Voltage Cultivation from Fresh Leaves of Air Plant, Climbing Spinach, Mint, Spinach and Indian Pennywort for Practical Utilization

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8 authors, including:

Noor Fazle Rab
Primeasia University

Kamrul Alam Khan
Jagannath University

Salman Rahman Rasel
AIU

Md. Hazrat Ali
European University of Bangladesh,Dhaka

Voltage Cultivation from Fresh Leaves of Air Plant, Climbing Spinach, Mint, Spinach and Indian Pennywort for Practical Utilization

M. N. F. Rab, K. A. Khan, Salman Rahman Rasel, M. Hazrat Ali, Lovelu Hassan, M. Abu Salek, S. M. Zian Reza, and M. Ohiduzzaman

Abstract It has been designed and developed to study the voltage, current and power production from fresh leaves of five different vegetative as a comparative study. It has been collected fresh leaves from different vegetative and then it was embedded by two pairs electrodes Zn–Cu and Zn–Ag materials as positive and negative electrodes, respectively. The open-circuit voltage, short circuit current and maximum power have been measured by calibrated millimeters. It has been shown that it is possible to generate voltage, current and power from the fresh leaves of five different vegetative but PKL (Pathor Kuchi Leaf) is the best for electricity generation among them. It has not been done before yet this type of comparative study from five different fresh

M. N. F. Rab · K. A. Khan (✉)
Department of Physics, Jagannath University, Dhaka 1100, Bangladesh
e-mail: kakhan01@yahoo.com

M. N. F. Rab
e-mail: noorfazlerab@yahoo.com

S. R. Rasel
Local Government Engineering Department (LGED), Fulbaria, Mymensing, Bangladesh
e-mail: salman_rasel80@yahoo.com

M. Hazrat Ali
Department of Electrical and Electronics Engineering, European University of Bangladesh (EUB), Mirpur, Dhaka, Bangladesh
e-mail: ahazrat31@gmail.com

L. Hassan
Department of Physics, Jahangirnagar University, Savar, Dhaka, Bangladesh
e-mail: lovelu.iu.bd@gmail.com

M. Abu Salek
Department of Chemistry, Adamjee Cantonment College, Dhaka 1206, Bangladesh
e-mail: salek@acc.edu.bd

S. M. Zian Reza
Department of Physics, Uttara University, Dhaka, Bangladesh
e-mail: smzianreza@gmail.com

M. Ohiduzzaman
Department of Physics, Jashore University of Science and Technology, Jashore 7408, Bangladesh
e-mail: ohid@just.edu.bd

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leaves of vegetative. The studies had been conducted on PKL electrochemical cell using PKL extract. But in this research it has been used fresh leaves for electricity production. But no research has been conducted on rest of the fresh leaves of four types vegetative. Furthermore, it has also conducted a comparative study between the two pair electrodes Zn–Cu and Zn–Ag, respectively.

Keywords Zn–Cu and Zn–Ag electrodes · Air plant · Climbing spinach · Mint · Spinach · Electrochemical cell

1 Introduction

Electrical energy is a blessing to human beings. Our daily life is absolutely dependent on this energy. At present, there have many ways to produce electrical energy in the world [1–4]. But these conventional ways for producing electrical energy have many disadvantages such as limitation of sources, causes environment pollution, etc. For this reason, scientists are diverting their attention to non-conventional sources [5–7]. Renewable energy sources are non-conventional sources. In this study, we have found voltage from fresh leaves of different vegetative plants [8–10]. We have measured the voltage from leaves of Climbing Spinach, Air plant, Mint, Spinach and Indian Pennywort. We have observed that the voltage was stable until the leaves were fresh. When the leaves were getting dry, the voltage was dropping gradually. So we can come to a decision that fresh leaves of these vegetative plants may be a source of electrical energy. Before this study, the performances of electricity generation using the juice/sap of different vegetative and fruits have been studied [11–14]. The electricity generation from the living air plant has also been studied. But power generation from fresh air plant leaves was not studied yet. This work can play an important role in power generation in the near future.

2 Chemical Reactions

Electrode reaction can be represented as equations using different substrate in the following equations.

Acetate as substrate: Anode half-cell reaction:

$$CH_3COO^- + 4H_2O \rightarrow 2HCO^- + 9H^+ + 8e^- \quad (1)$$

Cathode half-cell reaction:

$$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O \quad (2)$$

Total voltage generated from fresh leaves can be calculated from the Nernst potential of anode and cathode [15].

$$V_{\text{cell}} = V^{\text{o}}_{\text{cell}} - (RT/nF)\ln Q \tag{3}$$

where V_{cell} = cell potential (V), $V^{\text{o}}_{\text{cell}}$ = standard cell potential (V), R = universal gas constant (11 8.314 J mol^{-1} K^{-1}), T = Temperature (K), n = number of electrons involved in reaction, F = Faraday's constant = 96,500 C and Q = reaction quotient of the living PKL reaction.

Now, the Nernst potential of anode is described as:

$$V_{\text{anode}} = V^{\text{o}}_{\text{anode}} - (RT/nF)\ \ln\left(\left[\text{CH}_3\text{COO}^-\right]/[\text{HCO}_3]^2\left[\text{H}^+\right]^9\right) \tag{4}$$

where V_{anode} = anode Nernst potential (V), $V^{\text{o}}_{\text{anode}}$ = standard anode potential (V),

[CH COO$^-$] = acetate concentration (1 molL$^-$), [H_2O] = water concentration (1 molL$^-$), [H^+] = proton concentration (1 molL$^-$), [$HCO_3{}^-$] = bicarbonate concentration (1 molL$^-$). Hence, standard open cell potential of anode $V^{\text{o}}_{\text{cell}}$ is used which is typically −0.34 V versus standard copper electrode [16, 17]. Ideally, the reduction process in the cathode is, oxygen reduced in water Eq. (2), the Nernst potential can be determined as

$$V_{\text{anode}} = V^{\text{o}}_{\text{anode}} - (RT/nF)\left(\left[1/\text{pO}_2\left[\text{H}^+\right]^4\right)\right. \tag{5}$$

where V_{cathode} = cathode Nernst potential (V), $V^{\text{o}}{}_{\text{cathode}}$ = standard cathode potential (V), pO_2 = partial oxygen pressure (Pa), [H^+] = proton concentration (1 molL$^-$).

Ideally, we have the following equation:

$$V_{\text{cell}} = V_{\text{cathode}} - V_{\text{anode}} \tag{6}$$

It can be written as

$$V_{\text{cell}} = V_{\text{oc}} - R_{\text{in}} I, \tag{7}$$

where V_{oc} = open cell potential (V), R_{in} = internal resistance (Ω) and I = current density (A).

3 Methodology

Figures 1, 2, 3, 4 and 5 shows Air plants, Mint leaves, Spinach leaves, climbing spinach and Indian pennywort leaves, respectively collected from the agricultural

Fig. 1 Air plant

Fig. 2 Mint

field. The leaves are put between the two plates Zn and Cu firstly and then Zn and Ag as shown in Fig. 6. Using rubber and thread the plates are bound tightly [18]. Using calibrated multi-meter voltages are measured periodically. The collected data were tabulated shown in Tables 1 and 2, respectively, and then after it was graphically represented as shown in Figs. 7, 8, 9, 10, 11, 12, 13, 14 and 15.

Fig. 3 Spinach

Fig. 4 Climbing spinach

Fig. 5 Indian pennywort

Fig. 6 Experimental set up

4 Results and Discussion

4.1 The Variation of Voltage with the Variation of Time Duration of Different Fresh Leaves for Cu–Zn Pair Have Been Graphically Represented

It is shown (Fig. 7) that open-circuit voltage increases almost linearly with time up to 15 min. Then after it was almost the same up to 20 min. Then it increases again up to 25 min. Then after it decreases irregularly up to 65 min. It is shown that the obtained minimum voltage was 0.70 V and the maximum voltage is 0.76 V. Finally, it is 0.71 V after 65 min and then is almost stable. The maximum change in voltage variation for 65 min is 0.06 V and the minimum voltage variation is 0.01 V. Therefore, the % of voltage variation $(0.76 - 0.70)/0.70 \times 100\% = 8.57\%$.

It is seen (Fig. 8) that the voltage decreases about linearly up to 15 min. Then it increases linearly up to 20 min and approximately remains stable up to 65 min. The maximum voltage is 0.7 V and the minimum voltage is 0.4 V. Finally the approximate

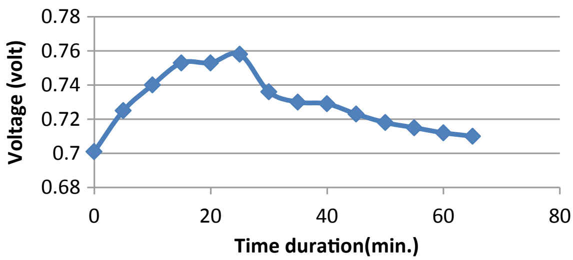
Table 1 Table for comparative voltage study of different vegetative leaves using Cu–Zn pair

Date	Local time	Time duration (min)	Spinach	Air plant	Climbing spinach	Mint	Indian pennywort
04.05.19	12.20	0	0.701	0.681	0.604	0.774	0.429
	12.25	05	0.725	0.624	0.591	0.766	0.419
	12.30	10	0.740	0.572	0.588	0.765	0.465
	12.35	15	0.753	0.430	0.587	0.764	0.423
	12.40	20	0.753	0.593	0.552	0.764	0.404
	12.45	25	0.758	0.592	0.581	0.763	0.403
	12.50	30	0.736	0.610	0.576	0.765	0.425
	12.55	35	0.730	0.600	0.585	0.769	0.403
	01.00	40	0.729	0.604	0.584	0.773	0.413
	01.05	45	0.723	0.571	0.547	0.775	0.410
	01.10	50	0.718	0.578	0.565	0.774	0.422
	01.15	55	0.715	0.574	0.554	0.772	0.408
	01.20	60	0.712	0.604	0.550	0.771	0.404
	01.25	65	0.710	0.604	0.548	0.772	0.406

Table 2 Table for comparative voltage study of different vegetative leaves using Zn–Ag pair

Date	Local time	Time duration	Spinach	Air plant	Climbing spinach	Mint	Indian pennywort
04.05.19	2.25	0	0.591	0.540	0.588	0.555	0.00
	2.30	05	0.589	0.539	0.587	0.552	0.00
	2.35	10	0.586	0.537	0.583	0.553	0.00
	2.40	15	0.587	0.541	0.585	0.554	0.00
	2.45	20	0.588	0.538	0.582	0.550	0.00
	2.50	25	0.506	0.558	0.552	0.528	0.00
	2.55	30	0.518	0.547	0.550	0.531	0.00
	3.00	35	0.521	0.539	0.551	0.532	0.00

Fig. 7 Variation of voltage with the variation of time duration for Spinach



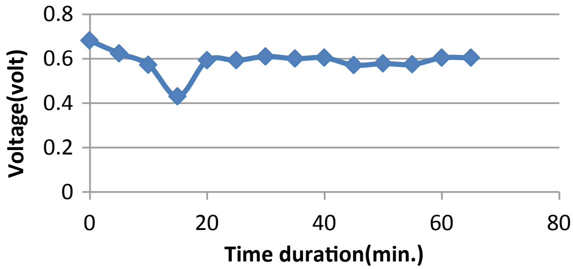


Fig. 8 Variation of voltage with the variation of time duration for air plant

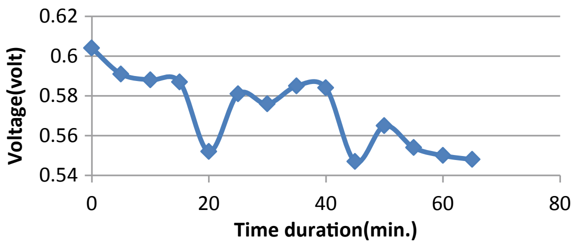


Fig. 9 Variation of voltage with the variation of time duration for climbing spinach

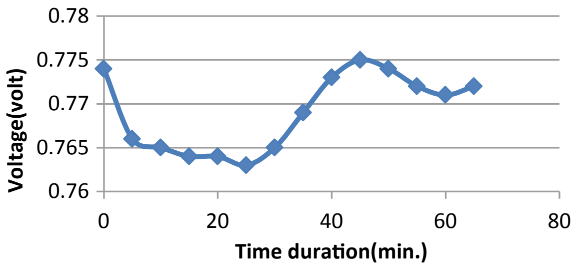


Fig. 10 Variation of voltage with the variation of time duration for mint

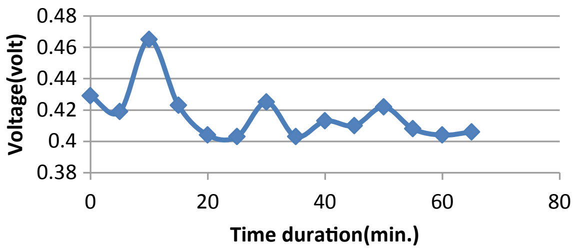


Fig. 11 Variation of voltage with the variation of time duration for Indian pennywort

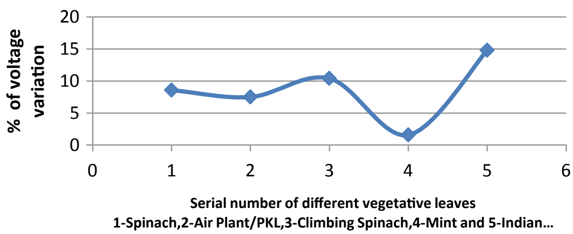


Fig. 12 Variation of % of voltage variation with the variation of the different vegetative leaves

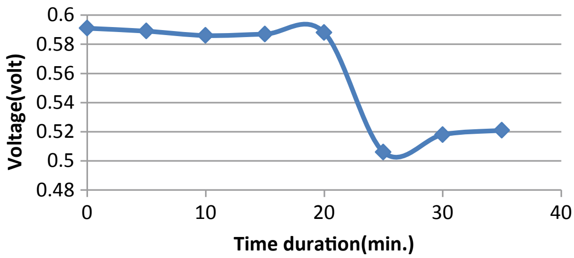


Fig. 13 Variation of voltage with the variation of time duration for spinach

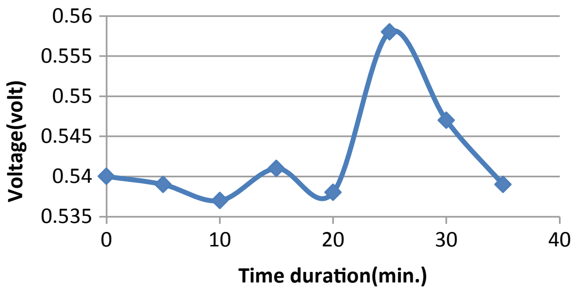


Fig. 14 Variation of voltage with the variation of time duration for air plant

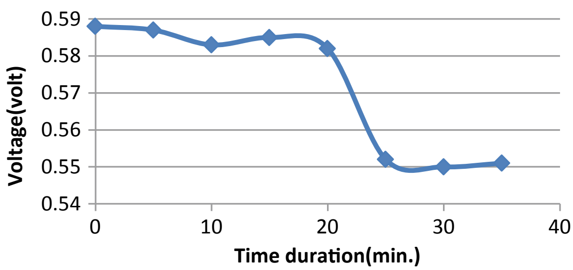


Fig. 15 Variation of voltage with the variation of time duration for climbing spinach

stable voltage was 0.6 V after 65 min. Therefore, the maximum voltage variation is 0.3 V and minimum variation is 0.1 V. The % voltage variation is $(0.7 - 0.4)/0.4 = 7.5\%$

It is seen (Fig. 9) that the voltage decreases about linearly up to 10 min. Then it remains stable up to 15 min then it decreases and increases irregularly up to 65 min. The maximum voltage is 0.605 V and the minimum voltage is 0.548 V. Therefore, the maximum voltage variation is 0.057 V. The % voltage variation is $(0.605 - 0.548)/0.548 = 10.40\%$.

It is seen (Fig. 10) that the voltage decreases up to 20 min exponentially and then it increases again up to 25 min almost linearly. Finally, it decreases up to 60 min. Then it increases again up to 65 min. The maximum voltage is 0.775 V and the minimum voltage is 0.763 V. Therefore, the maximum voltage variation is 0.012 V. The % voltage variation is $(0.775 - 0.763)/0.763 = 1.57\%$.

Table 3 Table for the % of voltage variation with different Zn/Cu fresh vegetative leaves electrochemical cells

Name of the different vegetative leaves	Serial no. of the different vegetative leaves	% of voltage variation
Spinach	1	8.57
Air Plant/PKL	2	7.5
Climbing spinach	3	10.40
Mint	4	1.57
Indian pennywort	5	14.81

It is seen (Fig. 11) that the voltage decreases about linearly up to 5 min. Then it increases linearly up to 10 min then it decreases and increases irregularly up to 65 min. The maximum voltage is 0.465 V and the minimum voltage is 0.405 V. Therefore, the maximum voltage variation is 0.065 V. The % voltage variation is (0.465 − 0.405)/0.405 = 14.81%.

Table 3 shows the % of voltage variation with different Zn/Cu fresh vegetative leaves electrochemical cells. It is also shown that the maximum % of voltage variation is 14.81 for Indian Pennywort and the minimum % of voltage variation is 1.57 for Mint.

4.2 *The Variation of Voltage with the Variation of Time Duration of Different Fresh Leaves for Zn–Ag Pair Has Been Graphically Represented*

It is shown (Fig. 12) that the variation of % of voltage variation with the variation of the different vegetative leaves is not steady but always flexible. The maximum value was 14.81% and the minimum value was 1.57%.

It is seen (Fig. 13) that the voltage remains almost stable up to 20 min. Then it decreases up to 25 min. Then it increases about linearly up to 35 min. The maximum voltage is 0.590 V and the minimum voltage is 0.505 V. Therefore, the maximum voltage variation is 0.085 V. The % voltage variation is (0.590 − 0.505)/0.505 = 16.83%.

It is seen (Fig. 14) that the voltage decreases about linearly up to 10 min. Then it increases and decreases irregularly up to 35 min. The maximum voltage is 0.558 V and the minimum voltage is 0.537 V. Therefore, the maximum voltage variation is 0.021 V. The % voltage variation is (0.558 − 0.537)/0.537 = 3.91%.

It is seen (Fig. 15) that the voltage remains almost stable up to 20 min. Then it decreases up to 25 min. Then it remains almost stable up to 35 min. The maximum voltage is 0.588 V and the minimum voltage is 0.550 V. Therefore, the maximum voltage variation is 0.038 V. The % voltage variation is (0.588 − 0.550)/0.550 = 6.90%.

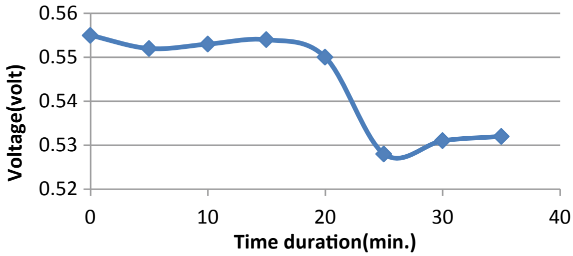


Fig. 16 Variation of voltage with the variation of time duration for mint

Table 4 Table for the % of voltage variation with different Zn/Ag fresh vegetative electrochemical cells

Name of the different vegetative	Serial number of the different vegetative	% of voltage variation
Spinach	1	16.83
Air plant/PKL	2	3.91
Climbing spinach	3	6.90
Mint	4	5.11

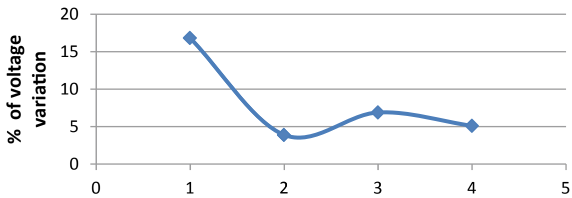


Fig. 17 Variation of % of voltage variation with the variation of different vegetative leaves

It is seen (Fig. 16) that the voltage decreases linearly up to 5 min. Then it increases up to 15 min. Then it decreases linearly up to 25 min and again increases about linearly. The maximum voltage is 0.56 V and the minimum voltage is 0.528 V. Therefore, the maximum voltage variation is 0.027 V. The % voltage variation is $(0.56 - 0.53)/0.59 = 5.11\%$.

Table 4 shows the % of voltage variation with different Zn/Ag fresh vegetative electrochemical cells. It is also shown that the maximum % of voltage variation is 16.83 for Indian Pennywort and the minimum % of voltage variation is 3.91 for Mint.

From Fig. 17, it is shown that the variation of % of voltage variation with the variation of the Different Vegetative is not steady but almost it is always flexible.

5 Conclusions

The fresh leaves are available in our country due to the development of agricultural research. Anybody can harness this electricity as a homemade product. Anyone can cultivate these vegetative leaves in the garden to get homemade electricity instead of kerosene. This electricity can be used to power LED bulb. This is useful for remote areas of any country. This electricity is environmentally friendly and low-priced.

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