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Non-invasive assessment of mango ripening using fluorescence spectroscopy

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ABSTRACT

This paper presents noninvasive assessment of mango ripening using fluorescence spectroscopy. Fluorescence spectra have been recorded from the peel of Dusehri mango using Light-Emitting Diode at 460 nm as an excitation source. Results suggest that carotenoids pigments fluorescence depicts similar results as chlorophyll pigments for fruit maturity assessment. The argument is further strengthened by recording the fluorescence spectra of mango pulp using the same experimental setup. It has also been demonstrated that for the Langra mango, where the peel remains green even after fully ripening, the fluorescence peaks at 680 nm give false negative results. Our studies suggested that the carotenoids fluorescence emission at 540 nm, which exists in each case, may be useful for assessing the ripening stages of mangoes.

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1. Introduction

Mango is a tropical and subtropical climate fruit being cultivated in more than 100 countries worldwide mainly in Asia, Africa, and America. Mango is famous for its unique taste, attractive colors, affordability, and high nutrition value. Now a day's mango is the best fruit in world market [1]. It is the second leading fruit after citrus in Pakistan. Pakistan is the 4th largest mango producing country in the world [2]. There are more than 300 varieties of mangoes in Pakistan and the most famous are named in local language as Dusheri, Langra, Chaunsa, Sindhri, Anwar Retool, SwarnRekha, Siroli, Zafran, Malda and Fajri [3].

Usually, mangoes are harvested at an un-ripped (hard green) stage. It is the stage where fruit quality meets or exceeds the minimum level acceptable to the consumer. These partially mature green mangoes are then ripe taking 8 to 10 days at 25 °C or through postharvest treatment. A fully mature ripe mango is best in taste than a premature ripeone [4,5]. Sorting of post harvested mangoes in the picking house is important to discriminate among prematured, partially-matured and fully-matured to improve ripening [6].

Now a day, different type various noninvasive techniques are in practice for assessing the ripening stages of fruits and vegetables and for the evaluation of the quality. Among these, near infrared (NIR) spectroscopy has been use for predicting maturity, quality, sorting and grading of fruits and vegetables [7–10]. However, water absorption in the NIR region limits its use. Acoustic response technique is good for predicting fruit maturity and firmness evaluation [11,12]. Magnetic Resonance Imaging (MRI) is expensive but at the same time more valuable in evaluating fruit ripening. It is also helpful in diagnosis of fruit diseases like bruise, worm damage, chilling and freezing [13,14].

In recent years, fluorescence spectroscopy proved itself as an emerging and primary research tool in the field of biochemistry, biophysics and biotechnology. It is becoming a dominant tool for assessing maturity/ripening stages as well as quality of different fruits and vegetables based on chlorophyll and other pigments like carotenes fluoresce when illuminated [15–17]. Fluorescence spectroscopy is more sensitive technique. It provides cellular or even sub-cellular information when light is shine on a biological sample. This article presents assessment of mango fruit ripening based on the fluorescence spectra of carotenoids and chlorophyll.

2. Materials and methods

2.1. Sample collection

Unripe, partially ripe and fully ripe Dusehri mangoes were arranged from the local market. On the minimum 12 samples of each stage have used in this study. Fluorescence spectra have been recorded from the peel of all samples using the experimental setup shown in Fig. 1. Likewise, fluorescence spectra from partially and fully ripe Dusheri pulp have also been recorded. The experiment has also been repeated on fully ripe Langra mangoes acquired from the

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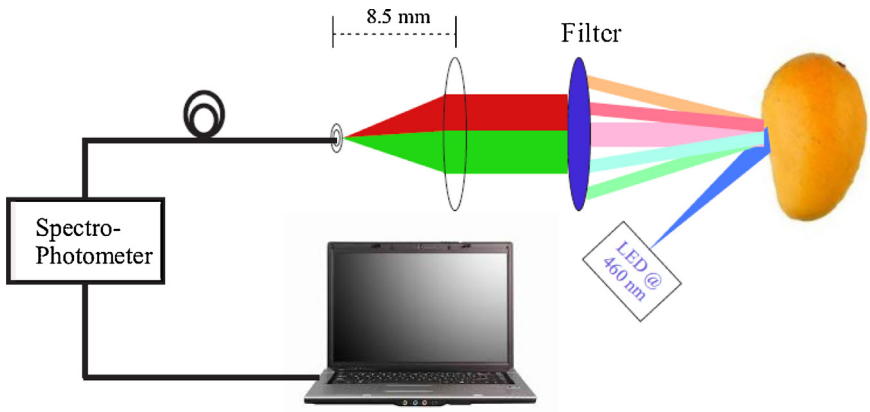

Fig. 1. Experimental setup used for peel and pulp of mango.

local market. Fluorescence spectra from their peel and pulp have been recorded for the purpose of comparison.

2.2. Experimental setup

Fig. 1 shows a schematic overview of the experimental setup. Light Emitting Diode at 460 nm has been used as an excitation source. A cut off filter at 480 nm has been introduced in front of the lens for filtering principle scattered light from reaching the detector. The fluorescence emitted from the samples has been coupled with fiber through focusing lens. The distal end of the fiber has been coupled with a portable miniature spectrometer (USB4000, Ocean Optics, Dunedin, Florida, USA). Fluorescence data from all the samples have been recorded using this experimental setup. The fluorescence spectra of entire samples have been processed and analyzed through self-written code in Mat-Lab.

3. Results and discussion

Figs. 2–4 show the fluorescence spectra of unripe, partially ripe and fully ripe mangoes. The spectral range of the detector has been set from 480 to 950 nm. For distinction three colors, green for unripe, yellowish for partially ripe and red for fully ripe mangoes have been used. The fluorescence spectra recorded from the peel as well as pulp of all samples show four major peaks at 540, 680, 705, and 740 nm as shown in Figs. 2–4.

Chlorophyll pigments absorb light in two bands 400–500 nm and 600–700 nm and emit at 680 nm and 740 nm. In this particular case, the absorption has been made at 460 nm. Fluorescence should have occurred at 680 nm as reported earlier [15,18,19]. However, it is not visible in Fig. 2(a) that shows the spectra of an unripe mango peel. It is understood that reabsorption has occurred at 680 nm due to high chlorophyll content. Re-emission of the absorbed 680 nm occurs at 705 nm [20,21].

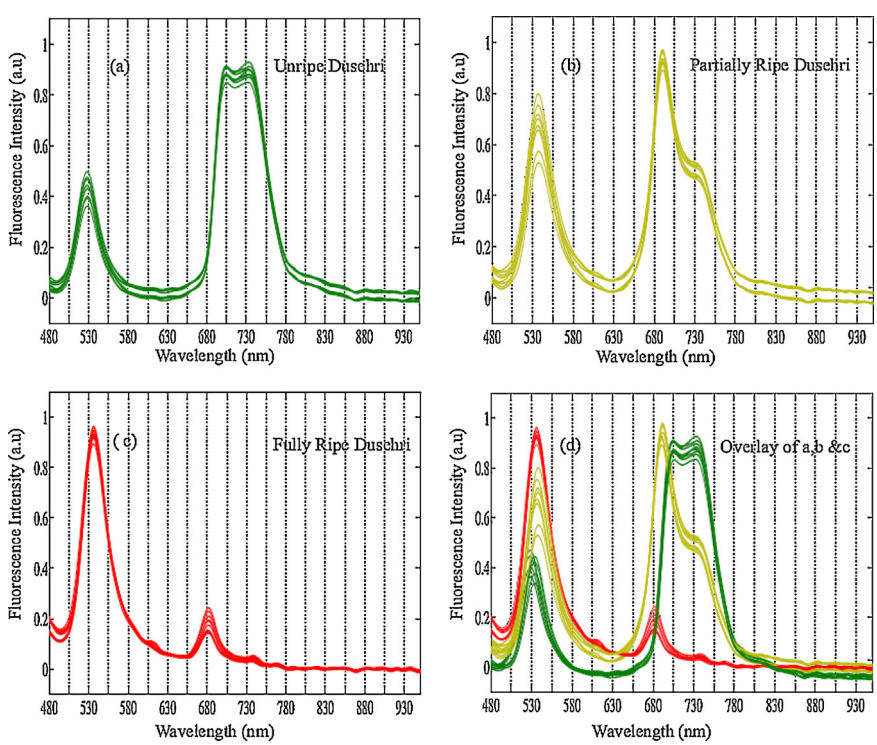

Fig. 2. Fluorescence spectra of un-ripped, partially and fully ripped Dusehri mango. These spectra were acquired from the peel of mango using LED at 460 nm as an excitation source.

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