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# Absorbance and Transmittance Capability of Mangoes, Grape and Orange in NIR Region

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**Abstract.** This paper focuses on the usage of absorption and transmission properties in the near infra red (NIR) spectrum for quality monitoring of fruits particularly mangoes, grapes and oranges. These three fruits are classified into climacteric and non-climacteric, and analyzed in terms of its absorbance and transmittance capabilities. Experimental works are mainly performed in the study with some preliminary results in fruit ripeness detection. In comparison, climacteric fruits are less tendencies to absorb or transmit light. The non-climacteric fruits display more absorptive power and higher transmission ability. Grape populated as the best in this work due to its thinner and partially transparent skin. Absorbance in grapes starts as early as at 365 nm. Grapes also shows a slight increase in its spectra due to volume of the seeds. However, it does not observed in oranges because the seeds volume is smaller than the total volume of orange. Unriped mangoes give the smallest transmittivity.

## 1 Introduction

Generally, the NIR (near infrared) works because of specific organic molecules absorbing certain wavelengths of NIR light energies. The absorptions are directly correlated with the concentration of the organic molecules. This relationship must be scaled by a primary technique, otherwise known as the wet chemistry laboratory. Therefore, the NIR is dependent upon the wet chemistry methods to attain the linear relationship between the molecular absorptions and the actual constituent concentrations [1]. One advantage is that NIR can typically penetrate much farther into a sample than mid-infrared radiation. Near-infrared spectroscopy is, therefore, not a particularly sensitive technique, but it can be very useful in probing bulk material with little or no sample preparation [2].

The molecular overtone and combination bands seen in the NIR are normally very broad, leading to complex spectra and can be difficult to assign specific features to specific chemical components. Multiple variables calibration techniques are often employed to

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extract the desired chemical information. Careful development of a set of calibration samples and application of multivariate calibration techniques is essential for near-infrared analytical methods [3].

Two major classifications of fruit ripeness, climacteric and non-climacteric, have been utilized to distinguish fruits on the basis of respiration and ethylene biosynthesis rates. Climacteric fruit, such as tomato, mango, avocado, banana, peaches, plums, and apples, are distinguished from non-climacteric fruits, such as strawberry, grape, and orange, by their increased respiration and ethylene biosynthesis rates during ripening [4]. Ethylene is not required for non-climacteric fruits ripening. In contrast, ethylene is necessary for the coordination and completion of ripening in climacteric fruits through analysis of inhibitors of ethylene biosynthesis and perception, and also in transgenic plants blocked in ethylene biosynthesis. It is also important to note that, though not nearly as well characterized in this regard, plant hormones, in addition to ethylene, are likely to influence climacteric fruits ripening [5]. Firmness decay, chlorophyll breakdown and carotenoid accumulation, controlled by ethylene, are major ripening events in mangoes. Pigment content and tissue structure affect the optical properties of the mesocarp, which can be measured nondestructively in the intact fruit by reflectance spectroscopy [6]. The source of light for this spectroscopy can be originated from the NIR.

Ideally mango is harvested at the preclimacteric and mature-green stage. The ripening stage is achieved in the postharvest time or phase. On the other hand, harvested fruits in a ripe condition are better quality as compare to preharvested. However, it lacks of lifetime which is important for long journey deliveries. Thus, identifying maturity level is critical in the relevant industries. NIR spectroscopy is one of the optical method to predict maturity state of fruits by observing its spectra [7]. This work is dedicated to evaluate the ripeness or maturity stage of mango, grape and orange by means of the NIR spectroscopy by looking at their spectrum.

## 2 Methodology

Observing light spectra that passes through fruits is the fundamental technique in this work. A spectrophotometer which is LAMBDA 950 that can emit ultra violet (UV), visible light (Vis) and near infra-red (NIR) is employed to measure the amount of light that a sample allows. Principally, a beam of light will go through a sample and the measurement is performed by collecting the intensity of light reaching the detector inside the LAMBDA 950. A simple technique yet, provides essential outcomes. The light beam consists of a stream of photons impinges on fruits analyte and being absorb partially. The analyte is firstly prepared from the fruits juice and placed in a transparent container that fits into the measurement slot of the spectrophotometer. The number of photons will reduce proportionally and thus making the intensity of light beam reduced as well. As a result, a spectra is produced.

Practically, there are three major steps that involved in the measurement. First, a blank container is used to measure the intensity of light ($I_0$) that passes through it. This light intensity determines the number of photons passes through per second. The container is filled with water since the actual sample is a liquid form which is obtained from blending process. Again, measurement is repeated and kept for baseline calibration. The filled container scatters light in a regular pattern that later will be superposed with the spectra of the fruits.

Secondly, measurement for the intensity of light ($I$) that passes through the sample (fruits) solution is conducted. In practical, the instrument does not measure the intensity of

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light but the power itself. The power is the energy generated per second, which is the product of the intensity (photons) and the energy per photon. In summary, energy generated per second is equal to the number of photon per second. In the last step, two quantities which are transmittance (T) and absorbance (A) are recorded from the output spectra of the spectrophotometer. Theoretically, the following equations can predict the experimental observation.

$$T = I/I_o \tag{1}$$

$$A = -\,Log_{10}\,T \tag{2}$$

The fraction of light in the original beam that passes through the sample and reaches the detector is being defined as transmittance. What is remain from the light, 1- T, is considered as the fraction of light being absorbed by the sample. In a lot of applications, it is common to relate the amount of absorbed light with the concentration of the absorbing molecules. Absorption spectra is more useful rather than the transmittance. If no light is absorbed, the absorbance will become zero, which means it has 100% transmittance. Each unit in absorbance corresponds with an order of magnitude in the fraction of transmitted light. For instance, if A is equal to 1, 10% of the light is being transmitted (T = 0.10) and the remaining which is 90% are absorbed by the sample.

## 3 Result and discussion

Three tested fruits in this work are mango (Chok Anam), red grape (Russian Seedless), and orange (Valencia). These fruits have difference visual, shape, color and also their characteristics. The fruits are taken from the local groceries and the percentage of its maturity is not properly defined by the supplier. To determine its maturity stage, spectra from LAMBDA 950 is solely analyzed and verified. A white light source sweeps from 200 nm to 1000 nm is used in the study. The absorbance and transmittance patterns can be seen in Fig. 1.

Fig.1 shows the absorbance spectrum for riped mango (purple) and unriped (blue), grape (black), and orange (red). These spectrum depict a huge difference between the three measured fruits. This is because both orange and grape are non-climacteric fruits while mango is a climacteric type of fruits. The highest value of absorbance goes to orange with the value of 4.13. The value is taken from the time it started to decrease and become constant which is in this case at 367 nm. The reference point is fixed at the starting point of 10. In grapes, the absorbance started to occur at 365 nm with the value of 3.54. The lowest value can be seen while doing the absorbance test for both mangoes. Aimed at unripe mango, the value of absorbance is around 0.04 while for ripe mango is 0.18 at 870 nm.

It can be summarized that orange starts to increase steadily from 500 nm and after it reaches about 850 nm, it starts to decrease and eventually becomes constant. In unripe fruit, the transmittance is about 0.06 percent. It means that most of the energy from the visible light source is being absorbed by the fruit as shown in Fig. 2. The highest value of absorbance is 3 at 850 nm. The unripe fruit has the least amount of sugar and water content, and less firmness compared to others making it to have more energy loss during transmittance. Orange tends to absorb more than grape because it has more free atoms and lower seeds volume, thus no bump is recorded. There is a slight increment for grapes in the range of 500-550 nm because the grape has seeds in it, thus making it to increase per short duration. Additionally, orange has more sugar and water contents.

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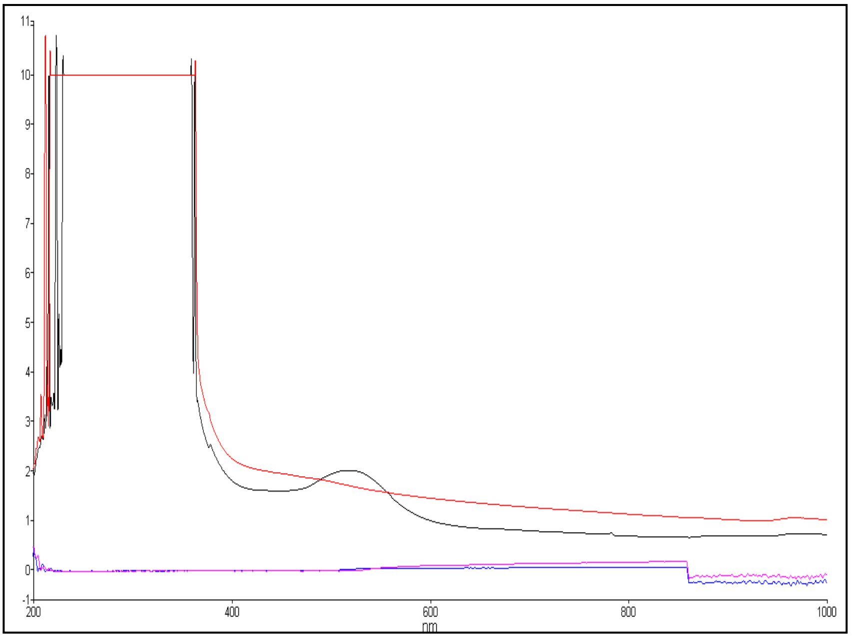


**Fig. 1.** Absorbance spectrum for grape (black) , mango (purple and blue), and orange (red).

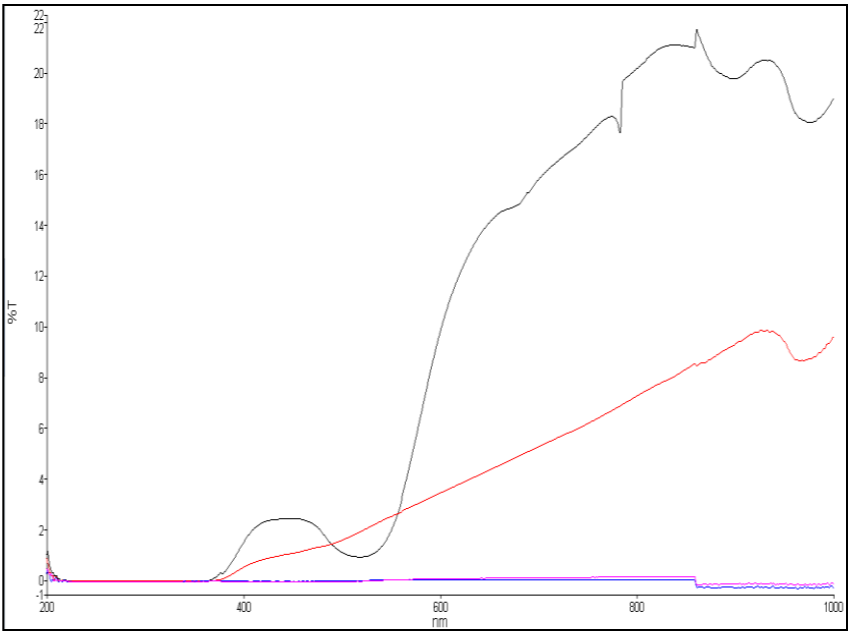


**Fig. 2.** Transmittance spectrum for grape (black), mango (purple and blue) and orange (red).

The transmittance spectrum sees grape as the highest with 22 percent leads orange by almost 15 percent. This is expected because the outer layer of the fruit itself can also give significant effect to the transmittance. Orange is a lot thicker skin than grape and mangoes. Environmental factor could also be one of the reasons why the value is different even though they are in the same type of non-climacteric fruits. Grapes are usually grown in high

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ground places, cold weather, and covered with vinyl while oranges are mostly grown in low ground and the tree is bigger and takes more time to grow. Table 1 summarizes and compares the findings in this work. Grape can be concluded as the good absorbance and transmittance fruit.

**Table 1.** A summary of findings.

| | CONDITION | | | |
|---|---|---|---|---|
| | **Mango Unripe** | **Mango Ripe** | **Grape** | **Orange** |
| **Absorbance** | 0.04 | 0.18 | 3.54 | 4.13 |
| **Transmittance** | 0.0005 | 0.002 | 0.22 | 0.07 |
| **Transmittance Percentage (%)** | 0.05 | 0.2 | 22 | 7 |

## 4 Conclusion

This preliminary study concludes a major gap between climacteric and non-climacteric fruits in terms of absorptivity and transmittivity. Climacteric fruits are inclined to have a small value of absorbance and transmittance as compared to non-climacteric fruits because of ethylene contents. Near infra red (NIR) is suitable as a light source in investigating tropical fruits.

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