

Cold Plasma Processing



Carmen Bueno-Ferrer
Dublin Institute of Technology

BioPlasma Research Group @ DIT





1. Dr. P.J. Cullen

2. Dr. Paula Bourke

3. Dr. Daniela Boehm

Microbiology

4. Dr. Carmen Bueno-Ferrer

Food Packaging

5. Dr. Vladimir Milosavljevic

Plasma Physics

6. Dr. N.N. Misra

Food Engineering

7. Lu Han

Microbiologist

8. Dana Ziuzina

Microbiologist

9. S.K. Pankaj

Food Packaging

10. Caitlin Heslin

Molecular biology

11. Apurva Patange

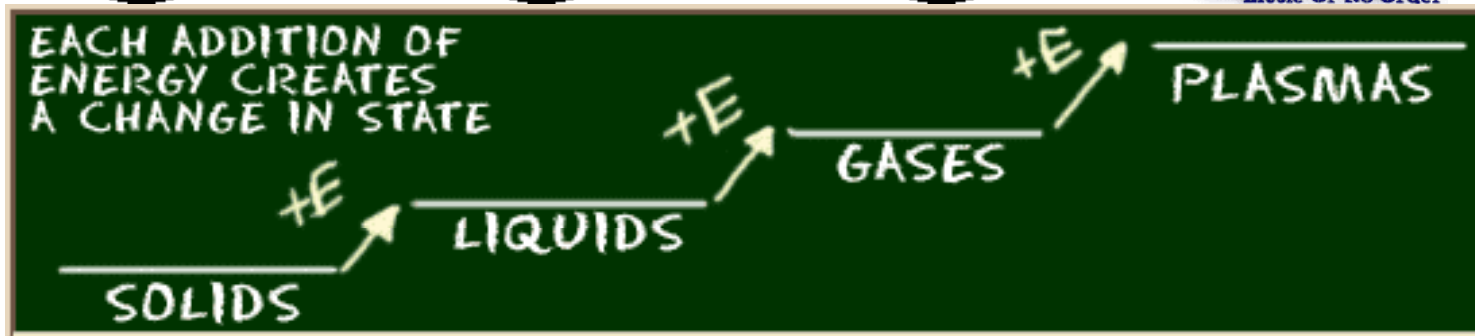
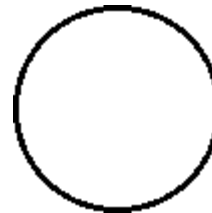
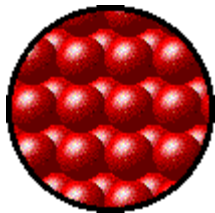
Microbiologist

12. Chaitanya Sarangapani

Food Engineering

What is plasma?

STATES OF MATTER



SOLID

Tightly packed, in a regular pattern
Vibrate, but do not move from place to place

LIQUID

Close together with no regular arrangement.
Vibrate, move about, and slide past each other

GAS

Well separated with no regular arrangement.
Vibrate and move freely at high speeds

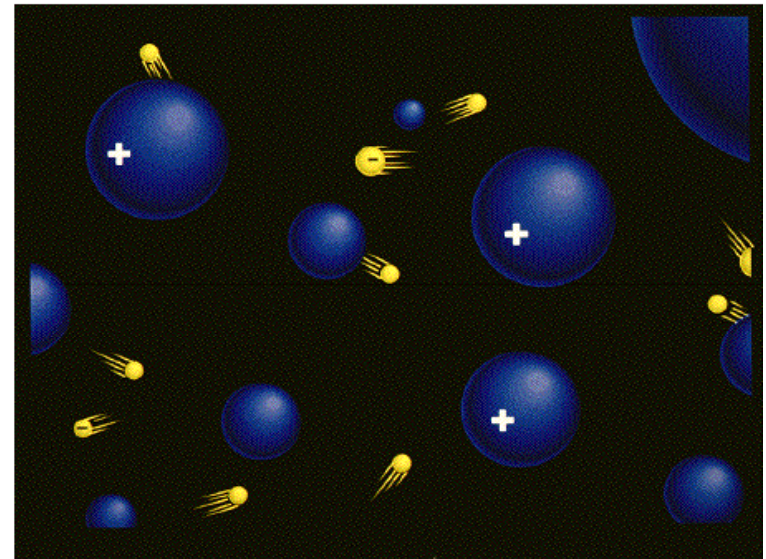
PLASMA

Has no definite volume or shape and is composed of electrical charged particles

What is plasma?

STATES OF MATTER

- A plasma is an ionized gas.
- **A plasma is a very good conductor of electricity and is affected by magnetic fields.**
- Plasmas, like gases have an indefinite shape and an indefinite volume.



❖ **Plasma is the common state of matter**

Types of plasma

Temperature

- Thermal
- Non-thermal/Cold

Pressure

- Low pressure
- Atmospheric pressure
- High pressure

Gas

- Air
- Oxygen
- Helium
- Argon.....

Mode

- Microwave
- Radio frequency
- Corona
- Dielectric barrier Discharge



Types of plasma

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Mode

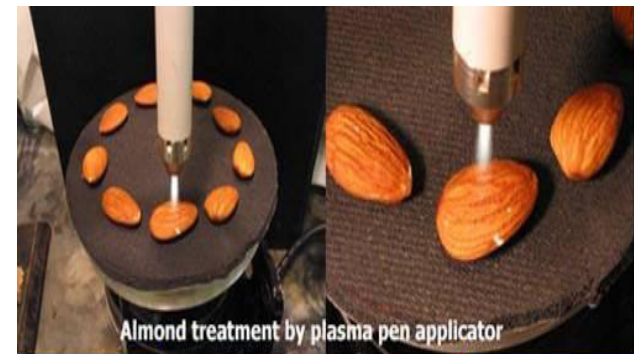
- Microwave
- Radio frequency
- Corona
- Dielectric barrier Discharge



Cold plasma

The term cold plasma has been recently used as a convenient descriptor to distinguish the one-atmosphere, near room temperature plasma discharges from other plasmas, operating at hundreds or thousands of degrees above ambient

In the context of *food processing*, a nonthermal plasma (NTP) is specifically an *antimicrobial treatment* being investigated for application to fruits, vegetables and other foods with fragile surfaces.

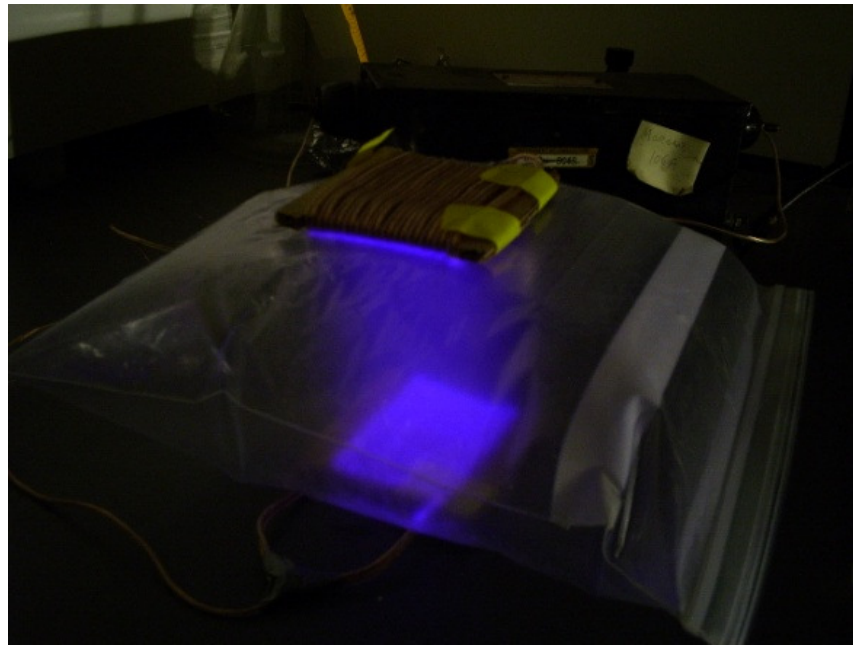


How can we contain the plasma and increase exposure time?

- Put it in a chamber ?
- What if one cannot afford a chamber ?
- What if one is manufacturing tonnes of product ?



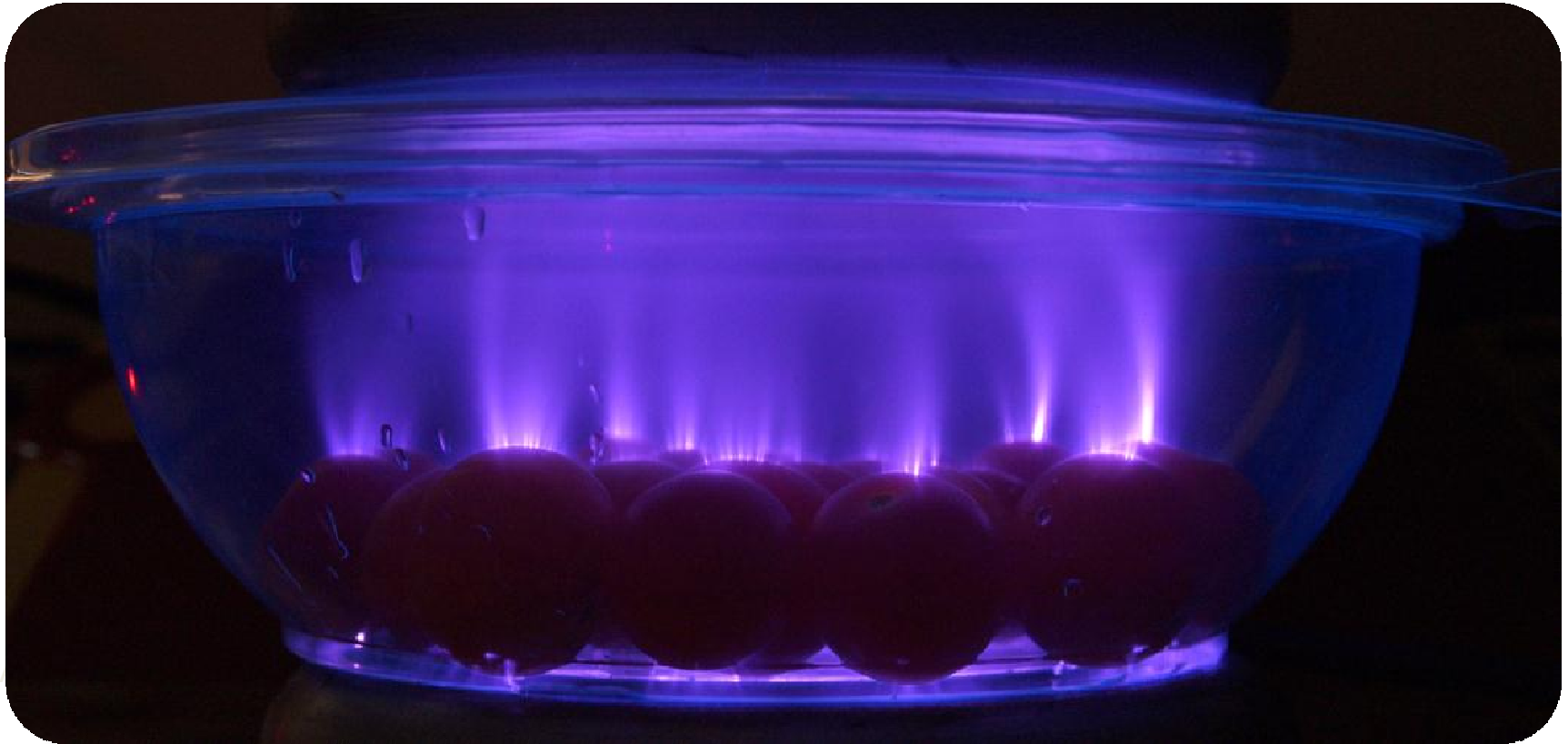
Generate it in a Package



VISION - Develop a technology that can decontaminate products (food, pharmaceuticals, consumer products, etc.) after packaging.



In-Package



Shelf-life extension – 4 weeks



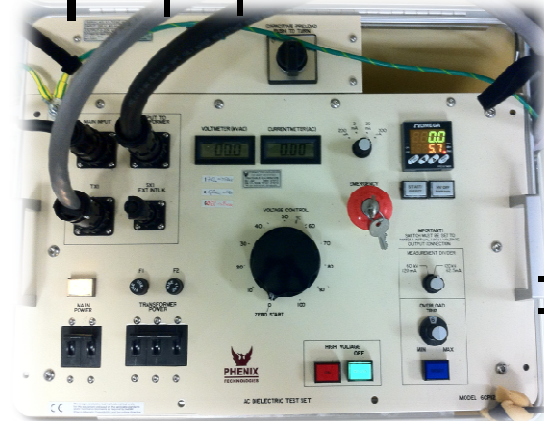
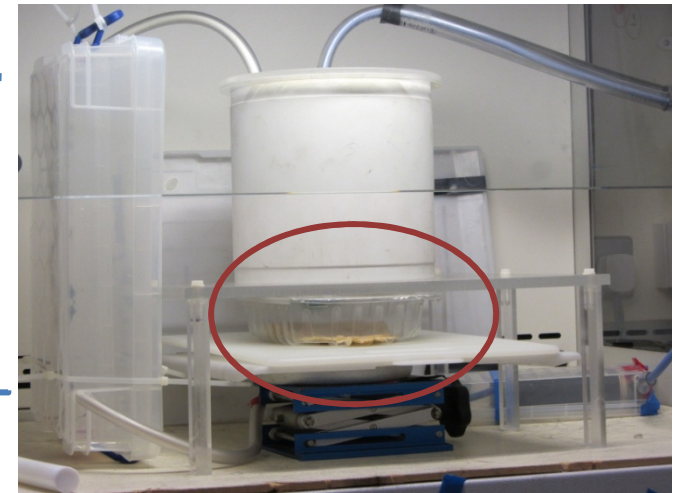
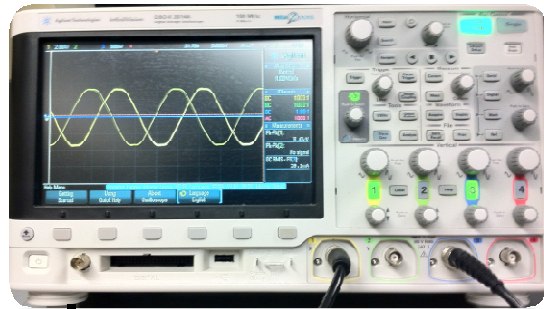
Treated



Un-treated



DBD system diagram for in-package meat treatment



220V
50Hz



Microbial inactivation

Investigation of critical control parameters for inactivation

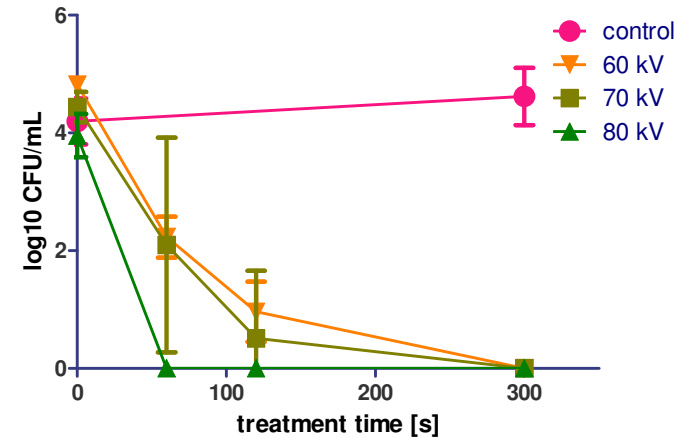
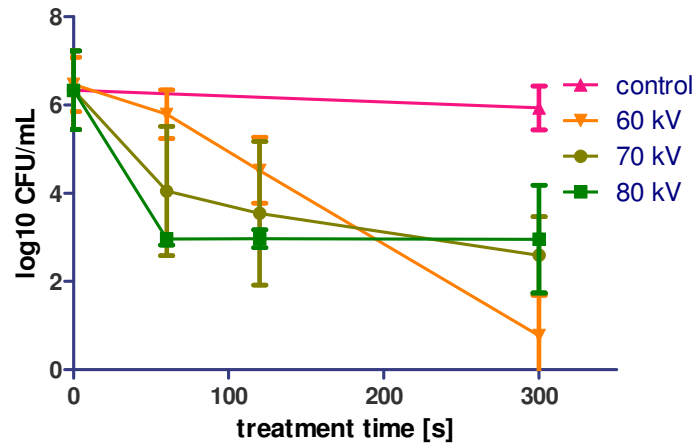
- Treatment times (60 - 300s)
- Mode of exposure (**direct**/indirect)
- Post-treatment storage (0h, 1h, **24h**)
- Voltage levels (60kV, 70kV, 80kV)
- Inducer gases (air, 30%CO₂/70%O₂, 30%CO₂/70%N₂)
- Biofilm vs. planktonic cells
- Media type (PBS, 3% beef extract, 12% beef extract)

Microbial inactivation

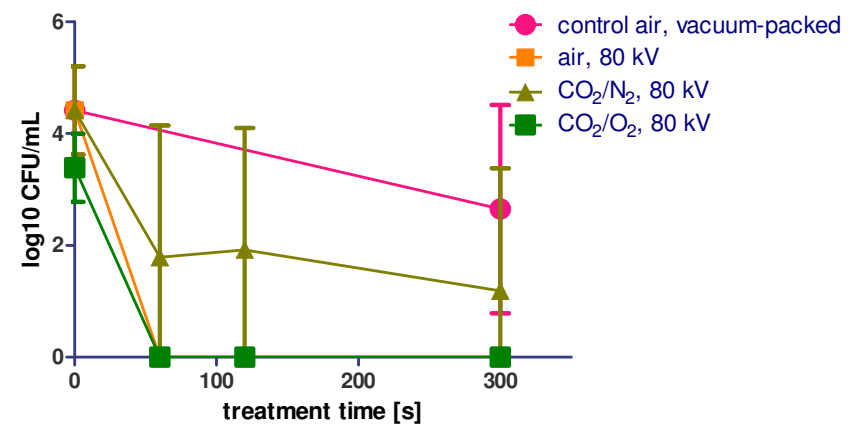
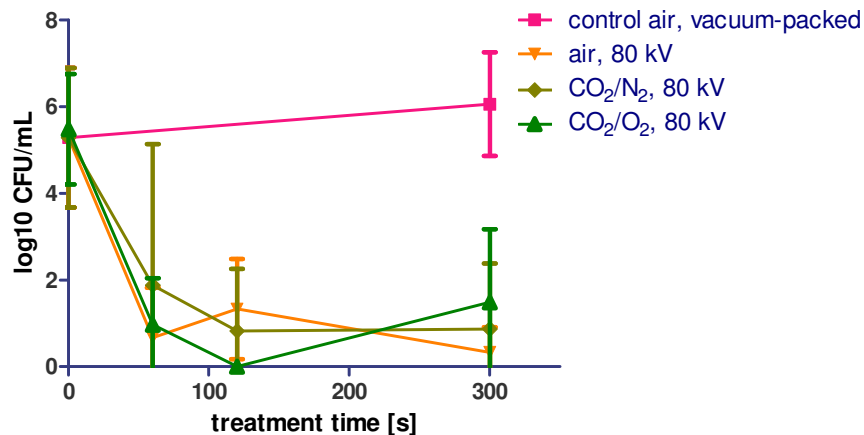
S. aureus

E. coli

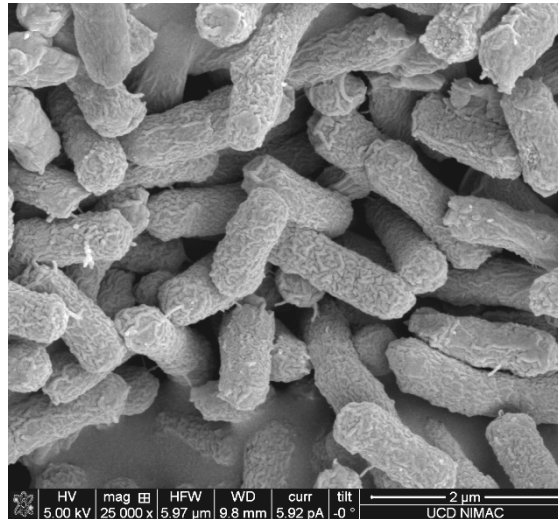
Effect of variable voltages



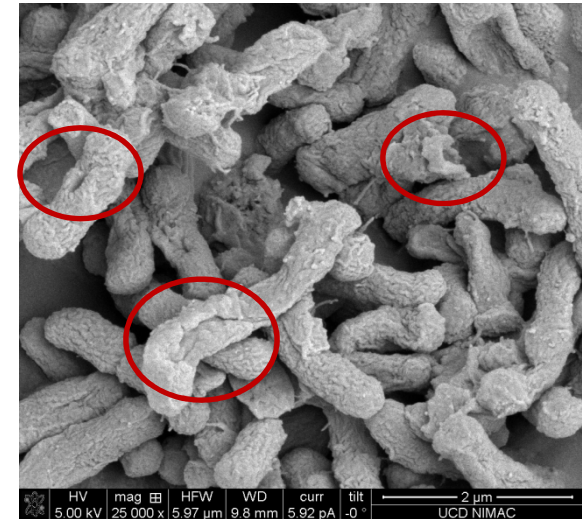
Effect of inducer gases



E.coli ATCC 25922
Gram Negative (G-)

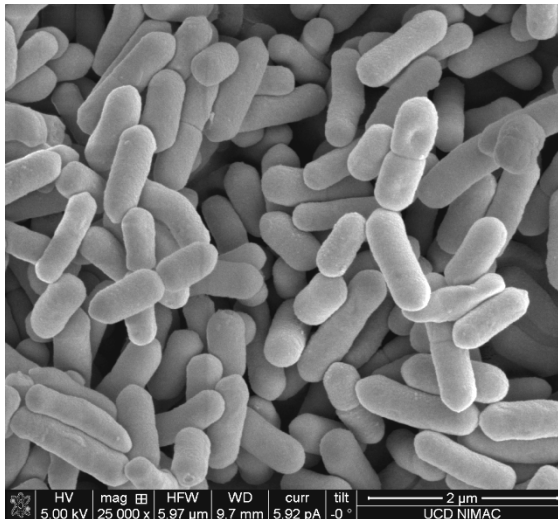


Control

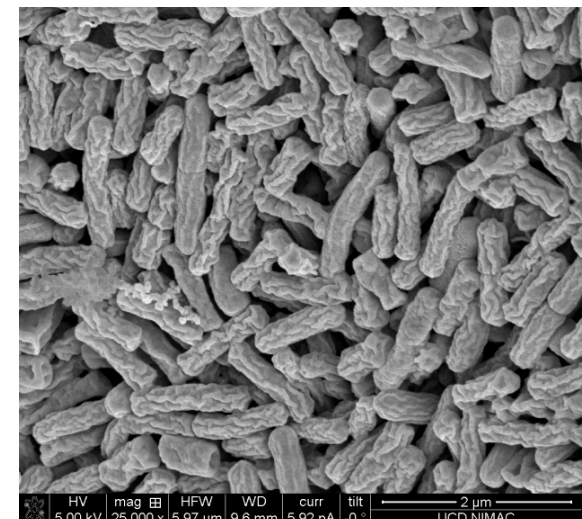


Treated

L. monocytogenes
NCTC 11994
Gram Positive (G+)



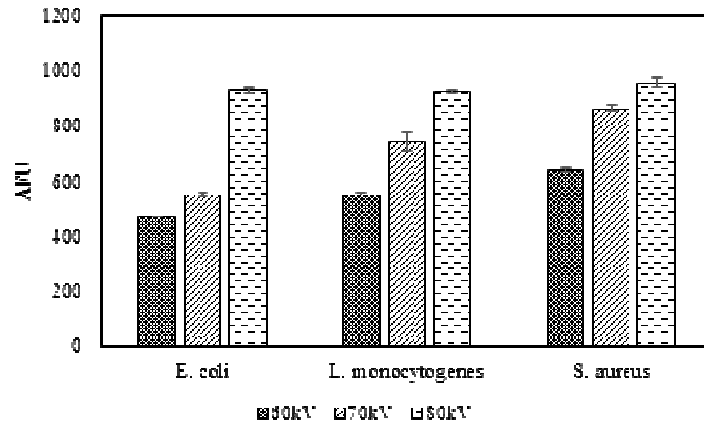
Control



Treated

Microbial inactivation

Voltage-dependent generation of intracellular ROS



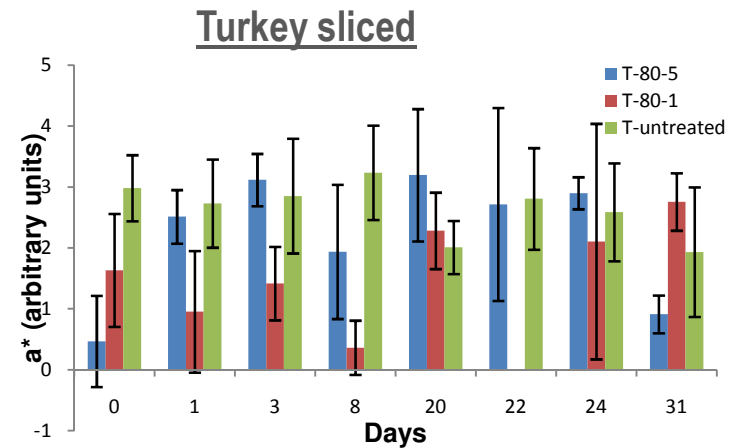
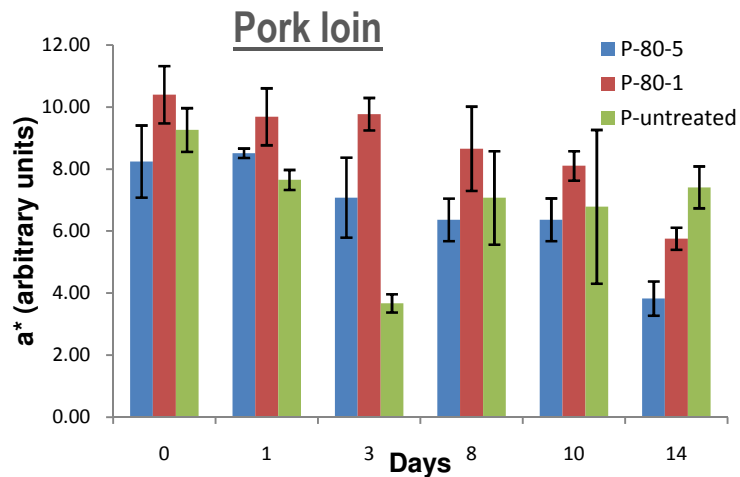
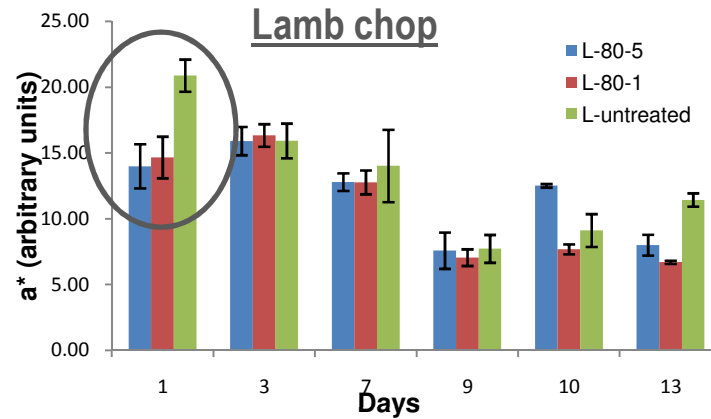
Increase of intracellular ROS with increasing voltage

Shelf-life study – Effect on background microflora

Meat type	MAP gas	Initial bacterial load Log ₁₀ CFU/g	Reduction day 0		Reduction end of study		Days within acceptable limits	Current shelf-life	Target shelf-life
			Log ₁₀ CFU/g	%	Log ₁₀ CFU/g	%			
Lamb chop	CO ₂ /O ₂	5.97	0.17	32	0.30	50	13	8	10-13
Pork loin	CO ₂ /O ₂	5.76	0.81	85	2.58	99.7	14	10	12-15
Sliced turkey	CO ₂ /N ₂	4.94	0.41	61	0.81	84	15-20	21	28-35

Food quality studies

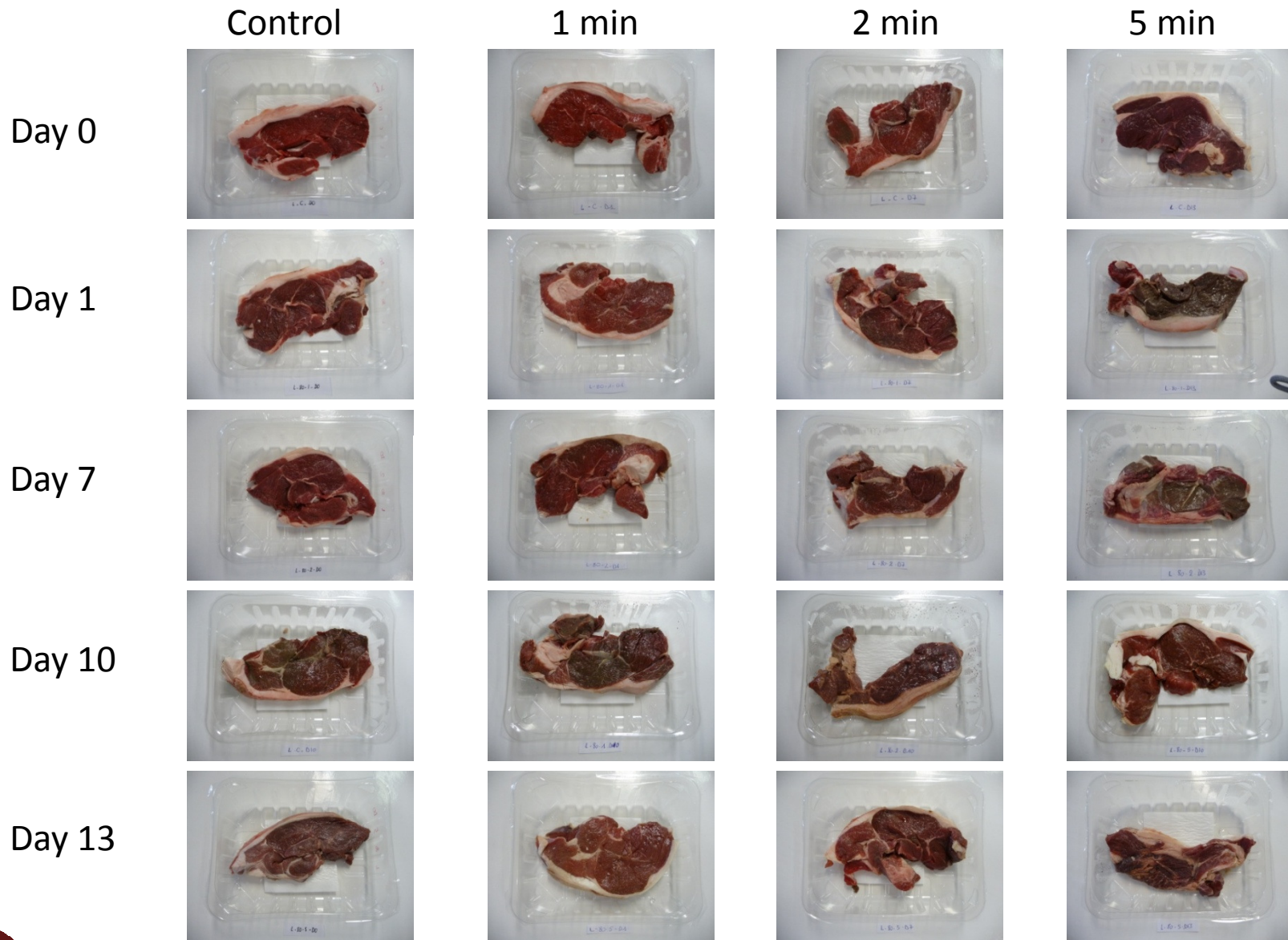
Colour changes



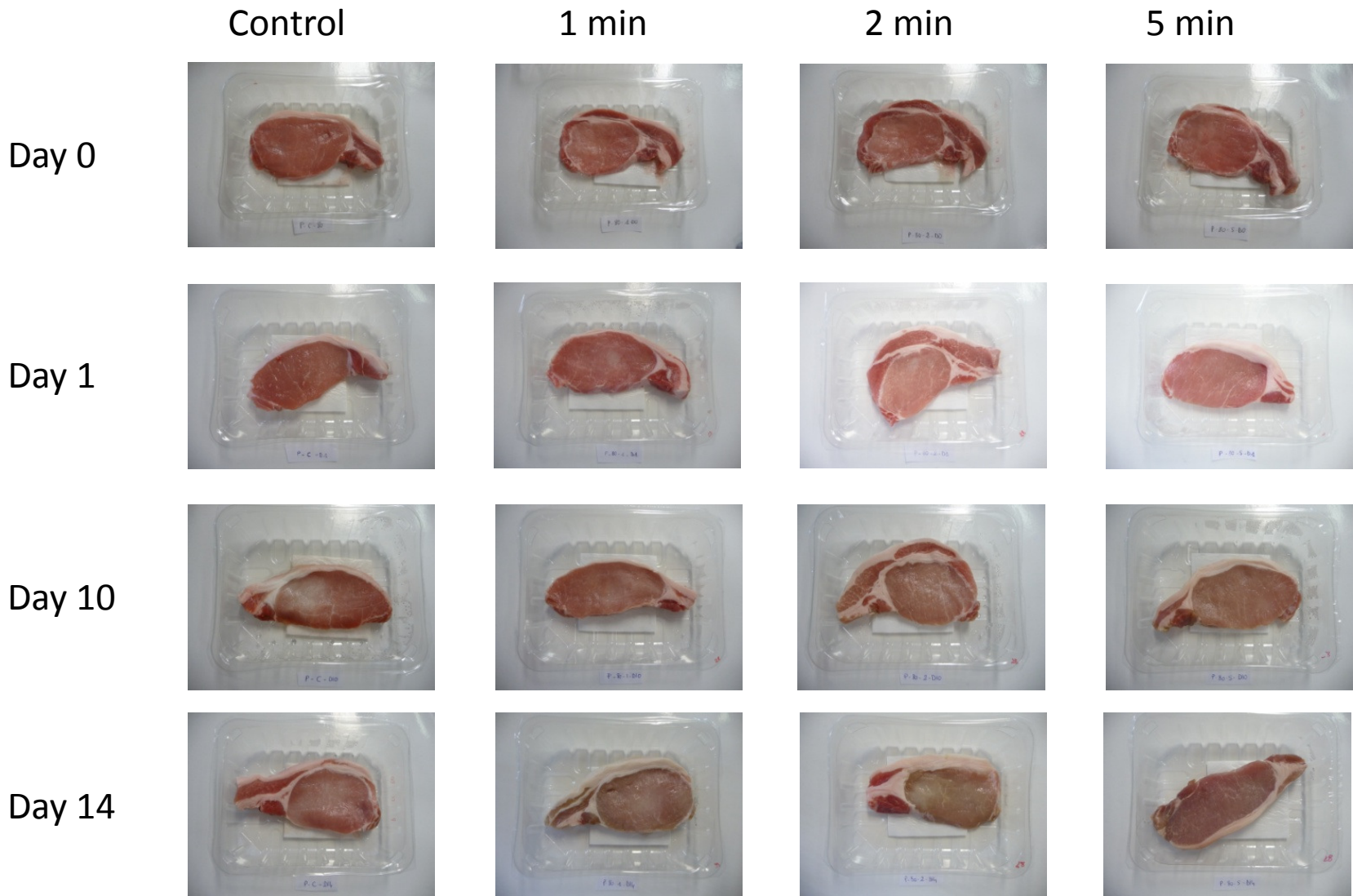
No significant colour changes in white meats



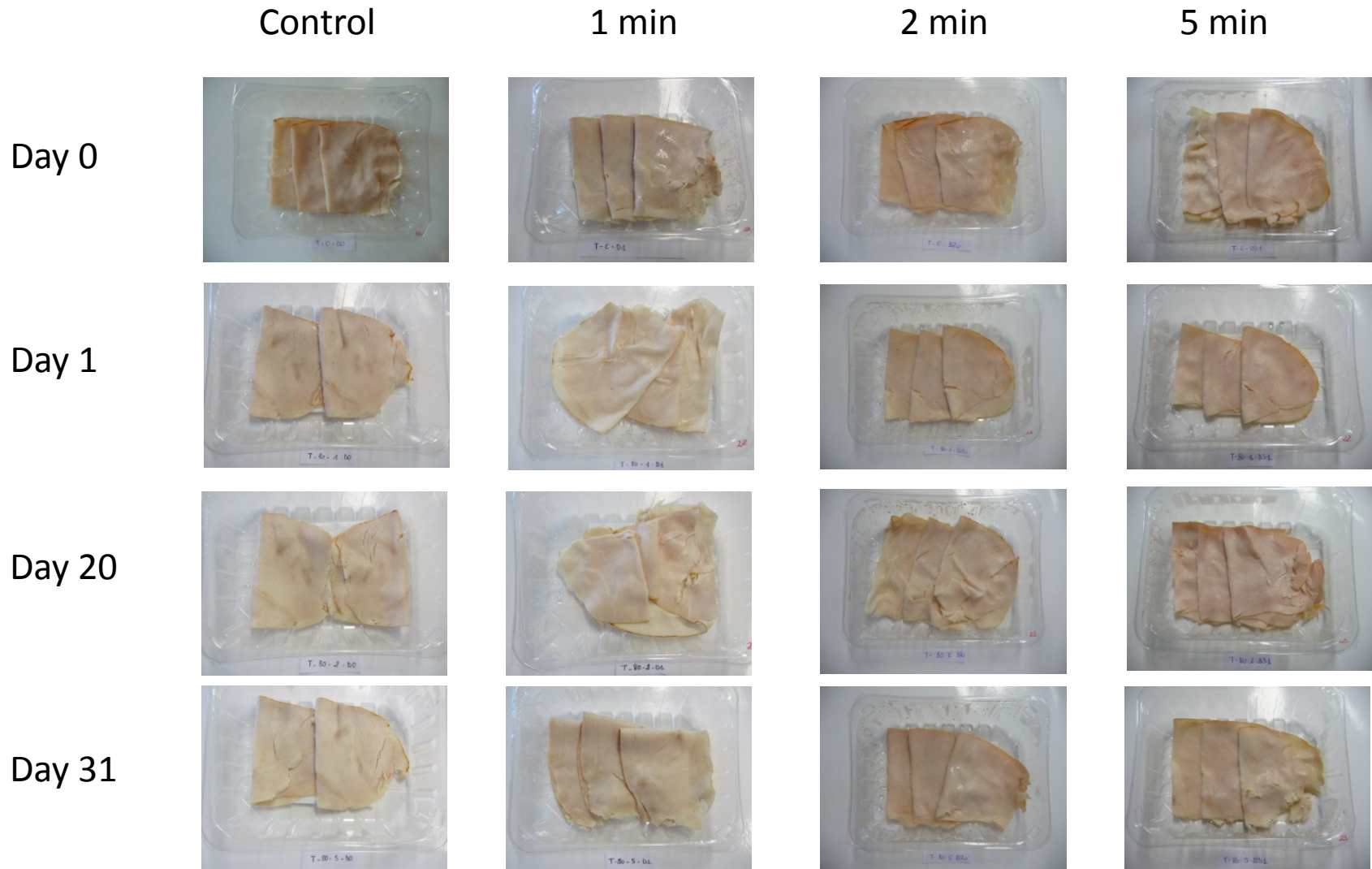
Food quality studies – Visual appearance



Food quality studies – Visual appearance

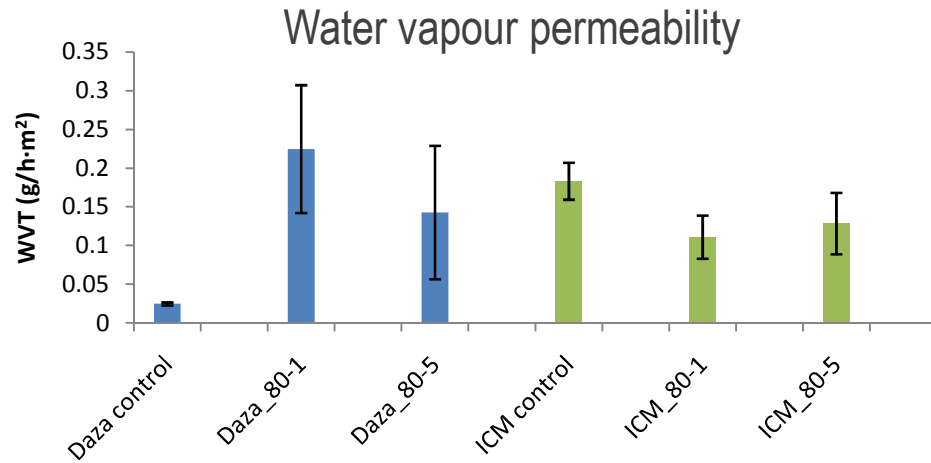


Food quality studies – Visual appearance



Food packaging studies

Effect on barrier properties



Very low values without significant changes were observed for oxygen permeability before and after plasma treatment.

Effect on transparency



Important remarks

- ✓ Cold plasma effectively inactivated *S. aureus* and *E. coli* in biofilms with major reductions at increasing voltages and increasing oxygen content.
- ✓ Background microflora studies suggest that plasma treatment can potentially extend the shelf-life of MA-packaged meat products with regards to acceptable levels of microbial content.
- ✓ Food quality was slightly affected in lamb samples after plasma treatment but no significant changes were observed in pork and turkey meat.
- ✓ Food packaging materials retained very low barrier properties after plasma treatment and transparency was not affected even after 5 minute treatment.

In-package cold plasma treatment of meat is a novel non-thermal technology for microbial inactivation and shelf-life extension which is also able to retain food quality in white meats.

MeatPack Partners

The industrial partners involved in the project are

- Embutidos Daza SL (Spain),
- Food Machinery Company (UK)
- Holfeld Plastics Limited (Ireland)
- Irish Country Meats (Ireland)
- Kamea Electronics SRO (Slovakia)
- Stephens Fresh Foods Ltd (UK)

The RTD providers are

- Dublin Institute of Technology (Ireland)
- Innovació i Recerca Industrial i Sostenible (Spain)
- Teknologisk Institut – Danish Meat Research Institute (Denmark)



Thank You