



# Processing Olives into Oil

**Sonoma – November 4, 2009**

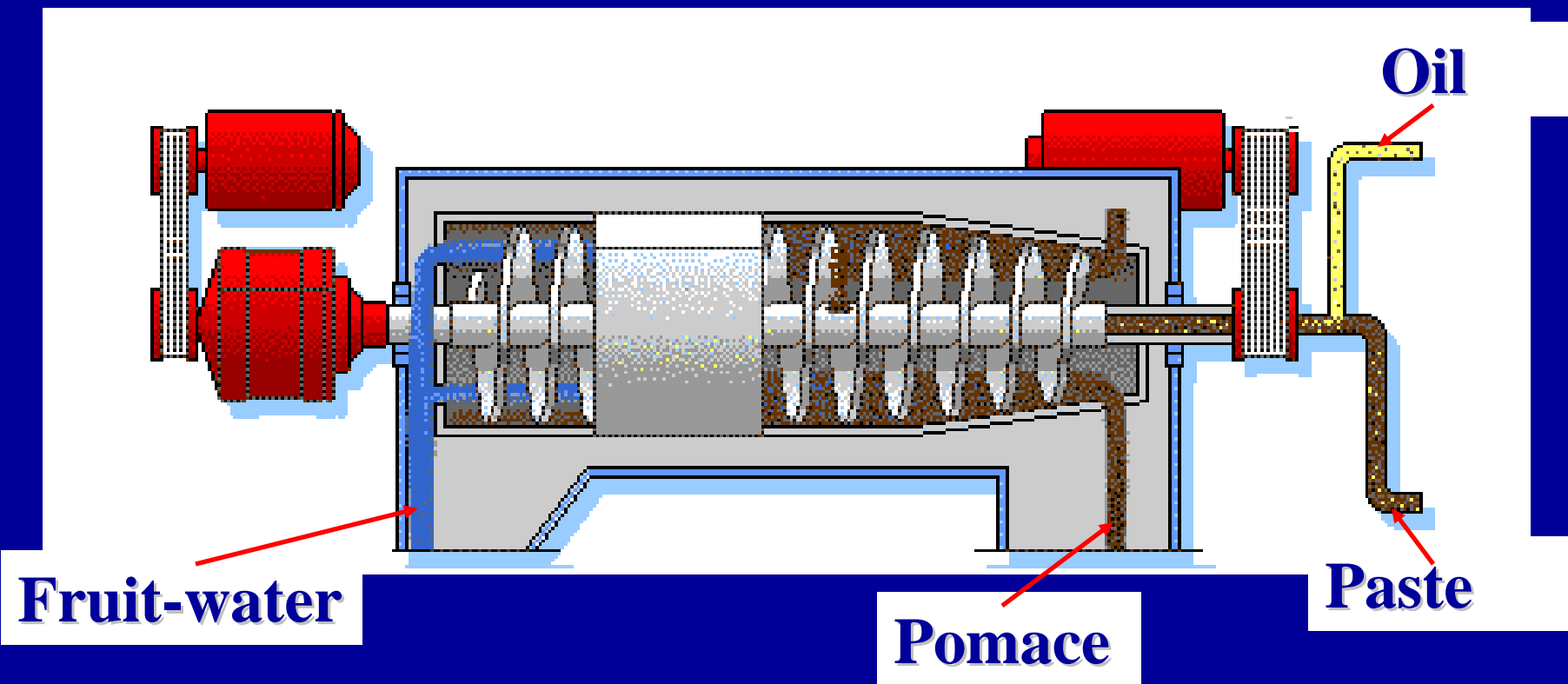
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## **Decanter – Horizontal Centrifuge**

# Presentation Topics

- How Olive Oil is Made (olives in the field, reception area, crushing, malaxation, separation, cleaning, storage, filtering, bottling)
- Efficiency and Quality



# Olive Oil Mechanization Innovation

## GROWING OLIVES

- Mechanical harvest
- Low vigor varieties
- Drip irrigation
- Mechanical pruning



## PROCESSING FRUIT

- Cont. flow system
- Electricity (pumps, motors, temp. control)
- Stainless steel



# HOW OLIVE OIL IS MADE

**Simple and Natural!**

- **Crush the fruit**
- **Separate the oil from fruit-water  
and solids**

# Extra Virgin Olive Oil

## Simple as 1-2-3-4-5

1. Good Fruit – no rot – not frozen
2. Handled carefully – no damage – short storage
3. Processed quickly – in modern clean equipment
4. Stored well – clean stainless steel - purged
5. Sold – within a year or less



# OLIVES on the TREE

- Quality is the best it can be
- Good fruit = extra virgin



# Pre-harvest defects can come from:

- Freeze
- Olive fly
- Pesticide



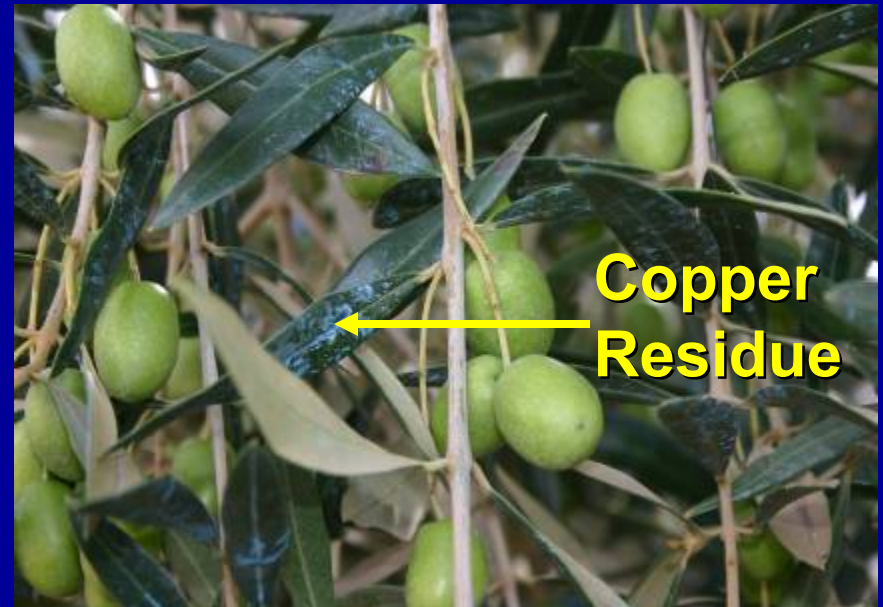
Maggot damage



OK



Frozen



Copper Residue

# Frozen Olives



# **OLIVE FLY DAMAGE and OIL SENSORY ANALYSIS**

**Can tolerate more damage if the fruit is not rotten**



# Irrigation influence on flavor:

- Severe drought stress
- Excess moisture



# Olive Harvest & Handling Problems

## Bruising



# Colossus Harvested Manzanillos





# Minor damage from workers stepping on the fruit on the nets



**ALMOST  
INSIGNIFICANT**

# Olive Harvest & Handling Problems

## Ground fruit



# Ground Fruit – Mechanical Pick-up





# Olive Harvest & Handling Problems

## Stored fruit









# **BIOGENESIS OF FUSTY, WINEY/VINEGARY & MUSTY DEFECTS**

**DAY 0 - Present in and on fruit**

**Enzymes, bacteria, yeast, molds**

**DAY 2 – Beginning of texture loss (skin breakdown)**

**Enterobacter and Clostridium (fusty & winey)**

**DAY 4 – Fermentation**

**Yeasts, lactobacillus, and acetobacter + sugars =  
ethanol, lactic acid, ethyl acetate, & acetic acid**

**(fusty and winey/vinegary)**

**DAY 6 – Mold growth**

**Fungus mycelium (musty)**

*Angerosa et al. 1998*

# GOOD OLIVE OIL STARTS WITH GOOD FRUIT



# FRUIT MATURITY

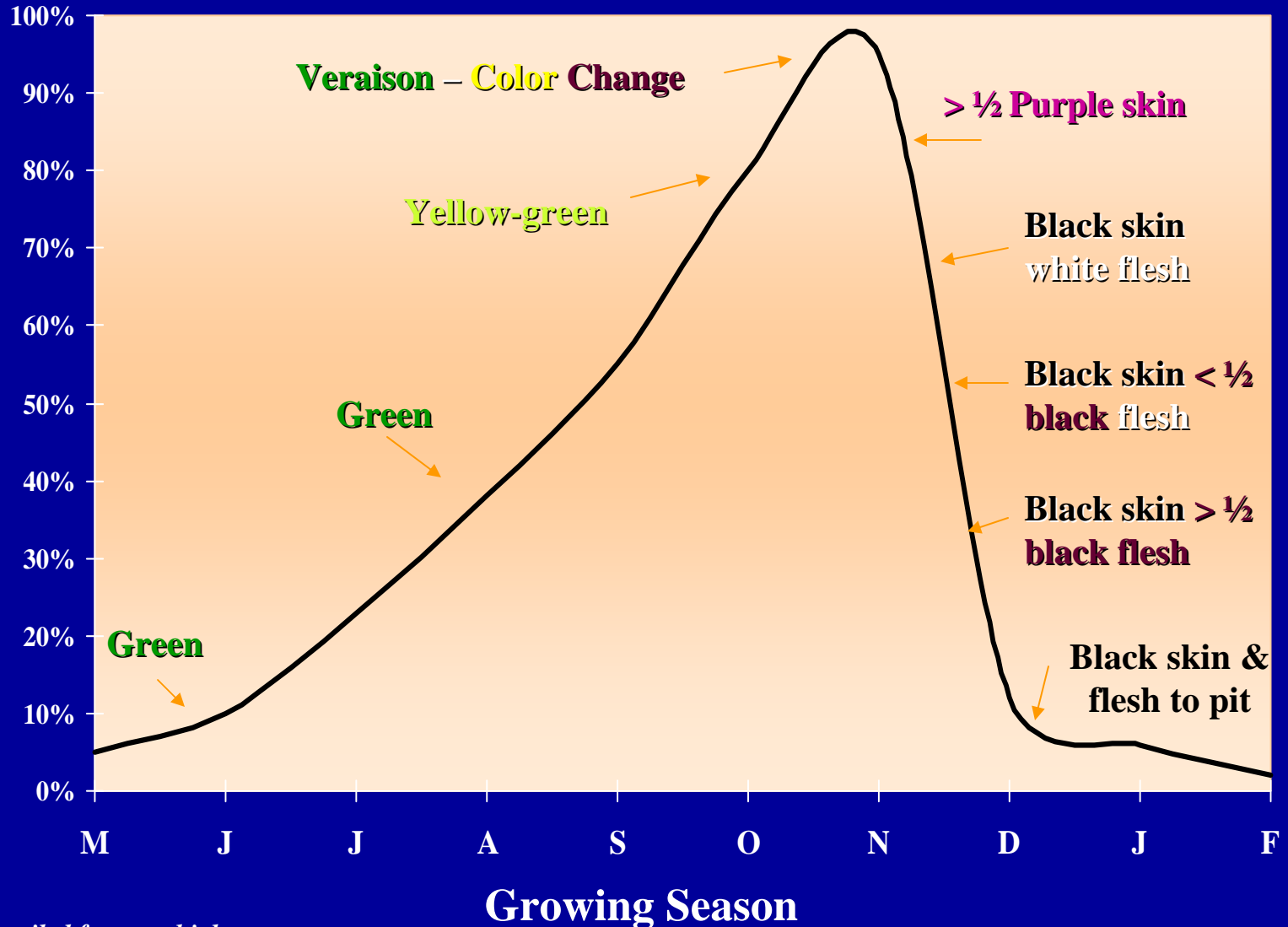
## Degree of Ripeness

- Hard Green
- Soft Yellowing
- Black Skin - Flesh Green
- Black Skin and Flesh



*Large influence on sensory attributes*

# FRUIT POLYPHENOL LEVEL & COLOR DURING THE GROWING SEASON



# Maturity Style Generalities

## Green

- Fruity – 8
- Green – 7
- Ripe Fruit – 0
- Bitter – 7
- Rough – 6
- Astringent – 6
- Pungent – 6
- Balance – 1
- Grass
- Herbaceous
- Nettle
- Tannic
- Woody

## Ripe

- Fruity – 6
- Green – 5
- Ripe Fruit – 5
- Bitter – 3
- Rough – 1
- Astringent – 1
- Pungent – 4
- Balance – 8
- Floral
- Nutty
- Almond
- Apple
- Berry

## Over-ripe

- Fruity – 2
- Green – 0
- Ripe Fruit – 8
- Bitter – 0
- Rough – 0
- Astringent – 0
- Pungent – 0
- Balance – 2
- Tropical
- Banana
- Eucalyptus
- Buttery

# Oil Yield Based on Fruit Maturity and 2<sup>nd</sup> Pressing

Variety	Maturity	Gallons of oil/ton	%
Mission	Green – yellow	37.7	14.3
Mission	Half ripe – red color	39.7	15.1
Mission	Fully ripe – black fruit	50.1	19.0
Mission	Fully ripe – shriveled fruit	58.2	22.1
Mission	Moldy pomace – 2 <sup>nd</sup> pressing	11.2	4.2

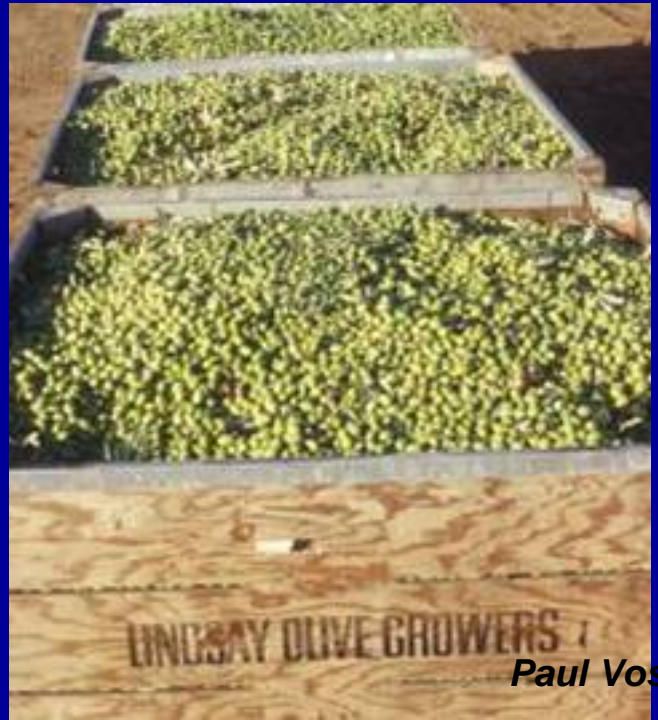
# TRANSPORT & STORAGE

## Farm to mill

- Bins - Boxes - Bags
- Shallow Depth
- Ventilation
- Short Distance or Time



*The olives should not be damaged.*



*Paul Vossen*

# PROCESSING STEPS

1. Fruit Transport
2. Fruit Storage
3. Fruit Cleaning
4. Fruit Washing
5. Fruit Crushing
6. Paste Malaxation
7. Oil Separation
8. Oil Cleaning
9. Oil Settling
10. Oil Storage
11. Oil Filtration
12. Oil Bottling
13. Bottle Storage
14. Waste Disposal

# GREAT OIL – BAD OIL

## *When its great*

- **Magic**
- **Perfect climate**
- **Perfect soil**
- **Old stressed trees**
- **Secret tradition**
- **Perfect variety mix**
- **Perfect maturity**
- **Good blending**

# GREAT OIL – BAD OIL

## When its great

- Magic
- Perfect climate
- Perfect soil
- Old stressed trees
- Secret tradition
- Perfect variety mix
- Perfect maturity
- Good blending

## When its bad

- Processor goofed



# Mill Capacity

- **Determined by the peak daily requirement**
- **Bottleneck is the decanter**
- **Difference between nominal & real capacity**
- **Size of washing machines**
- **Malaxing flexibility to change duration**
- **Vertical separators**
- **Storage capacity**

# Mill Location

- As close to production as possible
- Far from smoke/air pollutants & dust
- High enough – good drainage
- Not too close to a town
- Three-phase power availability
- Potable water availability



# Mill Design

Circulation perimeter

Receiving area (patio)

Processing area

Waste management area

Storage area

Bottling room

Laboratory

Office

# Mill Building

- Fenced - secure
- Compliant to Fed., State, County regulations
- Construction materials – no odors to the oil
- Waterproof washable resistant surfaces
- Roof and ceilings higher than 12 ft.
- Protected lights
- Natural light
- Clean/dirty areas recommended
- Aeration to avoid excessive heat and vapors
- Pipe identification through color codes
- Roof and ceilings higher than 4 meters

# Portugal



# Historical Ambiance



# Italy – Laudemio group



# New CORTO mill



# Patio



# Patio



# Patio



# Patio



# Patio



# Patio



# Leaf and stem removal

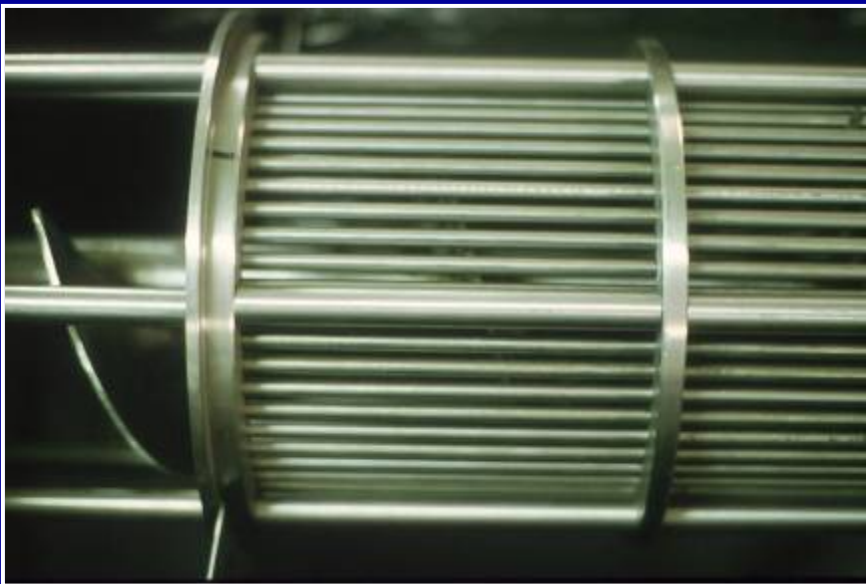
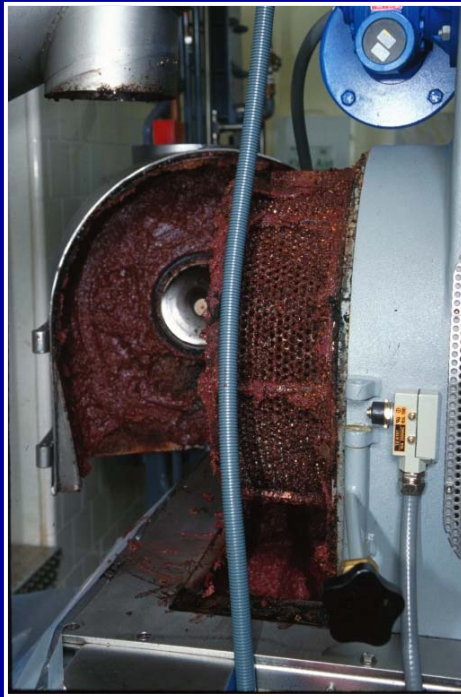


# WASHING OLIVES BEFORE MILLING

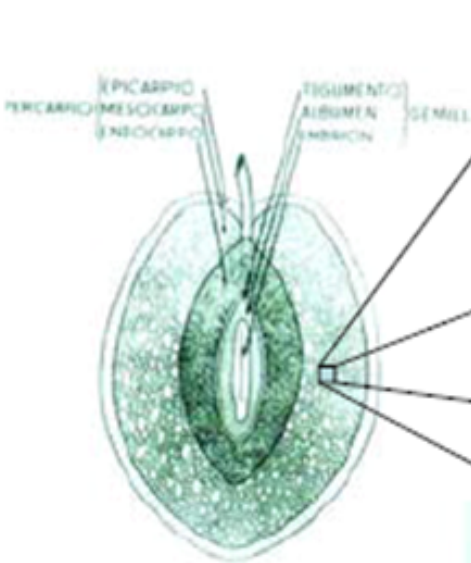


# OLIVE CRUSHING

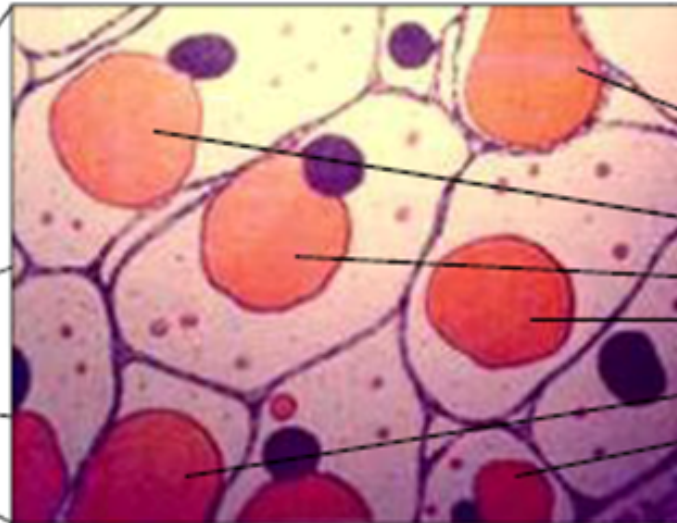
- Hammermill
- Disc Crusher
- Fruit Pitter
- Stone Mill



# Crush the cell walls and membrane surrounding the oil



Transversal view of an olive



Detail of cells in the olive flesh



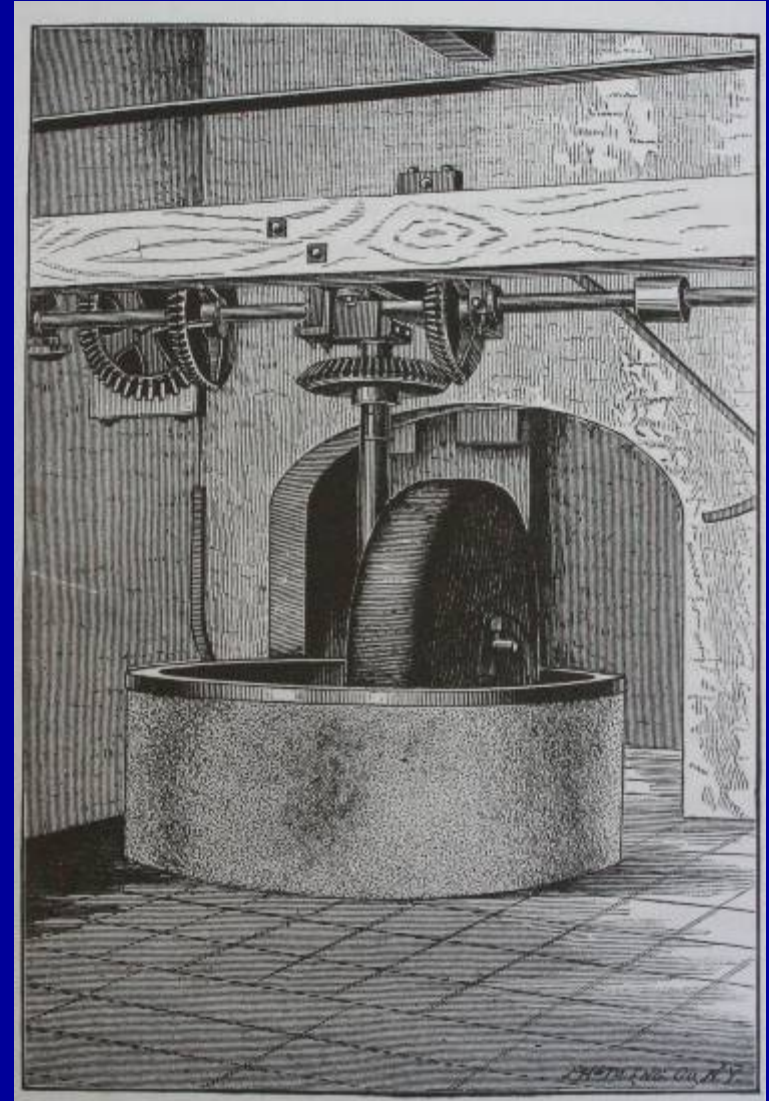
# Hand Olive Crusher (Morocco)



# Turkish Stone Crusher and Decantation Basins



# Animal or Water Powered Stone Crushers



# California Mission



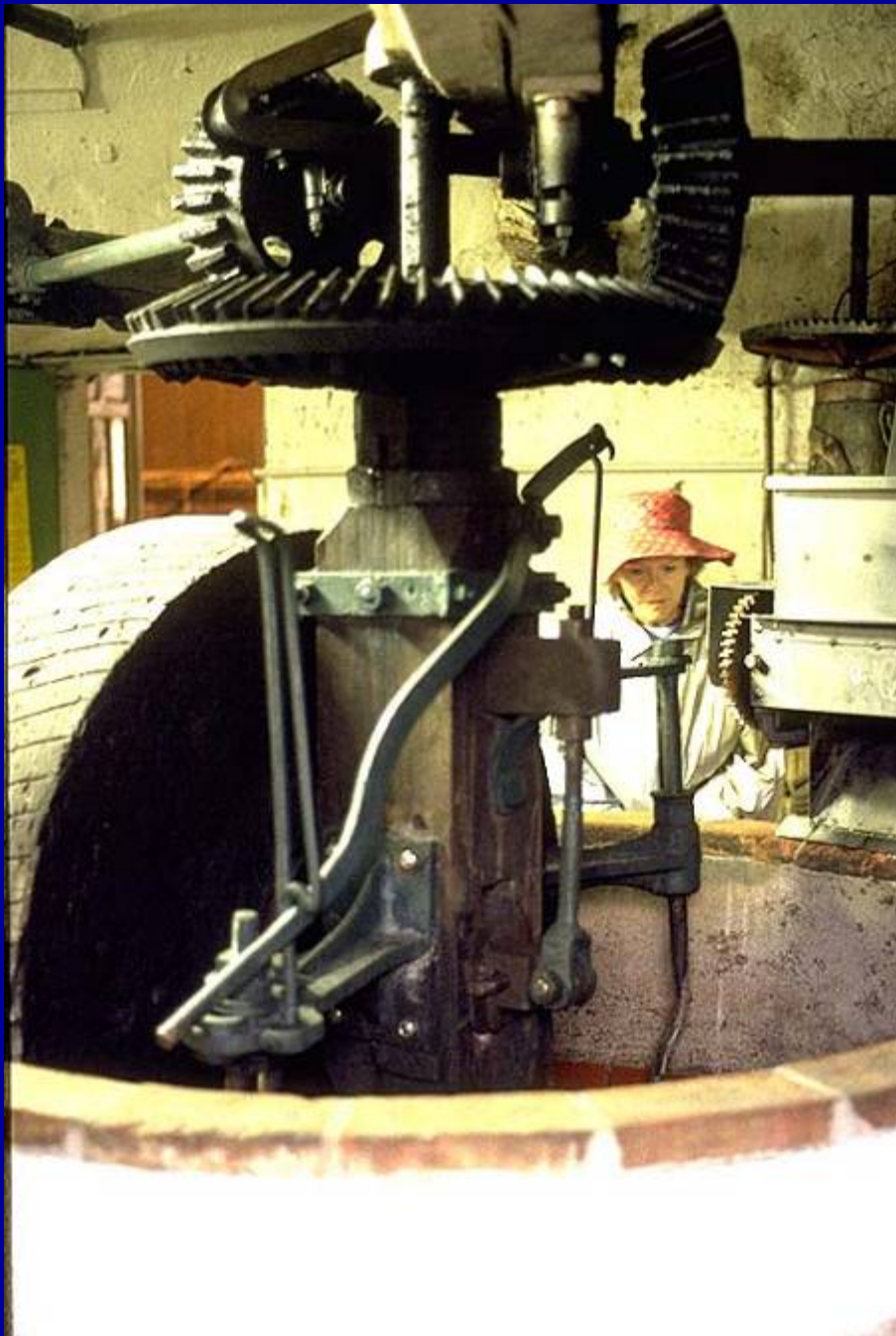
# California Mission Stone Crusher





# Morocco 2007





**Spanish Cones**

**Italian Wheels**

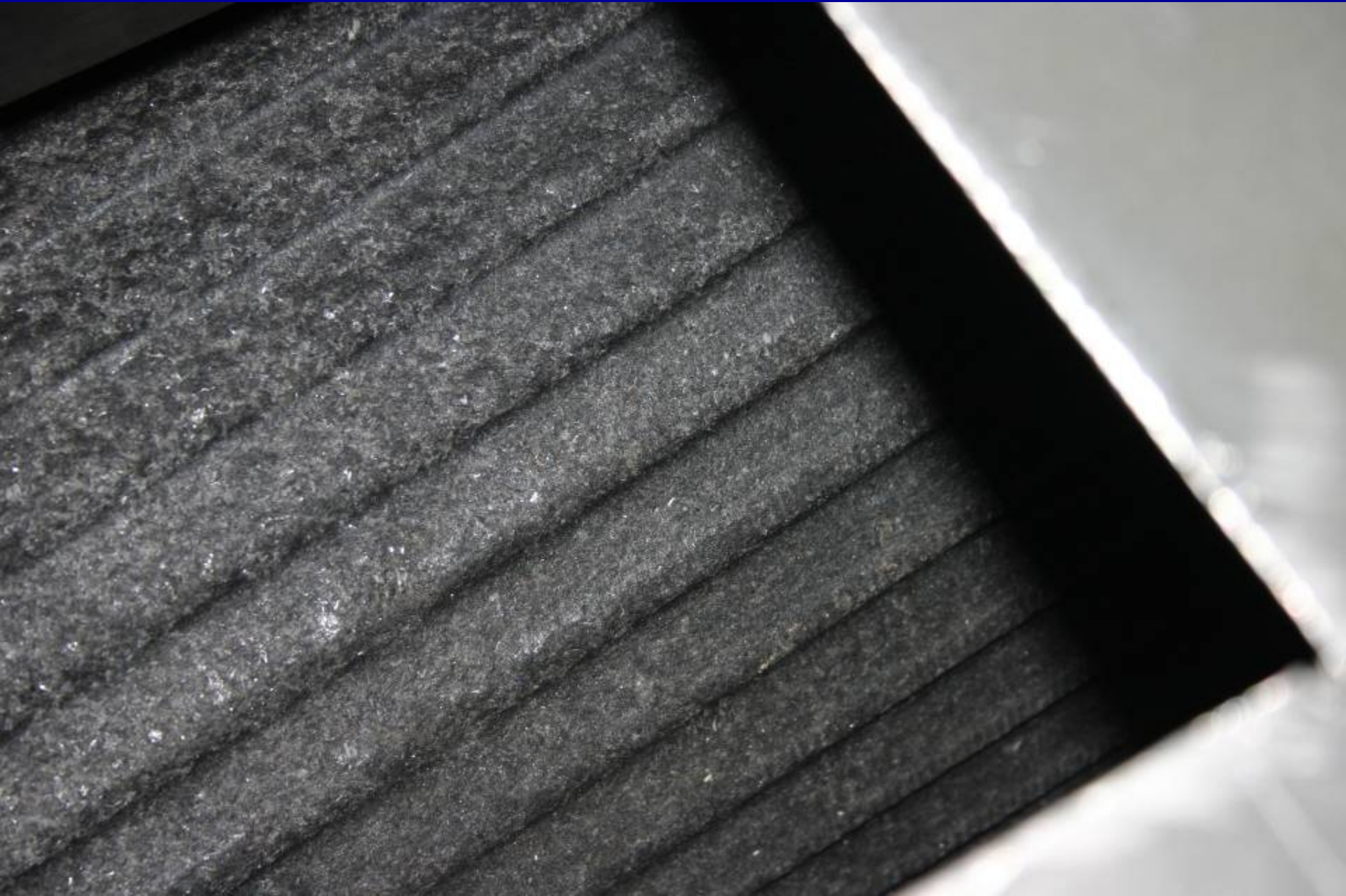


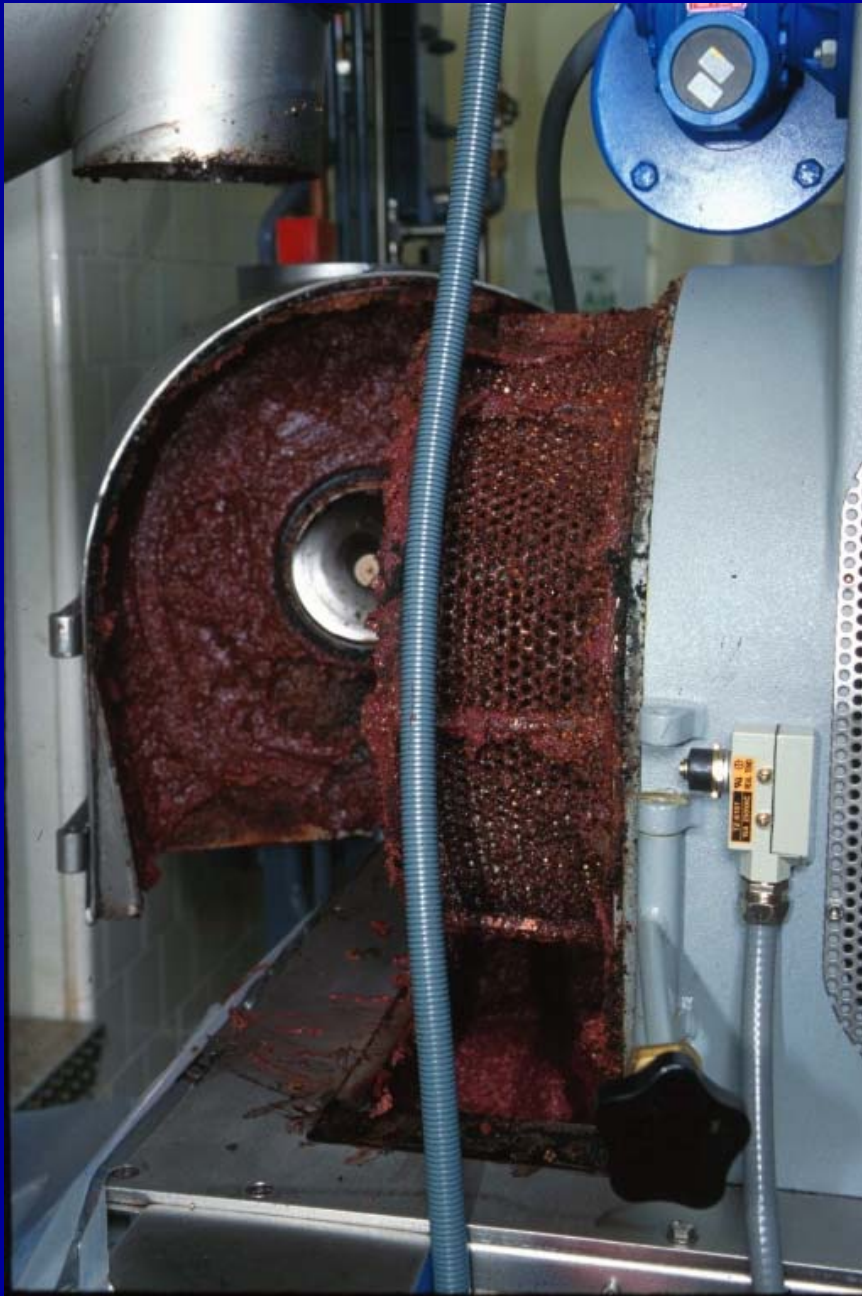
# Modern Italian Stone Crusher





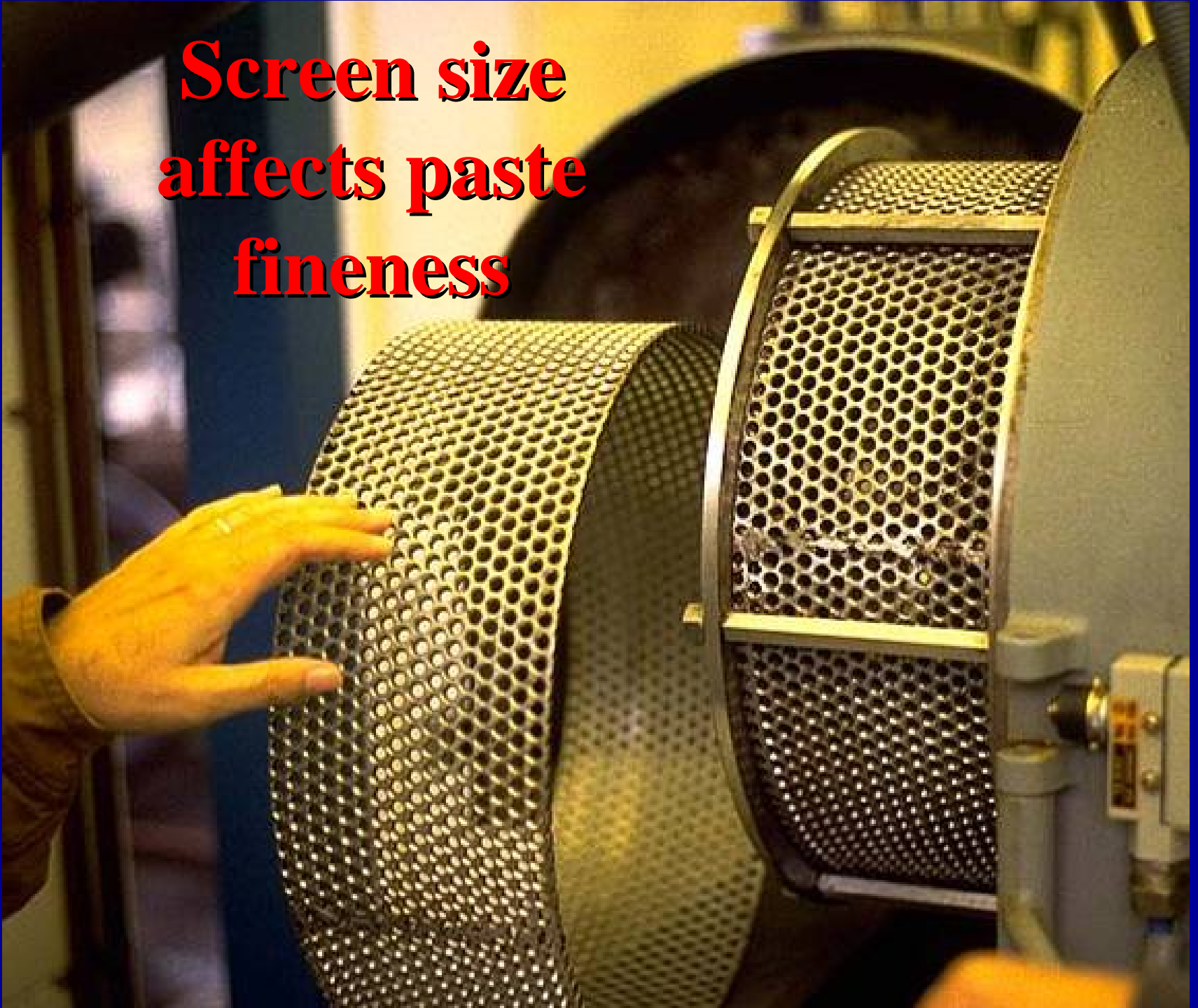
# Roller Crusher



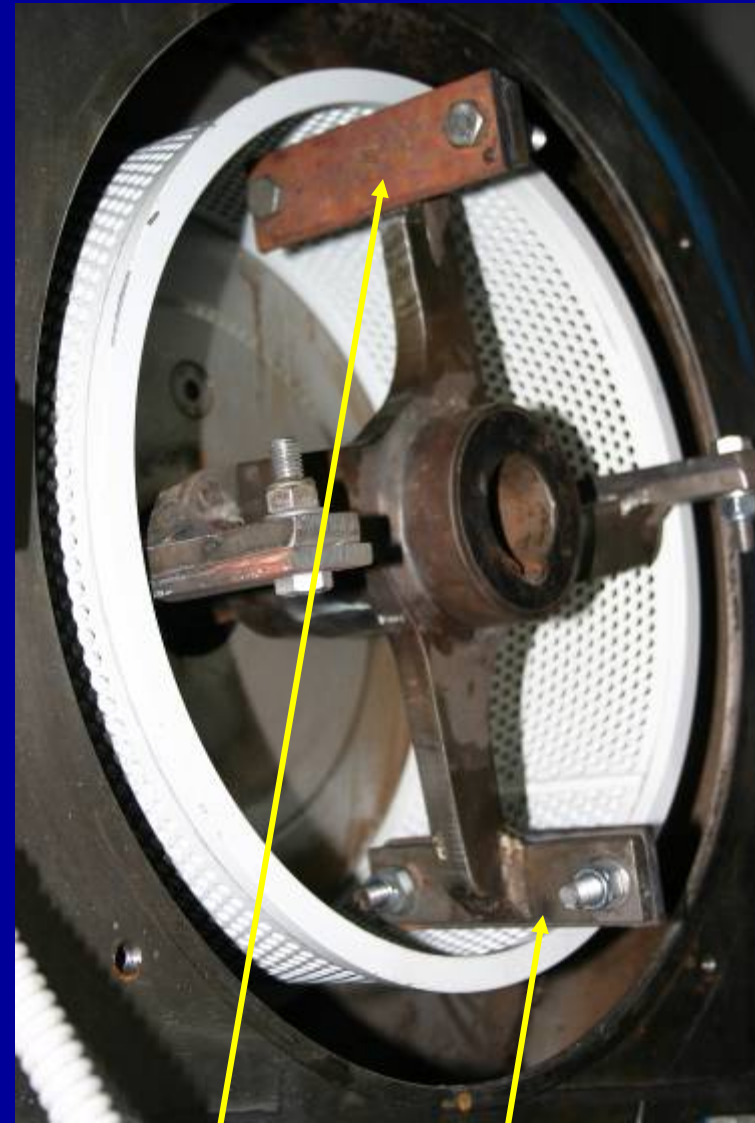
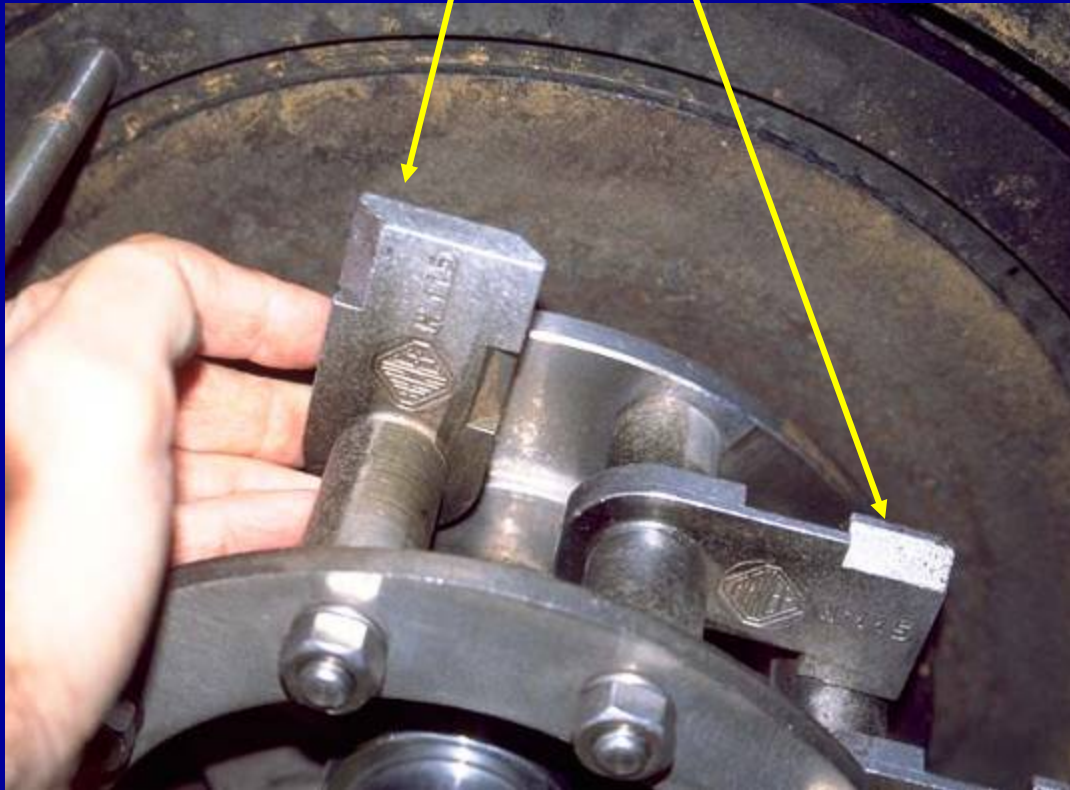


**The  
hammermill  
smashes the  
fruit and  
pushes it  
through a  
screen**

**Screen size  
affects paste  
fineness**



**Blades**



**Hammers**

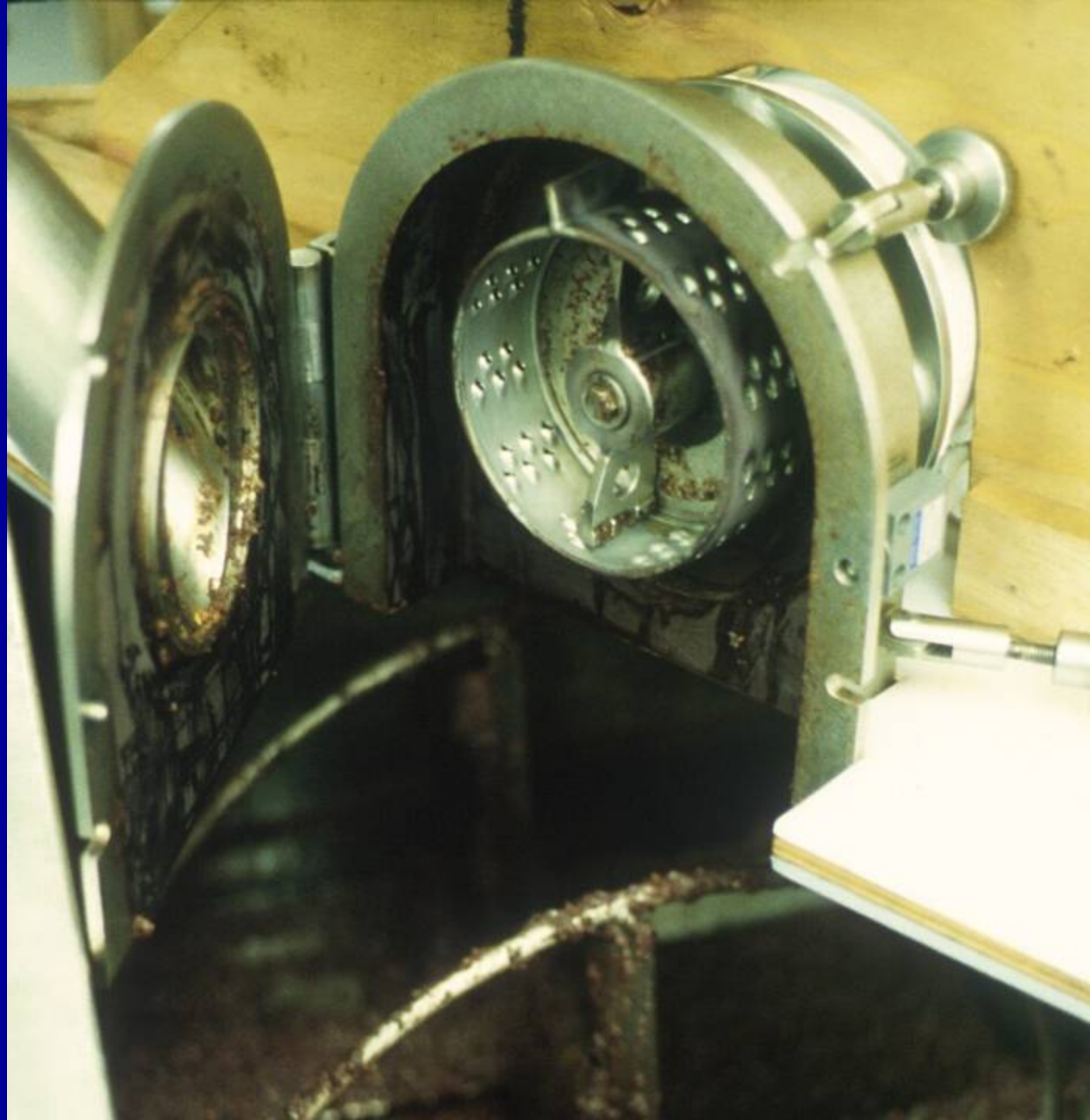
# Variable speed knife blade crusher



# Disk Crusher



# Cheese Grater Crusher



# Milling Area - Crushing



# Milling Area - Crushing



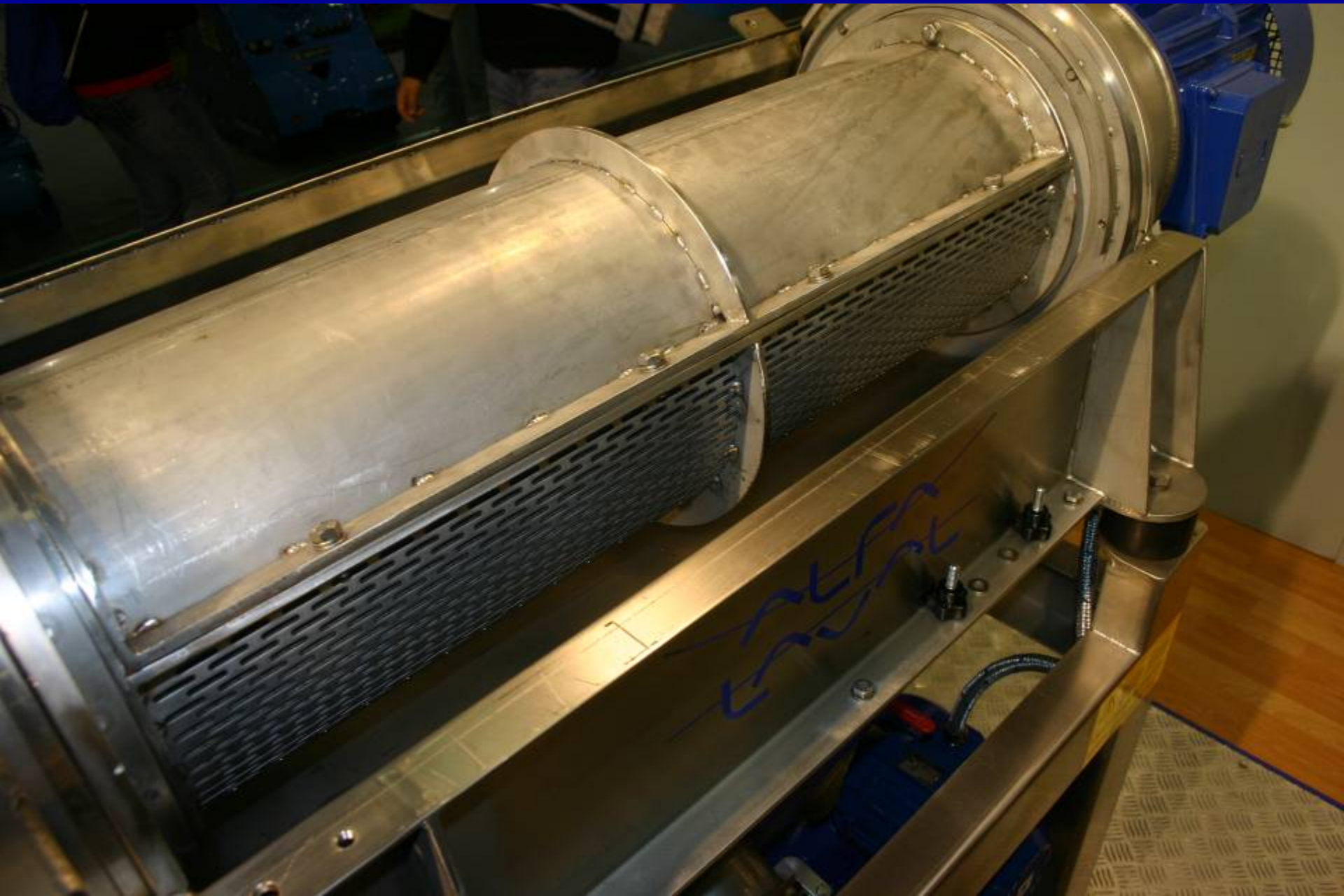
# Milling Area - Crushing



# Milling Area - Crushing



# De-pitter Crusher



# Pitter & Crusher





*Left – de-pitted paste*

*Right – pits crushed in paste*

# Processing Area



A photograph of a malaxation tank. The tank is open, revealing a thick, red, fibrous paste inside. A metal mesh screen is positioned in front of the tank, with some of the red paste visible through it. The tank is made of stainless steel and has a yellow warning label on the right side. The brand name "PIERA" is visible on the bottom right corner of the tank.

*Malaxation tank – jacketed to slightly warm paste*

# Malaxation tank blades



# Wet Paste

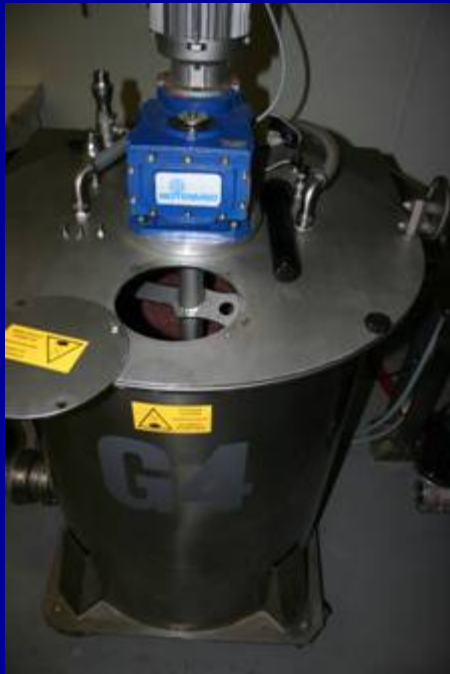


# Paste with free oil



# Time and Temperature





**Zero  
O<sub>2</sub>**





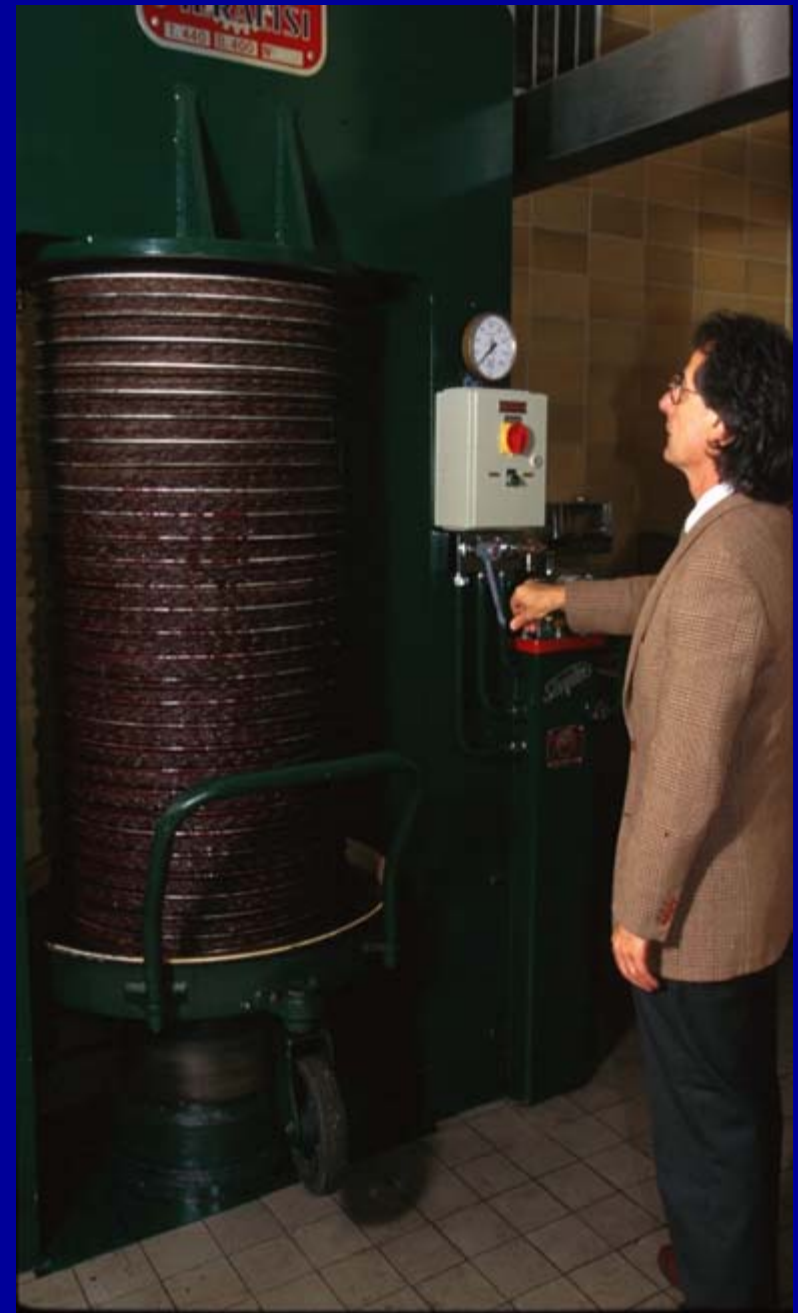
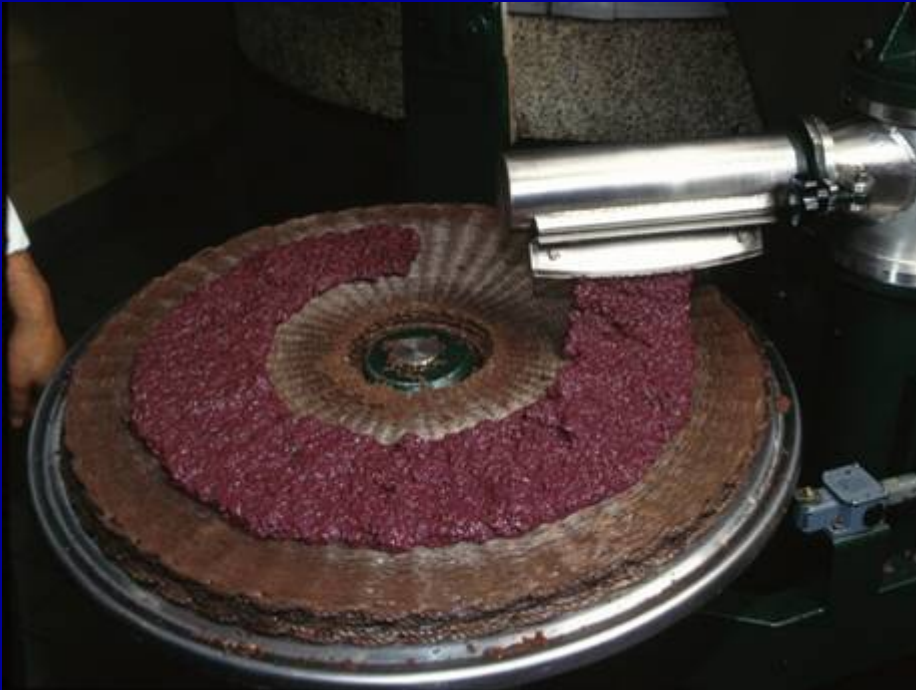


Alfa Laval

Alfa Laval

# TRADITIONAL PRESS

- Paste spread onto a filter mat
- Mats are stacked up
- Press cake is squeezed



# Stacking the mats







**Esparto**



**Steel Wire**



**Esparto  
and  
Nylon**



# Matty Defect

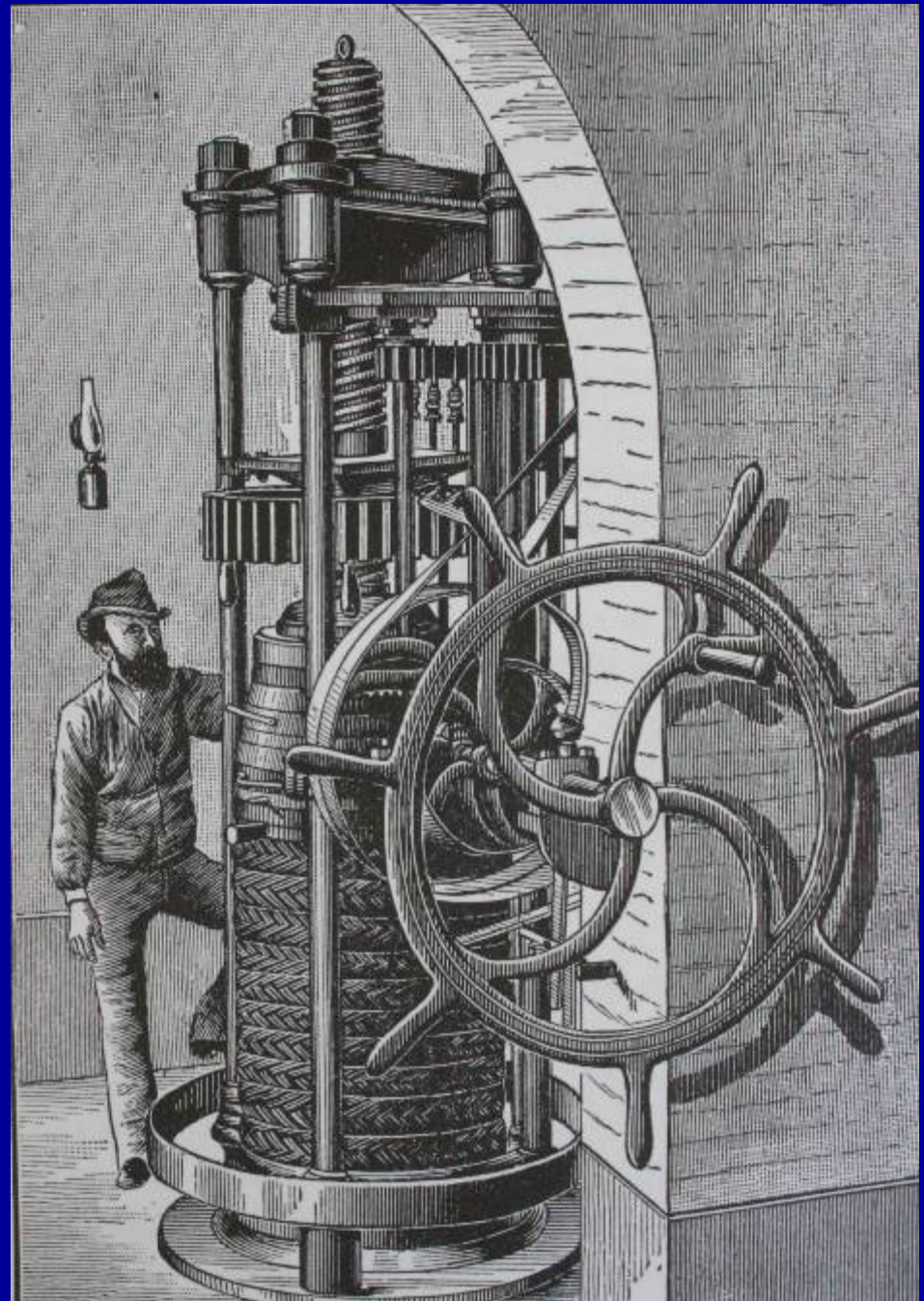
- Historical necessity
- Romantic diversion
- Almost non-existent in modern world



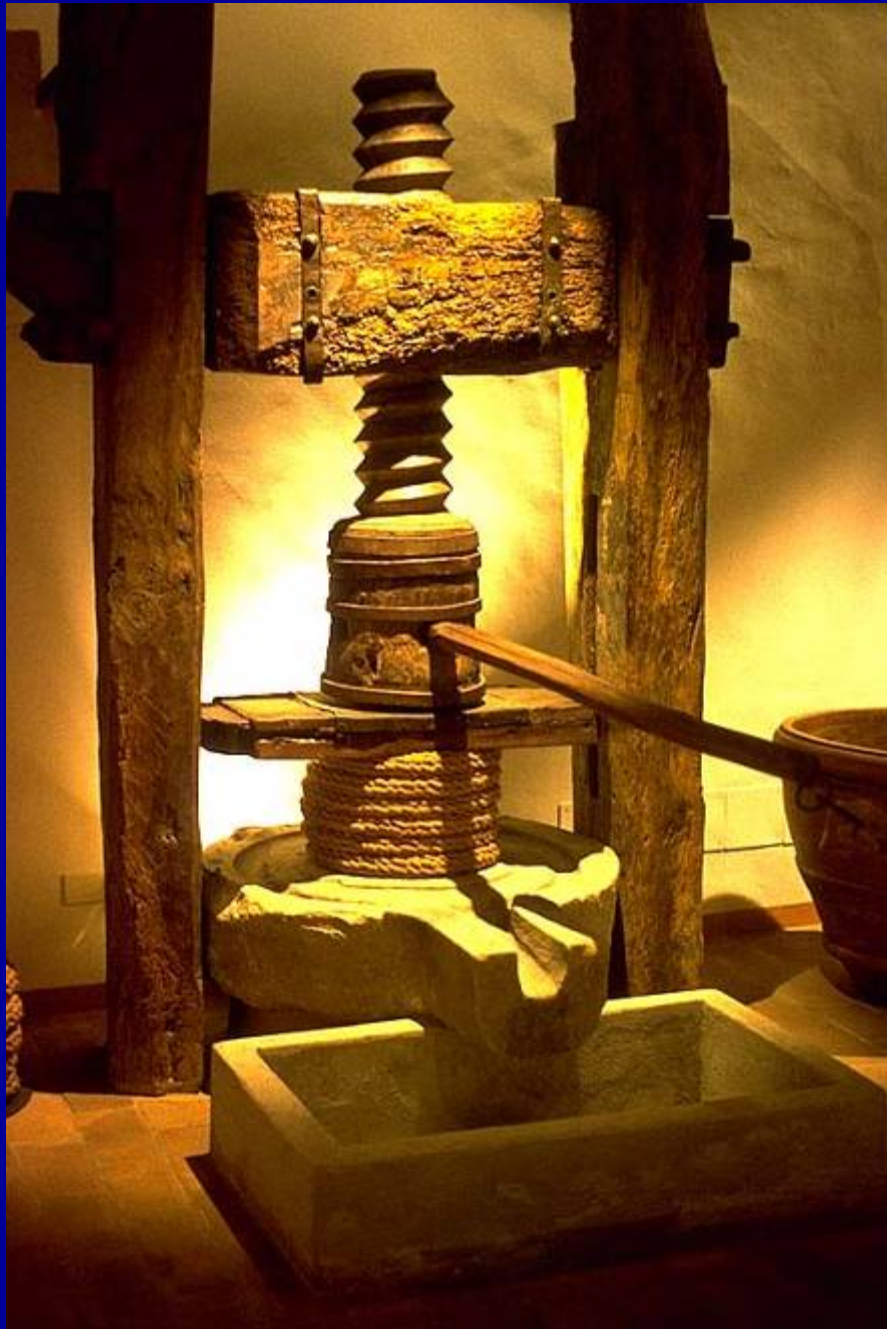
# Old Screw Press



# Screw Press

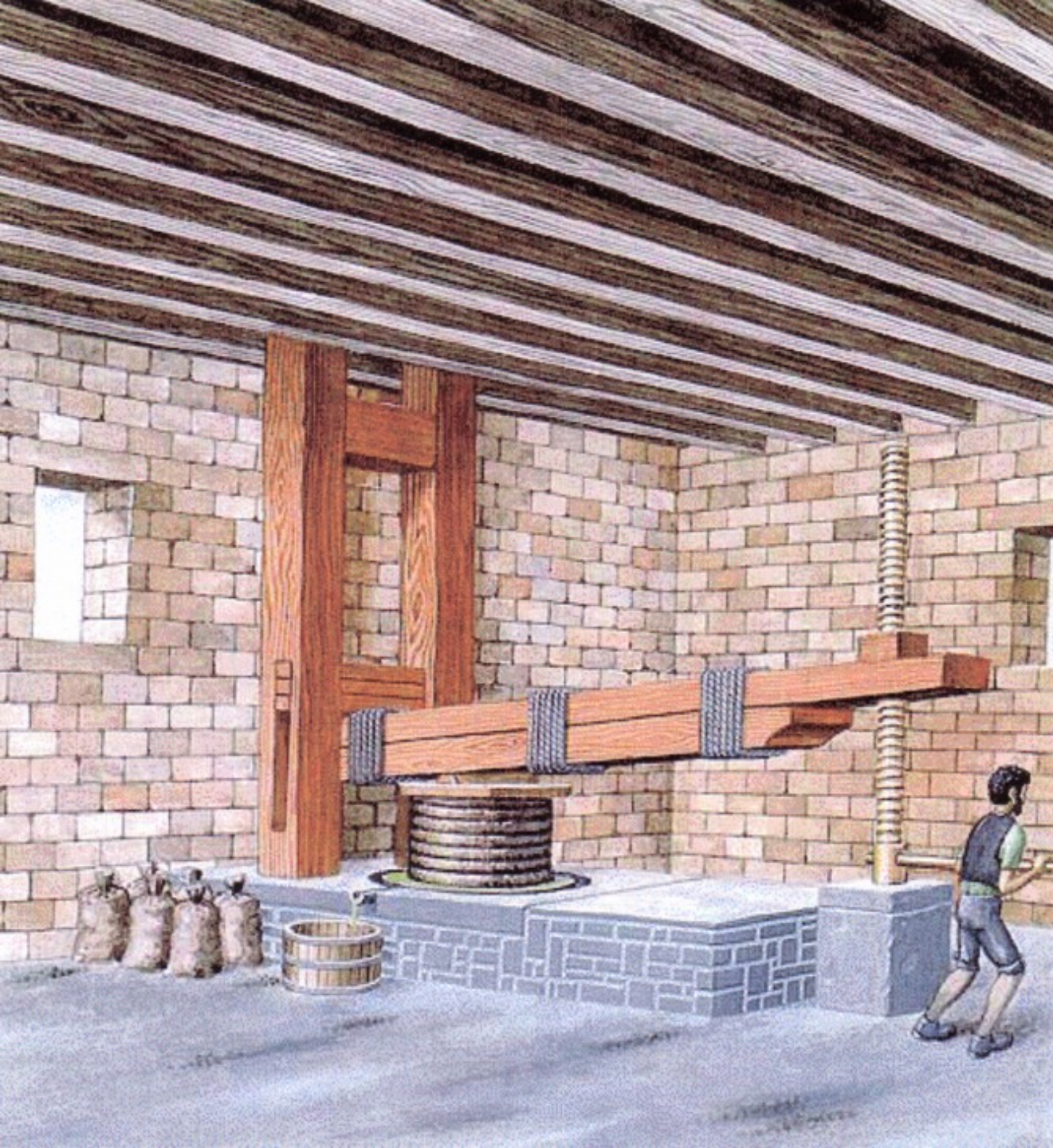


# Screw Press





# Old Lever Press



# Lever Press

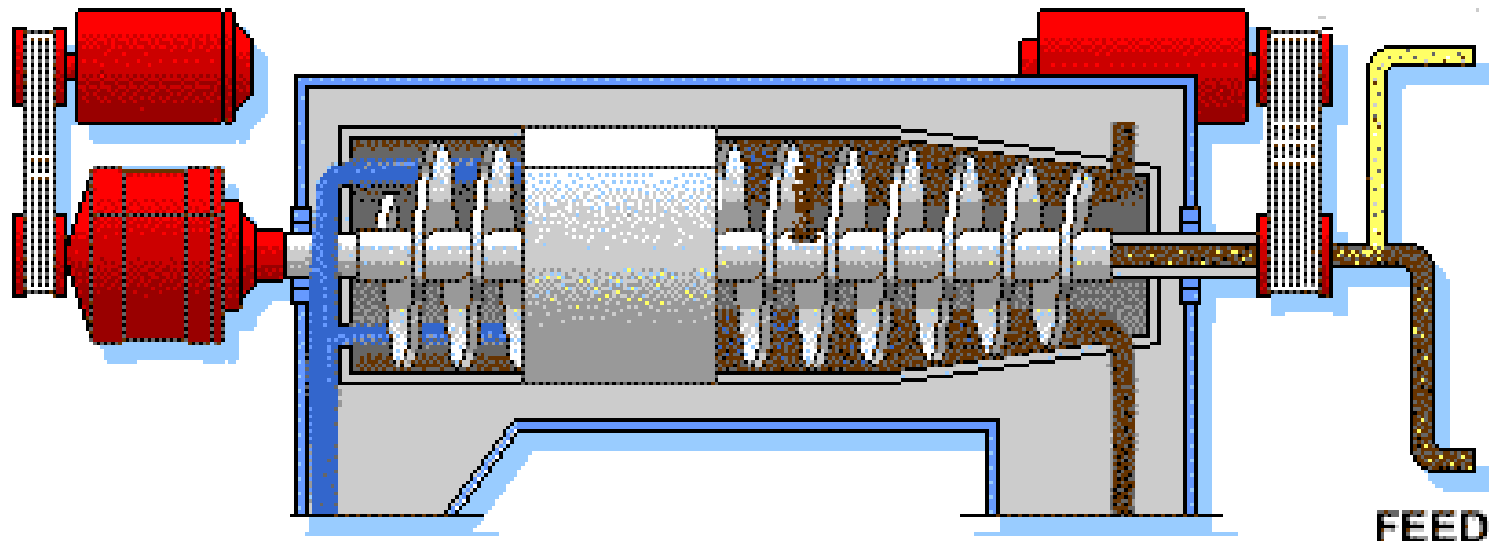


# Heated Turkish Presses



# DECANTERS

- Horizontal centrifuge
- Spins at 3,000 rpm, force decants oil
- 3-Phase (*Oil - Solids - Fruitwater*)
- 2-Phase (*Oil – Solids mixed with Fruitwater*)



# DECANTER – Horizontal Centrifuge







# Capacity of the decanter

# Processing Area



# Processing Area



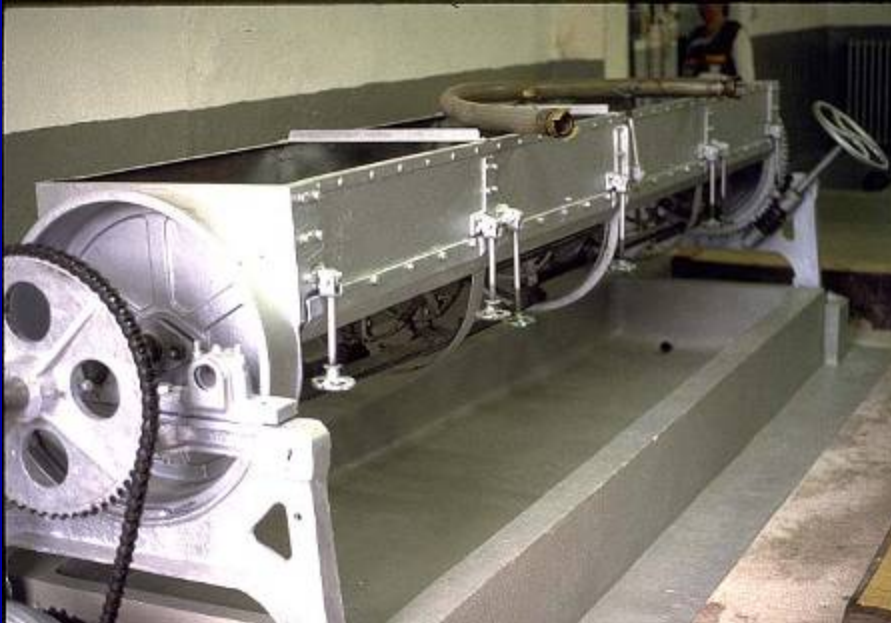
# Processing Area



# Processing Area



# Selective Filtration Screen



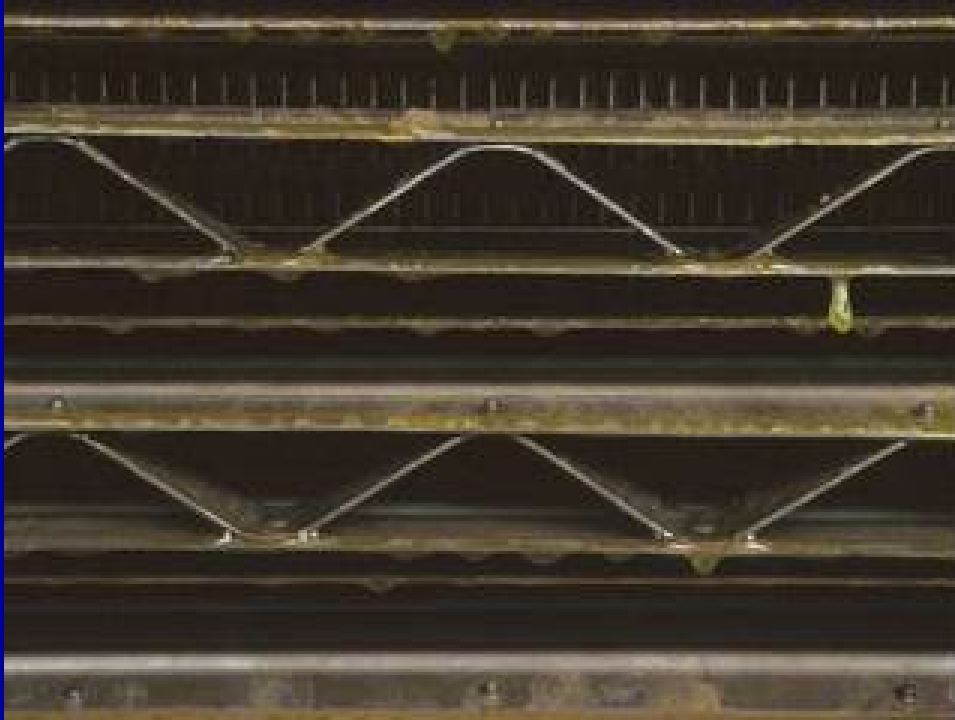


# Selective Filtration

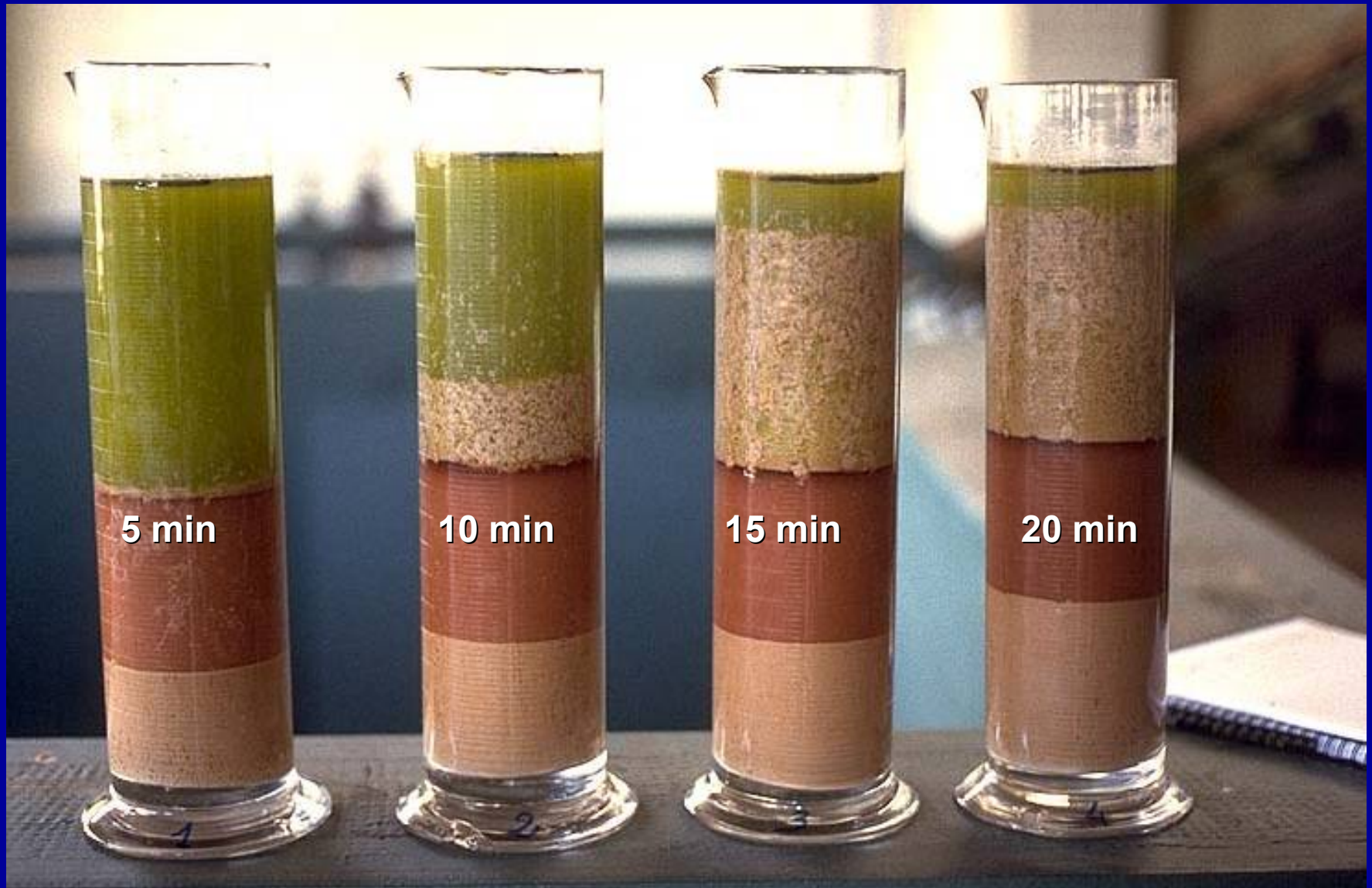
Rotating screen drums leak out liquid portion of paste via gravity

Paste moves through via an auger inside the drums

# Sinolea Separation



# Selective Filtration over time



# Vertical Centrifuge – oil cleaning



# Processing Area



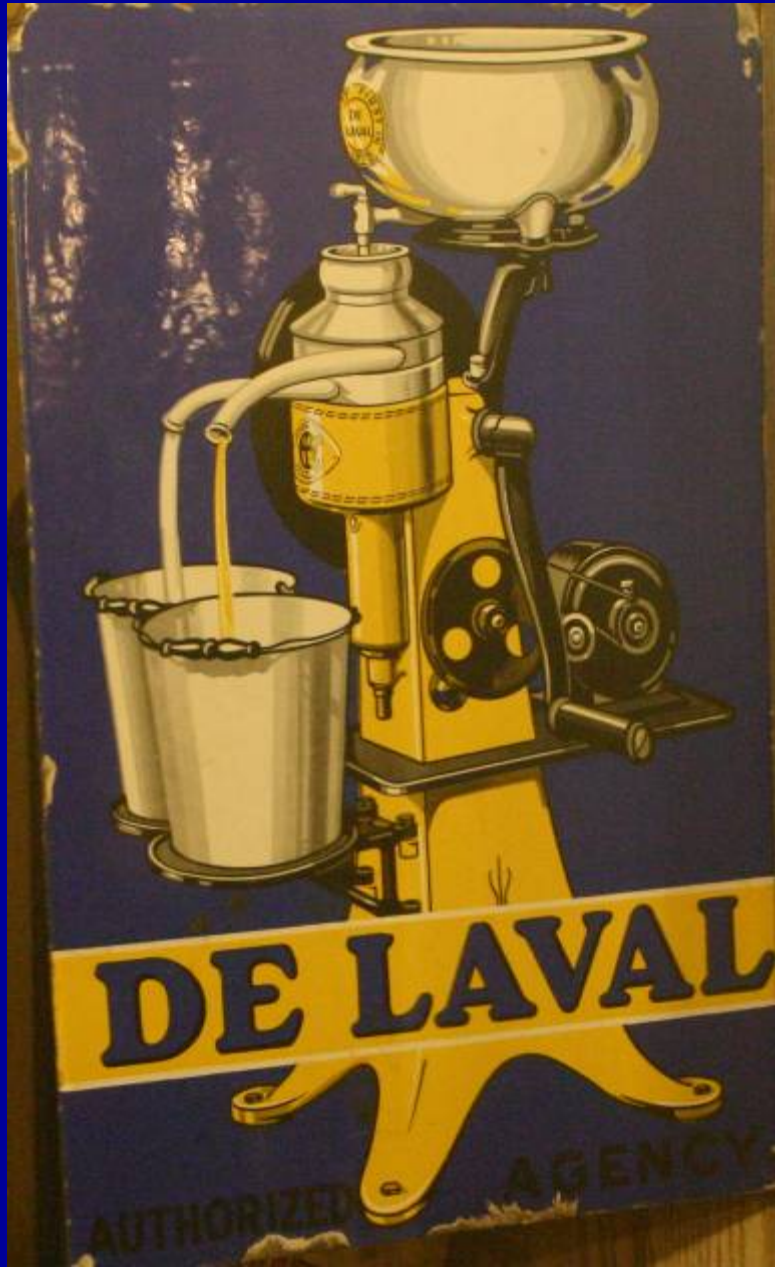
# Vertical Centrifuge



# Vertical Centrifuge



# Vertical Centrifuge



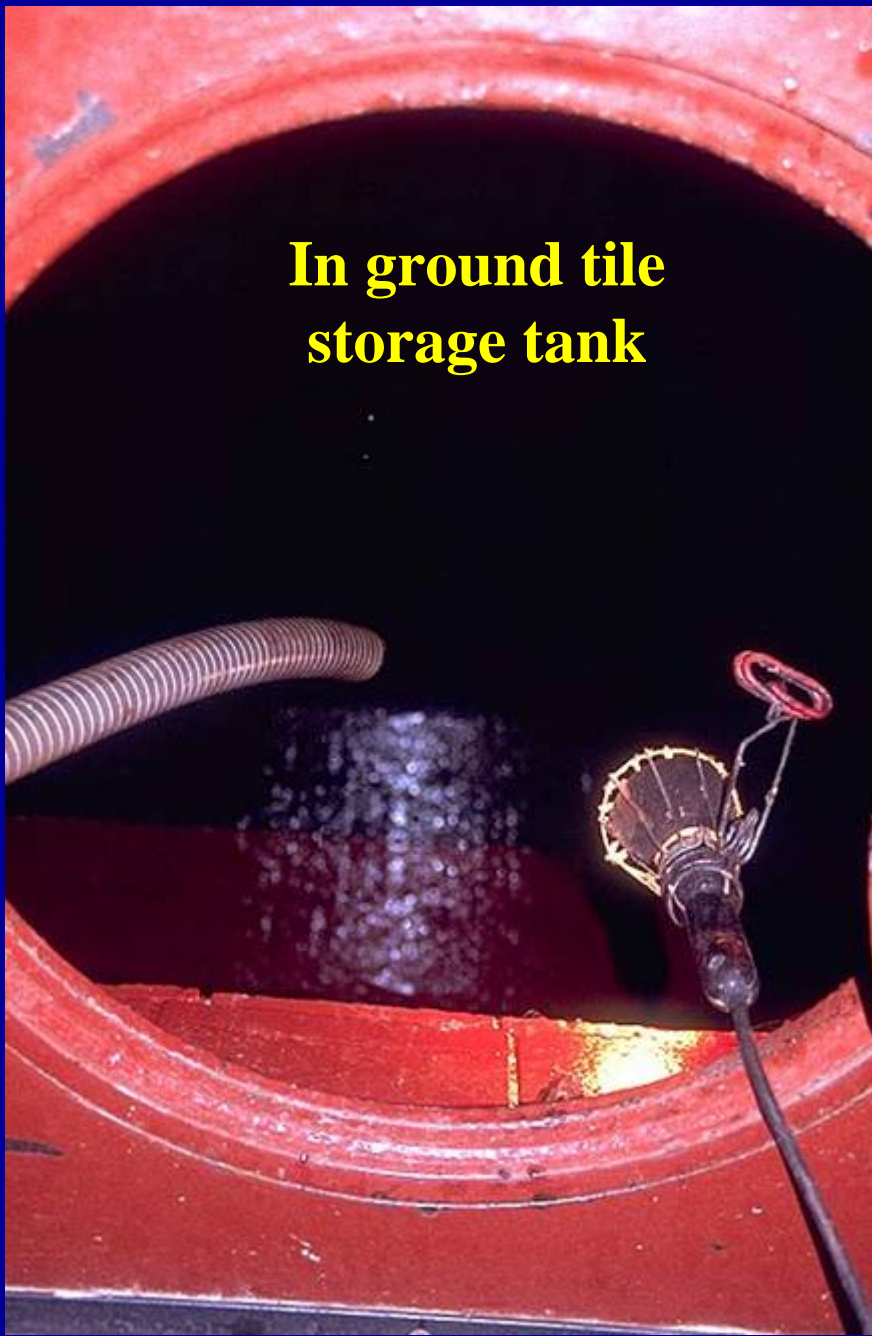
# Vertical Centrifuge



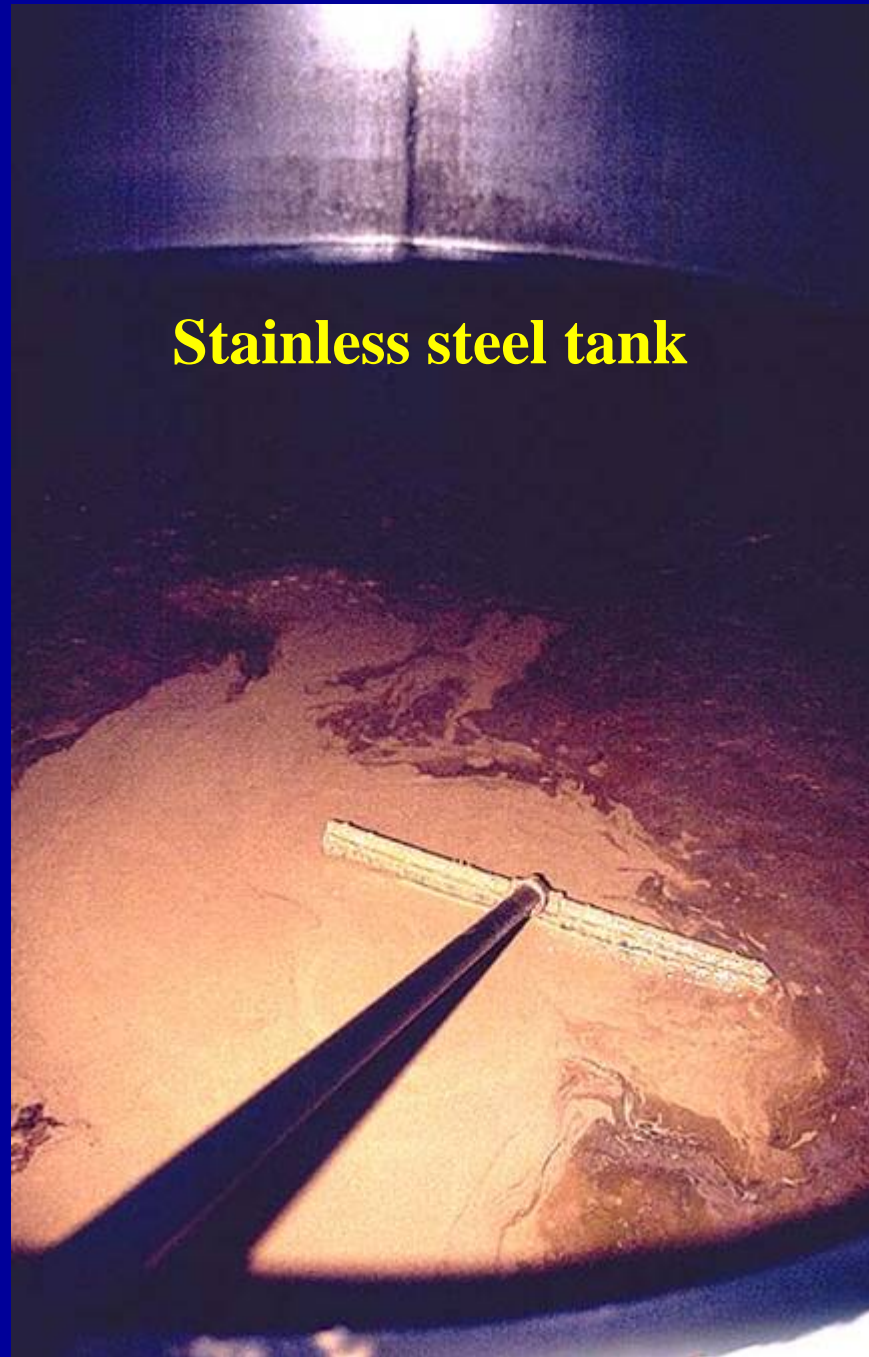
# Oil Storage Area



**In ground tile  
storage tank**



**Stainless steel tank**





# STAINLESS STEEL STORAGE TANKS

- *Cone shaped bottom to purge sediments periodically*
- *Nitrogen added to the air space*

# Antique Oil Storage Tanks



# Antique Oil Storage Vessels



# Steel and Clay Storage





**Metallic  
Defect**

# Oil Storage Area



# Oil Storage Area



# Oil Storage Area



# Oil Storage Area



# Oil Storage Area



# Filtering



# Filtering



# Filtering



# Filtering





Sugar.

det.

015-7040

CA 95914

# Bottling line



# Bottling line



# Bottling line



Matrice - lav  
Moulin Cuve de pé  
Centrifugeuse horizon  
ce  
de service 10,  
380  
80

oud Mohamed (E  
Fax Admin. : 02  
a@cogepma -

Ex. Chevalier Bar  
22 30 23 07 - Fax  
http://www

E.N.  
MA

# Bottling line



# Waste Management Area



# Waste Management Area



# Waste Management Area



# Waste Management Area



# Waste Management Area



# Waste Management Area



**Pit Removal**



# Waste Management Area



# Laboratory



# Laboratory Foss - NIR



**Water & oil content**

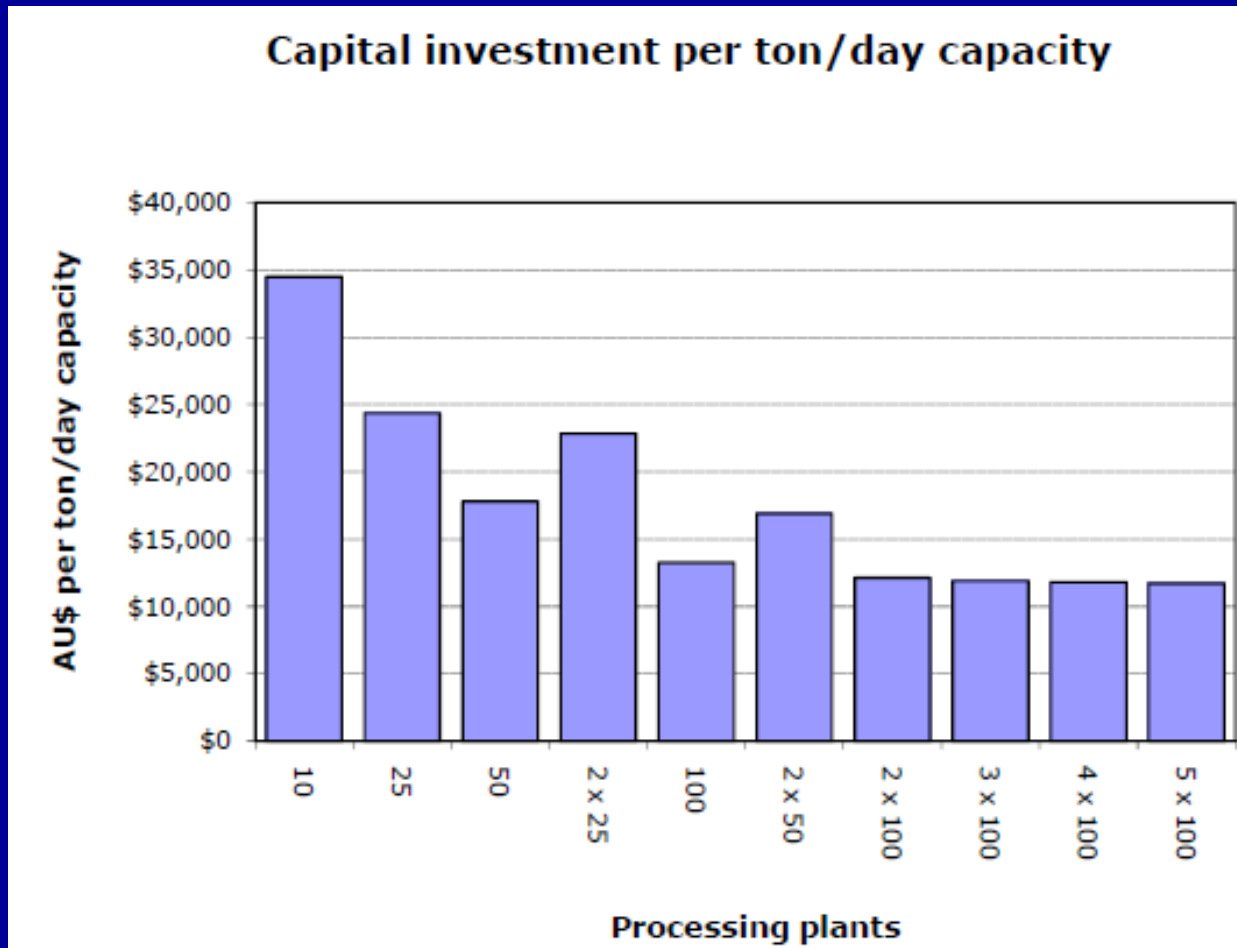
# Laboratory



# Automation and Control



# Economic Analysis



# Small-scale Plant Efficiency-Cost

- **25% capacity → \$605/ton**
- **50% capacity → \$310/ton**
- **75% capacity → \$255/ton**
- **100% capacity → \$230/ton**

# 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
<b>Total (l/kg)</b>	<b>0.66</b>	<b>1.24</b>	<b>0.25</b>

# Extraction Efficiency

- **Moisture – wash or leave dry**
- **Screen size – paste fineness**
- **Talc – enzymes**
- **Time – temperature (malaxation)**
- **Volume y capacity of the decanter**
- **Volume y temperature of the VC water**
- **Secondary extraction**

# Tolerances

- **> 85-90% extraction**
- **< 8% oil in the pomace dry matter**
- **< 3% oil in the wet pomace with olives of 50% water and < 2% with olives of 60% water**
- **< 0.3% oil in the wastewater**
- **Temperature 2-4°F + (malaxation paste)**
- **< 1.0% water & solids in storage tank**

# **OLIVE OIL STANDARDS**

## **Extra Virgin Olive Oil**

- **Less Than 0.8% Free Acidity**
- **Less Than 20 ppm Peroxide Level**
- **Made Mechanically**
- **Taste Panel Rating of Zero Defects**
- **Taste Panel Rating of Some Positive Attributes**

# IOC STANDARDS

- **Sterol Content**
- **Tocopherols – Polyphenols - Pigments**
- **Fatty Acid Profile**
- **Saturated Fatty Acids in 2-position**
- **Unsaponifiable Material**
- **Wax Content**
- **Stigmastadienes**
- **Erythrodiol + Uvaol**
- **Hydrocarbon Content**
- **Presence of *trans* fatty acids**
- **Color – Aspect**
- **Free Acidity – Peroxide Value**
- **UV Absorbency (bitterness & stability)**
- **Water and Insoluble Impurities**
- **Flash Point**
- **Metal Traces – Halogenated Solvents**
- **Sensory Characteristics**



# Australian National Show (Richard Gawel)

	1997	1998	1999	2000	2001
<b>Entries</b>					
<b>Total</b>	30	40	35	38	52
<b>FFA</b>					
<b>Ave. Small Vol</b>	0.45	-	0.20	0.20	0.20
<b>Ave. Large Vol</b>	0.40	-	0.24	0.26	0.25
<b>Ave. Bulk</b>	n/a	-	0.67	0.33	0.31
<b>Overall Average</b>	0.42	-	0.33	0.24	0.24
<b>Tasting Results</b>					
<b>Gold</b>	13%#	5%#	3%	3%	4%
<b>Silver</b>	7%	8%	11%	11%	2%
<b>Bronze</b>	7%	8%	26%	18%	38%
<b>Award Winners</b>	27%	21%	40%	32%	44%
<b>Disqualifications</b>	23%	15%	23%	18%	14%

# Free Fatty Acid Level

- Crude measure of quality
- 0.8 is very high – 0.5 is high
- In Australia – oils with 0.1 to 0.2 received the most and highest medals
- In Australia – oils above 0.3 received no medal or were disqualified



# Fancy Laboratories

**How much bad oil (high% FFA) can you mix with good oil (0.2% FFA) to meet the 0.5-0.8% FFA standard?**

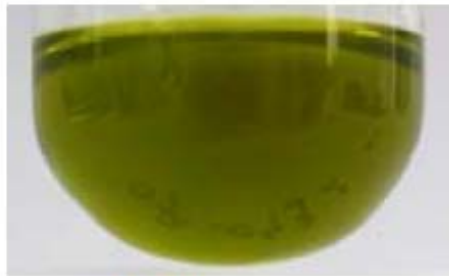


# REAL Olive oil is the most expensive

- Slippery business article – New Yorker
- Adulteration is and has been rampant
- Refined and Pomace mixes



# Soft Column Refining



Not heated



80°C 60 min



120°C 60 min



160°C 60 min

# Large Oil Companies



# Three Olive Oil Products

## Bulk & Low cost – Refined

- \$5.99 to \$9.99/bottle
- \$23-30 per gallon



## Medium Priced Imports – Low to ? Quality

- \$5 to \$13.99/bottle
- \$30-50 per gallon



## Specialty – Premium

- \$10 – 30 per bottle
- \$ 60-300 per gallon



# Common imported oils - \$6 to \$10 per ½ liter



# SUPERMARKET OILS



sugars, vitamin A, vitamin C, calcium, and iron.  
\* Percent Daily Values are based on a 2,000 calorie diet.  
Packed in Italy with select oils from Italy, Spain, Greece and Tunisia.

# **Cheap imports typically have defects**

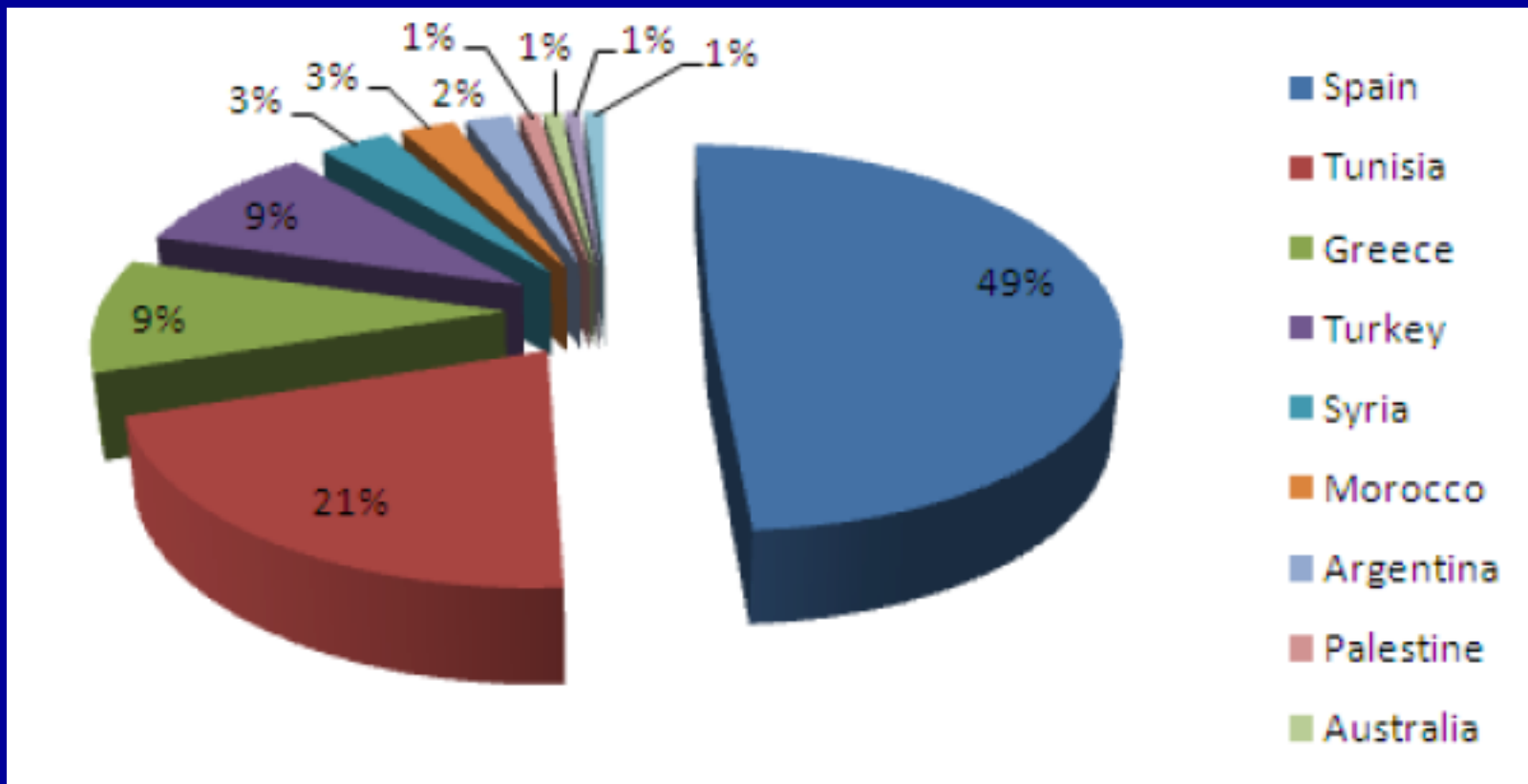


**#1 Defect = Rancid - old oils (not fresh)**

**#2 Defect = Fusty - cheap oils - low cost producers from ground harvested or poorly handled fruit**

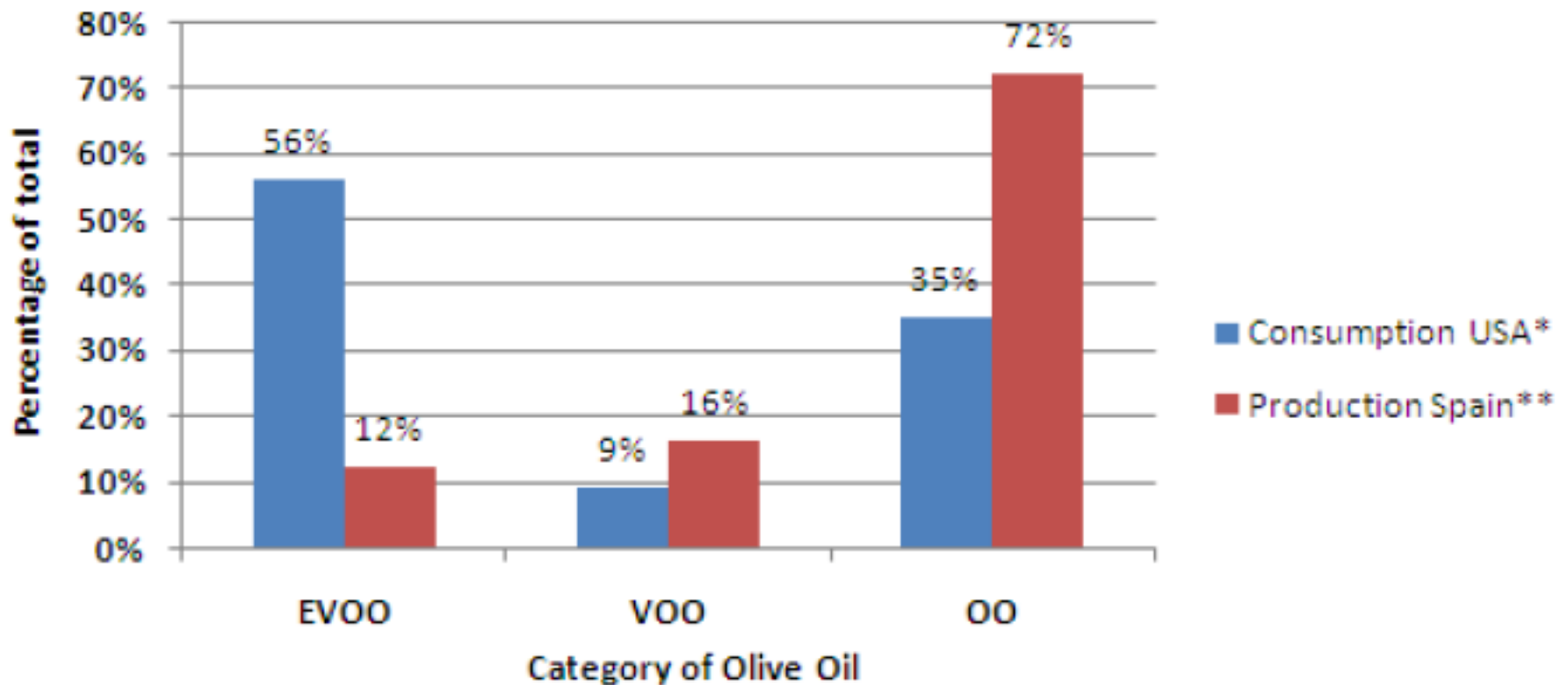
**#3 Defect = Heated Flavor - Mix of refined & pomace oil up to IOC standard of non-detectable**

# Excess Production for Export



# Adulteration with Refined Olive Oils

Olive oil types Produced and Consumed



\* Caiani & Co (2006); \*\* Olive Growing Manual (2006)

# New Australian Standards

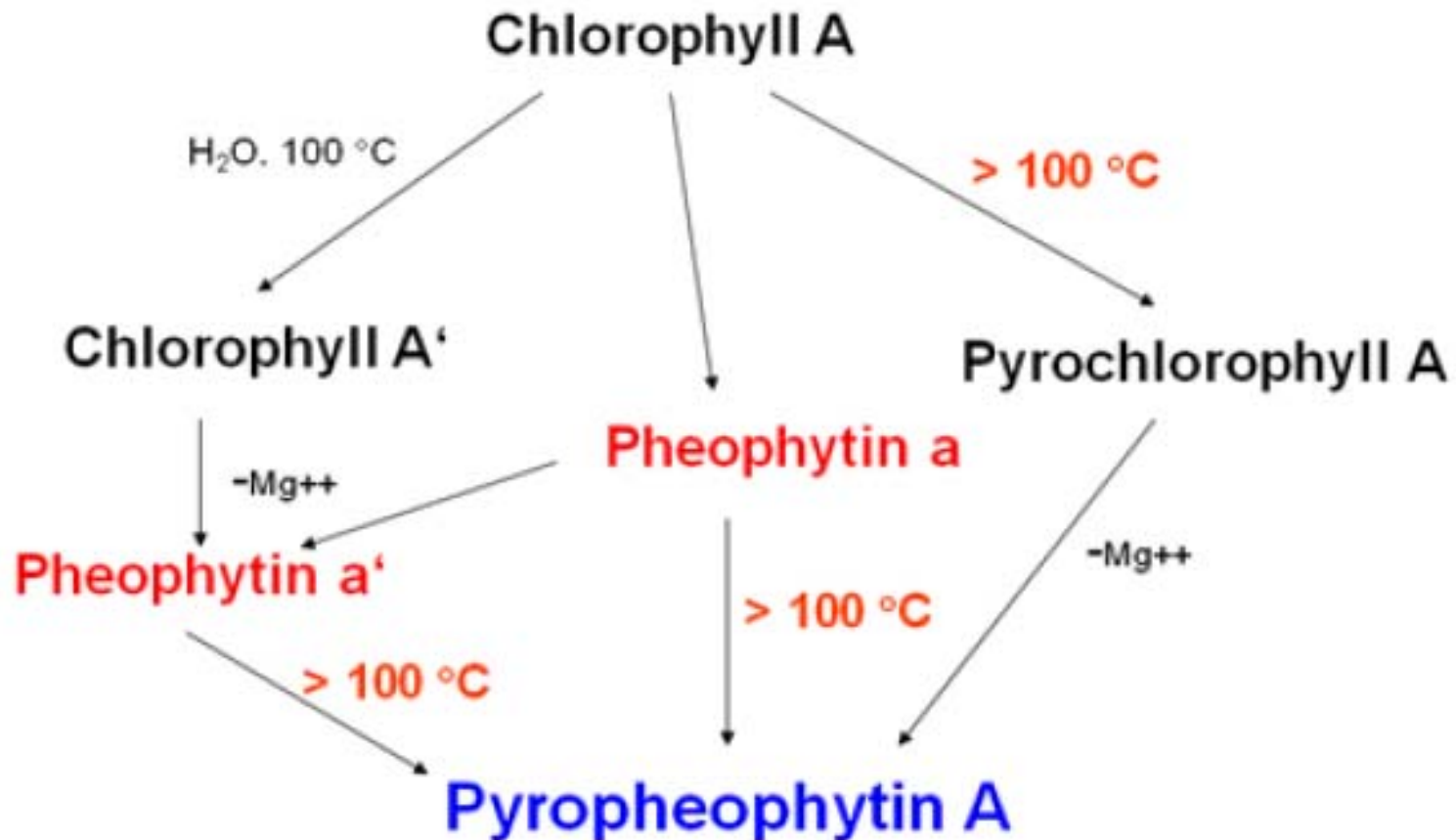


## Australian Competition and Consumer Commission

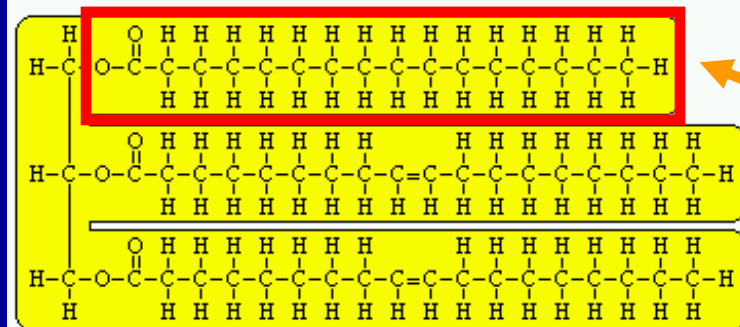
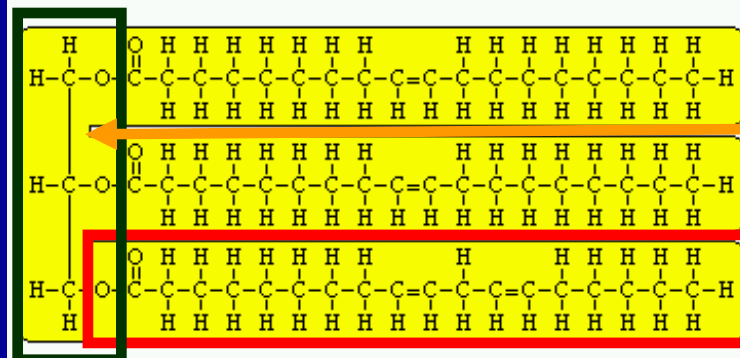
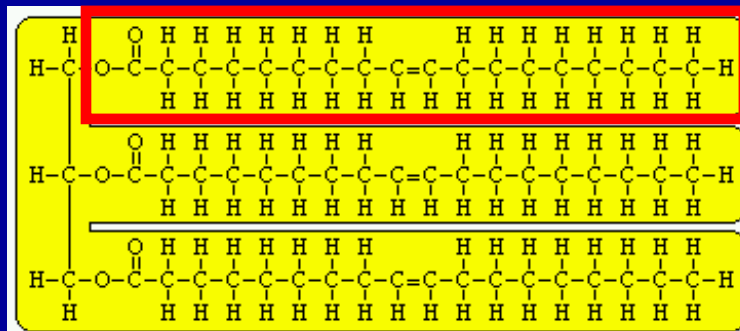
- Identifying adulteration with refined, pomace, and seed oils with new technology
- Setting standards that reflect REAL extra virgin grade

# Chlorophyll Degradation Products in Olive Oil

(Lit. K.Aizetmüller. Fett/Lipid 1986)



# Triglycerides in Olive Oil



- This is a fatty acid
- It has 18 carbons
- It has 1 double bond
- It is monounsaturated
- It is oleic acid

• This is the glycerol backbone of the molecule

- This is the polyunsaturated fatty acid linoleic acid

- This is a fatty acid
- It has 16 carbons
- It has no double bonds
- Therefore it is saturated
- It is palmitic acid

BOUNDARY  
BEND  
LIMITED



AUSTRALIAN  
EXTR  VIRGIN™



# We Use EUROPEAN Standards Because We Don't Know Any Better



European Standards are based on the  
**MINIMUM** (level of defects)

# Status quo

- **USDA & CDFA European Voluntary Standards**
- **COOC European Voluntary Standard**
- **No Independent Taste Panel**
- **No Marketing Order (Commission)**
- **No enforcement**



# What a Bargain



GENCO

POMACE OIL



GENCO

POMACE OIL



GENCO

POMACE OIL

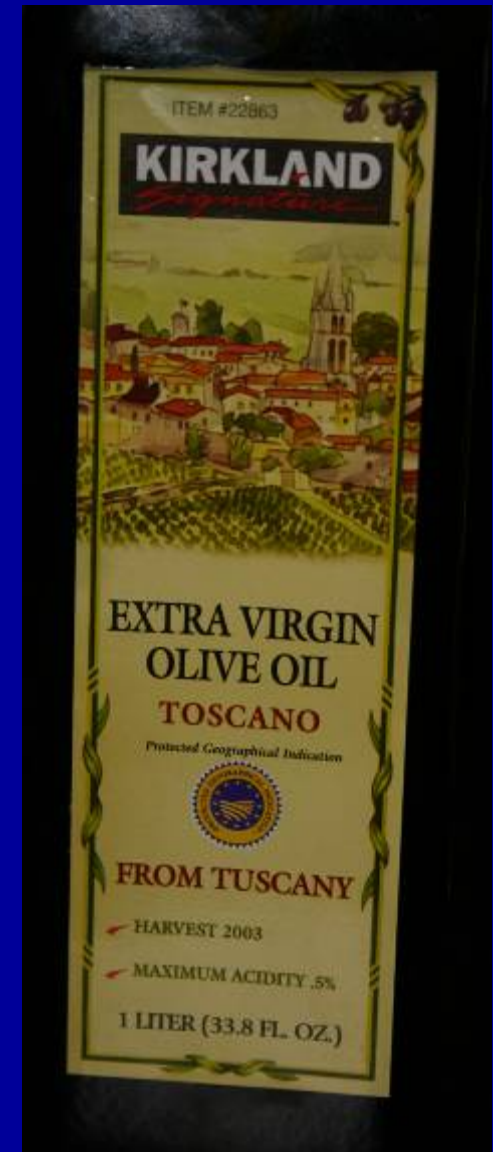


IMPORTED-FROM-ITALY  
SPECIAL-GENCO  
OLIVE-OIL

\$ 12.99 EACH  
1-GAL CAN

# Vocabulary of a Label

- **Extra Virgin**
- **Pure**
- **Light**
- **Acidity**
- **First Cold Press**
- **Harvest Date**
- **Bottled/Produced in Italy**
- **Seals and Medals**



# FRESH OLIVE OIL



*(extra virgin)*

## Grown in Placer County

25 acres of Olseninni Family Estate

11234 Woebegone Rd, Loomis, CA 92100

(916) 555-6124 – [www.fresholiveoil.com](http://www.fresholiveoil.com)

- 37% Picudo, 18% Bosana, & 45% Zaiti
- Harvested December 10, 2008
- Processed December 11, 2008 at the Corti Mill in Sacramento (1569 Folsom Blvd.)
- Polyphenol Content: 1,234 ppm
- Free Fatty Acid: 0.12%
- Peroxide Level: 8.3 meqO<sub>2</sub>
- Characteristic spicy flavor that is a balanced and complex blend of herbaceous grassy green and tropical ripe fruit flavors

# Refined Olive Oil

*Produced from the cheapest sources of oil from anywhere in the world*

The base of this oil is from rotten olives that have fermented or gone rancid. This technical process degums and neutralizes the oil with sodium hydroxide forming soap, which is washed out. Then we heat the oil to 500°F to volatilize off the bad odors, filter it to remove color, and then formulate it to meet the standards set forth by the large industrial manufacturers. Contains: just enough oil from olives to meet that legal standard.



This cheap source of refined old fat has the empty flavor of cooked or slightly rancid greasy oil

# Pomace Oil

*Produced from olive waste – “second hot press”*

**This oil is made from the leftover solids (pomace), that still contain some oil, after the fresh olive oil has been mechanically extracted. The dried rotting waste pomace is then treated with hexane which dissolves anything soluble in the solvent, including the oil. The solvents are then volatilized off, some of which pollute the air. The oil is then refined by adding sodium hydroxide in a heating, filtering process to produce a clear waxy oil.**



**This very cheap source of recovered waste oil has the cooked flavor of greasy solvents.**

# **How Do We Make the Best Olive Oil Possible?**



**How do we Improve Oils?**

# Influences on Flavor

- Irrigation
- Climate
- Stress
- Fruit Maturity
- Fruit Handling
- Processing
- Oil Handling
- Variety



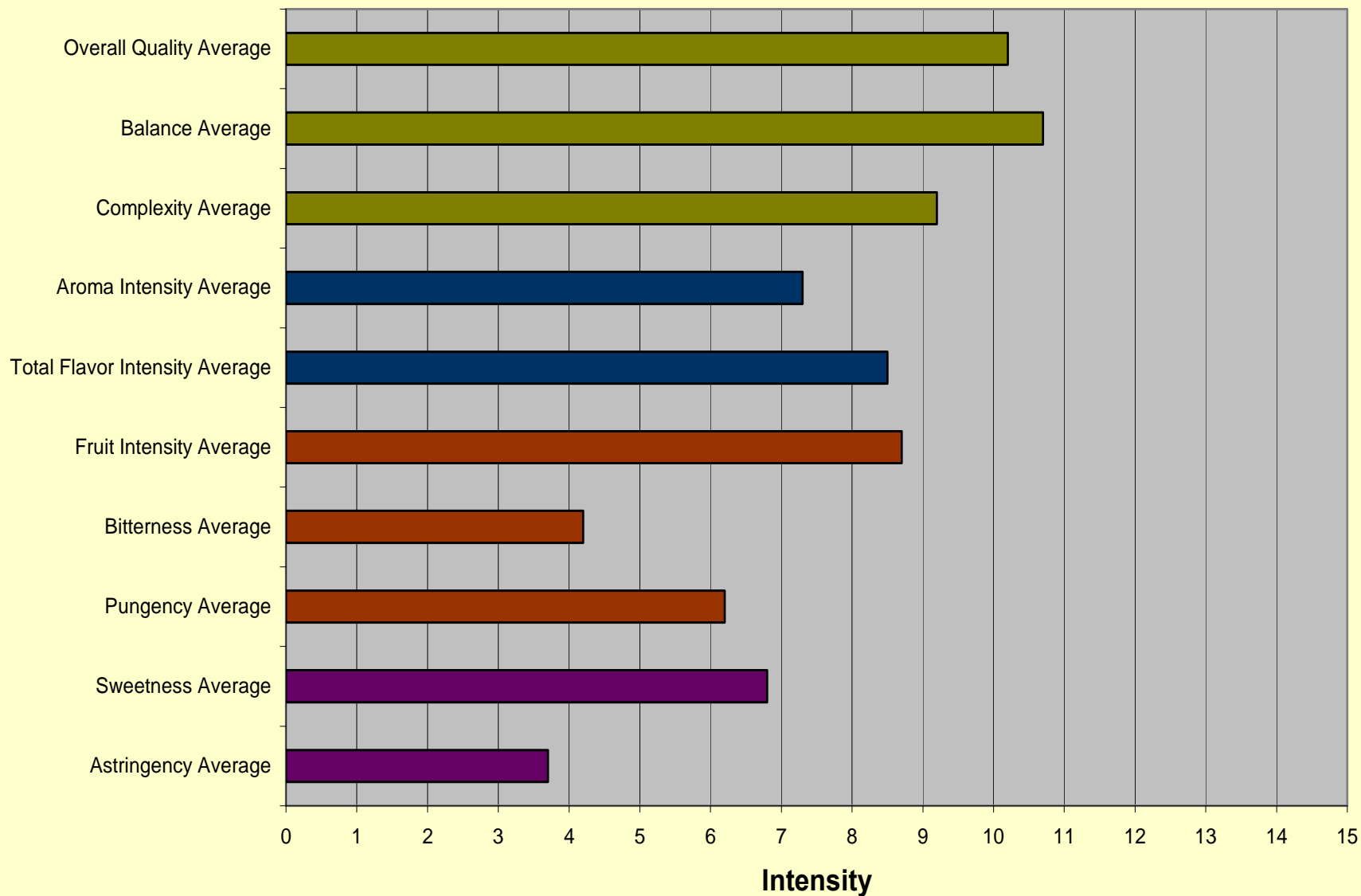
# UCCE Research Taste Panel

- 15 point profile sheet
- Cooperation with international panels
- Intensity of aroma, bitterness, pungency, fruit intensity, sweetness, total flavor, astringency, defects, complexity, balance, finish, overall quality, and positive flavor descriptors



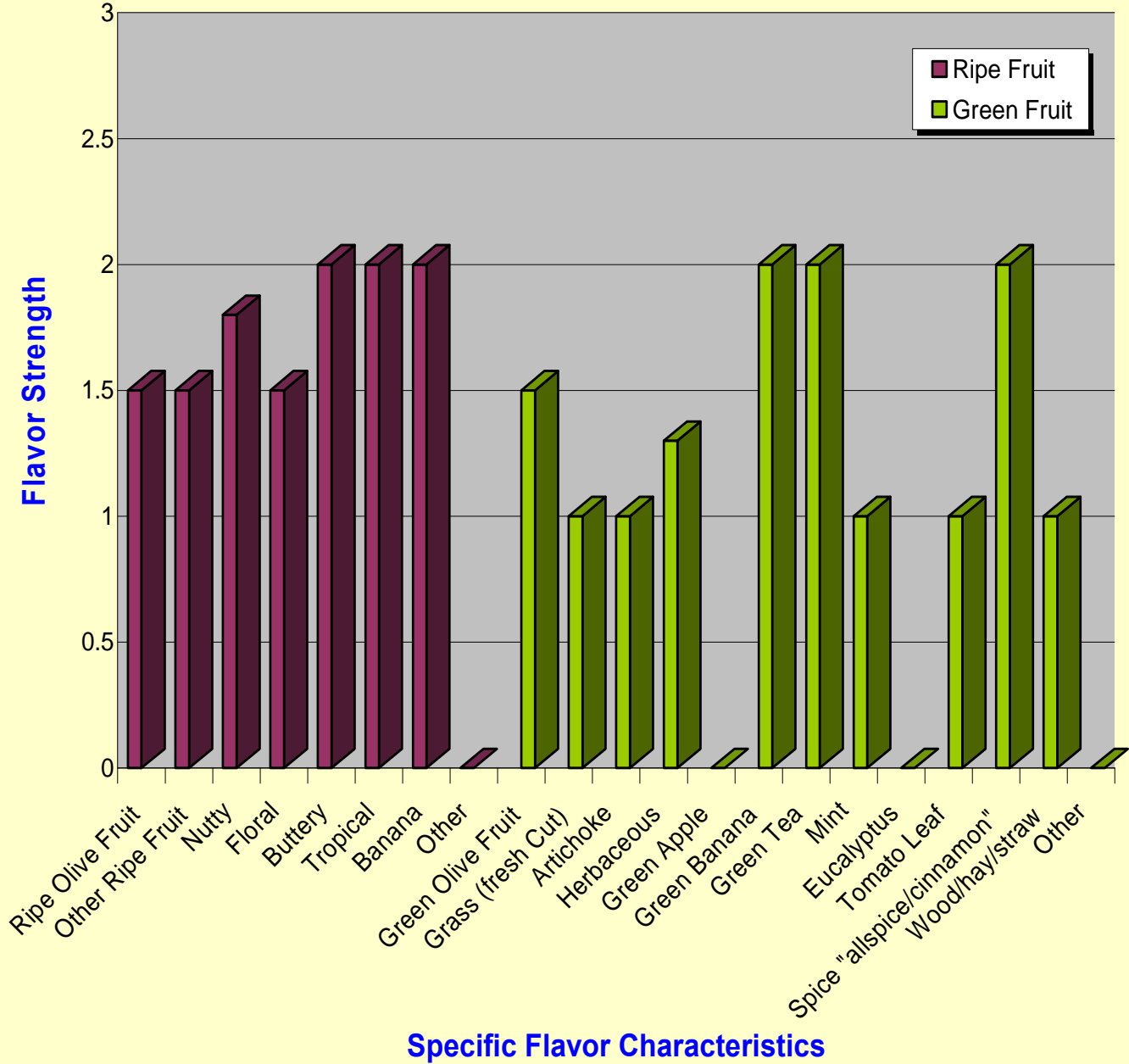
*Grass, herb, mint, artichoke, buttery, floral, apple, citrus, tropical, green tea, tomato, banana, berry, etc .*

# UC Davis Centennial Blend Tasted 1-8-09



# Olive Oil Flavor Characteristics

## UC Davis Centennial Blend Tasted 1-8-09



# Paul Vossen

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