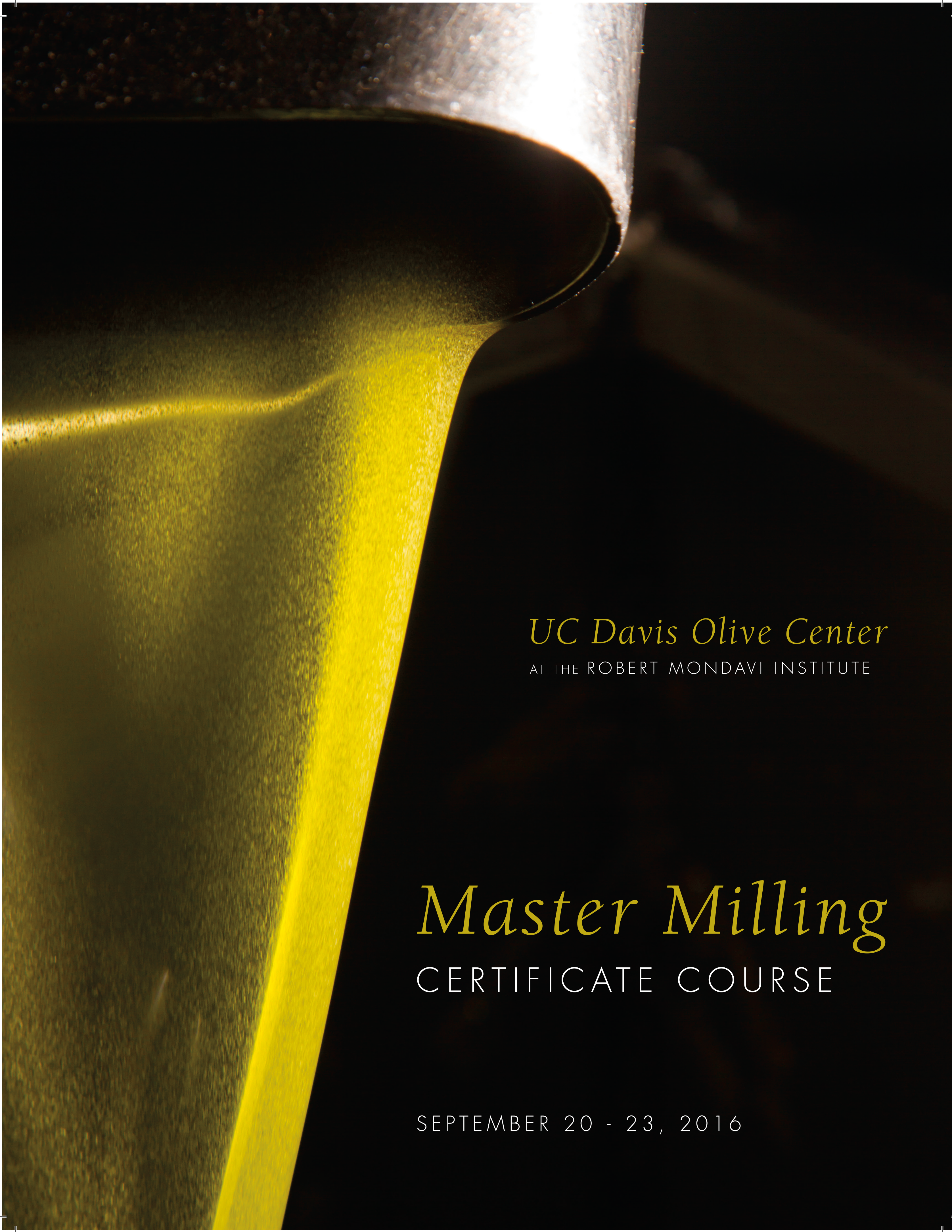

UC Davis Olive Center

AT THE ROBERT MONDAVI INSTITUTE

Master Milling

CERTIFICATE COURSE

SEPTEMBER 20 - 23, 2016

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Table of Contents

1 **Speaker Biographies**
2 **Agenda, Day 1**
3 **Agenda, Day 2**
4 **Agenda, Day 3**
5 **Agenda, Day 4**
6 **Day One Presentations**
83 **Day Two Presentations**
141 **Day Four Presentations**
166 **Useful Conversions**

To Access UC Davis WiFi:

- Set your computing device to search for available WiFi networks.
- Find the network called "ucd-guest"
- Connect to a browser.
- Follow the self-registration instructions.

Speaker Biographies

Leandro Ravetti

Executive Director, Boundary Bend Limited

Leandro Ravetti graduated as an Agricultural Engineer in Argentina, where he worked for the National Institute of Agricultural Technology in olive production research. He moved to Australia in 2001 where he now leads the Modern Olives technical team, which provides horticultural and olive specific technical advice to olive groves and olive oil processing plants that have planted nearly 3,500,000 trees, representing approximately 60% of the Australian olive industry by production. Leandro has been Executive Director of Boundary Bend Limited, Australia's leading fully integrated olive company, since 2005 and alternate director of the Australian Olive Association since 2009.

Dan Flynn

Executive Director, UC Davis Olive Center

Flynn has guided the UC Davis Olive Center to international leadership in olive research and education. He also oversees the production of UC Davis Olive Oil and other olive products that help support the center. He served 16 years as a legislative and policy consultant in the California State Legislature and also managed a small farm prior to coming to UC Davis. He has a M.A. in Political Science from Rutgers University. Based on his achievements with the Olive Center, Dan has received top staff awards from College of Agricultural and Environmental Sciences and Chancellor Linda Katehi. He has made guest appearances on The Dr. Oz Show, as well as on The Doctors and CNN.

Selina Wang

PhD, Research Director, UC Davis Olive Center

Dr. Wang is the research director of the UC Davis Olive Center and a faculty at the Department of Food Science and Technology. She has a PhD in Organic Chemistry from UC Davis and oversaw the olive center's 2010 and 2011 studies evaluating the quality of extra virgin olive oil in supermarkets, which received worldwide attention. Dr. Wang has developed more than 80 research projects in table olives and olive oil, ranging from international standards, best practices for harvesting/processing/storage, to byproduct management and health effects.

Day 1 Agenda

8:30 A.M.	**Registration**
9:00 A.M.	**Welcome and Overview** Dan Flynn
9:10 A.M.	**5 Things to Know Before Becoming a Miller** Dan Flynn
9:50 A.M.	**Introduction to Olive Oil Production** Leandro Ravetti
10:40 A.M.	**Break**
11:00 A.M.	**Designing a Milling Operation for Maximum Efficiency** Leandro Ravetti
12:00 P.M.	**Lunch**
1:00 P.M.	**A Miller's Guide to Analyzing Olive Oil** Dan Flynn, Selina Wang
1:45 P.M.	**Influence of Agronomic Aspects on Olive Oil Quality** Leandro Ravetti
3:00 P.M.	**Break**
3:15 P.M.	**Receival Area, Fruit Classification, Washing, Storage** Leandro Ravetti
4:00 P.M.	**Adjourn** No-host gathering at City Tavern, 216 F Street, Davis

Day 2 Agenda

8:00 A.M.	**Coffee, Tea, Pastries**
8:30 A.M.	**Crushing, Paste Preparation, Malaxing Temperature & Time** Leandro Ravetti
10:00 A.M.	**Break**
10:30 A.M.	**Crushing, Paste Preparation, Processing Aids** Leandro Ravetti
11:30 A.M.	**Evaluating Fruit and Making Paste Preparation Decisions** Olive2Bottle team; Leandro Ravetti
12:00 P.M.	**Lunch**
1:00 P.M.	**Solid – Liquid Phase Separation** Leandro Ravetti
2:30 P.M.	**Break**
2:50 P.M.	**Liquid – Liquid Phase Separation** Leandro Ravetti
3:30 P.M.	**How Processing Variables Affect Quality** Leandro Ravetti
4:00 P.M.	**Adjourn** No-host gathering at Our House, 808 2nd street, Davis

Day 3 Agenda

8:00 A.M.	**Board Bus and Depart UC Davis**
9:40 A.M.	**Yolo Press (Depart)** Mike Madison
11:30 A.M.	**Bondolio (Depart)** Karen and Malcolm Bond
4:00 P.M.	**Boundary Bend (Depart)** Adam Englehardt and Leandro Ravetti
4:30 P.M.	**Arrive UC Davis**

Day 4 Agenda

8:00 A.M.	**Coffee, Tea, Pastries**
8:30 A.M.	**Storage – Tanks – Buildings** Leandro Ravetti
9:30 A.M.	**How Processing Variables Influence Oil Quality and Yield** Leandro Ravetti
10:15 A.M.	**Break**
10:45 A.M.	**Blending** Leandro Ravetti
12:00 P.M.	**Lunch**
1:00 P.M.	**Economic Analysis** Leandro Ravetti
1:30 P.M.	**Varietal Considerations for Processing: Arbequina as a Case Study** Leandro Ravetti
2:20 P.M.	**Break**
2:40 P.M.	**The Future of Olive Oil Processing – Discussion and Wrap-Up** Dan Flynn, Leandro Ravetti, Selina Wang
4:00 P.M.	**Adjourn, Receive Course Certificates**

Day 1

SEPTEMBER 20 - 23, 2016

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5 THINGS TO KNOW BEFORE BECOMING A MILLER

Dan Flynn, Director, UC Davis Olive Center

1 Get a business plan

Get a business plan

Oliveoilsource.com

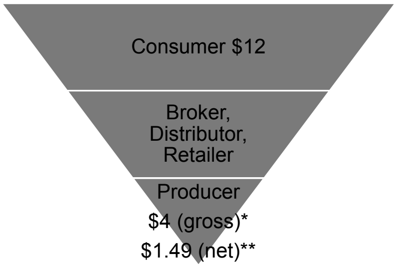
Get a business plan: Goals

- Why do I want to do this?
- What need am I filling?
- What is my business philosophy?
- How do I want my business to evolve?

Get a business plan: Market research

- Cheap, low-quality imports dominate
- Consumers don't know the difference
- Competition is stiff in all channels
- Quality oils gaining momentum
- Expensive oils may collect dust

Get a business plan: Costs and returns



*Oliveoilsource.com and **UC Davis: “Sample Costs to Establish a Medium-Density Olive Orchard and Produce Olive Oil,” 2011

Choose the processing site carefully

- Meet with local officials at the beginning
- Put site in the right place
- Design for expected growth
- Building permits
- Use permits
- Make it easy for local officials
- Waste management plan
- Storm water runoff plan

Think beyond the equipment

- Remember: working capacity = 60 – 75% of rated capacity for decanters
- Consider service responsiveness
- Stock extra parts
- Be prepared when the truck arrives

Food processing carries legal obligations

- Processed food registration
- Food facility registration
- Seller's permit
- Use/tax permit
- Organic registrations
- Farm product handler license
- Weighmaster license

Consider options

- Contract processing
- Co-packing
- Private label
- Work for an existing company

Further research

- Miller’s checklist (on flash drive)
- Olive Center website, “Learn” tab

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'Australia's premier olive company'

Introduction to Olive Oil Production

Olive Oil Processing Course

California, USA – September 2016

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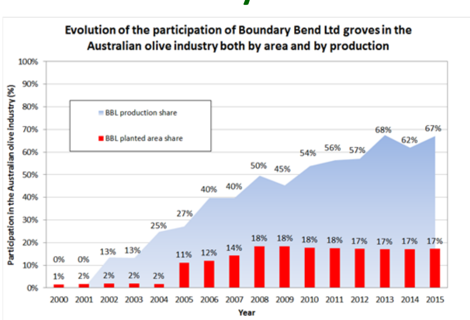

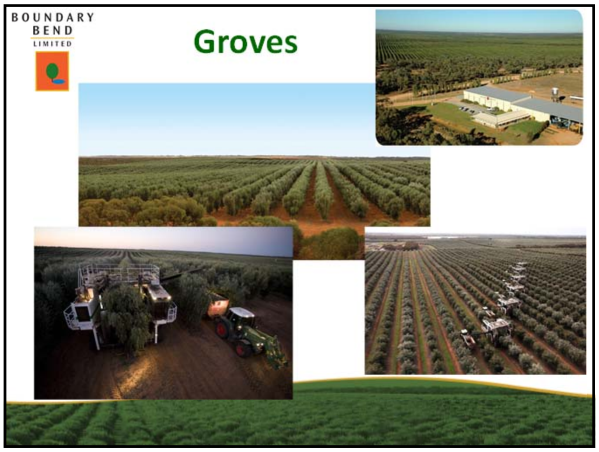
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Groves


BOUNDARY
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Processing


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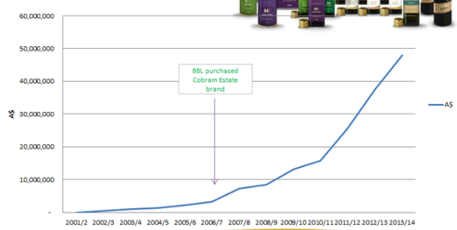
Marketing
Cobram Estate
Australian Extra Virgin
Cobram Estate
Australian Extra Virgin

BOUNDARY BEND LIMITED

Cobram Estate sales evolution



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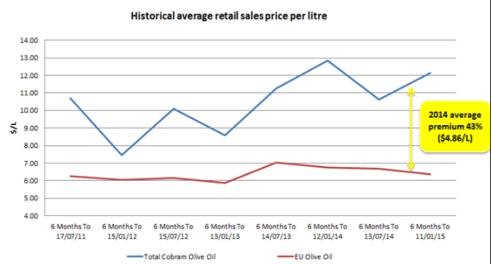
Marketing



Source: IRI Aztec 2015

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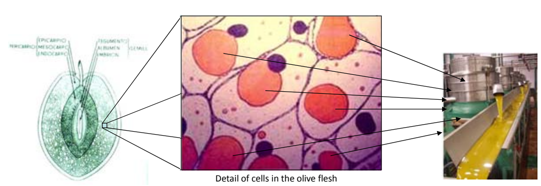
What is olive oil?

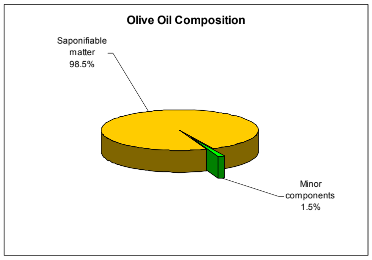
Olive oil is the oil obtained solely from the fruit of the olive tree (Olea europaea L.), to the exclusion of oils obtained using solvents or re-esterification processes and of any mixture with oils of other kinds.



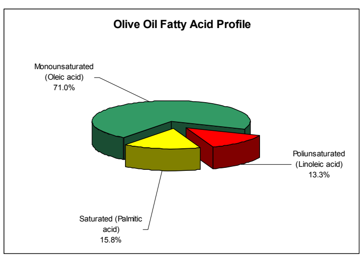
Detail of cells in the olive flesh

Transversal view of an olive

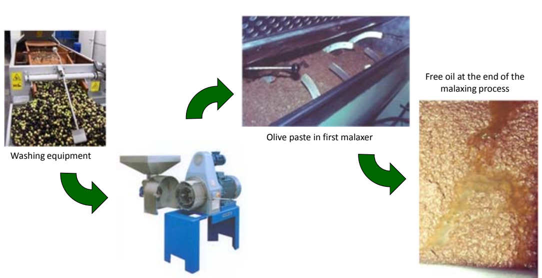
What is olive oil?



What is olive oil?



How is olive oil made?



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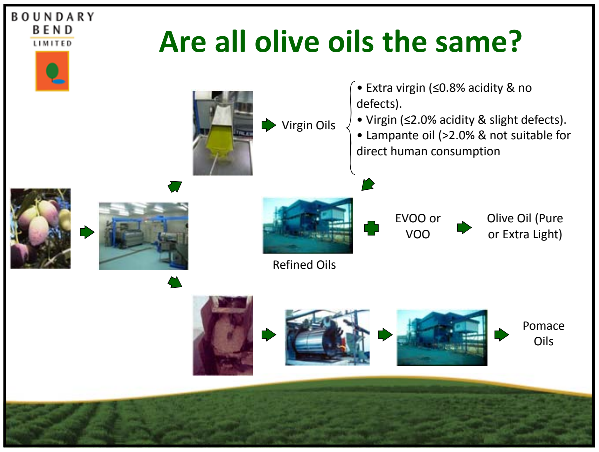
How is olive oil made?
Decanter separating olive oil from paste
FEED
Olive oil storage
Vertical separators clarifying the oil



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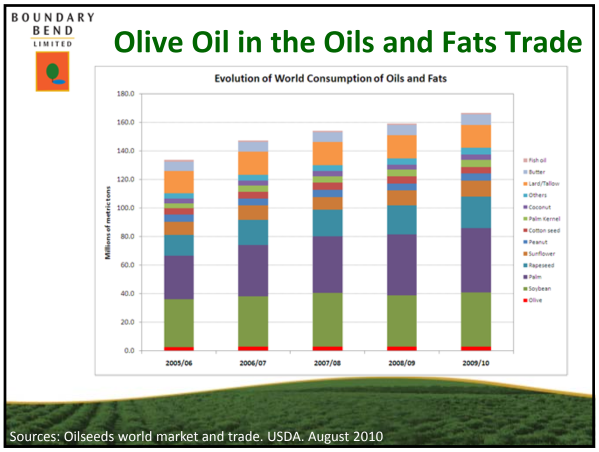
Are all olive oils the same?
Virgin Oils
• Extra virgin (≤0.8% acidity & no defects).
• Virgin (≤2.0% acidity & slight defects).
• Lampante oil (>2.0% & not suitable for direct human consumption
Refined Oils
EVOO or VOO
Olive Oil (Pure or Extra Light)
Pomace Oils



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Olive Oil in the Oils and Fats Trade
Evolution of World Consumption of Oils and Fats
Millions of metric tons
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
2005/06
2006/07
2007/08
2008/09
2009/10
Fish oil
Butter
Lard/Tallow
Others
Coconut
Palm Kernel
Cotton seed
Peanut
Sunflower
Rapeseed
Palm
Soybean
Olive
Sources: Oilseeds world market and trade. USDA. August 2010

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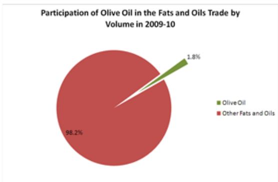
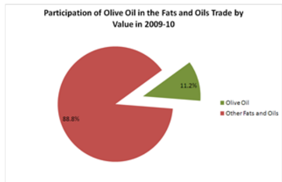
Olive Oil in the Oils and Fats Trade





Sources: Oilseeds world market and trade. USDA. August 2010 & Export Market Research. Caiani & Co. June 2006

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Olive Oil in the Oils and Fats Trade

Why does olive oil outperform other fats and oils by value?

- Health attributes, particularly Extra Virgin (EVOO).
- High production costs (limited mechanisation & low yields).
- Availability (limited olive growing areas in the world).
- Romantic perception of Mediterranean lifestyle.
- Flavour.

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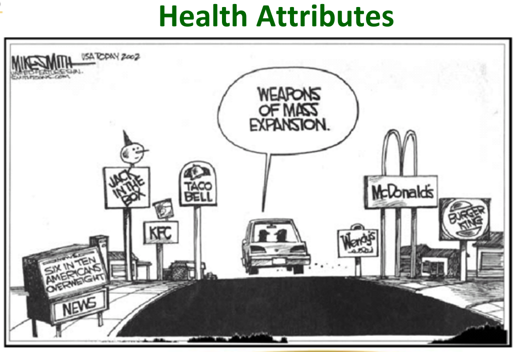
Health Attributes



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Limited Mechanisation

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Low Average World Yields

Great variability in production

Country	Yields (% of world)	Yields (litres/ha)
Spain	38.6%	482.6
Italy	22.8%	483.0
Greece	13.6%	400.8
Turkey	4.3%	218.2
Tunisia	6.2%	119.0
Boundary Bend (average 2015)	0.3%	2,837.0
Average		**318.2**

Source: IOC/FAO/BBL

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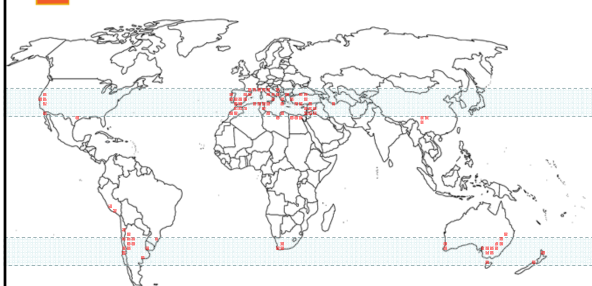
Limited Distribution of Olive Growing Areas



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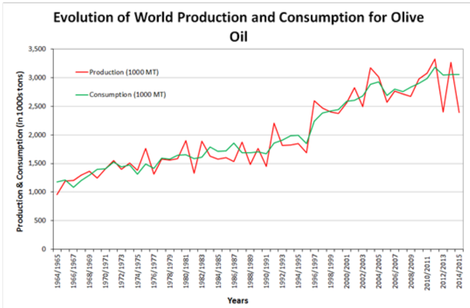
World Production and Consumption



Sources: International Olive Council. 2015.

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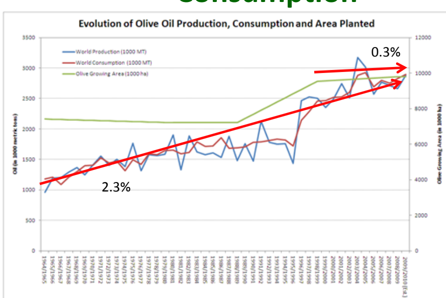
World Production and Consumption



Sources: International Olive Council. 2010; EC Report on Olive Oil. 2008; and Modern Olives.

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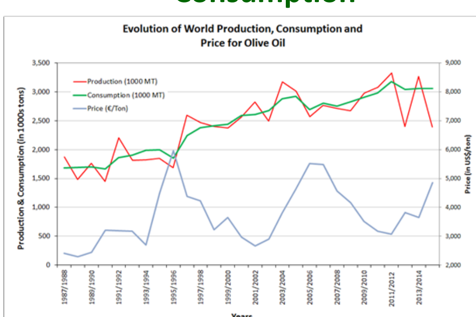
World Production and Consumption



Sources: International Olive Council. 2015; EC Report on Olive Oil. 2008; and Modern Olives.

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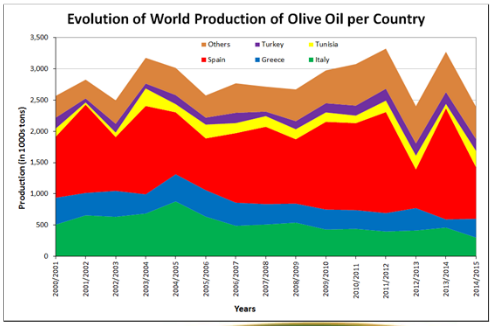
Alternating and Declining Production



Sources: IOC

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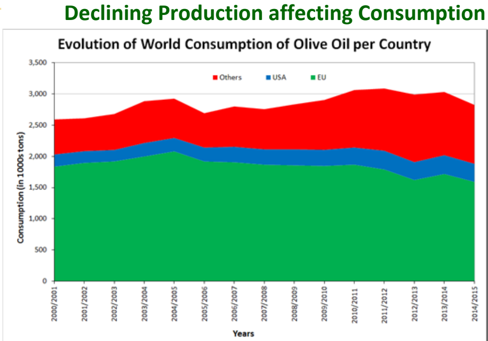
Declining Production affecting Consumption



Sources: IOC

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World Production and Consumption

Analysis of consumption growing trends

Parameter	2009/10	2020/21	Annual Growth	2020/21	Vs. 2009/10
Consumption (x 1000 Tn)	2,897	3,720	2.30%	**3,720**	**-823**
Population (x 1M)	6,869	7,756	1.11%	**3,271**	**-374**
Consumption per capita (kg/person/year)	0.42	0.48	1.18%		

•The world would require between 1,340,000 and 2,950,000 ha of average yields to cover the increasing demand.
•At current planting rates, world area under olives will grow only up to 330,000 ha.

Sources: International Olive Council; US Census Bureau

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Olive Oil Trade

Why did olive oil price, particularly EVOO, remain relatively low for a long period of time?

- Heavily subsidised industry.
- High concentration of demand and very atomised offer.
- Lack of financial resources amongst suppliers.
- Mislabelling and adulteration.

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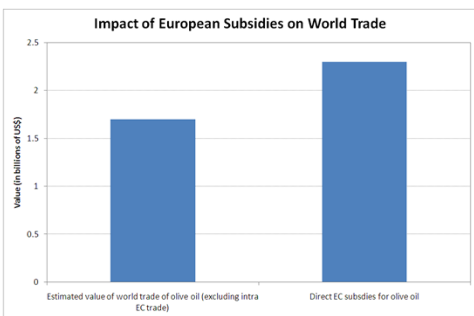
Olive Oil Subsidies



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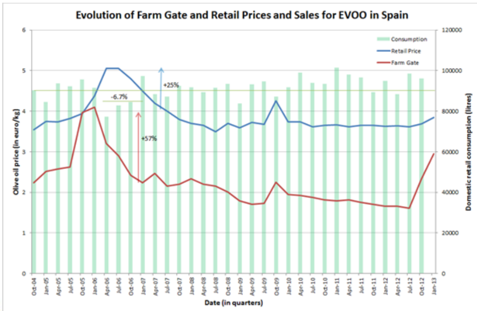
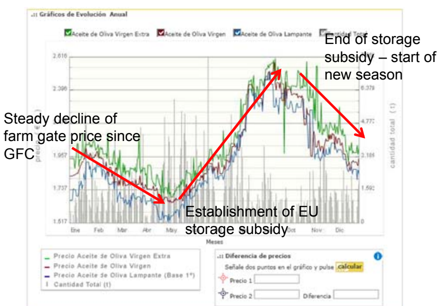
Concentration of demand and atomised offer

- 70 to 75% of the world's bottled olive oil is sold by 6 companies (DeOleo (Bertolli, Carbonell, Carapelli, Koipe); Sovena Group (East Coast Olive Oil, Agribética, ALCO); Ybarra Group (Ybarra, MiGaSa, Heinz); Aceites del Sur (CooSur, La Española); Hojiblanca (+Cargill); and Borges.
- There is a declared amount of approximately 2.5M growers in Europe at an average of 2.1 ha per grower.
- There are close to 11,000 declared processing plants in Europe at an average of just 192 tonnes of oil/processing plant.

Concentration of demand and atomised offer

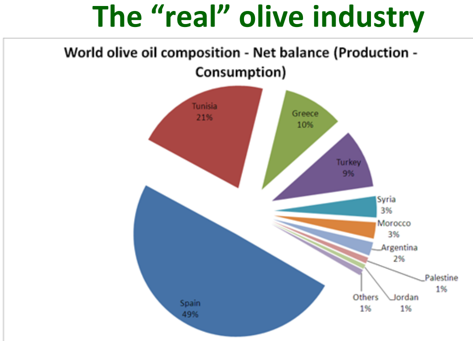


Access to Finance (2009 example)



Source: www.poolred.com & www.elolivar.blogspot.com

The "real" olive industry



Source: IOC/FAO

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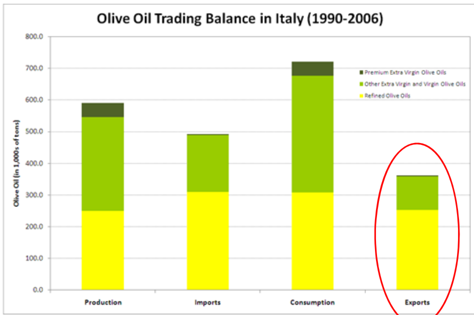
The “real” olive industry



Source: IOC & ISMEA

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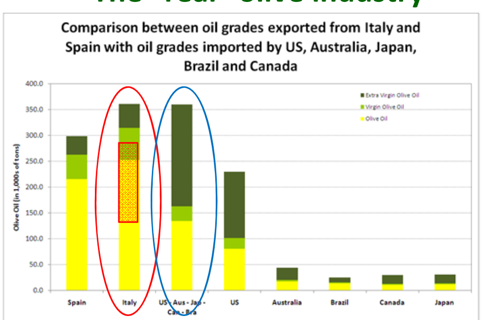
The “real” olive industry



Source: IOC; ISMEA; El Cultivo del Olivo; Caiani & co.

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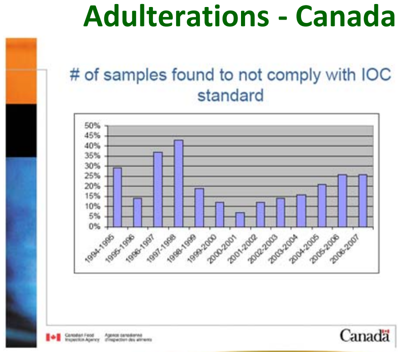
Adulterations - Canada



Sources: Surveillance and Analysis of Olive oil in Canada, Angela Sheridan, 2008

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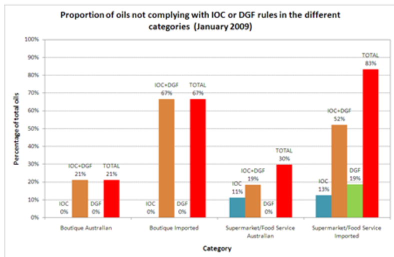
Adulterations - Australia



Sources: Choice Magazine 2010; RIRDC report on New Testing Methods for Olive Oil 2009.

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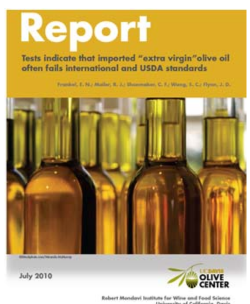
Adulterations - USA



Sources: UC Davis Report, 2010 & Slippery Business by Tom Mueller, 2007.

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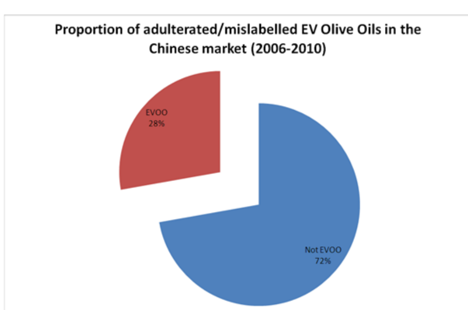
Adulterations - China



Sources: Modern Olives, 2006-2010.

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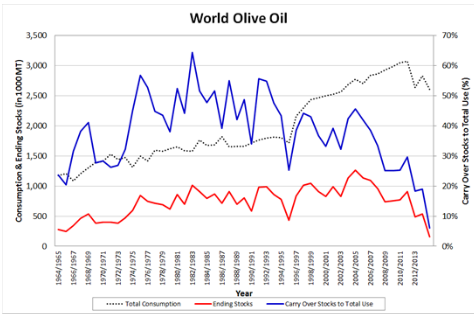
What is happening right now?



Sources: AAO & Modern Olives.

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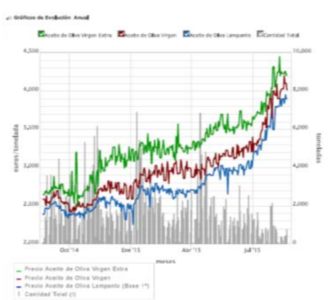
What is happening right now?



Sources: PoolRed.

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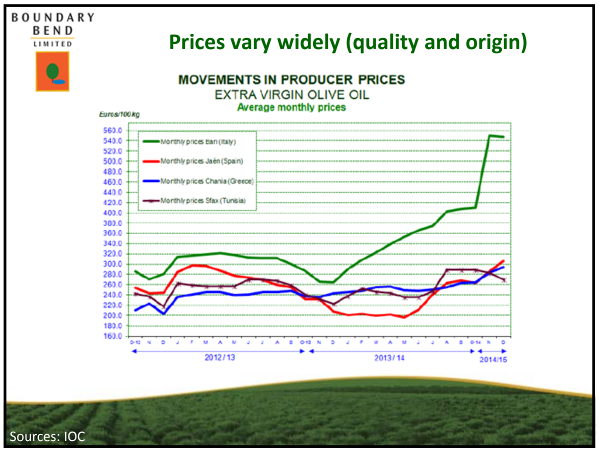
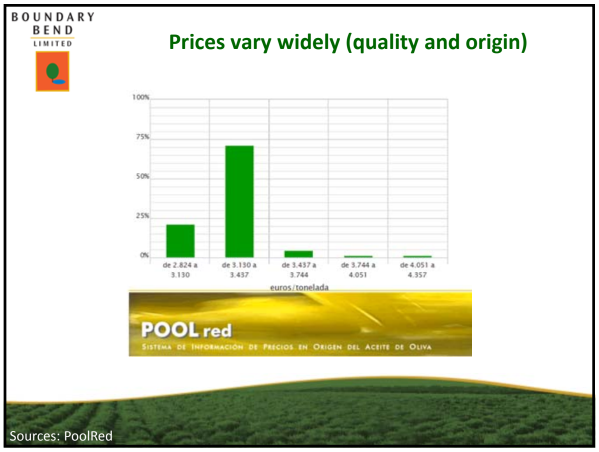
What is happening right now?

Sources: PoolRed.





Oli Dop- Prezzi medi settimanali

PRODOTTO	ANNO-MESE-SETT.	PREZZO	VARIAZ. SU SETT. PREC.	VARIAZ. SU SETT. ANNO PREC.	GRAFICO
Olio dop - Alto crotonese	2015-1-5	7,80 €/Kg	0,0%	85,7%	
Olio dop - Brisighella	2015-1-5	19,75 €/Kg	0,0%	9,7%	
Olio dop - Canino	2015-1-5	9,00 €/Kg	0,0%	16,9%	
Olio dop - Cilento	2015-1-5	6,60 €/Kg	0,0%	nd	
Olio dop - Colline Salernitane	2015-1-5	7,50 €/Kg	0,0%	70,5%	
Olio dop - Dauno	2015-1-5	6,05 €/Kg	2,5%	65,8%	
Olio dop - Garda	2015-1-5	19,50 €/Kg	0,0%	110,8%	
Olio dop - Laghi Lombardi	2015-1-5	18,00 €/Kg	0,0%	24,1%	
Olio dop - Lametia	2015-1-5	8,10 €/Kg	0,0%	100,0%	
Olio dop - Monte Etna	2015-1-5	7,05 €/Kg	0,0%	nd	
Olio dop - Monti Iblei	2015-1-5	7,80 €/Kg	0,0%	15,6%	
Olio dop - Riviera dei fiori	2015-1-5	12,50 €/Kg	0,0%	28,2%	
Olio dop - Riviera Ligure	2015-1-5	11,75 €/Kg	0,0%	20,5%	
Olio dop - Terre di Bari	2015-1-5	6,05 €/Kg	0,0%	113,0%	
Olio dop - Terre di Siena	2015-1-5	10,75 €/Kg	0,0%	51,4%	
Olio dop - Umbria	2015-1-5	8,75 €/Kg	0,0%	16,7%	

BOUNDARY BEND LIMITED

Health and Quality have been the growth drivers for olive oil

- PODs for EVOO grew from 7 to 98 in 10 years.
- Volume of oil sold under PODs grew from 250k to more than 40M litres.

BOUNDARY BEND LIMITED

Health and Quality have been the growth drivers for olive oil

BOUNDARY BEND LIMITED

Health and Quality have been the growth drivers for olive oil

There are more than 1,000 specialty olive oil stores in the USA at the moment. There were less than 10 eight years ago.

OLIVE OIL PROCESSING COURSE

modern olives

OLIVE OIL PROCESSING COURSE

Designing a milling operation for maximum efficiency

General Considerations

- Access to road.
- As close to production as possible.
- Access to electricity.
- Water availability.
- Access to staff.
- Waste management and environmental considerations (Natural drainage and distance from town).
- Timing!

General Considerations

Receival Area

- Easy to unload deliveries.
- Easy to clean.
- Well designed drainage system.
- Easy to access fruit loads for inspection/sampling.
- Adequate capacity.
- Visual access from main room.

Fruit receival

Fruit receival

Washing

Washing

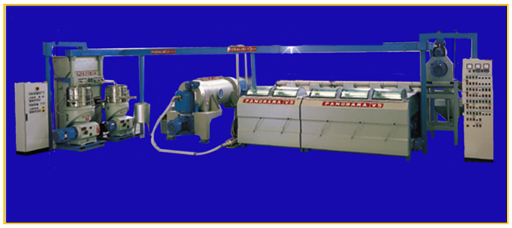
Fruit Storage

Processing Area

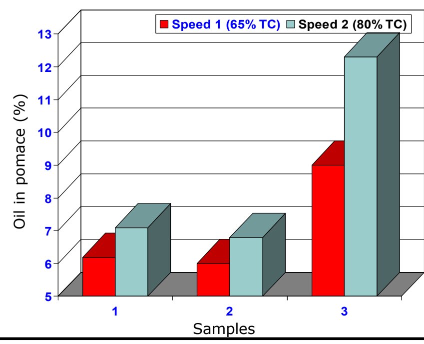
- Insulated.
- Protected electric illumination.
- Well designed drainage system.
- Air ventilation.
- Visual contact from office and with receival area.

Malaxing

Malaxing



Decanter capacity and efficiency



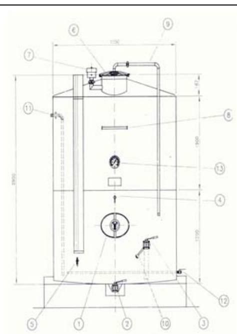
Oil Storage

- Temperature: 15 (59ºF) – 18ºC (64ºF)
- No light.
- Settlings drained regularly.
- Nitrogen.

Oil Storage Area

- Insulated.
- Electric illumination only.
- Well designed drainage system.
- Temperature control system.
- Secure.

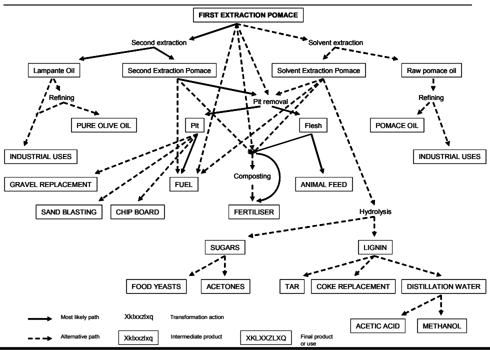
The Tank



Quality Control

Quality Control

Waste Disposal



Waste Disposal

Water Requirements

Measurements	Extraction system		
	Press	Centrifugation	
		3 phases	2 phases
Olive washing (l/kg)	0.04	0.09	0.05
Decanter (l/kg)	0.40	0.90	0.00
Centrifuge (l/kg)	0.20	0.20	0.15
General cleaning (l/kg)	0.02	0.05	0.05
Total (l/kg)	0.66	1.24	0.25

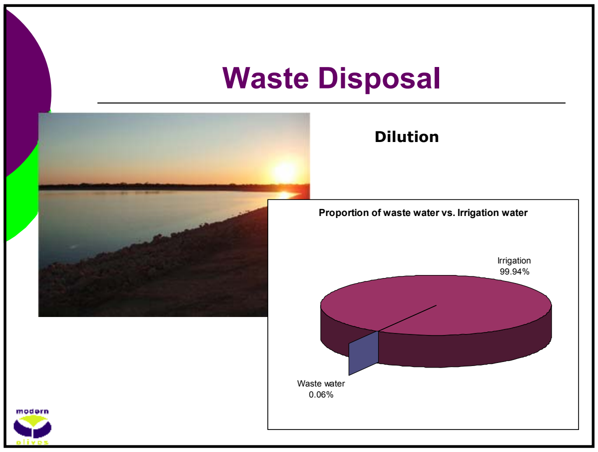
Waste Disposal

Water Characteristics

Measurements	Processing system					
	3 phases			2 phases		
	Solids	Oil %	Oxygen Demand	Solids	Oil %	Oxygen Demand
Olive washing	0.51 %	0.14 %	7.9 g/kg	0.54 %	0.10%	8.7 g/kg
Water centrifuge	6.24 %	0.96 %	73.8 g/kg	0.00 %	0.00 %	0.0 g/kg
Oil centrifuge	0.00 %	0.00 %	0.0 g/kg	1.43 %	0.57 %	11.7 g/kg
Final stream	5.67 %	0.88 %	67.2 g/kg	1.08 %	0.38 %	10.5 g/kg

Waste Disposal

Water Recycling


Waste Disposal
Dilution
Proportion of waste water vs. Irrigation water
Irrigation
99.94%
Waste water
0.06%


Waste Disposal
Pit Separation


Waste Disposal
Second Extraction

Waste Disposal

Nutritional Value

	Lucerne hay	Pasture hay	Wheat	Wet pomace flesh
Dry matter	90%	88%	90%	18.75%
Crude Protein	17%	6%	13%	2.6%
Energy (Mj/kg)	8.50	8.30	12.00	4.20
Moisture penalty	11.11	11.36	11.11	53.33
Prot. based cost	0.65	1.89	0.85	20.51
Energy based cost	1.31	1.37	0.93	12.70
Overall cost	0.98	1.63	0.89	16.61
Cost index vs wet pomace flesh	16.94	10.18	18.65	1.00

Waste Disposal

- **Fertiliser.**
- **Compost.**
- **Co-generation of electricity.**

A MILLER'S GUIDE TO ANALYZING OLIVE OIL

Dr. Selina Wang, Chemist, UC Davis Olive Center
Dan Flynn, Director, UC Davis Olive Center

Grades and standards: two types of oil

Olive oil is the oil solely obtained from the fruit of the olive tree, to the exclusion of oils obtained with solvents.

Olive-pomace oil is the oil obtained by treating olive pomace with solvents.

Classifications

A. **Virgin olive oil**
B. **Refined olive oil** (virgin that is refined)
C. **Olive oil** (mostly refined with bit of virgin)
D. **Olive-pomace oil** (mostly refined olive-pomace oil, with bit of virgin)

Grades available in US

Extra Virgin Olive Oil

Refined Olive Oil ***(Light, Extra Light)***

Olive Oil ***(Pure)***

Olive-Pomace Oil

Chemistry

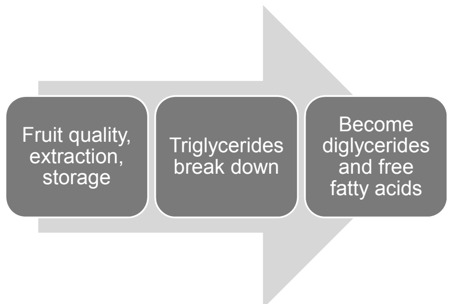
	TESTS	INDICATORS
Quality	Free Fatty Acidity Peroxide Value UV Absorbency DAGs PPP	Oxidation, fermentation, hydrolysis
Purity	Fatty Acid Profile Trans-fatty Acid Profile Sterol Profile Stigmastadiene Content Triacylglycerol Content Wax Content Unsaponifiable Matter Content of 2-glyceryl Monopalmitate	Whether the oil is olive oil

Chemistry quality standards

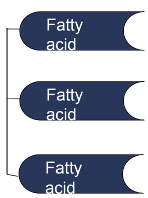
Grade	Free Fatty Acidity	Peroxide Value	UV K232	UV K270	UV ΔK	DAGs	PPP
Extra Virgin	≤0.8	≤20	≤2.50	≤0.22	≤0.01	≥35	≤17
Virgin	≤2.0	≤20	≤2.60	≤0.25	≤0.01		
Ordinary	≤3.3	≤20		≤0.30	≤0.01		
Lampante	>3.3	No limit					

IOC standards, except for DAGs and PPP (Australia and California)

Free fatty acids

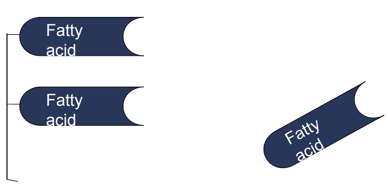


Hydrolysis



Triglyceride

Hydrolysis

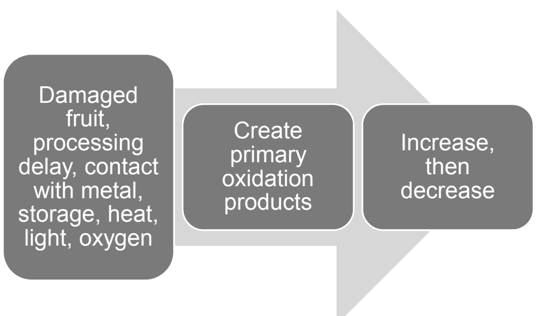


Diglyceride Free Fatty Acid

Free fatty acids

- No taste
- Pro-oxidant
- A quick test to assess initial oil quality
- Every batch should be tested during processing
- Changes very little after oil is produced, under proper storage conditions
- Fresh oil: ≤ 0.3%
- IOC standard: ≤ 0.8%

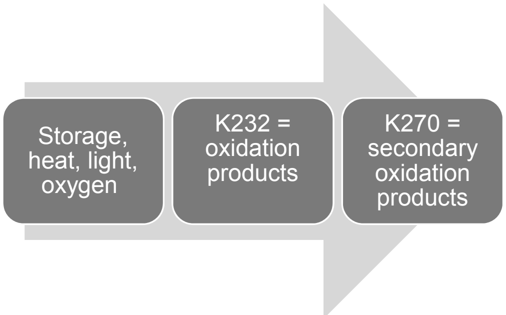
Peroxide value



Peroxide Value

- Crude method on primary oxidation
- Provides limited information on the oil's condition after storage/bottling
- Every batch should be tested during processing
- Fresh oil: ≤ 9 meq O_2/kg
- If more than 10 meq O_2/kg right after processing -> short shelf life
- IOC Standard: ≤ 20 meq O_2/kg

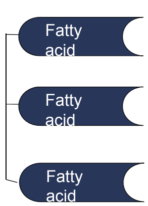
UV Absorbance



UV Absorbance

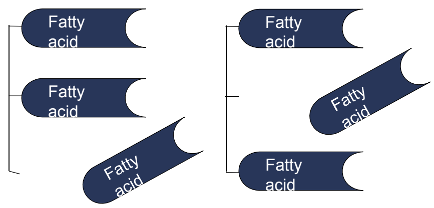
- Increases due to oxidation or refining process
- Increases with heat, light and oxygen
- Generally correlates with peroxide value
- Cannot be used alone but useful when combining with other chemical parameters

DAGs (Diacylglycerols)

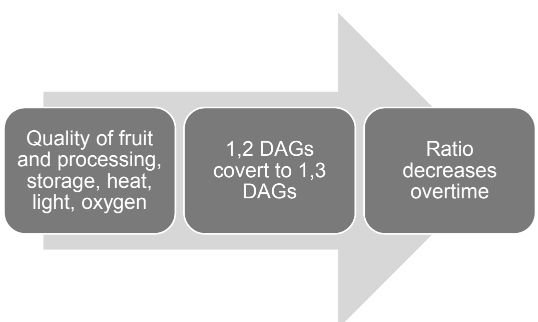


Triglyceride

DAGs (Diacylglycerols)



DAGs



DAGs

- Freshness indicator
- Fresh oil: > 75%
- Low values are associated with bad quality fruit and processing
- Decreases in storage over time, especially with high storage temp and high free fatty acidity
- IOC Standard: None
- Australia and California Standard: 35

PPP (pyropheophytin)

- Heat, light, oxygen
- Chlorophyll converts to pheophytin then pyropheophytin
- Ratio increases overtime

PPP

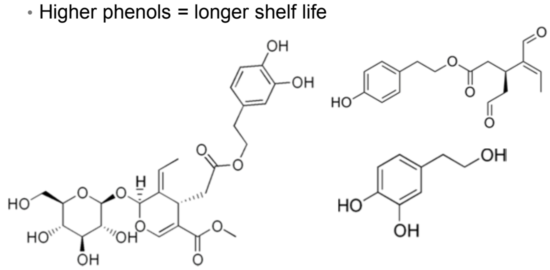
- Freshness indicator
- Fresh oil: < 3%
- Increases in storage over time, especially with high storage temp and exposure to light
- With time and in refining, PPP disappears completely

Phenols

- Water-soluble compounds in olives
- Processing extracts a portion into the oil
- Impact flavor and protect oil from oxidation

Phenols

- Phenols are the reason olive oil is good for you
- High phenols = high bitterness and pungency?
- Higher phenols = longer shelf life



Sensory standards of virgin olive oils

Grade	IOC	USDA/Codex
Extra Virgin	Defects = 0 & Fruity > 0	Defects = 0 & Fruity > 0
Virgin	Defects > 0 ≤ 3.5 & Fruity > 0	Defects > 0 ≤ 2.5 & Fruity > 0
Ordinary	Defects > 3.5 ≤ 6.0 & Fruity > 0, or Defects ≤ 3.5 & Fruity = 0	
Lampante	Defects > 6.0	Defects > 2.5

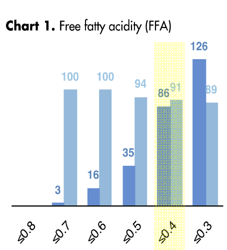
Causes of sensory defects

Cause	Defect
Fruit condition	Rancid Fusty Winey/Vinegary Musty Frozen Dried Grubby
Processing/Storage	Rancid Metallic Heated/Burnt Muddy Sediment

Relationship of sensory and chemistry

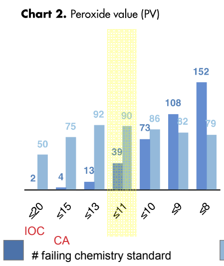
260 samples
141 failed sensory

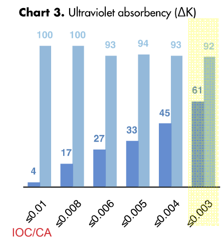
- # failing chemistry standard
- % also failing sensory standard



Source: UC Davis Olive Center, *Correlating Olive Oil Sensory and Chemistry Results*, 2014

Relationship of sensory with chemistry

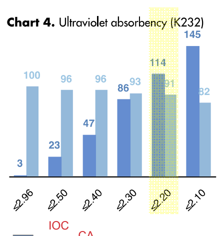


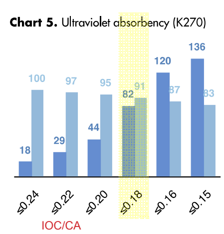


\# failing chemistry standard   % also failing sensory standard

Source: UC Davis Olive Center, *Correlating Olive Oil Sensory and Chemistry Results*, 2014

Relationship of sensory and chemistry

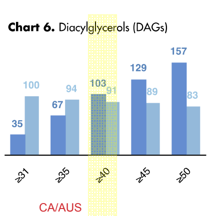


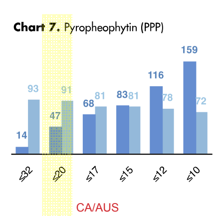


\# failing chemistry standard   % also failing sensory standard

Source: UC Davis Olive Center, *Correlating Olive Oil Sensory and Chemistry Results*, 2014

Relationship of sensory and chemistry





\# failing chemistry standard   % also failing sensory standard

Source: UC Davis Olive Center, *Correlating Olive Oil Sensory and Chemistry Results*, 2014

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modern olives

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Influence of Agronomic Aspects on Olive Oil Quality

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Agronomic Aspects

Factors which are difficult to change:

- Variety.
- Environmental conditions.

Factors which are easier to manipulate:

- Pests & diseases.
- Irrigation.
- Harvest & transport.
- Pruning.
- Fertilisation.

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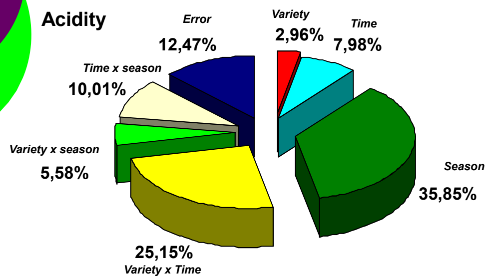
Acidity



Marino Uceda – Australia 2005

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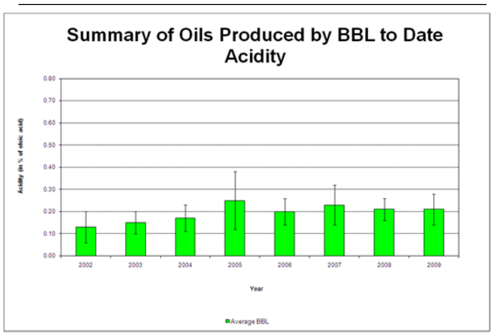

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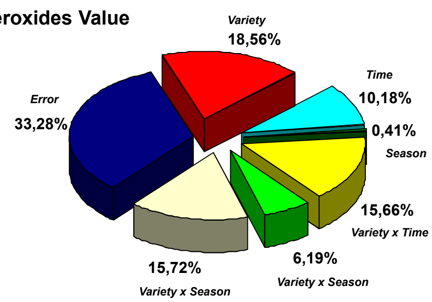
Peroxides Value



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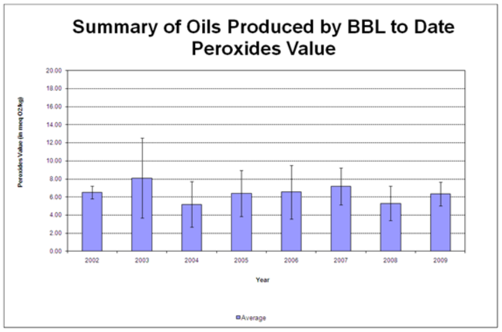

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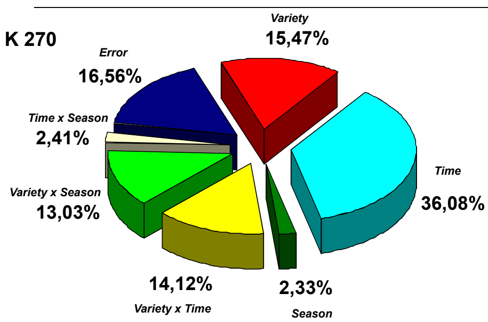

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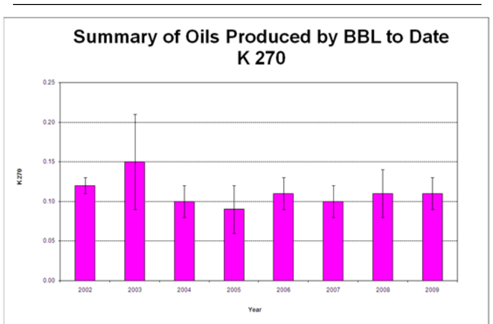

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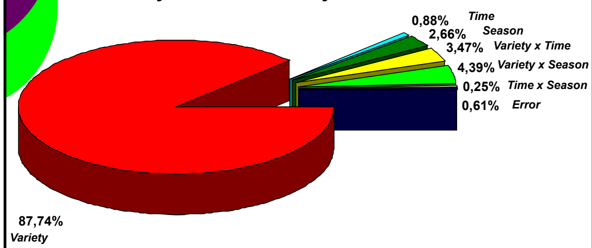
Mono/Polyunsaturated Fatty Acids



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SUMMARY OF OILS PRODUCED AT BOORT AND BOUNDARY BEND TO DATE

Fatty Acid Profile

Variety	Fatty Acid Profile														
	C14:0	C16:0	C16:1	C17:0	C17:1	C18:0	C18:1	C18:2	C18:3	C20:0	C20:1	C22:0	C22:1	C24:0	C24:1
Arbequina Average	<0.1	14.8	1.7	0.1	0.2	1.7	70.4	9.7	0.8	0.4	0.2	0.1	< 0.1	0.1	< 0.1
Arbequina Std. Dev.	0.0	0.3	0.5	0.0	0.1	0.1	3.6	2.9	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Barnea Average	< 0.1	11.7	0.9	0.1	0.1	2.1	72.2	11.4	0.7	0.4	0.3	0.1	< 0.1	0.1	< 0.1
Barnea Std. Dev.	0.0	1.1	0.1	0.0	0.0	0.2	3.3	2.5	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Coratina Average	< 0.1	11.9	0.5	0.1	0.1	1.9	76.5	7.1	0.8	0.4	0.4	0.1	< 0.1	0.1	< 0.1
Coratina Std. Dev.	0.0	0.8	0.1	0.0	0.1	0.1	0.6	0.9	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Frantoio Average	< 0.1	14.2	1.2	< 0.1	0.1	1.7	70.2	11.2	0.7	0.3	0.5	0.1	< 0.1	0.1	< 0.1
Frantoio Std. Dev.	0.0	1.2	0.2	0.0	0.0	0.2	2.8	1.7	0.1	0.1	0.8	0.0	0.0	0.0	0.0
Koroneiki Average	< 0.1	11.3	0.9	0.1	0.2	2.2	77.4	6.4	0.7	0.4	0.3	0.1	< 0.1	0.1	< 0.1
Koroneiki Std. Dev.	0.0	1.3	0.1	0.0	0.1	0.4	2.8	1.8	0.1	0.1	0.1	0.1	0.0	0.0	0.0
Leccino Average	< 0.1	13.5	1.2	< 0.1	0.1	1.8	73.9	8.0	0.7	0.3	0.3	0.1	< 0.1	0.1	< 0.1
Leccino Std. Dev.	0.0	0.9	0.1	0.0	0.0	0.1	1.7	1.9	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Picholine Average	< 0.1	13.0	1.0	0.1	0.1	2.1	71.0	11.0	0.9	0.4	0.3	0.1	< 0.1	0.1	< 0.1
Picholine Std. Dev.	0.0	1.3	0.3	0.0	0.0	0.4	3.9	4.2	0.1	0.0	0.1	0.0	0.0	0.0	0.0
Picual Average	< 0.1	11.9	1.0	0.1	0.1	2.8	77.6	5.1	0.8	0.3	0.3	0.1	0.1	0.1	< 0.1
Picual Std. Dev.	0.0	1.5	0.2	0.0	0.0	0.3	4.0	2.9	0.1	0.1	0.1	0.0	0.0	0.0	0.0

Australian Values*

Parameter	Fatty Acid Profile											
	C14:0	C16:0	C16:1	C17:0	C17:1	C18:0	C18:1	C18:2	C18:3	C20:0	C20:1	C22:0
Average	< 0.1	12.7	1.1	0.05	0.1	1.9	73.6	9.2	0.7	0.3	0.3	0.09
Minimum	< 0.1	6.8	0.3	0.02	0.04	1.1	52.2	2.2	0.3	0.2	0.05	0.04
Maximum	< 0.1	20.3	4.1	0.2	0.3	3.8	84.2	23.8	1.7	0.5	0.5	0.2

*Based on the publication 'The Natural Chemistry of Australian Extra Virgin Olive Oil'

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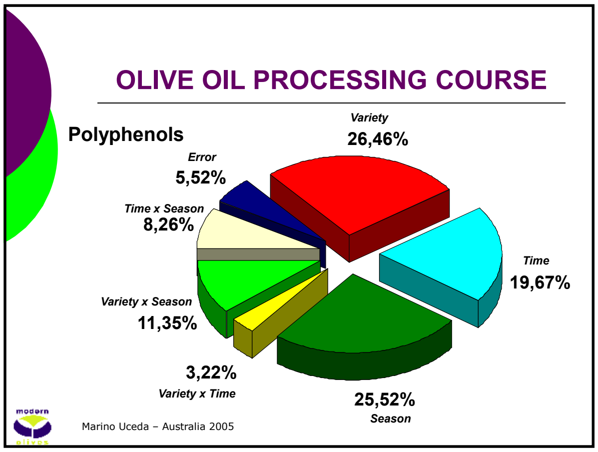
Arbequina Fatty Acid Profile in different environments

Place/Fatty Acids	C 16:0	C 18:1	C 18:2
La Rioja (Argentina)	20	52	21
Andalusia (Spain)	16	65	13
Catalonia (Spain)	13	72	10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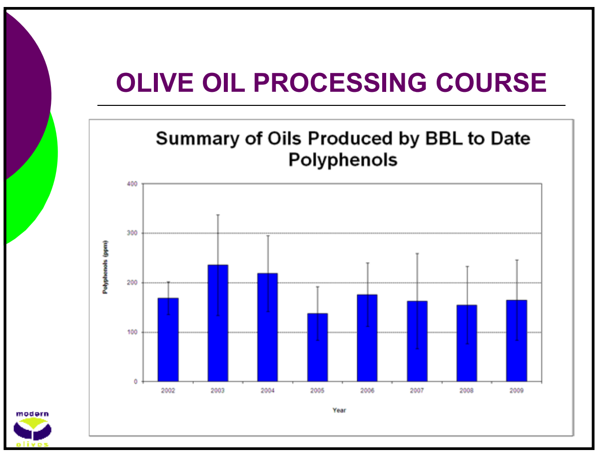
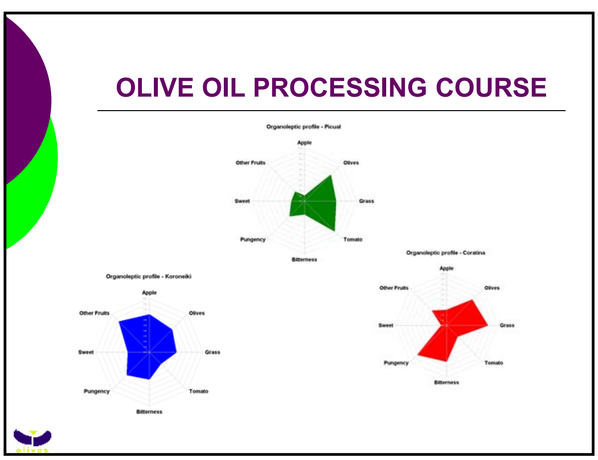
Polyphenols
Variety
26,46%
Error
5,52%
Time x Season
8,26%
Time
19,67%
Variety x Season
11,35%
3,22%
Variety x Time
25,52%
Season
Marino Uceda – Australia 2005


OLIVE OIL PROCESSING COURSE
Summary of Oils Produced by BBL to Date
Polyphenols
Polyphenols (ppm)
400
300
200
100
0
2002
2003
2004
2005
2006
2007
2008
2009
Year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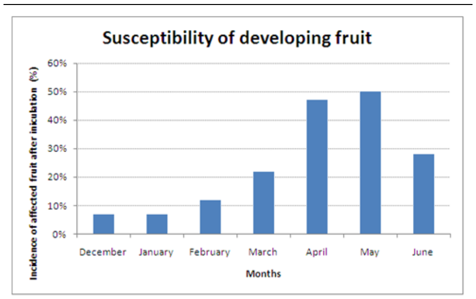
Organoleptic profile - Picual
Organoleptic profile - Koroneiki
Organoleptic profile - Coratina
Apple
Olives
Grass
Tomato
Bitterness
Pungency
Sweet
Other Fruits

Anthracnose (Soft Nose)

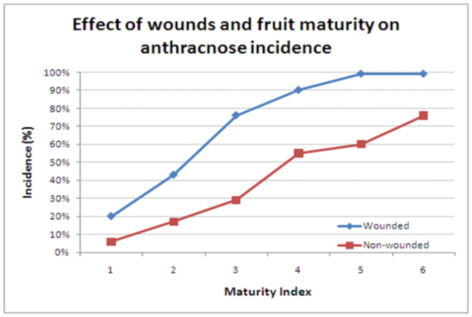
Soft Nose

- Sphaeropsis dalmatica.
- Gloeosporium olivarum.
- Alternaria sp.
- Fusarium sp.
- Cladosporium sp.
- Penicillium sp.

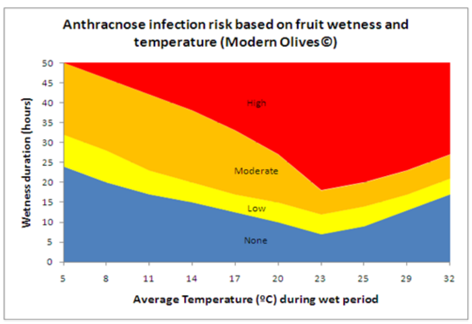
Soft Nose



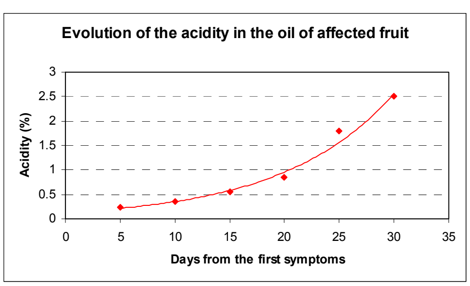
Soft Nose



Soft Nose



Soft Nose



Soft Nose

- Planting resistant varieties (like Picual). Manzanillo, Frantoio and Barnea are considered to be highly sensitive to this kind of diseases;
- Chemical control with fungicides early in the ripening period, particularly if there has been some kind of physical damage (like hail). The most recommended fungicides in the Mediterranean area are copper-containing fungicides such as 0.4% mixtures of copper oxychloride (37.5%) and zineb (15%) and 2% Bordeaux mixture.
- Repeating the chemical control if the environmental conditions are suitable for secondary infections (73ºF (59ºF-77ºF), high humidity & free water (Rain or dew);
- Harvesting as soon as possible, once the oil is completely accumulated.
- Withholding periods!

Frost Damage

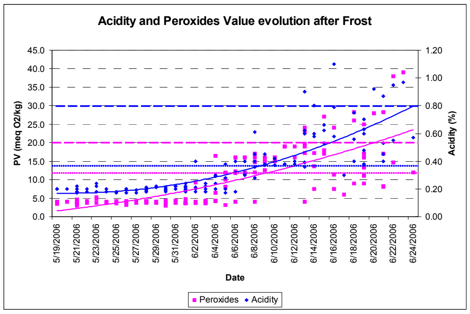
Frost Damage

• Sudden cold change will turn the olives into a brownish colour.

• Gradual cold change could lead to olive dehydration (Reversible or not).

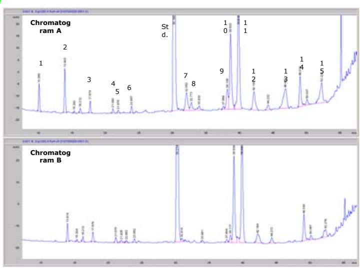
• Both will affect the organoleptic characteristics of the oil, its acidity and peroxides value.

Frost Damage



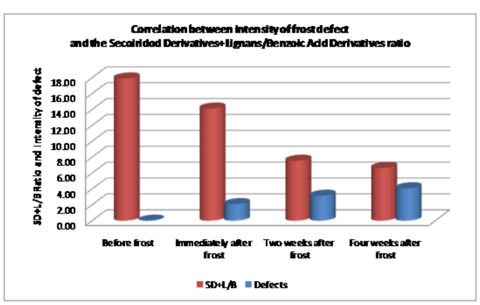
Frost Damage

HPLC chromatograms at 280 nm of phenolic extracts from before frost oil (A) and 4 weeks after frost (B)



1.Hydroxytyrosol; 2.Tyrosol; 3.Vainillic acid; 4.Vanillin; 5.p-coumaric acid; 6-Hydroxytyrosyl acetate; 7.DDOA; 8.DAO; 9. DLA; 10. Pinoresinol; 11.Cinnamic acid; 12. Luteolin; 13. AOA; 14. Apigenin; 15. ALA

Frost Damage



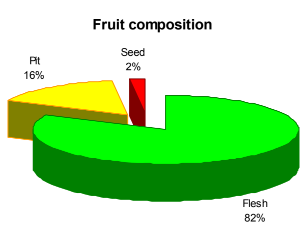
Frost Damage

- No significant problems with chemical quality parameters up to 2-3 weeks after frost event.
- Chemical parameters significantly affected but within the EV category 4 weeks after frost event.
- Peroxides above EV limits 5 weeks after frost event.
- Acidity above EV limits 6 weeks after frost event.
- Organoleptic issues almost immediate.

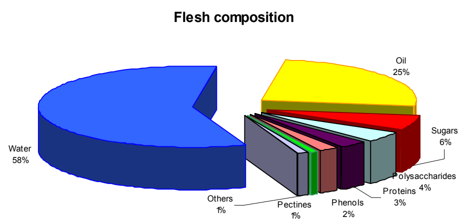
Frost Damage

- Frost fans.
- Harvest immediately.
- Frantoio first, Barnea second and then Picual.
- Low areas first.
- Crush with large grids and low temperatures in the malaxer.
- Deodorization.

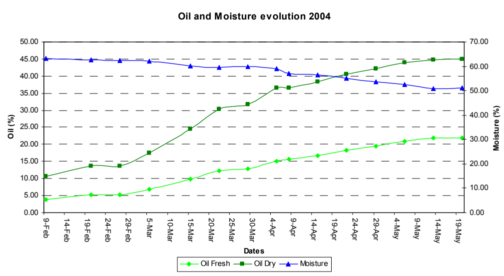
Fruit and moisture levels



Fruit and moisture levels



Fruit and moisture levels



Fruit and moisture levels

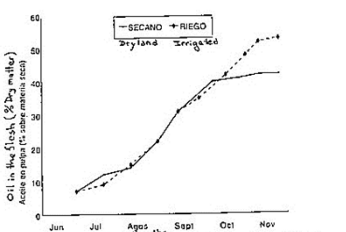
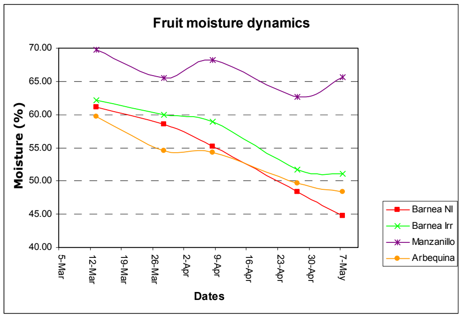
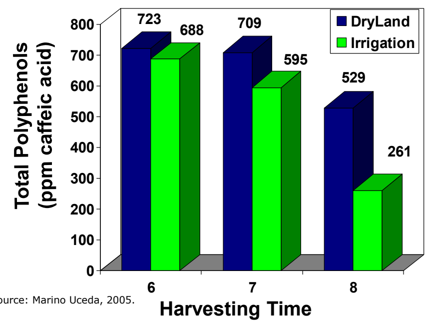


Figura 6.5. Acumulación del aceite (sobre materia seca) en la pulpa de frutos de 'Barnea' procedentes de olivos regados y no regados (Elaboración propia en base a datos de Lavee y Wodner, 1991).

Fruit and moisture levels

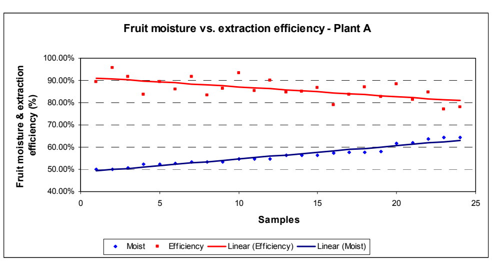


Fruit and moisture levels

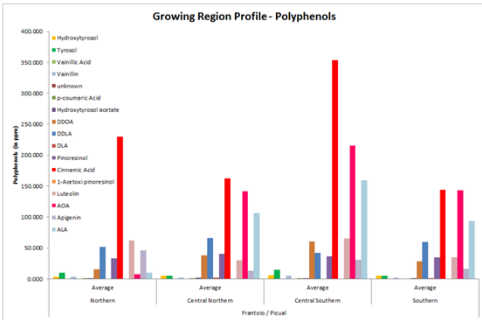


Source: Marino Uceda, 2005.

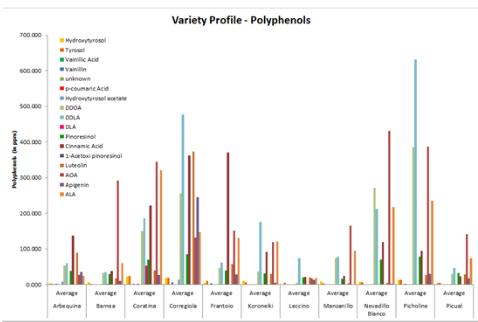
Fruit and moisture levels



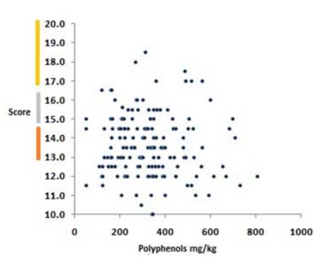
Polyphenols and oil quality



Polyphenols and oil quality



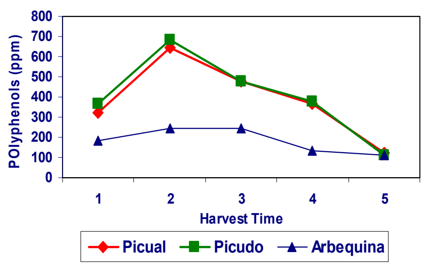
Polyphenols and oil quality



Graph produced by Richard Gawel with data from Australian Shows

Maturity Index

Maturity Index



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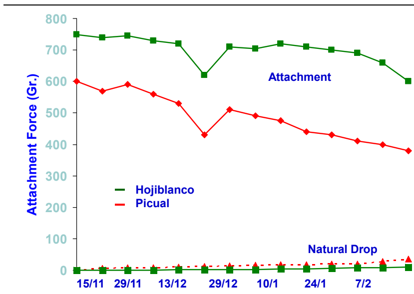
Maturity Index



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Maturity Index

Chlorophylls ↓ Polyphenols ↓

Carotenoids

Flavour	→	Sweeter
Colour	→	Green to Yellow
Shelf Life	→	Lower
Natural Drop	→	Higher

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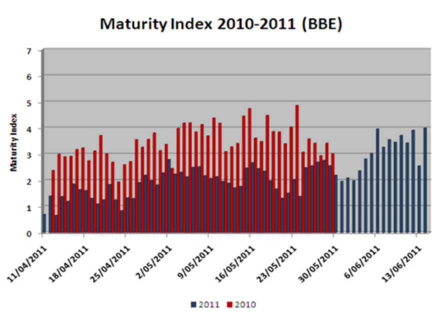
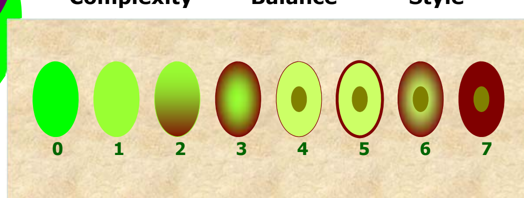
Maturity Index



Maturity Index

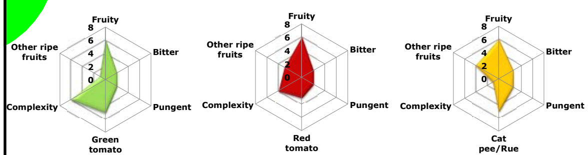
Complexity **Balance** **Style**



Maturity Index

Picual – Central & North Victoria

Early harvest	Mid to late harvest	Extremely late harvest



Single side shakers

Single side shakers

Side by side shakers

Grape harvesters

Gregoire 133

Straddle Harvesters with Ag Right heads

Straddle Harvesters with Ag Right heads

Colossus

Colossus

Harvester Performance
Fruit damage

Average oil acidity vs. harvester (Olive West)

Harvester	Acidity (%)
Ag-Right Heads	0.31
AOH Shaker + beaters	0.28
Colossus	0.22
Grape Harvester	0.20
Gregoire 133	0.31
Hand harvest	0.13
Sicma shaker + pneumatic rakes	0.56
Sicma shaker	0.13

Harvester Performance
MOO

PHOTO CHART FOR MATERIALS OTHER THAN OLIVES (MOO)
CLASIFICATION AT FRUIT RECEIVAL

MOO: 0 (<2.5% MOO)

MOO: 1 (2.5% – 7.5% MOO)

MOO: 2 (7.5% - 12.5% MOO)

MOO: 3 (12.5% - 17.5% MOO)

Harvester Performance MOO

MOO vs. harvester (Boort Estate)

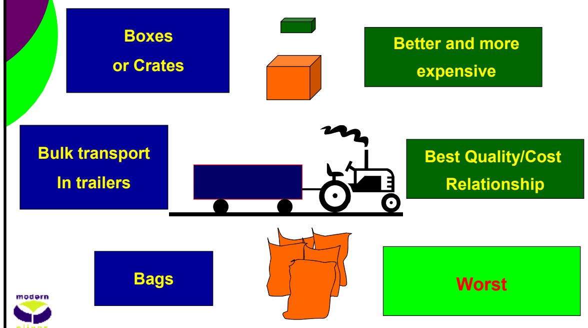
Harvester	MOO	MOO %
Grape Harvester	1.54	7.70
Gregoire 133	1.78	8.90
Coffee Harvester	1.59	7.95
Side by side shaker	1.56	7.80
Colossus	1.48	7.40

Materials Other than Olives (MOO)

Optimal:	< 5.0% (0-1)
Good:	5.0-15.0% (2-3)
Dangerous:	15.0-25.0% (4-5)
Not acceptable:	> 25.0%

- Feedback to grove manager about harvesters.
- Avoid astringent leaf flavours in the oil (More than 1% MOO).
- Avoid problems with washing equipment.

Fruit Transport



Harvesting-Processing delay

Harvesting-Processing delay

- One of the most important parameters affecting oil quality.
- Fruit should be processed within 12 hours to avoid quality issues.
- A delay longer than 24 hours will most likely have an impact on the oil quality.
- Aerobic and anaerobic fermentations inside the fruit pile end up increasing FFA, FAEEs, DAGs, etc.
- Organoleptic problems = Fusty and Musty!!

OLIVE OIL PROCESSING COURSE

modern

olives

OLIVE OIL PROCESSING COURSE

Receival Area
Fruit Classification
Washing – Storage

Processing Plant Manager

- Maximise oil yields.
- Minimise production costs.
- Obtain maximum quality oils.
- Make the most cost effective decisions at all times.
- Liaise with the grove manager/s.
- Liaise with marketing department.

Fruit receival

Fruit receival

Fruit receival

Fruit receival

Receival document

Grower:	
Date:	
Time:	
Harvester:	

	Information
Variety:	
Fruit Temperature:	
Bin type:	
Nº bins:	
Weight:	
MOO:	
Others:	
PPA signature:	

I will store my oil in the Modern Olives facilities YES/NO

I brought my own storage containers YES/NO

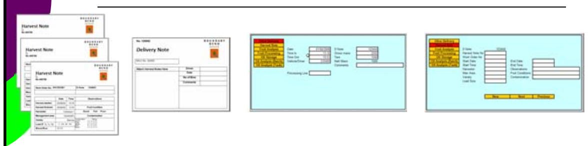
I have observed all withholding periods YES/NO

Grower signature: ....

TO BE FILLED BY THE PROCESSING PLANT ASSISTANT

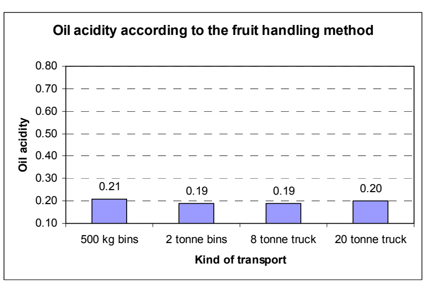
Batch Number:	

Fruit receival



10:25am 11:05am 11:20am 11:25am 11:30am

Fruit Transport



Fruit Temperature

Depth (cm/inches)	Temperature (ºC/ºF)
0	22/72
10/4	38/100
30/12	45/113
50/20	42/108
80/32	45/113
120/48	32/90
150/60	32/90

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Fruit Temperature

Optimal	< 5ºC (9ºF) above air Tº
Good	5-10º (9-18ºF) above air Tº
Increasing risk	10-15º (18-27ºF) above air Tº
Quality affected	15-20º (27-36ºF) above air Tº
Not acceptable	>20º (36ºF) above air Tº

modern olives

Materials Other than Olives (MOO)

modern olives

Materials Other than Olives (MOO)

Optimal:	< 5.0% (0-1)
Good:	5.0-15.0% (2-3)
Dangerous:	15.0-25.0% (4-5)
Not acceptable:	> 25.0%

- Feedback to grove manager about harvesters.
- Avoid astringent leaf flavours in the oil (More than 1% MOO).
- Avoid problems with washing equipment.

Visual inspection: Soft Nose

- Sphaeropsis dalmatica.
- Gloeosporium olivarum.
- Alternaria sp.
- Fusarium sp.
- Cladosporium sp.
- Penicillium sp.

Visual inspection: Frost

Fruit receival

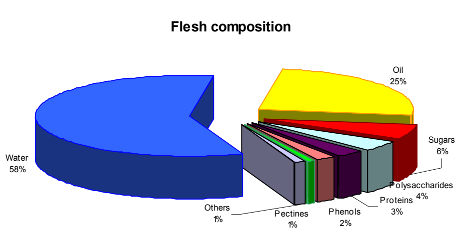
Fruit receival

Fruit Analysis Chart

Date:
Name of the Processing Plant Manager:

Batch Nº	Grower	Variety	Oil %	Moisture %	Average fruit weight	Maturity Index

Fruit and moisture levels



Oil and moisture content

NEAR INFRA RED

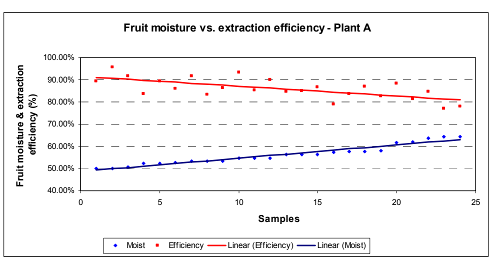
Oil and moisture content

Fruit moisture measurement

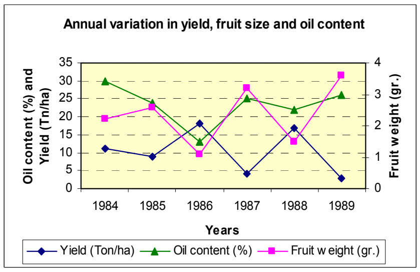
- Weigh cup without sample (“pc”)
- Weigh fruit sample, approx. 5 grams (“pm”)
- Put cup and sample in oven at 130°C/266°F for 1 hour
- Take sample, turn it over and put it back in the oven for another 1 hour at the same temperature. Ensure no sample is lost during this step
- Take sample from oven and let it cool down in a dry place
- Weigh cup and dried sample (“pc+r”)

- Fruit moisture % = $\frac{((\text{“pc”}+\text{“pm”}) - (\text{“pc+r”}))}{\text{“pm”}} \times 10$

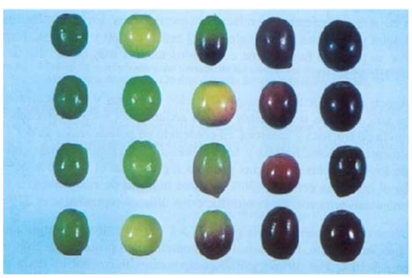
Fruit and moisture levels



Fruit weight



Maturity Index



Maturity Index

If A, B, C, D, E, F, G and H are the numbers of fruits in the categories 0, 1, 2, 3, 4, 5, 6 and 7, respectively, the maturity index is calculated with the following formula:

$$M.I. = \frac{Ax0 + Bx1 + Cx2 + Dx3 + Ex4 + Fx5 + Gx6 + Hx7}{100}$$

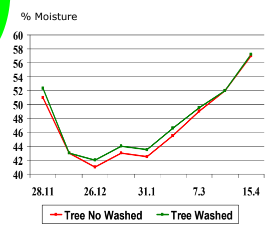
Washing

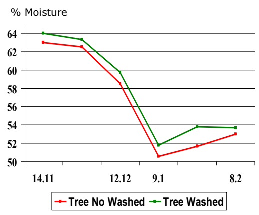
Washing

Washing

Washing or not?

PICUAL | **LECHIN**





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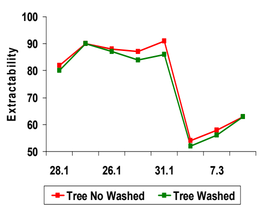
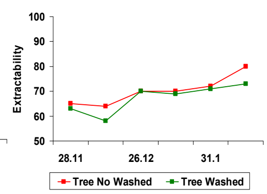
Washing or not?

PICUAL | **LECHIN**





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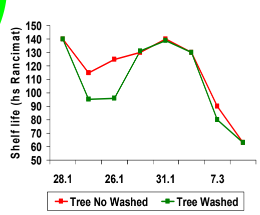
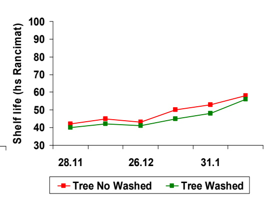
Washing or not?

PICUAL | **LECHIN**





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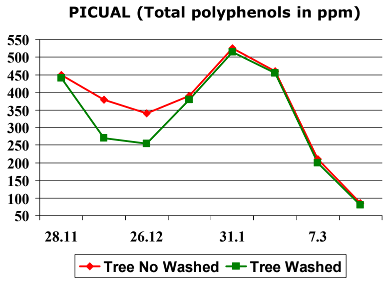
Washing or not?



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Washing or not?

No Changes

- *Oil/Dry Matter*
- *Peroxides Value*
- *K_{270}*
- *K_{232}*

Changes

- *Fruit Moisture* ↑
- *Oil losses in pomace* ↑
- *Extractability* ↓
- *Total Polyphenols* ↓
- *Shelf Life* ↓
- *Fruitiness* ↓

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When should I change the water?

When should I change the water?

< 0.10% Oil
< 0.50% Solids

Usually every 5-10 x capacity of washer

e.g. 7 tonne/hr washer

Replace water every 35 – 70 tonnes

Fruit Storage

Fruit Storage

Fruit storage

- High risk of ↑↑ **FFA** & "fusty" defect if not frequently inspected
- High risk of ↑↑ **FFA** if ripe, mashy fruit
- ↑↑ Chlorophyls content and greener oil if olives start fermenting
- Risk of increasing E+U, FAEEs and DAGs

Receival area assistant

Before the season:

- Suggest improvements in the receival area.
- General cleaning and maintenance of the receival equipment.

During the season:

- General cleaning and maintenance of the equipment.
- Inspection of the fruit and directing lines or washing needs.
- Fruit sampling.
- Changing washing water.
- Evaluating oil losses in washing water.
- Evaluating MOO after washing.
- Rotating fruit in clean fruit hoppers.

Day 2

SEPTEMBER 20 - 23, 2016

Master Milling

CERTIFICATE COURSE

OLIVE OIL PROCESSING COURSE

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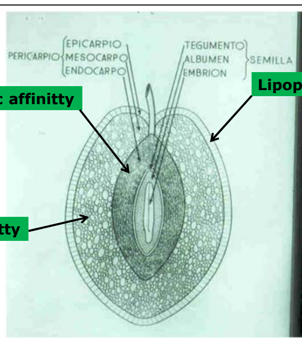
Crushing
Paste Preparation
Malaxing Temperature & Time

Crushing

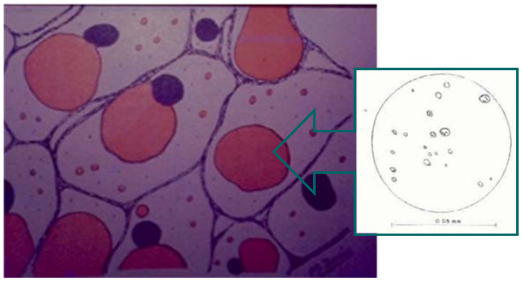


Hydrophylic affinitty

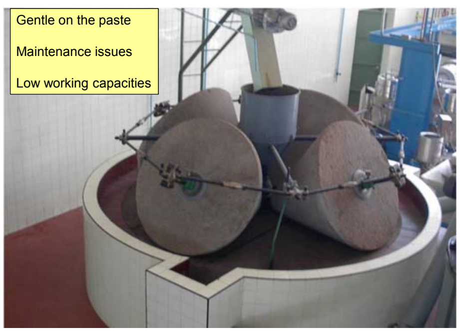
Lipophylic affinitty

Variable affinitty

Crushing



Crushing



Gentle on the paste

Maintenance issues

Low working capacities

Crushing

Teeth crusher

Gentle on paste

Less polyphenols

Low working capacity

Cog crusher

Gentle on paste

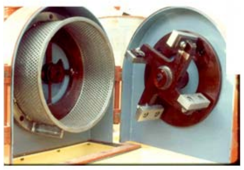
Less polyphenols

Low working capacity

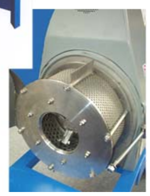
Photos Jose Alba – Australia 2005

Crushing

Simple
Easy maintenance



Less emulsions
Less bitterness in the oil



Photos Jose Alba – Australia 2005

Crushing

Listello grid
High working capacities

Crushing

Crushing

Effect of Fruit Stoning on Olive Oil Quality

M. Patumi*, S. Terenziani, M. Ridolfi, and Giuseppe Fontanazza
Istituto di Ricerche sulla Olivicoltura—Consiglio Nazionale delle Ricerche, 06128 Perugia, Italy

TABLE 2
Free Acidity, Peroxide Number, Total Phenols, o-Diphenols, Spectrophotometric Indices, and Racimat Test of Oils Obtained from Two Different Extraction Systems

Sample[a]	Oil yield (% FW[b])	Free acidity (calculated as oleic acid, g%)	Peroxide number (meq O_2 kg^{-1})	Polyphenols[c] (mg kg^{-1})	o-Diphenols[d] (mg kg^{-1})	1% K_{232} (1 cm)	1% K_{270} (1 cm)	ΔK	Rancimat test (h)
NBw100yg	17.4	0.23	5.6	183	54	0.4	0.03	0.024	8.7
NBs100yg	15.8	0.38	4.5	140	36	0.7	0.07	0.001	6.7
NBw40cc	18	0.25	3.5	169	48	0.4	0.05	0.001	6.9
NBs40cc	15.2	0.22	3.7	194	49	0.9	0.18	0.005	8.2
Mw100yg	18.04	0.34	5.5	115	29	1.7	0.15	0.003	5.0
Ms100yg	15.8	0.41	7.6	126	33	1.4	0.08	0.001	5.0
Mw80cc	19.1	0.76	12.9	119	45	2.1	0.12	0.002	3.5
Ms80cc	17.5	0.71	9.0	130	48	1.7	0.09	0.001	4.9
NEw100yg	15.6	0.44	7.0	189	29	1.8	0.10	0.002	5.8
NEs100yg	13	0.43	6.4	172	24	1.5	0.09	0.001	6.1
Cw70cc	19.7	0.23	5.6	251	88	1.5	0.18	0.001	8.7
Cs70cc	17.3	0.20	4.8	272	94	1.4	0.14	0.001	9.5
Bw80cc	17.5	0.64	17.1	47	39	3.1	0.17	0.004	2.7
Bs80cc	15.6	0.86	19.9	33	28	3.4	0.19	0.007	2.0

[a]For sample codes see Table 1.
[b]FW, fresh weight.
[c]The data represent the means of three measurements ($LSD_{0.05}$ 16), where LSD = least squares difference.
[d]The data represent the means of three measurements ($LSD_{0.05}$ 7).

Crushing

Innovation in Extraction Technology for Improved Virgin Olive Oil Quality and By-Product Valorisation

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Table 3. Phenolic composition (mg/kg) in oils obtained by mechanical extraction with traditional process and with stoning. Source: Servili et al., 2007a.

	'Frantoio'			
	Traditional		Stoned	
3,4-DHPEA[a]	1.9	(0.3)a	1.8	(0.2)a
p-HPEA	4.6	(0.4)a	4.9	(0.4)a
3,4-DHPEA-EDA	88.8	(7.2)a	112.4	(10.1)b
p-HPEA-EDA	43.8	(3.1)a	54.8	(3.1)b
3,4-DHPEA-EA	30.3	(2.7)a	42.8	(3.6)b
(+)-1-acetoxypinoresinol	40.7	(2.3)a	42.8	(1.1)a
(+)-pinoresinol	4.2	(0.4)a	4.5	(0.5)a
	'Coratina'			
	Traditional		Stoned	
3,4-DHPEA	3.1	(0.2)a	2.8	(0.3)a
p-HPEA	14.9	(1.1)a	15.0	(0.8)a
3,4-DHPEA-EDA	365.2	(18.6)a	507.1	(19.9)b
p-HPEA-EDA	92.8	(7.8)a	115.9	(6.2)b
3,4-DHPEA-EA	101.2	(5.8)a	125.9	(7.1)b
(+)-1-acetoxypinoresinol	41.1	(1,1)a	44.0	(1,8)a
(+)-pinoresinol	8.4	(0.6)a	10.4	(0.6)b

[a] The phenolic content is the mean value of three independent experiments, standard deviation is reported in brackets. Values in a row having different letters (a-b) are significantly different from one another at P<0.01.

Table 4. Volatile compounds (μg/kg) in oils obtained by mechanical extraction with traditional process and with stoning. Source: Servili et al., 2007a.

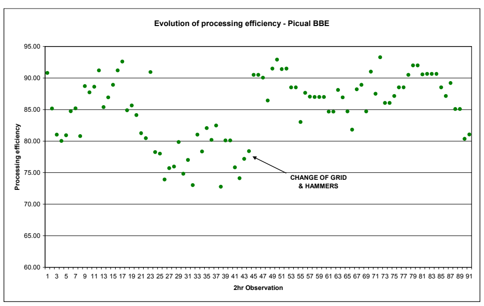
	'Frantoio'			
	Traditional		Stoned	
ALDEHYDES				
2-Pentenal (E)[a]	39.6	(2.5)a	35.7	(2.7)a
Hexanal	834.0	(37.9)a	748.4	(27.9)b
2-Hexenal (E)	24006.0	(650.5)a	27866.2	(705.5)b
2,4-Hexadienal (E,E)	200.3	(22.3)a	256.5	(12.1)b
ALCOHOLS				
1-Pentanol	95.5	(4.9)a	20.8	(1.7)b
2-Penten-1-ol (E)	36.3	(1.5)a	12.8	(2.1)b
1-Penten-3-ol	285.9	(10.7)a	114.5	(4.6)b
1-Hexanol	1457.0	(50.4)a	405.0	(18.4)b
3-Hexen-1-ol (E)	44.7	(1.8)a	21.5	(2.3)b
3-Hexen-1-ol (Z)	243.1	(18.8)a	163.7	(8.0)b
2-Hexen-1-ol (E)	19912.0	(705.9)a	6446.3	(205.9)b
	'Coratina'			
	Traditional		Stoned	
ALDEHYDES				
2-Pentenal (E)	33.1	(1.0)a	49.4	(1.7)b
Hexanal	608.6	(57.0)a	877.5	(68.5)b
2-Hexenal (E)	24083.5	(834.1)a	33362.1	(964.3)b
2,4-Hexadienal (E,E)	258.4	(33.0)a	385.4	(17.9)b
ALCOHOLS				
1-Pentanol	98.6	(4.4)a	17.2	(1.1)b
2-Penten-1-ol (E)	22.8	(0.8)a	23.0	(2.4)a
1-Penten-3-ol	335.8	(15.5)a	324.7	(20.4)a
1-Hexanol	1495.1	(86.5)a	349.5	(10.5)b
3-Hexen-1-ol (E)	37.2	(2.2)a	2.1	(0.4)b
3-Hexen-1-ol (Z)	252.4	(14.3)a	212.9	(16.5)b
2-Hexen-1-ol (E)	16913.9	(874.8)a	3529.4	(742.6)b

Data are the mean values of three independent experiments, standard deviation is reported in brackets. Values in a row having different letters (a-b) are significantly different from one another at P<0.01.

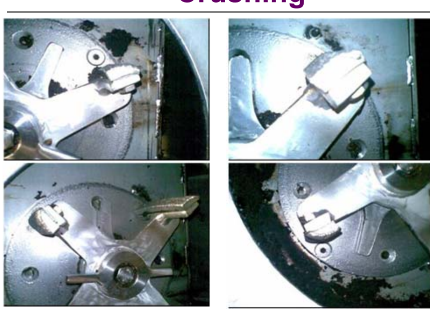
Crushing

Crushing

Crushing

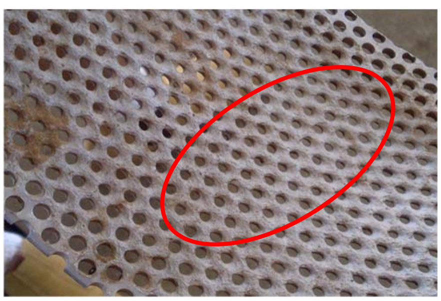


Crushing



Crushing

Crushing



Crushing

- The most common grid sizes are 5, 6 and 7 mm.
- We should try to crush as fine as possible.
- With small (< 3.0 gr), unripe (<4.0 MI), dry fruit (<56.0% moisture) use smaller grid sizes (5).
- With large, ripe, high moisture fruit use larger grid holes (6 or 7).

Crushing

Crushing adjustment with Picual 62.3% moisture and 3.8 M.I.

Set up	Processing speed	Extraction efficiency
Grid Nº 5 No talc or enzymes	2.75 tn/hr	78.46%
Grid Nº 5 Talc & enzymes	3.45 tn/hr	88.25%
Grid Nº 7 No talc or enzymes	3.75 tn/hr	75.45%
Grid Nº 7 Talc & enzymes	4.15 tn/hr	88.74%

Crushing

Crushing adjustment with speed of crushing

Variety	Crushing	Polyphenols (ppm)	Shelf life (days)	Fruitiness	Bitterness	Pungency
Barnea	Double grid	257	608	3.8	2.8	2.6
	Single grid	334	664	3.7	3.7	2.9
Picual	Double grid	123	935	4.2	1.7	2.1
	Single grid	208	901	4.2	1.9	2.7

Crushing

- Lower bitterness with double grid hammer mills
- ↑↑ rotating speed gives higher polyphenols and oxidation stability to oil
- Risk of ↑↑ **PV** if hammers wear out leaving metal traces in oil
- Smaller grid sizes: Higher chlorophyls content (greener oils) & higher polyphenols

Crushing

Processing degree of difficulty

1. High fruit moisture. Emulsions formation.
2. Lipophyllic affinity of the pulp.
3. Poor paste preparation.

Crushing

Emulsions

- They are a very stable mix of oil and water created by the crusher.
- The mix contains intermediate densities between water, oil and pomace that are difficult to separate by centrifugation.
- Lipoproteic membrane (microgel) that does not free up the oil.
- ↑↑ Pectins = ↑↑ Emulsions (green fruit).
- ↑↑ Fruit moisture = ↑↑ Emulsions

Crushing

Emulsions

- Increase crushing size.
- Allow for a longer malaxing time that is not excessive.
- Cold or frozen fruit tends to form emulsions more easily.
- Talc – Helps avoiding the formation of emulsions.
- Enzymes – Help breaking the emulsion already formed.
- Common salt & calcium carbonate.

Malaxing

Malaxing

Malaxing

Malaxing

Malaxing

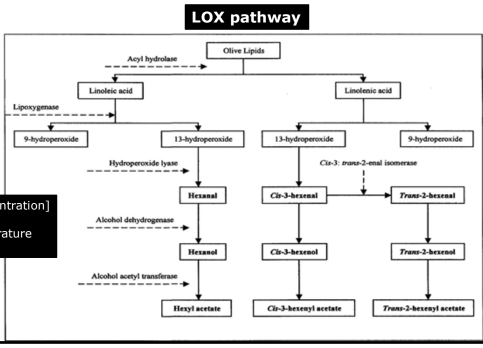
	Oil droplets diameter (microns)					
	<15	15-30	30-45	45-75	75-150	>150
After crushing	6	49	21	14	4	6
After malaxing	2	18	18	18	19	25

Source: Di Giovacchino

Malaxing

LOX pathway

[Concentration]
pH
Temperature



Malaxing

The Malaxation Process: Influence on Olive Oil Quality and the Effect of the Control of Oxygen Concentration in Virgin Olive Oil

Antonia Tamborrino[1], Maria Lisa Clodoveo[1], Alessandro Leone[2], Paolo Amirante[1] and Alistair G. Paice[3]
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[2]Department of Production and Innovation in Mediterranean Agriculture and Food Systems (PrIME), University of Foggia, Italy
[3]Department of Clinical Biochemistry, Nutrition and Dietetics, King's College London, UK

TABLE 9.2 The amount of C_6 and C_5 compounds, derived from the lipoxygenase pathway, found in virgin olive oil generated by the two different paste malaxation conditions being studied. The effect of the two different paste malaxation conditions on volatile compounds. When air was used in the head-space of the mixer, the oils extracted contained much higher amounts of 'pleasant' volatile compounds than when nitrogen was used.

Volatile compounds ($mg\,kg^{-1}$)	100% air		100% nitrogen	
	m	SD	m	SD
Hexanal	11.6	0.5	3.1	0.1
trans-2-Hexenal	147.3	5.8	43.5	2.1
1-Hexanol	45.2	3.1	3.9	0.7
trans-2-Hexen-1-ol	11.9	0.3	4.6	0.9
cis-3-Hexen-1-ol	7.7	0.4	1.4	0.1
cis-2-Penten-1-ol	3.6	0.1	nd	Nd

Data represent mean (m) and standard deviation (SD) values. Significant differences in the same row are statistically significant ($p < 0.01$). Adapted with permission from: Amirante, P., Clodoveo, M. L., Leone, A., Tamborrino, A. 2008a. 'Influence of three different atmosphere composition of head space of mixer on total phenol content of de-stoned virgin olive oil'. Proceedings book of the International Symposium on Food and Bioprocess Technology. Brazil, 31 August to 4 September 2008. ISSN 1982-3797. CD printed.

Malaxing

Innovation in Extraction Technology for Improved Virgin Olive Oil Quality and By-Product Valorisation

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Via S. Costanzo - 06126 Perugia
Italy

Table 5. Phenolic composition (mg/kg) of extra-virgin olive oils obtained after malaxation under different initial atmosphere compositions. Source: Servili et al., 2008a.

	Initial O_2 partial pressure in the malaxer chamber headspace (kPa)							
	0[1]		30[2]		50		100	
'Ogliarola'								
3,4-DHPEA[3]	1.0	(0.02)a	0.8	(0.05)b	0.6	(0.004)c	0.8	(0.01)d
p-HPEA	3.1	(0.03)a	3.1	(0.7)a	4.1	(0.001)b	4.2	(0.03)b
3,4-DHPEA-EDA	247.7	(1.9)a	235.2	(5.5)b	117.8	(0.8)c	118.1	(0.03)c
p-HPEA-EDA	126.4	(0.4)a	118.6	(5.9)b	86.3	(0.3)c	85.4	(0.62)c
(+)-1-Acetoxypinoresinol	21.0	(0.4)a	25.4	(1.5)b	22.3	(0.3)ac	24.1	(0.09)bc
(+)-Pinoresinol	6.8	(0.07)a	7.6	(0.3)b	7.0	(0.04)a	7.1	(0.03)a
3,4-DHPEA-EA	212.2	(0.1)a	186.4	(4.8)b	100.9	(1.1)c	98.2	(0.2)c
'Coratina'								
3,4-DHPEA	6.8	(0.7)a	3.2	(0.8)b	4.4	(0.7)b	1.4	(0.2)c
p-HPEA	10.0	(1.1)a	5.9	(0.5)bc	7.8	(0.9)b	4.4	(0.4)c
3,4-DHPEA-EDA	478.9	(16.2)a	437.7	(14.3)b	343.1	(11.5)c	229.9	(9.2)d
p-HPEA-EDA	144.2	(1.8)a	135.3	(1.59)b	126.2	(1.4)c	125.1	(3.1)c
(+)-1-Acetoxypinoresinol	30.8	(0.94)a	25.8	(2.8)b	29.2	(0.4)ab	27.1	(0.5)ab
(+)-Pinoresinol	8.1	(0.03)ab	8.0	(0.04)a	8.6	(0.4)b	7.9	(0.1)a
3,4-DHPEA-EA	475.6	(13.9)a	361.9	(14.1)b	339.2	(6.9)b	170.6	(2.3)c

[1] Saturated with N_2.
[2] Corresponding to the air composition.
[3] Data are means of three independent experiments. Values in a row having different letters (a-d) are significantly different from one another at $P<0.01$.

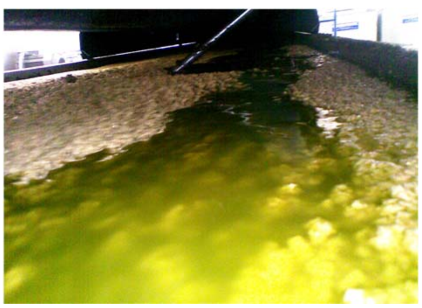
Malaxing

Visual checks:

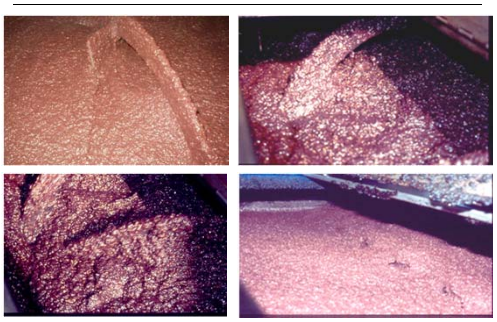
- There is a large amount of oil floating on top of the paste in the last vat of the malaxer.
- The blades of the malaxer come out clean from the paste
- The paste shows an evident cracking with a bright dark colour
- The paste behaves as a solid, not as a liquid

Malaxing

Malaxing



Malaxing



Photos Jose Alba – Australia 2005

Malaxing

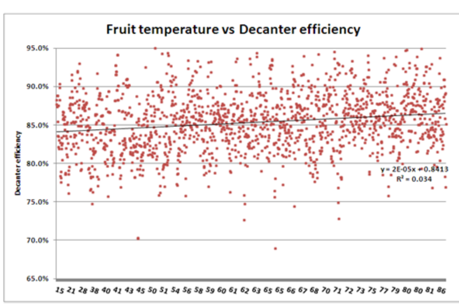
- Time.
- Temperature.

Malaxing

Fruit/paste temperature evolution (°F) at Boort Estate, 2011

	Hopper	Crusher		Malaxer	
Time	Receival hopper	Before crusher	After crusher	Top Vat	Bottom Vat
9.30	39.5	42.4	48.7	69.1	81.1
10.30	43.9	48.7	56.7	72.1	91.6
11.30	47.8	50.2	58.1	75.9	91.9
12.30	50.2	56.1	63.1	78.6	86.9
13.30	52.2	56.5	61.0	75.0	93.7
14.30	54.1	59.4	68.0	71.1	89.2
15.30	56.5	58.8	67.8	73.8	87.3
16.30	61.5	65.8	73.2	80.1	94.3
17.30	61.2	65.1	70.5	82.9	87.1
Average	**51.9**	**55.9**	**63.0**	**75.4**	**89.2**

Malaxing



Malaxing

What temperature?

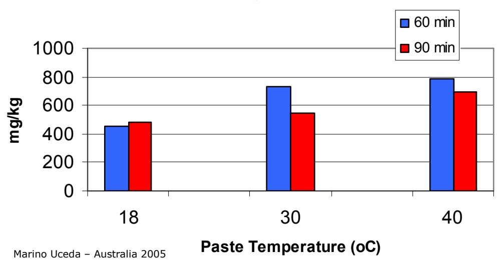
• As low as possible but not lower than 22ºC (72°F) . (Problems with efficiency and solubilization of PPH and chlorophylls)
• EC regulation "Cold extraction" < 27ºC (80.6°F).
• Between 25ºC and 30ºC (77°F & 86°F).
• Start at 28ºC (82°F) and apply variations controlling the oil in pomace.

How much time?

• As short as possible but not less than 45 min.
• Between 45 min and 120 min.
• Start at 75 min and apply variations controlling the oil in pomace.
• According to research studies, sealed malaxer minimise the negative impact of longer malaxing times on quality.

Malaxing

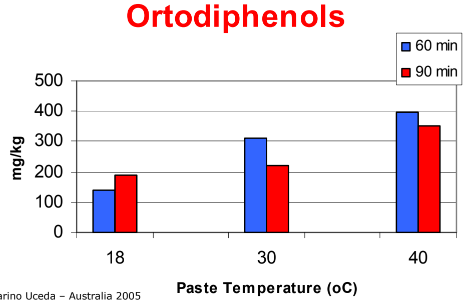
Total Polyphenols



Marino Uceda – Australia 2005

Malaxing

Ortodiphenols



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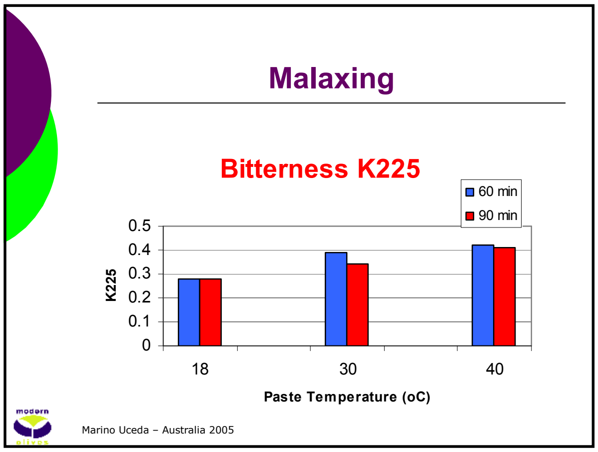
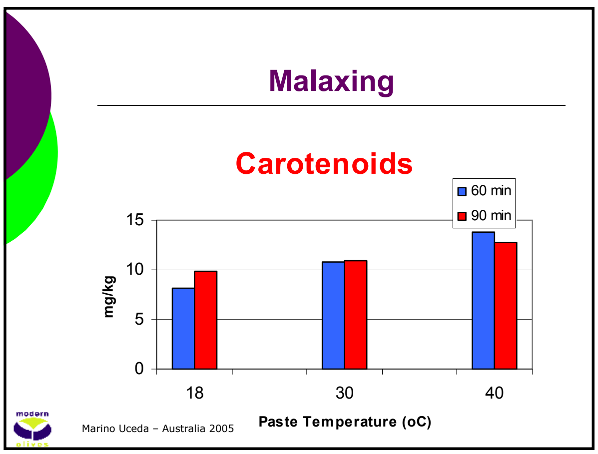
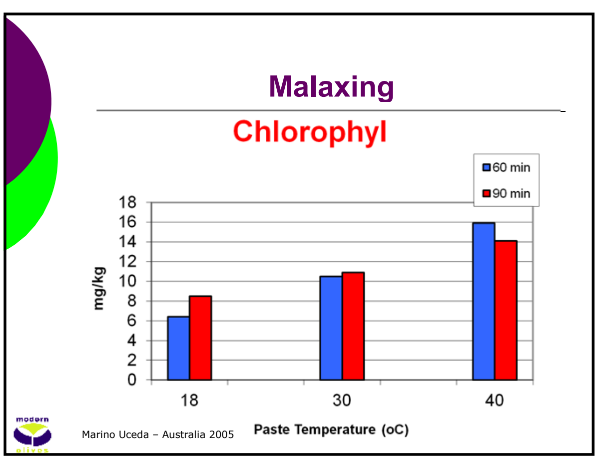
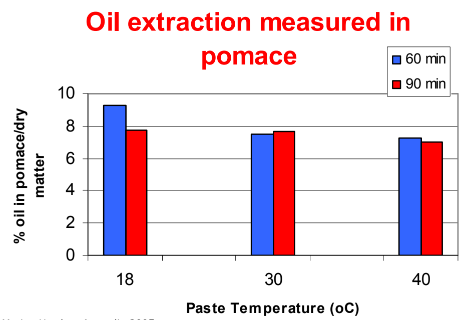

Malaxing
Bitterness K225
60 min
90 min
K225
0.5
0.4
0.3
0.2
0.1
0
18
30
40
Paste Temperature (oC)
Marino Uceda - Australia 2005


Malaxing
Carotenoids
60 min
90 min
mg/kg
15
10
5
0
18
30
40
Paste Temperature (oC)
Marino Uceda - Australia 2005


Malaxing
Chlorophyl
60 min
90 min
mg/kg
18
16
14
12
10
8
6
4
2
0
18
30
40
Paste Temperature (oC)
Marino Uceda - Australia 2005

Malaxing



Marino Uceda – Australia 2005

Malaxing

Malaxing

Correlations between Fruit and Processing Parameters and Oil Chemistry in cultivar Barnea (Victoria, Australia)

Parámetro	Parámetros de fruta				Parámetros de procesamiento						
	Oil	Moisture	Fruit weight	Maturity	Grid size	Malaxing temperature	Malaxing time	Water addition	Talc	Enzymes	Oil temperature
FFA	-1%	25%	20%	27%	-18%	15%	21%	19%	45%	29%	31%
PV	-17%	34%	32%	14%	-13%	-12%	48%	33%	30%	40%	-24%
K232	9%	14%	51%	21%	4%	-19%	61%	31%	28%	59%	-19%
K270	30%	-40%	-23%	2%	-21%	-21%	19%	20%	-9%	5%	-35%
Δ K	0%	-10%	-2%	6%	14%	-9%	66%	35%	52%	58%	-7%
Polyphenols	-62%	46%	0%	-67%	6%	29%	-24%	-21%	-35%	-32%	11%
K225	-58%	27%	-16%	-77%	-10%	-11%	-35%	-10%	-49%	-46%	-9%
Moisture	-4%	-36%	-72%	-42%	-25%	19%	5%	23%	55%	38%	55%
IND (h)	-87%	64%	-11%	-81%	-18%	27%	-21%	-5%	-11%	-3%	46%
GQI	-20%	14%	0%	-16%	28%	14%	-39%	-34%	-23%	-29%	21%
Campesterol	-72%	75%	41%	-45%	10%	65%	-32%	-27%	19%	-15%	63%
Stigmasterol	-6%	-16%	-16%	-37%	-22%	3%	17%	33%	55%	44%	37%
Total sterols	27%	-60%	-53%	-26%	24%	17%	0%	-26%	-3%	-27%	-27%
E+U	-51%	24%	-21%	-68%	-41%	-26%	37%	55%	45%	55%	-1%
UNSAP	-40%	31%	2%	-38%	42%	3%	-14%	-33%	-5%	-11%	-13%
TAA	37%	-38%	-28%	12%	44%	-10%	-13%	-29%	-16%	-28%	-21%
Waxes	80%	-88%	-59%	35%	23%	31%	2%	-23%	-3%	15%	38%

Temperature

- ↑↑ **PV**
- ↓↓ Rancimat® stability
- ↑↑ Polyphenols & ortodiphenols
- ↑↑ Bitterness & "harshness" taste feeling
- "Overcooked" defect
- ↓↓ Fruitiness in nose
- ↑↑ Chlorophyls
- ↑↑ Trans fatty acids (18:1T).
- ↑↑ E+U, Stigmasterol and Total sterols

Malaxing

Are virgin olive oils obtained below 27 °C better than those produced at higher temperatures?

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[b] Gruppo Pieralisi, Via Don Battistoni, 1, 60035 Jesi, Ancona, Italy

Table 1
The oil quality parameters.

	25 °C					35 °C					45 °C				
Time (months)	T_0	T_3	T_6	T_9	T_{12}	T_0	T_3	T_6	T_9	T_{12}	T_0	T_3	T_6	T_9	T_{12}
F/L															
Free acidity[a]	0.30	0.30	0.31	0.37	0.34	0.30	0.30	0.33	0.37	0.37	0.40	0.40	0.34	0.41	0.39
Total phenols[b]	84.7	92.9	109	122	99.4	133	143	179	157	128	143	145	170	160	140
Induction period (h)	21.4	19.5	18.1	19.5	19.6	28.9	24.8	24.3	23.1	24.8	29.4	24.2	24.5	22.6	21.4
Cor															
Free acidity[a]	0.20	0.20	0.26	0.25	0.22	0.20	0.20	0,21	0.22	0.22	0.30	0.30	0.22	0.28	0.25
Total phenols[b]	172	235	259	234	201	201	274	270	327	270	241	359	326	351	384
Induction period (h)	43.70	40.7	40.0	37.3	39.1	47.8	42.4	41.6	41.7	41.2	53.9	51.2	48.9	48.6	50.5

F/L, Frantoio/Leccino; Cor, Coratina. 25 °C, 35 °C and 45 °C: different malaxation temperatures; T_0, freshly obtained oils; T_3, T_6, T_9, and T_{12} months of storage.
[a] g Oleic acid in 100 g of oil.
[b] mg of Gallic acid kg^{-1} of oil.

Malaxing

E. Boselli et al. / LWT - Food Science and Technology 42 (2009) 748–757

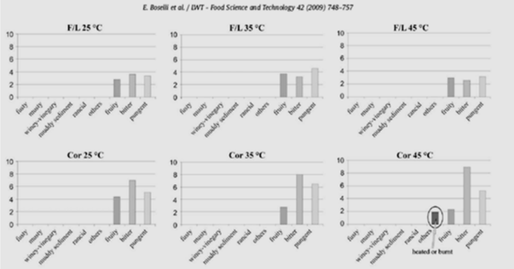

Fig. 2. Sensory scores of the fresh VOO samples (at T_0).

Time

- ↓↓ Polyphenols & ortodiphenols
- ↓↓ Bitterness
- “Pomacy” taste feeling
- ↑↑ E+U and Stigmasterol
- ↑↑ Waxes & aliphatic alcohols

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OLIVE OIL PROCESSING COURSE

Crushing
Paste Preparation
Processing Aids

Legislation

EC definition (n°1513/2001): "Oils obtained from the fruit of the olive tree solely by mechanical or other physical means under conditions that do not lead to alteration in the oil, which have not undergone any treatment other than washing, decantation, centrifugation or filtration, to the exclusion of oils obtained using solvents or using adjuvants having a chemical or biochemical action, or by re-esterification process and any mixture with oils of other kinds"

Article 7: "In order to preserve the natural characteristics of virgin olive oils, the use of oil-extraction adjuvants having a chemical or biochemical action should be excluded"

Legislation

IOC definition (COI/T.15/NC no.3/Rev.3): "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"

Codex definition (33-1981 (Rev. 2-2003)): "Virgin olive oils are the oils obtained from the fruit of the olive tree solely by mechanical or other physical means under conditions, particularly thermal conditions, that do not lead to alterations in the oil, and which have not undergone any treatment other than washing, decanting, centrifuging and filtration"

Legislation

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

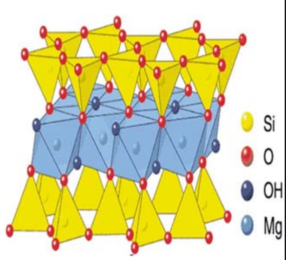
Traditional aids	New aids
◦ Talc powder ◦ Enzymes ◦ Water	◦ Microtalc powder ◦ Common salt ◦ Calcium carbonate ◦ Enzymes with side activities ◦ Warm water dipping ◦ Ultrasound

Equipment

Talc

Talc & microtalc powder

- Natural mineral (hydrated magnesium silicate) of laminar structure
- Provokes aggregation of particles and provides structure to the olive paste in the malaxer
- It does not allow the paste to stick to the internal walls of the decanter



Talc & microtalc powder

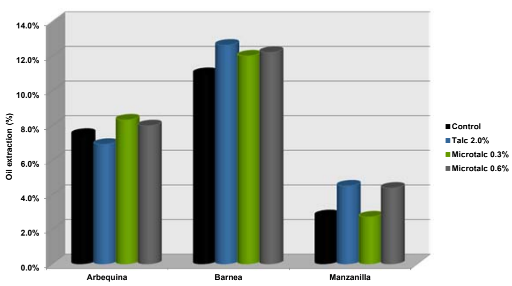
Talc powder

- Oldest powder used in the industry
- Magnesium silicate with high adsorption surface
- d50% = 8µm
- Specific surface area = 3.6 m2/gr
- Dose = 0.5-3%

Microtalc powder

- New product in the industry
- Same as talc powder, but finer particle size
- d50% = 2µm
- Specific surface area = 7.0 m2/gr
- Dose = 0.3-1%

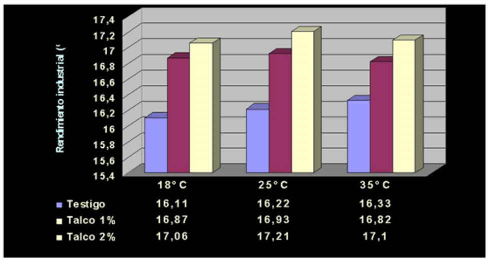
Talc & microtalc powder



Talc & microtalc powder

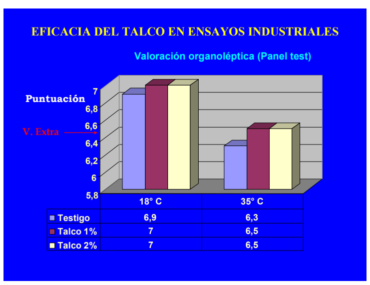
- Beneficial impact on FFA, PV, K232, K270 & **Δ**K in Arbequina, Barnea & Manzanilla
- Higher PPH content in Barnea & Manzanilla
- No impact on taste or colour
- Microtalc powder is more cost effective than talc due to less product transport, handling & storage

Talc



Jose Alba et al.

Talc



Jose Alba et al.

Talc

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

Talc rate	Processing speed	Extraction efficiency
0.0%	2.95 tn/hr	74.36%
0.5%	3.45 tn/hr	81.25%
1.0%	3.90 tn/hr	86.34%
1.5%	4.15 tn/hr	88.35%
2.0%	4.15 tn/hr	89.15%
2.5%	4.15 tn/hr	88.74%

Talc

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

Talc

When should I consider the use 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).
- 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.

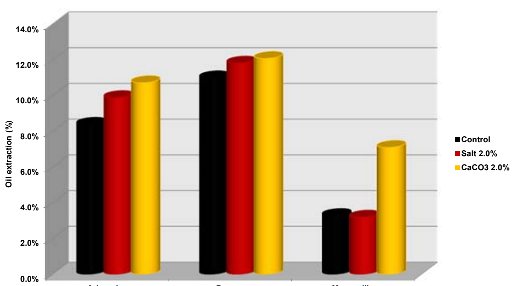
Common Salt (NaCl)

- 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

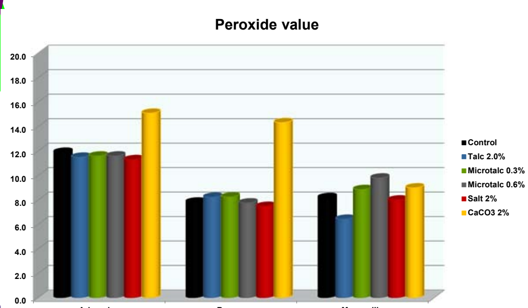
Calcium carbonate

- Natural mineral with crystalline structure (calcite)
- 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



Solid aids



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

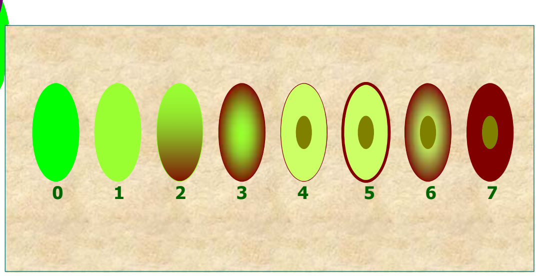
Calcium carbonate

- 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

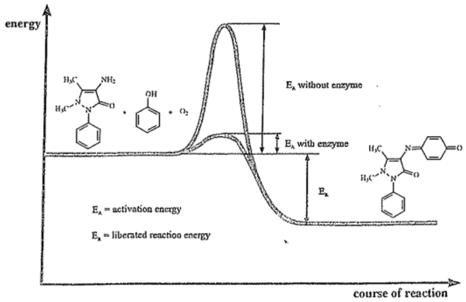
Enzymes

- 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

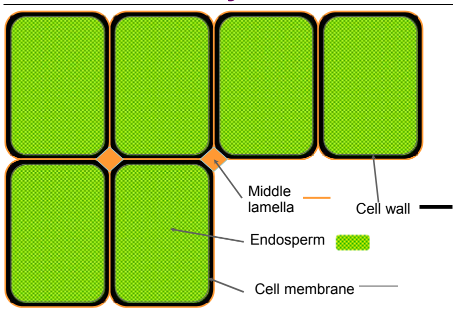
Enzymes



Enzymes



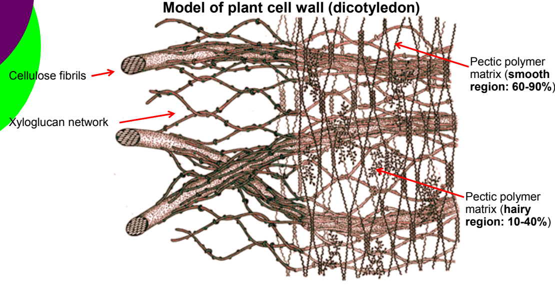
Enzymes



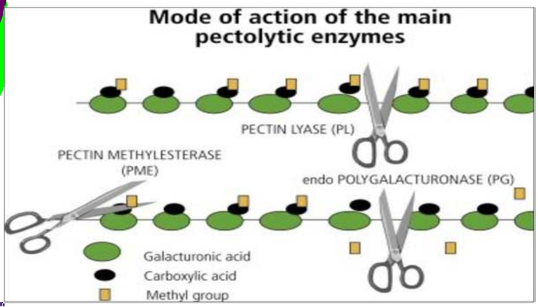
Source: Gunter Maier (NOVOZYMES)

Enzymes

Model of plant cell wall (dicotyledon)



Enzymes



Maturity Index

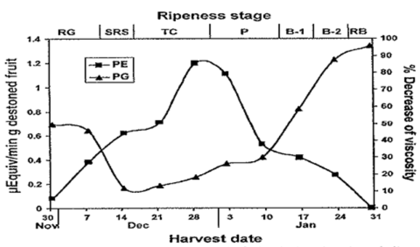


FIG. 1. Changes in PE and PG activity in fruits during ripening of olives. Abbreviations: RG, ripe-green; SRS, small reddish spots; TC, turning color; P, purple; B, black; RB, ripe-black; B-1, fruits with black surface and white pulp; B-2, fruits with black surface and purple pulp; µEquiv, microequivalents;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

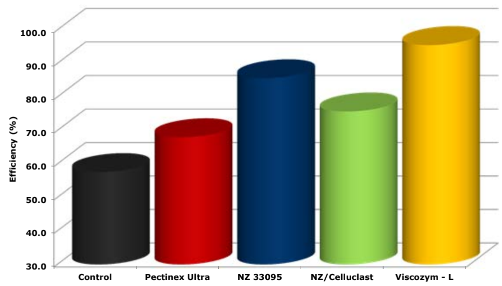
Enzymes

Enzymes trialed:

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

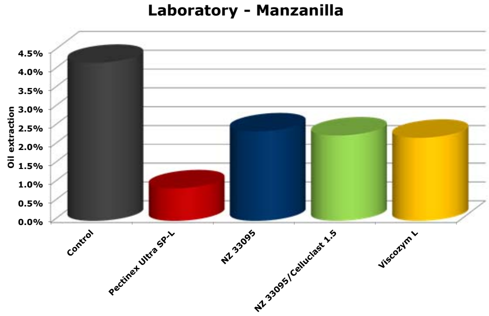
Results 2010

Field trial - Barnea



Results 2009

Laboratory - Manzanilla



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.

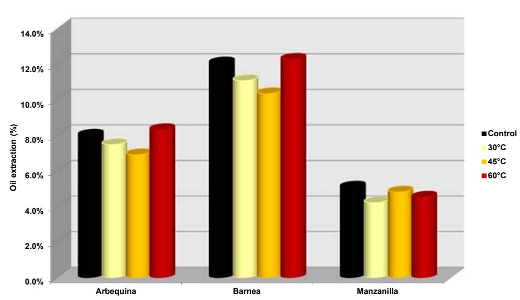
Enzymes

- 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

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

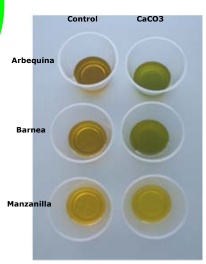


Warm water dipping

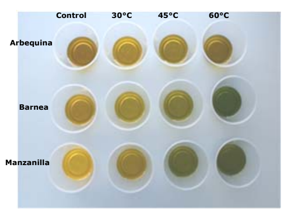
- Simple to implement in small Plants working in "batching" modality. More complicated for larger Plants
- Paste extractability showed slight improvements only at 60°C
- Increase in the moisture content of the fruit, making the extraction process more difficult
- Combined with talc could be interesting
- 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

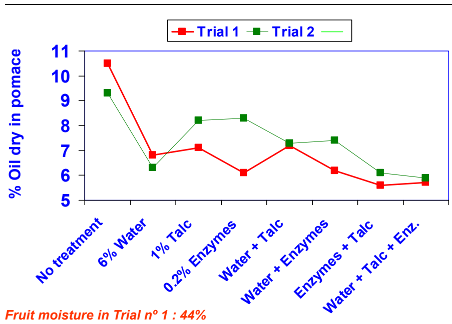
Calcium carbonate



Warm water dipping



Water of injection



Fruit moisture in Trial nº 1 : 44%

Fruit moisture in Trial nº 2 : 40%

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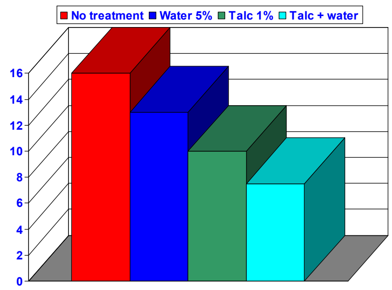
Water of injection



Fruit: 45% moisture

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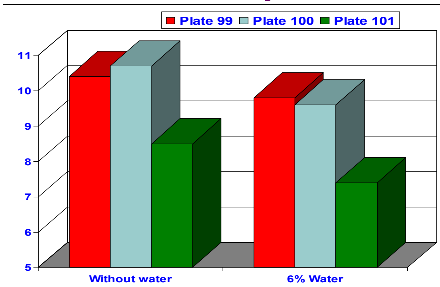
Water of injection



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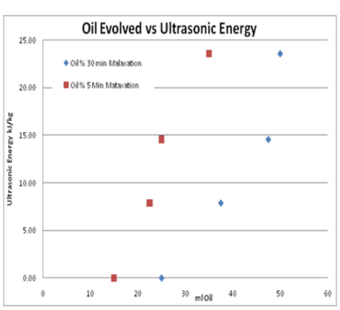
Ultrasound



Ultrasound

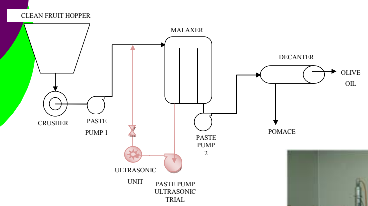
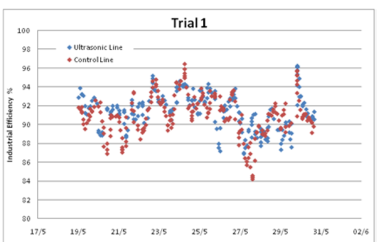


Figure 1: Process Flow Diagram

Ultrasound

Ultra Sound



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

Paste preparation

Summary

- Variety
- Season
- Fruit condition (pest & diseases, frosts, etc)
- Moisture content
- Maturity index
- Grid size
- Malaxing time
- Malaxing temperature
- Processing aids

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Solid - Liquid Phase Separation

2 & 3 phases

2-phases	3-phases
• Oil & wet pomace	• Oil, water & pomace
• Lower water consumption	• High water consumption
• More dependent on paste preparation than 3-phase systems	• More flexible to fix paste preparation issues

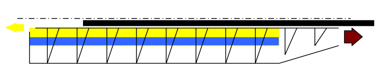
2 & 3 phases

	3 phases	2 phases
Pomace (kg/kg of olives processed)	0.5	0.8
Pomace moisture	45-55%	55-75%
Waste water (lts/kg of olives processed)	1.25 lt/kg	0.25 lt/kg
Polyphenols (ppm)	10,000	2,500
COD (ppm)	80,000	10,000

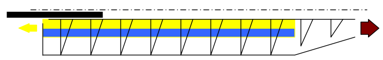
Two-phase system

- Reduced production of waste water with low contaminant power
- Water saving
- Lower investment (just 1 CV)
- Energy saving (no need to heat up injected water to the decanter)
- Oil quality

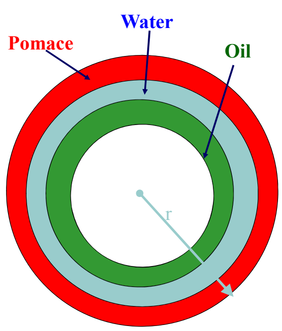
Capacity vs. Equipment



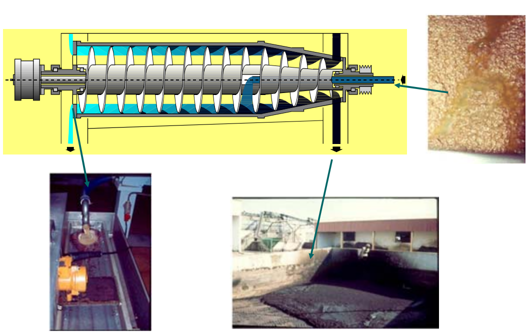
Capacity vs. Equipment



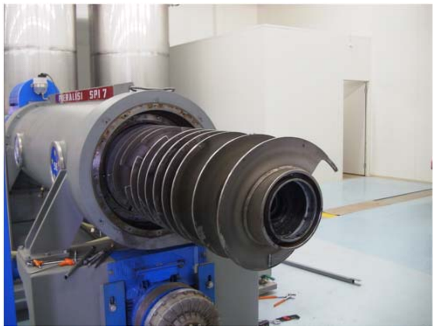
Decanter



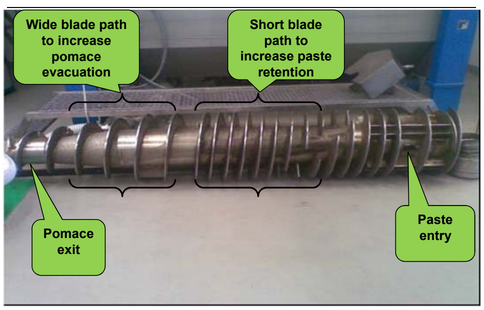
Decanter



Decanter



Decanter



Decanter

- Retention time
- Sedimentation time

Decanter

- Capacity.
- Efficiency.

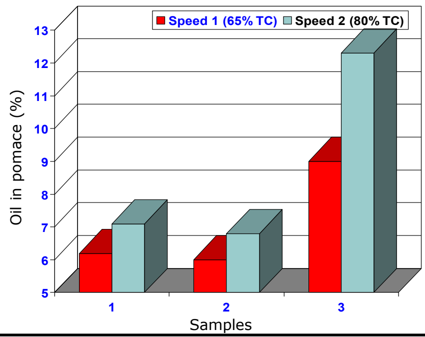
Capacity of the Decanter

- Viscosity (Temperature).
- Length.
- Diameter.
- Differential between screw and bowl.
- Particle size (Crushing).

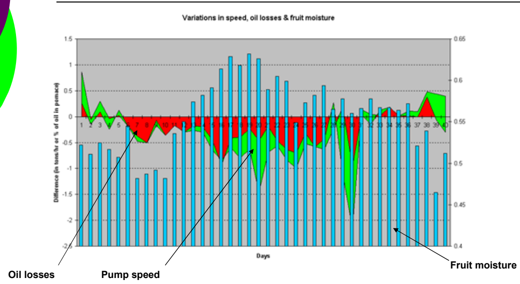
Efficiency of the Decanter

- Density difference between phases (Talc – Water – Crushing degree).
- Speed of rotation.
- Size of phases (Decanter plates).
- Separation time (Pumping speed).

Pumping speed



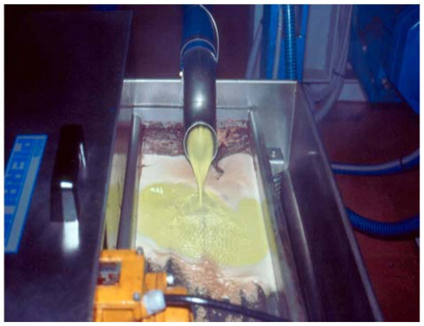
Pumping speed



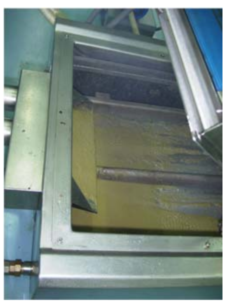
Pumping speed

- How do I know if I am pumping too fast?
  - Oil losses above limit.
  - Oil comes out dirty (Not always).
- How do I know if I am pumping to slow?
  - No problems apart from increased costs.
  - Do not go under 40% NC of the Decanter.

Pumping speed



Pumping speed

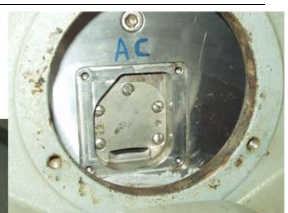


Feeding cane

Feeding cane

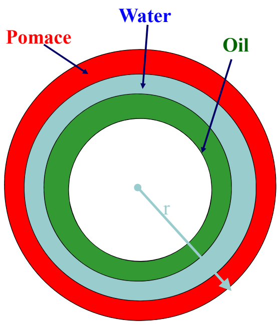
- It has an impact on the retention time and the working capacity.
- There are limitations. There usually are no more than 2-3 positions available.
- The short feeding cane proved to be more effective when dealing with difficult or unripe fruit at the start of the processing season.

Decanter plates

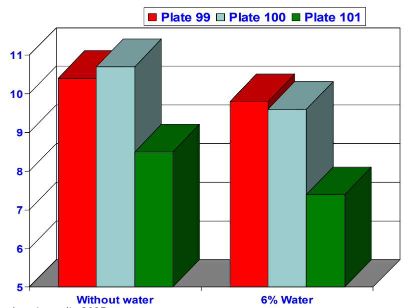


Decanter plates

Decanter plates



Decanter plates



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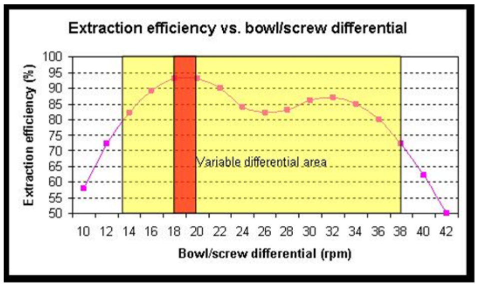
Decanter plates

- How do I know when to change the plate?
  - Once you have tried everything else and the oil still comes out very dirty and with very low Decanter capacity. Put an smaller plate.
  - Or if there is too much oil in the decanter. Stop the feeding pump into decanter, flush it with water and the amount of oil that is obtained should not exceed 1.5 % of the TC of the decanter. E.g.: 5 tn/hr should not produce more than 50-75 litres (13-20 gallons). Put a larger plate.

Differential speed



Differential speed

Decanter

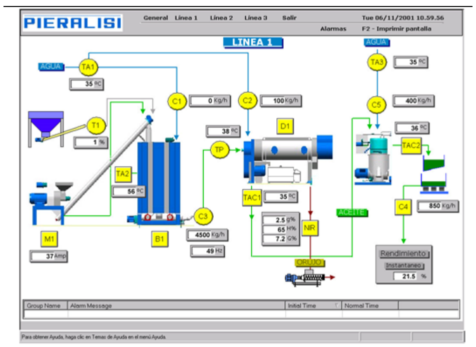
- ↑↑ **PV** if water of addition to decanter is too hot. It should not exceed 30-32°C (86-90ºF).
- Fruitiness intensity is affected, and “burnt” defect in oil

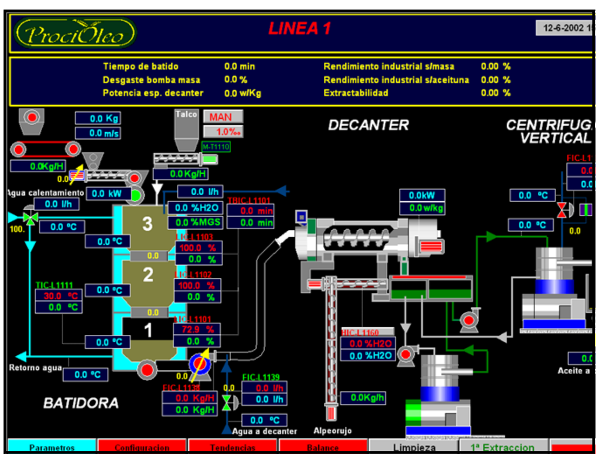
Processing records

Fruit Processing Chart

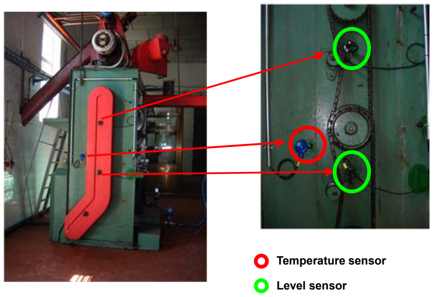
Grid size	Paste		Coadjuvants		Oil			Pomace		Final
	T°	Speed	Talc	Enzymes	T°	Flow	Acidity	Oil	Moisture	Tank

Automatic control

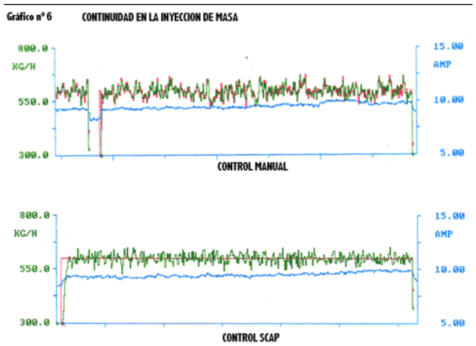




Automatic control

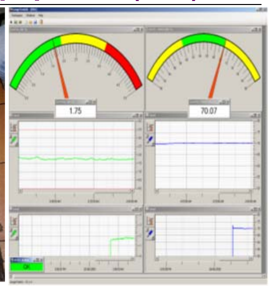


Automatic control



Infrared equipment (NIR)

Infrared equipment (NIR)



Nuclear magnetic resonance (NMR)

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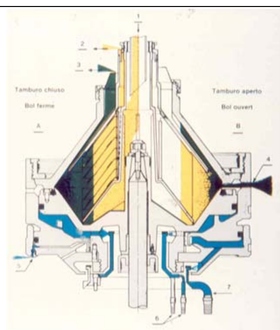
Liquid - Liquid Phase Separation

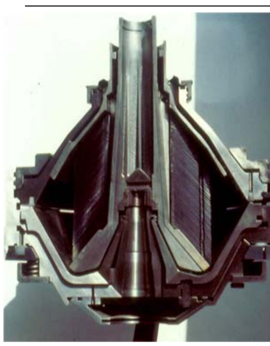
Centrifugation

Centrifugation

Centrifugation



Centrifugation

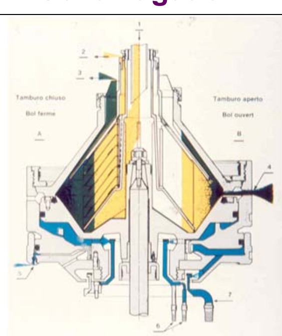


Photos Jose Alba – Australia 2005

Centrifugation

Centrifugation

Centrifugation



Centrifugation

Centrifugation

Oil in water:

Ideal:	< 0.1%
Unacceptable:	> 0.3%

Water in oil:

Ideal:	< 0.2%
Unacceptable:	> 0.6%

Water temperature:

Ideal:	1-2ºC (2-4ºF) higher than malaxing Tº
Unacceptable:	Lower than malaxing Tº, or > 5ºC (9ºF) higher than malaxing Tº

Centrifugation

- Accurate selection of regulation ring.
- Check oil aspect at all times (Clean milky aspect).
- Check foam aspect at all times (White as soon as it is formed).
- Do not over feed the separator.
- Do not add more than 40% of water/oil.
- Temperature of water between 31-34ºC (88-93ºF). Never colder than the oil.
- Constant flow of oil and water.
- Regulate discharge times (1-2 hours).
- Maintain clean all parts.

Centrifugation

Centrifugation

Centrifugation

- ↑↑ **PV** if water of addition to the separator is too hot. It should not exceed 32-35°C (90-95°F).
- Polyphenols losses due to ↑↑ T°C and excess of water of addition
- Fruitiness intensity is affected, and "burnt" defect in oil.
- Water ring in separator too small: moisture and impurities.

Centrifugation

Parameter	Oil at decanter outlet	Oil at Separator outlet					
		Water/oil 1:1			Water/oil 1.5:1		
		86°F	104°F	122°C	86°C	104°C	122°C
PPH (ppm)	605	495	463	444	434	422	411
K225	0.38	0.31	0.30	0.29	0.30	0.28	0.26
Rancimat (hr)	23.1	21.2	21.7	19.1	18.5	18.8	17.3

Settling

Settling

Settling

- Maintain oil in settling for 24-48 h.
- Drain settlings every two hours.
- Remove foam every six hours.
- Avoid contact with open air or light.
- If we drain more than 1% settlings for total oil produced we have to check the separator.
- Maintain temperature above 18ºC (65ºF).
- Check acidity and peroxides before sending to final tank.

Extraction efficiency

Very good efficiency:	>90.0%
Benchmark efficiency:	>85.0%
Unacceptable:	<70.0%

Extraction efficiency

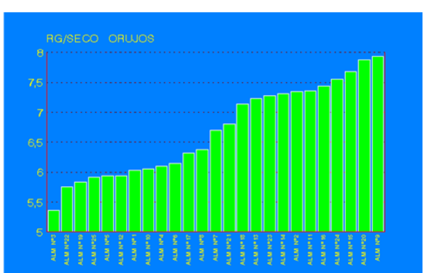


Gráfico 9. Valores medios Rg/seco orujos de 2 fases de 25 almazaras. Var. Picual.

Marino Uceda – Australia 2005

Extraction efficiency

- **Methodology "micro":** It helps us detecting changes in extractability depending on the adjustment of the processing equipment. It measures efficiency up to the decanter.

I.E.=1-(% Oil in pomace*(100-%oil in fruit))/(% Oil in fruit*(100-% Oil in pomace))

Or a reference,

< 8.0% oil/dry matter

With 50% fruit moisture = 3.0% oil/fresh matter

With 60% fruit moisture = 2.0% oil/fresh matter

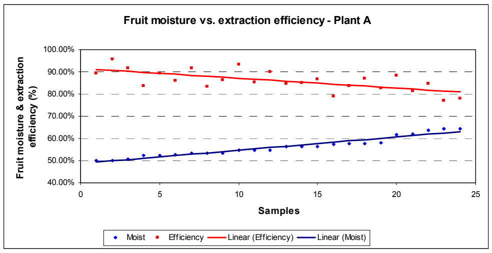
Extraction efficiency

- **Methodology "macro"**: It determines the efficiency of the plant as a complete unit. It should be measured weekly.

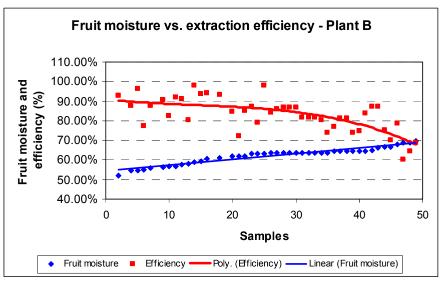
% Oil in fruit = 19.2%
% Moisture in fruit = 55.5%
Clean net weight of the batch = 7835 kg/17273 lbs
Volume of oil obtained = 1445 litres/382 gallons
Oil density = 0.915 gr/cm3

Extraction efficiency

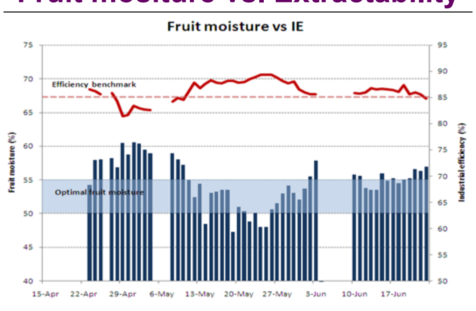
Fruit and moisture levels



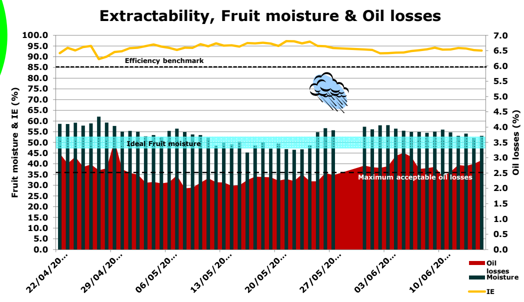
Fruit and soil moisture



Fruit mositure vs. Extractability



Fruit mositure vs. Extractability



Day 4

SEPTEMBER 20 - 23, 2016

Master Milling

CERTIFICATE COURSE

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Storage – Tanks – Buildings

Oil storage

Oil storage

Olive Oil
Storage Chart

BOUNDARY BEND ESTATE

Unit N°	Variety	Batches	Date	Acidity	Peroxides	Defects	Final tank	PPM

Oil storage

11:30am 12:30am 12:30am 01:30pm 09:30pm

Oil storage

- Temperature: 15 (59ºF) – 18ºC (64ºF)
- No light.
- Settlings drained regularly.
- Nitrogen: Max. = [4.0%] of O2
- Minimise head space

Oil storage

- Insulated.
- Electric illumination only.
- Well designed drainage system.
- Temperature control system.
- Secure.

Oil storage

Photos Jose Alba

Oil storage

Photos Jose Alba

Oil storage

Photos Jose Alba

Oil storage

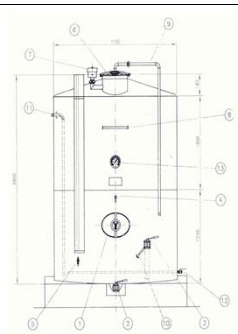
Photos Jose Alba

Oil storage

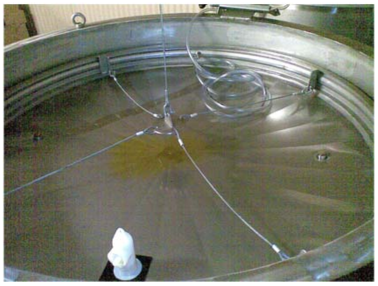
Photos Jose Alba

Oil storage

The Tank



The Tank



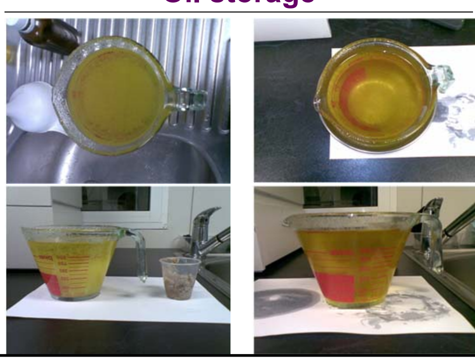
The Tank

The Sediments

Oil storage

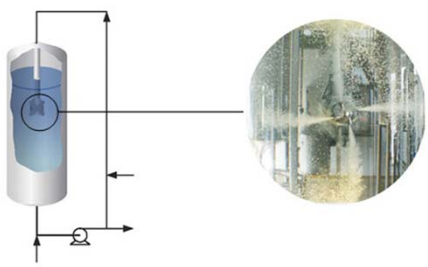
Oil storage

Oil storage



Nitrogen

Nitrogen

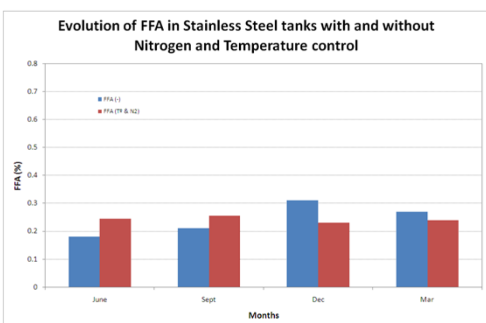


Nitrogen

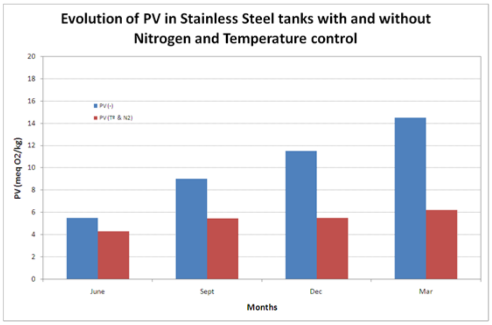
Nitrogen

Nitrogen

Quality evolution during storage



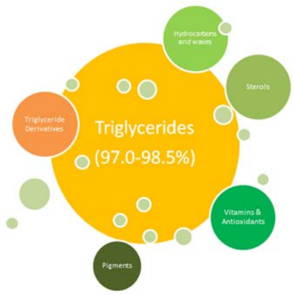
Quality evolution during storage



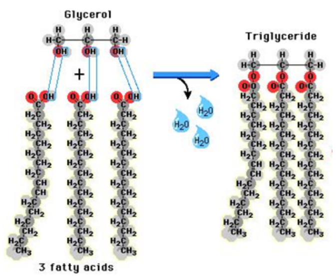
Quality Control

Quality Control

Extra Virgin Olive Oil Composition



Triglycerides



C 16:0 = Palmitic Acid
(7% – 20%)

C 18:1 = Oleic Acid
(53% – 85%)

C 18:2 = Linoleic Acid
(3% - 22%)

C 18:3 = Linolenic Acid
(< 1.5%)

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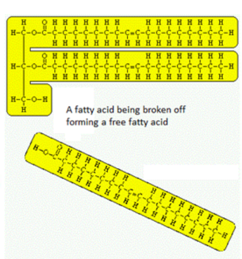
Triglyceride Derivatives (Oil Fermentation)



1,2 DAGs & 1,3 DAGs

Free Fatty Acids

(and Fatty Acid Alkyl Esters)

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Free Fatty Acids (Acidity)

- Provides a good indication of the fruit condition before crushing it, the time between harvesting and crushing and the storage conditions of the oil (sediments).
- **Extra virgin olive oils must have a free acidity level under 0.8%.** Nonetheless, it is expected that sound fruit processed immediately should produce oil with less than 0.35% FFA.

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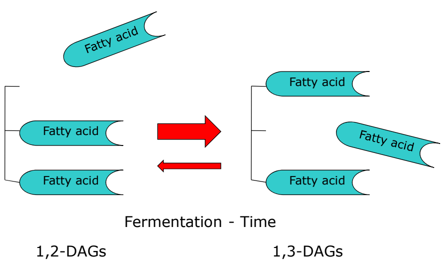
DAGs



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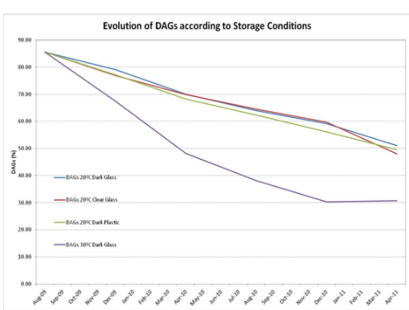
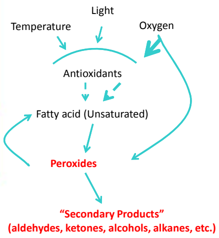
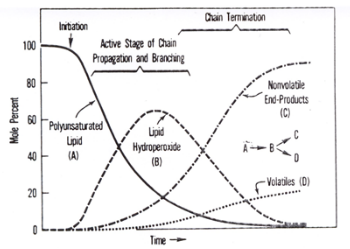
DAGs



BOUNDARY BEND LIMITED Australia's premier olive company Cobram Estate

Olive oil oxidation





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Peroxides Value

- This value is the primary measurement of oils initial oxidation and it gives us an idea of oils' freshness, processing conditions and storage conditions.
- **Extra virgin olive oils must have a peroxides value under 20 meq/kg.** Nonetheless, it is expected that sound fruit processed immediately should produce oil with less than 12 meq/kg.

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K232 & K270

- These values are the primary measurements of oils secondary oxidation and they give us an idea of oils' freshness, processing conditions and storage conditions.
- **Extra virgin olive oils must have K232 and K270 values of less than 2.50 and 0.22 respectively.** Nonetheless, it is expected that sound fruit processed immediately should produce oil with K values under 2.00 and 0.18 respectively.

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Quality evolution during storage

Effect of Storage Containers on Olive Oil Quality

RIRDC Publication No. 09/160

Quality evolution during storage

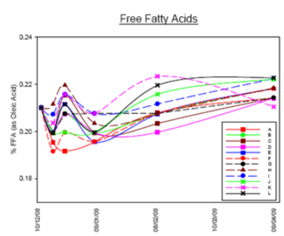


Figure 4.2 Effect of 12 alternative types of storage material on free fatty acids of olive oil stored for 16 weeks

Effect of Storage Containers on Olive Oil Quality

RIRDC Publication No. 09/160

Quality evolution during storage

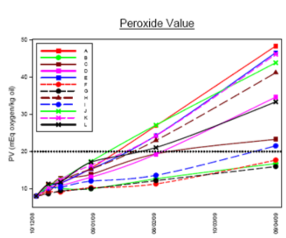


Figure 4.1 Effect of 12 alternative types of storage material on the peroxide value of olive oil stored for 16 weeks

Effect of Storage Containers on Olive Oil Quality

RIRDC Publication No. 09/160

Quality evolution during storage

Specific Extinction Coefficient

K_{232nm}

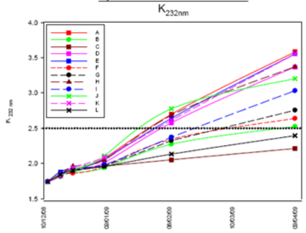


Figure 4.6a Effect of 12 alternative types of storage material on K_{232nm} of olive oil stored for 16 weeks

Effect of Storage Containers on Olive Oil Quality

RIRDC Publication No. 09/160

Bulk Deliveries

Finish Products

Evolution of quality parameters at 20ºC Dark Glass

Date	FFA	PV	K232	K270	DK	IND	PPH	K225	PPPs	DAGs	DEF	FRU	BIT	PUN
Aug-09	0.19	6.24	1.600	0.073	-0.001	5.7	155	0.09	1.79	85.59	0	5	3	[illegible]
Dec-09	0.17	8.97	1.760	0.128	0.000	4.9	165	0.10	5.99	79.16	0	5	3	[illegible]
Apr-10	0.18	9.84	1.957	0.138	0.001	4.8	126	0.13	7.18	69.97	0	5	2	[illegible]
Aug-10	0.20	9.81	1.926	0.175	0.002	4.1	122	0.13	8.00	64.04	0	5	2	[illegible]
Dec-10	0.21	10.97	1.876	0.186	0.003	4.4	140	0.12	10.47	59.17	0	5	3	[illegible]
Apr-11	0.24	10.44	1.850	0.190	0.005	4.2	133	0.12	13.59	51.03	0	4	2	[illegible]

Evolution of quality parameters at 20ºC Clear Glass

Date	FFA	PV	K232	K270	DK	IND	PPH	K225	PPPs	DAGs	DEF	FRU	BIT	PUN
Aug-09	0.19	6.24	1.600	0.073	-0.001	5.7	155	0.09	1.79	85.59	0	5	3	[illegible]
Dec-09	0.17	10.16	1.810	0.146	0.002	4.2	159	0.14	5.41	76.84	0	5	2	[illegible]
Apr-10	0.18	15.48	2.187	0.165	0.002	4.2	123	0.12	11.86	69.82	0	4	2	[illegible]
Aug-10	0.21	9.31	1.945	0.212	0.005	3.9	127	0.11	18.95	64.57	0	5	2	[illegible]
Dec-10	0.22	14.02	1.924	0.230	0.006	3.6	129	0.10	25.23	59.66	0	4	2	[illegible]
Apr-11	0.24	10.93	1.915	0.222	0.003	3.6	127	0.12	27.32	48.08	1	3	2	[illegible]

Evolution of quality parameters at 20ºC Dark Plastic

Date	FFA	PV	K232	K270	DK	IND	PPH	K225	PPPs	DAGs	DEF	FRU	BIT	PUN
Aug-09	0.19	6.24	1.600	0.073	-0.001	5.7	155	0.09	1.79	85.59	0	5	3	[illegible]
Dec-09	0.17	6.17	1.889	0.111	0.000	3.9	188	0.14	3.88	77.23	0	5	3	[illegible]
Apr-10	0.17	12.78	1.953	0.172	0.003	4.1	131	0.14	6.41	68.27	0	5	2	[illegible]
Aug-10	0.19	11.65	2.089	0.158	0.001	3.7	138	0.13	7.63	62.29	0	4	2	[illegible]
Dec-10	0.21	15.40	2.216	0.177	0.003	3.1	139	0.11	10.08	56.16	0	5	2	[illegible]
Apr-11	0.22	14.74	2.087	0.158	0.003	3.2	139	0.13	12.90	49.61	0	4	2	[illegible]

Evolution of quality parameters at 30ºC Dark Glass

Date	FFA	PV	K232	K270	DK	IND	PPH	K225	PPPs	DAGs	DEF	FRU	BIT	PUN
Aug-09	0.19	6.24	1.600	0.073	-0.001	5.7	155	0.09	1.79	85.59	0	5	3	[illegible]
Dec-09	0.17	6.06	2.103	0.114	-0.001	4.4	177	0.14	10.11	67.40	0	5	3	[illegible]
Apr-10	0.20	13.88	2.108	0.147	0.001	3.9	107	0.13	24.10	48.14	0	5	2	[illegible]
Aug-10	0.25	11.26	3.497	0.199	0.002	2.8	98	0.10	43.34	38.14	1	5	2	[illegible]
Dec-10	0.30	15.71	3.412	0.286	0.006	2.6	89	0.10	84.35	30.33	1	4	1	[illegible]
Apr-11	0.36	12.38	3.384	0.280	0.004	2.8	89	0.10	90.80	30.75	3	3	1	[illegible]

Quality evolution during storage

Evolution of quality parameters at 20ºC Dark Glass for high quality oils (FFA < 0.20%)

Date	FFA	PV	K232	K270	DK	IND	PPH	K225	PPPs	DAGs	DEF	FRU	BIT	PUN
Aug-09	0.16	5.16	1.483	0.087	-0.001	6.3	187	0.10	1.44	90.80	0	6	3	[illegible]
Dec-09	0.13	8.48	1.611	0.125	-0.001	5.7	202	0.12	5.30	85.00	0	5	3	[illegible]
Apr-10	0.14	9.80	1.692	0.148	0.001	5.6	157	0.17	6.64	78.31	0	5	3	[illegible]
Aug-10	0.16	8.28	1.741	0.174	0.002	5.3	155	0.14	7.62	72.53	0	5	3	[illegible]
Dec-10	0.17	10.27	1.662	0.166	0.003	5.1	157	0.13	9.83	70.36	0	5	3	[illegible]
Apr-11	0.19	9.16	1.703	0.200	0.004	4.8	154	0.14	13.32	55.53	0	4	3	[illegible]

Evolution of quality parameters at 20ºC Dark Glass for lower quality oils (FFA > 0.20%)

Date	FFA	PV	K232	K270	DK	IND	PPH	K225	PPPs	DAGs	DEF	FRU	BIT	PUN
Aug-09	0.29	6.64	1.689	0.112	-0.002	7.3	301	0.12	2.48	79.24	0	5	3	[illegible]
Dec-09	0.26	9.54	1.837	0.158	0.000	6.8	268	0.16	5.24	68.52	0	5	4	[illegible]
Apr-10	0.27	12.21	1.997	0.194	0.002	6.6	255	0.24	6.96	57.37	0	5	3	[illegible]
Aug-10	0.30	10.11	1.966	0.207	0.002	6.3	253	0.19	8.76	49.79	1	5	3	[illegible]
Dec-10	0.32	12.61	1.960	0.228	0.005	6.1	233	0.17	10.98	45.86	0	5	3	[illegible]
Apr-11	0.35	10.14	1.932	0.236	0.006	6.0	242	0.19	14.55	38.44	1	4	3	[illegible]

Plant cleaning & maintenance

Floors: Neutral detergents (no foam)

Equipment (during season): pressurized hot water

Equipment (end of season): Caustic soda based products, specific products for separators

Tanks: Caustic soda & citric acid

Plant cleaning & maintenance

Cleaning and maintenance program

- Cleaning of the processing plant immediately after the season ends
- Start from receival area and follow the path of the olive fruit through the equipment
- All conveyor belts to be dismantled. Check condition of belt rollers
- Remove crusher grids and replace old hammers for new ones
- Pull apart piston pumps and monopumps. Remove olive pit and pomace deposits. Check piston seals and stators condition

Plant cleaning & maintenance

- Thoroughly wash decanter with water 2-3 times. Check bearings condition.
- Pump caustic soda/water through all paste and oil piping.
- Clean separator with caustic soda and remove inside drum. Clean separator plates.
- Ensure all full tanks are properly labelled. Clean with caustic soda all empty tanks
- Clean outside areas to minimise the impact of rodents.
- Ensure all electrical panels/cabinets are properly sealed to avoid the action of rodents
- Remove talc powder left over from inside talc powder dispensers. Do the same with enzyme dosing machines

Plant cleaning & maintenance



Plant cleaning & maintenance

CIP Tank cleaning sequence

- Hose down bottom of tank to remove mud
- Caustic soda [2%] – 15 minutes
- Fresh water – 10 minutes
- Citric acid [2%] – 15 minutes
- Fresh water – 10 minutes
- Check pH of water on walls of tank
- Re-cycle fresh water if pH is <6
- Open valves and main door of tank to let dry overnight
- Before putting any oil ensure tank is dry and valves & doors are closed
- Assess the condition of the caustic soda solution to see if it can be re-used

Why blending is necessary?

- To improve the overall taste profile of the blended oils (Balance).
- To meet customer requirements.
- To lift one dimensional or particularly flat oils.
- To maintain consistency from year to year and within a year.
- To win medals (Marketing).
- To meet legal chemical parameters.

What to do before blending?

- Obtain as much background information about the oils to be used as possible (Variety, location, processing method, storage conditions, etc.).
- Use laboratory tests (FFA, Peroxides, Polyphenols, Bitterness, Shelf Life, fatty acid profile and sterols if out of limit values are suspected).
- Ideally wait between 5 and 7 weeks before blending.
- Have a clear idea of what you want to achieve.

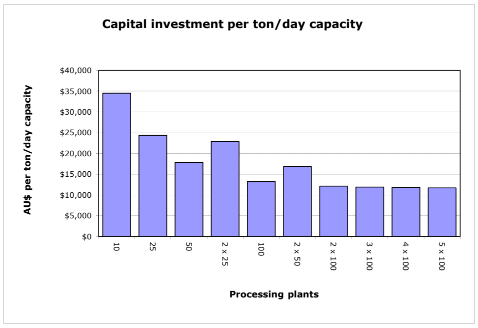
What to do while blending?

- Taste all the available oils several times.
- Write detailed notes about them highlighting the most distinctive characteristics of each oil.
- Compare strengths and weaknesses of each oil.
- Rank them according to intensities.
- **BLEND.**
- At the completion of each blend review the final product, keep notes and samples of each blend attempt.
- Are you happy with the blend?

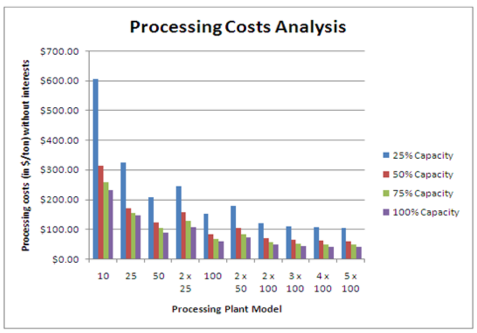
Some facts about blending

- It is far easier to reduce the quality of a good oil by blending than it is to increase the quality of a poor oil.
- Excellent oils are blended from very good oils.
- Only small inadequacies can be improved by blending.
- Blending can not mask a fermentative fault (Fusty, musty, muddy, etc.).
- Some oils have no place in a blend.
- Remember that dirty mouth feeling will increase with age.
- Bitterness is not easy to mask.
- Strong dominant varieties (Picual) will dominate the profile of a blend if added in more than 30%.

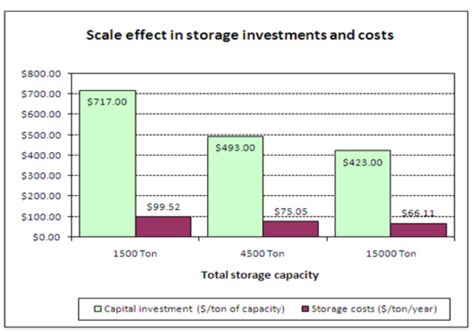
Economic analysis



Economic analysis



Economic analysis



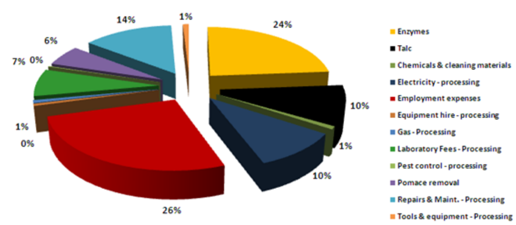
Economic analysis

Direct processing costs (US$/Ton)

Facility size	Fruit processed per year (Ton)	Direct costs (US$/Ton)
Large	> 15,000 Ton	30 – 65
Medium	3,000 – 5,000 Ton	95 - 130
Small	200 – 300 Ton	180 - 230

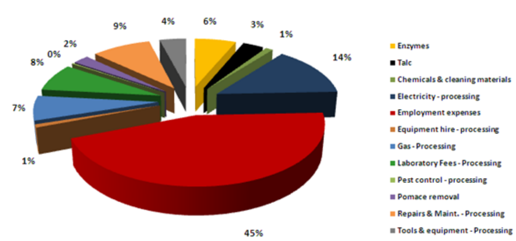
Economic analysis

Large size facility - Direct cost distribution



Economic analysis

Small size facility - Direct cost distribution



Economic analysis

Comparison between a poorly managed operation and two well managed operations focused on costs or quality (20 tons/day operation or approximately 200 acres)

	Fruit Oil Content	Extraction Efficiency	Gallons/ton	Cost ($/gallon)	%
Poor Management Standards	15%	75%	27.2	$5.51	62%
High Quality Focus	18%	85%	37.0	$4.05	19%
Low Cost Focus	20%	91%	44.0	$3.41	0%

Useful Conversions

WEIGHT

- 1 Short Ton = 2,000 Lbs
- 1 Metric Ton = 2,205 Lbs
- 1 Lb = 0.45 Kg
- 1 Kg = 2.20 Lbs
- 1 Gallon of Olive Oil weighs 7.6 Lbs or 3.45 Kg on average (depending on temperature)

VOLUME

In the U.S., professionals in the olive oil business often refer to bottle size the same way the Europeans do, using metric numbers, with the exception of gallons. For instance, a producer may talk about gallon bottles and 375ml bottles in the same sentence.

BASIC CONVERSIONS

- 1 U.S. Gallon = 3.785 Liters = 128 Fl. Oz.
- 1 Liter = 1,000 ml = 33.8 Fl. Oz.

The most common sizes for olive oil bottles are:

200 ml = 0.2 Liters = 6.8 Fl. Oz.
375 ml = 0.375 Liters = 12.7 Fl. Oz.
500 ml = 0.5 Liters = 16.9 Fl. Oz.
750 ml = 0.750 Liters = 25.4 Fl. Oz.

Number of Bottles per Gallon
One gallon of olive oil will give you:

3.8 x 1 Liter/33.8 Fl. Oz. bottles
5 x 750 ml/25.4 Fl. Oz. bottles
7.6 x 500 ml/16.9 Fl. Oz. bottles
10.0 x 375ml/12.7 Fl. Oz. bottles (almost exactly)
15.14 x 250ml/8.5 Fl. Oz. bottles
18.9 x 200ml/6.8 Fl. Oz. bottles (almost 19)

OLIVE OIL YIELD

The olive oil yield refers to the volume of oil per weight of olives. In the U.S. it is generally expressed either in Gallons / Ton (Volume of Oil in Gallons per Weight of Olives in Short Tons) or in % (Weight of Oil in Lbs divided by Weight of Olives in Lbs, or Weight of Oil in Kgs divided by Weight of Olives in Kgs).

Use the following formulas to convert from one to the other:

Yield in % = Number of Gallons * 7.6 / 20
Yield in Gallons/Ton = Yield in % * 20 / 7.6

For example, 10 Gallons / Ton = 3.8%. A 10% yield is equivalent to 26 Gallons / Ton.

LENGTH

- 1 Mile = 1.61 Km
- 1 Km = 0.62 Miles
- 1 Meter = 3.28 Feet
- 1 Foot = 0.35 meters
- 1 Inch = 25.4mm = 2.54cm = 0.0254 meters

AREA

- 1 Acre = 0.40 Hectares
- 1 Hectare = 2.47 Acres

TEMPERATURE

The formulas to convert Fahrenheit degrees into Celsius degrees and vice-versa are:

Temperature in ºF = (Temperature in ºC / 5 * 9) + 32
Temperature in ºC = (Temperature in ºF – 32) / 9 * 5

For instance 27 ºC = 80.6 ºF (temperature used in definition of extra virgin olive oil).

Adapted from an article on OliveOilSource.com.

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