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Novel Non-Thermal Methods of Food Processing / Preservation

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Objectives of Food Processing / Preservation

Stated Objective:

- Presenting a Great Product that meets Consumer Demand

Subsumed Objectives:

- Preservation or extending the shelf life of food – "First Day Fresh"
- Controlling & Inactivating the enzymes that potentially spoil food when exposed to free air
- Hold Away the most "Heat Resistant Spoilage / Disease causing organism" in food*
- Commercial Sterilization not Total Sterilization

** Vegetative cells or Spores*

4 Basic Principles of Food Processing

(1) “Make it Safe”

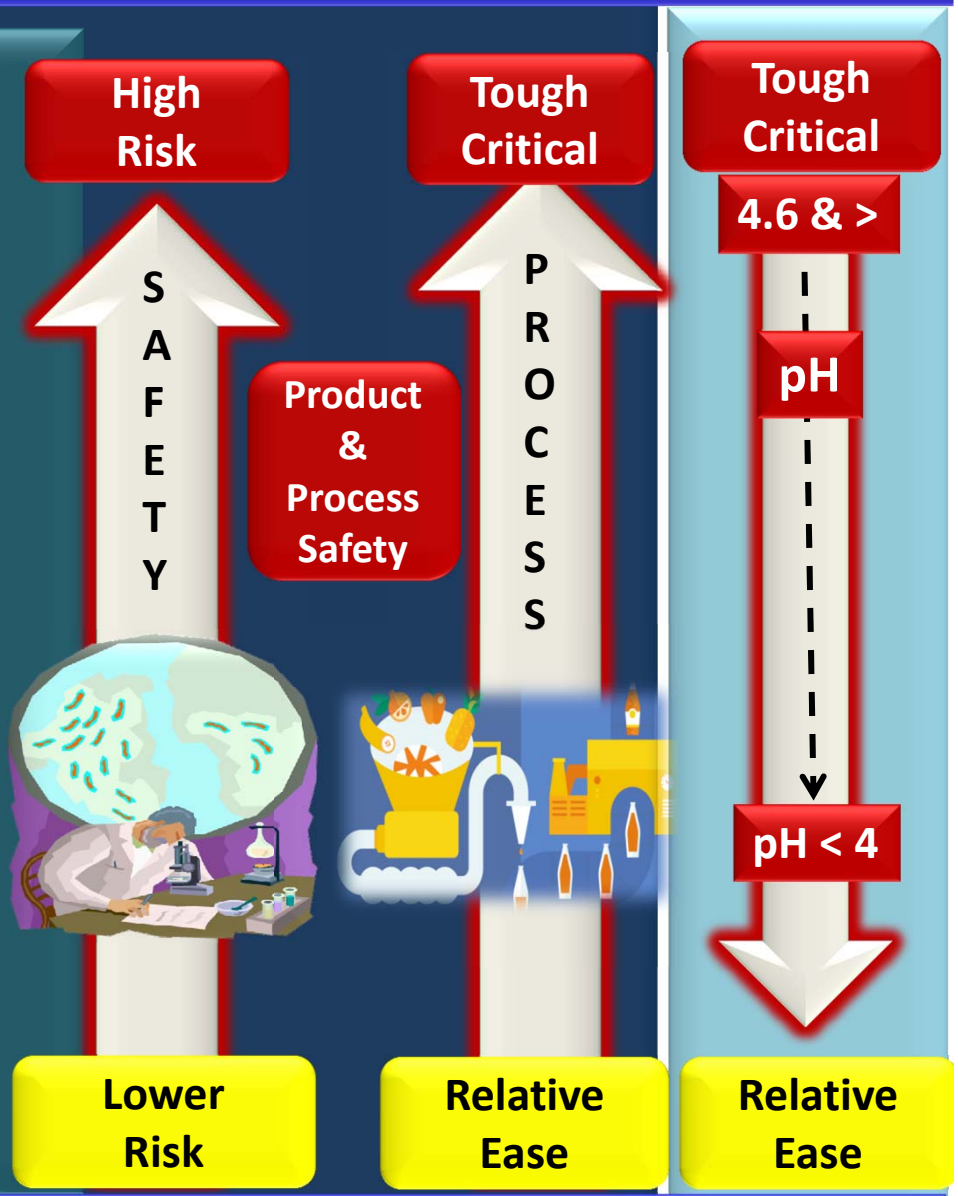
(2) “Make it Consistent”

(3)“Verify Compliance”

(4) Deliver Consumer Appreciated Quality

Foods - Natural Risk factors and Processing

- **Low acid spore formers (Major concern in meat, fish and vegetable processing) – pH > 4.6**
- **Spore Forming Bacteria**
- Pathogenic organisms – Salmonella, Listeria etc.
- **Fecal Contaminants**
- **Yeasts & Molds**
- **Non-spore forming bacteria (LAB, AAB etc.) & Protozoans**
- **Enzymes**



These Factors are relatively common to all processes

What steps do we take to overcome the risks?

- **Microbial contamination is the single biggest Food Risks**
- **Microbes can be inactivated by proper processing of foods**
- **Food Processing includes steps beginning from➔**

➔Selection of Raw materials, → Cleaning → Preparation → Product Fill → <u>Processing*</u>

- ***Every step in the process is of critical importance & Last step alone cannot be assumed to solve all problems***

Thermal Food Processing – Role of Heat

Heat Treatment (+)

Use Heat to Process & Preserve

- Pasteurization
- Hot Fill Process
- Tunnel Pasteurization
- Aseptic Processing
- De-hydration

Water Removal by the use of heat

Heat Removal (-)

Water Binding

- Bulk Freezing
- IQF

Freezing in Air-Flotation

- Freeze Drying

Water Binding - Freezing

Water Removal-Heat

Freezing + Drying

Why the Need for Alternate Preservation Technologies?

- Heating is Dominant in Food Industry
- Energy Intensive & Impacts environment – Bad temperature profiles – 1) Process 2) Stack 3) Therefore Losses etc. Tendency to be Poorly managed
- High Heat Treatment , non-optimized ***will*** cause
  - Protein Denaturation
  - Non-Enzymatic Browning & Loss of Vitamins
  - Loss of Volatile Flavor Compounds
  - Caramelized, Burnt
  - Distasteful

Critical Factor

- **Consumer Demand for fresh, non-treated, but fresh and safe products**

Non-thermal Technologies

Innovations

Emerged / Emerging

- High Pressure Processing
- Pulsed Electric Fields
- Radio Frequency Drying
- Microwave Heating
- Membrane Filtration
- Ozonation
- Osmotic Treatment
- Other Hurdle technologies
  - Single
  - Combination

Others

- Ultra Sound
- Plasma
- UV

Under development

- Cold Plasma
- Electrolyzed water
- Sonication
- Low dose e-beam irradiation

Emerging Preservation Technologies

Innovations

Technology

- High Pressure Processing
- Pulsed Electric Field (PEF)
- Electro Magnetic Spectrum
  - Radio Frequency
  - Micro-wave
  - Infra Red
  - Ultra- violet
  - Ionizing Radiation
- Ozonation
- Ultraviolet Radiation

Progress *fx*

- Understanding microbial physiology
- Behavior of microbial cells during and after treatment
- Cost of the Fixed Asset, Depreciation
- Revenue impact
- Consumer Demand

DESIGN: **Produce safe food, while maintaining its nutritional and sensory qualities & desired shelf life at optimal cost**

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High Pressure Processing..

High Pressure Processing

- High Pressure Processing (HPP) or High Hydrostatic Pressure Processing
- Cold Pasteurization technique
  - Raw materials, cleaned, prepared, Product sealed in its final package, introduced into a vessel
  - Subjected to a high level of Isostatic* pressure
  - “Pressure ” transmitted using Water as a media
- *With application of Uniform Pressure in all directions – Pascal’s Law

High Pressure - How High is high?

Increasing Pressure (MPa)

0.03

Mt. Everest

100

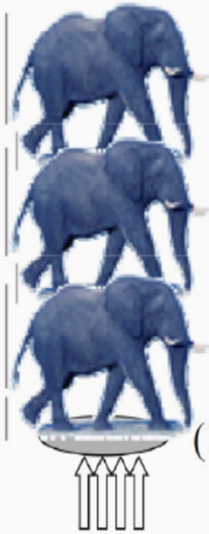
1000

High Pressure Processing

360000

Centre of Earth

Three African elephants (~5 tons each) standing on a 18 mm (dia.) disk



(18 mm in diameter)

600 MPa or 87,000 psi

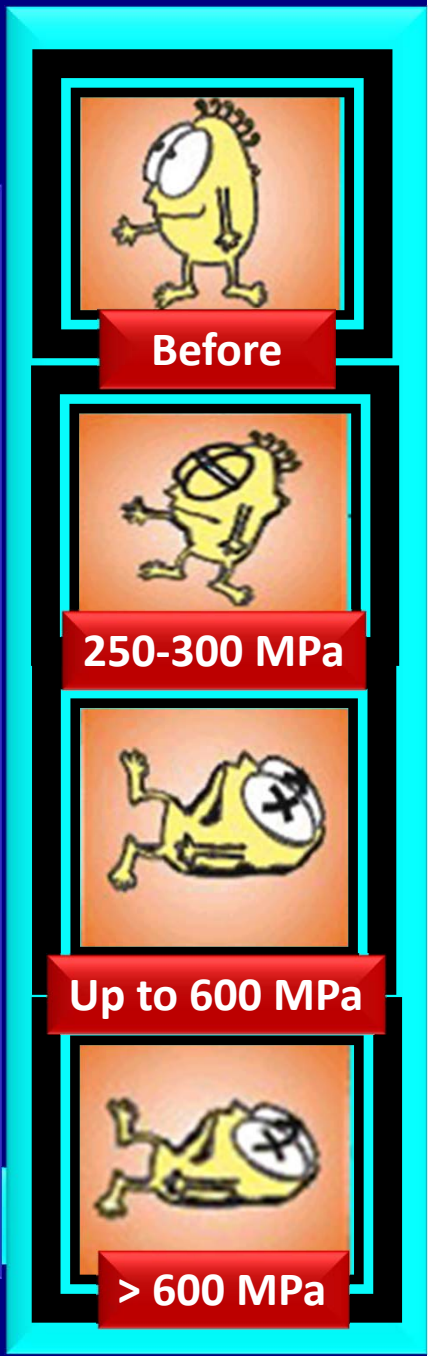
85,000 PSI approx.

Principles of High Pressure Processing

- Pascal's law
- Pressure applied- 100-1000 MPa (Mega Pascal)
- Duration- 1-20 minutes (for 600 Mpa)
- Working principle
  - Packaging in flexible container
  - Loaded in high pressure chamber
  - Pressure transmitted through package
  - High pressure processed product
  - Fruit Juices /pulps, Jams produced commercially
  - Practically not affected (e.g. nutrients & flavour comps)

Impact of Pressure on Microbes

- Pressure – Disrupts the cell membrane permeability of microbes leading to destruction
- Microbial Enzymes De-grade and De-generate
- No Basic damage to Fruit Juices, Juices remain fresh. Enzymes in fruits – Degraded
- *Salmonella & E.Coli E0157 destroyed*
- A Pressure exposure of 8000 Psi (550 M Pa Approx.)
  - 30 sec Exposure leads to 3-5 log reduction of pathogens



High Pressure Processing

It is a Batch Process – Video…..

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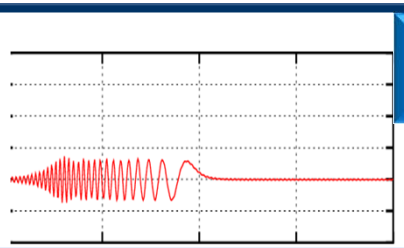
High Pressure Processing

Now also called as

“PASCALIZATION”

In honour of dr. blaise pascal

Pulsed Electric Field (PEF)



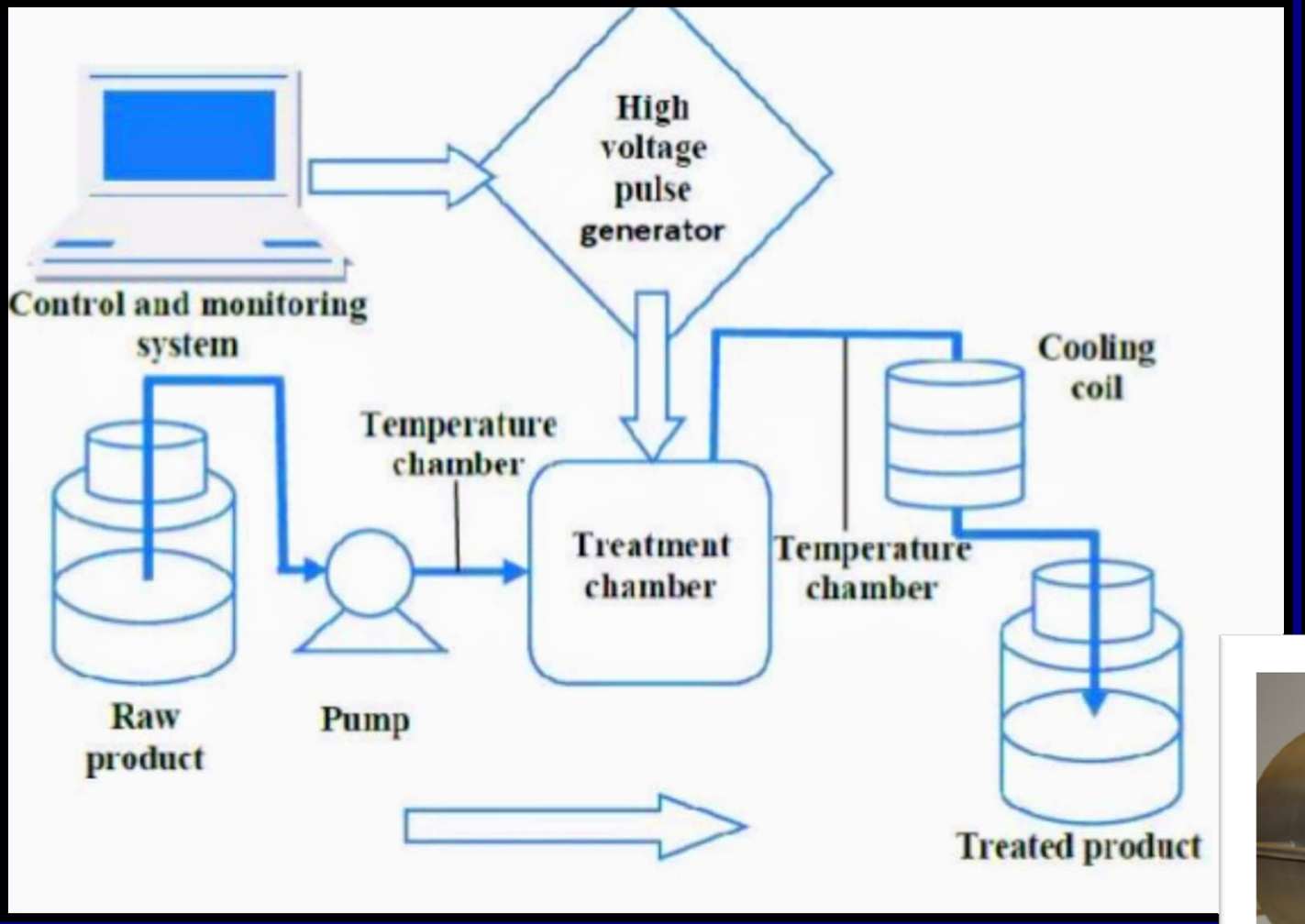
Pulsed Electric Field (PEF)

- Use of short Electric Pulses to Preserve Foods

- Application of high V (20-80 KV / cm) very short exposure to electric fields (Milli Seconds to Seconds in short series of waves)

- This results in a rapid electric breakdown and Electroporation of cells
- Minimal energy is lost during the heating. Retains fresh and tasty characteristics of food
- Good for processing liquids, maintains functional constituents, retains sensorial attributes
- Significantly increases Juice yields from fruits

Pulsed Electic Field (PEF)



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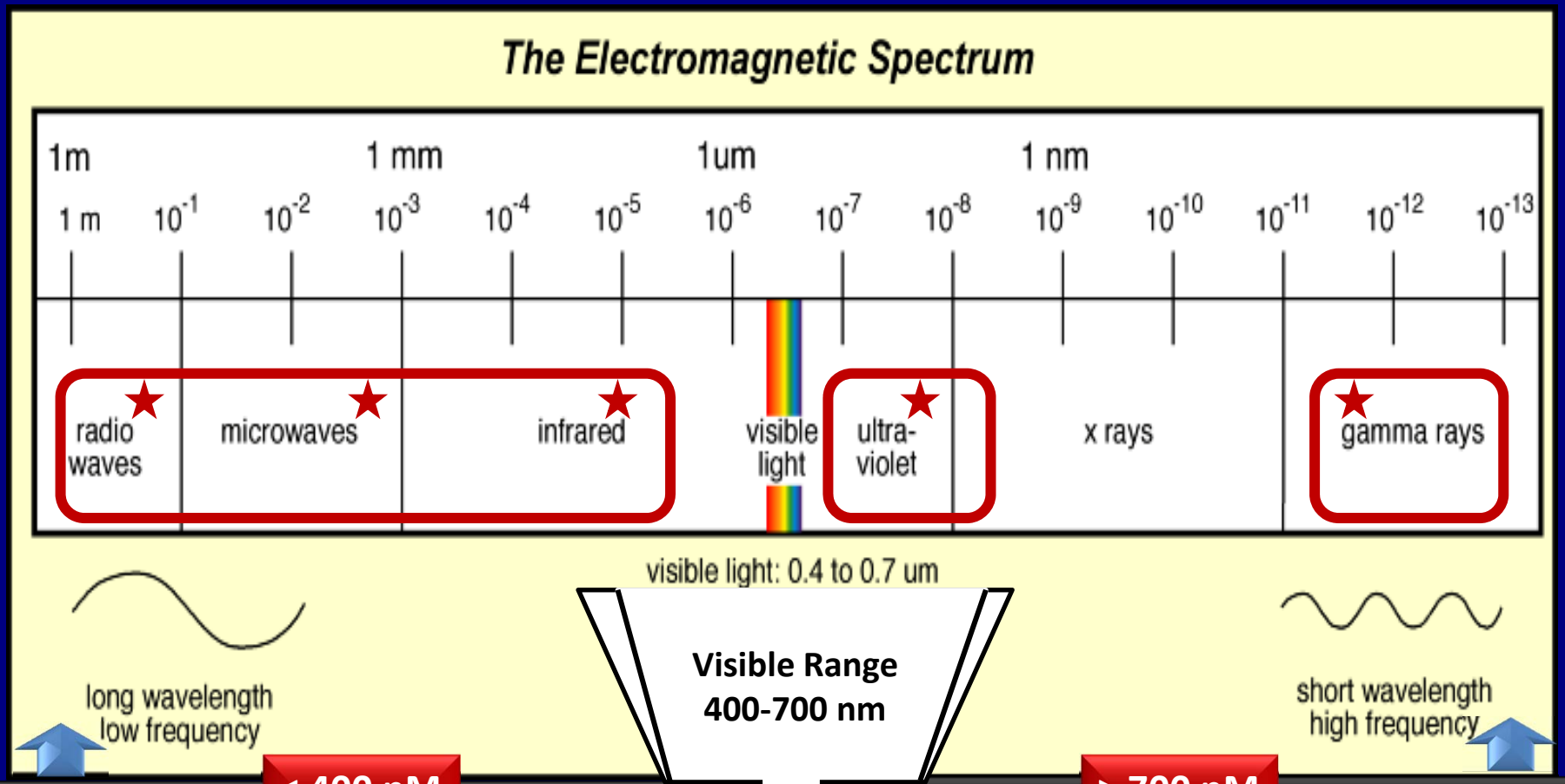
Use of Electro Magnetic Spectrum

Electromagnetic Spectrum



< 400 nM

- Longer Wavelength
- Lower Frequency
- Lower Energy
- Infra Red, Microwaves, Radio waves

> 700 nM

- Shorter Wavelength
- Higher Frequency
- Higher Energy
- UV, X-Rays, and Gamma Rays

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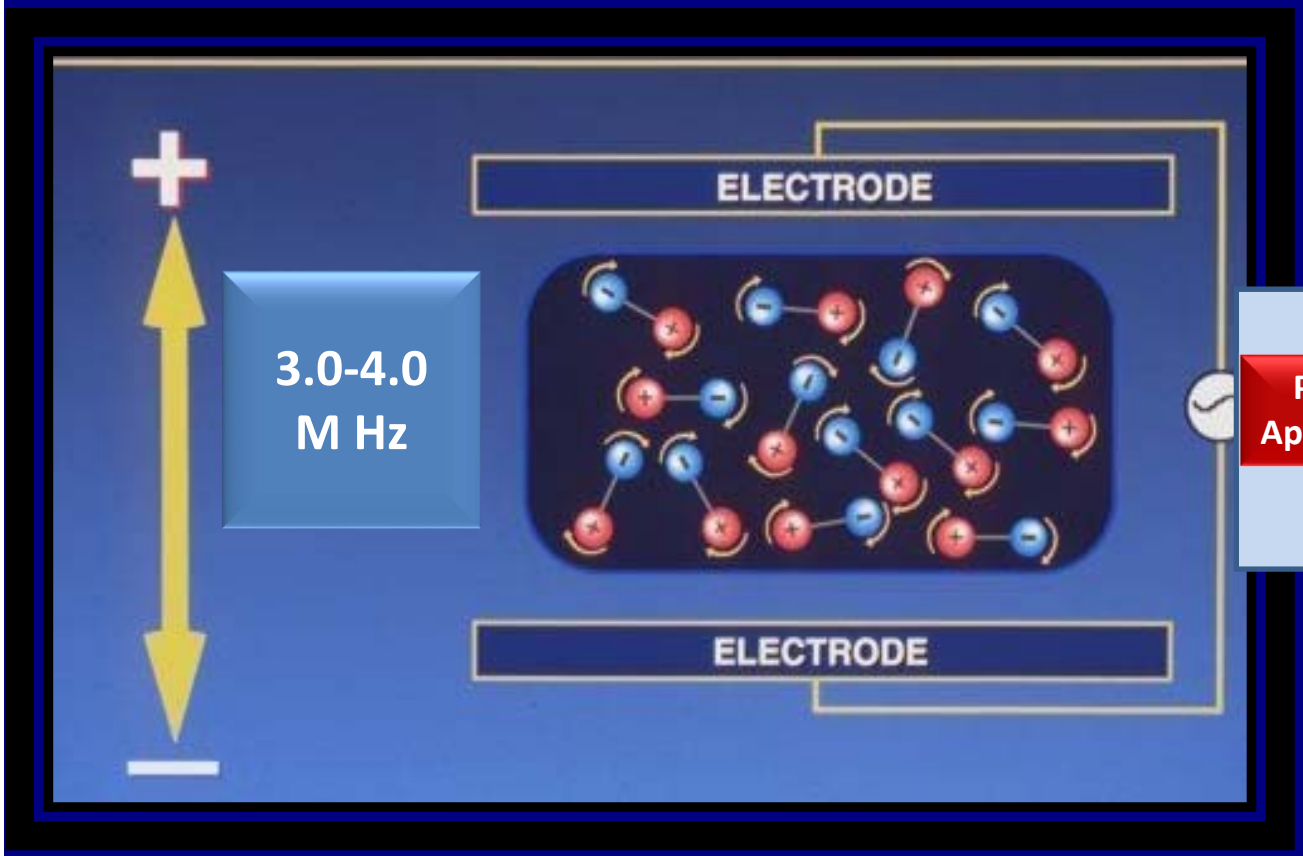
Use of Electro Magnetic Spectrum

1. Radio- Frequency Drying
2. Microwave Heating

RF – Heating / Drying

- Alternating electric field between two electrodes by the RF Generator
- The material is conveyed between the electrodes
- The alternating energy causes polar molecules to re-orient and vibrate
- The friction of this movement causes the water in the material to rapidly heat throughout its entire mass.
- Is ideal for applications where uniformity of product dryness is an important requirement.
- Deep penetration due to lower wavelength

Radio-Frequency Drying – RF Heating



Possible Applications

Baked Products

Cocoa Beans

Snacks

Potato Chips

- Radio Frequency RF- Waves of 3-4 kHz — 300 MHz to 400 MHz) are part of the electromagnetic spectrum
- Heating of dielectric materials through molecular vibration

Applications – RF Heating

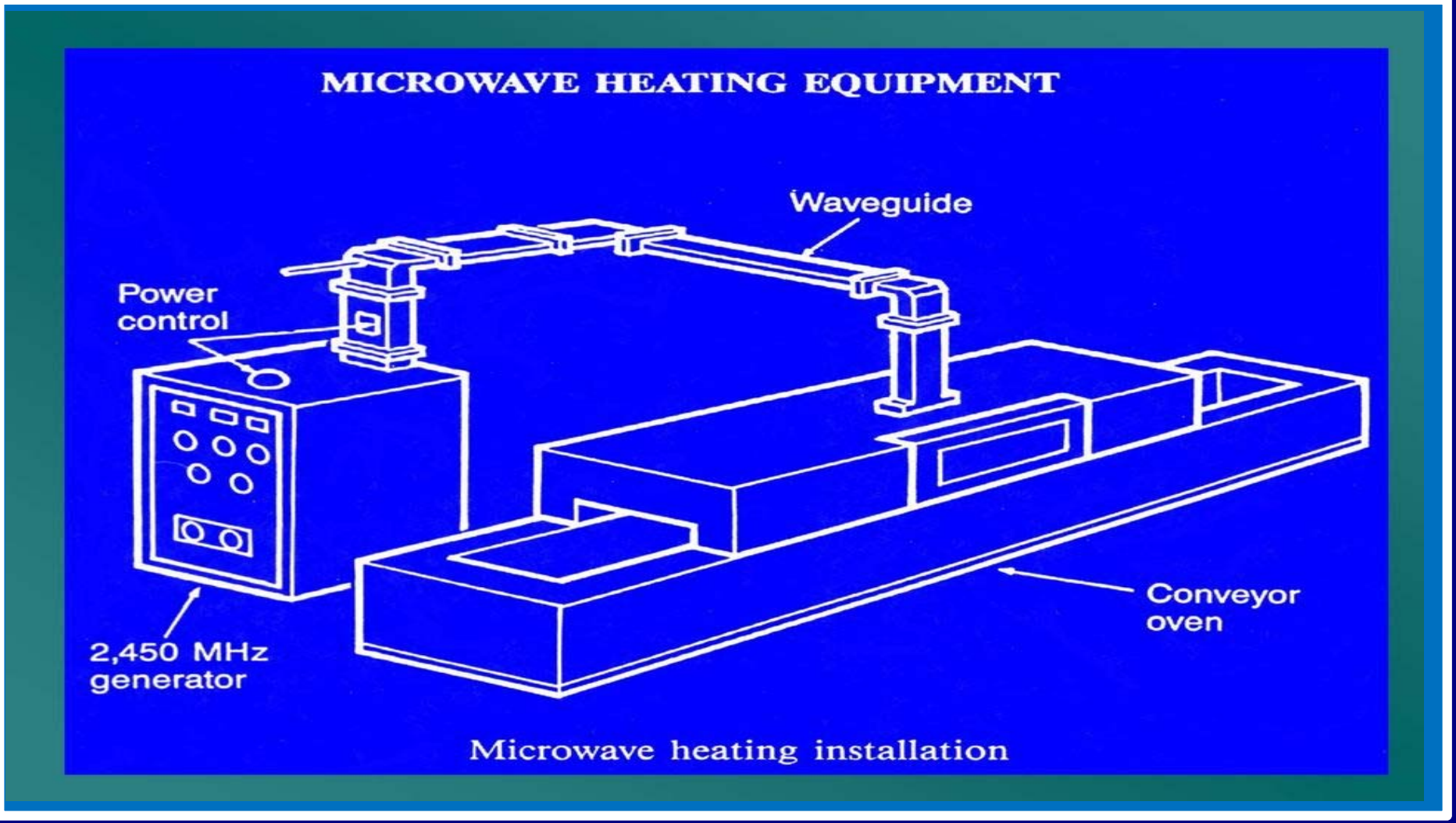
Process	Frequency, MHz	Food Items	References
Thawing of frozen foods	14–17	Eggs, fruits, vegetables	Cathcart et al., 1947
	36–40	Fish	Jason and Sanders, 1962
	36–40	Meat	Sanders, 1966
Tempering	10–300	Meat	Experimental Station, Parma, Italy, 1997
Post-baking drying	27.12	Cookies, crackers, snack foods	Radio Frequency Co., MA Mermelstein, 1998
Pasteurization	9	Meats	Pircon et al., 1953
	60	Cured hams	Bengtsson et al., 1970
	27	Sausage emulsion	Houben et al., 1991, 1994
Cooking	13.56	Ham	Tulip International, 1995
Roasting	60	Cocoa beans	Electrotechnology application center, PA

Microwave Heating

- Microwaves are electromagnetic waves
  - Only Limited frequencies permitted for Public Use across Globe
  - 915 Mega Hertz (MHz)
  - 2450 MHz
- It consists of both electric and magnetic fields
- It is part of electromagnetic spectrum with wavelengths from 1 mm to 10 cm
- Polar molecules such as water molecules(dipole) inside the food will rotate, which generates immense heat

- Household electric current operates at 60 Hz AC
- Being Alternate current – it reverses cycle every 60 rotations
- Microwave heating speeds up rotation of DIELECTRIC MOLECULES – WATER
- E.g. 2450 X 10^{6} a second or 2.4 Billion rotations a second
- Generates immense kinetic Energy

Microwave Heating



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Ozonation

Use of Ozone - Ozonation

- Ozone is widely used as a HURDLE in processing of Foods
  - Most Powerful Anti-Oxidant
  - Instant Destruction of Microbes
  - Eliminates “Most” unwanted surface adhering chemicals
  - Destroys / stops Mould Spores
  - No harmful by-product
  - Does not impact product taste
  - Eco-safe
  - Low cost technology
  - Wide Applications

- Recycle wastewater
- Sanitize equipment
- Decrease chemical levels on fresh produce

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Food Irradiation

Food Irradiation

A process involving the exposure of food, either pre-packaged or in bulk, to γ-rays, X-rays, or electrons in a special room and for a specific duration.

- Three types of radiation are used in the irradiation process:
  - Gamma radiation, Electron beams, and X-rays.
  - Of the three, gamma irradiation is the most commonly used
  - Cobalt-60 and Cesium-137.
  - Cesium-137 has a melting point of approximately 28.4 °C
  - Also, Cesium-137 reacts with water
  - Cobalt-60 is most widely used

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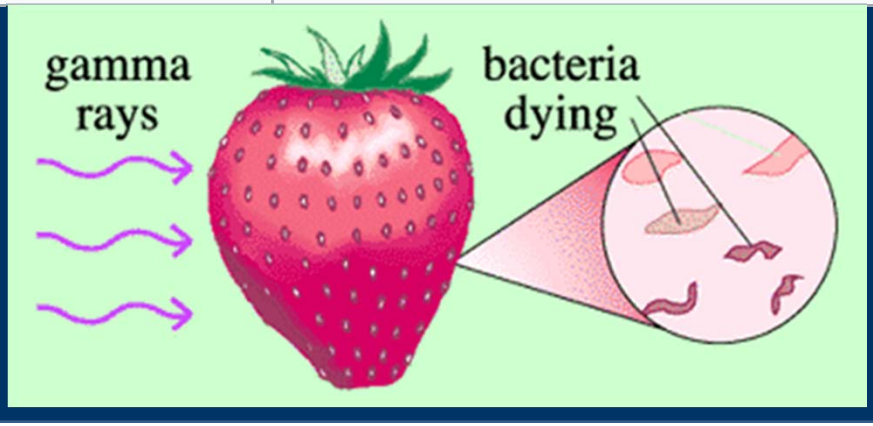
Food Irradiation Unit

Units	**SI Unit: Gray *(Gy)* Named to honour Louis Harold Gray**
Unit of	**Absorbed Dosage of Ionizing Radiation**
Symbol	**Gy**
1 Gy in ...	***1 Gy = 1 Joule of energy absorbed / per Kg***
• **SI Unit**	**Joule / Kg**
• **CGS unit**	**100 Rad : (1Rad = 0.01 Gy)**



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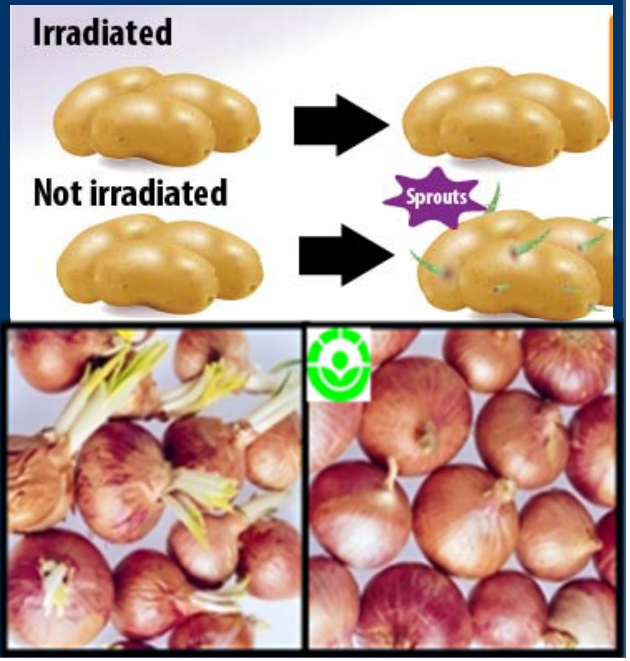
Food Irradiation Facts

- 50 years of in-depth research Globally
- Irradiated food is NOT radioactive
- Irradiated food is labeled to give consumer the option and choice
- Food Irradiation
  - Reduces microbial levels
  - Destroys pathogens
  - Extents shelf life
  - Removes insect infestation
  - Prevents Sprouting – Onions & Potatoes
  - Delays ripening - Strawberry



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Ohmic Heating

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Ohmic Heating

- Ohmic heating may be defined as a process where an electric current is passed through the food with the main purpose of heating it.
- Heating happens inside- to outside, speed of heating is high
- Unlike normal thermal process – heating is very effective, fast, can heat particulate with speed, no charring

And Summarizing

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Summarizing..

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- Alternative newer Food processing methods are taking shape , few of them RAPIDLY
- However, along with added aspects of good Quality - RM, PM, clean and safe Process etc. will project significant summation to overall Final Product FSQ
- Consumer demand, Optimization of line cost, Quality, Affordability , Revenue cost of operation will play a major role in success.

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