Evaluation of traditional and new processing aids for olive oil extraction

Research work funded by Rural Industries Research & Development Corporation

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Processing aids

- Substances that are used to facilitate the olive oil extraction process. They do not remain in the final product (they are not additives)

- Processing aids must not alter the chemical and organoleptic quality of the oil

- Objective: To evaluate the processing aids being used in other countries or studied in main research institutes in Europe
• **Australian standard (AS 5264-2011):** “Olive oil is the oil obtained solely from the fruit of the olive tree (Olea europaea L.), to the exclusion of oils obtained using solvents or re-esterification processes and of any mixture with oils of other kinds”

• **Article 9.3:** “Processing aids are allowed to be used during the oil extraction process to the extent allowed by the *Australia New Zealand Food Standard Code*”

• **ANZFA (Section 1.3.3: Processing aids):** Talc powder, Pectinase enzymes.
# Processing aids & techniques

<table>
<thead>
<tr>
<th>New aids</th>
<th>Traditional aids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talc powder</td>
<td>Microtalc powder</td>
</tr>
<tr>
<td>Enzymes</td>
<td>Common salt</td>
</tr>
<tr>
<td>Water</td>
<td>Calcium carbonate</td>
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<td>Enzymes with side activities</td>
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<td>Warm water dipping</td>
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<td>Ultrasound</td>
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</tbody>
</table>
Talc & Microtalc powder

- Magnesium silicate with high adsorption surface
- Lipophyllic nature: adsorbs oil droplets making them larger in size
- Provides structure to the paste in the malaxer
- It does not allow the paste to stick to the internal walls of the decanter
<table>
<thead>
<tr>
<th>Talc powder</th>
<th>Microtalc powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oldest powder used in the industry</td>
<td>New product in the industry</td>
</tr>
<tr>
<td>Magnesium silicate with high adsorption surface</td>
<td>Same as talc powder, but finer particle size</td>
</tr>
<tr>
<td>d50% = 8µm</td>
<td>d50% = 2µm</td>
</tr>
<tr>
<td>Specific surface area = 3.6 m2/gr</td>
<td>Specific surface area = 7.0 m2/gr</td>
</tr>
<tr>
<td>Dose = 0.5-3%</td>
<td>Dose = 0.3-1%</td>
</tr>
</tbody>
</table>
Equipment
Talc dispensers
Talc & Microtalc powder

<table>
<thead>
<tr>
<th></th>
<th>Oil extraction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>19%</td>
</tr>
<tr>
<td>Talc 2.0%</td>
<td>18,6%</td>
</tr>
<tr>
<td>Microtalc 0.3%</td>
<td>17,9%</td>
</tr>
<tr>
<td>Microtalc 0.6%</td>
<td>14,9%</td>
</tr>
</tbody>
</table>

- Arbequina: 14,9%, 9,8%, 10,5%
- Barnea: 19%, 61,1%, 58,4%
- Manzanilla: 61,1%, 58,4%
Talc & Microtalc powder

- Beneficial impact on FFA, PV, K232, K270 & $\Delta K$ in Arbequina, Barnea & Manzanilla
- Higher PPH content in Barnea & Manzanilla
- No impact on taste or colour
- Microtalc powder seems to be more cost effective than talc due to less product transport, handling & storage
## Talc powder

Talc trial in Manzanillo fruit with 61.1% moisture and 3.1 M.I.

<table>
<thead>
<tr>
<th>Talc rate</th>
<th>Processing speed</th>
<th>Extraction efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0%</td>
<td>2.95 tn/hr</td>
<td>74.36%</td>
</tr>
<tr>
<td>0.5%</td>
<td>3.45 tn/hr</td>
<td>81.25%</td>
</tr>
<tr>
<td>1.0%</td>
<td>3.90 tn/hr</td>
<td>86.34%</td>
</tr>
<tr>
<td>1.5%</td>
<td>4.15 tn/hr</td>
<td>88.35%</td>
</tr>
<tr>
<td>2.0%</td>
<td>4.15 tn/hr</td>
<td>89.15%</td>
</tr>
<tr>
<td>2.5%</td>
<td>4.15 tn/hr</td>
<td>88.74%</td>
</tr>
</tbody>
</table>
Talc powder

Talc trial in Manzanillo fruit with 61.1% moisture and 3.1 M.I.
Talc powder

When should I consider the use of talc and how much of it?

- With difficult varieties (Arbequina, Leccino, Picual, Hojiblanca, Manzanillo).
- With high moisture levels (>56.0%).
- With small grids (4 or 5 mm), to help provide structure.
- With “fleshy” fruit (high pulp/pit ratio).
- With low extraction efficiencies (< 85.0%).
- Others (Low pumping capacity <60.0% of decanter capacity).
- Start with 1.0% and adjust according to oil content in pomace and pumping capacity.
Common Salt (NaCl)

- High solubility in water. It does not make the oil “salty”
- Action: It changes the density of the water stretching out the gap of water:oil densities
- Greener oils as it increases chlorophyll solubility
- Dose = 1-3%
- Significantly cheaper than talc & microtalc powder
Calcium carbonate

- Natural mineral with crystalline structure (calcite)
- Hydrophillic affinity
- It facilitates flocks agglomeration by adsorption (similar action to Talc powder)
- d50% = 2.8µm
- Density = 2.7 gr/ml
- Dose = 1-2%
- Cheaper than Talc powder
- Used in Spain with excellent extraction efficiency results
Salt & Calcium carbonate

Arbequina
- Control: 17.7%
- Salt 2.0%: 27.7%
- CaCO3 2.0%: 27.7%

Barnea
- Control: 9.5%
- Salt 2.0%: 9.8%
- CaCO3 2.0%: -2.7%

Manzanilla
- Control: 115.4%
Solid aids

Peroxide value

- Arbequina
- Barnea
- Manzanilla

Control
Talc 2.0%
Microtalc 0.3%
Microtalc 0.6%
Salt 2%
CaCO3 2%
## Solid aids

### Pomace

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>Conductivity (µS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>5.07</td>
<td>17750</td>
</tr>
<tr>
<td>Salt</td>
<td>5.02</td>
<td>46040</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>5.53</td>
<td>23140</td>
</tr>
</tbody>
</table>
Salt & Calcium carbonate

Salt (NaCl)

- Improves extractability
- No impact on taste
- Slightly greener oils
- Higher PPH content in oil and slightly higher stability
- Increases CE of pomace

Calcium carbonate

- Aggressive on paste
- Very high extractability
- Reduces FFA
- Increases pH of pomace
- Oxidative action (PV, UV)
- ↓↓ PPH, stability & bitterness
- Very green oils
- Changes in taste
Enzymes

- Very effective in improving the paste extractability
- Biologically active protein substances that help in degrading the pectin & cellulose of the cell walls & vacuoles
- They are produced from Aspergillus aculeatus or niger
- Same enzymes that the fruit has in its tissues
- Endogenous enzyme system depends on the season, variety & maturity and is inactivated by polyphenols
- Dose = Variable (200-500ml/tn). Higher in dry years
- Water soluble and easily removed by centrifugation
- Absolutely essential when dealing with low maturity fruit
Equipment
Enzymes
Enzymes

$E_a$ = activation energy

$E_x$ = liberated reaction energy
Enzymes

Source: Gunter Maier (NOVOZYMES)
Enzymes

Model of plant cell wall (dicotyledon)

- Cellulose fibrils
- Xyloglucan network
- Pectic polymer matrix (smooth region: 60-90%)
- Pectic polymer matrix (hairy region: 10-40%)

G. Maier, 2003
Enzymes

**Mode of action of the main pectolytic enzymes**

- **PECTIN LYASE (PL)**
  - **PECTIN METHYLESTERASE (PME)**
  - **endo POLYGALACTURONASE (PG)**

- **Galacturonic acid**
- **Carboxylic acid**
- **Methyl group**
Enzymes

**FIG. 1.** Changes in PE and PG activity in fruits during ripening of olives. Abbreviations: RG, ripe-green; SRS, small reddish spots; TC, turning color; P, purple; B, black; RB, ripe-black; B-1, fruits with black surface and white pulp; B-2, fruits with black surface and purple pulp; μEquiv, microequivalents; PE, pectin esterase; PG, polygalacturonase.

Source: Minguez-Mosquera et al, 1996
Enzymes

Enzymes trialed:

1. Multi low PG/PL/PE & High side activities (Pectinex Ultra SP-L)
2. High PG/PL/PE & Average side activities (NZ 33095)
3. Average PG/PL/PE & High cellulose activity (NZ33095/Celluclast)
4. Low PG/PL/PE & High betaglucanase side activities (Viscozym-L)

Dose = 0.3%
Enzymes

Impact of the use of enzymes in paste extractability

- Arbequina-09: 22.9%, 27.4%, 16.6%
- Barnea-10: 22.8%, 24.8%, 24.8%
- Manzanilla-09: -80%, -44%, -46%

Extractability

- Control
- Pectinex Ultra SP-L
- NZ 33095
- NZ 33095/Celluclast 1.5
- Viscozym L
Enzymes

Field trial 2010 - Barnea

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Oil losses in pomace (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>21.4%</td>
</tr>
<tr>
<td>Pectinex</td>
<td>17.9%</td>
</tr>
<tr>
<td>NZ 33095</td>
<td>25.0%</td>
</tr>
<tr>
<td>NZ/Celluclast</td>
<td>32.1%</td>
</tr>
<tr>
<td>Viscozym</td>
<td></td>
</tr>
</tbody>
</table>
Enzymes

- Very good results in Arbequina & Barnea. It was not a solution for high moisture Manzanilla without talc powder
- No alteration of oil quality for better or worse
- No changes in taste and colour
- No clear impact on fermentation parameters: FFA, DAG
- No significant impact on oxidative parameters: PV, UV, PPH & Rancimat
- It seems that the relative content of “smooth” and “hairy” regions in the fruit cell walls each year is different and that determines which composition will be more effective
Enzymes

When should I use enzymes and how much of it?

• With difficult varieties (Arbequina, Leccino, Picual, Hojiblanca, Manzanillo).
• With green fruit (MI <3.5)
• With large grids (6 or 7 mm).
• With low extraction efficiencies (< 85.0%).
• Others (Low pumping capacity <60.0% of decanter capacity).
• Start with 0.2% and adjust according to oil content in pomace and pumping capacity.
Warm water dipping

- It consists of pre-heating olives before crushing to achieve a higher temperature at beginning of malaxing.
- Technique: Immersion of olives for 3 minutes in warm water at 30-45-60°C.
- Research works in Spain indicate that dipping:
  1. Increases paste extractability
  2. Reduces bitterness
  3. Inhibits LOX enzyme → Delays oil oxidation
  4. Increases chlorophyll content → Greener oils
  5. No changes in taste
Warm water dipping

<table>
<thead>
<tr>
<th></th>
<th>Arbequina</th>
<th>Barnea</th>
<th>Manzanilla</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.0%</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>4.0%</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>6.0%</td>
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<tr>
<td>8.0%</td>
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<td></td>
</tr>
<tr>
<td>10.0%</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>12.0%</td>
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<td></td>
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</tr>
<tr>
<td>14.0%</td>
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<td></td>
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</tbody>
</table>

**Oil extraction (%)**

- **Control**
- **30°C**
- **45°C**
- **60°C**
Warm water dipping

- Simpler to implement in small Plants working in “batching” modality. More complicated for larger Plants
- Paste extractability showed slight improvements only at 60°C
- Increase in the moisture content of the fruit, making the extraction process more difficult
- Combined with talc could be interesting
- Oils are greener, but there is a change in taste too
- There is a clear reduction of the bitterness
- There is a reduction of the oxidative stability
Warm water dipping

Calcium carbonate

Warm water dipping

Control 30°C 45°C 60°C

Control CaCO3

Arbequina

Barnea

Manzanilla

Control 30°C 45°C 60°C

Arbequina

Barnea

Manzanilla
Water of injection

Fruit moisture in Trial nº 1 : 44%
Fruit moisture in Trial nº 2 : 40%

Marino Uceda – Australia 2005
Water of injection

Fruit: 45% moisture

Marino Uceda – Australia 2005
Water of injection

![Bar graph showing the impact of water on injection performance for Plate 99, Plate 100, and Plate 101.](image_url)

- **Without water**: Red bars for Plate 99, blue bars for Plate 100, green bars for Plate 101.
- **6% Water**: Similar bars showing performance improvement with water.

Marino Uceda – Australia 2005
Ultrasound

The diagram shows a graph titled "Oil Evolved vs Ultrasonic Energy". The x-axis represents mL of oil, ranging from 0 to 60. The y-axis represents Ultrasonic Energy in kJ/kg, ranging from 0 to 25.00.

- There are two data sets: Oil% 30 min Maturation and Oil% 5 Min Maturation.
- The data points are represented by symbols: diamonds for 30 min maturation and squares for 5 min maturation.

In the image, there are two cylindrical containers labeled "US treated" and "Control". The "US treated" container appears to have a different appearance compared to the "Control" container.
Ultrasound

Figure 1: Process Flow Diagram
Ultrasound

Trial 1

- Ultrasonic Line
- Control Line

Industrial Efficiency %

Date

17/5 19/5 21/5 23/5 25/5 27/5 29/5 31/5 02/6
Ultrasound

- Research in very early stages
- Olive paste is supplied with ultrasound energy in order to break down wall cell and release the oil
- There is a beneficial increase in the paste temperature
- It seems to be more effective on green fruit
- Lab trials showed very good results on paste extractability
- Field trials with variable results. More work to be done here
- No apparent impact on oil quality
Summary

- **Talc & microtalc powder**: essential with difficult pastes or high moisture fruit. No impact on oil quality.
- **Common salt**: Low cost option. No impact on oil quality, though there is a significant increase in conductivity of pomace.
- **Calcium carbonate**: another cheap option. High paste extractability. Increases pH of pomace and could impact quality if not properly used.
- **Enzymes**: Effective under most conditions. Doses depend on the year and fruit ripeness. No impact on oil quality.
- **Warm dipping**: Difficult to implement. Only effective with temperatures above 60°C. It does change the oil quality.
- **Ultrasound**: Promising technology. No impact on quality.
- **Microtalc powder & enzymes** could be an interesting combination depending on the fruit condition.
Thank you