Dielectric, Ohmic, and Infrared Heating
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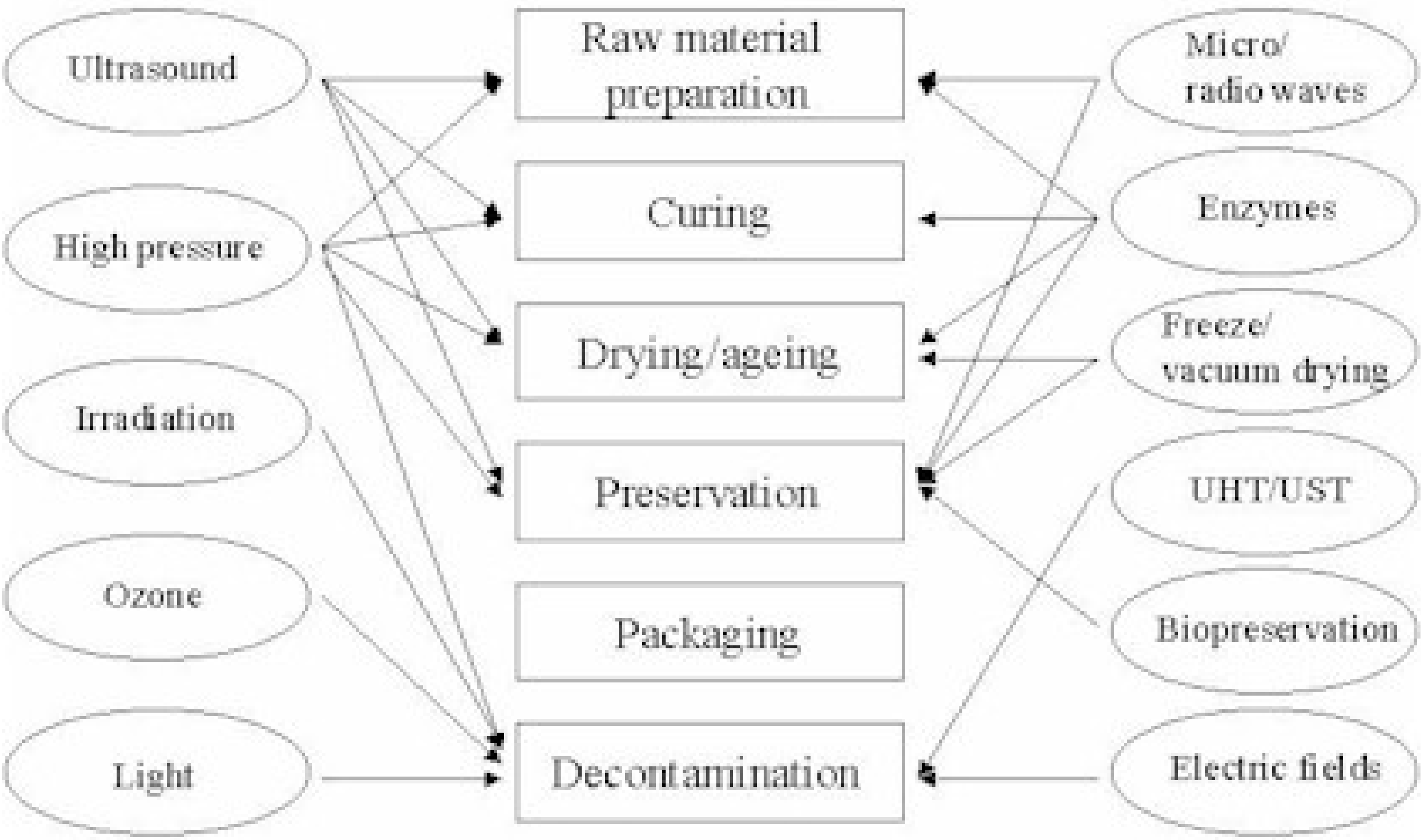
  - Effect on foods

- References

New technologies and equipment for meat manufacturing and processing



Danish meat research institute

INTRODUCTION

- Dielectric: Electromagnetic energy (Fig. 18.1)
- Ohmic or resistance heating: electrical energy

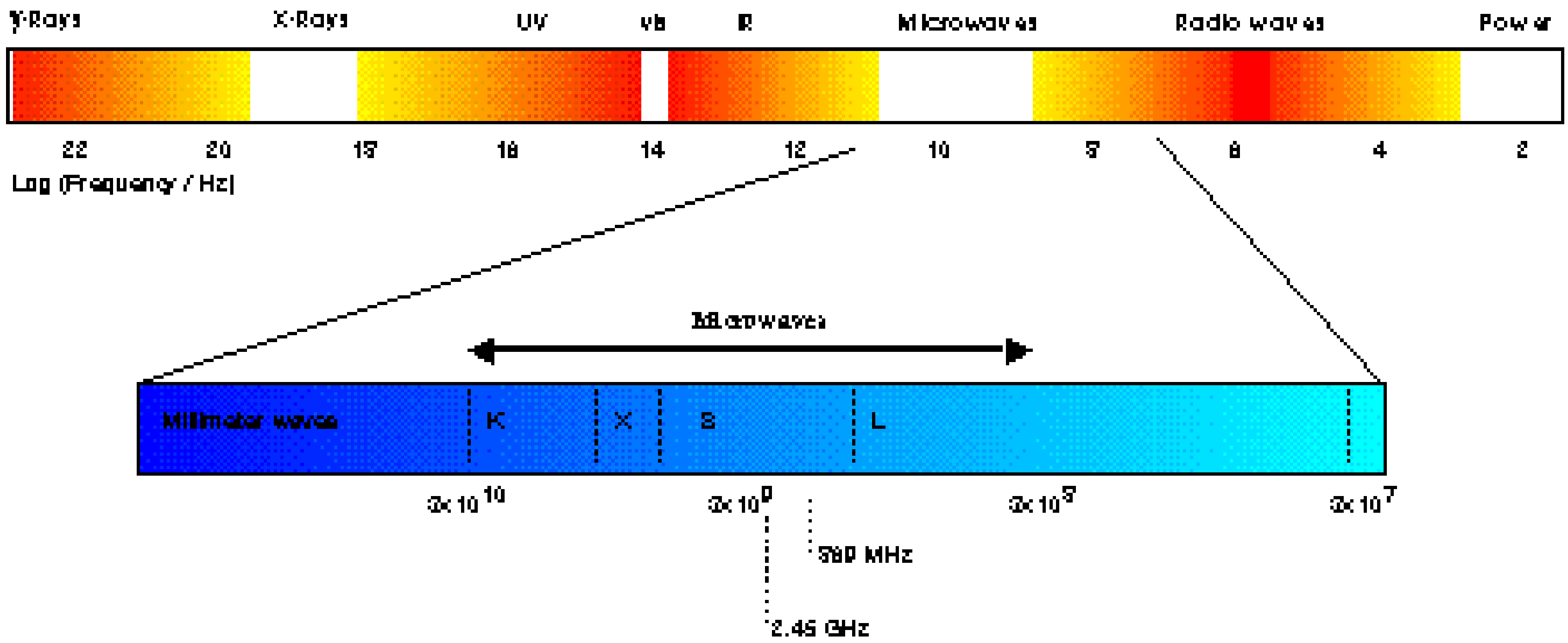
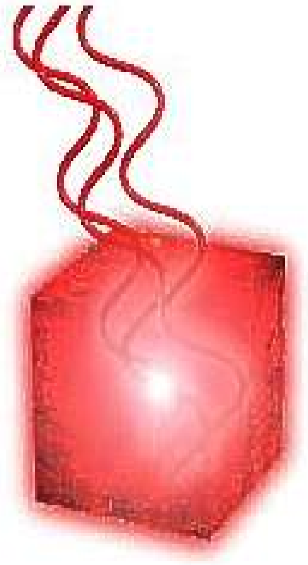

X-Rays
UV
Microwaves
Radio waves
Power
22
20
14
12
10
4
2
Log (Frequency / Hz)
Microwaves
Millimeter waves
K
X
S
L
2.45 GHz

Table 1. Frequencies assigned by the FCC for industrial, scientific, and medical use.

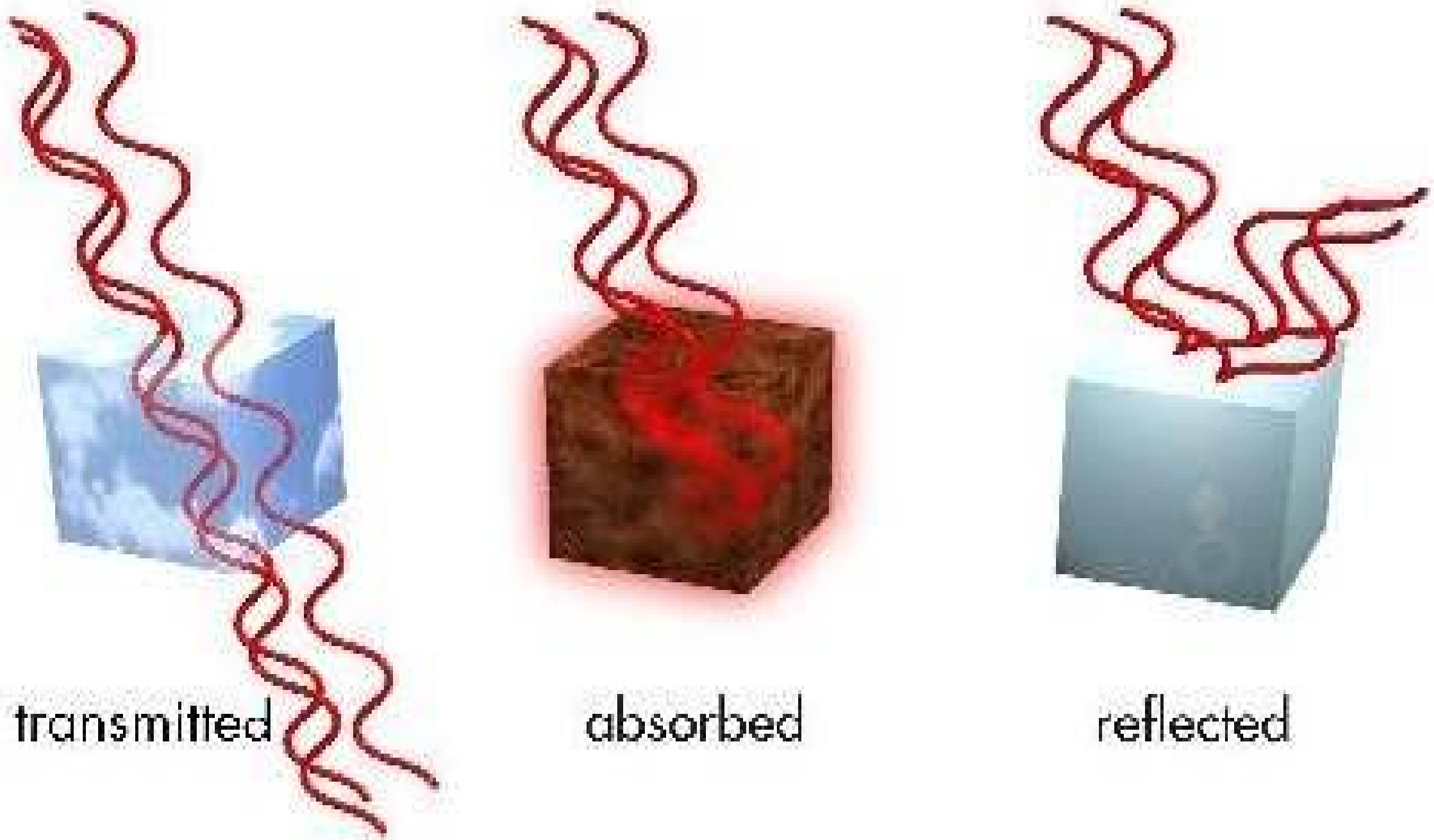
	Frequency
Radio	13.56 MHz ± 6.68 kHz
	27.12 MHz ± 160.00 kHz
	40.68 MHz ± 20.00 kHz
Microwaves	915 MHz ± 13 MHz- industrial
	2450 MHz ± 50 MHz- home & ind.
	5800 MHz ± 75 MHz
	24125 MHz ± 125 MHz

Microwave Heating vs. Conventional Heating

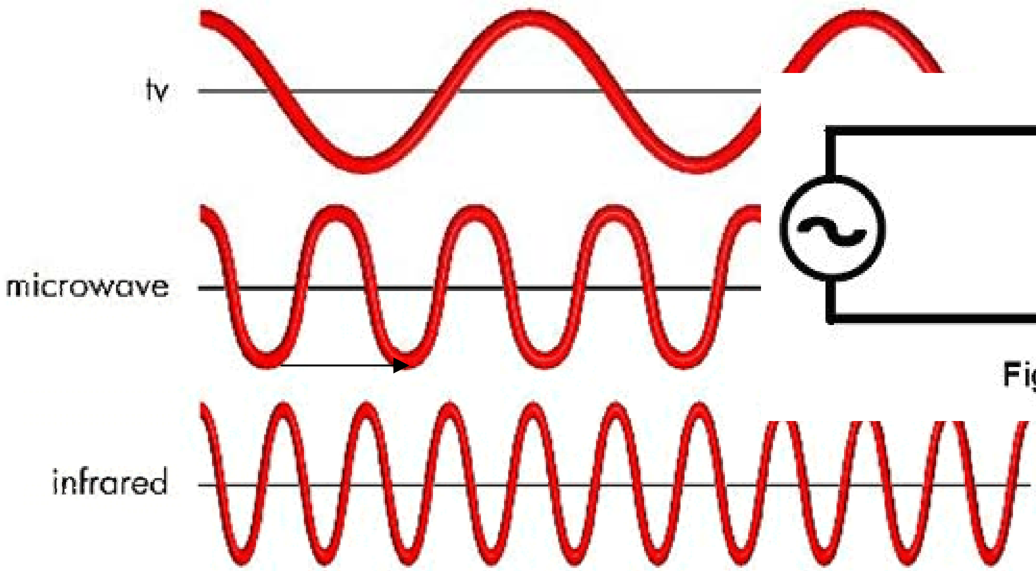


Volumetric heating
Fast and controllable
Energy is directed to product
Environmentally friendly

Surface heating
Limited by heat transfer modes
Heats surrounding areas


transmitted
absorbed
reflected

Dielectric heating principle



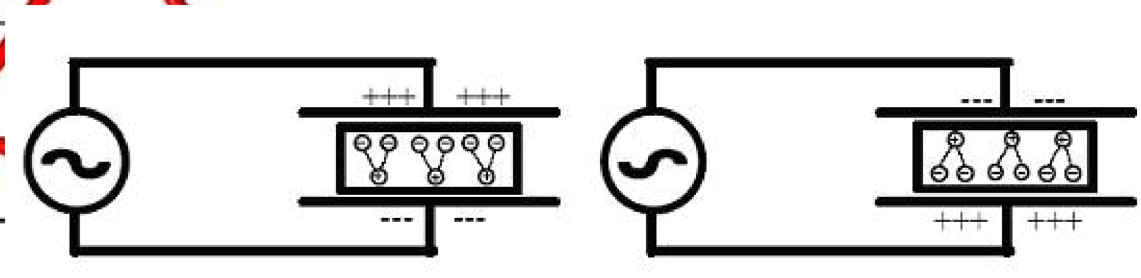
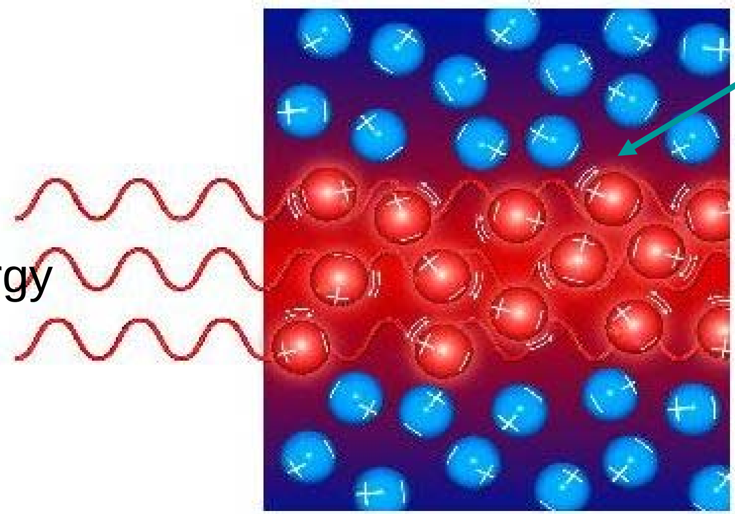


Fig. 2 Reversal of polarity causes the material to heat

f (Hz- cycles/sec)= c (cm/s)/**λ (cm)**



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

Power/unit volume = 2p f eoer tan d E2 watts - (Equation 1)

$$Dp = \frac{1}{2\alpha} = \frac{\lambda}{2\pi \times \tan\delta\sqrt{\varepsilon_r'}}$$

Drying of Biscuits with RF

75kW Strayfield Post Baking Dryer in Stainless Steel.

Tony Koral. 2004. Biscuit World Issue 4 Vol 7

Applications

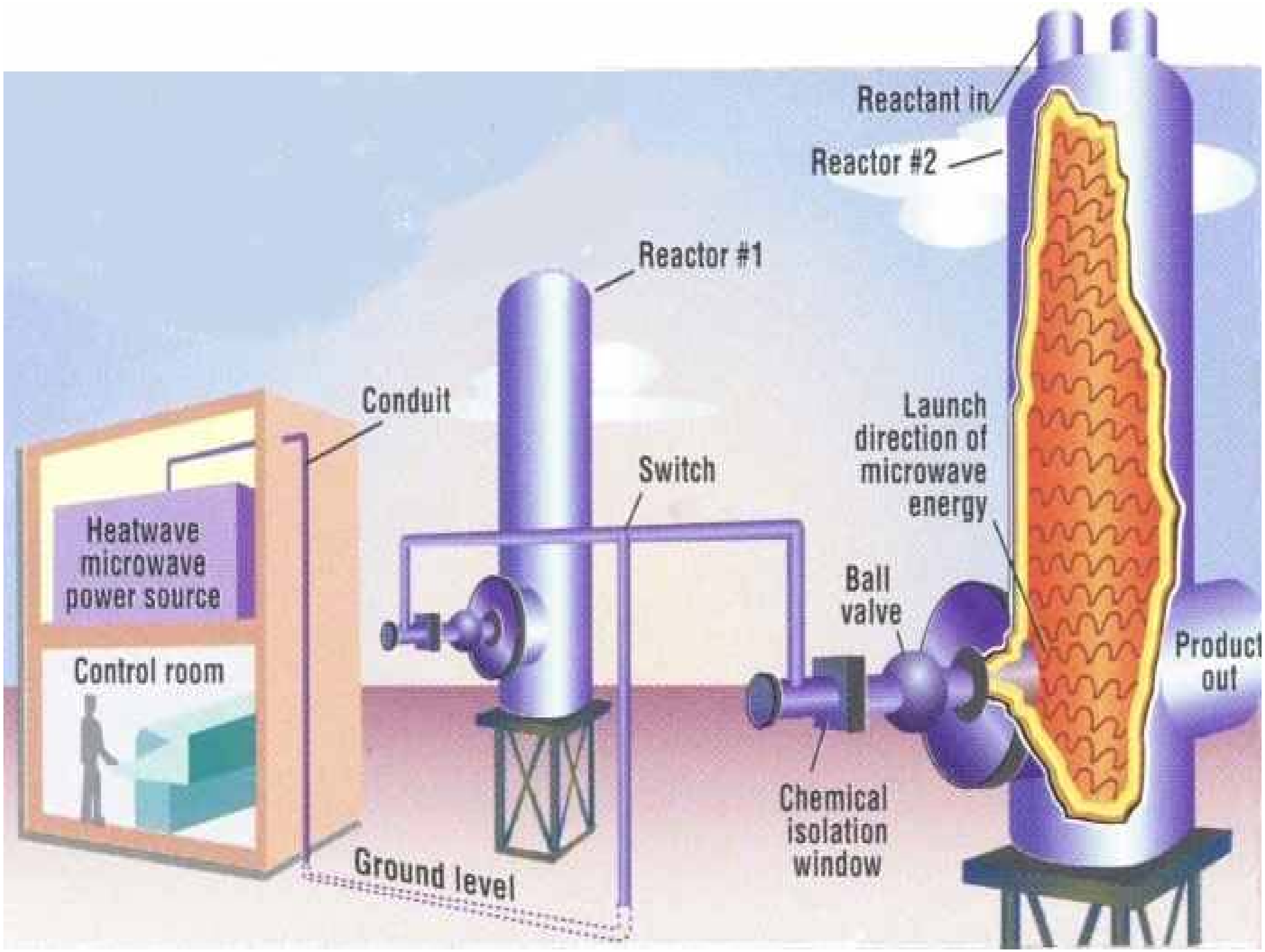
- Radio Frequency Drying is a simple precise process and is in common use in the food industry with proven processes available for a wide range of applications such as:

  - Post bake drying and moisture control.
  - Preheating of dough and cake mixes.
  - Rapid heating of tube fed products for both pre-cook and pasteurisation/sterilisation requirements.

Reduces checking (surface cracking) in biscuits by creating a uniform drying product. This is done after conventional oven drying/cooking

Tony Koral. 2004. Biscuit World Issue 4 Vol 7

Equipment



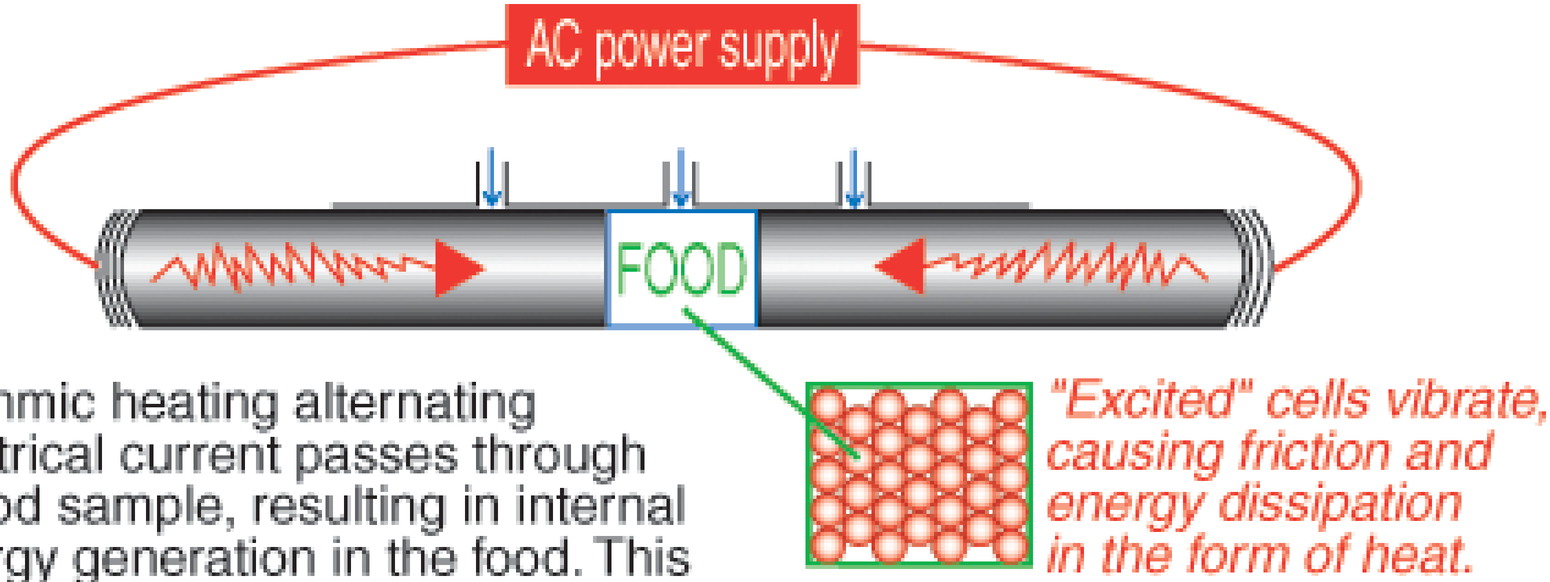
Reactant in
Reactor #2
Reactor #1
Conduit
Switch
Launch direction of microwave energy
Heatwave microwave power source
Ball valve
Control room
Product out
Chemical isolation window
Ground level

Magnetron Generators

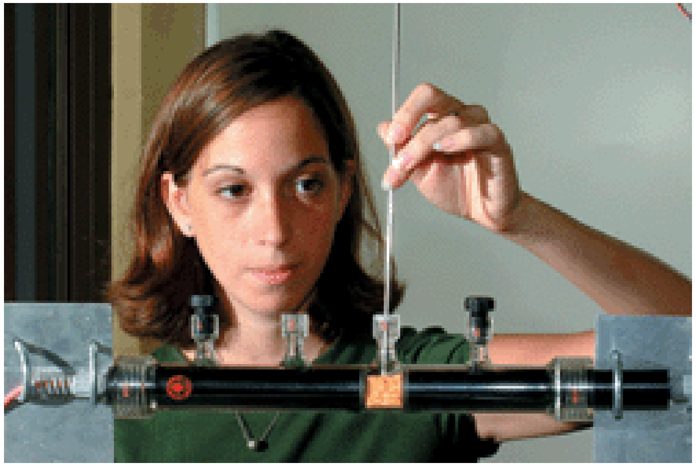
http://www.cpii.com/bmd/cpinew/Products/Magnetron_Generators/magnetron_generators.html

Ohmic heating (sometimes also referred to as Joule heating, electrical resistance heating, direct electrical resistance heating, electroheating, and electroconductive heating) is defined as a process wherein (primarily alternating) electric currents are passed through foods or other materials with the primary purpose of heating them. The heating occurs in the form of internal energy generation within the material.

Ohmic heating



In ohmic heating alternating electrical current passes through a food sample, resulting in internal energy generation in the food. This produces an inside-out heating pattern.



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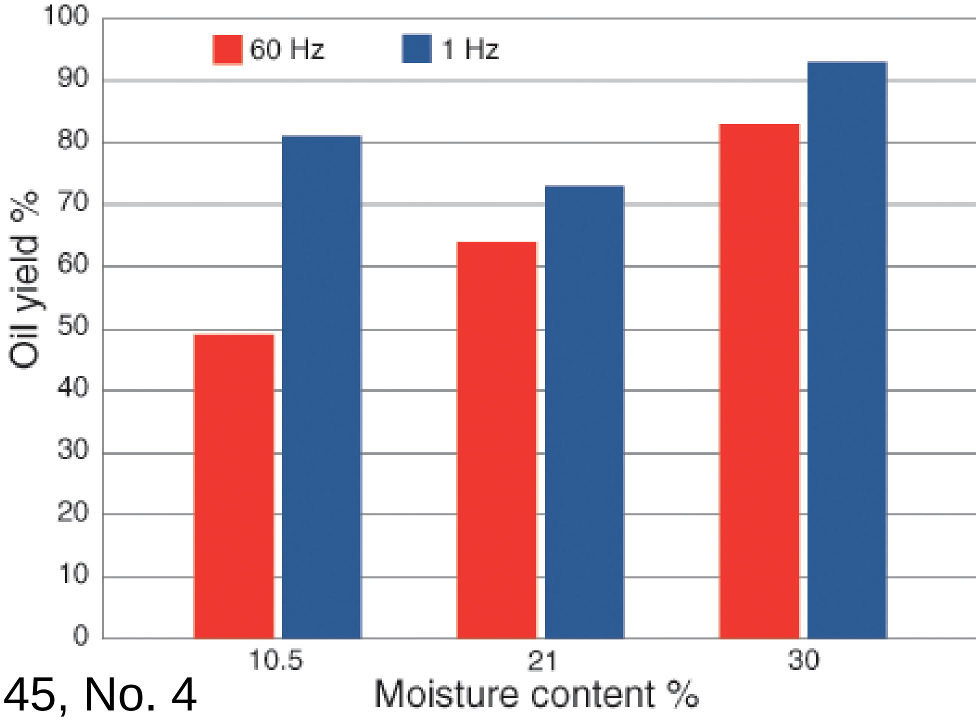
Microbial Inactivation

- The principal mechanisms of microbial inactivation in ohmic heating are thermal in nature.
- A mild electroporation mechanism may occur during ohmic heating. The principal reason for the additional effect of ohmic treatment may be its low frequency (50 - 60 Hz), which allows cell walls to build up charges and form pores.

Applications

- Accelerate freeze drying rate of SPs (by 25%)
- Increase rice bran oil extraction (lower f resulted in higher yield)



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Equipment

Ohmic heating

- Dependant on the electrical conductivity of food
  - Most foods contain a moderate percent of free water and dissolved ionic salts
- Advantages
  - Fast
  - More uniform heating
- Disadvantage
  - Nonuniformity in product will distort field

Glossary

Conductivity (Electrical), σ. Physical property of a food material that determines its ability to conduct electricity and is expressed in Siemens per cm (S/cm). In ohmic heating, it enables heating to occur.
Conductivity (Thermal). Physical property of a food material which determines its ability to conduct heat. Expressed in Watts/meter oC.
Conventional heating. Heating of a substance by transfer of thermal energy from a heating medium to a low temperature product.
Cross-field. An ohmic heating system where the electric field is aligned across the product flow path.
Electroheating. See ohmic heating
Inclusion particle. A food particle of significantly different electrical conductivity than its surroundings.
Interstitial fluid motion. The motion of fluid in the spaces between solid particles.
Non-thermal effects. Effects due to the exposure to a process that are not of thermal origin, i.e., cannot be explained by measured temperature changes.
Specific heat. The ability of a material to store heat. Described technically as the amount of energy required to raise the temperature of unit mass of an object by a unit increment in temperature.
Thermophysical properties. Properties that influence the heating rate of a material. Examples of thermophysical properties are thermal conductivity (the ability of the material to conduct heat), specific heat (the ability of the material to store heat), and density (the mass per unit volume of the material).

References

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