Cell structure changes during cold-pressed ‘Hass’ avocado oil extraction

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Outline

• Background
  1) Avocado oil & cold-pressed oil extraction
  2) Methods for determining cell rupture

• Objectives

• Experiment results

• Conclusions
Cold-pressed avocado oil

- 80% monounsaturated fatty acids
- High level of antioxidants
  - Tocopherols
  - Carotenoids
- High level of phytosterols
- High smoke point
  - Over 250 °C
Oil localization in avocado flesh

1. Parenchyma cell
   - ≈ 98%
   - Oil: Triacylglycerol (TAG)
   - Broken by grinding
Oil localization in avocado flesh

1. Parenchyma cell
   - \( \approx 98\% \)
   - Oil: Triacylglycerol (TAG)
   - Broken by grinding

2. Idioblast cell
   - \( \approx 2\% \)
   - Oil: TAG < polarity < phospholipids
   - Remain intact
Cold-pressed extraction

Ripe Avocado

Washing
Cold-pressed extraction

Ripe Avocado → Washing → Destoner → Remove skin & stones
Cold-pressed extraction

Ripe Avocado → Washing → Destoner → Remove skin & stones → Grinder

Background:
Cold-pressed extraction

Remove skin & stones

Grinder
Cold-pressed extraction

Ripe Avocado → Washing

Destoner → Remove skin & stones

Grinder

Malaxing (mixing) 45-50 °C 120 min

Malaxer
Cold-pressed extraction

Ripe Avocado

Remove pomace & water

Washing

Destoner

Remove skin & stones

Grinder

Malaxing (mixing) 45-50 °C 120 min

Disc centrifuge

Decanter centrifuge

Remove water

Malaxer
Cold-pressed extraction

Ripe Avocado

Washing

Destoner

Remove skin & stones

Grinder

Malaxing (mixing)
45-50 °C
120 min

Disc centrifuge

Remove pomace & water

Decanter centrifuge

Remove water

Malaxer

Storage & Bottling
Cold-pressed extraction

Intact flesh → Grinding → Breaking parenchyma cells → After grinding
Cold-pressed extraction

Intact flesh → Grinding → Breaking parenchyma cells → After grinding

0 min malaxing → Malaxing → Oil aggregation → 120 min malaxing
Methods for determining cell rupture

1. Light microscopy
2. Electrical impedance spectroscopy
3. Electrolyte leakage
Light microscopy

• Cell walls
  Toluidine Blue staining
Electrical impedance spectroscopy

Higher resistance
Electrical impedance spectroscopy

Higher resistance

Lower resistance
Electrolyte leakage

Lower conductivity value

Higher conductivity value
Objectives

To determine factors that affect cell integrity during extraction:

1) Fruit firmness

2) Fruit maturity (Harvest time in season)
Effect of fruit firmness on cell integrity

- August 2016
- Lab-based experiment (1L malaxer)
- 3 stages of ripening

Minimally ripe
Firmometer value: **55 Fv**

Fully ripe
Firmometer value: **80 Fv**

Over ripe
Firmometer value: **105 Fv**
Lab scale extraction – sampling points

1. Intact flesh
2. Time 0 malaxing
3. + 60 min
4. + 120 min
5. Oil
Oil yield

<table>
<thead>
<tr>
<th>Total oil content Minimally ripe</th>
<th>Fully ripe (80 FV)</th>
<th>Over ripe (105 FV)</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>4</td>
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<td>8</td>
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Solvent extraction

- Minimally ripe (55 FV)
- Fully ripe (80 FV)
- Over ripe (105 FV)
Fresh intact fruit

a. Minimally ripe (55 Fv)

b. Fully ripe (80 Fv)

c. Over ripe (105 Fv)
0 min malaxing

Unbroken parenchyma cells

a. Minimally ripe (55 Fv)
b. Fully ripe (80 Fv)
c. Over ripe (105 Fv)
60 min malaxing

Unbroken parenchyma cells

a. Minimally ripe (55 Fv)
b. Fully ripe (80 Fv)
c. Over ripe (105 Fv)
120 min malaxing

Unbroken parenchyma cells

a. Minimally ripe (55 Fv)

b. Fully ripe (80 Fv)

c. Over ripe (105 Fv)
Electrical impedance spectroscopy

(a) Fresh intact flesh
Electrical impedance spectroscopy

(a) Fresh intact flesh

![Graph showing the relationship between resistance (Ω) and frequency (Hz)]

- Black lines with square markers: Minimally ripe
- Red circles: Fully ripe
- Blue triangles: Over ripe
Electrical impedance spectroscopy

(a) Fresh intact flesh

- Minimally ripe
- Fully ripe
- Over ripe

Resistance (Ω)

Frequency (Hz)
Electrical impedance spectroscopy

Frequency (Hz)

Minimally ripe
Fully ripe
Over ripe

Resistance (Ω)

Low-frequency current

High-frequency current

(a) Fresh intact flesh
Electrical impedance spectroscopy

Minimally ripe
Fully ripe
Over ripe

(a) Fresh intact flesh
Electrical impedance spectroscopy

(a) Fresh intact flesh

Resistance (Ω) vs. Frequency (Hz)

- Minimally ripe
- Fully ripe
- Over ripe
Electrical impedance spectroscopy

(a) Fresh intact flesh
(b) 0 min malaxing
Electrical impedance spectroscopy

(a) Fresh intact flesh
(b) 0 min malaxing

Minimally ripe
Fully ripe
Over ripe
Electrical impedance spectroscopy

(a) Fresh intact flesh

(b) 0 min malaxing

(c) 60 min malaxing

(d) 120 min malaxing
Electrolyte leakage

- **Conductivity (µS/cm)**
  - Minimally ripe (55 FV)
  - Fully ripe (80 FV)
  - Over ripe (105 FV)

- **Sampling points**
  - Intact flesh
  - 0 min malaxing
  - 60 min malaxing
  - 120 min malaxing

The graph shows the electrolyte leakage over time for different stages of ripeness and malaxing conditions.
Electrolyte leakage

Sampling points

Conductivity ($\mu$S/cm)

Intact flesh
0 min malaxing
60 min malaxing
120 min malaxing

Minimally ripe (55 FV)
Fully ripe (80 FV)
Over ripe (105 FV)
Electrolyte leakage

**Conductivity (μS/cm)**

- Intact flesh
- 0 min malaxing
- 60 min malaxing
- 120 min malaxing

**Sampling points**

- Minimally ripe (55 FV)
- Fully ripe (80 FV)
- Over ripe (105 FV)
Summary

1. Cells can be disrupted more easily with softer, riper fruit

2. The cold-pressed oil yield increased with fruit ripeness
Objectives

To determine factors that affect cell integrity during extraction:

1) Fruit firmness

2) Fruit maturity (Harvest time in season)
Effect of fruit maturity on cell integrity

- Factory sampling (650L malaxer)
- Olivado NZ Ltd, New Zealand
- 6 samplings through 2016/17 production season

<table>
<thead>
<tr>
<th>Early season</th>
<th>Mid season</th>
<th>Late season</th>
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<tbody>
<tr>
<td>Sep 2016</td>
<td>Oct 2016</td>
<td>Dec 2016</td>
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<td></td>
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<td>Jan 2017</td>
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<td>Mar 2017</td>
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<td>Apr 2017</td>
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Cold-pressed oil yield & total oil content

Commercial cold-pressed oil yield %
Dry matter or oil content %
Sampling date
Dry matter content %
Total oil content %
Commercial oil yield %

Dry matter %
Total oil content % (Solvent extraction)
Commercial cold-pressed oil yield %
0 min malaxing

Unbroken parenchyma cells

a. September 2016
   (Early season)

b. December 2017
   (Mid season)

c. March 2017
   (Late season)
120 min malaxing

Unbroken parenchyma cells

a. September 2016 (Early season)
b. December 2017 (Mid season)
c. March 2017 (Late season)
Electrical impedance spectroscopy

(a) Fresh intact flesh

![Graph showing resistance vs. frequency for fresh intact flesh with data points for different months from September 2016 to April 2017.](image-url)
Electrical impedance spectroscopy

(a) Fresh intact flesh

(b) 0 min malaxing

Early
Late
Electrical impedance spectroscopy

(a) Fresh intact flesh

(b) 0 min malaxing

(c) 60 min malaxing

(d) 120 min malaxing
Electrolyte leakage

![Graph showing electrolyte leakage over time and sampling points.](image)
Summary

1. Cells are easier to be disrupted when the fruit is harvested later in the season

2. The cold-pressed oil yield increased with fruit maturity
Conclusions

1. Cells can be disrupted more easily with riper and late maturity fruit

2. The cold-pressed oil yield increased with fruit ripeness and maturity
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