Radio frequency assisted freezing

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Radio frequency (RF) technology

Technology alternative to conventional ones to heat foods rapidly and uniformly

Heat is generated volumetrically within the material by the passage through electromagnetic radiation of a certain frequency (1-300 MHz; 27.12 MHz for scientific application)

Principles of RF heating

- The material is placed between but not in contact with parallel electrodes
- RF is generated by a triode valve and is applied to material via a pair of electrodes
- When an alternating electric field is applied, **ionic depolarization** and **dipole rotation** phenomena occur and lead to heat generation
- The rate of heat generation per unit volume, *Q*, during RF heating is:

$$Q = 2\pi f \varepsilon_0 \varepsilon'' E^2$$

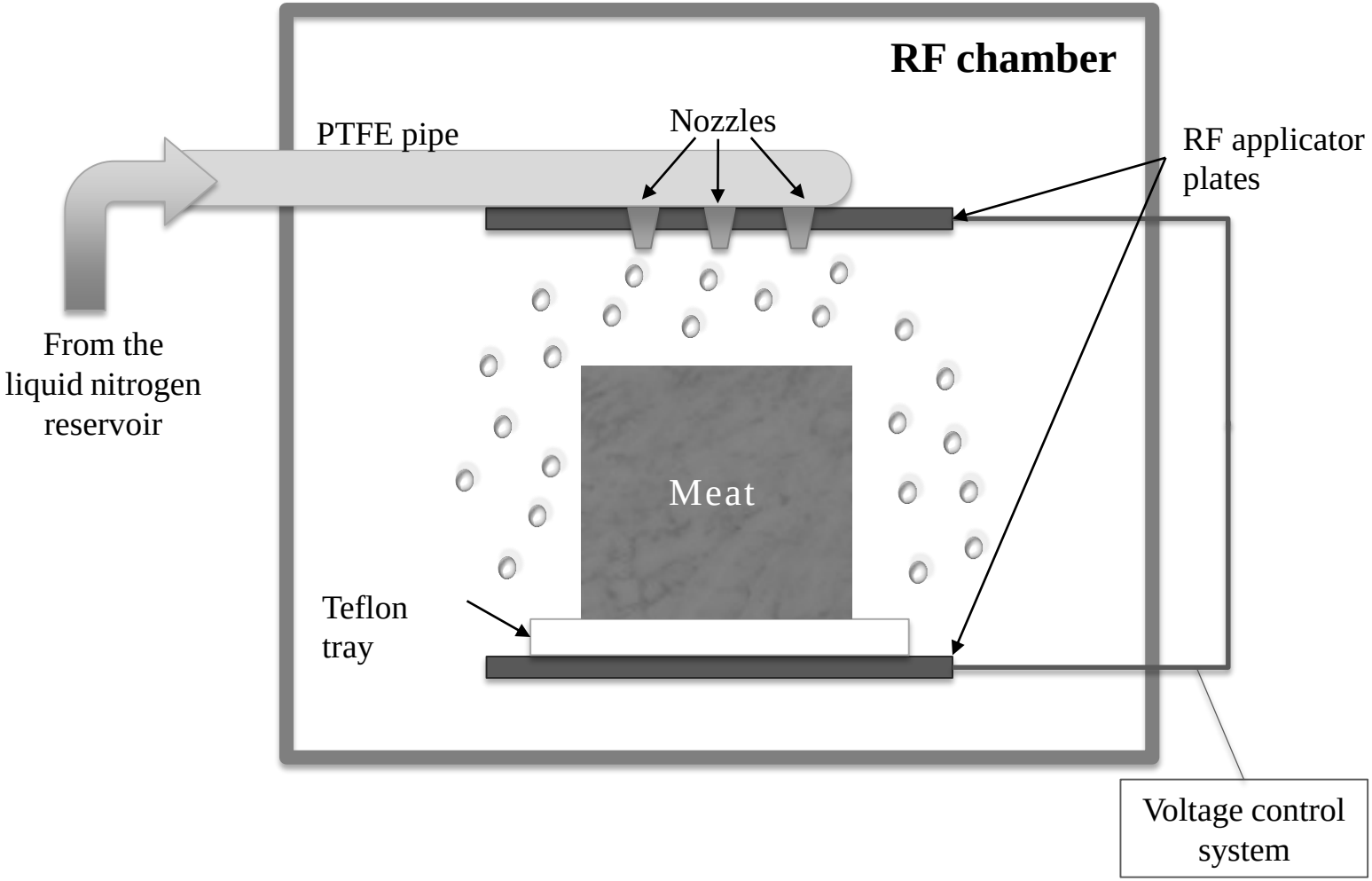
f : frequency
ε_0 : the permittivity of free space
E : strength of electric field
ε'' : dielectric loss factor of the material, that represents the material's ability to absorb the wave

Radiofrequency assisted freezing

RF at low voltage pulses was used to assist cryogenic freezing with liquid nitrogen of meat

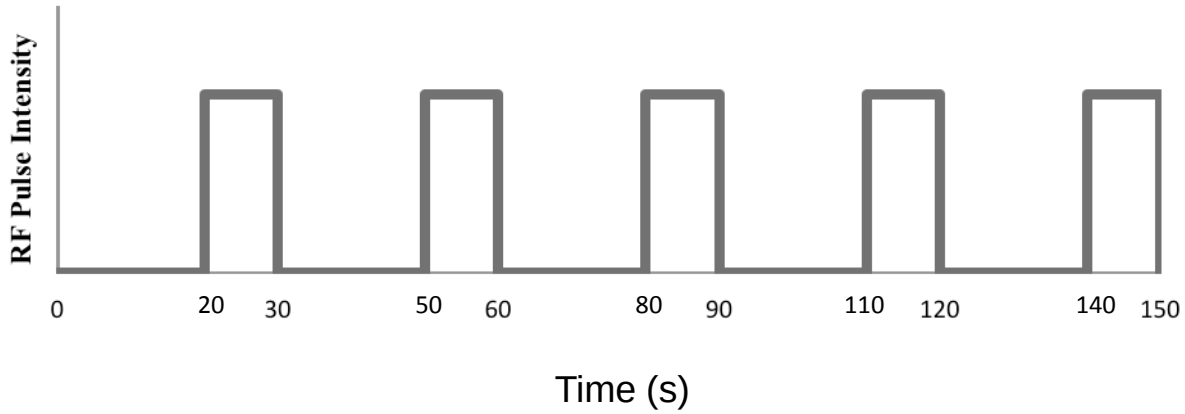
Anese M, Manzocco L, Panozzo A, Beraldo P, Foschia M., Nicoli MC. Effect of radiofrequency assisted freezing on meat microstructure and quality. Food Research International, 46, 50-54, 2012

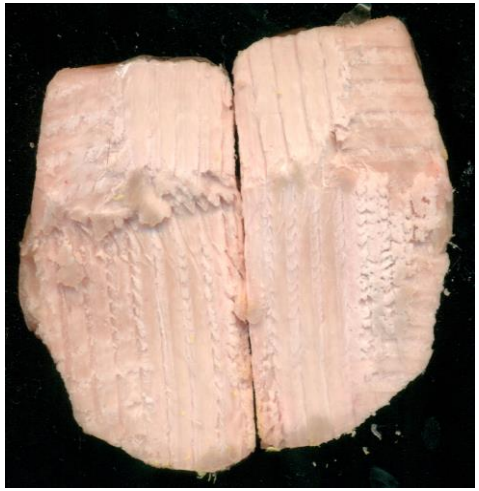
Set up of RF assisted freezing procedure



Preliminary trials

- ✓ RF voltage: **2 kV**
- ✓ Modality of RF application: **pulsed**





Frozen meat

Effect of RF cryo-freezing on meat cube (4.5 cm edge)

RF (2 kV, pulsed modality) plus liquid nitrogen

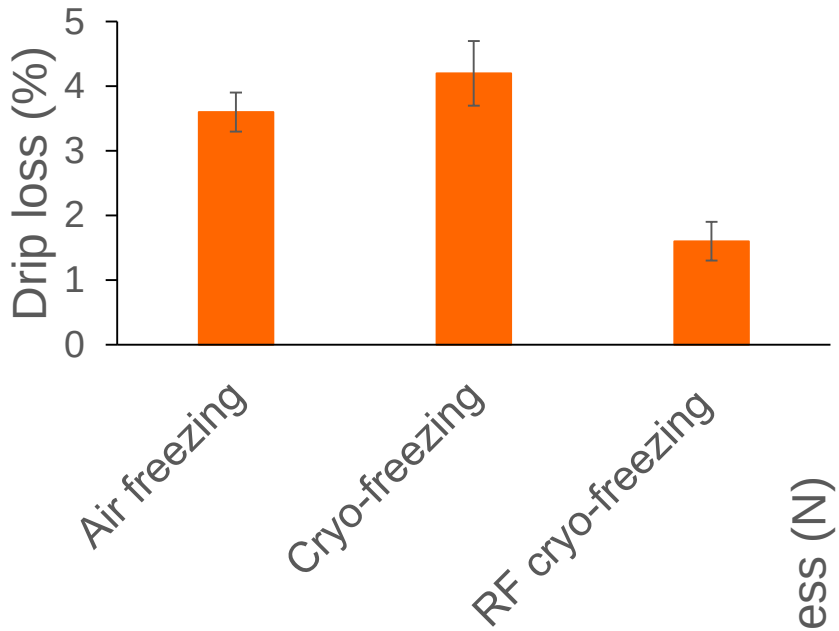
Thawing of meat and analysis of:

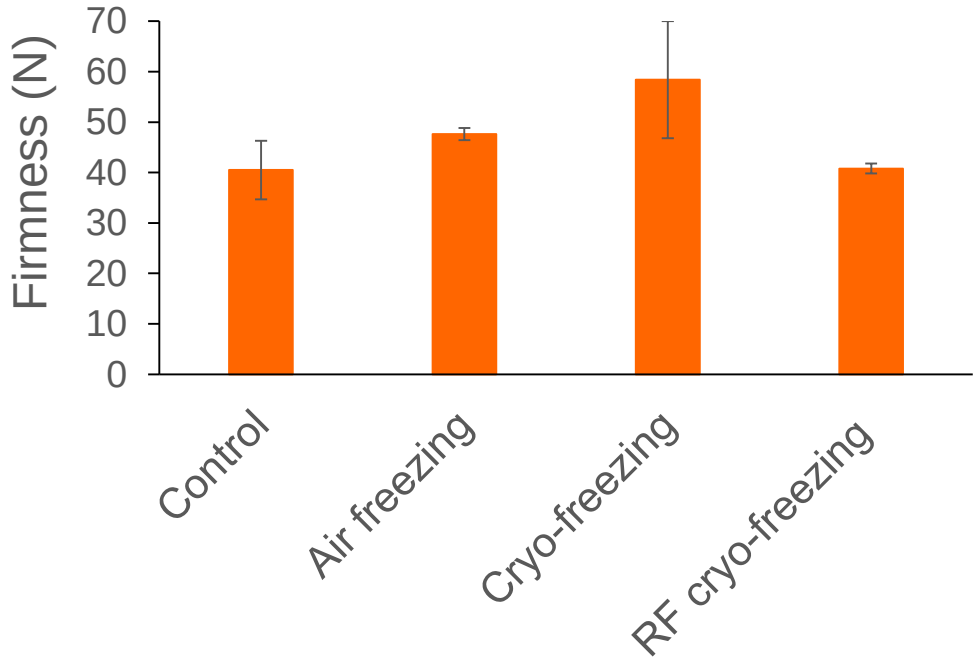
- Drip loss
- Firmness

Comparison with meat samples frozen by means of:

- Air blast freezing at -40 °C
- Cryo-freezing (liquid nitrogen)

Effect of RF cryo-freezing on meat





RF pulse effect (2 kV; 27.15 MHz)

Low voltage electric field applied can generate torque in water molecules through changing their equilibrium relationships in the ice cluster

Water dipole rotation can be exploited to control the size of ice crystals during freezing

Issue

Liquid nitrogen assures high freezing rates but it is expensive

Air: low cost, non-toxic and easy-to-use alternative cryogenic fluid

Process variables that need to be investigated :

- Plant configuration to efficiently apply RF to assist freezing by using cold air as cryogenic fluid
- Cooling parameters (e.g. air temperature and speed)
- RF power, pulses pattern and duration