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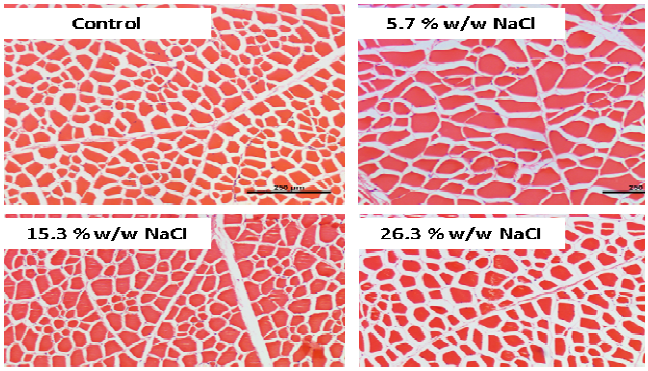
Accelerated meat curing using Ultrasound and Pulsed Electric Fields



Key external stakeholders:

Meat processors
Food retailers
Consumers

Practical implications for stakeholders:

Meat curing is one of the oldest meat preservation methods and it is still widely used today to produce a range of meat products with desirable characteristics. However, brine penetration into meat is a slow process so most processors use multi-needle injectors to produce bacon and ham in a few days rather than a few weeks. However, this produces products of lower quality. We have shown that the rate of brine penetration can be speeded up by applying high intensity ultrasound (US) to the meat while it is immersed in brine. Processors could use US to shorten processing times without adversely affecting the quality. Pulsed electric fields (PEF) is another novel technology with potential, but we have found that it is not as effective as US.

Main results:

- In lab-scale studies a range of US treatments (10, 25 or 40 min at US intensities of 4.2, 11 or 19 W cm^{-2}) increased the salt content of pork at a set time
- Diffusion studies confirmed that the rate of salt uptake was increased (46%) by US treatment
- In pilot scale studies (pork pieces of 300g approx.) three US treatments (2 h; 10.7, 17.1 or 25.4 W cm^{-2}) halved the time to reach a salt content of 2.2%
- US treatment did not affect any quality attributes
- PEF treatment of pork prior to curing increased the salt uptake but only by about 17%
- US is easier to apply to meat pieces than PEF and it showed greater potential for reducing curing times

Opportunity / Benefit:

Ultrasound is a technology that is already in use in the food industry. Commercial systems could be adopted to reduce curing times for high quality products. PEF systems are also available to the food industry, mainly for liquids. Although PEF showed some potential for accelerating the curing of pork it needs a considerable amount of development to optimise it for this purpose.

Collaborating Institutions

University College Dublin

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External collaborators: Dr. James Lyng, UCD

1. Project background:

Curing of pork to produce ham and bacon products that are safe and attractive to the consumer requires that the salt and other curing agents are evenly distributed throughout the meat. Penetration of salt into pork is a slow process, so long processing times are required with traditional processing. The industry uses multi-needle injectors to accelerate the process but this produces a lower quality product. Ultrasound (US) and Pulsed Electric Fields (PEF) are 2 novel technologies that have the potential to accelerate the rate of brine diffusion. By different mechanisms they both cause physical disruption of tissues which may allow faster ingress of salt into meat. These were both investigated to assess their potential for accelerating the curing of pork.

2. Questions addressed by the project:

- Can US accelerate the uptake of brine by pork?
- What is the optimum combination of frequency and treatment time?
- Does US treatment affect the sensory and technological properties of the ham?
- Can PEF accelerate the uptake of brine by pork?
- What is the optimum combination of field strength, frequency, pulse number and treatment time?
- Does PEF treatment affect the sensory and technological properties of the ham?

3. The experimental studies:

Pork cylinders were placed in a jacketed vessel with a coolant flowing through the outer jacket to remove heat. Brine was place above the meat and ultrasound was applied to the brine by a probe. Optimum treatment time and US frequency was determined by measuring the salt content of the pork after treatment. The rate on brine uptake was calculated by Fick's law.

Water compartmentalization in pork was assessed by NMR spectroscopy. Protein denaturation was measured by Differential Scanning Calorimetry.

The studies on US curing were scaled up using samples of 300g in sealed bags containing brine. US was applied in a US bath with two US probes inserted in the water in the bath.

The effect of PEF parameters on brine uptake was assessed on small (6 x 2 x 2 cm) samples in a batch PEF equipment. Samples were immersed in brine for a fixed time after PEF treatment when the salt content was assayed to determine the effectiveness of the PEF treatment.

4. Main results:

- The rate of salt uptake increased with increasing US intensity
- There was no effect of US on water binding capacity (WBC) or cook loss
- The only texture attributes affected by US were a reduction in gumminess and cohesiveness
- The rate of diffusion (independent of temperature changes) was successfully modeled
- US also caused protein extraction at the surface which would aid in ham processing
- In a pilot scale study a 50% reduction in curing time was achieved by subjecting brines meat pieces sealed in a bag and immersed in a US bath with 2 US probes
- PEF increased the uptake of salt by up to 13%
- PEF was most effective at low frequency (100Hz) and high pulse rate (300 pulses), though this combination gave the highest cook looses

5. Opportunity/Benefit:

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6. Dissemination:

Main publications:

C. K. McDonnell, P. Allen, E. Duggan, J. M. Arimi, E Casey, G Dunne and J. G. Lyng (2013). The effect of salt and fibre direction on water dynamics, distribution and mobility in pork muscle: a low filed NMR study. Meat Science 95: 51-58.

C. K. McDonnell, P. Allen, C. Morin and J. G. Lyng (2013). The effect of ultrasonic curing on meat protein and water-protein interaction in meat. Food Chemistry, 147:245-251.

C. K. McDonnell, J. G. Lyng and P. Allen, (2014). The use of power ultrasound for accelerating the curing of pork. Meat Science, 98(2):142-149.

C. K. McDonnell, P. Allen, C., F. Chardonnereau, J. M. Arimi and J. G. Lyng (2014).
The use of pulsed electric fields for accelerating the curing of pork. LWT - Food Science and Technology 59(2) part 1:1054-1060.

Popular publications:

C. K. McDonnell, P. Allen, C. Morin and J. G. Lyng (2013). The effect of ultrasonic curing on water-protein interactions in meat. *Proceeding for the Institute of Food Technologists Annual Meeting*, 11-16th June 2013, Chicago, USA.

C. K. McDonnell, P. Allen, F. S. Chardonnereau, J. M. Arimi and J. G. Lyng (2013). The use of pulsed electric fields for accelerating the curing of pork. *Proceedings of the 42nd Annual Food Research Conference*, 27-28th June 2013, Dublin, Ireland, p. 13.

C. K. McDonnell, P. Allen, G. Duane, C. Morin, E. Casey, and J. G. Lyng. (2013). The influence of power ultrasound on NaCl diffusion in pork. *Proceedings of the 42nd Annual Food Research Conference*, 27-28th June 2013, Dublin, Ireland, p. 41.

C. K. McDonnell, P. Allen, J. M. Arimi and J. G. Lyng (2013). Optimisation of pilot-scale production of ultrasound-cured hams. *Proceedings of the 59th International Congress of Meat Science and Technology*, 18-23rd August 2013, Izmir, Turkey, p. 105.

C. K. McDonnell, P. Allen, F. S. Chardonnereau, J. M. Arimi and J. G. Lyng (2013). The use of pulsed electric fields for accelerating the curing of pork. *Proceedings of the 59th International Congress of Meat Science and Technology*, 18-23rd August 2013, Izmir, Turkey, p.16.

7. Compiled by: Dr Paul Allen