Effect of Olive Maturity at Harvest on Quality of Extra Virgin Olive Oil in New Zealand

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Presentation outline

• Background
  – NZ olive industry
• Objectives
• Pilot study methodology
• Results
  – Maturity indices
  – Composition
  – Sensory
• Conclusions to date
• Continuing research
NZ olive and olive oil industry

- Area planted 2173 hectares
- 2010 estimated olive oil production - 350,000 L

(Sources: Edwards, 2007; Plant & Food, 2008; ONZ 2009)
Background – when to harvest

• Harvest decision in the field up until now:
  – External colour
  – Squeezing an olive with fingers
  – Others are picking!
  – Send fruit for analysis  → costly

• No maturity index defined for NZ growing conditions

→ Inconsistency in flavours, problems with balance and oil yields

When is the best time to pick?
Objectives

• To develop a maturity index for New Zealand, for harvesting olives for extra virgin olive oil.

• To determine the composition and sensory qualities of New Zealand extra virgin olive oil.
Pilot study in Auckland Region

- > 8 – 10 years old
- ‘Frantoio’, ‘Leccino’, ‘Koroneiki’
- Early, mid and late harvest
Methodology – Year 1

• **Measures of maturity**
  – colour maturity index, dry matter, fruit weight, fruit colour, fruit firmness, oil content (solvent)

• **Cold pressed oil**
  – 10 kg batches
  – quality: % free fatty acids (FFA), Peroxide value (PV)
  – composition: phenolic content, fatty acids, sterols, tocopherols and pigments

• **Sensory analysis of cold pressed oil**
Colour Maturity Index

\[ MI = \frac{Ax0 + Bx1 + Cx2 + Dx3 + Ex4 + Fx5 + Gx6 + Hx7}{100} \]

Traditionally recommended to harvest time at colour grade 4 to 5 (Barranco et al., 2004)

*Is this the optimal maturity to harvest for New Zealand growing conditions?*
Total oil and phenolic content related to harvest date – ‘Frantoio’ (Bombay)
Total oil and phenolic content related to harvest date – ‘Frantoio’ (Waiheke)
Total oil and phenolic content related to harvest date – ‘Leccino’ (Bombay)

%Total Oil (fresh weight)

Total Phenolics (ug.gOil⁻¹)
Colour maturity index - summary

• Not a good predictor for total oil content or phenolic content

• Varied with cultivar and orchard location

• Using the colour maturity index may result in harvesting at the wrong time
Dry matter vs total oil content for Avocados

\[ r^2 = 0.96, p < 0.0001 \]

\[ Y = -8.75937 + 0.92839X \]

(Source: Woolf et al., 2009)
Dry matter vs total oil content for Olives, Year 1 data
# Quality of cold pressed oils

<table>
<thead>
<tr>
<th></th>
<th>Pooled SE</th>
<th>‘Frantoio’</th>
<th>‘Koroneiki’</th>
<th>‘Leccino’</th>
<th>Extra virgin limits (IOC)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PV</strong> (meq/kg oil)</td>
<td>± 0.02</td>
<td>2.22 – 5.71</td>
<td>3.69 – 5.13</td>
<td>2.44 – 4.95</td>
<td>≤ 20</td>
</tr>
<tr>
<td>(n = 89)</td>
<td></td>
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</tr>
<tr>
<td><strong>% FFA</strong> ((^\text{w/w}) as oleic acid)</td>
<td>± 0.01</td>
<td>0.10 – 0.19</td>
<td>0.12 – 0.36</td>
<td>0.08 – 0.14</td>
<td>≤ 0.8</td>
</tr>
<tr>
<td>(n = 66)</td>
<td></td>
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</tr>
<tr>
<td><strong>K(_{232})</strong></td>
<td>± 0.03</td>
<td>1.54 – 2.04</td>
<td>1.49 – 1.56</td>
<td>1.40 – 1.98</td>
<td>≤ 2.5</td>
</tr>
<tr>
<td>(n = 29)</td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td><strong>K(_{270})</strong></td>
<td>± 0.01</td>
<td>0.13 – 0.19</td>
<td>0.11 – 0.16</td>
<td>0.11 – 0.16</td>
<td>≤ 0.25</td>
</tr>
<tr>
<td>(n = 29)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Fatty acid compositions

<table>
<thead>
<tr>
<th>Fatty Acid</th>
<th>‘Frantoio’</th>
<th>‘Koroneiki’</th>
<th>‘Leccino’</th>
<th>IOC limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palmitic acid C16:0</td>
<td>8.19 – 12.00</td>
<td>8.34 – 9.07</td>
<td>9.50 – 12.37</td>
<td>7.5 – 20.0</td>
</tr>
<tr>
<td>Palmitoleic acid C16:1</td>
<td>0.54 – 1.29</td>
<td>0.65 – 0.78</td>
<td>0.76 – 1.48</td>
<td>0.3 – 3.5</td>
</tr>
<tr>
<td>Heptadecanoic acid C17:0</td>
<td>0.04 – 0.06</td>
<td>0.04 – 0.05</td>
<td>0.03 – 0.06</td>
<td>≤ 0.3</td>
</tr>
<tr>
<td>cis-10Heptadecenoic acid C17:1</td>
<td>0.08 – 0.12</td>
<td>0.07 – 0.09</td>
<td>0.09 – 0.13</td>
<td>≤ 0.3</td>
</tr>
<tr>
<td>Stearic acid C18:0</td>
<td>1.23 – 2.08</td>
<td>1.69 – 2.25</td>
<td>1.17 – 1.37</td>
<td>0.5 – 5.0</td>
</tr>
<tr>
<td>Oleic acid C18:1</td>
<td>75.81 – 82.94</td>
<td>81.32 – 82.94</td>
<td>76.91 – 82.37</td>
<td>55.0 – 83.0</td>
</tr>
<tr>
<td>Linoleic acid C18:2</td>
<td>4.35 – 7.94</td>
<td>4.28 – 4.98</td>
<td>4.44 – 6.53</td>
<td>3.5 – 21.0</td>
</tr>
<tr>
<td>α-Linolenic acid C18:3</td>
<td>0.47 – 0.81</td>
<td>0.66 – 0.99</td>
<td>0.56 – 0.79</td>
<td>≤ 1.0</td>
</tr>
<tr>
<td>Arachidic acid C20:0</td>
<td>0.29 – 0.43</td>
<td>0.40 – 0.46</td>
<td>0.23 – 0.31</td>
<td>≤ 0.6</td>
</tr>
<tr>
<td>Gadoleic acid C20:1</td>
<td>0.23 – 0.41</td>
<td>0.28 – 0.37</td>
<td>0.27 – 0.33</td>
<td>≤ 0.4</td>
</tr>
<tr>
<td>Behenic acid C22:0</td>
<td>0.07 – 0.13</td>
<td>0.11 – 0.15</td>
<td>0.04 – 0.08</td>
<td>≤ 0.2</td>
</tr>
</tbody>
</table>
## Sterol compositions

<table>
<thead>
<tr>
<th></th>
<th>‘Frantoio’</th>
<th>‘Koroneiki’</th>
<th>‘Leccino’</th>
<th>IOC limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cholesterol</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>≤ 0.5</td>
</tr>
<tr>
<td>Brassicasterol</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>≤ 0.1</td>
</tr>
<tr>
<td>Campesterol</td>
<td>2.1 – 3.3</td>
<td>3.3 – 5.0</td>
<td>2.5 – 3.9</td>
<td>≤ 4.0</td>
</tr>
<tr>
<td>Stigmasterol</td>
<td>0.2 – 1.0</td>
<td>0.2 – 1.4</td>
<td>1.1 – 2.1</td>
<td>≤ campesterol</td>
</tr>
<tr>
<td>Δ-7-Stigmastenol</td>
<td>0.0 – 0.6</td>
<td>0.0</td>
<td>0.0 – 0.2</td>
<td>≤ 0.5</td>
</tr>
<tr>
<td>Betasitosterol</td>
<td>76.7 – 82.6</td>
<td>73.3 – 85.2</td>
<td>72.3 – 79.1</td>
<td></td>
</tr>
<tr>
<td>Apparent Betasitosterol&lt;sup&gt;a&lt;/sup&gt;</td>
<td>95.7 – 97.6</td>
<td>93.8 – 96.5</td>
<td>95.0 – 96.1</td>
<td>≥93.0</td>
</tr>
<tr>
<td>Total sterols</td>
<td>60.32 – 102.68</td>
<td>45.65 – 67.29</td>
<td>61.57 – 101.83</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Apparent Betasitosterol = Betasitosterol+Δ-5-avenasterol+Δ-5,23-stigmastadienol+clerosterol+sitostanol+Δ-5,24-stigmastadienol
## Tocopherol compositions

<table>
<thead>
<tr>
<th></th>
<th>‘Frantoio’</th>
<th>‘Koroneiki’</th>
<th>‘Leccino’</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alpha-tocopherol</strong></td>
<td>11.6 – 19.1</td>
<td>18.6 – 44.7</td>
<td>23.4 – 33.7</td>
</tr>
<tr>
<td><strong>Beta-tocopherol</strong></td>
<td>0.0 – 0.4</td>
<td>0.2 – 1.0</td>
<td>0.1 – 0.6</td>
</tr>
<tr>
<td><strong>Gamma-tocopherol</strong></td>
<td>0.0 – 0.2</td>
<td>0.1 – 0.2</td>
<td>0.3 – 1.5</td>
</tr>
<tr>
<td><strong>Delta-tocopherol</strong></td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td><strong>Total tocopherols</strong></td>
<td>11.8 – 19.3</td>
<td>19.4 – 45.1</td>
<td>23.8 – 34.8</td>
</tr>
</tbody>
</table>
Sensory Analysis - Methodology

- Nine experienced panellists (36 to 53 years old)
- International Standard Descriptors (IOC)
- Screened a large range of flavours and aroma references
- Generated lexicon with 28 odour and flavour, and mouth feel attributes
- Assessed oils from 24 harvests in triplicate for their individual profiles
Institute of Food, Nutrition and Human Health

Pungent

Vanilla toffee flavour
Nutty flavour
Banana aroma
Apple flavour
Fresh herb flavour
Cut grass flavour
Rocket aroma
Chilli/Spicy
Green tea flavour
Black pepper
Bitter salad flavour
‘Koroneiki’ mid harvest

Rocket aroma
Bitter Salad aroma
Floral aroma
Apple aroma
Cut grass flavour
Bitter salad flavour
Rocket flavour
Banana flavour
Nutty flavour
Apple flavour
Fresh herb flavour
Vanilla/Toffee...
Green tea flavour
Black pepper
Sweet
Astringent
Fruity
Pungent
Bitter

MangawhaiH2
HellensvilleH2
WaihekeH2
Summary of Sensory Results

- ‘Frantoio’, ‘Leccino’ and ‘Koroneiki’ olive oils have distinct sensory profiles
  - ‘Frantoio’ – ‘green tea’ and ‘black pepper’ moving to ‘nutty’
  - ‘Leccino’ – ‘pungent’ moving to ‘vanilla’ and ‘toffee’
  - ‘Koroneiki’ – ‘fresh herb’ and ‘rocket’ moving to ‘apple’ and ‘banana’

- Time of harvest and orchard location influences the sensory properties of the oils
Conclusions

• Colour maturity index not ideal for NZ growing conditions

• As oil content increases, phenolics decrease - as expected; varies with cultivar

• An alternative maturity index is needed

• Time of olive harvest important - influences oil yield, sensory qualities and stability.
Continuing Research

Year 2

- More harvests
- Other regions in New Zealand
- One cultivar – ‘Frantoio’
Acknowledgements

NZ Olive Growers

[Logos]

Sustainable Farming Fund

[Other logos]