EFFECT OF ELECTRICAL IMPEDANCE DUE TO INFLICTION ON ALOE BARBADENSIS MILLER (ALOE-VERA) LEAVES

Sanjeev Sharma[1], Randhir Singh[1], Jang Bahadur Singh[2], Sandeep Arya[2], Saleem Khan[2], Parveen Lehana[2,*]

[1]Department of Electronics & Comm., SSCET, Badhani, Pathankot, Punjab, India
[2]Department of Physics and Electronics, University of Jammu, Jammu, India.
pklehanajournals@gmail.com

ABSTRACT

Aloe barbadensis (aloe-vera) also famous as a first aid plant is a valuable natural medicine. Its leaves have parallel venation that contains a soothing thick gel inside it and is useful for treatment and curing of wounds and diseases. In this paper, investigations were carried out to study the effect of dc and ac resistances of the aloe barbadensis leaves. The resistance of the leaf measured shows a proportional change with the change in the length of the leaf. The resistance of the leaf tissue increases with the increased distance between the electrodes due to circumvent current path. Both, fresh and the dry leaf of a aloe barbadensis plant was taken for the investigations. For fresh leaf, the dc resistance increases steeply along the length of a leaf while ac resistance comparatively shows a very slow increase in resistance, where as the results verified some fascinating changes in resistance as the leaf dried up.

KEYWORDS

Aloe-vera, aloe barbadensis, ac signal, dc signal, impedance

1. INTRODUCTION

Living things exhibit the character of responding to external stimuli. Plants being multi-cellular living organisms also show several remarkable properties [1]. A number of investigations have been carried out exploit the environmental and biological propertied of the plants and their effects on plant physiology. For example, attempts have been made to show the similarities between the behavior of animal and plant tissues [2]. The effect of music has also been investigated and the results of these investigations showed definite effect of music on plants metabolism [3]. Plants feel pleasure in the presence of some music patterns, as their biological signals are affected by different amounts and it has been reported that some musical sounds can also damage the plants tissues as well [4]. A powerful beating of heavy metals and rock music should never be played around a plant. Researchers had observed that if the plants are continually exposed to such music for more than 10 days, they will ultimately die [5]. In contrast, the impact of soft and light music enhances the plant growth and increases yield. Soft and light kind of music has gentle vibrations that relax the plants tissues. Violin music considerably increases plants growth. Some researchers concluded that the gentle vibrations of a music helps in the rapid growth of the plants, making them stronger. All this may help the farmers to increase the production of crops [5].

The plants also show response to the stimulating electrical signals. These signals may set off different physiological reactions [6]. For example, the signals can cause

swift leaf movements in certain plants and some changes in plant physiology are reported in [7]. Photosynthesis is the one important biological process. Plants exhibit respiration that releases the energy stored in carbon compounds for cellular use. Although respiration is common for all eukaryotic organisms, the photosynthesis is confined only to the plants kingdom and also to some prokaryotic bacteria. Many environmental factors can affect the rate of photosynthesis and respiration. Concentration of O_2, CO_2, temperature, water and nutrient supply are the most often designated for these effects [8] [9]. It is pertinent to mention that electrical signals generated by plants have also impact on these processes. In addition to photosynthesis and respiration processes, others physiological responses to electrical signals have also been reported [10-15]. Each green plant exhibits different electrical conductivity. The process of electrical conduction varies from plant to plant and it may be possible that each plant exhibits a unique response to electrical stimuli. The possessions persuaded due to environmental factors show impulsive distinctions of parameters due to potential applied [6] [8].

Our hypothesis is that the health of each plant may be predicted by recording the electrical signatures of the plants in response to external stimuli such as sound or vibrations. A limited work has been reported on recording and relating the electrical signatures of the plants with their health. The objective of this paper is to investigate the effect of physical damages on the leaves of Aloe vera with respect to dc and ac resistances. Aloe vera has been chosen because of its numerous applications in medicine and beauty. The electrical resistances were estimated for the leaves immediately after piercing and after one month, when due to piercing, the Aloe vera leaves start decaying.

2. ALOE-VERA

Aloe-vera is a multifarious and enormously adaptable plant having botanical name as Aloe barbadensis miller and is a well known for its health, beauty, medicinal and skin care properties [16]. The name aloe was derived from the arabic word Alloeh means “shining bitter substance,” while Vera in Latin means “true.” It belongs to asphodelaceae (Liliaceae) family, and is shrubby or arborescent, perennial, xerophytic, succulent, pea- green color plant. It can grow from 80 cm to 100 cm tall. The leaves are 40 to 60 cm long with thorns on both edges, with a width at the base as 6 cm to 15 cm. It grows mainly in the dry regions of Africa, Asia, Europe, and America. There are over 400 species of Aloe-vera in the Lily family. So, it is famous by the name Lilly of desert [16]. The plant has triangular, ample leaves with saw-like edges, blonde tubular flowers and fruits that contain several seeds. Each leaf has a three layers composition, (i) Aloe Rind- the protective, green, outer leaf skin. This layer does not attain any significant nutritional value, (ii) Aloe Latex- the pungent, yellowish, deplete fluid which has strong odor and flows in between the leaf ring and the inner fleshy part of leaf. Aloe latex is not recommended for consumption and, (iii) Inner Leaf Juice- the lucid, inner fleshy portion of leaf has a tremendous nutritional value for the health and can be consumed both internally and externally. Aloe-vera has seventy five active constituents and documented as- 20 minerals, 20 amino acids, 12 vitamins, and water [17]. Vitamins present in Aloe-vera are vitamin A (as Beta Carotene), vitamin B (as Thiamine), B2 (Riboflavin), B3 (Niacin), B5, B6 (Pyridoxine), B12, Vitamin C, Vitamin E, and Folic Acid. Vitamin B complex and vitamin C does play an important role in reducing stress and inflammation. Besides vitamins, enzymes, minerals, sugars, lignin, saponins,

salicylic acids and amino acids etc are also present in it [18] [19]. Minerals found in the aloe-vera are calcium, sodium, zinc, chromium, potassium, magnesium, copper, manganese, and selenium.

(a) (b)

Fig.1 (a) Aloe-vera leaf marked at every 2 cm distance (b) Aloe-vera plant grown in the pot.

It provides 20 out of 22 required amino acids required for human being and 7 of the 8 essential amino acids. Essential amino acids present are alanine, arginine, asparagine, cystenine, glutamic acid, glycine, histidine, proline, serine, tyrosine, glutamine, and aspartic acid. Moreover, it contains salicylic acid that possesses anti-inflammatory and antibacterial properties [20]. Lignin, an inert substance, when included in topical preparations, enhances penetrative effect of the other ingredients into the skin. *Saponins* that are the soapy substances form about 3% of the gel and have cleansing and antiseptic properties. As we age, the level of collagen in our bodies naturally decreases and is one of the reason for older people to heal up the wound as compared to the children. Aloe-vera contains the bulk of the required amino acids and vitamins that the human skin needs to heal. The glue-like substance keeps out any bacteria or agents that could cause healing to slow or cease completely [20]. Several researchers had reported different hypothesis that attest the effects of Aloe-vera. Still the researchers are reporting latest information as every person has a different genetic structure that requires different amounts of nutrients depending on the particular situation [19] [20]. Thus, Aloe-vera is an excellent source of nutrients that can help our body in a multitude of ways.

3. METHODOLOGY

The experiment was carried out on the leaves of the Aloe-vera plant to investigate the effect of electrical signals on the health of the leaves. The effect due to physical damages on the leaves of Aloe-vera is recorded with respect to dc and ac resistances. The plant was grown in a pot containing fertile soil under natural environmental conditions. Plant was watered every day and the care has been taken for its sustenance.

The experimental setup is shown in Fig. 2 and is used to measure the resistance with respect to the distance between two different electrodes along the length of Aloe-vera leaf. The triangular shaped electrodes of zinc (Zn) and copper (Cu) measuring in area as 0.04 cm^2 with resistance of approx. 0.7 Ω to 1.2 Ω were used for establishing contact with the leaf tissues. Extra care was taken to ensure that the plant tissues does not damage while connecting the electrodes with leaf. Two set of experiments were conducted. First experiment was conducted after 30 minutes of inserting the electrodes on the fresh leaves while the other experiment was done on the same leaf that gets dried after 30 days.

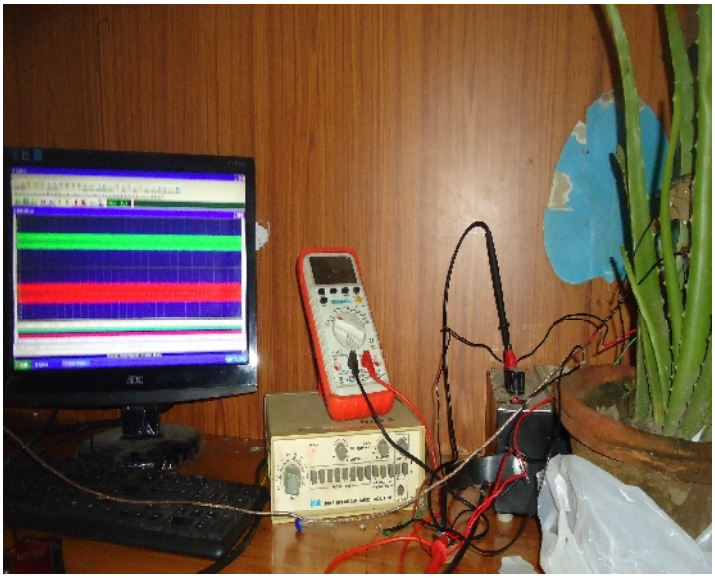

Fig. 2 Experimental set up used for estimating dc and ac impedances of Aloe-vera leaves.

The effect of dc and ac resistance was observed on the health of aloe-vera leaves due to increase in distance between the electrodes along the length of a leaf. A total of 11 equidistant points were marked on the leaf each of 2 cm apart from lower to upper position of leaf. Copper (Cu) electrode is kept fixed at the lower part of a leaf and acts as base electrode while zinc (Zn) electrode is moved up to the next step. Measurements were started about half an hour after connecting the electrodes to the leaf to allow the null offset potentials and currents to settle down due to induced processes in plant tissues.

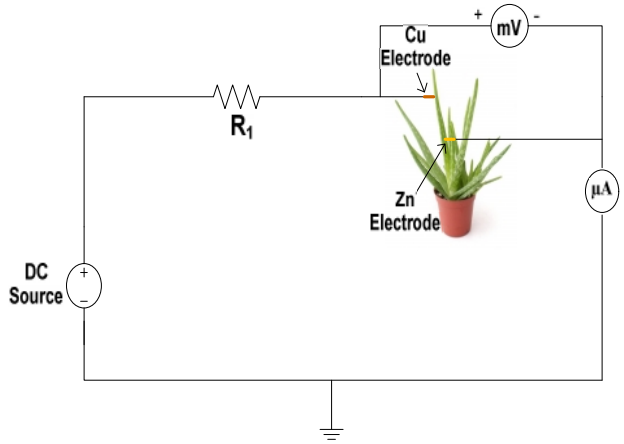

Fig. 3 Schematic for dc resistance measurement.

For D.C measurement, the experimental circuit comprised of an external dc source (E_{Th}), potentiometer (R_1), micro-ammeter (µA), and a milli-voltmeter (mV) connected along the length of Aloe-vera leaf between two electrodes. The schematic for the dc circuitry is shown in Fig. 3. The dc source used was kept static at 2.5 volts. The readings for voltage and currents were recorded using at each site. For estimating the dc resistance, the following equation was used:

$$E_{Th} = IR_1 + IR_L + E_{Offset}$$

where I is the series current, R_L the leaf resistance, and E_{Offset} the offset voltage developed due to electrode electrolyte interface. The dc resistance was estimated by dividing the voltage developed across leaf by the current flowing through it.

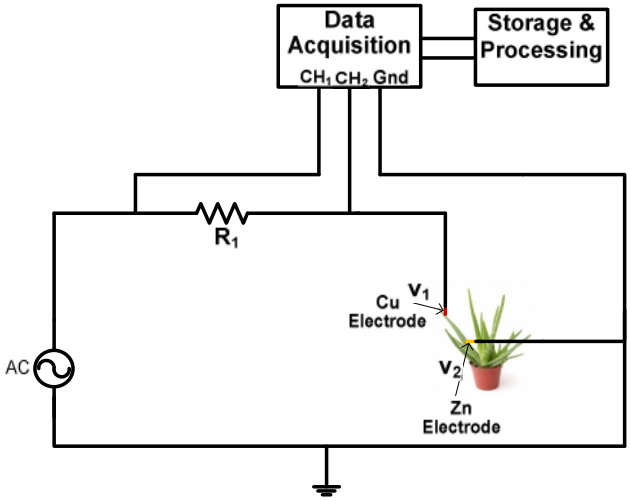

Fig. 4 Schematic for ac impedance measurement.

For estimating the ac resistance, the circuit setup of Fig. 4 was employed. The voltages v_1 and v_2 were recorded using two channels of a data acquisition card. The impedance of the leaf was estimated by calculating the ratio of rms voltage and rms current derived from the recorded waveforms.

4. RESULTS AND DISCUSSIONS

Table 1 shows the dc resistance estimated from the ratio of dc voltage and dc current recorded at 11 sites on the fresh and dry leaves. The dc resistance obtained at different sites is also plotted in Fig. 5. It is clear from the plot that dc resistance increases with the increasing distance between the electrodes. The deviation from the exact straight line relationship may be due to the variation in shape and offset voltages developed at the contact junctions. Further, dried leaf shows more resistance as compared to that of the fresh leaf.

The results of ac measurements are shown in Table 2 and plotted in Fig. 6. Although, the ac resistance of the fresh and dried leaves varies linearly with distance, the interesting observation is that the ac resistance of the fresh leaf is more as compared to the dried leaf. This is just opposite of the fact observed in case of dc analysis of the leaves. It may be due to the increase in the capacitance of a leaf because of the increase of the dielectric of the dead tissues of the leaves. The gel inside the leaf acts as a conducting path for the dc signals and when the leaf dries up after 30 days, due to decrease in the gel of the leaf, the resistance of the leaf increases.

Table 1. Resistance calculated using dc source for fresh and dried leaf.

Distance (cm)	d.c. Resistance (KΩ)	
	Fresh Leaf	Dried Leaf
2	16.575	50.000
4	25.049	65.625
6	33.200	91.666
8	43.121	101.818
10	58.375	112.500
12	66.551	127.222
14	90.000	143.750
16	101.000	167.857
18	107.894	196.666
20	122.352	238.000
22	131.250	480.000

Table 2. Resistance calculated using ac source for fresh and dried leaf

Distance (cm)	a.c resistance (KΩ)	
	Fresh Leaf	Dried Leaf
2	13.505	5.053
4	16.189	6.735
6	18.077	8.452
8	20.074	9.720
10	22.113	10.616
12	23.038	11.516
14	25.070	12.231
16	27.423	13.115
18	27.396	13.850
20	28.849	14.436
22	29.780	14.936

For ac signals, the gel may act as dielectric. When leaf is fresh the gel shows low dielectric value and hence low capacitance. That means, higher reactive impedance. For dried leaf, the gel inside leaf may shows high dielectric value. Thus the capacitance increases and the reactive impedance decreases.

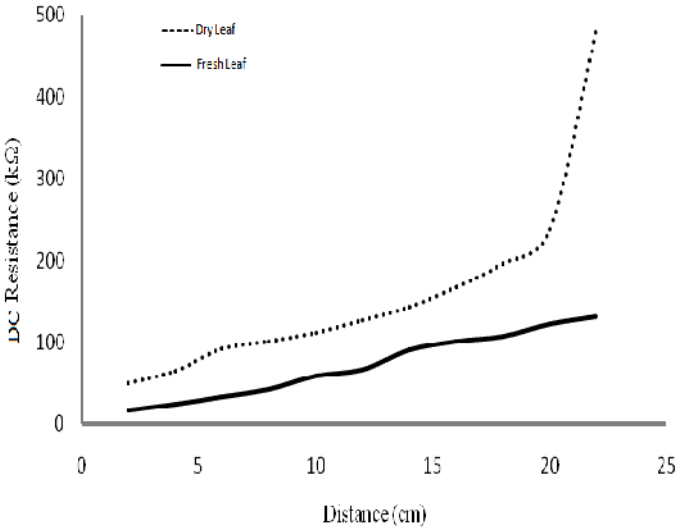

Fig. 5 Graphical representation showing impedance for fresh and dried leaf with respect to distance between electrodes using dc source.

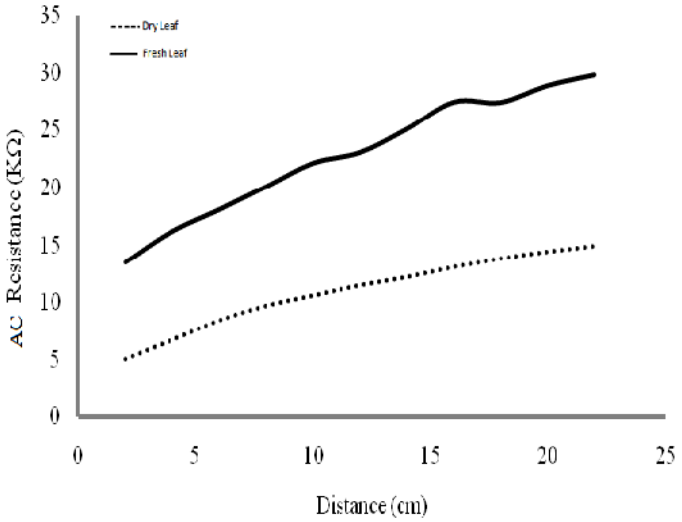

Fig. 6 Graphical representation showing impedance for fresh and dried leaf with respect to distance between electrodes using ac source.

The analysis of the results showed that the ac resistance of an aloe-vera leaf may be modelled using three dc resitances, one capcitor, and one voltage source. The propsed model is shown in Fig. 7.

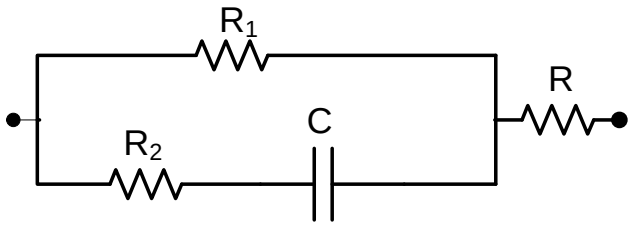

Fig. 7 Equivalent circuit of the Aloe-vera leaf containing dc and ac impedances.

5. CONCLUSION AND FUTURE SCOPE

Investigations were carried out to study the electrical behavior of Aloe vera leaves for both dc and ac signals. The investigations have shown that the dc resistance of the fresh leaves is more as compared to that of dried leaves. Investigations using ac current have shown that the ac resistance of live fresh leaves is more as compared to that of dried leaves. This may be due to the increased capacitance because of the increase in dielectric value of the dead tissues in the dried leaves. Investigations have shown that the ac resistance of the leaves can be modeled using three dc resistors, one capacitor, and one dc offset voltage source. The investigations may be very important for further improving the medicinal values of the Aloe vera plant by controlling the amount of nutrition by studying the electrical properties of the leaves during their growth.

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