Megasonics for increased EVOO recovery

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NATIONAL OLIVE INDUSTRY 2018 conference & exhibition
18th - 20th of October | Wagga Wagga NSW

CSIRO

The project team

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Sponsor

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Supporters
Salute Oliva
RVS Industries
Tarle Brothers
University of Bari, Italy
University of Perugia, Italy
University of Uruguay
University of Mannheim
University of Wageningen

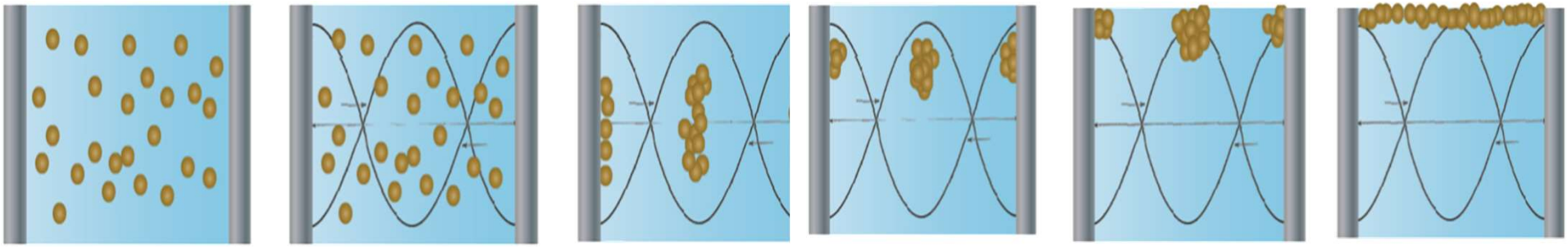
Outline

- Megasonics – definition
- Applications in the edible oil industry
- Megasonics application for olive oil recovery
- Pilot to industrial demonstration
- New process to avoid malaxation
- Outlook

Megasonic separation technology

Treatment of oil bearing materials with high frequency ultrasound waves provides

- Increased oil recovery in oil extraction processes
- Faster oil separation

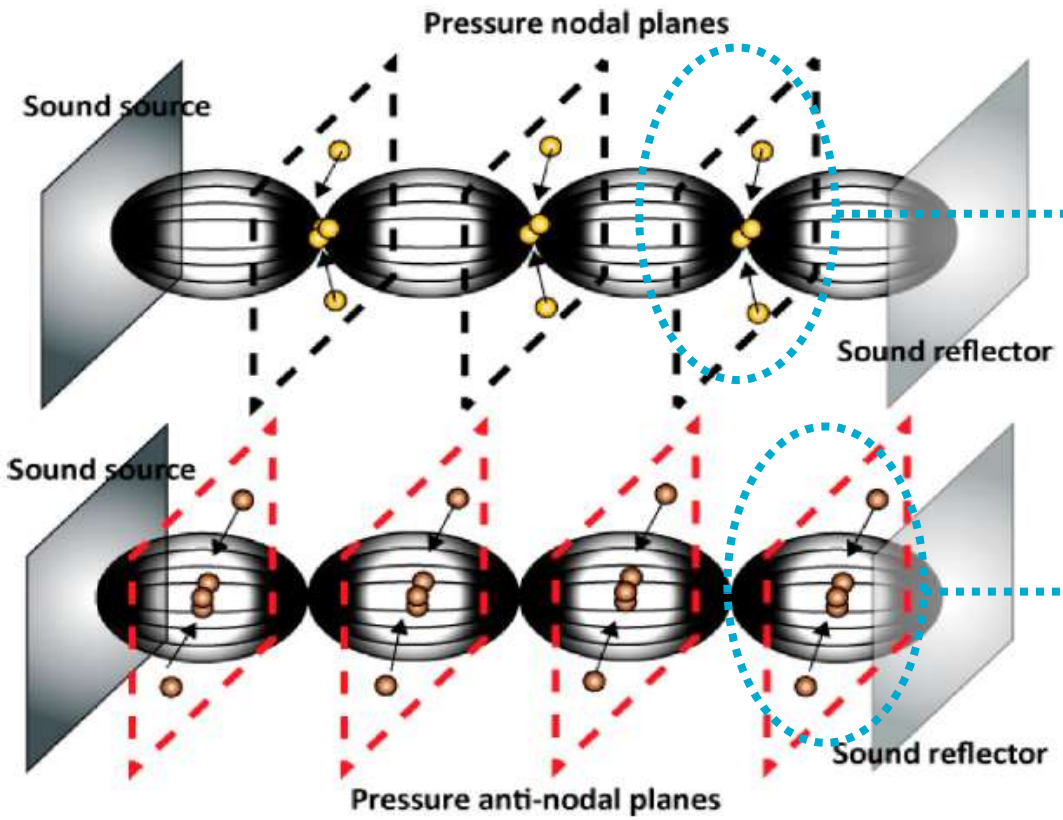


Megasonic waves for oil separation

-acoustic trapping of particles in standing waves

-de-emulsification through droplet-droplet collisions or microjets from bubbles or microstreaming

Megasonic separation technology
Solid to liquid particle separation

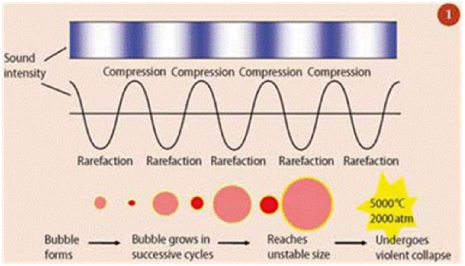


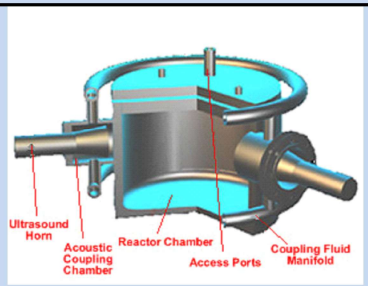
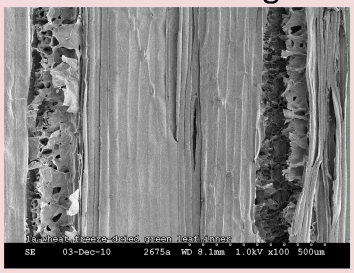
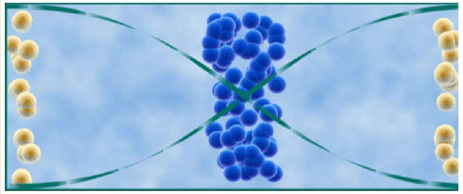
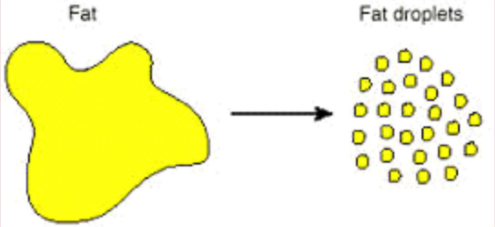
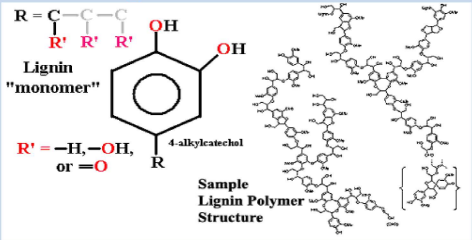
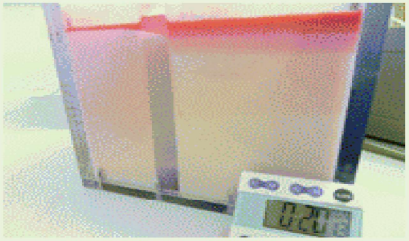
Solid particles with ***high specific density***

Food droplets with ***low specific density*** (e.g. emulsified oils)

Leong et al. 2013

Ultrasound in Processing



Low Frequency (20-100 kHz)	Medium Frequency (100-400 kHz)	High Frequency (Megasonics) (400 - 3000 KHz)
		
Surface Damage 	Chemical Reactions $C_{10}H_{22} \rightarrow 2R^{\bullet}$ $R^{\bullet} \rightarrow R^{\bullet} + C_2H_4$ $R^{\bullet} \rightarrow RCH{=}CH_2$ $R^{\bullet} + C_{10}H_{22} \rightarrow RH + R{-}CH^{\bullet}{-}R$ $H^{\bullet} + C_{10}H_{22} \rightarrow H_2 + R{-}CH^{\bullet}{-}R$ $R{-}CH^{\bullet}{-}R \rightarrow RCH{=}CH_2 + R^{\bullet}$	Standing Wave Separation 
Emuslification 	Lignin Breakdown 	Oil Separation (De-emulsification) 

Megasonic de-emulsification of milk fat

Proof of concept in recombined milk

US on

US off

- Reconstituted solution
  - 4% milk fat coarse emulsion (added with oil-red-O dye 0.05%), particle size 6-7 microns
  - 3.5% MSNF reconstituted skim milk
- US treatment: 400 kHz, 90% amplitude

1 + 2 MHz dual frequency, 150 W/L, 15 minutes treatment

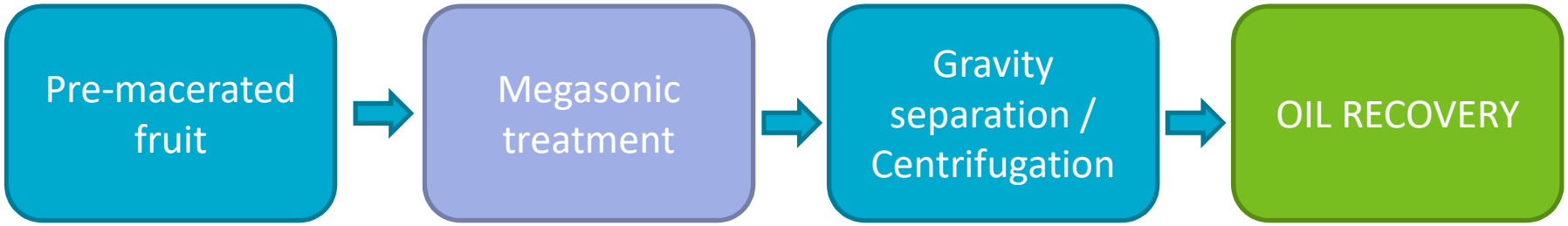
Juliano et al. 2013. Ultrasonics Sonochemistry, 20:52-62





Megasonic applications in oils

Megasonic process – principle for aqueous extraction



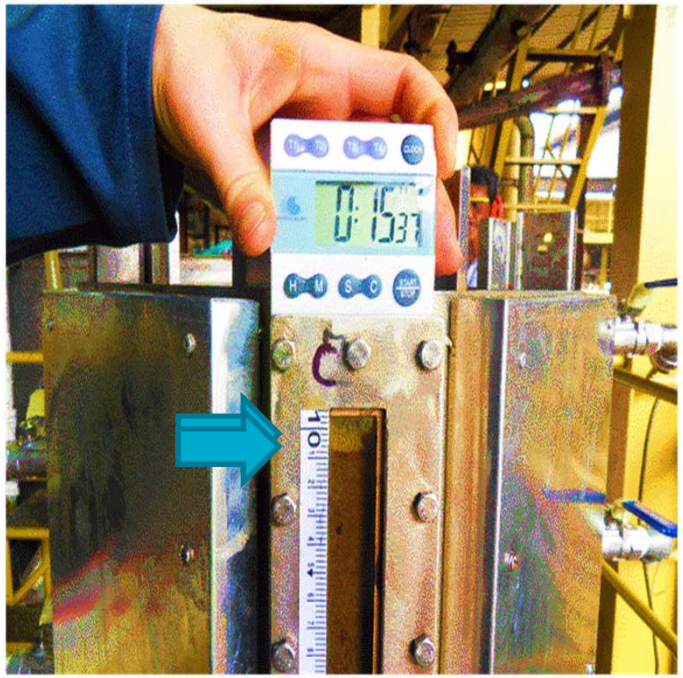
Megasonic separation technology

Challenge for oil recovery

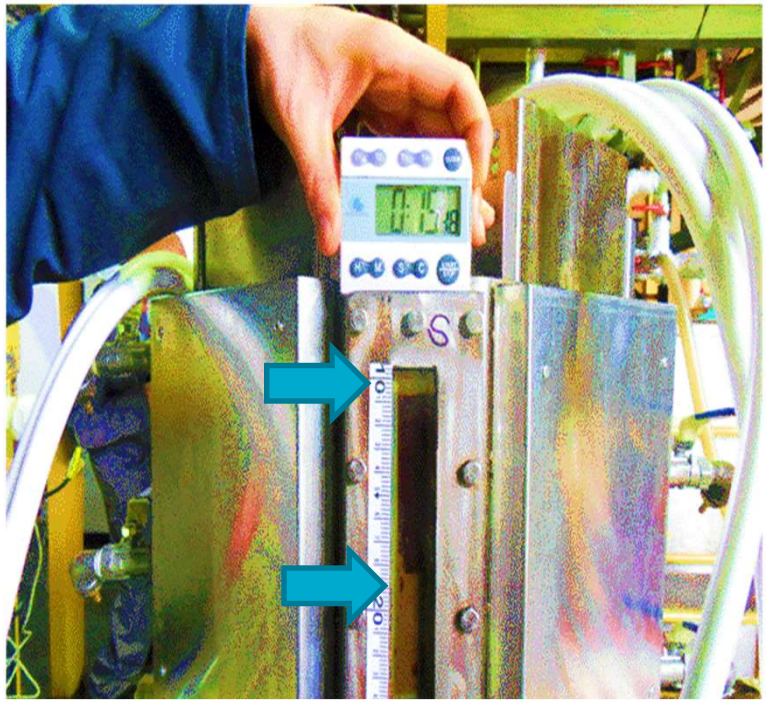
0.5-1% increase in oil recovery = US$300,000 per year per average plant

Megasonic separation technology

Key benefits and applications



No megasonics



Megasonics

- Increased oil yield and extractability
- Reduced centrifugation through faster oil separation
- No moving parts; reduced maintenance cost from centrifugation

Industrial application for palm oil extraction -Palm oil separation – Industrial reactor (353 L)

Megasonics application in olive oil recovery

- ✓Enhanced oil recovery
  - ✓Reduced paste viscosity

- ✓Works in combination with enzymes for even more oil recovery
- ✓Malaxation time reduction
- ✓Increased phenolics in oil

Small plant demo for olive oil extraction

-Olive oil separation – pilot reactor (2016) – Salute Oliva

Additional 1.2% oil recovery
18 kJ/kg

300 kg olive fruits

Crushing
7-11 min

Malaxation
T = 35ºC
t= 70 minutes

+30% water

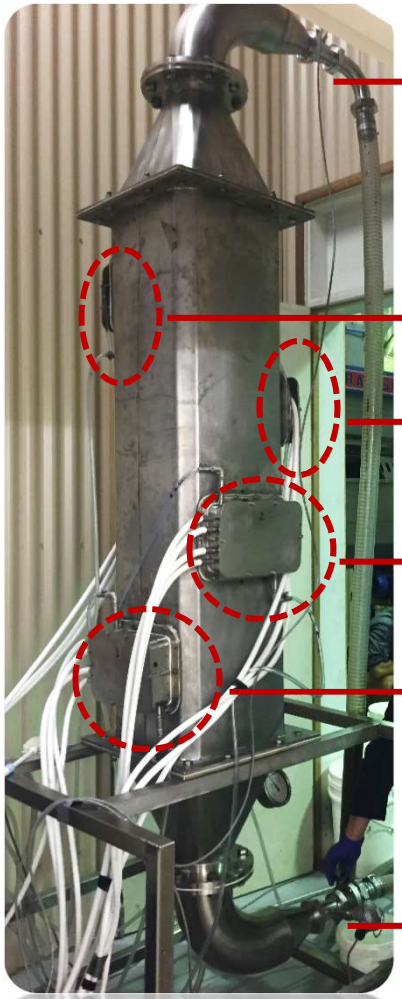
+/-
MS-treatment

Centrifugation

Vegetable water

Olive pomace

Olive oil



Juliano et al. 2017, Ultrasonics Sonochemistry

Italy trials (2016)

Additional 2.1% oil recovery
18 kJ/kg

Olive maturity index 1.5
350 kg/h

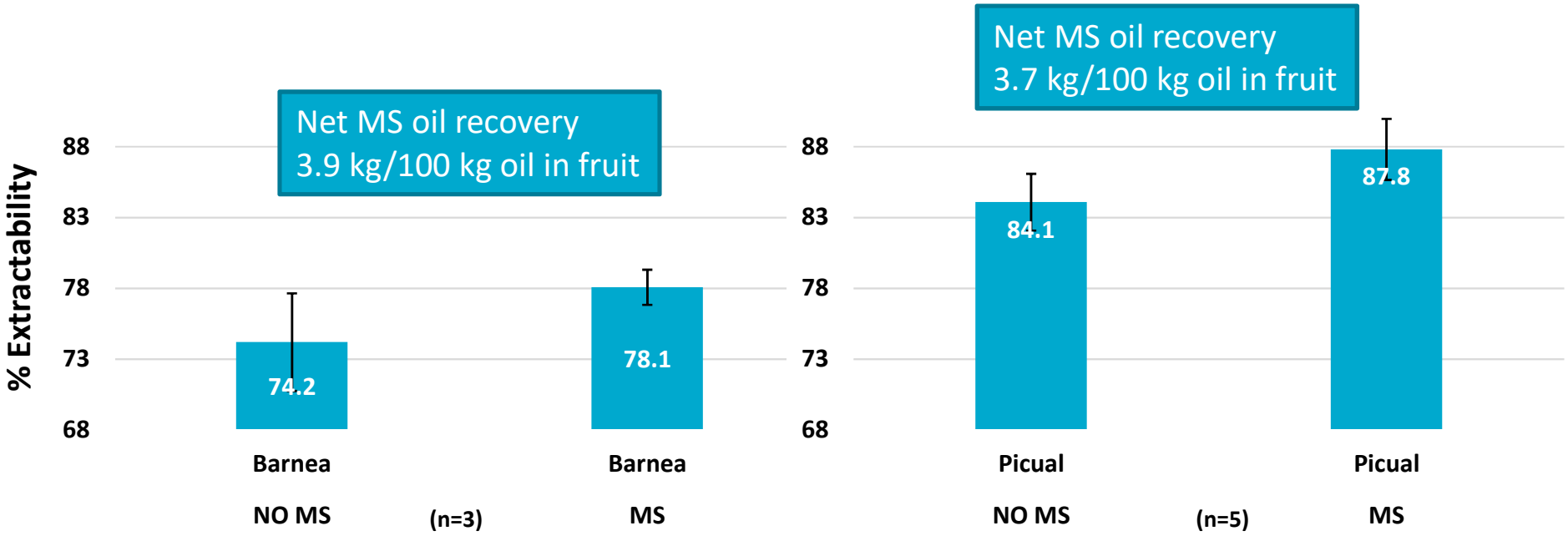
Mori-Tem mill

Leone et al. 2017, Innovative Food Science and Emerging Tech

Industrial (3 tonne/h) demonstration olive oil extraction (2018)

Industrial demonstration olive oil extraction (2018)

No enzyme addition trials

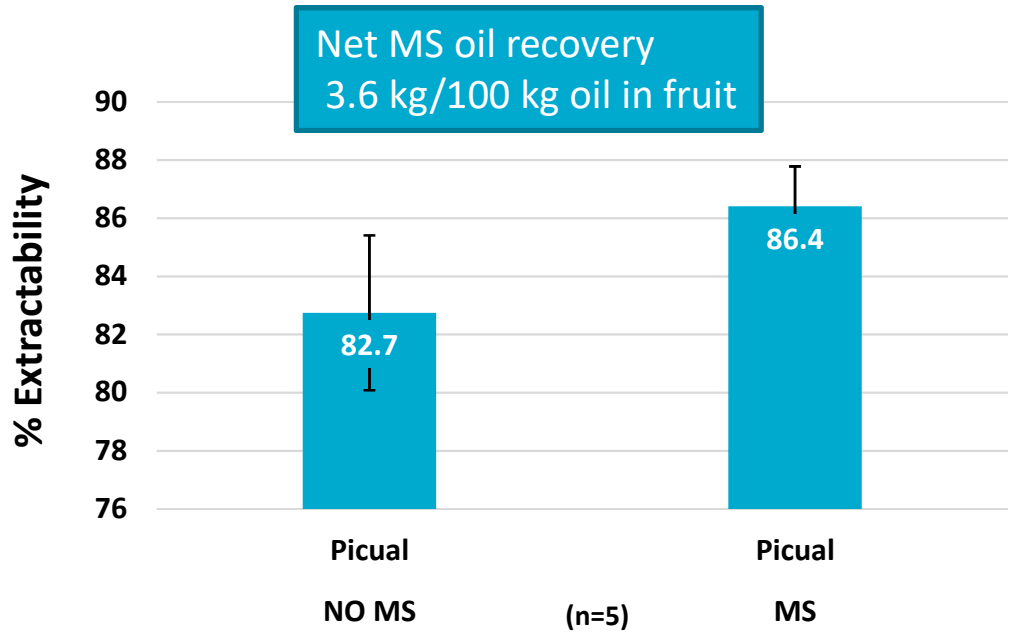


- 60 min malaxation time
- 2.8 tonnes/h
- Maturity index 2.0-2.6
- Ultrasound energy 10 kJ/kg

Opportunity:
Additional oil recovery of $270-300k per year
Plant 1000 L oil/year

Industrial demonstration olive oil extraction (2018)

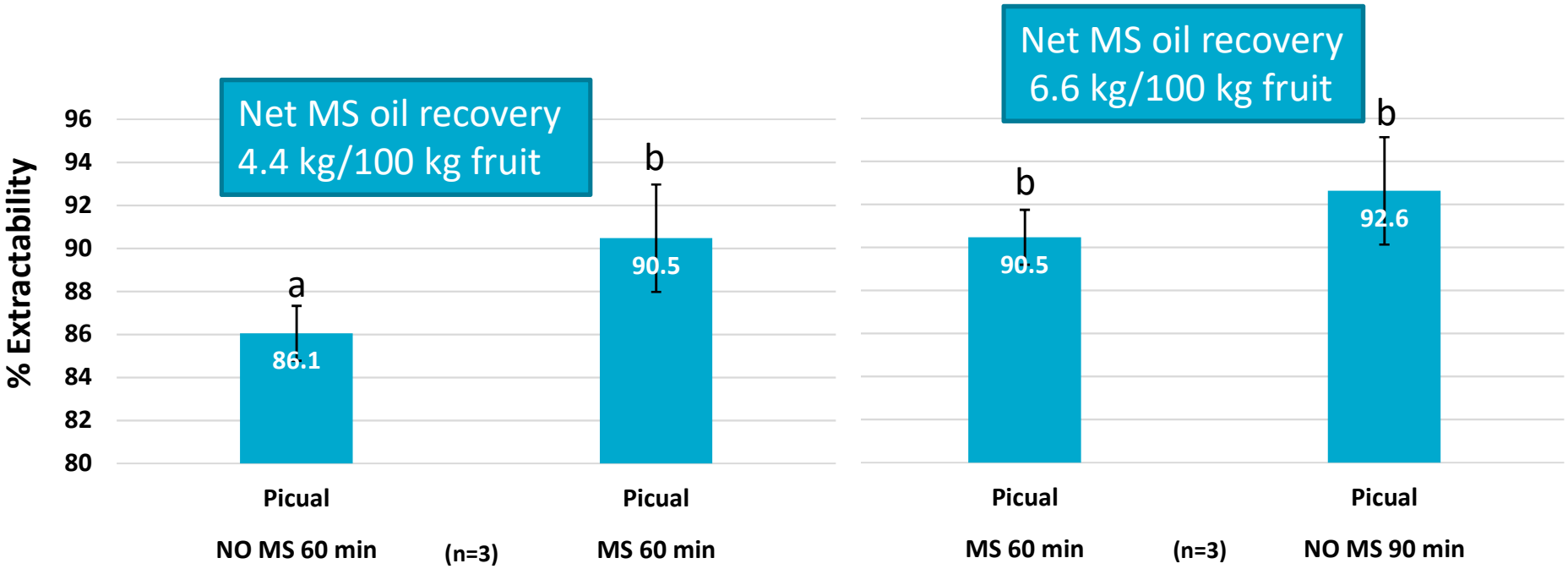
Enzyme trials



- Additional oil recovery demonstration
- 60 min malaxation time
- 2.8 tonnes/h
- Maturity index 3.2-3.9

Industrial demonstration olive oil extraction (2018)

Malaxation time reduction



- Additional oil recovery demonstration
- 60 min (MS ON/OFF) & 90 min malaxation time (MS OFF)
- 2.8 tonnes/h
- Maturity index 4.1-5.0

Industrial demonstration olive oil extraction (2018)

Oil quality (phenolics composition)

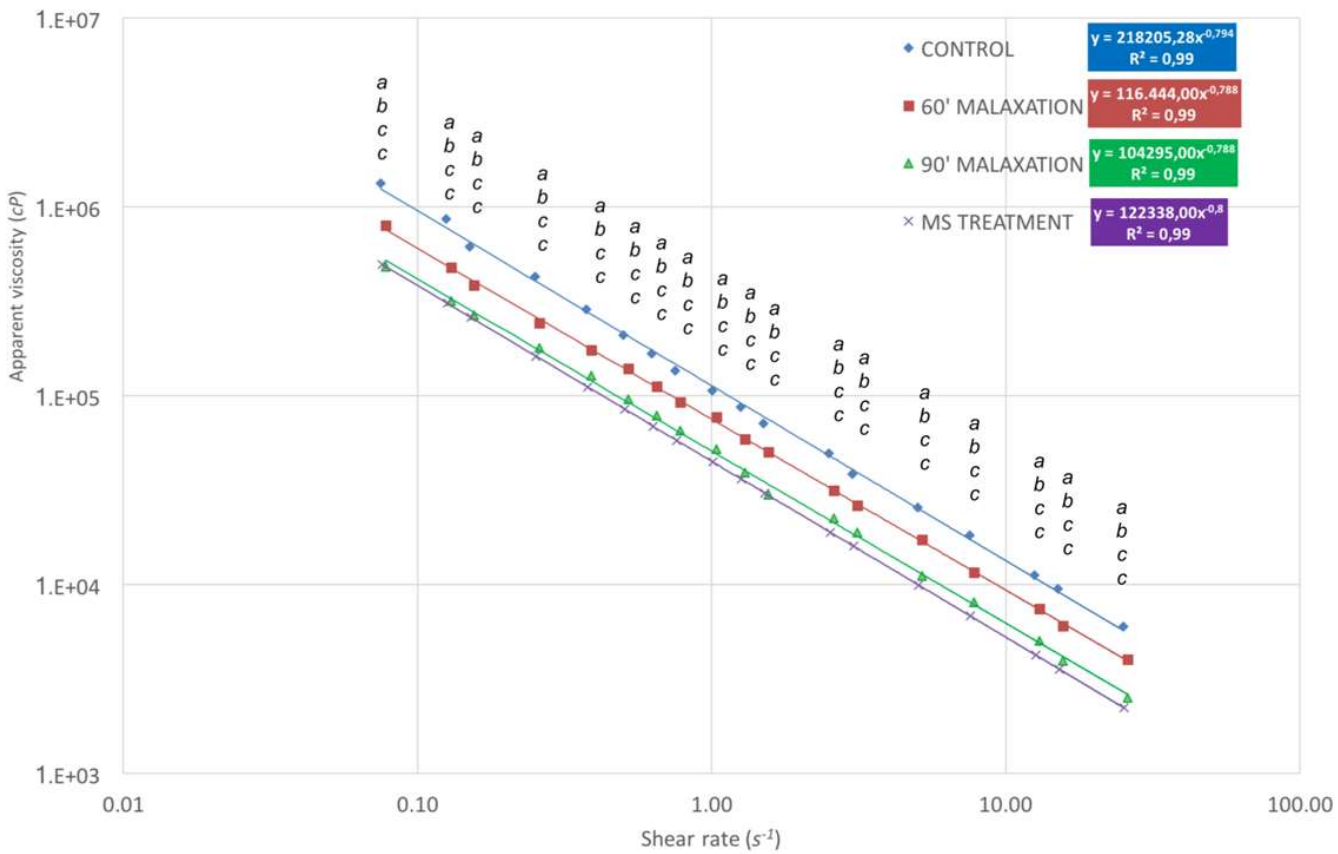
Parameter	Control (No MS treatment)	With MS treatment
3,4-DHPEA	3.8 ± 0.9[a]	2.5 ± 0.3[b]
p-HPEA	5.7 ± 0.8[a]	4.6 ± 0.4[b]
Vanillic acid	0.8 ± 0.1[a]	0.7 ± 0.1[ab]
3,4-DHPEA-EDA	702.2 ± 103.5[a]	823.5 ± 71.7[a]
p-HPEA-EDA	134.6 ± 17.9[b]	166.9 ± 7.0[a]
(+)-1-acetoxypinoresinol	47.0 ± 4.9[ao]	47.1 ± 0.8[a]
(+)-pinoresinol	21.4 ± 1.1[c]	24.8 ± 0.8[bc]
3,4-DHPEA-EA	281.2 ± 22.2[b]	356.6 ± 33.3[a]
Ligstroside aglycone	25.5 ± 7.3[a]	27.8 ± 6.1[a]
Total phenolics	**1222.2 ± 110.0[b]**	**1454.5 ± 86.3[ab]**

(n=4), $p<0.05$ (Tuckey's test)

Quality unchanged with an increased total phenolics

Other parameters, free acidity, PV, induction time, DAG and volatiles were also unchanged.

Effect of MS on paste viscosity reduction

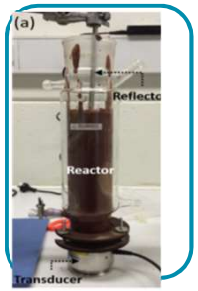


Increase in malaxation time reduces apparent viscosity of the paste
A megasonic treatment further reduces viscosity!

Industrial application for palm oil extraction

-Olive oil separation

Control Ultrasound



2015

Start R&D lab scale megasonics olive oil separation

2016

300 kg batches

Salute Oliva

Boundary Bend

2017

350 kg/h

Andria Italy

Technology Evaluation Agreement Univ Foggia

SIP ON project

SIEF GRANT

Demo 3 t/h

2018

Eureka Award nomination

FIAL GRANT

-Growth Centre projects

-Enterprise solution centre

Megasonics olive oil next steps

- Currently exploring opportunities with FIAL
  - GROWTH CENTRE – Boundary Bend + Investor
  - ENTREPRISE SOLUTION CENTRE – Multiple olive oil producers

- Engagement with potential users and commercialisation partners

Next Challenges

- 6 tonnes/h trials
- Vessel functional re-design (easy-cleaning)

Thank you

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