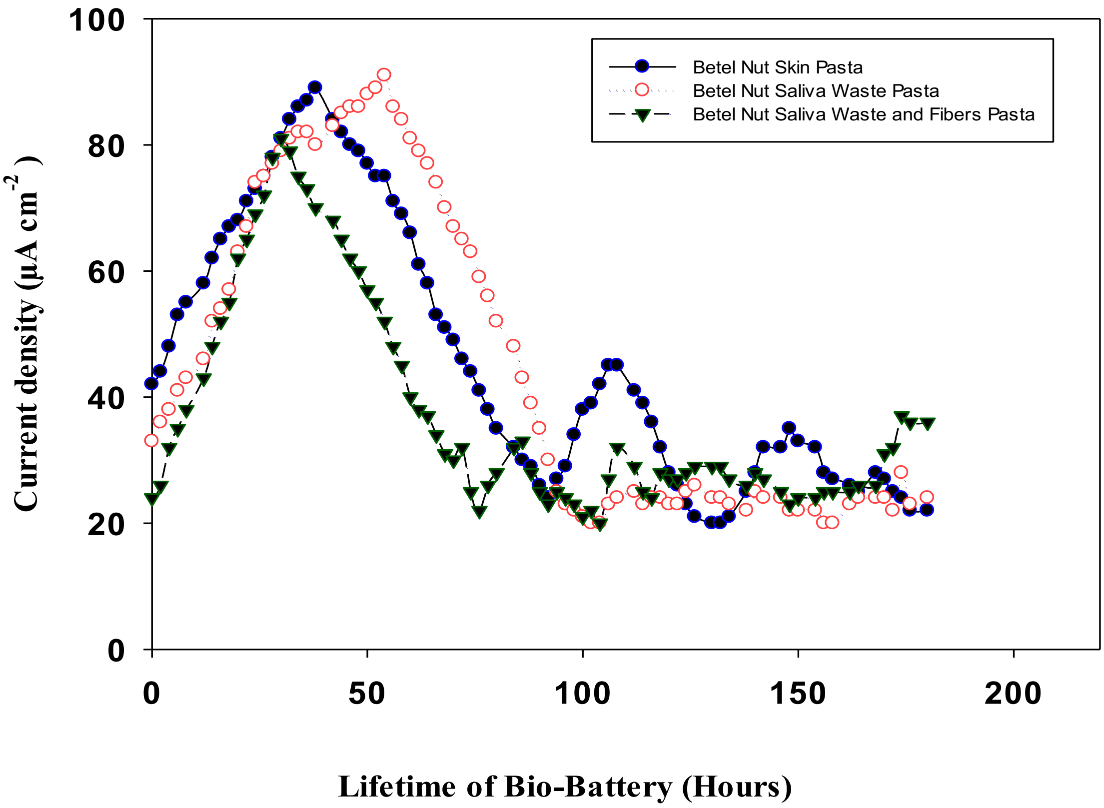

Fig. 4. Lifetime of Bio-battery.

3.3. Acidity Level of Pastas

Based on the finding from this study, Fig. 5 presents the performance of bio-battery systems that consisted of pasta made from betel nut skin possesses the highest acidity level compared to the other two pastas. For betel nut skin, the lowest pH observed was 4.8 while the highest was at 6.2. Meanwhile, two other pastas were performed at pHs close to neutral of 7 and the highest pH was observed from betel nut waste liquid and fibers corresponding to pH value of 7.8. This pH was categorized as low assumed due to the presence of calcium when the chewing process of the betel nut took place. The amount of pH is related to the amount of ion H^+ was released into the system (pasta set). Hence, when pH was found low, ion H^+ found in the system increased. This finding presented in Fig. 5 was found to support the current density performance of Fig. 4 where the lowest pH recorded happened to generate the highest current density measured and in accordance to statements found in two previous reports [19-20].

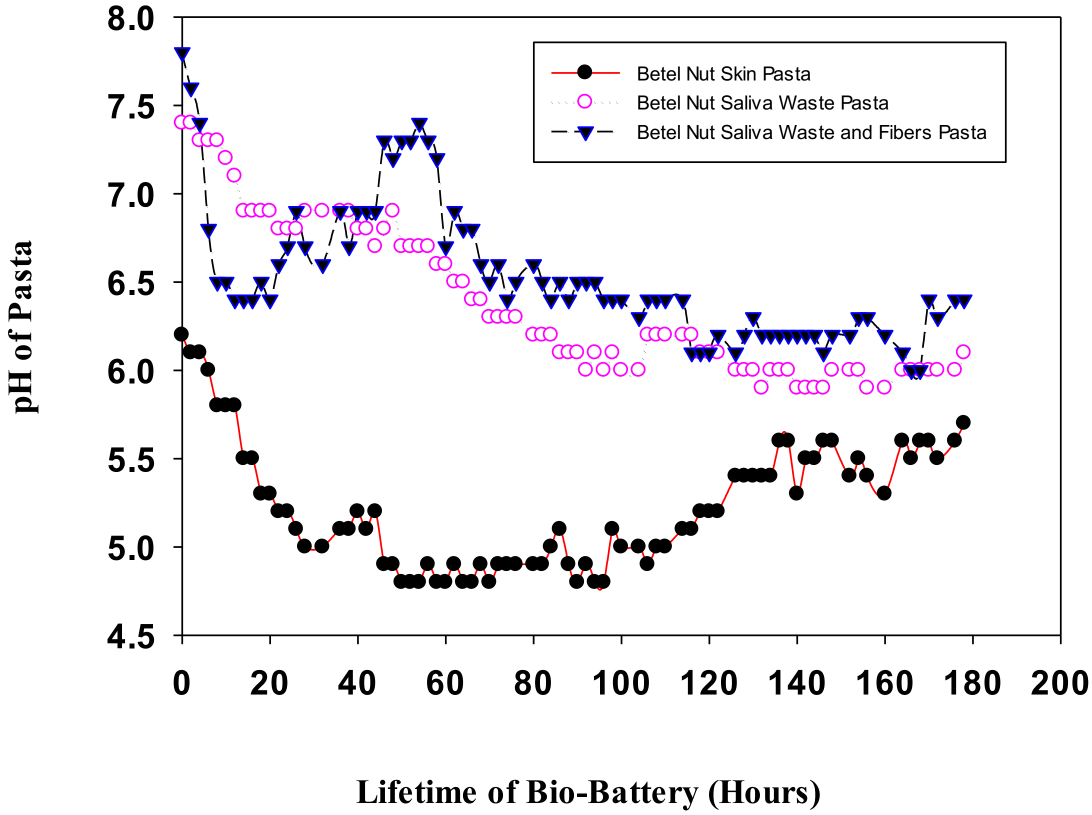

Fig. 5. Lifetime of Bio-battery.

4. Conclusions

From findings obtained, betel nut has the potential to be utilized as bio-battery source to generate electricity proved by power density and current density measured corresponding to values of 6.67 µW cm^{-2} and 48 µA cm^{-2}, respectively. For later work, some modification of batch containing bio-battery and possibly additional enzymes will assume to improve the performance of the bio-battery. In addition, saliva waste after chewing betel nut is considered to be a source for generating electricity, as this saliva performs as an enzyme to break down the carbohydrate from the betel nut. Additionally, future work to focus on making ready prototype containers for bio-battery will be produced to support the idea of generating electricity from betel nuts from Papua.

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