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## Non-invasive, Real Time *in-situ* Techniques to Determine the Ripening Stage of Banana - Development of a Banana Ripening Index

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### Abstract

The objective of the work was to elaborate non-destructive, real-time, *in situ* opto-electronic techniques to determine the ripening stage of Cavendish banana. Four methods were used 1) chlorophyll degradation (DA-meter), 2) colour change (Minolta), 3) change in light reflectance (spectroscopy), and 4) peel gloss (Keyence CH72Z) and maybe develop a ripening index.

Cavendish bananas were examined starting from ripening stage R2 (green) to stage R7 (overripe), to identify suitable non-invasive, real time in-situ technologies to separate the ripening stages:

1. Chlorophyll degradation, measured by the DA meter, decreased from ca. 2.1 (R2) to 0.2 IAD units (R7), i.e. 10-fold decline.
2. Colour CIE-Lab a values dramatically increased as indication of chlorophyll breakdown and enable differentiation between all ripening stages R2 to R7. Colour angles declined from 98.7° hue (R2), 97.3° hue (R3), 92.7° hue (R4), 89.4° hue (R5); 87.5° hue (R6) until 82.0° hue (R7).
3. Spectroscopy showed two light reflectance troughs at 494 nm and 679 nm. A novel banana ripening index (BRI) was developed and is proposed to identify and distinguish the ripening stages of banana with values starting at 4 at R1 and peaking at 8.1 at ripening stage R7.
4. Peel gloss increased from stage R2 (150 a.u.) to stage R7 (220 a.u.) in the order of ca. 50 % followed by a subsequent decrease thereafter.

All the above results identified the fruit centre (rather than the tip) as a suitable candidate due to the most advanced ripening and least curved surface region of the fruit with easy access, when a carton is opened and the hands become accessible. This novel approach based on a comparison has shown the DA-meter, colorimeter and spectrometer as suitable candidates for the identification of each ripening stage. The combination of these three devices may be suitable for monitoring of banana ripening rooms in terms of temperature and humidity in addition to the present, colour-based ripening scale.

**Keywords:** Banana (*Musa sapientum*), chlorophyll degradation, colour, glossiness, non-invasive measurement, precision horticulture, ripening, spectral index, storage life

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