



CLUB OF BOLOG
strategies for the development of a



34th Members' Meeting of the «Club of Bologna

Mechanisation and Technologies for New Farmers Needs

11-12 October 2025

Bari, Italy

Advanced field and mechanical milling technologies to enhance the olive oil supply chain
and sustainability: towards artificial intelligence

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University teachings:

- Food Processing Plants
- Agricultural Mechanics and Mechanization

Research topics:

- Development of:
 - agricultural machinery.
 - food processing plants
 - innovative processes for the recovery by-products and wastewater
 - systems to reduce energy and water consumption.
- Safety assessment of food and agricultural machinery and workplaces, in compliance with Directive 2006/42/EC and relevant national regulations.
- Integration of machine learning protocols to optimize the performance of agricultural machinery and agri-food processing plants.



International cooperation:

Engagement in international cooperation programs coordinated by CIHEAM Bari, involving Egypt, Iraq, Palestine, Pakistan, Libya, Morocco, and Tunisia, focused on enhancing agricultural mechanization and improving agri-food processing plants.

Leone Family Farm



1. What is the concept of olive oil quality as perceived by consumers today?

2. The milestones of innovation in the olive oil supply chain over the years

3. Examples of innovations in the field and in the mill

4. Future direction of mechanical innovation in the olive oil supply chain



The levels of olive oil quality



Legal Quality

FREE ACIDITY, PEROXIDE NUMBER, K270 Y K232, PANEL TEST

SEFETY

CONTROL OF CONTAMINATION FROM PESTICIDES, PHTHALATES, MINERAL OILS (MOAH, MOSH)

HEALTHY

OLEIC ACID, β -SITOSTEROL, SQUALENE, TOCOPHEROLS (Vitamin E), PIGMENTS, HYDROPHILIC PHENOLS

SENSORY

MAINLY PHENOLIC AND VOLATILE COMPOUNDS

The milestones of innovation in the olive oil supply chain



- Increase olive yield per hectare and olive oil yield at the mill
- Improve olive and olive oil quality
- Reduce consumption of water, fertilizers, and pesticides
- Reduce energy consumption
- Optimize the input/output ratio
- Promote a circular olive oil supply chain



What are the key steps to reach high olive oil quality and ensure sustainability?

How can agricultural engineering contribute to achieving quality and sustainability goals?

in the field



during the olive's growing cycle

in the mill



during the extraction process

in the storehouse



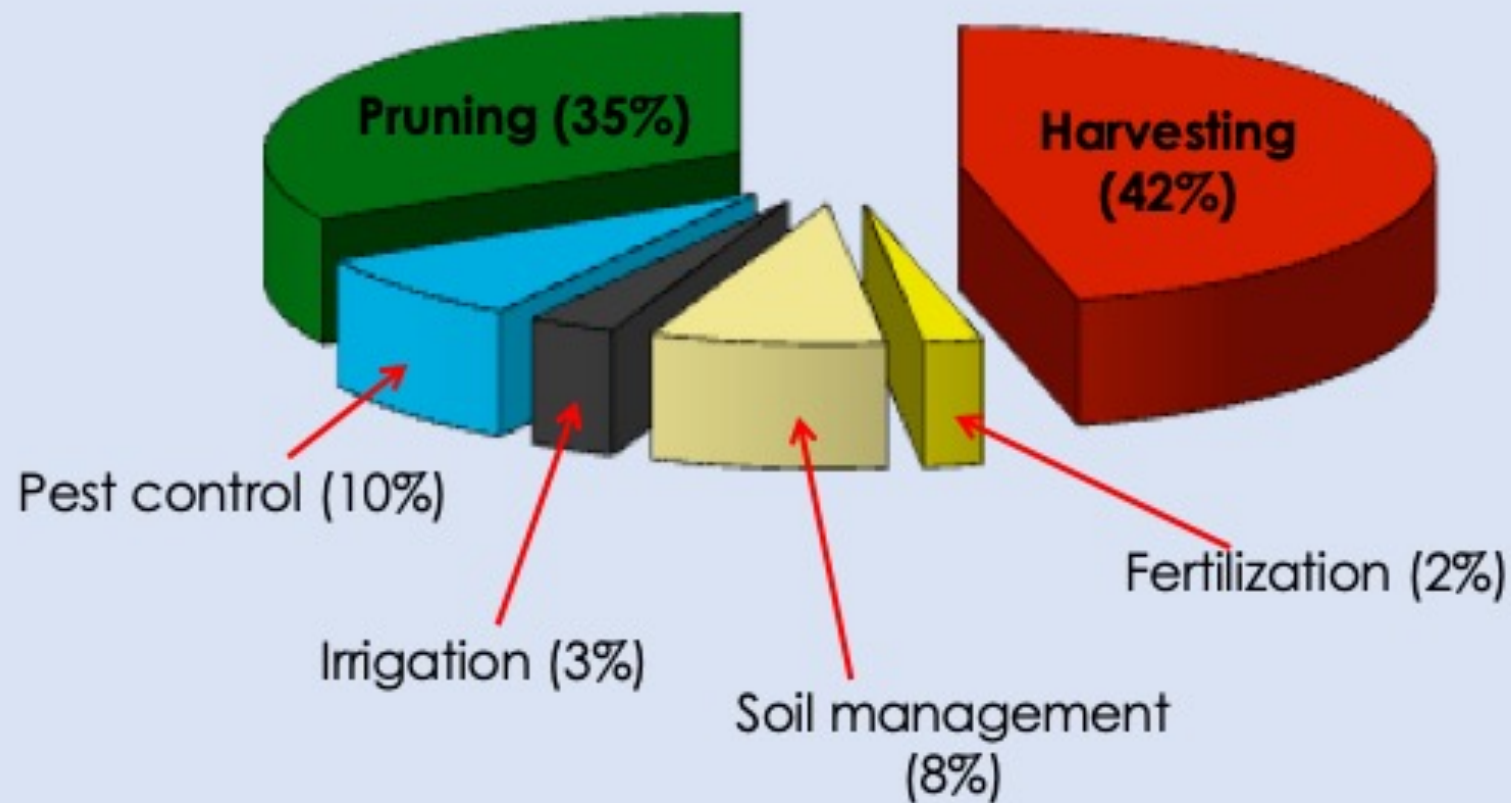
during olive oil storage

Advancements in the field



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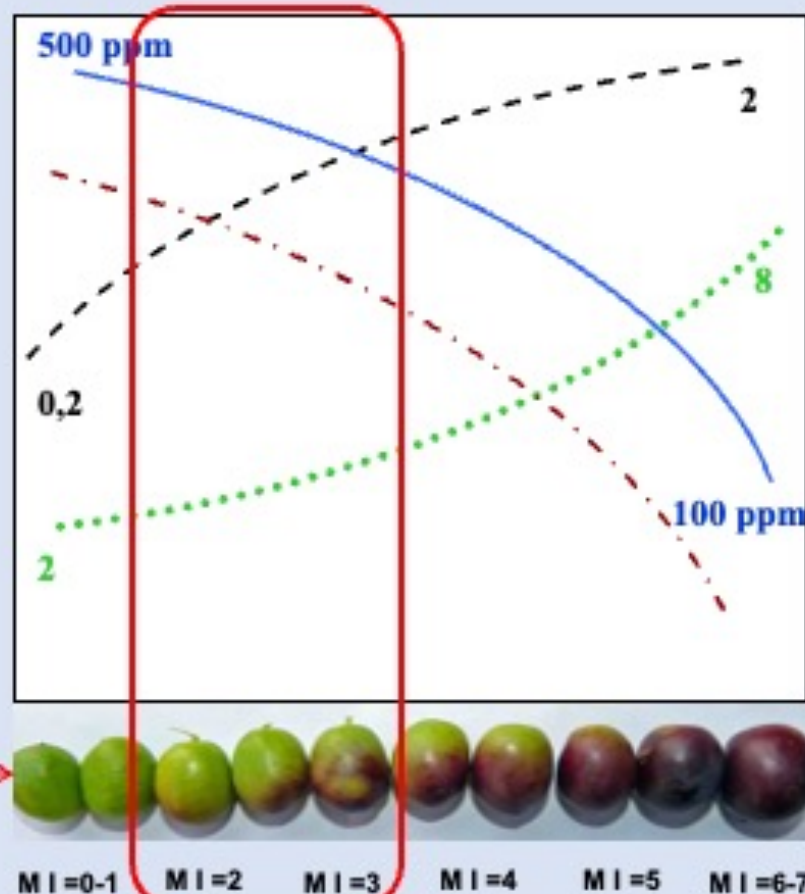
Costs of cultivation practices in olive groves



Fast harvesting is key



from September to December



Free acidity

Peroxide value

Phenolic compounds

Aromatic compounds

Planting distances

10-15m X 10-15m; 44-100 trees/ha



5-6 m X 6-7 m; 238-333 trees/ha



4m X 2,5m; 1000 trees/ha



6m X 4m; 416 trees/ha



Discontinuous productive
canopy wall

Continuous productive
canopy wall



First level of mechanization: hand-held machines

Hand-held machines

Hook shaker



Pneumatic combs



Electric combs



Harvesting system	Harvest efficiency (%)	Work capacity (trees / hour)
n. 1 machine and 3 workers	> 90%	4-5

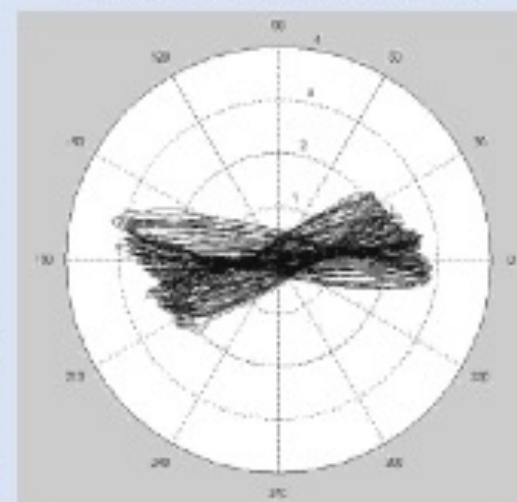


Second level of mechanization: trunk shaker

Truck shaker and head clamp (20 - 40 Hz)



Multidirectional vibrations



Self-propelled harvesting machine



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Front-mounted shaker arm on the tractor

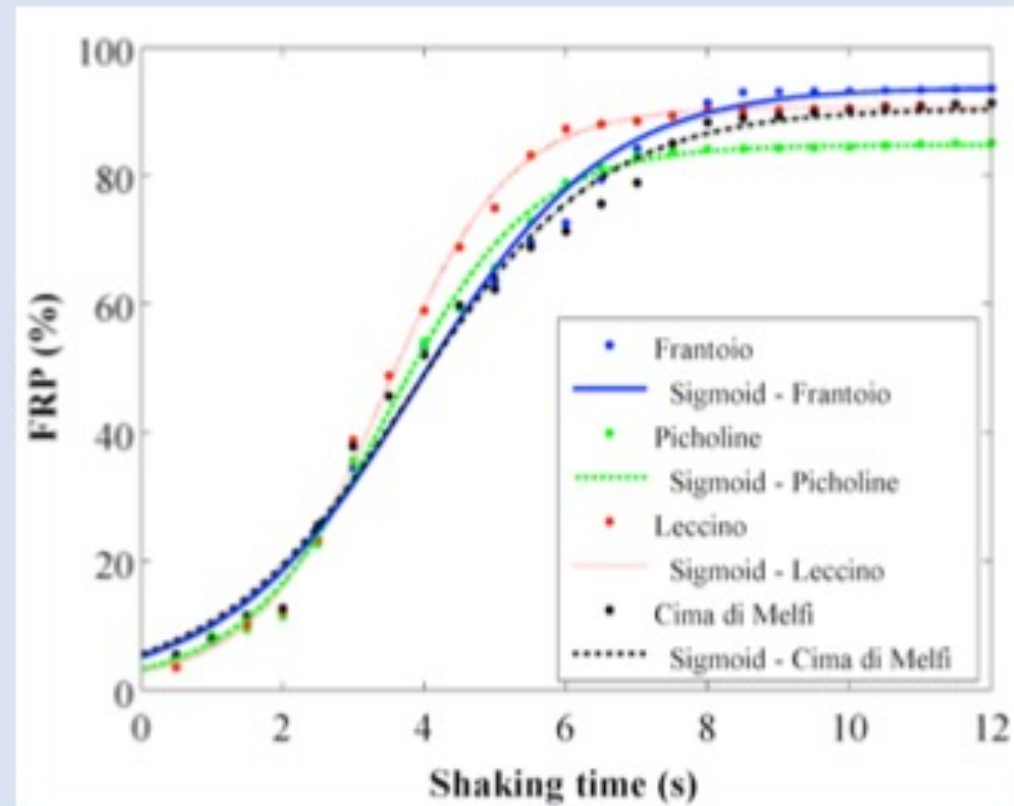


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Tractor-trailed shaker



Articulated shaker arm



Fruit removal percentage vs shaking time for four olive varieties

Reverse umbrella for olive collection



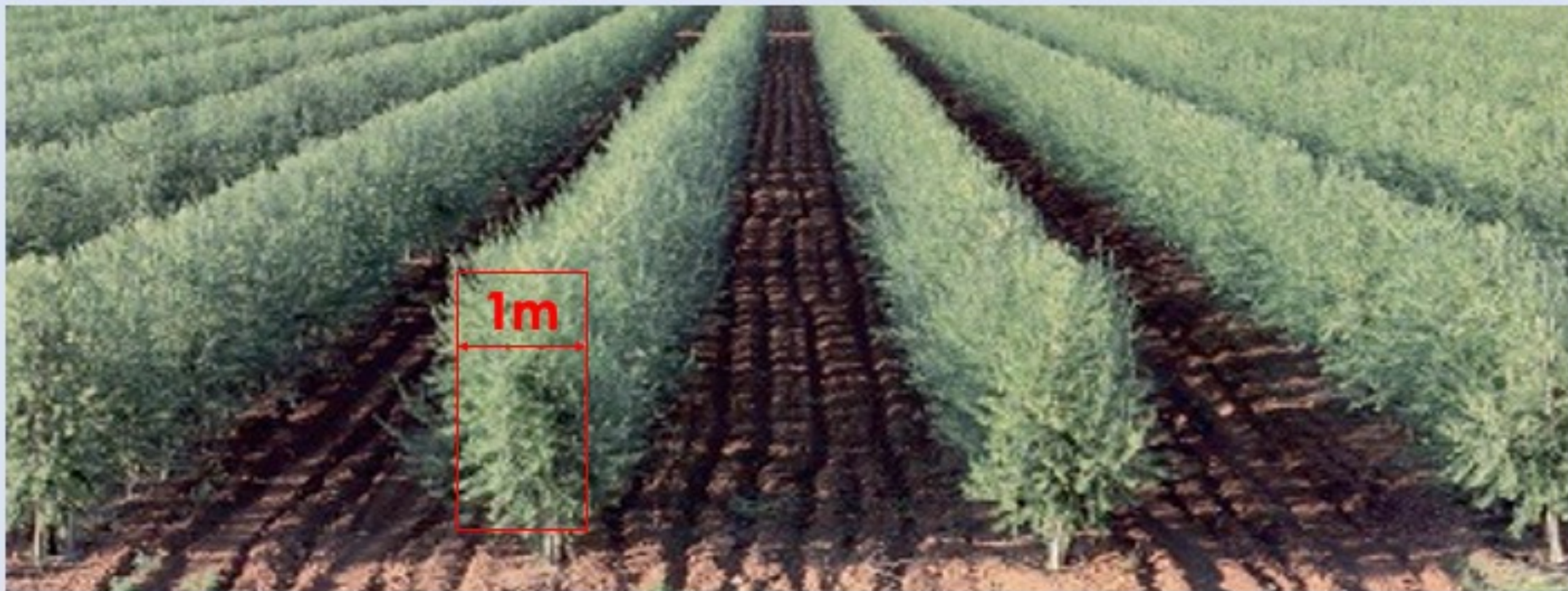
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The problem of bark stripping



<i>Harvesting system</i>	<i>Harvest efficiency (%)</i>	<i>Workers (number)</i>	<i>Work capacity (trees / hour)</i>
Trunk shaker + hand-held nets	90%	6	35-40
Trunk shaker+ reverse-umbrella	90%	2	25

Continuous productive canopy wall



**Third level of mechanization:
over-the-row machine**

Over-the-row machine



Self-propelled



Trailed

Machines for soil management



Machines for pruning management



**Continuous productive
canopy wall**



**Fourth level of mechanization:
over-the-row machine**

Over-the-row machine



pivoting vertical beaters



Double parallel harvesting system



Planning olive harvest using image analysis



Useful parameters for harvest planning

- maturity index
- quantity of olives per hectare



How is monitoring done nowadays?
By means of visual inspection by a competent agronomists.



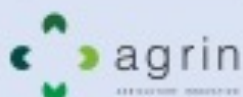
Image analysis at the service of olive growing



University of Bari



University of Foggia



GreenAtlas



Cartographer



Quad speed: 20-40 km/h
Frames per second: 2

N. 2 Cameras RGB

To collect images to process
(2 frame/sec)

N. 2 Scanner Lidar

To collect three-dimensional
images of vegetation, fruits
and other objects

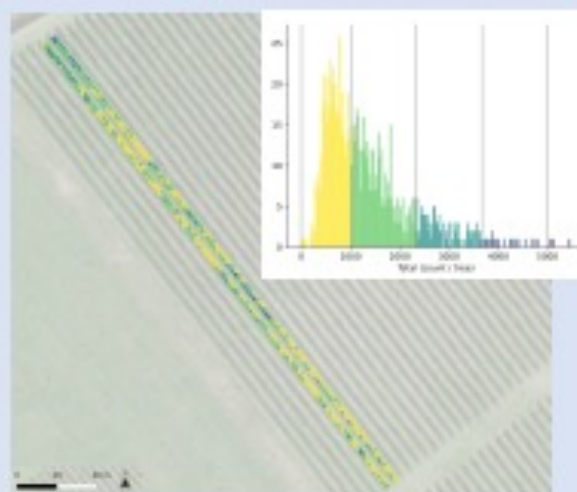
N. 2 Strobe lights

To delete the effect of external
light

N. 1 GPS devices

To georeference the collected
images

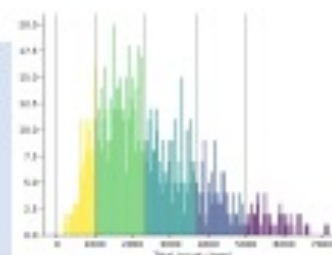
Olive production per hectare detected with image analysis



Total (count / tree)	
5,000+	0 %
3,667 - 5,000	2 %
2,333 - 3,667	11 %
1,000 - 2,333	42 %
0 - 1,000	45 %

Olives kg 660

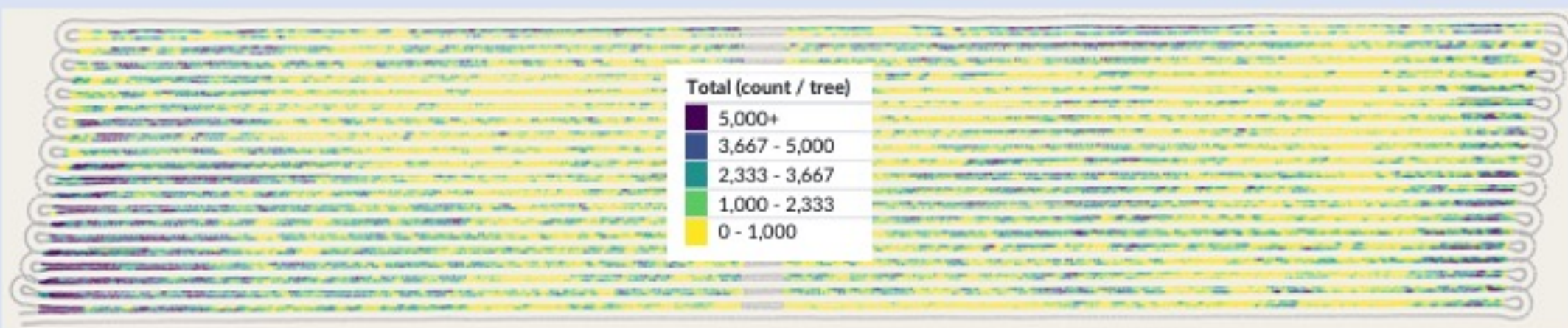
Statistics	
Mean	1347 / tree
CV	66 %
Block total	370.381
Area	0.56 hectare



Total (count / tree)	
5,000+	6 %
3,667 - 5,000	12 %
2,333 - 3,667	26 %
1,000 - 2,333	44 %
0 - 1,000	12 %

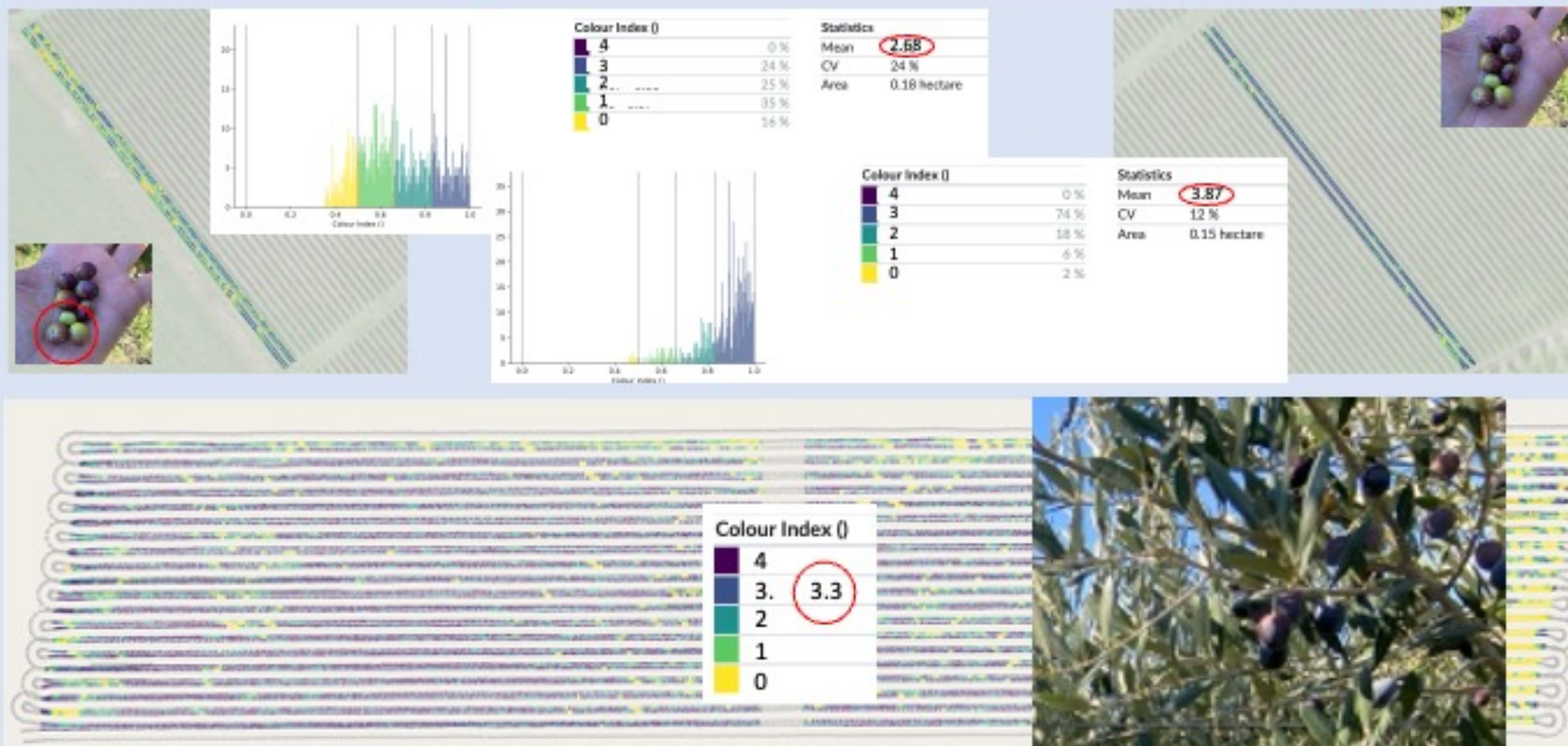
Olives kg 1304

Statistics	
Mean	2448 / tree
CV	55 %
Block total	732.852
Area	0.18 hectare



Total (count / tree)	
5,000+	
3,667 - 5,000	
2,333 - 3,667	
1,000 - 2,333	
0 - 1,000	

The maturity index detected with image analysis

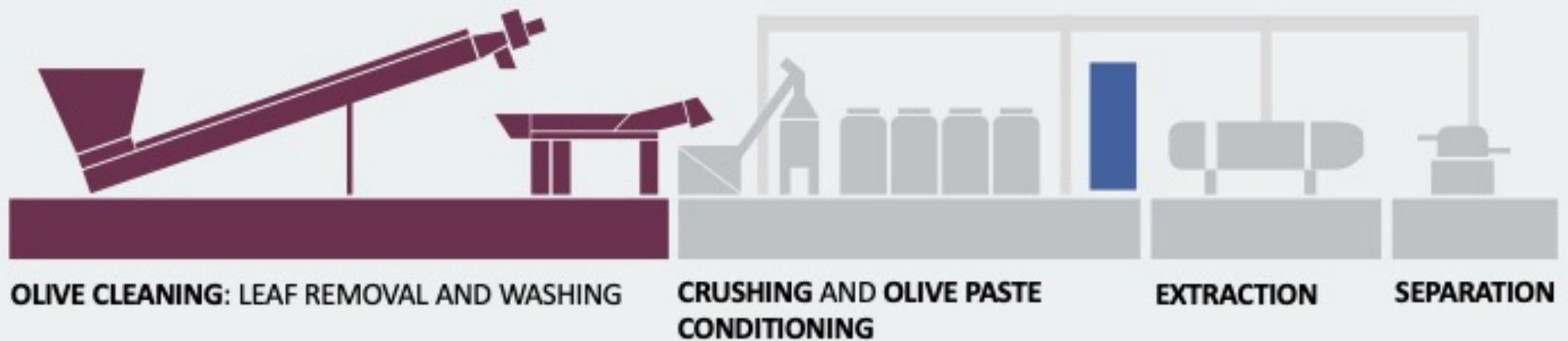


Advancements in olive oil extraction processes



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The extraction process: olive cleaning

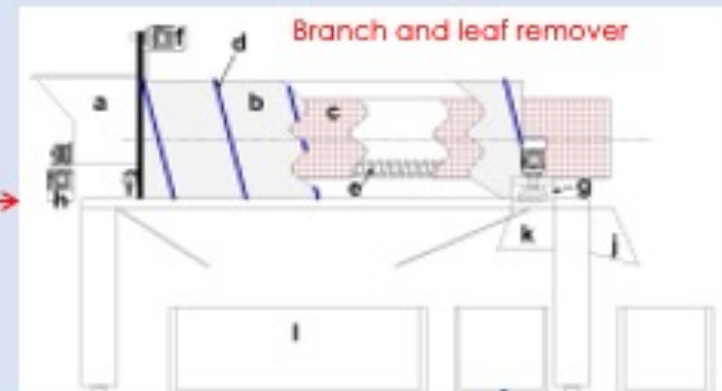


Olive cleaning



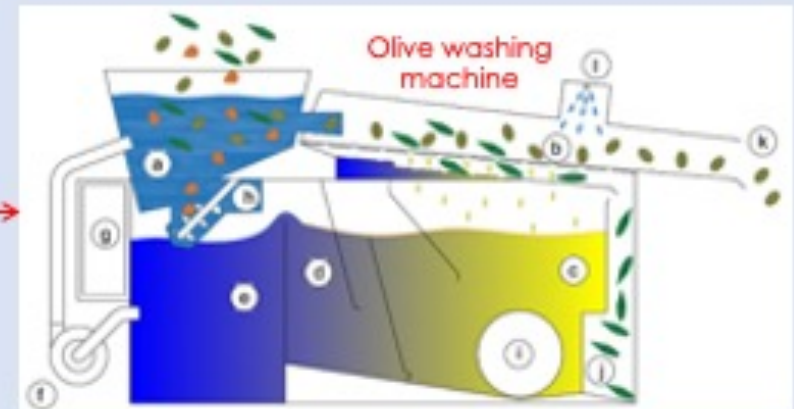
leaves, twigs,
stone and soil
residues

Dry cleaning



Water cleaning

removal of dirt from the
surface of the olives



Traditional methodology of olives cleaning



Optical sorting of the olives

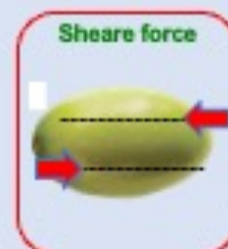
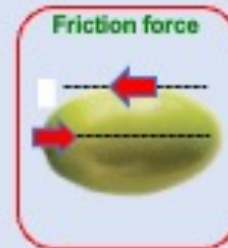
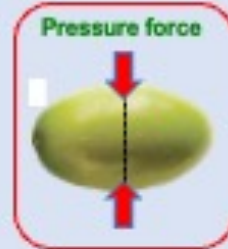
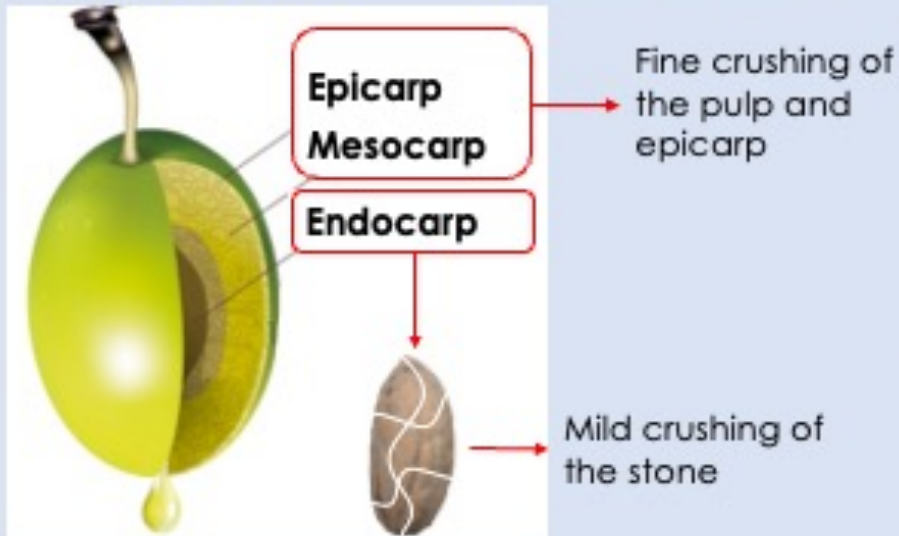


Olive crushing



The crusher

The crushing operation consists in transforming the olives into a homogeneous olive paste **by means of mechanical actions**.



Hammers crusher



Knives crusher



AMENDUNI
NICOLA SPA

Experimental tests



Università of Bari



Università di Perugia



Università di Foggia

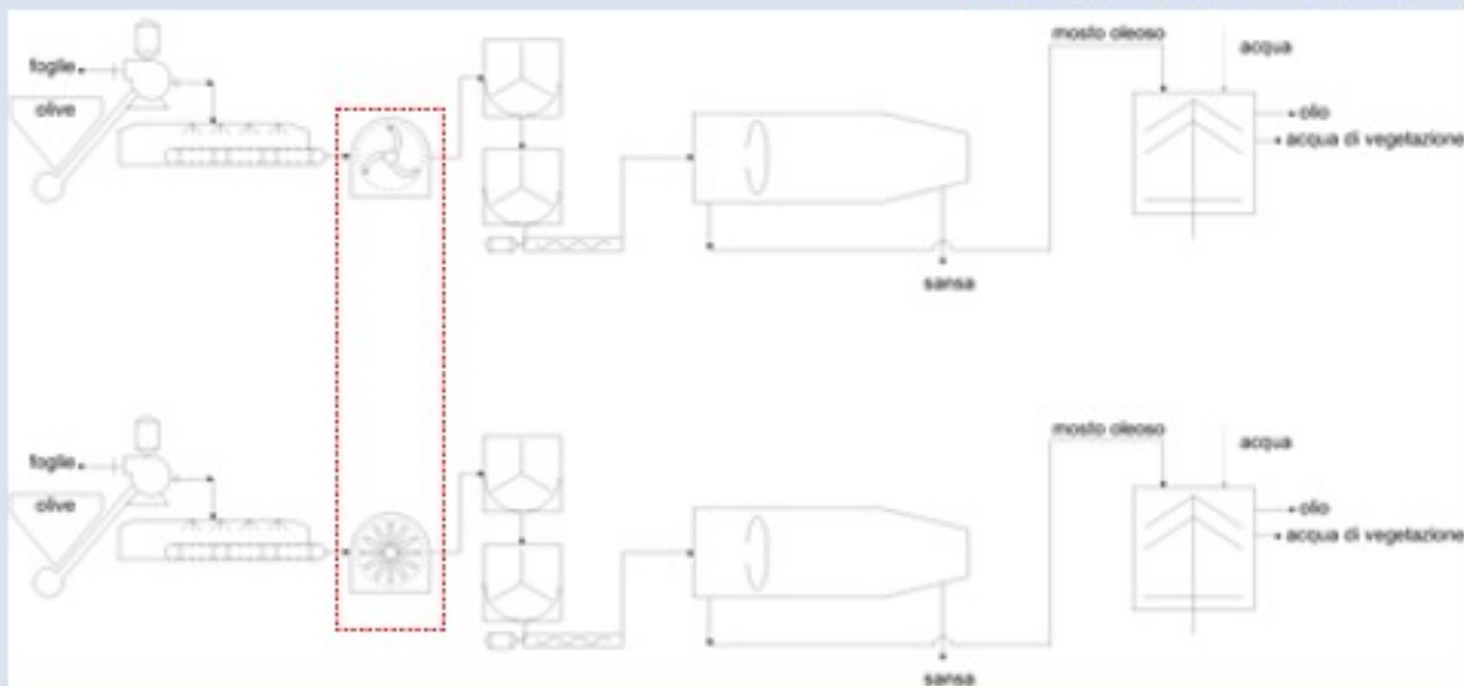


Coratina MI 1.6



Coratina MI 2.3

Line A



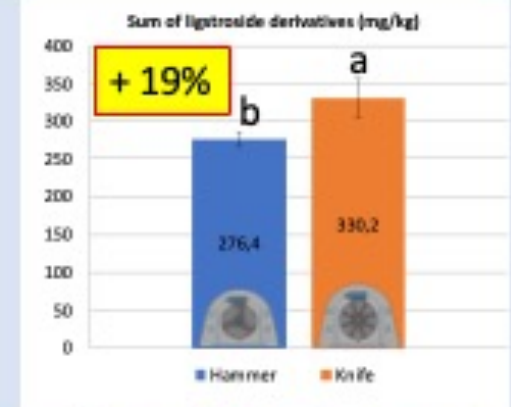
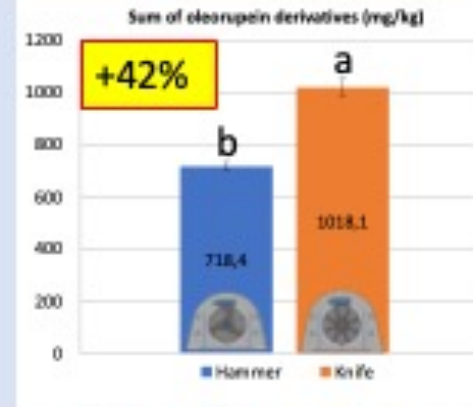
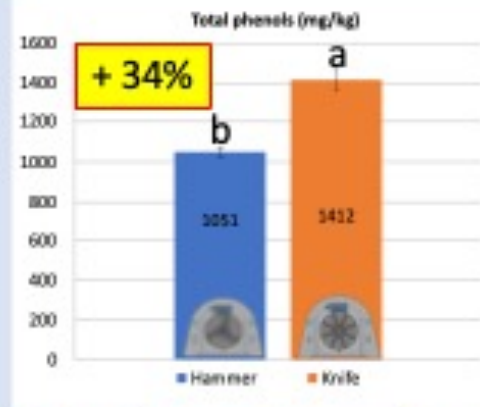
Line B



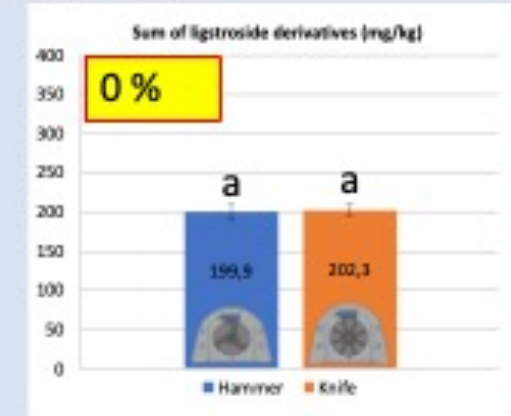
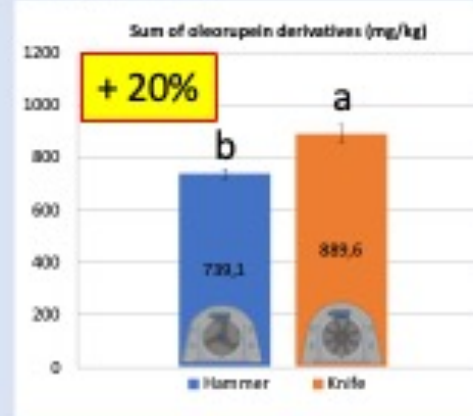
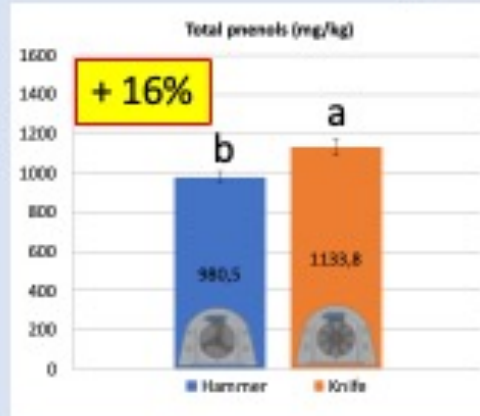
Crushers vs phenols



Coratina MI 1.6

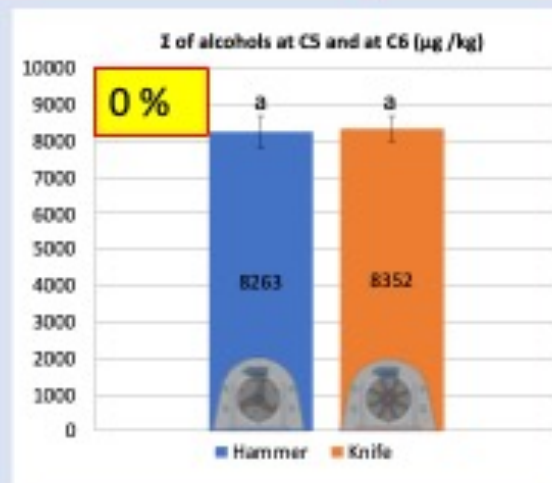
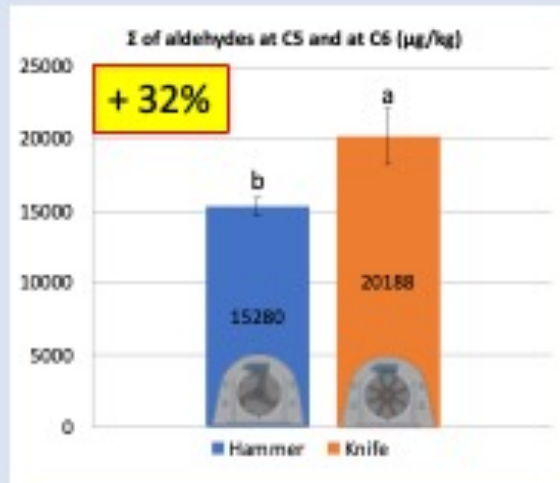


Coratina MI 2.3

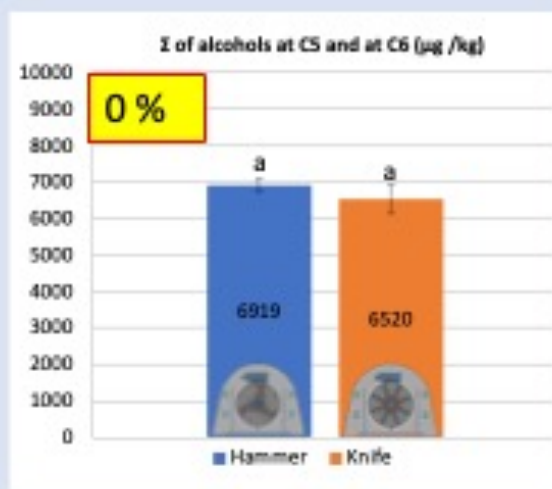
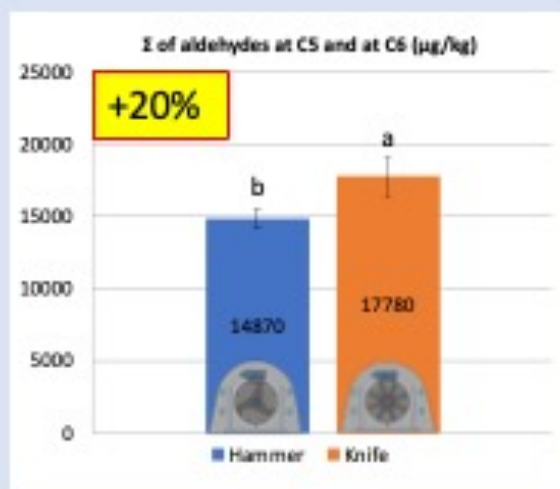


Crushers vs volatile compounds

Coratina MI 1.6



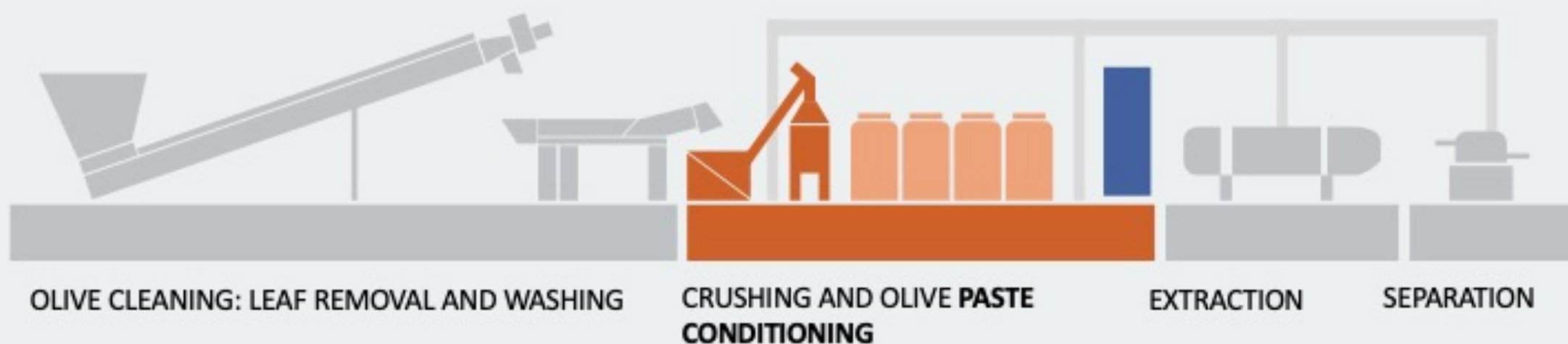
Coratina MI 2.3



Green attributes



Thermo-mechanical conditioning of olive pastes



Malaxer machine



rotary mixing reel



Malaxer machines

horizontal flat malaxers



horizontal flat malaxers

horizontal overlapping malaxers



vertical flat malaxers



horizontal flat malaxers

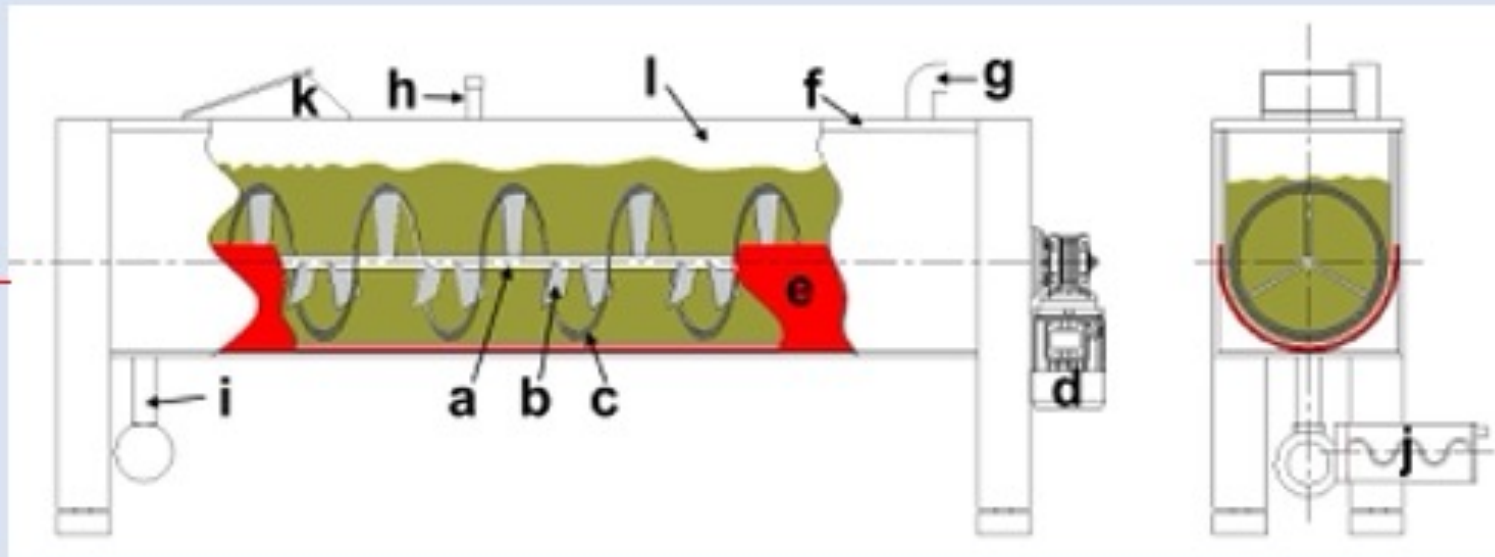
Olive paste conditioning



- ✓ Mechanical action
- ✓ Thermal action
- ✓ Biochemical action



The limitations of the malaxer



→ **Mixing of the olive pastes**



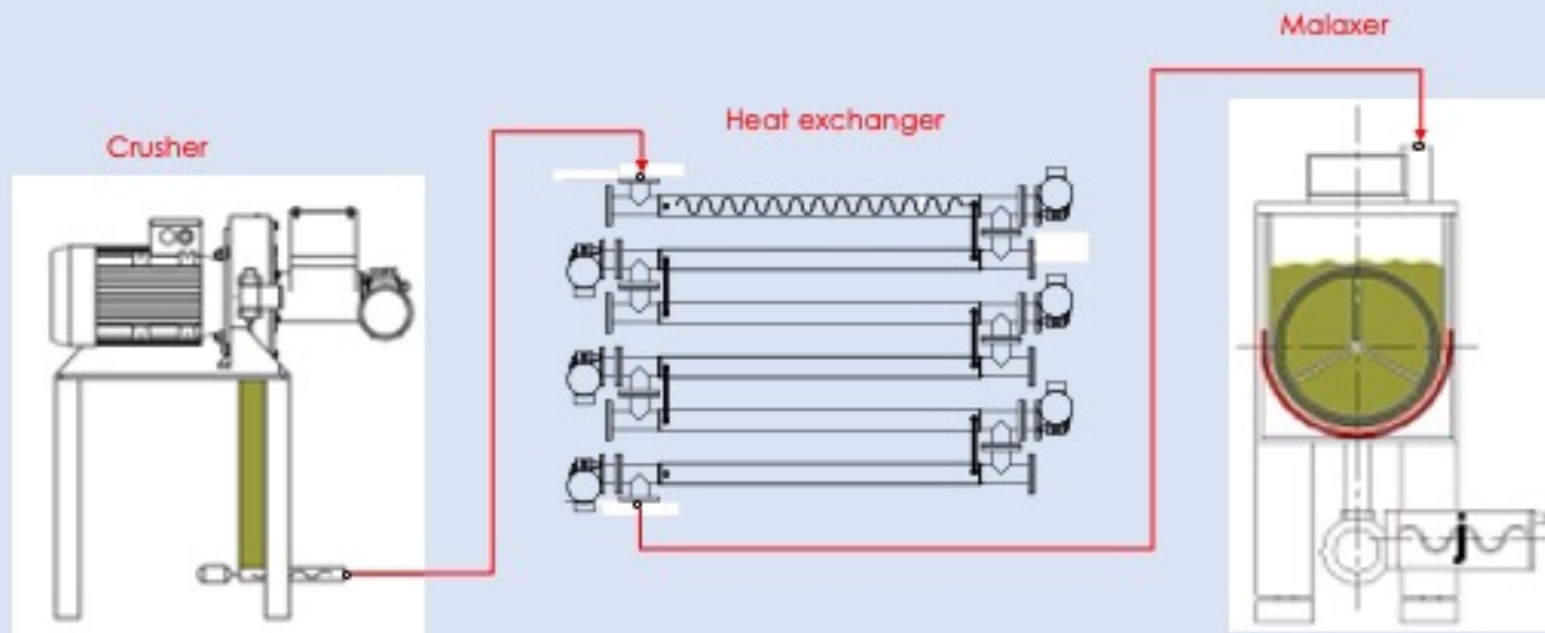
→ **Thermal conditioning**



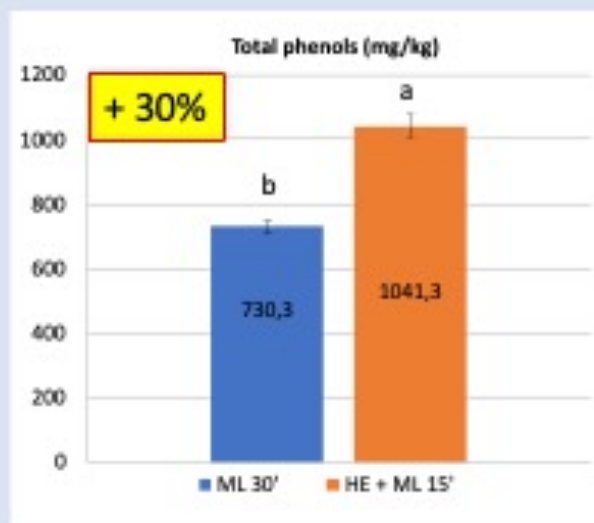
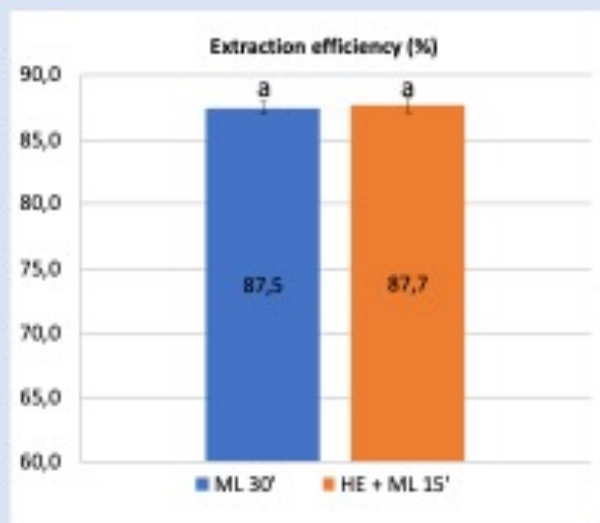
Problems

1. low thermal diffusivity of olive pastes ($\alpha = \text{m}^2/\text{s}$);
2. low overall heat transfer coefficient of the malaxer $U = \text{W}/\text{m}^2\text{K}$, due to a low heat exchange surface-to-volume ratio ($2,5\text{-}4,5 \text{ m}^{-1}$);
3. fouling of the walls
4. poor ability of the reel to mix the olive pastes in an efficient way

Heat exchanger between crusher and malaxer



Heat exchanger: experimental results

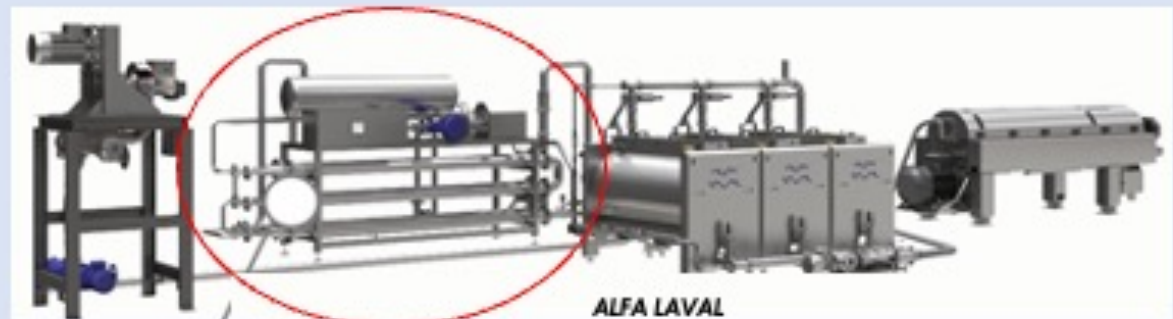
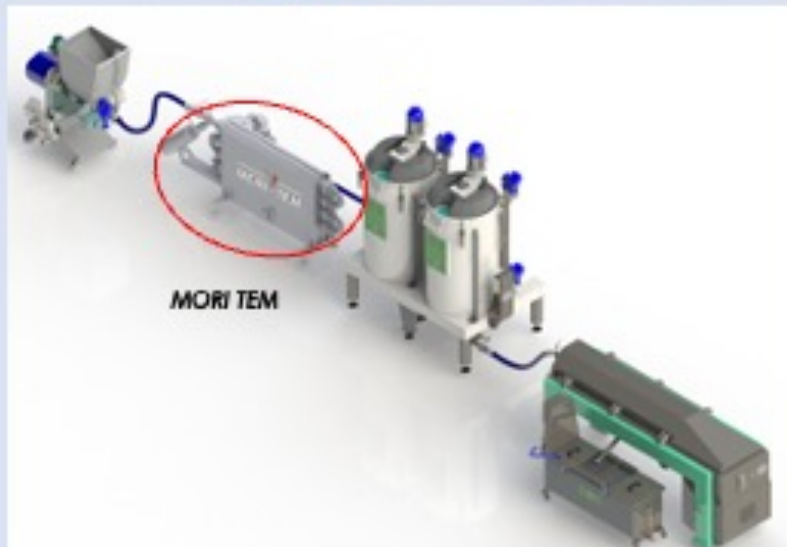
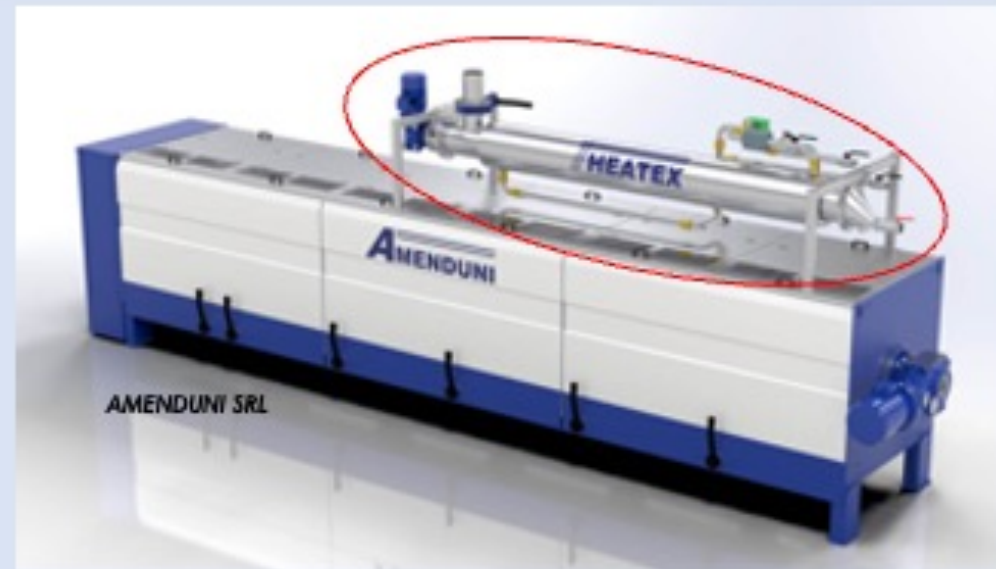


Summarizing

- same extraction efficiency
- increase in phenolic content
- decrease in malaxation time



Examples of heat exchangers



Ultrasound and vacuum malaxer

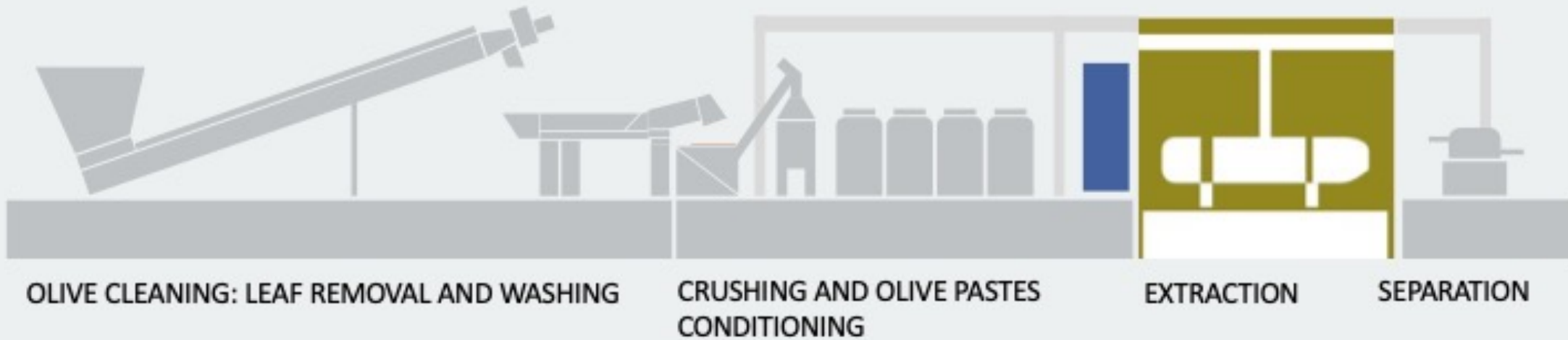


Ultrasound system

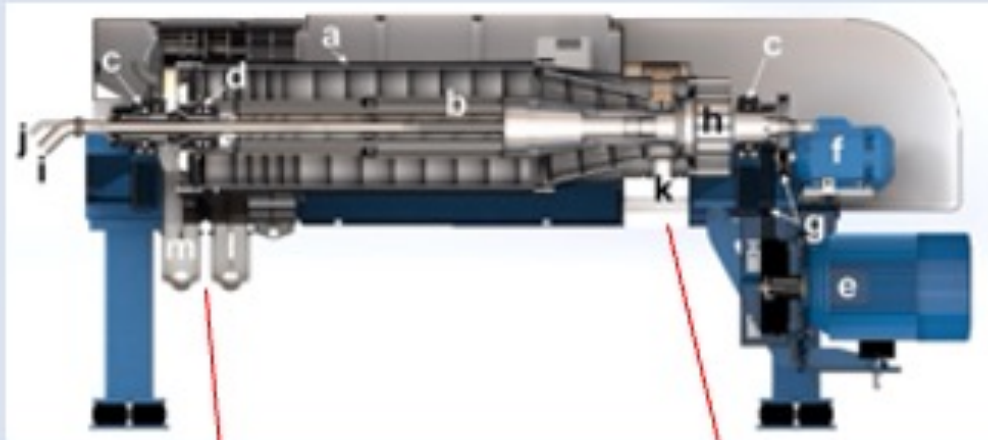


Vacuum malaxer

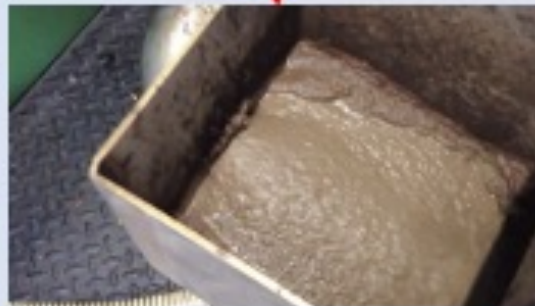
Olive oil extraction



Solid-liquid separation



Unclarified olive oil



2-Phase Pomace

Habemus Olive Oil



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Future direction of innovation in the olive oil supply chain

In the field

1 Data collection



Spring bud



Flowering



Fruit formation



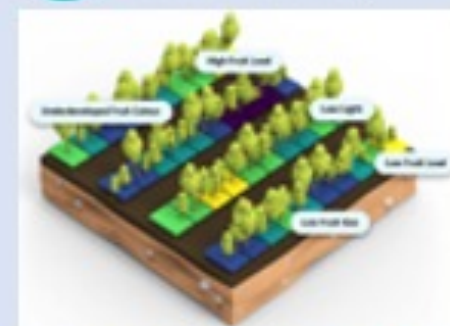
2

Data processing, final information and make decisions



3

make the field operations in an automated way



In the mill: make the process circular and sustainable



Olive stone

Pomace destoned



Anaerobic digestion to produce energy



What will be the next step?

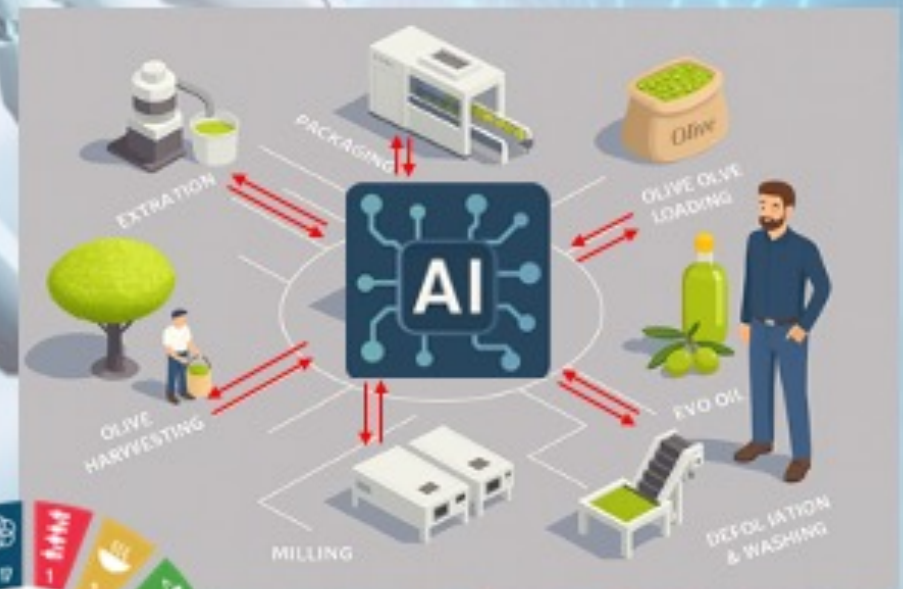
Operator expertise



Operator expertise + sensor tools



Sensor tools + Machine learning + Actuators



- The highest extraction efficiency
- The highest olive oil quality
- Optimizing electricity and water consumption





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Thank you for your attention

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