

# Innovations in Food Processing Technologies: Impact on Nutrient Composition & Food Safety



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**The food industry is driven by and responsive to both customer and consumer trends and needs, such as:**

- ✓ **Safety – all food sold should be safe both in terms of microbiology and toxicology, as well as providing acceptable shelf-life;**
- ✓ **Health and well-being – increasingly consumers are responding to health concerns by seeking food which delivers (or claims to deliver) nutritional and health benefits;**
- ✓ **High quality – the consumer expects food to look and taste good; additives free and all natural**

- ✓ **Convenience** – the number of ready meals sold is increasing, as is the percentage of meals eaten outside the home;
- ✓ **Price** – all of the above must be provided at a price the consumer is prepared to pay;
- ✓ **Environment** – to minimise their carbon footprint and waste;
- ✓ **Sustainability** – the development of new plant based industries, such as biofuels production, is putting strain on the supply of raw materials, leading to increasing costs.

# **Search for new alternatives**

- **Consumer demand for very high organoleptic and nutritional qualities**
- **For many years thermal processing was the main technology**  
**Disadvantages: Flavour & nutrient loss, physicochemical properties affected**

## **Desirable feature of a technology**

- ✓ **Minimum losses of flavour and food quality**
- ✓ **Avoids or reduces the detrimental changes of the sensory and physical properties**
- ✓ **Low processing temperatures**
- ✓ **Inactivation of microorganisms and enzymes**
- ✓ **Lower cost and fewer environmental impacts**
- ✓ **Superior to traditional technologies**

**INNOVATIVE  
FOOD  
PROCESSING  
TECHNIQUES**



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graph LR; A[INNOVATIVE FOOD PROCESSING TECHNIQUES] --> B[THERMAL]; A --> C[NONTHERMAL]; B --> D[Microwave]; B --> E[Radiofrequency]; B --> F[Ohmic Heating]; B --> G[Induction Heating]; C --> H[High Hydrostatic Pressure]; C --> I[Pulsed electric fields]; C --> J[Ultrasound]; C --> K[Ultraviolet]; C --> L[Irradiation]; C --> M[Cold Plasma]; C --> N[Dense Phase CarbonDioxide]; C --> O[Ozone];
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**THERMAL**

- ❖ Microwave
- ❖ Radiofrequency
- ❖ Ohmic Heating
- ❖ Induction Heating

**NONTHERMAL**

- ❖ High Hydrostatic Pressure
- ❖ Pulsed electric fields
- ❖ Ultrasound
- ❖ Ultraviolet
- ❖ Irradiation
- ❖ Cold Plasma
- ❖ Dense Phase CarbonDioxide
- ❖ Ozone

# **NONTHERMAL PROCESSING**

**Pathogen  
Inactivation**

**Innovative  
Products**

**Shelf Life  
Extension**

**Enzyme  
Inactivation**

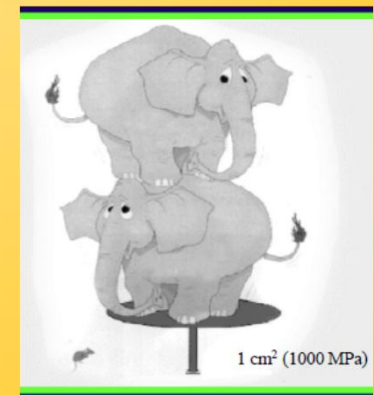
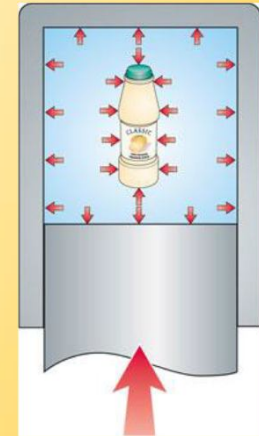
**Unwanted  
OR Reduced  
Constituent**

**Clean-label  
Products**



# High Pressure Technology

- High pressure kills microorganisms and preserves food - the fact was discovered in 1899
- Food Technologist accepted recently in 1980 that HPT has many things to offer to Food Industries
- HPT can replace/supplement conventional thermal processing and addition of chemical preservatives
- HHP treatment is an athermic decontamination process which consists in subjecting packaged food to water pressures from 100 to 900 MPa
- The pressure applied is iso-statically transmitted inside a pressure vessel



# **How High Pressure Can Preserve Foods?**

- **Similar to high temperature**
- **Death of MO due to permeabilization of cell membranes**
- **Changes – reversible at low pressure and irreversible at high pressure.**
- **Reduction of enzymes activity ensures high quality and shelf stable products**
- **Only non covalent bonds are affected - Little, if any, effects on organoleptic and sensorial characteristics**

# **The key advantages of HPT**

- ✓ **enables food processing at ambient temperature or even lower temperatures;**
- ✓ **enables instant transmittance of pressure throughout the system, irrespective of size and geometry, thereby making size reduction optional, which can be a great advantage;**
- ✓ **it causes microbial death whilst virtually eliminating heat damage and the use of chemical preservatives/additives, thereby leading to improvements in the overall quality of foods; and**
- ✓ **it can be used to create ingredients with novel functional properties**

## **Food that can be HP treated**

### **Solid foods, mainly vacuum packed**

- Dry-cured or cooked meat products
- Cheeses, Fish, seafood, marinated products
- Ready to eat meals, sauces
- Fruits, marmalades / jams, Vegetables

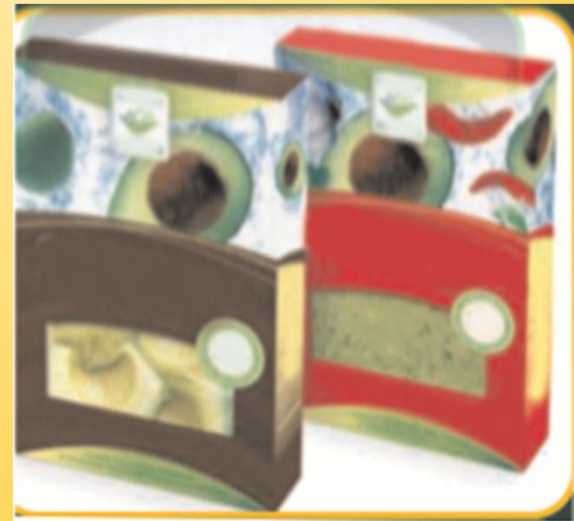


### **Liquid foods, in flexible packaging**

- Dairy products
- Fruit juices
- Nutraceutical formulations

## **Food that can not be HP treated**

- Solid foods with air included: Bread, Mousse
- Packaged foods in completely rigid packaging: In glass or canned
- Foods with a very low water content: Spices, Dry fruits



# **Physico-Chemical effects of HPP**

## **❑ On Food color and flavor:**

- Fresh/marinated meat - Iron in the myoglobin changes from ferrous to ferric and globin is denatured – the red color is lost**
- Cooked meat color is largely unaffected**
- Fruits and vegetables – slight modification**
- Fruit juices – little or no affect**
- Flavors are mostly unaffected**

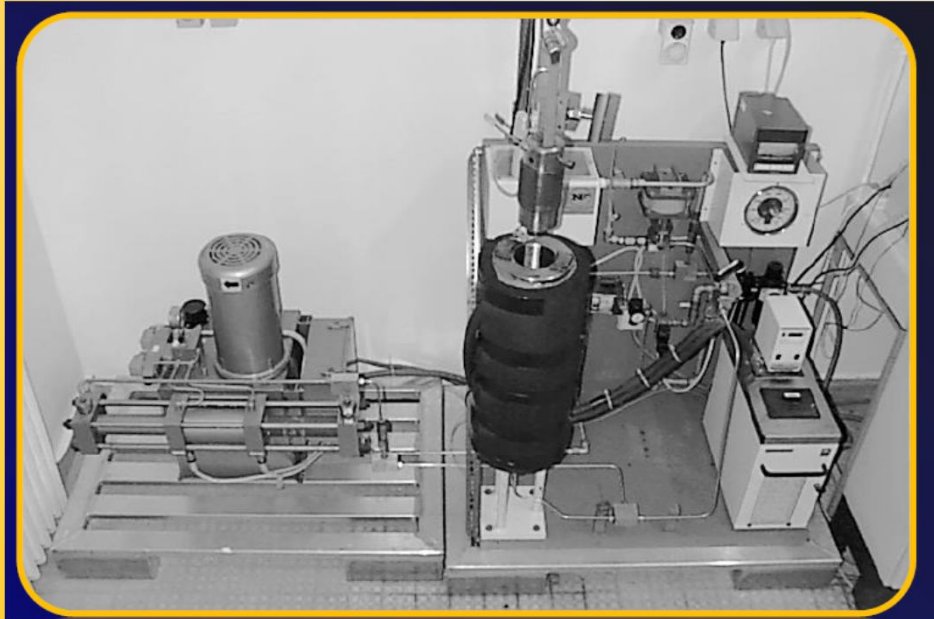
## **❑ On Food texture:**

- Slight softening**

## **❑ On fats and lipids**

- Reversible crystallisation**

## **National Forge Europe, Belgium**



**Working Volume 700 ml, Maximum  
working pressure 600 MPa**

## **Stansted Fluid Power, UK**



**Working Volume 2.0 liter, Maximum  
working pressure 900 MPa**

# Stansted 5L HP ISO-Lab Processing System



**Operating pressures 0 to 700MPa , temperatures from - 20 to 120°C**

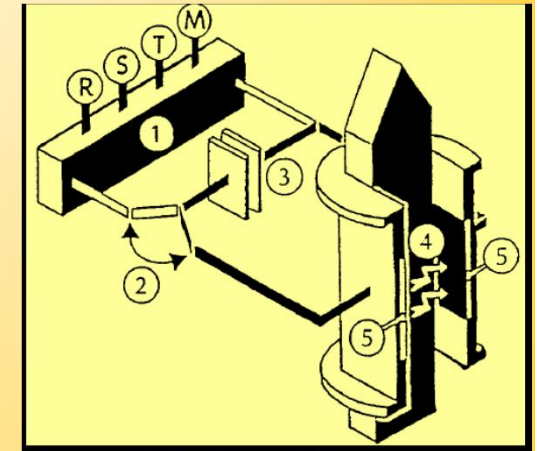


**Large-scale high pressure processing equipment Avure Technologies, USA**

# High Intensity Pulsed Electric Field

## Features

- ✓ Short burst of high voltage to a food placed between two electrodes
- ✓ Electric current is passed only for microseconds (short pulses) through the food
- ✓ Destroys cell membrane by mechanical effects without heating
- ✓ Inactivates enzymes
- ✓ Economic & Efficient energy use
- ✓ Microbiology safe
- ✓ Minimally processed
- ✓ Nutrition
- ✓ Fresh



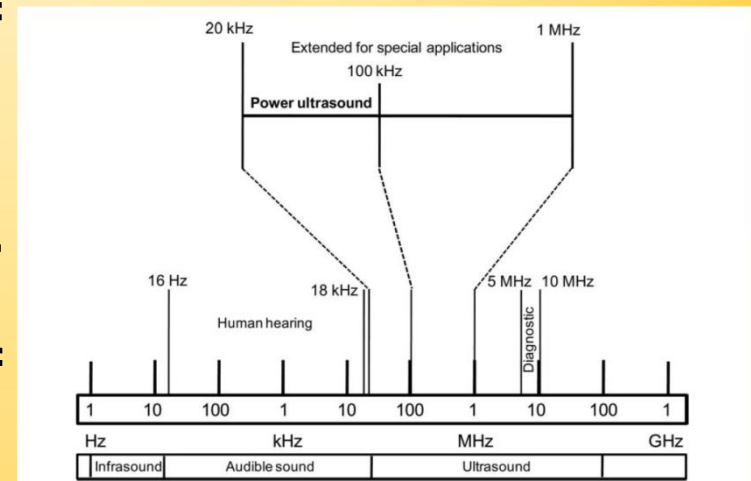
1. High voltage generator
  2. Switch,
  3. Capacitor,
  4. Medium,
  5. Electrodes,
- R,S,T,M connector points for the main supply

- ✓ **Microbial cells exposed to few  $\mu$ s results in cell breakdown, permeabilization**
- ✓ **Formation of electrolytic products or highly reactive free radicals, oxidation and reduction reactions within the cell structure disrupting metabolic processes and disruption of internal organelles and structural changes**
- ✓ **Minimum losses of flavor and food quality**
- ✓ **Low processing temperatures and short processing time allows energy efficiency**
- ✓ **Lower cost and fewer environmental impacts**

- ✓ **Avoids or reduces the detrimental changes of the sensory and physical properties**
- ✓ **Wide application range from increasing the efficiency of the process to food preservation processes**
- ✓ **Most ideal for heat sensitive fluid foods; Non fluid food and food containing particles can also be processed.**
- ✓ **Continuous application and the short processing time makes it an attractive candidate as a novel non-thermal unit operation**
- ✓ **Still substantial research and development activities are required to understand, optimize and apply this complex process to its full potential**

# Ultrasound Technique for food processing

- ✓ Ultrasonic waves have the ability to influence the biochemical and microbiological properties of food
- ✓ Ultrasound cause shear disruption, cavitation, thinning of cell membranes, localized heating, and free radical production, which have a lethal effect on microorganisms

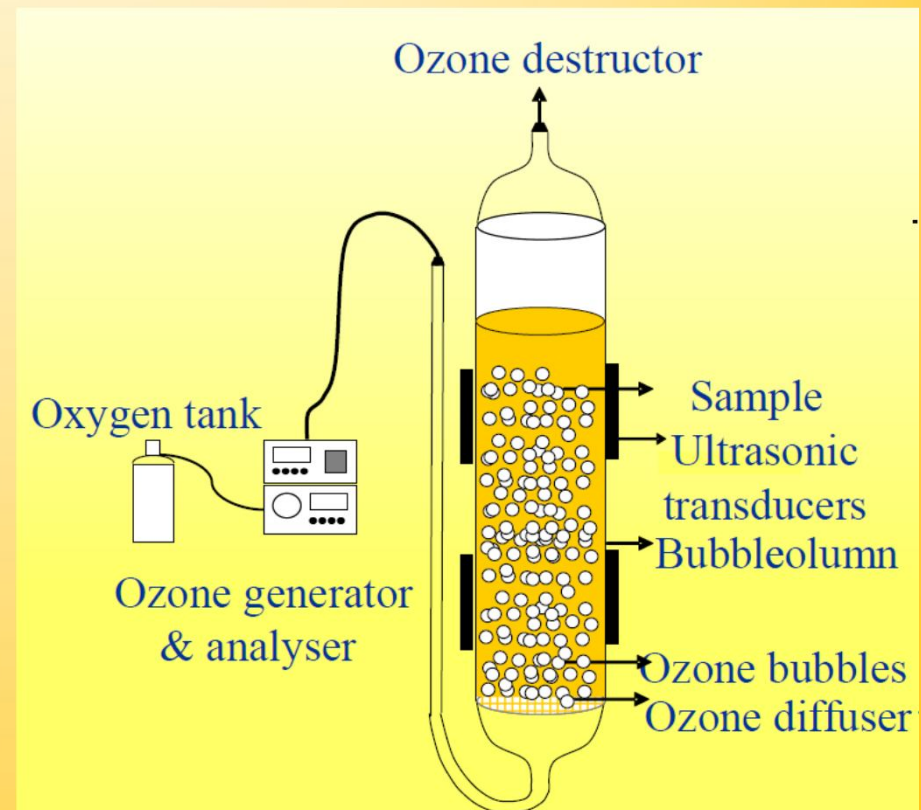


# **Ultrasound application in food industry**

- ✓ **Inactivation of microorganisms and enzymes**
- ✓ **Crystallization**
- ✓ **Drying**
- ✓ **Degassing**
- ✓ **Extraction**
- ✓ **Filtration**
- ✓ **Homogenization**
- ✓ **Meat tenderization**
- ✓ **Oxidation**
- ✓ **Sterilization**
- ✓ **Efficiency enhancement of various operations and**
- ✓ **Online detection of contaminants in foods**

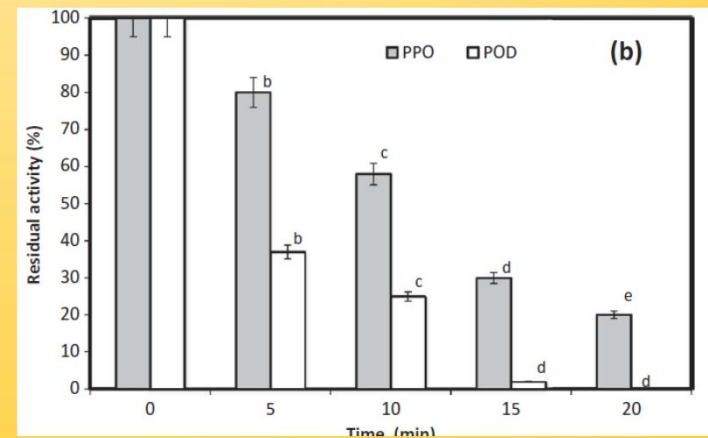
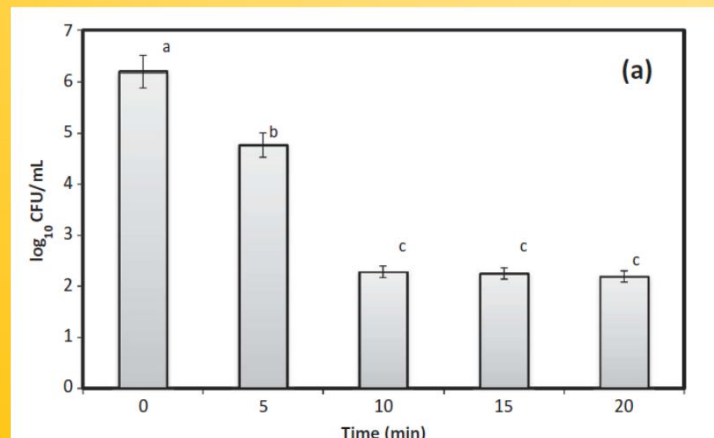
# Application of Ozone in Food Processing

- Ozone processing of liquid food is a non-thermal method of processing
- Active against bacteria, fungi, viruses, protozoa, and bacterial and fungal spores pertinent to fruits and vegetables and their products



# Advantages

- ✓ Ozone is a powerful antimicrobial agent
- ✓ Reacts faster than chlorine with many organic materials and produces fewer decomposition products
- ✓ Excess ozone auto-decomposes rapidly to produce oxygen (half-life 20 – 30 min at ~20°C), and thus it leaves no residues in food.
- ✓ Ozone processing results in color change for fruit juices such as apple cider and orange juice, blackberry juice, strawberry juice



Effect of ozone treatment on a) Aerobic plate count and b) browning enzymes of sugarcane juice

## **Combined treatment (Ozone and Ultrasound)**

- ✓ **Efficacy of can be increased by synergistic effect**
- ✓ **Disaggregating effect of ultrasound upon solid matter and on gas bubbles - increasing surface area**
- ✓ **Accelerates sedimentation of oxidizable organic matter -reducing ozone demand**
- ✓ **Microorganisms exposed to ultrasound become more sensitive to lower concentrations of ozone**

# **INNOVATIVE FOOD PROCESSING TECHNIQUES**

- ✓ **Regarded as techniques that can be used successfully in obtaining a food product with minimal loss of nutrients and less changes in the food structure and the sensory properties**
- ✓ **Shelf life extension without the use of preservatives or additives,**
- ✓ **Capital cost of equipment remains an issue, still offers a lot of opportunity to the food industry.**
- ✓ **Opportunity for the development of new foods**
- ✓ **Reduced energy and water consumption - decreasing the carbon and water footprint of food processing - towards environmental sustainability and global food security**

# **NEW INITIATIVES AT CSIR-CFTRI**

- **High pressure processing of fruit juices**
- **Application of ozone for decontamination of fruit juice**
- **Non-aqueous application of membrane technology - extraction and refining of edible oils which will eventually result in big energy savings in vegetable oil refining industries**
- **Advanced drying techniques - EMR Based Process for improved quality and energy savings**
  - ✓ **IR Drying of cashews - Reduced processing time, higher yield of whole kernels, improved whiteness**
  - ✓ **Hybrid drying – IR and Hot air/Microwave and hot air – Reduced processing time (30-40%); energy efficient (30-40% saving)**
  - ✓ **Enzyme inactivation – alternative to hot water blanching – retaining the water soluble nutrients**

- **Smart Packaging - spoilage indicators, self heating/cooling pouches**

Fresh Milk Indicator



Spoiled Milk Indicators



- **Vacuum Frying System - low fat snacks with better health benefits**



- **Low Glycemic products, gluten free products, millet based products**



- **Prebiotics & probiotics, nutraceuticals, natural flavors and colors**



- **Super foods – Quinoa, chia, teff, spirulina**



- **Specialty foods – anticancerous, antidiabetic**
- **Omega-3 fatty acid from new sources – Microbial, plants (Chia, Portulaca, Buglossoides)**



➤ **Natural antimicrobial compounds  
as food preservatives**

➤ **Natural food protectants**



➤ **Plant based meat alternatives**



**and Many more – Visit [www.cftri.com](http://www.cftri.com)**

# THANKS TO,



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