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Detection of Adulteration in Honey using Optical Sensor

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ABSTRACT: A fiber optic approach was developed to detect the sugar contents in the honey. This was achieved by measuring the output signal of both pure and adulterated honey samples. Green laser of 535nm is used as an optical source for measuring the output signal. The screening test was undertaken to measure the concentration of adulterants in the honey. Performance of the first screening test showed that voltage gradually increased with increase in concentration of adulterant. In second screening test fructose and glucose contents of honey is analysed. In third level screening, slope analysis is done for samples of pure honey and adulterated honey. Rapid increase of output voltage is obtained in non-adulterated honey, whereas gradual increase in output voltage is observed in adulterated honey.

KEYWORDS: Honey, Adulteration, Refractive index, Fiber optic cable.

I.INTRODUCTION

Honey is a sweet and viscous food which is produced by honey bees from sugary secretion of plants (floral nectar). It has millions of medicinal effects for young and old people. The constituents of honey include fructose, glucose of specific quantity. Honey is known to have antioxidant, antimicrobial and soothing effects. It is used as traditional ayurvedic medicine. Due to its high demand and high expense, honey is adulterated with additional substances. The artificial sweeteners such as molasses, beet sugar, cane sugar, corn syrup and inverted sugar are used as adulterants [1],[8]. Sugar syrup is mainly used as adulterant because it is easily available and cost effective . Adulteration in honey can be classified into two types namely C3, C4 based on their origin. Plants that are sources of substances used for honey adulteration can be classified as C3 and C4 plants, based on their carbon metabolism. Most of honey-contributing plants like rice, wheat and beet are C3 plants whereas maize and sugar cane are C4 plants [9],[10]. Techniques of finding adulteration in honey includes Gas Chromatography and Liquid Chromatography analysis, Near Infrared Transflectance spectroscopy, FTIR spectroscopy, High-performance Anion Exchange Chromatography, High Pressure Liquid Chromatography and many other calorimetric methods [1],[2],[6],[7],[9],[10]. However these methods require expensive isotopes, highly skilled operators with sufficient knowledge to handle equipments and devices, expertise knowledge about chemical separation process and are time consuming process [1], [2].

Fiber optic approach is a simple, feasible technique of detecting adulteration in honey. The advantages of this process are it is chemical free approach, cost effective, and it is not a time consuming procedure. Moreover it requires only small quantity of sample for testing [1]. In this process Green laser is used as an optical source to measure output voltage from various samples taken. Refractometer is used to measure the refractive index of different honey samples. Sugar component of different samples were calculated and slope of each honey sample and some other sweeteners were taken to validate pure and adulterated honey. The refractive index of pure honey ranges from 1.494 to 1.51.

II.EXPERIMENTAL SETUP

Green laser is used as light source because the wavelength of honey lies around the transmission range of 535nm. Plastic optic fiber is used for transmission and reception of optical signal. The core Plastic optic fiber (POF) is made up

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of polystyrene and PMMA (polymethyl-methacrylate). The fiber cladding is made up of silicon resin and has the refractive index of 1.46. It has high mechanical flexibility. Quartz cuvette of path length 10 mm and of high transmission quality is used for the complete transmission of passed light to the sample. The glass cuvette or other holder will absorb some light and then it is transmitted to the sample. Phototransistor is used to sense the variation of optical signal from the receiving fiber. It converts the light signal obtained at the output is converted into the electrical signal. Readings were noted for different samples at different concentration of sugar solution adulterated honey. Digital brix refractometer is used to measure refractive index of honey samples. Initially a reading was taken for calibration with distilled water and the refractive index of 1.33 is obtained which is equal to the standard refractive index value of distilled water. Then refractive index was measured for various honey samples with and without adulterants. A linear relationship is formed between the measured voltage and refractive index for honey samples. For any given honey samples, the refractive index can be calculated from the proposed set up and can be compared with refractive index range for pure honey. If the obtained refractive index falls inside this range, it is passed to the next level of screening.

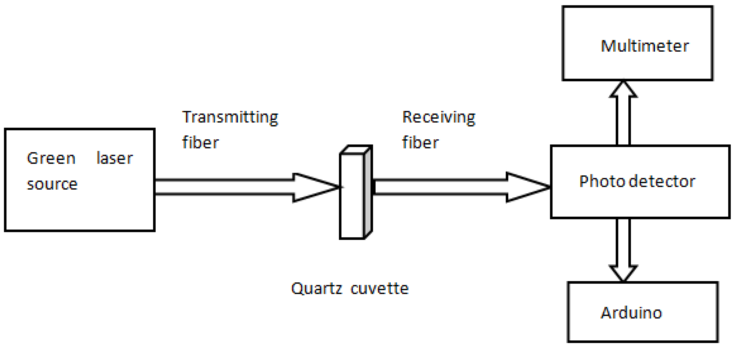

Fig.1 Experimental Setup

Five different samples of honey are taken as sample A, B, C, D, E and palm sugar is taken as sample F. The light from green laser source is transmitted into the fiber kept at the transmitting side. The light scatters, depending on the characteristics of honey, after entering into sample which is kept in quartz cuvette. The portion of light scattered is collected by receiving fiber and the light is detected by photo detector in the receiving side. The corresponding voltage from the output of photo detector is measured. Sugar syrup is prepared by adding equal amount of distilled water to sugar and it is added to honey samples in different proportion of 2, 4 and 6 drops in all samples and the same procedure is repeated for every increase of 2 drops and the output voltage for 2, 4 and 6 drops are noted.

The refractive index of different honey samples were measured using digital refractometer. The output voltages obtained from the honey samples are related to the refractive index.

III.RESULTS AND DISCUSSION

After the optical sensor was set up, the output voltage obtained from different honey samples is noted and the refractive indices of same samples obtained using refractometer were compared for calibration. Sample A was tested with pure sample and the voltage was measured. As adulterant was added to the pure sample, voltage and sucrose contents increase gradually and corresponding refractive indices decreases as summarized in Table. I. The increase in voltage is due to change in characteristics of honey with addition of adulterants. Addition of sucrose concentration lowers the angle of refraction leading to less refractive index values. Generally output voltage is directly proportional to addition of sugar concentration.

In second level of screening test the sucrose concentration of each honey sample is measured using the equation [1]:

$$C = 0.0184\, V + 61.26$$

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Where C is sugar content in each sample, V is voltage in millivolt. The sugar content of all samples is measured and are listed in Table. I to Table.V. The increase in sugar content than the original level results in more transmission of light into the sample.

TABLE.I
SAMPLE.A

Adulteration with sugar syrup	Voltage (mv)	Refractive Index	Sucrose Content
0 drops	6.4	1.4858	61.377
2 drops	7.5	1.4811	61.398
4 drops	8.2	1.4796	61.410
6 drops	14.8	1.4746	61.532

The graph Fig.2 is plotted against voltage and refractive index for sample A and the pattern is observed.

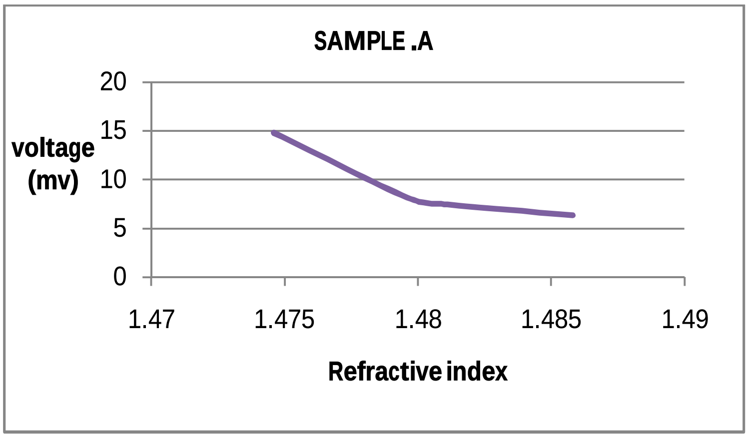

Fig.2 refractive index versus voltage for sample A

TABLE.II
SAMPLE.B

Adulteration With sugar syrup	Voltage (mv)	Refractive Index	Sucrose Content
0 drops	6.8	1.4817	61.385
2 drops	8.5	1.4794	61.416
4 drops	10.1	1.4751	61.445
6 drops	11.2	1.4706	61.466

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Sample B was found to have more concentration of adulterants since volatge level is high and refractive index is less compared to sample A. Voltges increases gradually as adulaterant is added and is given in Table.II and the corresponding values are plotted as shown in Fig.3 for sample B.

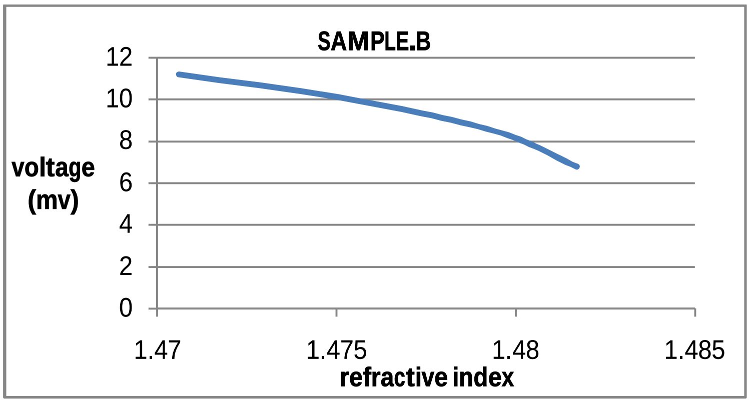

Fig .3 refractive index versus voltage for sample B

TABLE.III
SAMPLE.C

Adulteration With sugar syrup	Voltage (mv)	Refractive index	Sucrose Content
0 drops	9.3	1.4837	61.43112
2 drops	12.5	1.4781	61.49
4 drops	14.5	1.4743	61.5268
6 drops	16.1	1.4708	61.55624

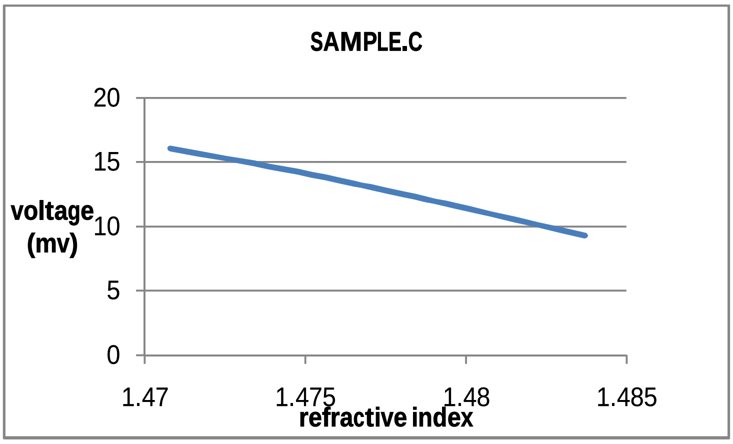

Fig .4 refractive index versus voltage for sample C

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Voltage value increases and refractive index decreases as adulterants are added with sample C and values are listed in Table.3 and is plotted as shown in Fig.4.

TABLE.IV
SAMPLE.D

Adulteration With sugar syrup	**Voltage (mv)**	**Refractive Index**	**Sucrose Content**
0 drops	7.3	1.4809	61.39432
2 drops	8.7	1.4778	61.42008
4 drops	9.0	1.4763	61.4256
6 drops	11.7	1.4748	61.47099

The volatge and refractive index was measured with sample and listed in Table 4
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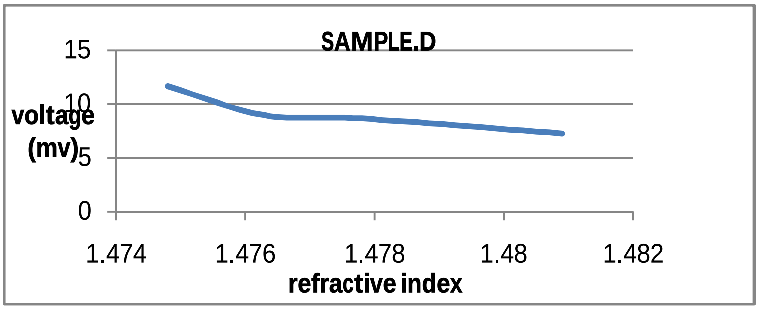

Fig.5 Refractive index versus voltage for sample D

TABLE.V
SAMPLE.E

Adulteration With sugar Syrup	**Voltage (mv)**	**Refractive index**	**Sucrose Content**
0 drops	5.3	1.4944	61.35722
2 drops	11.7	1.4809	61.47528
4 drops	31.3	1.4728	61.83592
6 drops	37.2	1.4723	61.94448

Sample E was found to have less voltage compared to other samples and the corresponding refractive index is also 1.4944 which is in the refractive index range of pure honey as shown in Fig.5. The plot of sample E increases drastically.

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The refractive index of honey varies from tropical area and floral origin. The refractive index of pure honey ranges from 1.490 to 1.51.On comparing with all other honey samples sample E is highly pure which is validated by both voltage and refractive index.

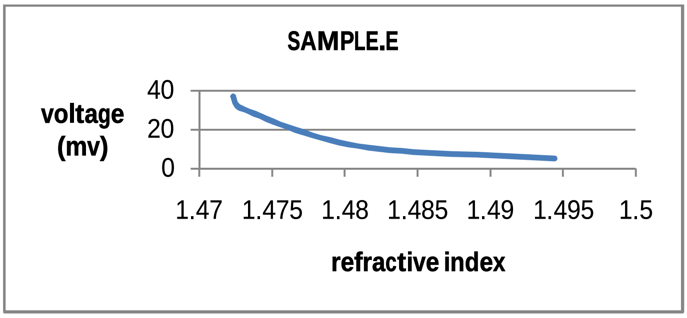

Fig.6 Refractive index versus voltage for sample E

The graph is plotted for all honey samples and the equation relating refractive index and voltage is obtained from Fig.7

$$n = -1024.86\ V + 1527.887$$

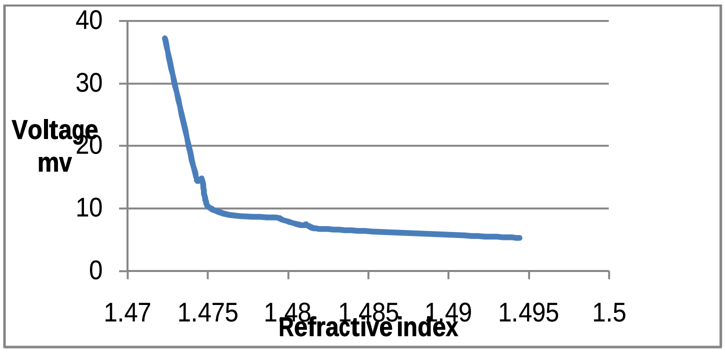

Fig.7 Refractive index versus voltage

Where n is refractive index and V is voltage in millivolt. From the above equation the refractive index value can be calculated by measuring the output voltage from the sample.

In third level of screening test, the palm sugar sample is taken as sample.F. The sample F is tested and the output voltage is measured using the proposed setup. Here the adulterant is added with higher concentration and slope of palm sugar sample is analysed.

Rapid increase of output voltage is observed in non –adulterated sample of palm sugar whereas in adulterated sample, the output voltage increased gradually as shown in Fig.8. The blue line corresponds to pure sample and the red line corresponds to adulterated sample.

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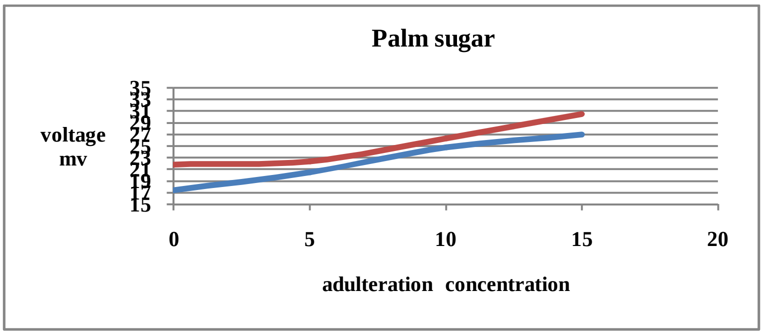

Fig.8 palm sugar and adulterated palm sugar

The pure sample of palm sugar increased rapidly for increase in concentration of adulteration and the adulterated sample of palm sugar increased gradually with increase in addulteration concentration as shown in Fig .8.

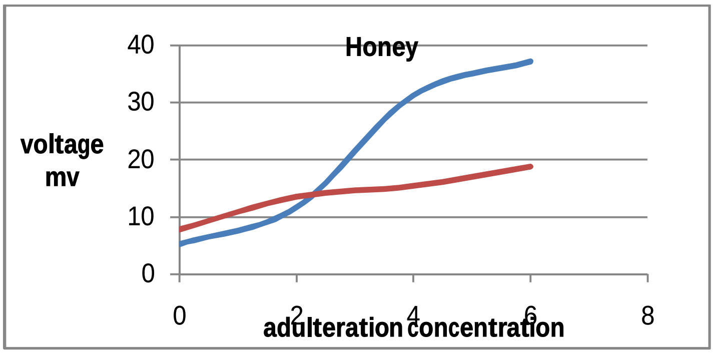

Fig.9 Pure honey and adulterated honey.

Similar pattern is observed in samples of pure and adulterated honey. The ouput voltage of pure honey increased rapidly.whereas in adulterated honey the voltage increase is gradual as shown in Fig.9.

IV.CONCLUSION

From the various results obtained it was found that higher the adulterant added to pure honey, it results in rapid increase of output voltage and decrease in refractive index. Thus the proposed method can be used to differentiate and discriminate the pure honey and adulterated honey sample by three levels of screening tests. The developed setup can be used to measure the refractive index by relating it with output voltage. Handheld device can be developed using this procedure to find the quality of honey.

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