NIRS Technology for determining maturity in avocados

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Brett Wedding

JCU James Cook University

BT BRET•TECH PTY LTD AUTOMATION AND ENGINEERING

Queensland Government

Avocados - a consumers perspective

- Horticultural products struggle with delivering adequate consistent quality.
- **Retail & consumer surveys indicate**: consumers are not always satisfied with avocado quality mainly due to poor flesh quality = Aust. expect discard 1 in 4.
  – Consumers expect certain quality & if disappointed will not repeat purchase for up to 6 weeks.
  – Consumers are prevented from purchasing more frequently by variable fruit quality and difficulties in judging ripeness = poor unit price - repeat sales.
- **KEY FACTOR:** Remove inconsistencies & provide what the consumer expects.
- Main factors influencing consumer shopping behaviour:

- 95% Taste / flavours
- 94% freshness / ripeness
- 77% Visual appeal
- 75% Cleanliness (Bellon et al., 1992)

How to ensure product consistency?

- Maturity is a major component of avocado quality and a prime factor in palatability.
- Commercially maturity measured by %DM / oil analysis.
- Industry minimum standard for Hass 21% DM.
  - Consumer prefers at least 25% DM.

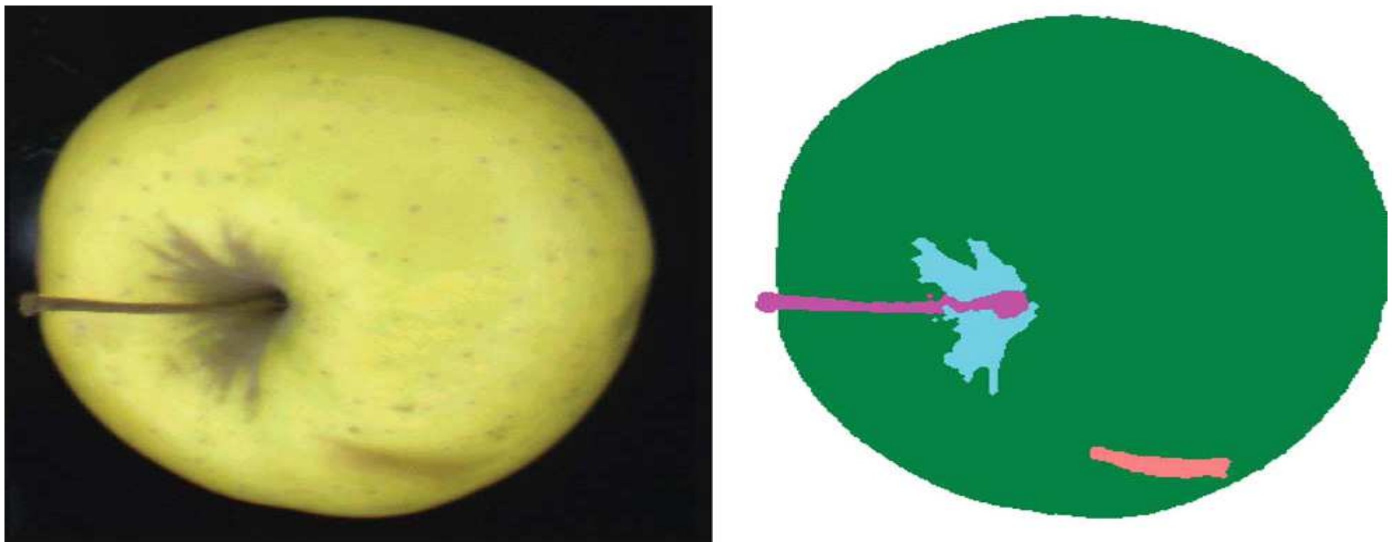
- **Need:** Provide a rapid and non-destructive system that can accurately and rapidly monitor internal quality attributes (i.e., %DM).

- **Outcome:** Would allow the avocado industry to provide a more consistent eating quality to the consumer, thus assist in improving industry competitiveness and profitability.

Non-invasive smart sensing technologies

Vision based methods

- Make up ~50% of non-destructive techniques used for food analysis.
- Majority based on RBG camera systems.
- Used for sizing, colour sorting, external defect grading.
- Some units are capable of measuring pigments in the visible range (380-770 nm).
- Some systems capable of full product imaging:

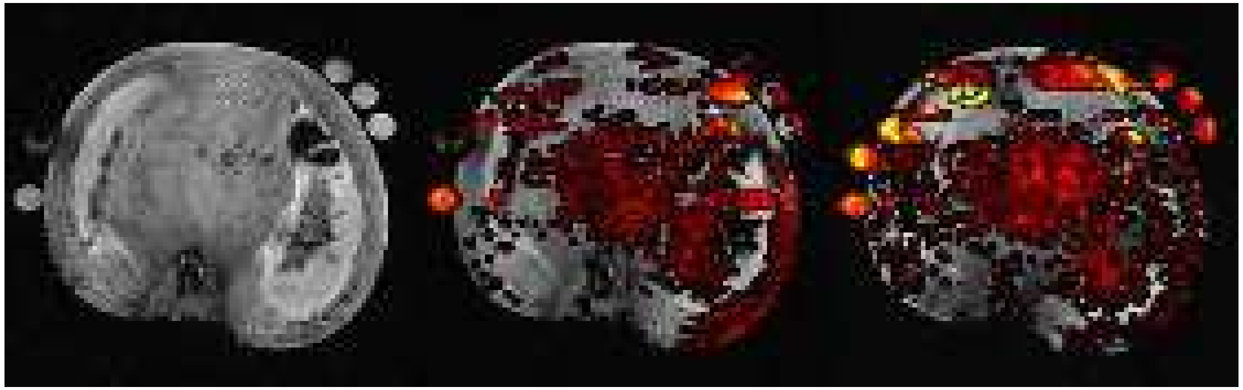


Blasco et al., 2003

Nuclear Magnetic Resonance & Magnetic Resonance Imaging

- Magnetic resonance methods are based on the magnetic properties of materials (e.g., protons: H, C, P).
- RF pulse excites the protons and a radio signal is emitted by the sample when it returns to equilibrium.

Sugar distribution in a tomato.
(Cheng et al., 2006)



Limitations:

- Equipment generally large and quite expensive.
- Method very time consuming (slow speed of measurement).
- Sample size & issues with image capture of moving samples.
- **Recent years** - low-cost MRI sensors used for horti products (2005).

X-ray & Gamma rays

- Both penetrate materials, the shorter the wavelength the greater the penetration strength.
- Method dependent on density of the tissue and not chemical composition.

Peach

- Fresh

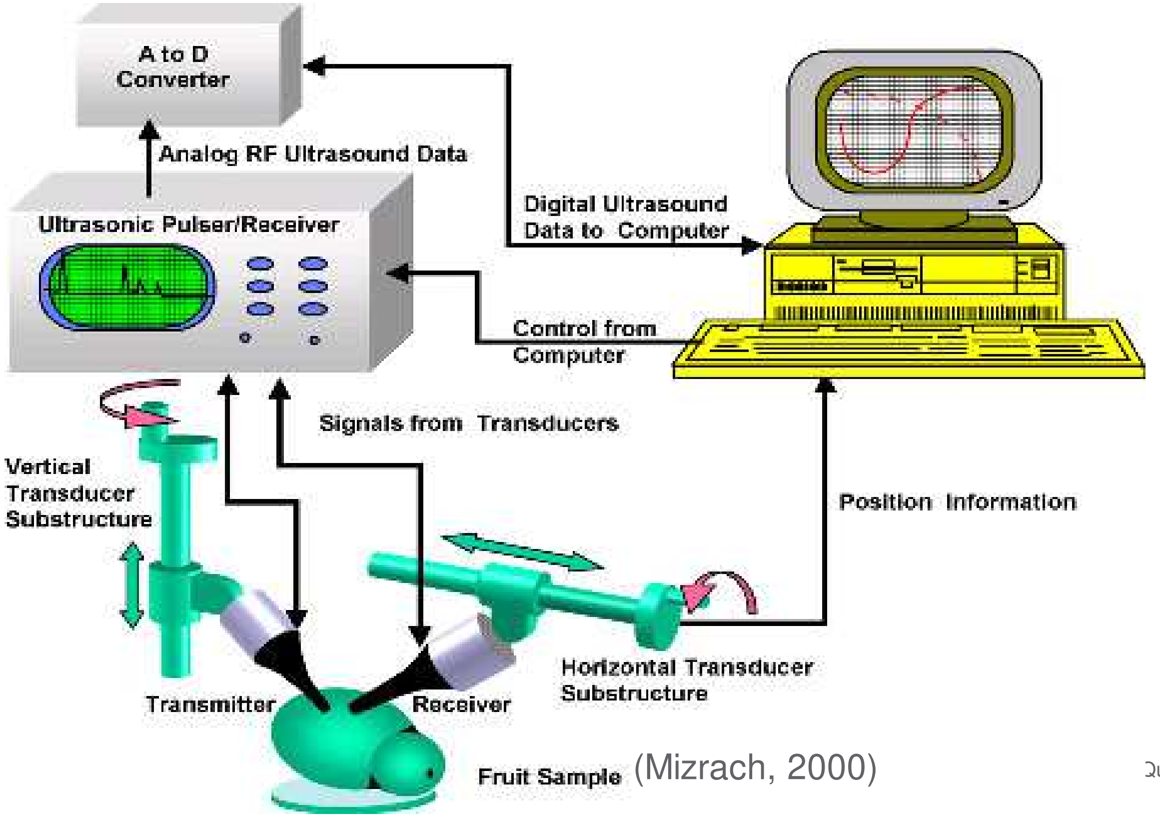
- Ripened 2 weeks

(Eufemio et al., 1999)

- R&D applications:
  - Bitter pit, water core & brown core, seed germination, black rot, hollow heart, bruises, black heart in potato, freeze damage in citrus.
- Limitations: High cost, WH&S issues.

Sonic and Ultrasonic vibration

- Waves applied to the fruit will pass through until the waves encounter an impedance change, indicating a change in density &/or velocity of the sound wave providing amplitude peaks.
- Great potential, slow to be implemented commercially due to the lack of appropriate equipment.



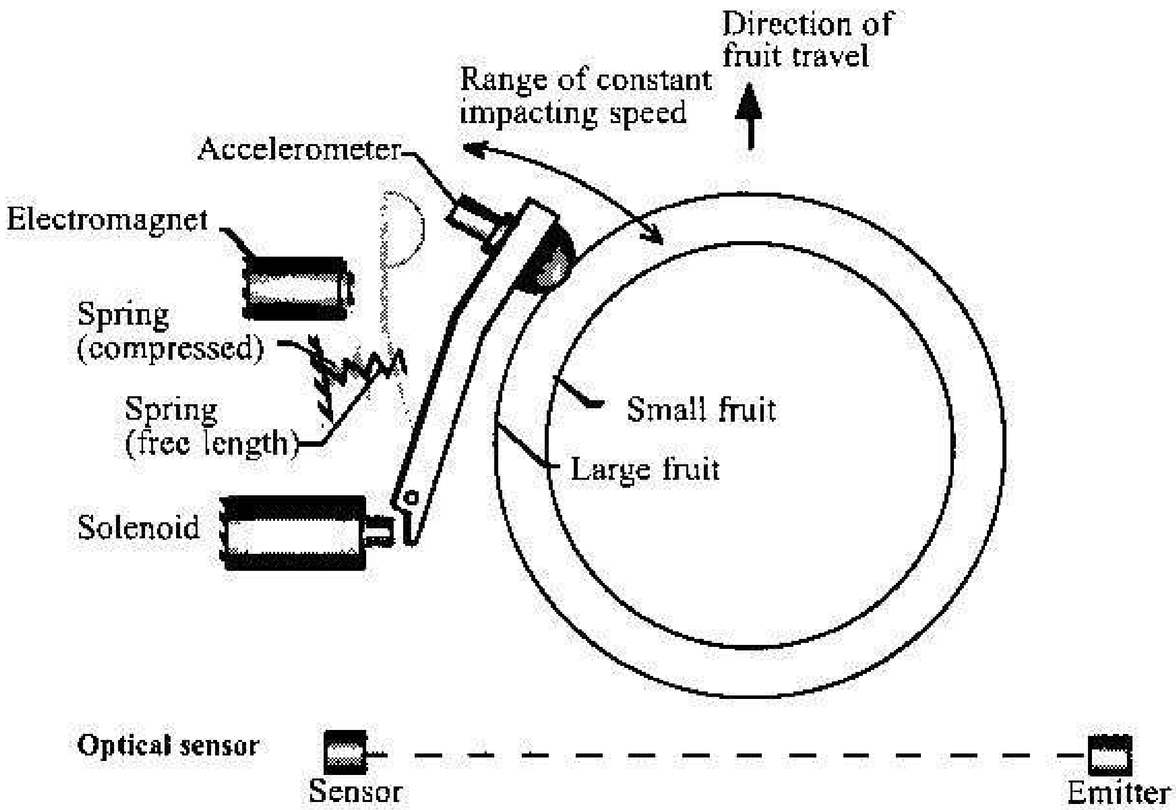
(Mizrach, 2000)

R&D applications to detect:

seeds / stones,
foreign materials
bruises, rots.

Mechanical technologies - Acoustic impulses

- Acoustic responses are related to elasticity, internal friction, shape, size and density.



(García-Ramos et al, 2000)

(Al-Haq and Sugiyama, 2004)

Limitations:

- Impact angle & location.
- Variations in fruit shape.

Mechanical technologies - Compression & Impact

- Force of deformation related to per unit pressure.

iFD - Greefa Ltd

~5-7 fruit per second

Sinclair International SIQ-FT

~10 fruit per second

Non-invasive smart sensing technologies

Electrical conductivity

- Is based on the property of a material to resist electrical current flow.

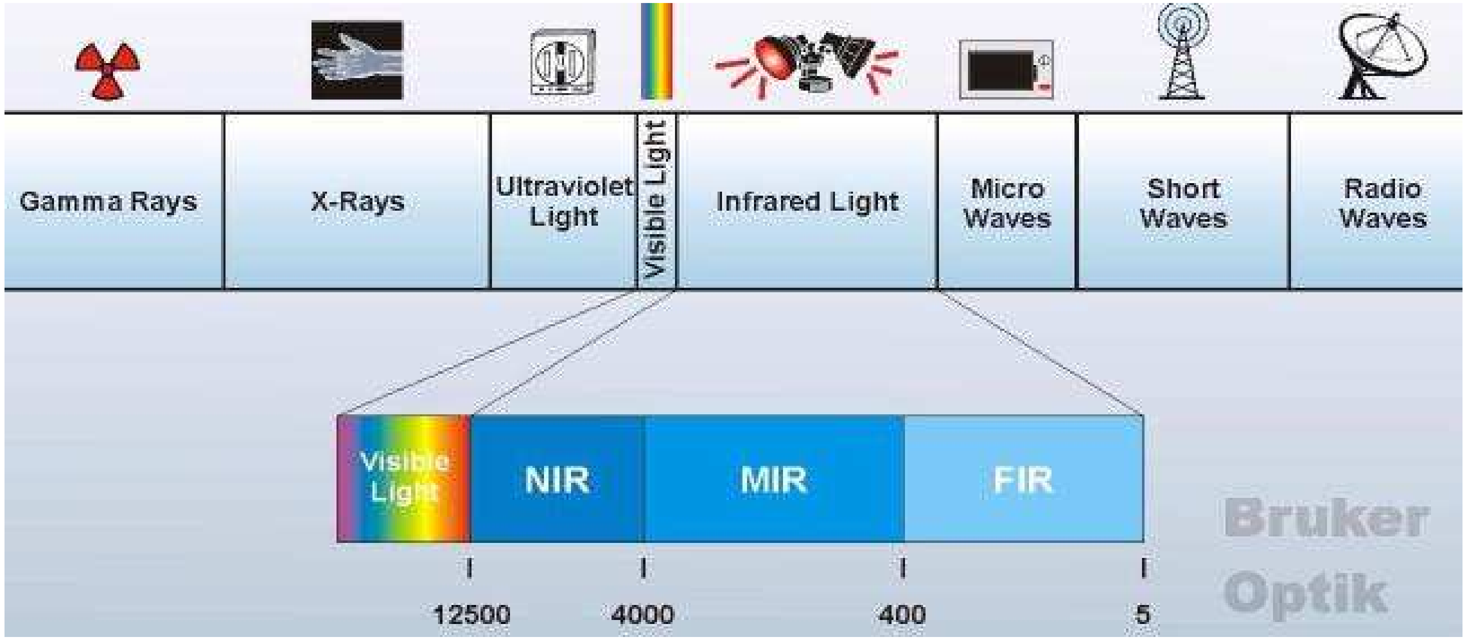
- Impedance in biological material depends on:
  - Concentration of ionic substances in the cells.
  - The capacitive effects of cell membranes and of droplets or discrete particles in the cells (i.e., oil droplets).

- Methods:
  - Majority required insertion of probes into the product.
  - More recently - non-invasive.

Near Infrared Spectroscopy

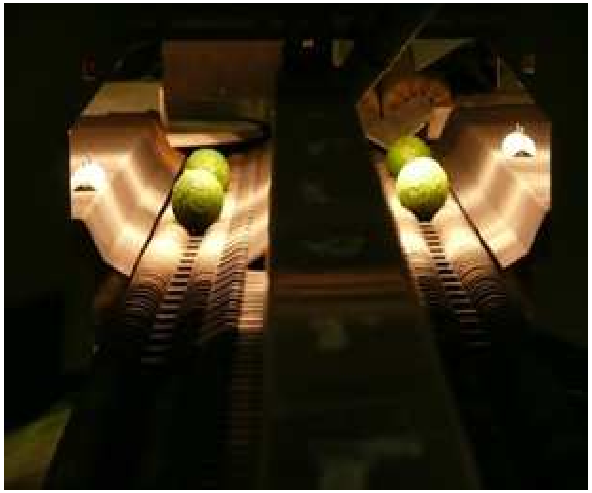
- Optical light (750 – 2500nm) to determine chemical composition.
- Used to assess grain since the 1960 (Norris).
- Late 1980's high moisture horticultural products.
- Secondary method of determination.
- Calibration models include seasonal & geographical variation.

Electromagnetic Spectrum



HyperVision™ System

10-15 items / second.

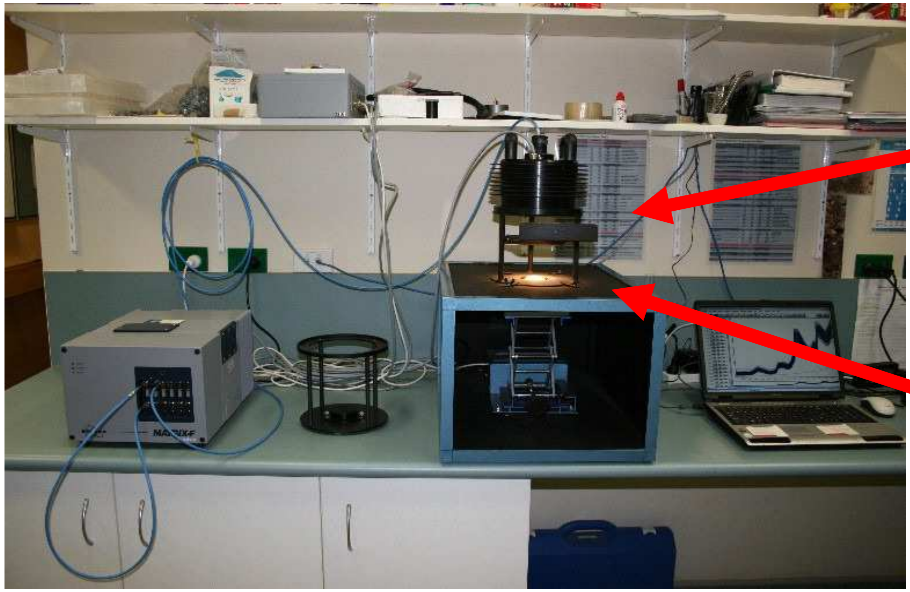


ARC Project – NIRS to predict avocado quality (%DM)

Calibration model development

- Fruit from 3 regions – Atherton Tablelands, Bundaberg, Toowoomba
- Collected over 2006, 2007, 2008, (2009) seasons.
- Biological variation of early, mid and late season harvests.

Lab set up: High resolution FT-NIR spectrometer



Light source & detector

Fruit

Preliminary results: % dry matter prediction

Research Instrument - FT-NIR instrument

- **Individual regional models** (3 years)
  - Regional models showed good correlation with %DM:

    Typically: Rv^2 >0.8 RMSEP = +/- 1.3 to 2 %DM

  - Large variation of biological variability between years.
  - Grain calibration models built over 5-7 years.
- **Generic model** (all regions combined over 3 years)

    Rv^2 = 0.8 RMSEP = +/- ~2 %DM

In-line assessment of avocado maturity (%DM)

- Conducted trials in-line on the commercially available HyperVision™ system: Hass and Shepard varieties.
- Currently capable of sorting for size, colour, external defects & has NIR capabilities.
- NIR prediction results: $Rv^2 = \sim 0.87$ RMSEP = +/- ~ 2 %DM

NIRS prediction of Rot susceptibility (Shelf life)

- Preliminary results indicate that it is possible to use NIRS to predict rot susceptibility of whole avocado fruit.

- Fruit scanned at hard green, stored at 20°C until eating ripe, cut & assessed.

- Separating into **2 categories** (% body and stem end rots):

  a) 0-30% rots b) 31-100% rots

  83% correctly classified.

- Further work required for method development & model development for use commercially.

NIRS bruise detection resulting from impact

- Avocado dropped & scanned at the sprung stage of softness (simulating dropping, poor handling etc).

- Fruit stored, cut & assessed at eating ripe based on bruise rank & % rot of impact area:

Bruise rank - **3 categories**:

a) 0-10% bruising b) 10-50% bruising c) 50-100% bruising

86% correct classified.

% Rot of impact area - **2 categories:**

a) 0-30% rots b) 31-100% rots

85% correctly classified.

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