UCD Institute of Food & Health

Green Cooking – The potential for moderate electric field (MEF) processing for milder heat processing of meats

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www.ucd.ie/foodandhealth

Structure of presentation

1. Mention a new project in this area (MEFPROC)

2. General introduction to MEF heating

3. Prior knowledge of MEF heating of meat wprt impact of
   - Product/Environmental parameters on heating
   - MEF heating on meat product quality

4. MEFPROC
   a. How could MEF be applied in meat processing?
   b. How will MEFPROC contribute to this?

1. A new project in the area (MEFPROC)

Title: *Improving Sustainability in Food Processing using Moderate Electric Fields (MEF) for Process Intensification and Smart Processing (MEFPROC)*

What is the technical focus?

- **Technologies:** Moderate Electric Fields (MEF)(± assisted/combined by/with Ultrasound)
- **Applications:** Food applications (Heat & Mass Transfer – Preservation & Mass Transfer)
- **Foods: A wide range (not just meat!)**

What is the ultimate aim?

- Facilitate **technology transfer/innovation** in the food industry & improve process control

Why these technologies?

Improve process intensification, sustainability, product quality and/or extraction/impregnation

Who is involved?

Research Performing Organisations + Equipment Manufactures + Food Manufacturers
(Strong Track Records) (Capability) (Technology Interest)

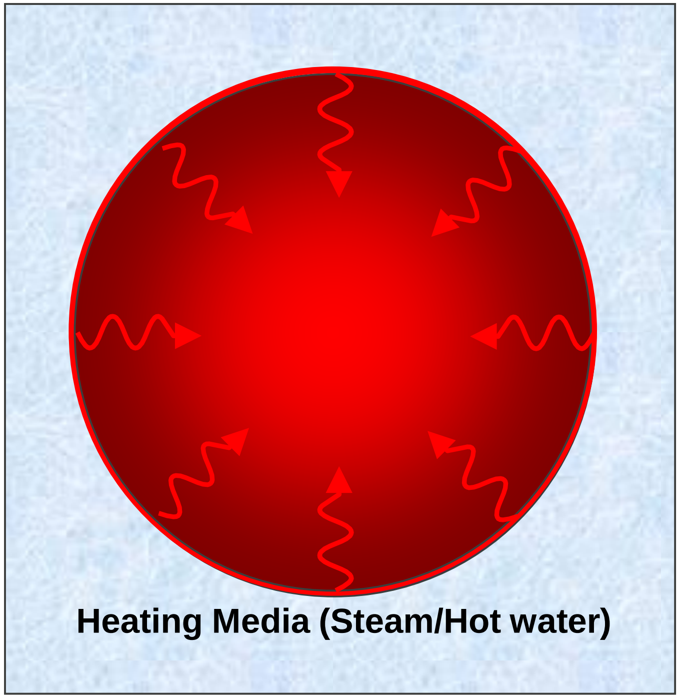
UCD Dublin · Sheffield Hallam University · UPV · Lund University · TU berlin

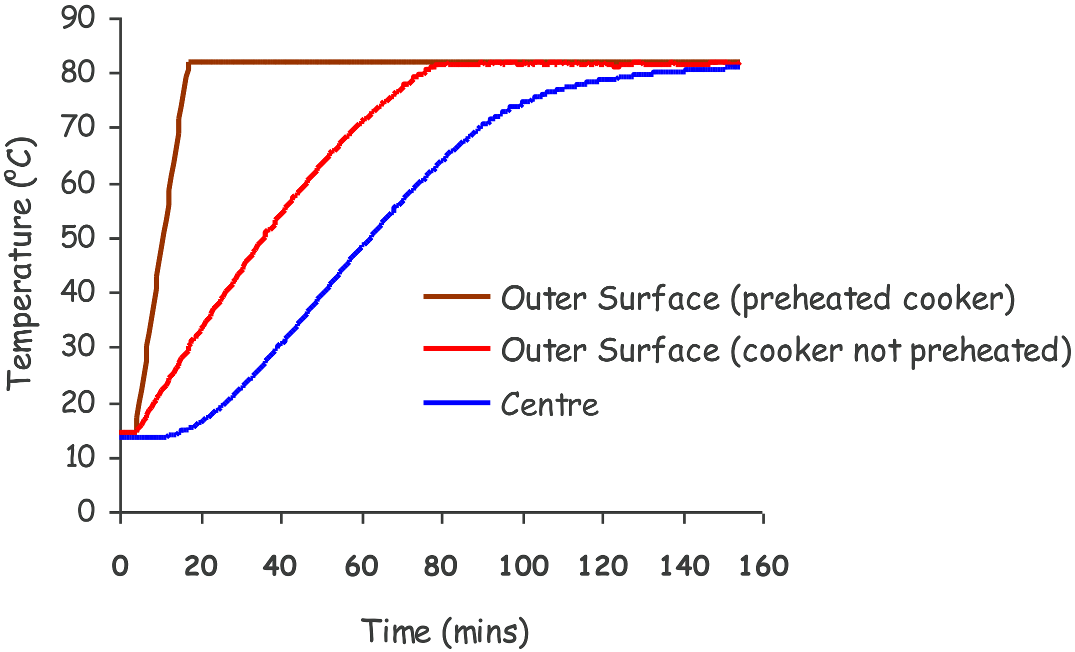
2. General introduction to MEF heating

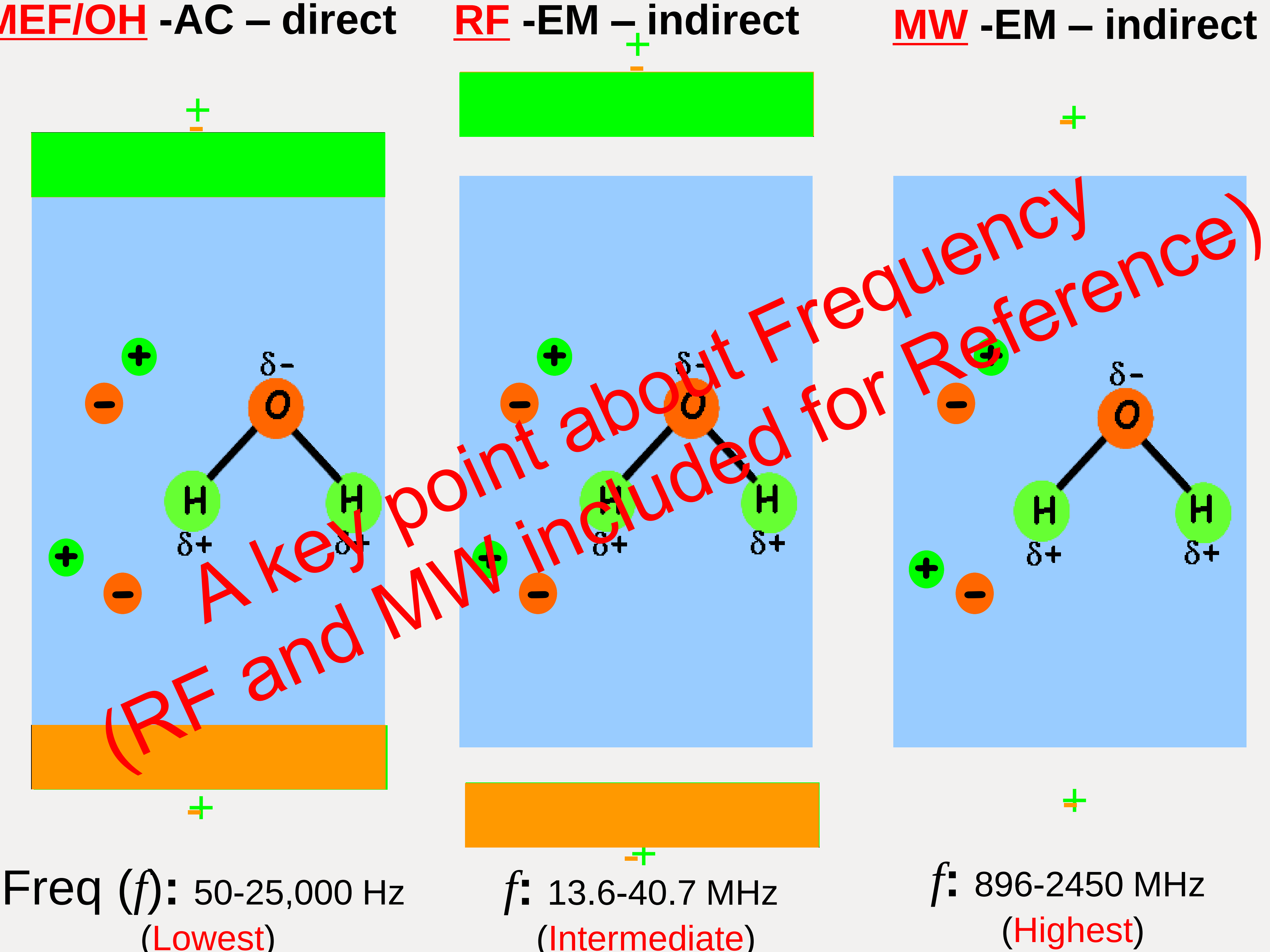
Conventional heating of meat

Heat transfer ≈ conduction (slow)

Conventional temperature profile



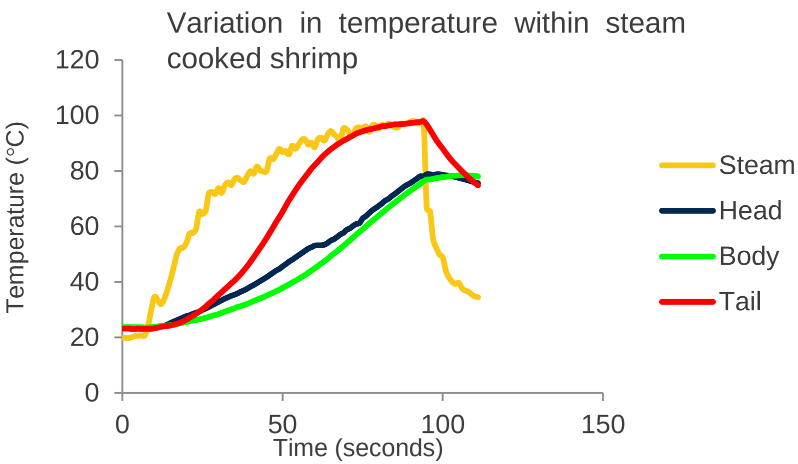


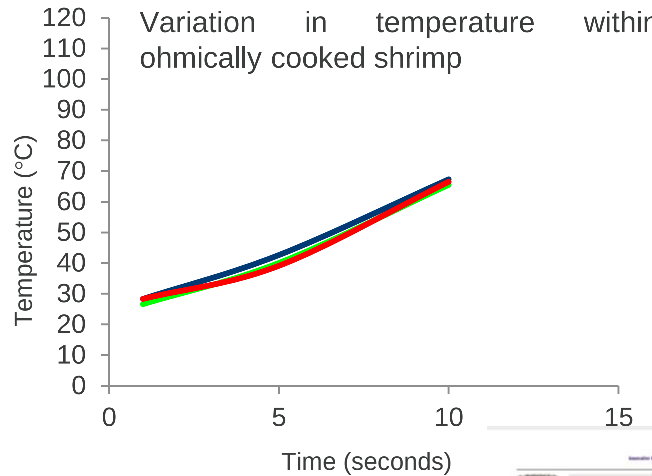


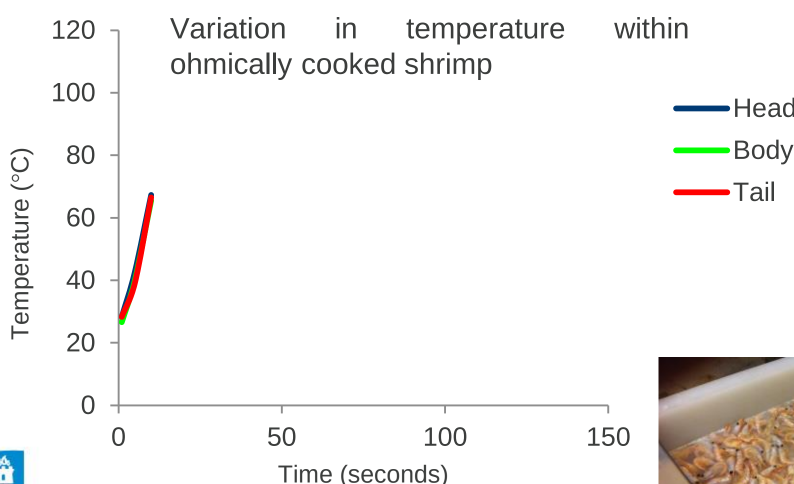
MEF/OH -AC – direct
RF -EM – indirect
MW -EM – indirect
δ-
O
H
H
δ+
δ+
A key point about Frequency
(RF and MW included for Reference)
Freq (f): 50-25,000 Hz
(Lowest)
f: 13.6-40.7 MHz
(Intermediate)
f: 896-2450 MHz
(Highest)

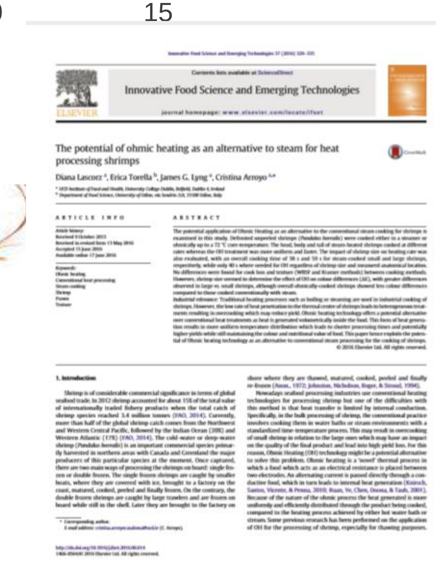
2. MEF (volumetric) benefits (shrimp) - Example

Large Shrimps (steam vs MEF)








Innovative Food Science and Emerging Technologies

The potential of ohmic heating as an alternative to steam for heat processing shrimps

Diana Lascorz, Erica Torella, James G. Lyng, Cristina Arroyo

2. MEF systems at UCD?

6 x systems, largest 18 kW (18,000W) – Theoretically it can heat

1 × 200 g white pudding 5-73°C (ΔT 68 °C) in 3 seconds <u>or</u>

10 × 200 g white pudding 5-73°C (ΔT 68°C) in 30 seconds <u>or</u>

25 × 200 g white pudding 5-73°C (ΔT 68°C) in 75 seconds

<u>MEF preheating (!!!)</u> followed by <u>conventional holding</u>

e-Cooker®

IXL important in innovation

2. Where does "Green heating" and "process intensification" come in?

Basic energy balance

Energy Required: Fixed by quantity (m), c & ΔT

$$P\psi = \frac{mc(\Delta T)}{t}$$

Conversion Efficiency: Much higher in MEF vs. Conventional

(e.g. MEF ≤95% vs. conventional 50%)

Power input vs. time

(shorter t > P)

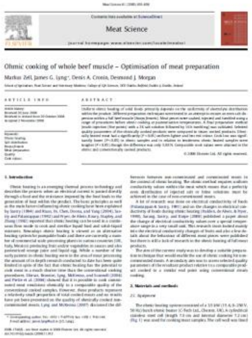
with volumetric nature of heating + Correct System design

→ Continuous cooking of meat is possible

3. Prior knowledge

Critical parameters - Product - Electrical conductivity σ (S m^{-1})

Distribution is critical: Emulsions easier than injected/tumbled



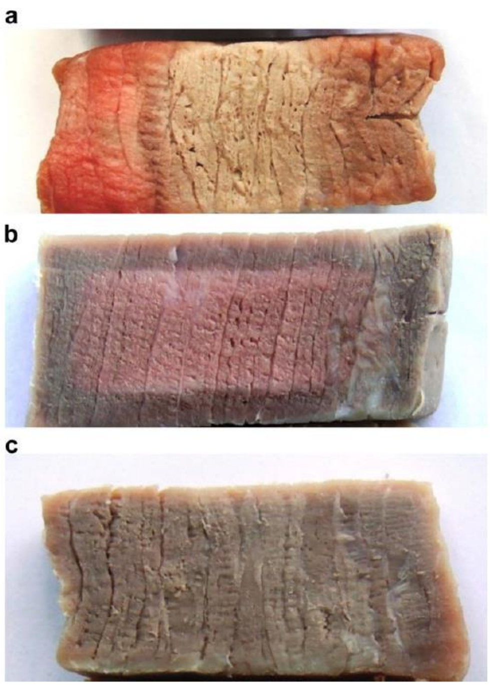
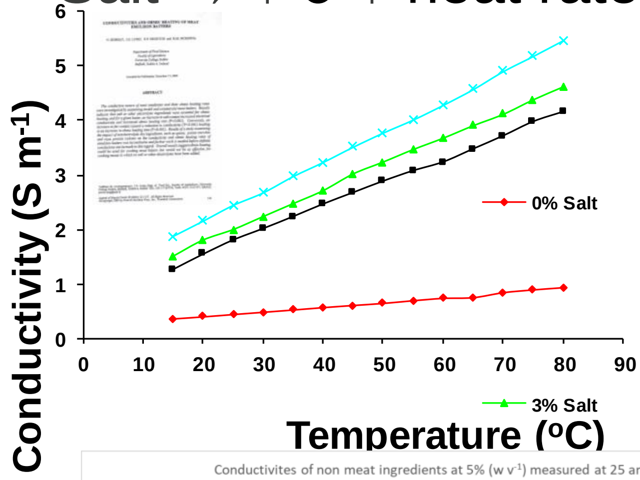
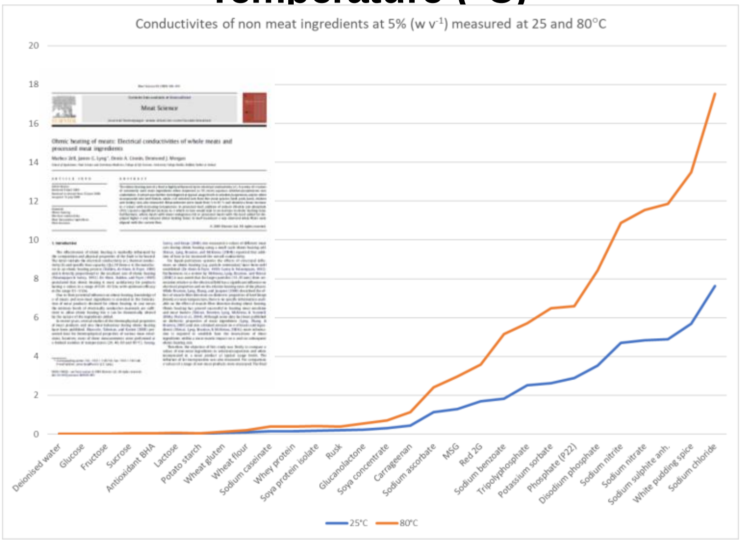


Fig. 3. A selection of beef meat cross-sections prepared by (a) centre injection (3% saline) (b) soaking (5% saline for 48 h) and (c) multi-injection (3% saline, 16 h in bag tumbling) followed by ohmic cooking.

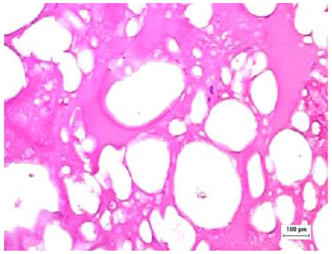
Ionic Ingredients (e.g. Salt): ↑ Salt → ↑ σ ↑ heat rate

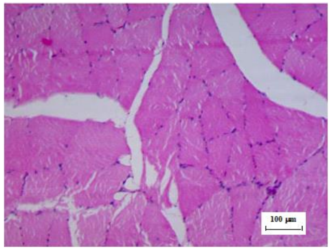


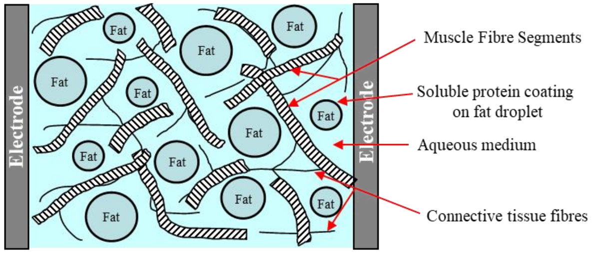


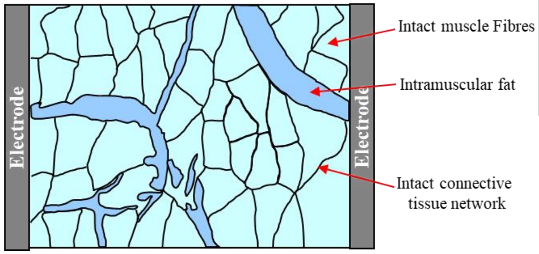
3. Prior knowledge

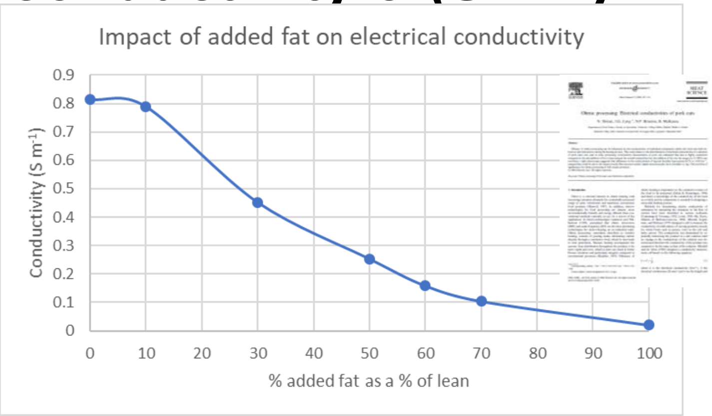
Critical parameters - Product - Electrical conductivity σ (S m^{-1})



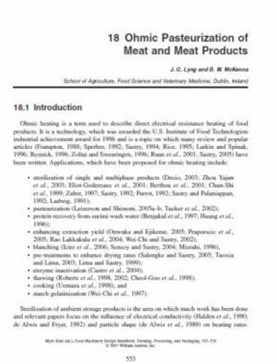






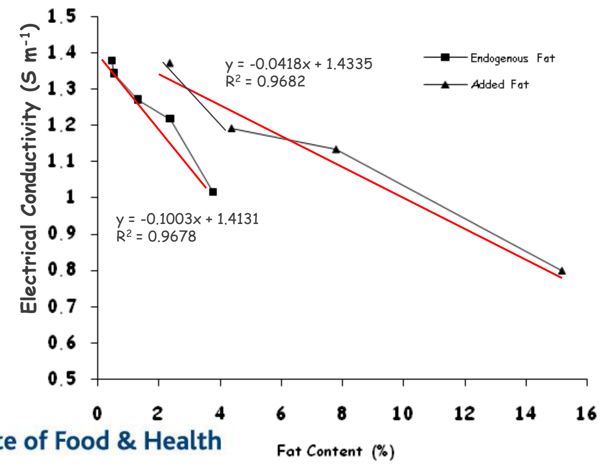


Fat Content: ↑ Fat (partic – Salt) → ↓ σ ↓ heat rate


18 Ohmic Pasteurization of Meat and Meat Products

J. G. Lyng and B. M. McKenna

18.1 Introduction



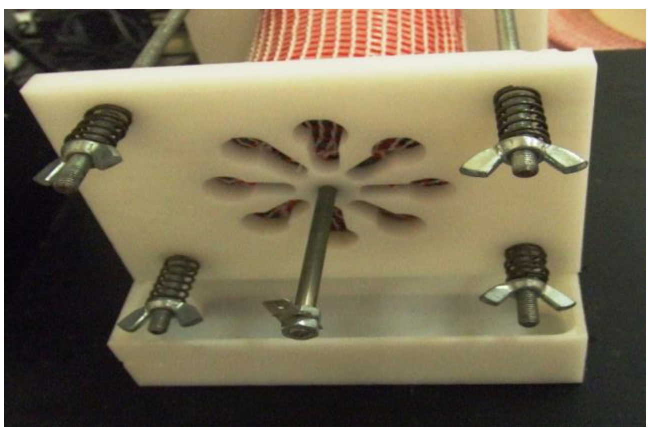
Endogenous vs. added fat

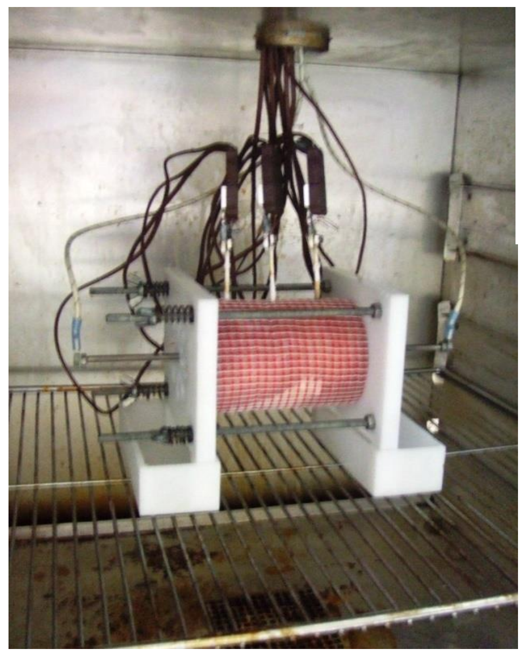
↑added fat % less impact on σ vs. ↑endogenous fat%

Easier for current to negotiate emulsified fat?

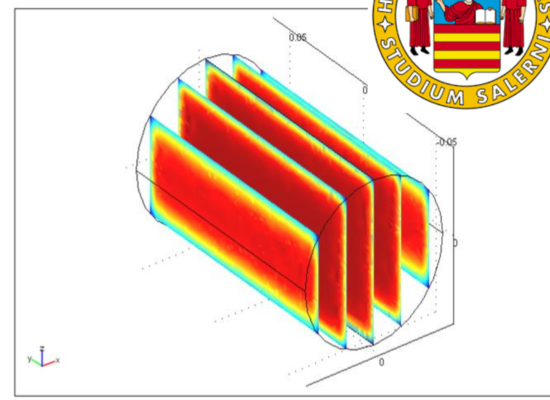
3. Prior knowledge
Critical parameters – Environmental impact on heating uniformity

Electrode: Thinner & ext. heated





Cell: External heating vs. surface cooling



Journal of Food Engineering
Analysis of heat transfer during ohmic processing of a solid food

Food and Bioproducts Processing
Minimising heat losses during batch ohmic heating of solid food

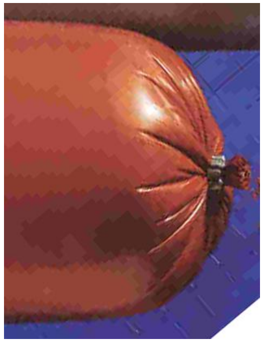
Journal of Food Engineering
Development of rapid response thermocouple probes for use in a batch ohmic heating system

3. Prior knowledge
Critical parameters – Product Packaging

Direct electrode contact
(seal product after)

Shuttle mission (packaging with conductive regions) – Astronaut OH dinners

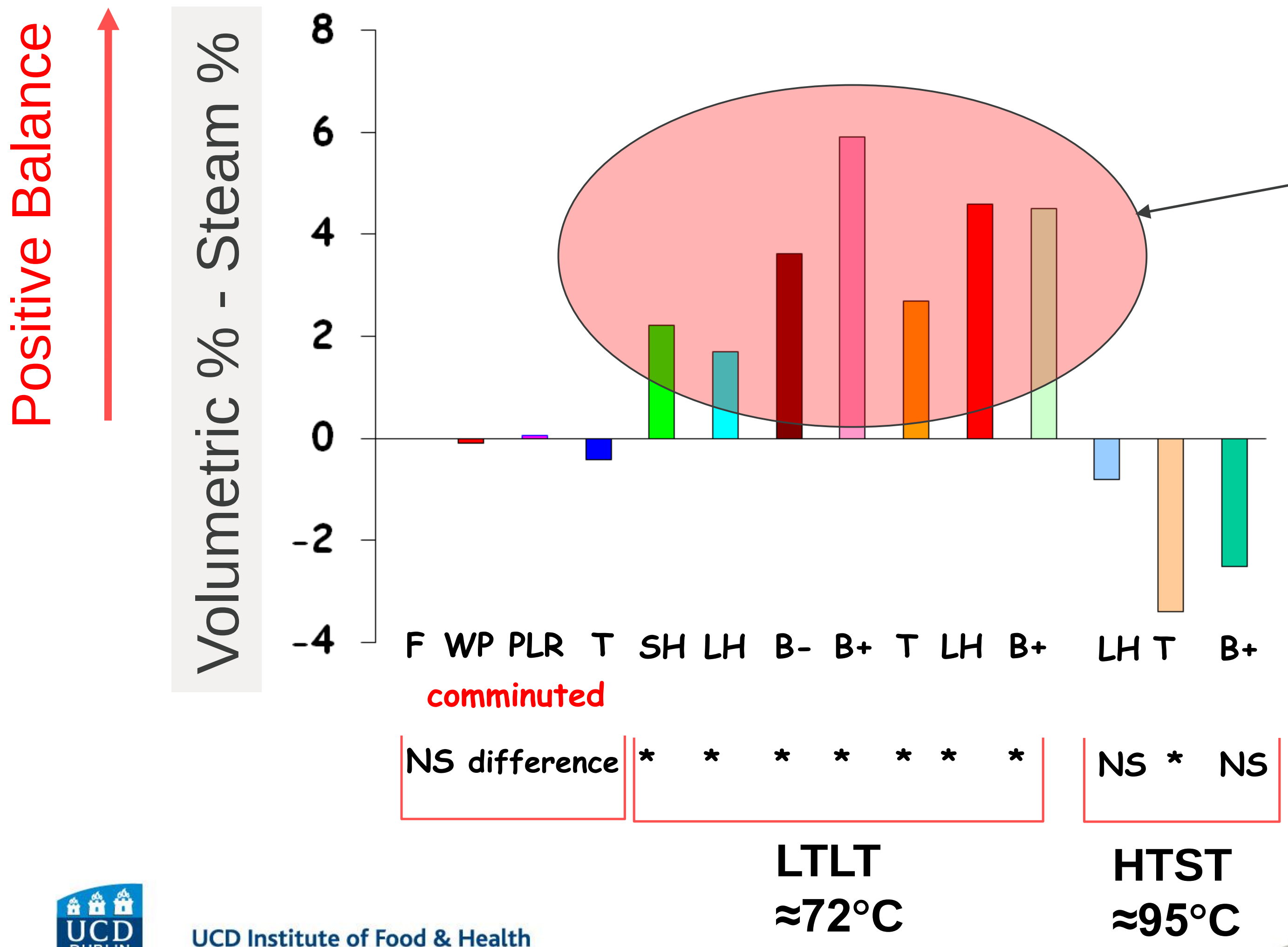
Sealed Casing
+
Plastic Clips



Sealed Casing
+
Metal Clips

3. Prior knowledge

Impact on product: Post Cooking Yield



Vol >MC <PR + F (dilution)

Suggest-less heat induced protein (myosin/collagen) denat.

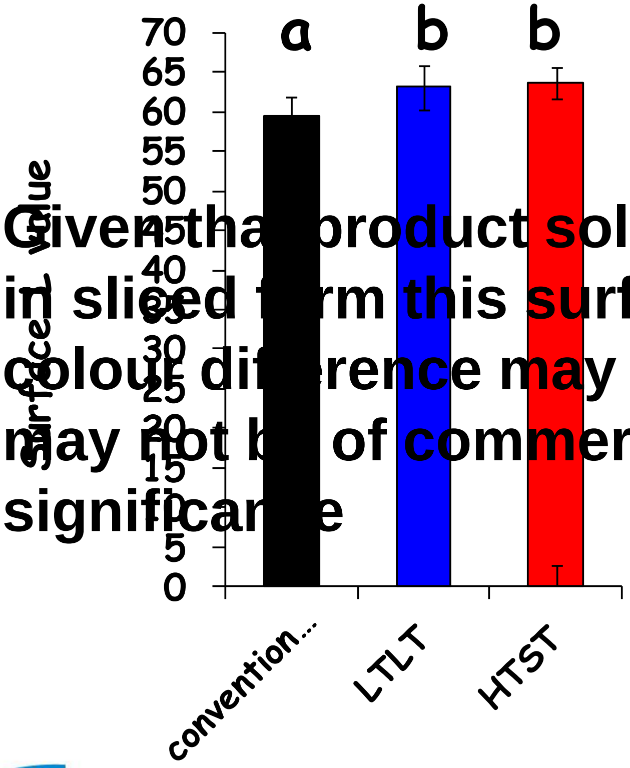
3. Prior knowledge
Impact on product: Surface Colour

Instrumental colour (L, a, b, hue angle and chroma)

<u>Centre</u> ≈ no differences or very small

<u>Surface</u> a, b, hue angle and chroma ≈ as above

But: L (Lightness) → Lighter surface in MEF processed non- comminuted



Given that product sold in sliced form this surface colour difference may or may not be of commercial significance

Conventionally cooked beef *Semitendinosus* (105 min)

MEF HTST cooked beef *Semitendinosus* (7 min)


Meat Science

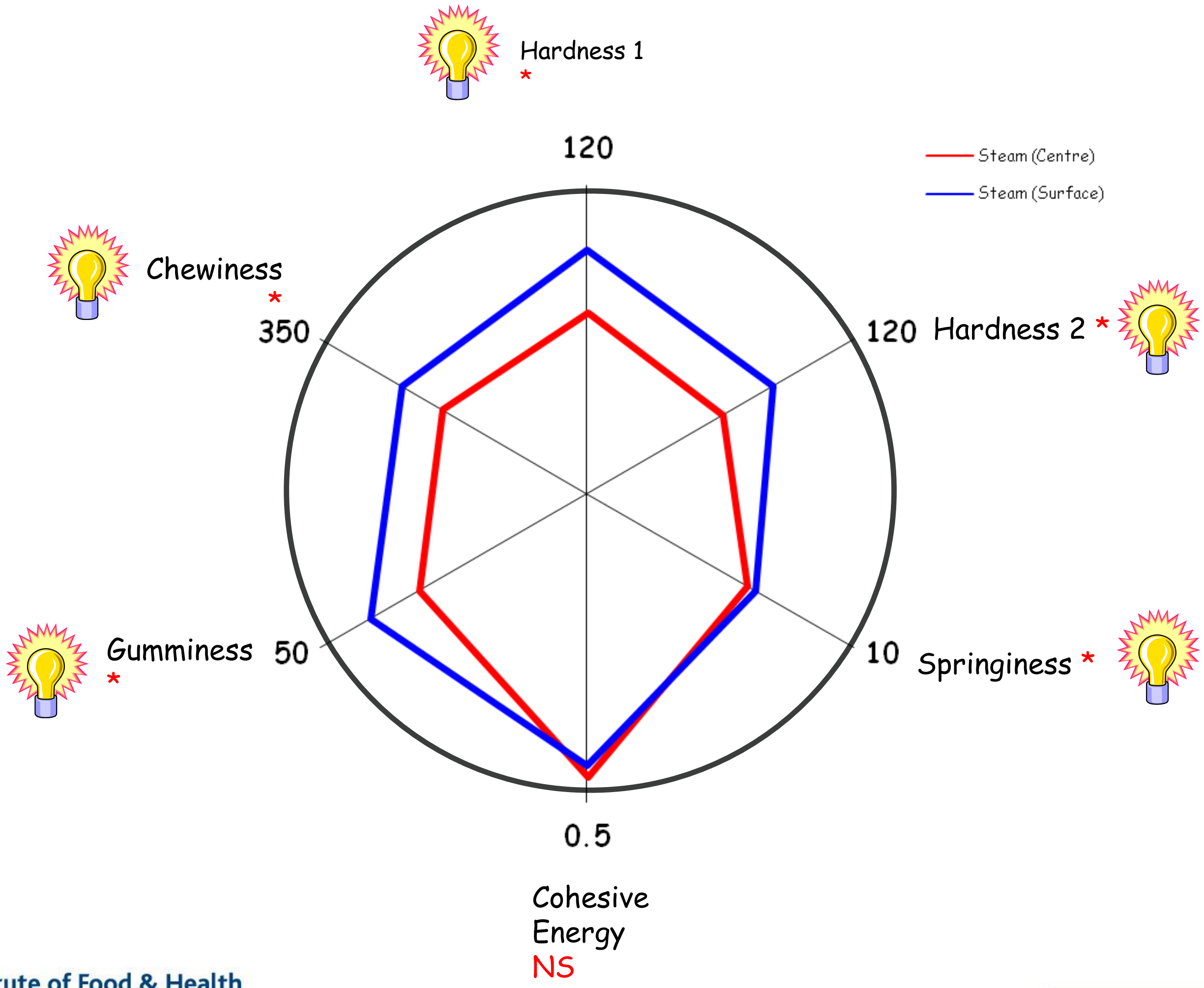
Ohmic cooking of whole beef muscle – Evaluation of the impact of a novel rapid ohmic cooking method on product quality

Markus Zell, James G. Lyng, Denis A. Cronin, Desmond J. Morgan

3. Prior knowledge

Impact on product: Texture (surface vs centre)

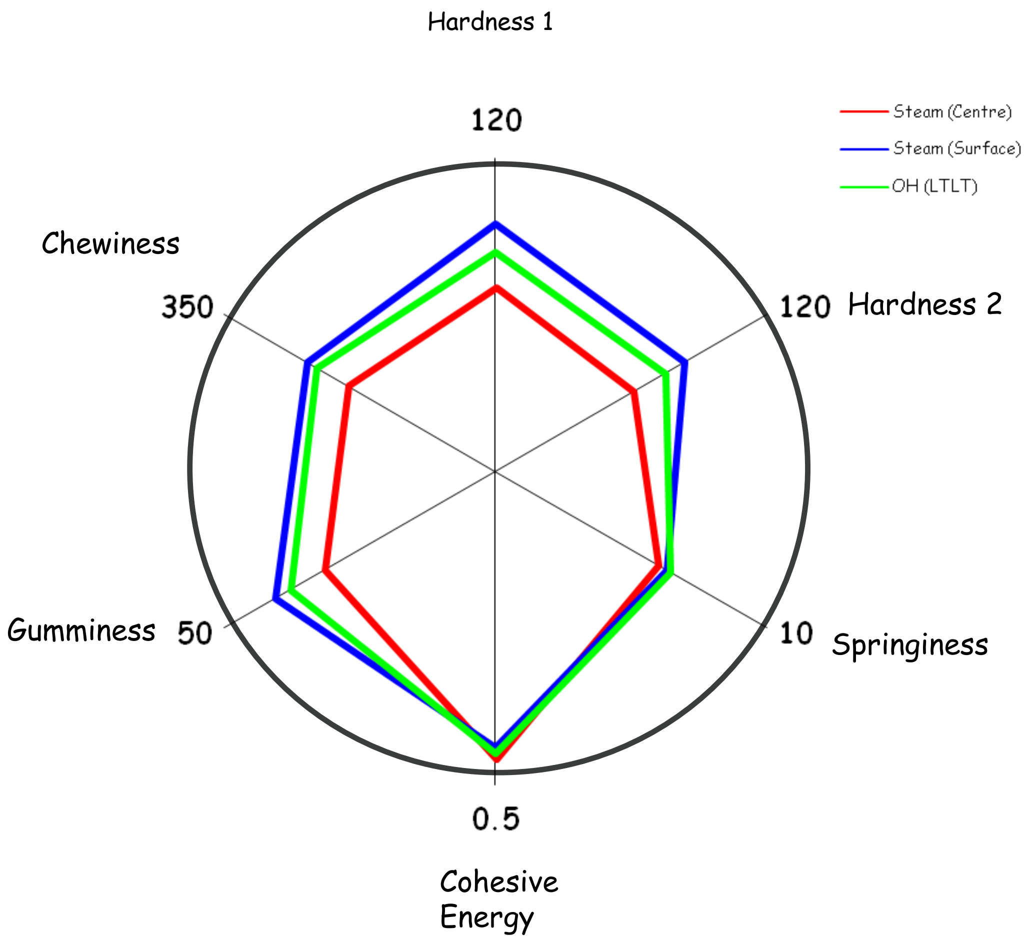
TPA - (Conventional Turkey – Variation across diameter)



3. Prior knowledge

Impact on product: Texture (surface vs centre)

TPA - (MEF Turkey – Variation across diameter)

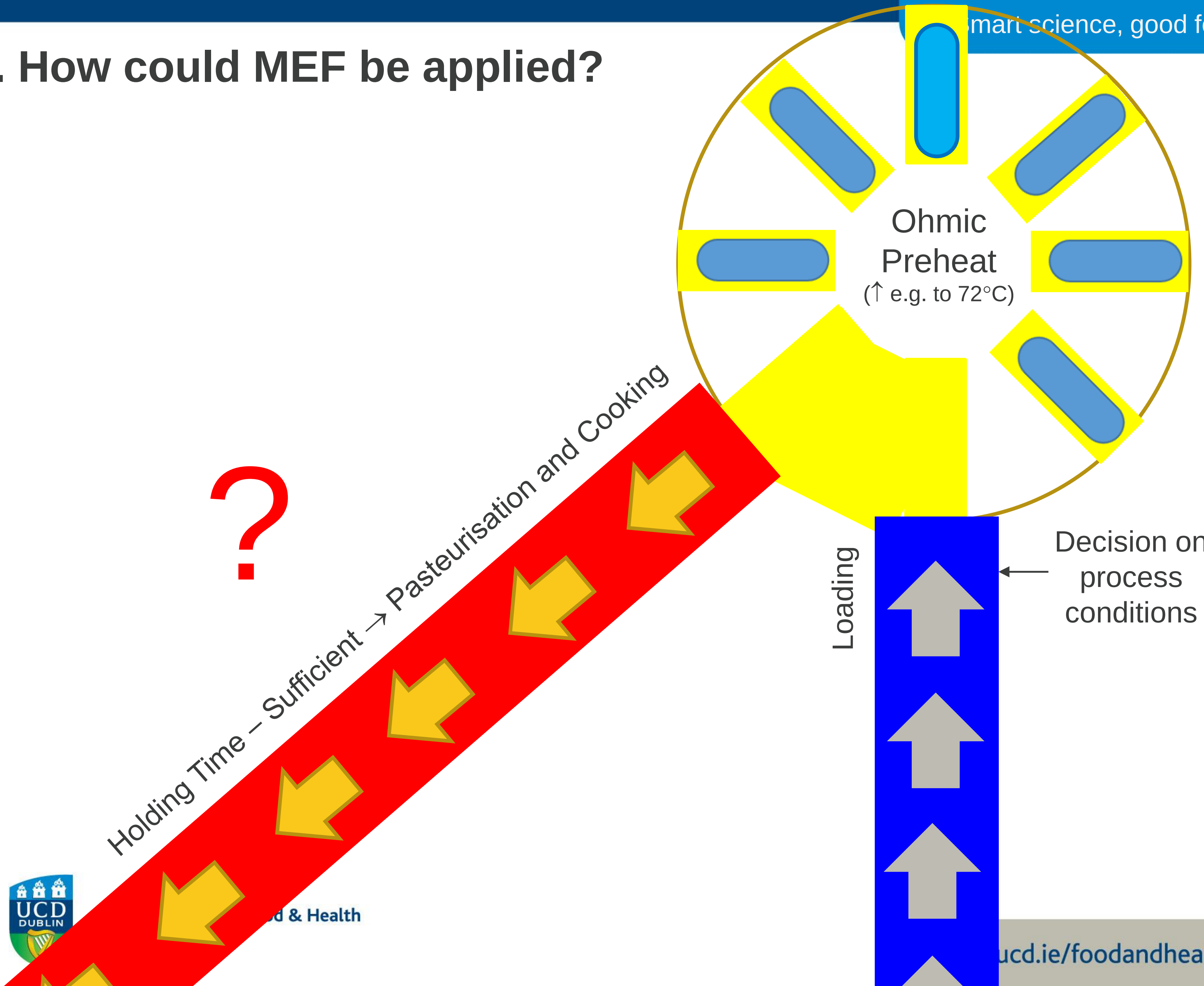



Food Chemistry

Ohmic cooking of whole turkey meat – Effect of rapid ohmic heating on selected product parameters

Markus Zell, James G. Lyng*, Denis A. Cronin, Desmond J. Morgan

4. How could MEF be applied?

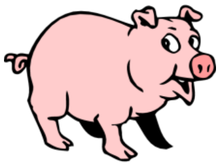


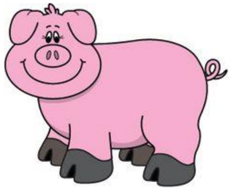
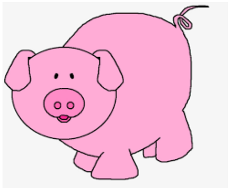
4. What will MEFPROC do that's new?

Smart Cooking of meat

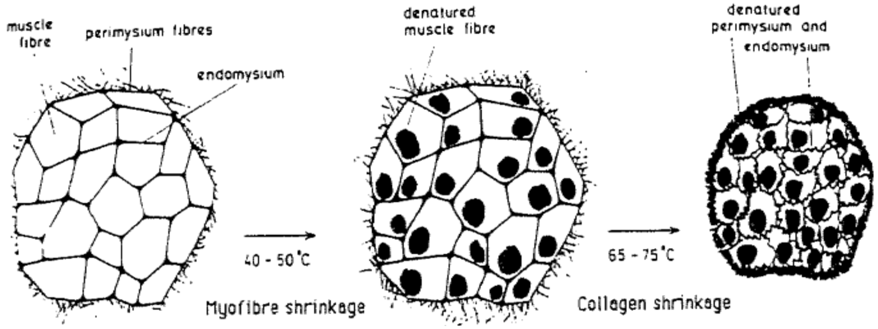
a. **Tailoring cooking** – Predicting requirements for variable cuts – decision?





b. **Optimising Power delivery during MEF Preheating** - feedback loop to optimise delivery to optimise structure and maximise yield**?**



Sims and Bailey (1991)

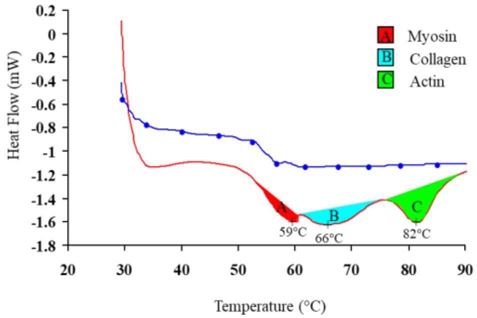
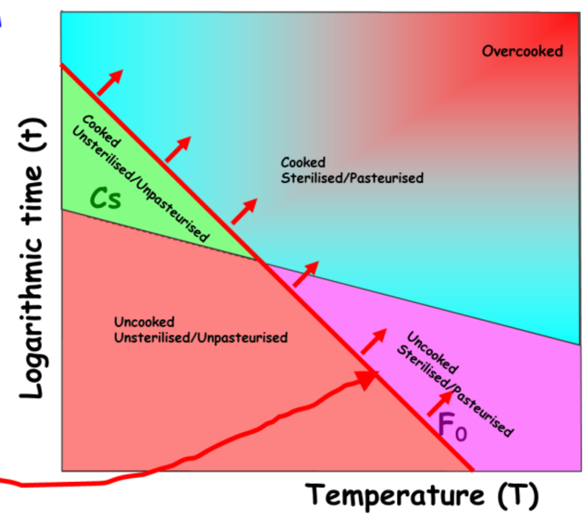


Fig. 3. Differential scanning calorimetry thermogram of uncooked — and cooked beef muscle

4. What will MEFPROC do that's new?

c. **Optimising conventional holding time to optimise structure/yield**
Pasteurisation (micro) is rapidly achieved but when is optimal structure (chemical) achieved? (i.e. how long/short should your holding time be)

Source: Adapted from Holdsworth (1984)



[Note: With most beverages aim is generally to end up uncooked (i.e."fresh like") not overcooked]

Whatever the heat process, it must be sufficient to render the product microbiologically safe

Minimum C_s ($C_{s\text{-min}}$)?

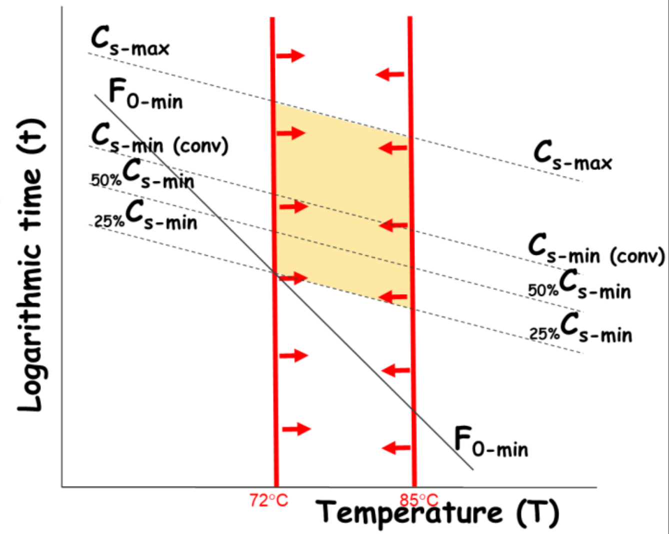
Can we go lower than $C_{s\text{-min (conv)}}$?

Finding the "edge of this envelope" and particularly the minimum C_s ($C_{s\text{-min}}$) will form the basis of Kims MSc!

Lower the C_s the shorter the cooking time, higher the throughput, lower the energy cost (Yield could be better)!

Will always be microbiologically fine as will be above target F_0

However, don't want chemically undercooked



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Thank you for your attention!

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Smart science, good food

Comments?