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Preface: International Conference on Science and Applied Science

(ICSAS 2019)

International Conference on Science and Applied Science (ICSAS) 2019 was held at the Alana Hotel, Surakarta, Indonesia on 20 July 2019. The ICSAS 2019 conference is aimed to bring together scholars, leading researchers and experts from diverse backgrounds and application areas in Science. Special emphasis is placed on promoting interaction between the science theoretical, experimental, and education sciences, engineering so that a high-level exchange in new and emerging areas within Mathematics, Chemistry, Physics and Biology, all areas of sciences and applied mathematics and sciences is achieved.

In ICSAS 2019, there are seven parallel sessions and four keynote speakers. The speakers are Dr. Rifai Chai, Dr. Bambang Sumintono, Prof. Dra. Suparmi, M.A., Ph.D., and Prof. Rachmadian Wulandana, Ph.D. It is an honour to present this volume of AIP Conference Proceedings and we deeply thank the authors for their enthusiastic and high-grade contribution. There are 279 abstracts and 198 papers submitted to ICSAS 2019. From the review results, there are 130 papers that will be published in AIP Conference Proceedings. We would like to express our sincere gratitude to all in the Programming Committee who have reviewed the papers and developed a very interesting Conference Program, as well as thanking the invited and plenary speakers. Finally, we would like to thank the conference chairman, the members of the steering committee, the organizing committee, the organizing secretariat and the financial support from the Sebelas Maret University that allowed ICSAS 2019 to be a success.

The Editors

Prof. Dra. Suparmi, M.A., Ph.D
Dewanta Arya Nugraha, S.Pd., M.Pd., M.Si.

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Determining sugar content in sugarcane plants using LED spectrophotometer

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Determining sugar content in sugarcane plants using LED spectrophotometer

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Abstract. Sugar production from sugarcane plants depends on their sugar content in the unit of % Brix. The higher value of Brix percentage, the sugar production will be increase. In the field of sugarcane, there is term of Commercial Cane Sugar (CSS) or Sugarcane quality index which describes the approximation percentage of sugar content from fresh sugar cane. The idea of non-destructive measurement leads us to propose the designed non-destructive Brixmeter based on the optical properties of sugar content. This design of measurement in the scale of Brix uses photometer with spectroscopic techniques. Our instrument employs LED as a light source and photodiode array as a detector. The system employed a pin photodetector as a sensor, LED, operational amplifiers (Op-Amp), an ADC, and a computer. The main operation of the measurement system was conducted by the sensor and the computer controlled system. The signal from pin photodiode sensor was sent to the signal processing unit (op-amp and ADC). Then the digital code was counted by controller and displayed in the computer screen. The LED-refractometer was calibrated using a standard solution liquid, and the results compared to the digital spectrophotometer (scientific spectrophotometer). The results showed that the LED-refractometer is able to measure sugar content of sugarcane plantation in field in the accuracy of 95% compare to the digital spectrophotometer as a standard meter to measured sugar content of solution.

INTRODUCTION

Sugarcane (Saccarum officinarum L.) is an important crops in Indonesia as they are a main source of sugar production (Soependi and Arianto 2015). Sugar demand in Indonesia in 2014 reached 5.7 million tons (Hendaryati and Arianto 2017). To meet these needs, sugarcane crops are essential to be cultivated as a support for the production of sugar independently in Indonesia (Soependi and Arianto 2015). Sugar production from sugarcane plants depends on their sugar content in the unit of % Brix. The higher value of Brix percentage, the sugar production will be increase.

In the tree crop estate of sugar cane, there is term of Commercial Cane Sugar (CSS) or Sugar cane quality index (Hendaryati and Arianto 2017) which describes the approximation percentage of sugar content from fresh sugar cane (in the scale of % Brix as stated above). The sugar content is one of the basic parameters used to determine the maturity of sugarcane plantations in which they are ready to be harvested (Nazmi et al. 2014). Delaying harvesting time to be longer can lead to the decreasing sugar content in the sugar cane. Therefore the measurement of sugar content is important to get the highest sugar production according to the best harvesting time.

The sugarcanes with a certain minimum value of % Brix can be considered as mature sugarcanes and so they are ready to be harvested (Staunton, Donald and Pope 2011). The maturity analysis conducted by Mukhtar (2014) mentioned other criteria to ripe sugar canes i.e. sugar cane is good to be riped when visually the most cane leaves are dried up, except the bud. Or we can say that the mature sugarcane is marked by the fall off of the most leaves. Chemically the mature condition is indicated by the equal value of %brix of sugar cane in the bottom and top part of the plant (Ftwi, Mekibib and Tesfa 2017).

In order to get information of sugar content of sugarcane in the field, we have to do measurement. The recent method to detect sugar content is by cutting some sugar cane plant samples and squeezing them into the milling, then passing the liquid solution to the laboratory to be identified. This method is considered as difficult, time consuming and expensive way.

A possibility of alternative method to measure the sugar content has been introduced by (Flaschka, McKeithan, & Barnes (1973), Mehrotra and Siesler (2003), and Liu (2004). They used photometric detector

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emitter (LED) as a light source and sensor applied are LDR (Mehrotra and Siesler 2003, O'Toole and Diamond 2008) and photodiode array (Liu 2004). In addition Yeh and Tseng (2006) tried to design low cost spectrophotometer using LED and LDR. However, all of the instrument described above should use sugar liquid solution from the sugar cane. It means that the tested material is destructed. Also the utilization of LED as a light source has a spectrum backdraw.

A non-destructive method was described by Naderi-Boldaji et. al. (2015). They explained the method of sugar content based on the dielectric constant properties using parallel plate capacitor. The idea of non-destructive measurement leads us to propose the designed non-destructive Brixmeter based on the optical properties of sugar content. This design of measurement in the scale of Brix uses photometer with spectroscopic techniques. Our instrument employs LED as a light sources and photodiode array as a detector.

MATERIALS AND METHODS

The employed sugarcane samples to be measured their sugar content come from Bondowoso. We took 4 different types of sugarcanes and ripped the sugar liquid from those sugarcanes from bottom, middle, and top part of sugarcane rod. There are 72 sugar liquid samples which is aimed to make 3 times measurement to each types of and each part of rod sugarcane with two different measumrement tools (Brix meter and the designed LED spectrophotometer).

The measurement processes are performed using digital spectrophotometer (Brix meter) and LED spectrophotometer (the designed instrument). The light sources utilized in the LED spectrophotometer consist of 3 different spectrum LEDs that are red, green, and blue LED and the used detector is PIN photodiode (BPW34). The data acquisition by computer uses ADC interface and then the data are processed by Labview. The measurement diagram is shown in Fidure 1.

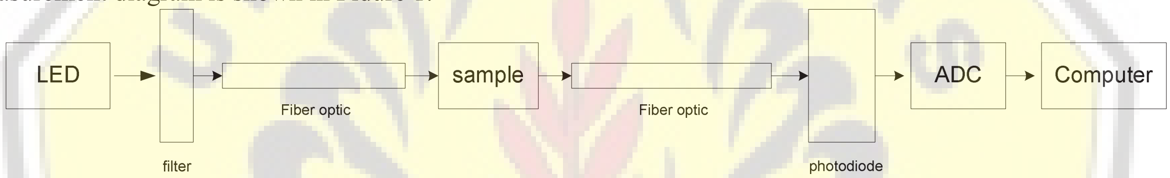

FIGURE 1. Measurement diagram of sugar content using designed LED spectrophotometer

The Measurement Calibration

The measurement calibration is conducted to figure out the relationship characteristic of sugar concentration and the output voltage of BPW34 sensor for each LED sorce (red, green, and blue). The first calibration step is transmitting the LED's light to the sample through the optical fiber. Secondly, the beam has passed through the sample is then passed through a fiber optic and fed to the photodiode sensor. PIN photodiode sensor (using photodiode BPW 34 has a catchment area of 7.5 mm2 and photon peak response in the area is the wavelength 900 nm). It will convert the intensity into the current by using Opamp transimpedance amplifier, and then the current is converted into the voltage. The voltage is linked to computer through ADC (Analog to Digital Converter).

Measurement of Sugar Concentration

Sample Preparation

A number of of 12 stems come from sugarcane type A, type B, type C, and type D, which comes from sugar cane plantation in Bondowoso. From the stem taken as many as 72 samples consisting of parts of the lower stem segment, the middle section, and the upper section. The sample of the sugarcane segment is taken through the extraction process by grinding each segment to obtain in liquid form. Half of the samples (36 samples) were used for measurement using brixmeter (36 samples) and the remainder used for measurement using the LED-spectrometer. There was also provided a sample of sucrose solution with concentrations of 0, 25, 50, ..., 225 grams / liter for testing the LED response as a light source for the LED- spectrometer.

Set up the LED-spectrometer

The measuring instrument used consists of brixmeter (digital spectrometer) as a comparator and LED-spectrometer. Spectrometer-LED is a spectrometer that is being made there are three pieces (each using a red LED light source, green LED, and blue LED). The LED peak response is based on the manufacturer's reference to each of the wavelengths of 620 nm (red), 545 nm (green), and 460 nm (blue). The LED-sized (1x2x1) cm spectrometer sample container is illuminated using an LED source. The LED light through the sample is passed to the photodetector (pin photodiode BPW 34) via a multimode optical fiber (0.5 mm diameter) and forwarded to the computer via the ADC. Of the three LED sources used will be compared with the highest response to the sample being tested. The LED source response will be tested through the output voltage of each photodetector. Brixmeter used is Model RHB production Huake Instrument (China) with scale Brix 0-35.

Signal Processing System

The signal processing system uses Labview devices to process signals on the LED-spectrometer devices. The light from the LED through the sample is passed to the photodetector and the computer. The software used for signal processing is Labview. For calibration, the sample used is a solution of sucrose at levels of 0, 25, 50, ..., 225 grams / liter on this LED-spectrometer.

Data Acquisition

A number of 72 sugar cane bar is used as measurement samples. Those samples were taken from 4 different types of sugarcane and each type of sugarcane was ripped in three different segments that are bottom, middle and top segment. The measurement process was done in two methods with 3 times repetition in each method. Samples collected from the stalks of sugarcane plantation at Bondowoso in 2015. The plant is planted on October 2014 and will be harvested at the age of 9 month. The samples are crop plants that are planted in September 2011 and harvested at 8 months old. Rod taken from a variety of commercial trials represented three different stages of maturity, which is early-maturing, mid-maturity, and late maturity. Selection of these three varieties are designed to ensure that the model developed in this study include Brix range (6-15) are often experienced during commercial harvest. Samples stalk across it first to remove all the leaves and then a third material is cut into individual segments using the cutting and the rest is taken just under the segment, the middle segment, and the segment above. After cutting, each piece is cut and taken liquid immediately scanned into the spectrometer.

MATERIALS AND METHODS

Sugar concentration Vs V out of BPW 11 sensor (Calibration with pure sucrose)

This section shows the measurement results of BPW11 output voltage associated with sugar concentration for every tyoe of LE|D source. Results of the output voltage of measurement system using three various LED sources are listed in Table 1 below:

TABLE 1. Concentration measurement of sugar using LED source

Concentration (gram/liter)	Average of output voltage (mV)		
	LED red	LED green	LED blue
0	68,6	63,7	71,5
25	61,7	61,7	69,6
50	57,8	58,8	66,6
75	51,0	53,9	62,7
100	45,1	50,0	56,9
125	43,1	46,1	51,9
150	38,2	40,2	50,0
175	33,3	38,2	46,1
200	28,4	36,3	39,2
225	23,5	26,5	38,2

Based on the above table it can be seen that the output voltage of the circuit will always changing in every variation of the concentration of sugar solution. From the table it can be seen that in average the red LEDs produces the highest output voltage changes compare to the green LEDs and blue LEDs. The relationship patterns of sucrose concentration and the output voltage of each type of LED are shown in figure 2 below.

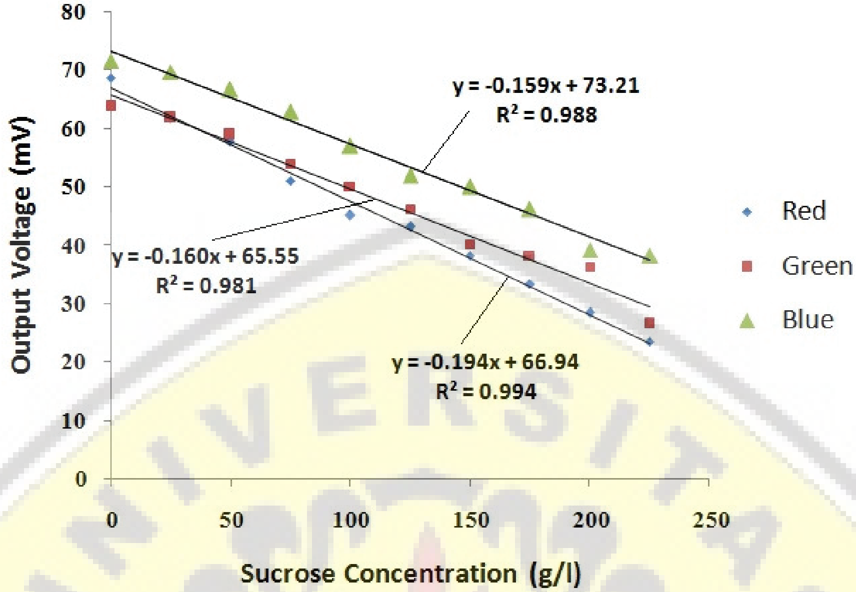

FIGURE 2. The relationship between the sensor response to the type of light source

Based on the figure 2, it is obvious that the line's gradient of red LEDs is the most steeply or we can say that the red LEDs is the most sensitive to the changing of sucrose concentration variation. Therefore this red LEDs is than utilized as a sensor in the designed spectrofotometer in this research.

Sugar content in % Brix and measured output voltage in every segment and every type of cane

Measurement of sugar content in this study used a measurement system that has been created (Spectrometer with LED source). As a comparison we used a digital spectrophotometer (Brixmeter). The measurement results using both systems are shown in Table 2 below. The data obtained were converted into the amount of concentration based on a calibration curve which has been obtained from measurements on the sugar solution. The results show that the sugar content (sucrose concentration) come from the bottom segment of sugarcane has the highest value in every type of sugarcane. Oppositely the top segment has the lowest sugar content. There are different values of concentration resulted from the two measurement systems. In average the difference is 4,3 g/l. The difference is due to the limitations of the tools that have been created. Module Arduino UNO has a voltage of 4.9 mV resolution.

TABLE 2 . The measurement results on the liquid cane sugar content using digital spectrophotometer

Cane Type	Segment	Brixmeter		Spectrofotometer		Concentration difference (gram/liter)
		% Brix	Concentration (g/l)	Vo (mV)	Concentration (g/l)	
A	Top	13,3 ± 0,1	156,2	37,2 ± 2,7	152,9	3,3
	Middle	15,8 ± 0,1	186,2	31,4 ± 4,4	183,1	3,1
	Bottom	17,6 ± 0,1	208,8	27,4 ± 2,7	203,3	5,5
B	Top	13,8 ± 0,1	162,2	36,30 ± 2,7	157,9	4,3
	Middle	15,4 ± 0,1	181,4	32.3 ± 2,7	178,1	3,3
	Bottom	16,7 ± 0,1	197,5	29,4 ± 3,5	193,2	4,3
C	Top	14,6 ± 0,0	172,0	34,3 ± 3,5	168,0	4,0
	Middle	15,9 ± 0,0	188,1	31,4 ± 4,4	183,1	5,0
	Bottom	17,5 ± 0,1	206,6	27,4 ± 2,7	203,3	3,3

TABLE 2 Continued

Cane Type	Segment	Brixmeter		Spectrofotometer		Concentration difference (gram/liter)
		% Brix	Concentration (g/l)	Vo (mV)	Concentration (g/l)	
D	Top	13,8 ± 0,1	163,2	36,3 ± 2,7	157,9	5,2
	Middle	15,6 ± 0,1	183,8	32,3 ± 2,7	178,1	5,7
	Bottom	17,5 ± 0,1	207,6	27,4 ± 2,7	203,3	4,3

According to Hebrianto (2014), the bottom segments of sugarcane stem has higher sugar content comparing to the upper segments. It because the process of formation of the yield of sugar in sugar cane running from ripeness level depends on the age of segment. Bottom Segments (older) provide more sugar content than the segment on top of it (the younger), and so forth until the top end of the shaft.

T-test of digital spectrometer and LED-BPW11 system for every segment and every type of cane

The concentration of liquid sugar obtained from measurements using a digital spectrophotometer and sensor LED-photodiode pairs were tested statistically using t-test. The test is performed to determine whether the measurement using the sensor LED- photodiode pair equal to measurements using a digital spectrophotometer. The t-test results on those two independent data sets are shown in table 5.

Based on t-test results in Table 5, the t value is 0.6 and then the t value is compared to the value of standard t -able. The standard value of t-table for the 95% confidence level and degrees of freedom 22 is 2.1. Because t test value is less than t table then the measurement results using the sensor LED-photodiode pair is not significantly different compare to the measurement values using a digital spectrophotometer (Brixmeter). So, the measurement of sugar content in sugarcane using the sensor LED-photodiode pair can be used as an alternative measurement.

TABLE 3. T-test results of the measurement using Brixmeter and LED spectrophotometer

Parameter	Using digital spectrophotometer l	Using LED- photodiode sensor
Average	184,5	180,2
Standart deviation (S)	18,4	18,3
Variance (S^2)	337,7	335,1
Quantity data	12	12
Standart deviation combined(s)	18,3	
t test	0,6	
Degrees of freedom	22	
t tabel	2,1	

CONCLUSION

This research has successfully designed the sugar content measurement system of sugarcane based on the LED-photodiode pair to be a spectrophotometer. The assessment results show that there are different measurement values resulted from the designed system in the nominal of 4.3 g/l compared to the Brixmeter which was considered as a standard sugar content measurement device. The statistical analysis show that this different values are not significantly different and therefore this designed LED spectrophotometer can be applied as alternative tool to determine the sugar content of sugarcane in the field. This finding is considered as the novelty of this reseach activity.

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