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A Method to Distinguish Between Different Fruits by Measuring the Magnitude of the Transmission Coefficient

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ABSTRACT: *This paper proposes measurements to distinguish between different fruit and vegetables types, different sorts of the same fruit or vegetables, and to determine the level of maturity of the same fruit .The measurements are based on measuring the magnitude of the transmission coefficient using optical communication system with three different optical sources. The measured data is provided in decibel (dB).*

Keywords : *Transmission coefficient , quality of fruit, optical detection.*

I. INTRODUCTION

The interest in quality of fruits and vegetables has got attention many authorities and institutions. The most popular method and technology used to measure and test the quality of the fruits and vegetables uses the near infrared spectroscopy [1] and [2].The used wavelength of the spectrum is about 700-2500 nm. What makes this wavelength range is most useful range for this application, is that the structure of molecules can resonate due to wavelength in this range .In other words the structure of molecules can absorb the energy of the incident wave. The resonant wavelength of these molecules depends on the compounds and the bond-length [3]. This method is mainly based on measuring the reflected power from the specified sample and ignoring the power passing through the sample. In this paper we propose a method to distinguish between different fruit and vegetables types, different sorts of the same fruit or vegetables, and to determine the level of maturity of the same fruit using the magnitude of the transmission coefficient.

II. MEASUREMENT SETUP

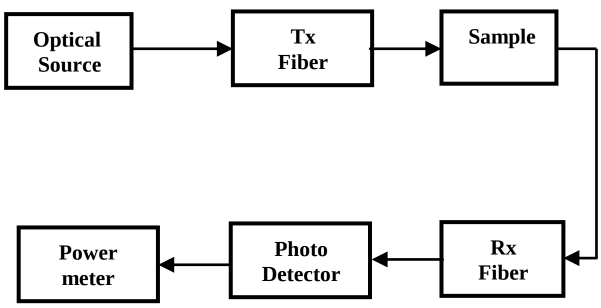

Figure 1 Block diagram of the measurement setup.

The setup consists of three optical sources with different wavelengths. The wavelengths of the sources are 650 nm, 665 nm, and 950 nm. The power emitted from the optical sources is coupled into an optical fiber (Tx fiber) from one end. At the other end of the fiber sample is placed perpendicularly to the fiber axis. The optical power penetrate in the sample and then coupled into another fiber (Rx fiber), that is connected from the other end a photo detector. The power is then measured by a powermeter. The 0dB level is taken by placing an empty glass slide at the fiber to fiber interface. The block diagram of our setup of is shown in Fig. 1.

III. THEORETICAL BACKGROUND

According the electromagnetic theory [4], if a wave travelling in a medium with intrinsic impedance η_1 hits another medium with different intrinsic impedance η_2, part if this wave will penetrate in the second medium call transmitted wave, and another part will be reflected called reflected wave. However, some the power of the incident wave will be lost according the conductivity σ of the media. The intrinsic impedance is defined as $\eta = |\eta| e^{j\theta_\eta}$ where

$$|\eta| = \frac{\sqrt{\frac{\mu}{\varepsilon}}}{\left(1+\left(\frac{\sigma}{\omega\varepsilon}\right)^2\right)^{\frac{1}{4}}} \tag{1}$$

$$\tan(2\theta_\eta) = \frac{\sigma}{\omega\varepsilon} \tag{2}$$

Where μ the permeability of the medium is, ε is the permittivity of the medium, and ω is the angular frequency of the wave. Since the we are interested in measuring dried fruits with very low conductivity, and the frequency of the used incident wave is every high the term $\left(\frac{\sigma}{\omega\varepsilon}\right) \approx 0$, then $\eta \approx \sqrt{\frac{\mu}{\varepsilon}}$. Here $\eta = |\eta|$.

The wave penetrating in the sample is defined by the electric field as

$$E_t = \tau E_i \tag{3}$$

Where E_t is the electric field of the penetrating wave, E_i is the electric field intensity of the incident wave, and τ is the transmission coefficient. The transmission coefficient is given for normal incidence as

$$\tau = \frac{2\eta_2}{\eta_2 - \eta_1} \tag{4}$$

Where $\eta_1 = \eta_o = 120\pi$, where η_o is the intrinsic impedance of the free space.

IV. MEASUREMENT

To do the measurement, samples of same thickness for different fruits were prepared on glass slides by using special laboratory tools. In order to make sure that there are no water molecules in the samples, these samples were dried using special drying process. Next, the system has been calibrated by setting an empty glass slide between the fiber ends. The measurement has have been carried out as the following :

A. **To Distinguish Different Fruit Types:**

In this part we examine tomato, guava, lemon, cucumber, onion, potato and carrot. The measured values are shown in Table I. The first column provides the fruits name, the second column shows the magnitude of the transmission coefficient (τ) by applying optical wave with wavelength of 650 nanometers (nm), the third column shows the magnitude of the transmission coefficient(τ) by applying wave of wavelength 665 nm, and the last one for wavelength of 950nm. As declared in Table I, the transmitted power in the direction of the receiver decreases by increasing the wave length of the optical source for the same sample. Also, it is worth noting that the values of transmitted power through the samples have varied from fruit to other. The largest power is transmitted through guava which is about -1dB, while the lowest power is -4 dB throughout potato.

The type of fruit	λ =650nm τ	λ =665nm τ	λ =950nm τ
Tomato	-2.3	-7.7	-7.9
Guava	-1	-3.3	-5.6
Lemon	-2.8	-6.8	-8.2
Cucumber	-1.1	-4	-6.5
Onion	-0.6	-2.9	-6.3
potatoes	-4	-6.9	-7.9
Carrot	-2.4	-7.9	-8.5

Table 1: Different Fruits with magnitude of transmission coefficients

B. **Different Class of Same Fruit Type**

Three different classes of tomato known in Palestine are examined using the same setup and process. Fig. 2 shows a photograph for the three different classes. The measured transmission coefficients for the three classes are tabulated in Table II. The second, third, and fourth columns show the magnitude of transmission coefficients for wavelength of 650, 665, and 950 nanometers, respectively. It can be noticed from the table that the is big difference in the value transmission coefficient for each class of the measured tomato, this gives an indication that each class of the tomato consist of compounds different than the other.

(a) (b) (c)

Figure 2. Photograph of three different tomato classed, (a) class I, (b) classII, and (c) classIII.

The class	λ =650nm τ	λ =665nm τ	λ =950nm τ
ClassI	-3.1	-5.6	-5.8
ClassII	-1.4	-3.5	-5
ClassIII	-0.9	-3.1	-4

Table 2: Different Fruits with magnitude of transmission coefficients

C. **To distinguish between different stages of maturity**

Determining the stage of maturity is also included. Three samples of same tomato but has different degree of maturity have been prepared, and tested. Figure 3 shows three tomato pieces of same class but differs in level of maturity .The measurements are carried out using two different wavelengths. The measured values are tabulated in table III. As shown in the table, the transmitted power through the sample is larger for mature tomato (see part c in figure 2), while it is much less for immature tomato (see part a in figure 3). Same measurements have been done for guava; samples have been prepared, tested for guava with three different stages of maturity. The measured magnitudes of the transmission coefficient are given in table IV. Unlike tomato, for guava the transmitted power through the sample in the case of mid mature is the highest, while the lowest is when the guava is immature.

(a) (b) (c)
Figure 3. Photograph for three tomato pices of the same class but different maturity stage, (a) immature, (b) mature, and (c) classIII.

The stage of maturity	At λ =650nm τ	At λ =665nm τ
Stage1	-6.5	-9.2
Stage2	-3.1	-5.6
Stage3	-3.6	-9

Table 3: stages of maturity of tomato with magnitude of transmission coefficients

The stage of maturity	λ =650nm τ	λ =665nm τ
Stage1	-6.4	-7.7
Stage2	-2	-3.8
Stage3	-4.1	-6.9

Table 4: stages of maturity of guava with magnitude of transmission coefficients

V. CONCLUSON

This paper has proposed a method to distinguish between different fruits by measuring the magnitude of the transmission coefficient. The method has been extended to distinguish between different classes of the same fruit, different level of maturity.

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