NIRS Technology for determining maturity in avocados

4th Australian and New Zealand Avocado Growers Conference 21 - 24 July 2009, Cairns Convention Centre, Queensland, Australia.

Brett Wedding

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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:
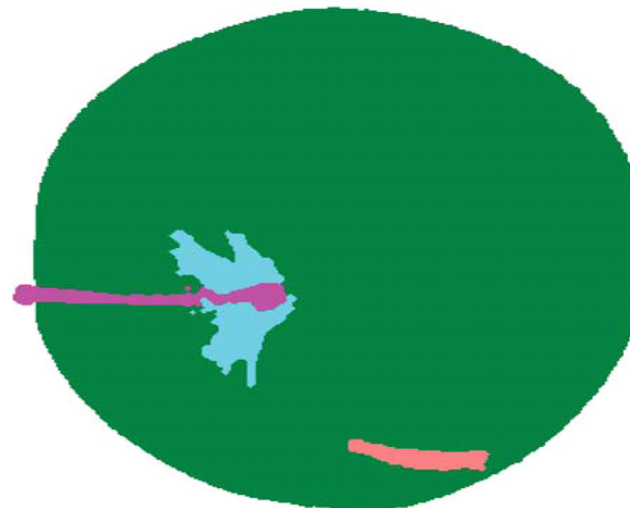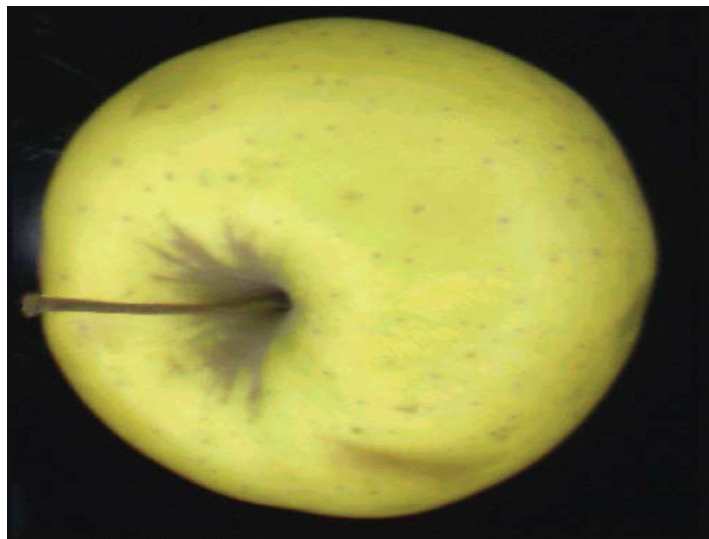
Blasco et al., 2003

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)
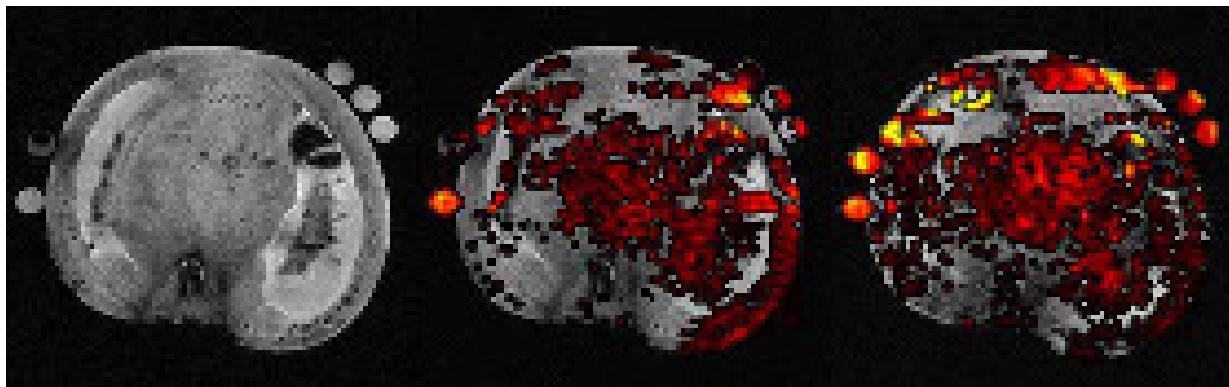
Limitations:

- Equipment generally large and quite expensive.

- Method very time consuming (slow speed of measurement).

- Sample size & issues with image capture of moving samples.

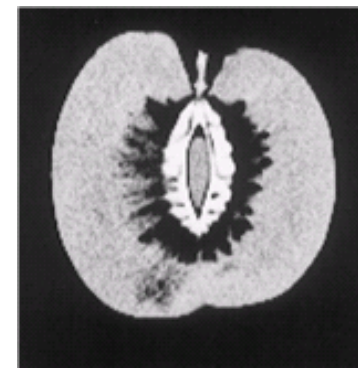- **Recent years** - low-cost MRI sensors used for horti products (2005).

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.
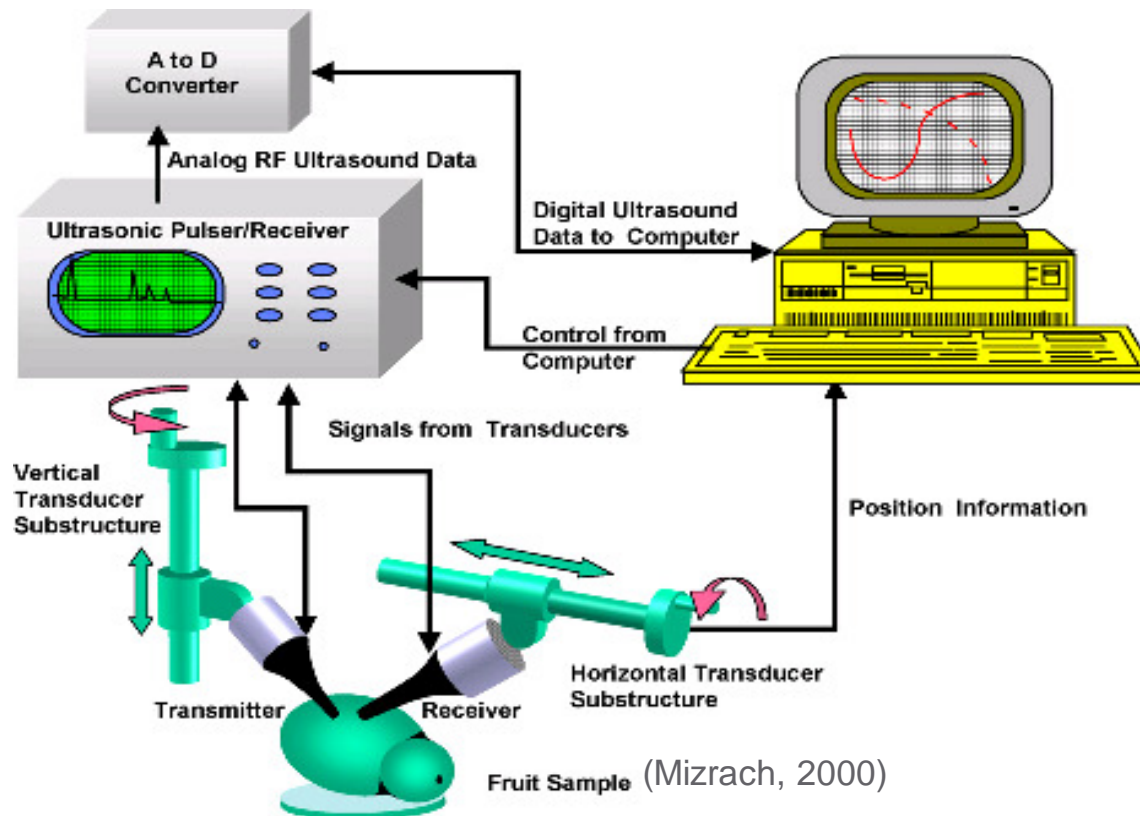
Peach

- 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.

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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.

A to D Converter

Analog RF Ultrasound Data

Ultrasonic Pulser/Receiver

Digital Ultrasound Data to Computer

Control from Computer

Signals from Transducers

Vertical Transducer Substructure

Position Information

Horizontal Transducer Substructure

Transmitter   Receiver

Fruit Sample (Mizrach, 2000)

R&D applications to detect:

seeds / stones,
foreign materials
bruises, rots.

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Mechanical technologies - Acoustic impulses

- Acoustic responses are related to elasticity, internal friction, shape, size and density.
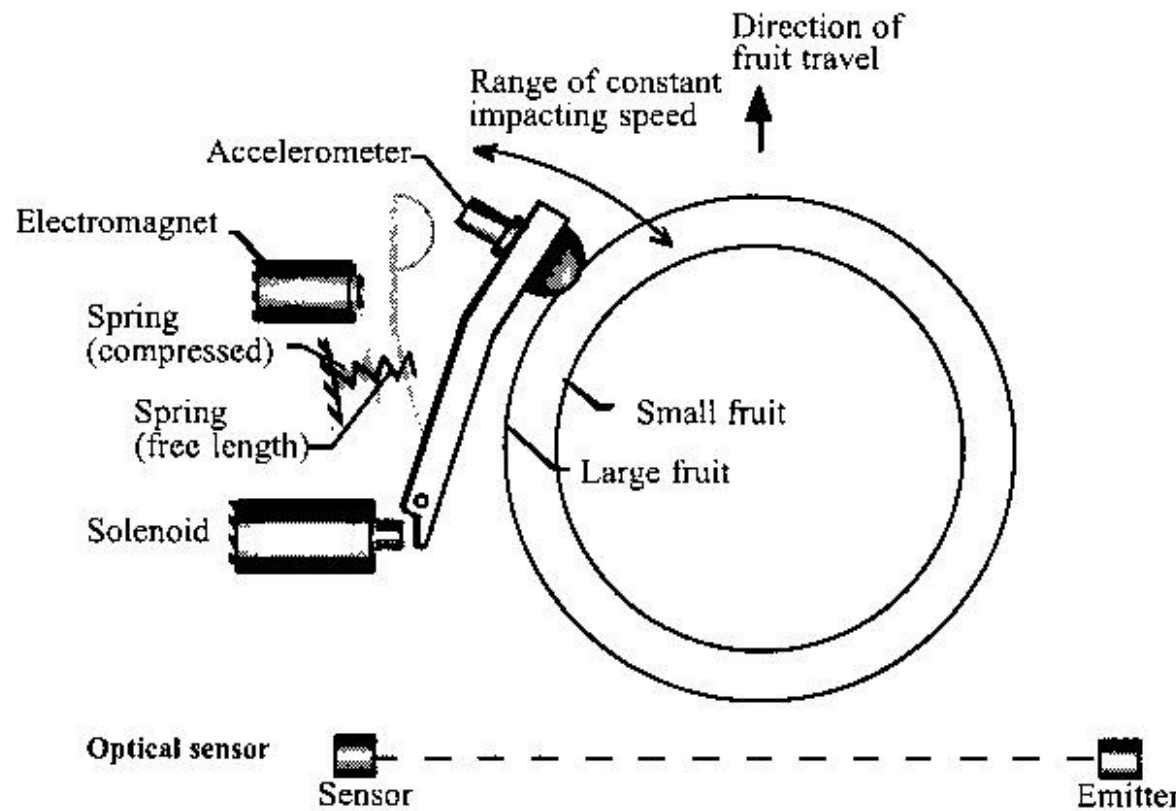
(García-Ramos et al, 2000)

(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.

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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
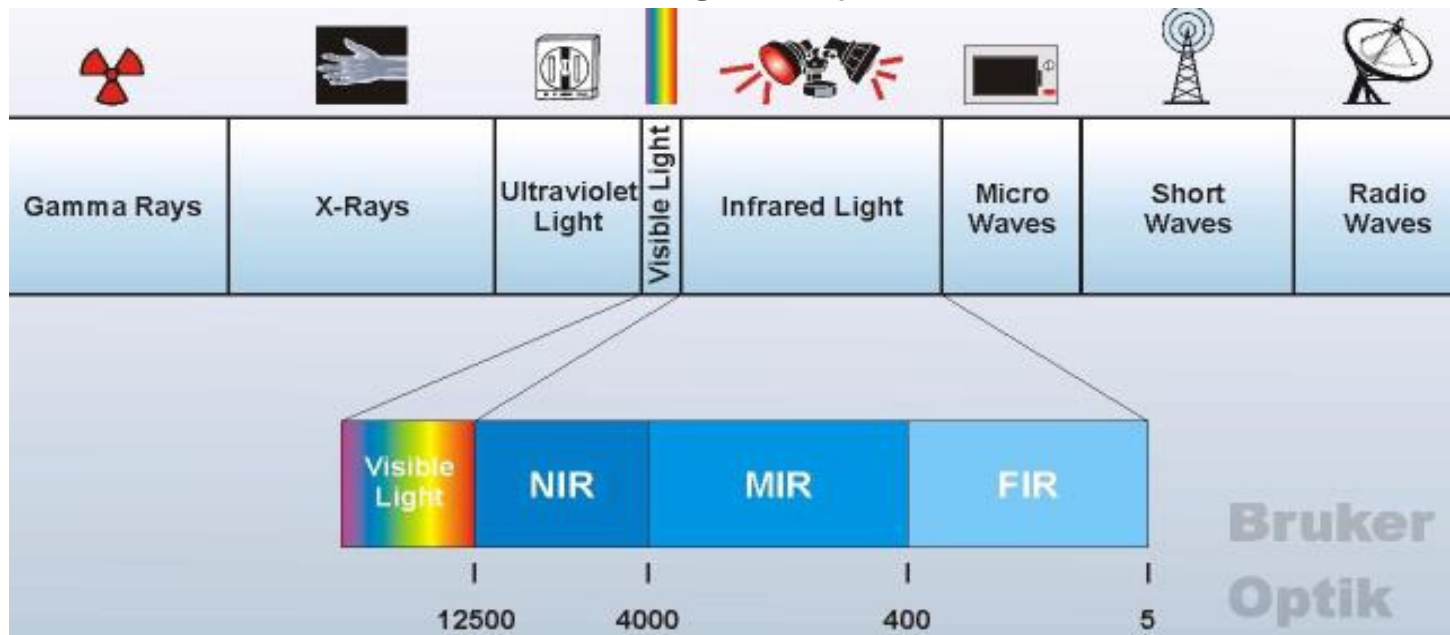
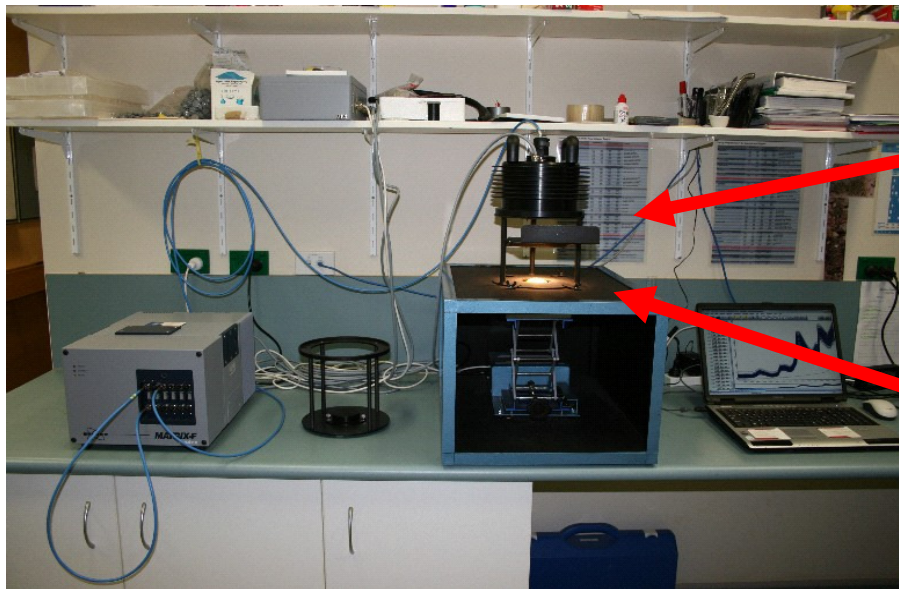HyperVision™ System

10-15 items / second.
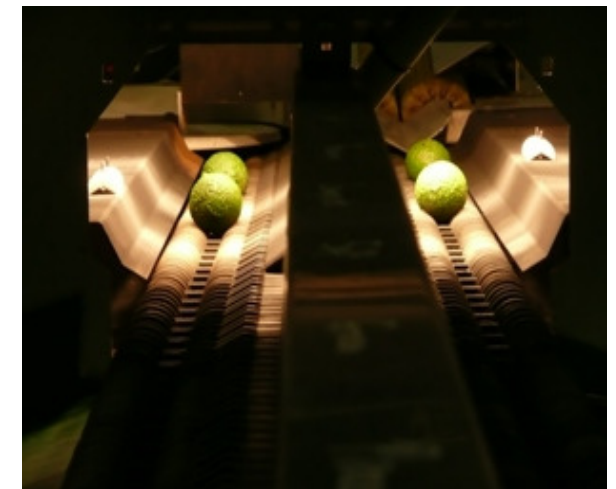
ARC Project – NIRS to predict avocado quality (%DM)

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.

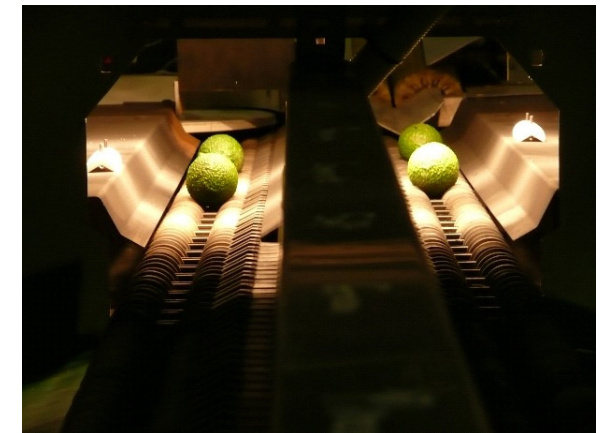- **Generic model** (all regions combined over 3 years)

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

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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 = ~0.87   RMSEP = +/- ~ 2 %DM

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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.

Acknowledgements

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