



Vicerrectoría de
Investigaciones
Dirección de Relaciones Internacionales



EIFA
GCITEC
Globalizando el Conocimiento en
Ciencia y Tecnología de los Alimentos

Electric Fields Technology in Food Processing

Ricardo N. Pereira
rpereira@deb.uminho.pt



University of Minho
School of Engineering

Agenda

- ☐ CEB – University of Minho
- ☐ Introduction – novel and emergent food processing
- ☐ Ohmic Heating
- ☐ Electric Fields
- ☐ Applications
- ☐ Conclusions



CEB is rated with EXCELLENT in the latest Evaluation of R&D Units

Core research is allocated to 4 interdisciplinary thematic areas from biotechnology and bioengineering that cover the molecular, cellular and process scales:

Environmental



Food



Health



Industrial



Needs and Trends creating opportunities...

- ❑ Clean claims (preservatives free)
- ❑ Clear labels
- ❑ “Green foods” benefits of plants
- ❑ Lifestyle enhancers - high energetic foods
- ❑ Functional foods - nutraceutical function
- ❑ Minimally processed foods - natural ingredients
- ❑ “Zero” waste – biorefinery concept



Ohmic Heating = Joule effect = Electroheating = Moderate Electric Fields

1920 – 1935. Electropure Process



Anderson & Finkelstein
A Study of the Electro-Pure Process of Treating Milk
Journal of Dairy Science
Volume 2, Issue 5, September 1919, Pages 374-406

2021, Continuous units at 8000 kg/h (480 kW)



Italy, Emmepiemme srl , <https://www.emmepiemme-srl.com/>
Japan, Yanagiya Machinery, <http://ube-yanagiya.com/>
Netherlands, Alfa-Laval, <http://www.alfalaval.nl/>
UK, C-Tech, www.ctechinnovation.com

Which parameters to control ?

Table 7

Pictures of stainless steel electrodes after a single experimental run with Trizma-HCl and Mclvaine buffer solutions at different electric field strength, frequency, σ , and pH. $T_i = 25\text{ }^\circ\text{C}$; $T_f = 90\text{ }^\circ\text{C}$.

OH conditions and heating medium	$\sigma = 1\text{ mS/cm}$		$\sigma = 3\text{ mS/cm}$		$\sigma = 5\text{ mS/cm}$		
	20 V/cm	40 V/cm	20 V/cm	40 V/cm	20 V/cm	40 V/cm	
Conventional low frequency (50 Hz) OH	Trizma-HCl (pH 7.0)						
	Mclvaine (pH 7.0)						
	Mclvaine (pH 3.5)	-	-	-		-	-
Pulsed high frequency (25 kHz) OH	Trizma-HCl (pH 7.0)	-		-		-	
	Mclvaine (pH 7.0)	-		-		-	
	Mclvaine (pH 3.5)	-	-	-		-	-

Process

Product

Electric field strength

Electrical conductivity

Temperature

pH

Treatment time

Composition

Specific energy

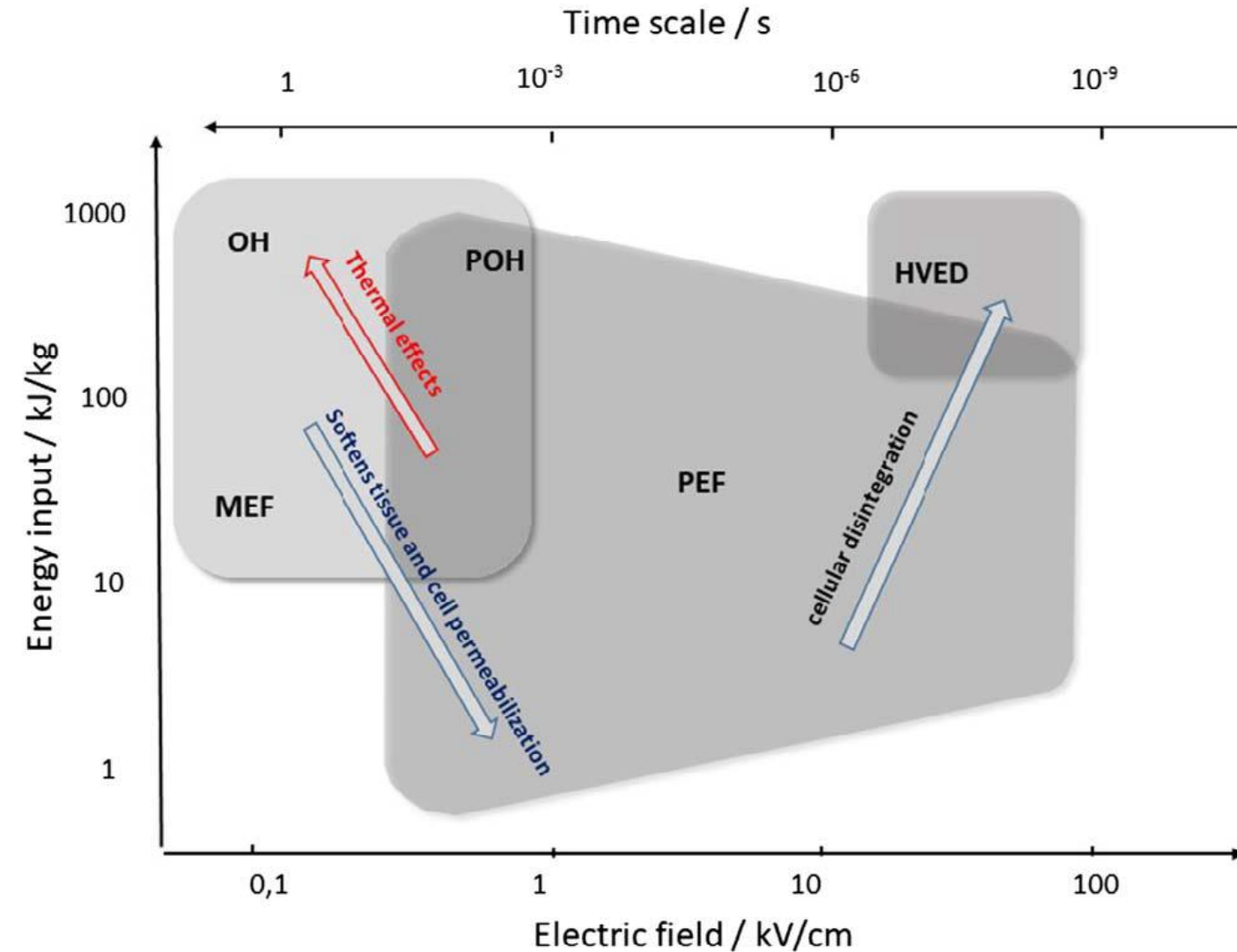
Microbiology

Electrical waveform

Electrical frequency

Electrolysis

Corrosion



MEF, Moderate Electric Fields

OH, Ohmic Heating

POH, Pulsed Ohmic Heating

PEF, Pulsed Electric Fields

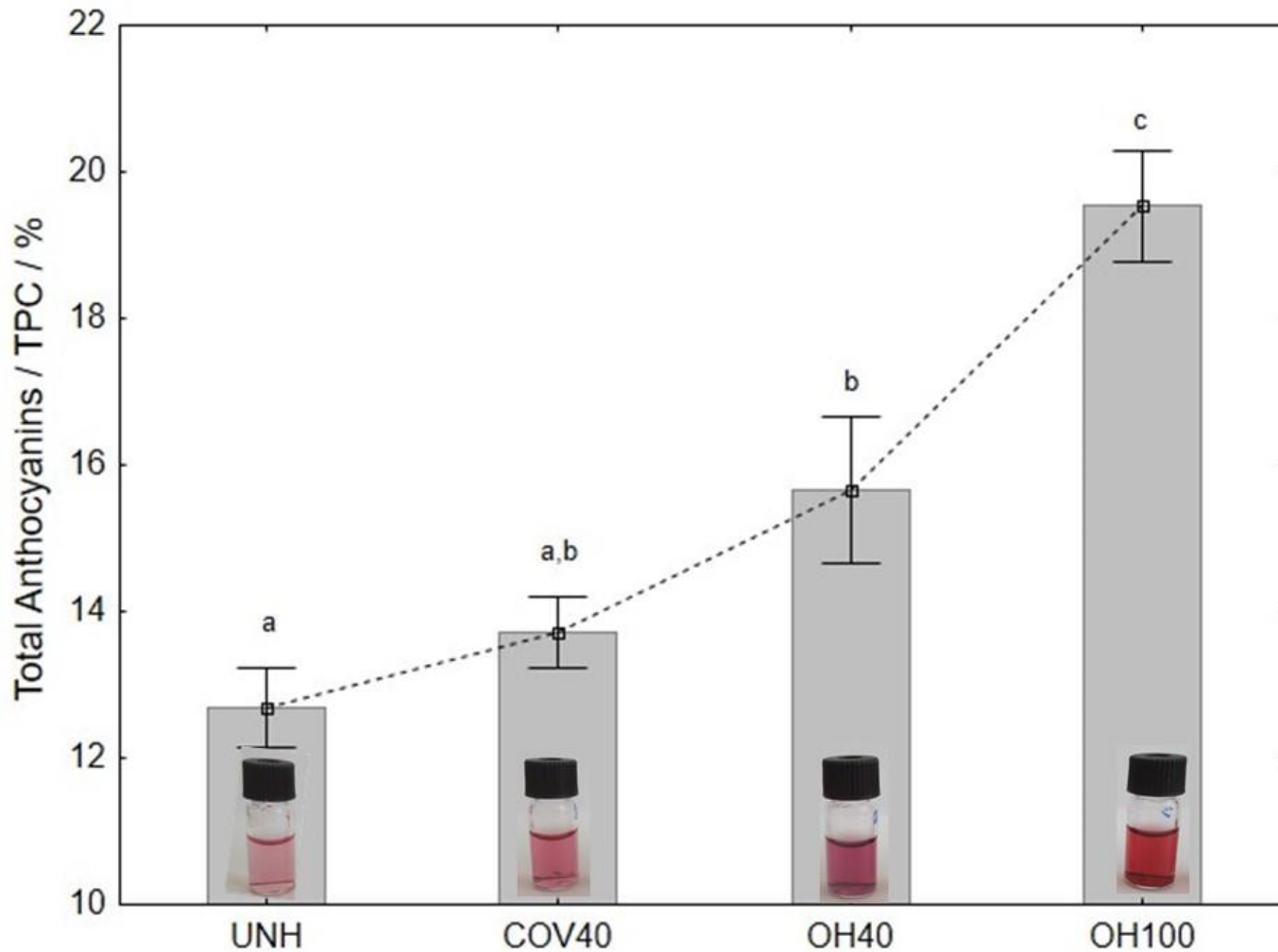
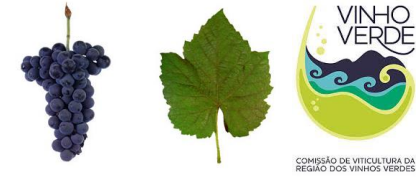
HVED, High Voltage Electric Discharge

- ❑ Biological materials are good electrical conductors
- ❑ Electrical waves and instantaneous internal heating effects
- ❑ Electrical + Thermal = Synergy
- ❑ Extraction through an efficient and “clean-label” approach



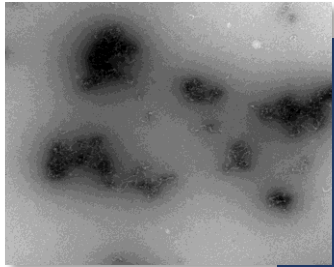
Grape seeds





- UNH – unheated
- COV40 – Conventional heating 40°C (20 min)
- OH40 – Ohmic Heating at 40°C (20 min)
- OH100 – Ohmic Heating a 100 °C (1 s)

Ohmic Heating provides an efficient extraction of antioxidant compounds

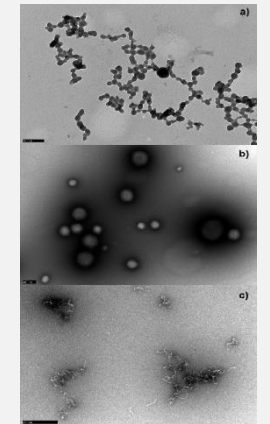


Protein Science and Technology

- ❑ Protein structure and interactions
- ❑ Development of nano/micro protein network systems
- ❑ Protein gelation (heat and cold-set gels)

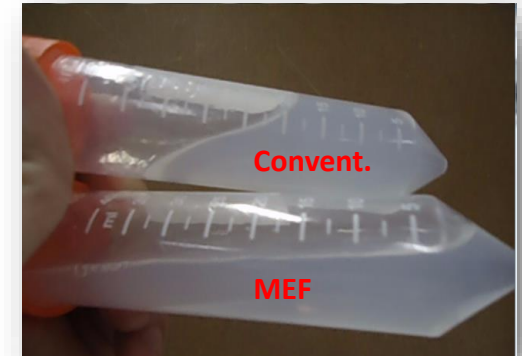
- OH can significantly change denaturation kinetics of whey proteins, and, consequently, their aggregation
- Impact of OH over allergenicity should not be overlooked

Pereira et al. J. Agric. Food Chem. 66, 11227–11233, 2018

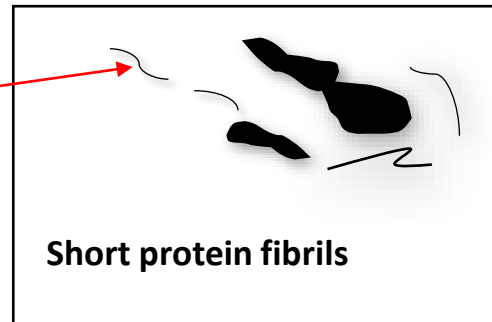
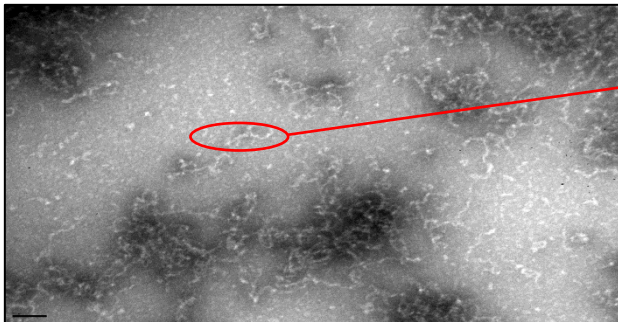


Functionalization of whey proteins gels (with incorporation of Fe^{2+})

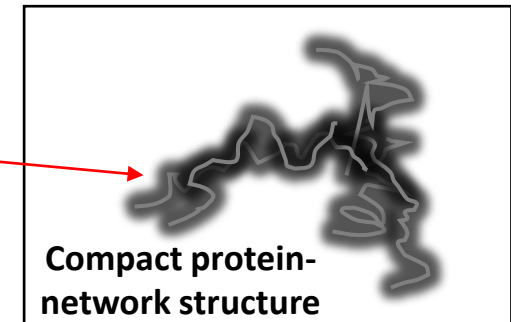
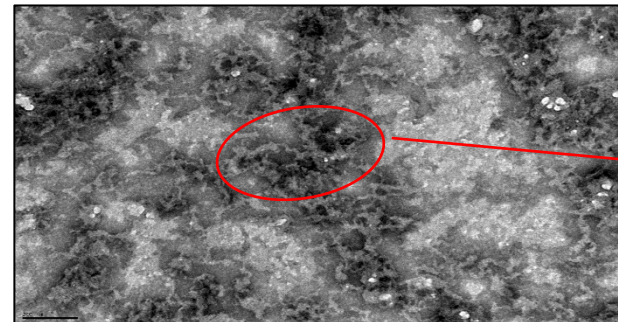
Cold set hydrogels produced after application of electric fields gave rise to a homogenous and compact microstructure



1. OHMIC HEATING AT MEF OF 3 V/CM



2. Fe^{2+} COLD GELATION



- ✓ Conventional extraction operations can be replaced – less time consuming and more efficient and “clean” technology
- ✓ Synergy of fast internal heating and moderate electric fields on extraction protocols of sensitive bioactive compounds
- ✓ Need of more fundamental knowledge about interaction of electric fields and macromolecules
- ✓ Impact on bioaccessibility of bioactive molecules
- ✓ Interdisciplinary approach combining different competences chemical/biological engineering, biophysics...





*Linking life and technology
to shape the future*



University of Minho
School of Engineering

Thank you for listening

ACKNOWLEDGEMENTS

- António Vicente
- Rui Rodrigues
- José Teixeira
- Food Innovation and Technology (FIT) Research group
- Industry and Processes Laboratory (LIP)

This study was supported by the Portuguese Foundation for Science and Technology (FCT) under the scope of the strategic funding of UIDB/04469/2020 unit.



Centre of Biological Engineering
University of Minho
Campus de Gualtar
4710-057 Braga



Email: ceb@ceb.uminho.pt
Website: www.ceb.uminho.pt

