COURSE TITLE: FOOD AND INDUSTRIAL MICROBIOLOGY
COURSE NO. - DTM-321: CREDIT HRS-3 (2+1)

FOOD PRESERVATION

ADVANCE NON THERMAL METHOD OF PROCESSING -1

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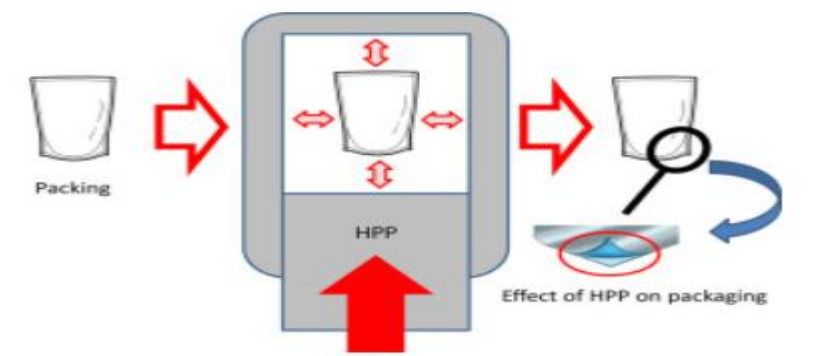

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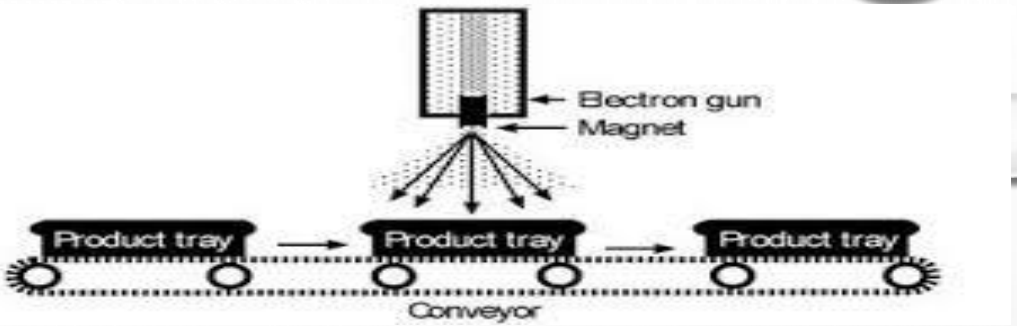
During food preservation, the processing method used ensures the safety and quality of food. The traditional technologies used during processing, such as pasteurization, high temperature sterilization, drying and evaporation can guarantee the microbiological safety or stability of their products, but can destroy some of the food ingredients, especially the heat sensitive vitamins and polyphenols, which were related to the quality of the food. Higher processing temperatures and longer process times during food processing also produce some potentially harmful components that threaten human

- The main problem with the thermal processing of food is loss of volatile compounds, nutrients and flavour.
- To overcome these problems non thermal methods came into food industries to increase the production rate and profit.
- The non thermal processing is used for all foods for its better quality, acceptance, and for its shelf life.
- The new processing techniques are mostly employed to the liquid packed foods when compared to solid foods.

Disadvantages of thermal processing are:

- It gives cooked flavor to food ex: milk
- It also change organoleptic properties of food.
- Alteration in nutritional properties occurs. Ex: Protein denaturation, Loss of Heat liable vitamins and some volatile flavors.
- It is also energy expensive one.

NON THERMAL PROCESSING



Why ?

- Since the non thermal methods are used for bulk quantities of foods, these methods of food preservation are mainly used in the large scale production.

- The cost of equipment's used in the non thermal processing is high when compared to equipment's used in thermal processing.

- After minimizing the investment costs of non thermal processing methods, it can also be employed in small scale industries.

NON-THERMAL PROCESS ARE:-

- Ohmic Heating
- Microwave heating
- Radio frequency heating
- Infrared heating
- High Pressure Processing
- Pulsed Electric Field
- Ultrasonics
- Pulsed Light Technology
- Irradiation
- Oscillating Magnetic Field

Ohmic heating

Ohmic heating is an advanced processing method where in the food material which serves as an electrical resistor, is heated by passing electricity through Which result in rapid and uniform heating.

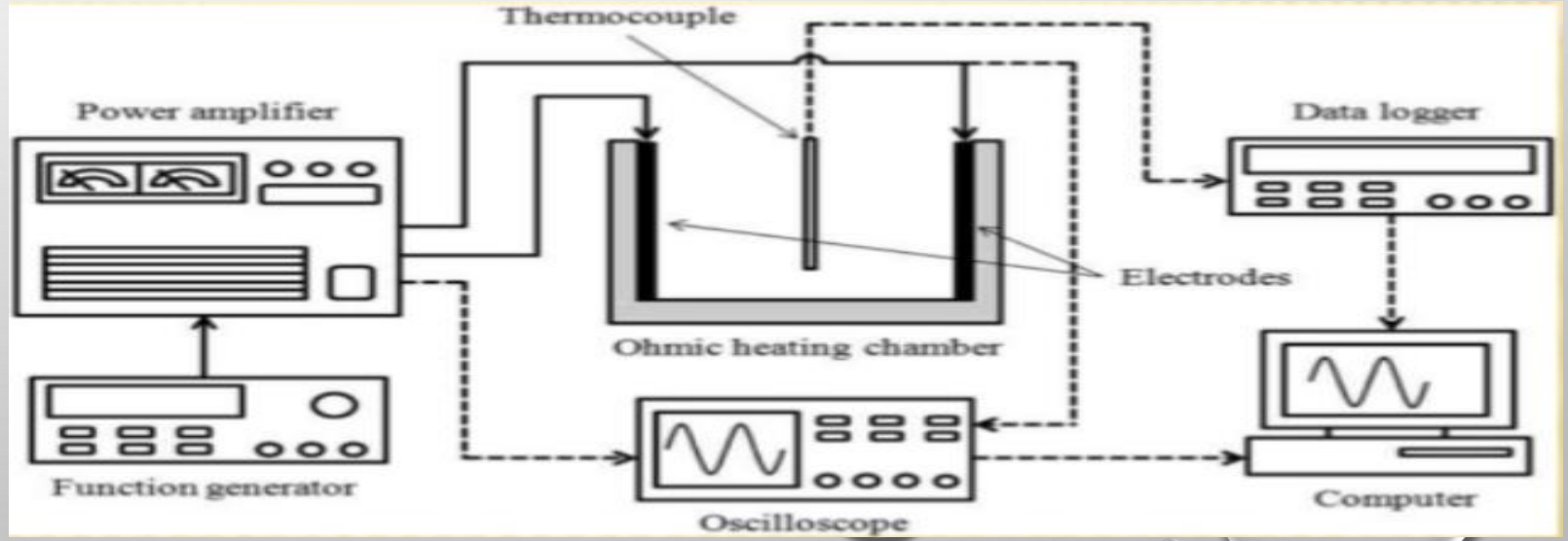
Ohmic heating takes its name from Ohm's law: The food material switched between electrodes has a role of resistance in the circuit. It is a process wherein electric current is passed through materials with primary purpose of heating. The electrical conductivity of food products usually increases with water content and temperature. There is a linear relationship between temperature (T) and electrical conductivity.

Electrical resistance heating or joule heating or electro-heating Important benefits

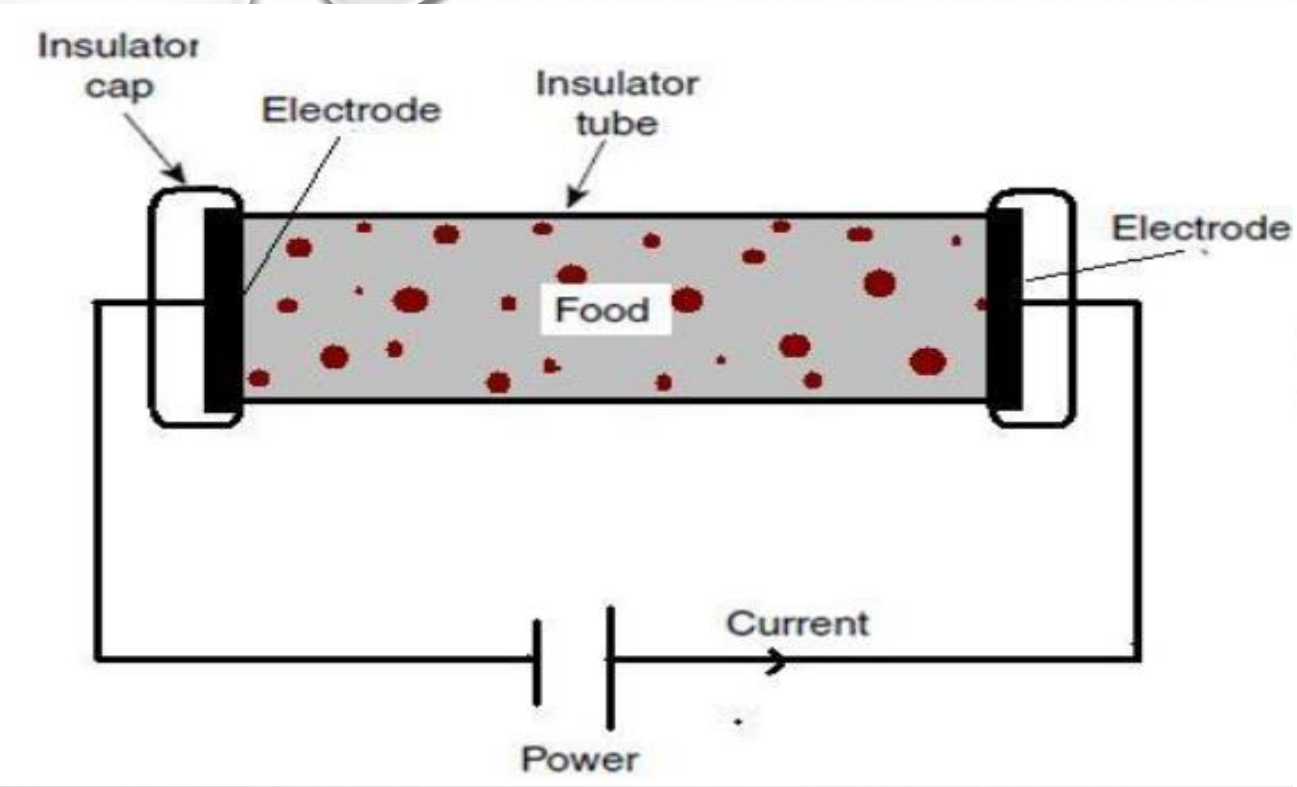
1. Fast Processing

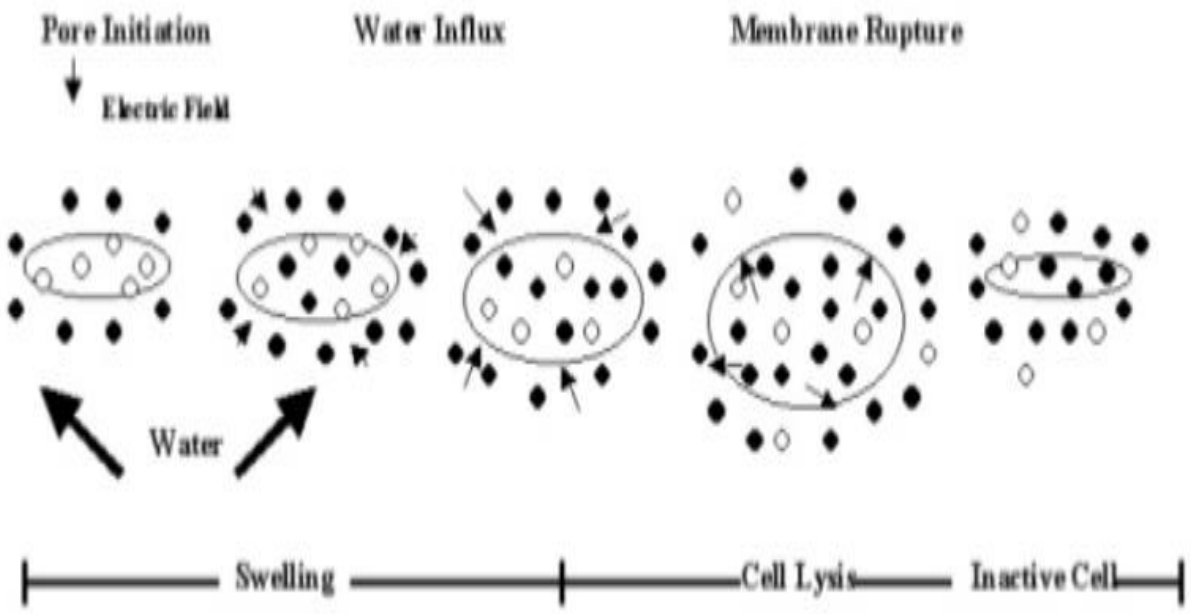
2. Homogeneous Treatment

3. More effective method



Mode of action – based on electroporation of cell





Ohmic heating results in faster heating of food along with maintenance of color and nutritional value of foods and it is an efficient alternative to the conventional heating method of enzyme inactivation, causes electroporation of cell membrane and also reduces energy requirement during processing.

- Electroporation is the formation of holes in a cell membrane due to individual ion pressure, which cause change in permeability of cell membrane.
- The low frequency used in ohmic heating (50-60Hz) allows cell wall to build up charges and form pores.

PRINCIPLE

- Based on the passage of alternating electrical current (AC) through a body such as a liquid-particulate food system which serves as an electrical resistance in which heat is generated.
- Foods contain water and ionic salts, capable of conducting electricity, but also have a resistance which generates heat when an electric current is passed through. This resistance produces heat.
- Inactivate microorganisms by heat and additional electroporatic effect.

WORKING ➜ Electrode: Platinized titanium electrodes are used to prevent leaching (coated with a high temp inert plastic material) (steel stainless steel electrodes are used working at frequencies of above 100 khz eliminates this problem) ➜ Temp 40-140 degree C for <90 sec followed by cooling for 15 minutes ➜ Pressure of up to 4 bar for UHT to prevent product from boiling.

Microwave Heating:

It refers to the use of electromagnetic waves of certain frequencies to generate heat in material. Container with food is placed in a microwave oven. And then oven is activated, the food at the edge of the container heats faster and a temperature gradient develops between the center and the edges.

Mechanism

Dipolar interaction: polar molecules such as water molecules (dipole) inside the food will rotate according to the alternating electromagnetic field. The rotation of water molecules would generate heat for cooking.

- Microwaves cause molecules in food to vibrate. This creates heat that cooks the food. Heat from the food warms the container that the food is in.
- Some areas get more microwaves, resulting in uneven cooking—hence rotating disk helps cook evenly
- Microwaves are attracted to water, fat, and sugar molecules causing them to vibrate and heat

Microwave Heating

Advantages	Limitations
Fast volumetric heating	High initial costs for industrial scale dryers
Higher drying rate	Partial loss of aroma and negative sensory changes
Short drying time	Product texture may be affected
Enhanced quality of the product	Specific sample size and shape may be required for effective drying
Reduced energy consumption	
Lower operating costs	

Mode of action:

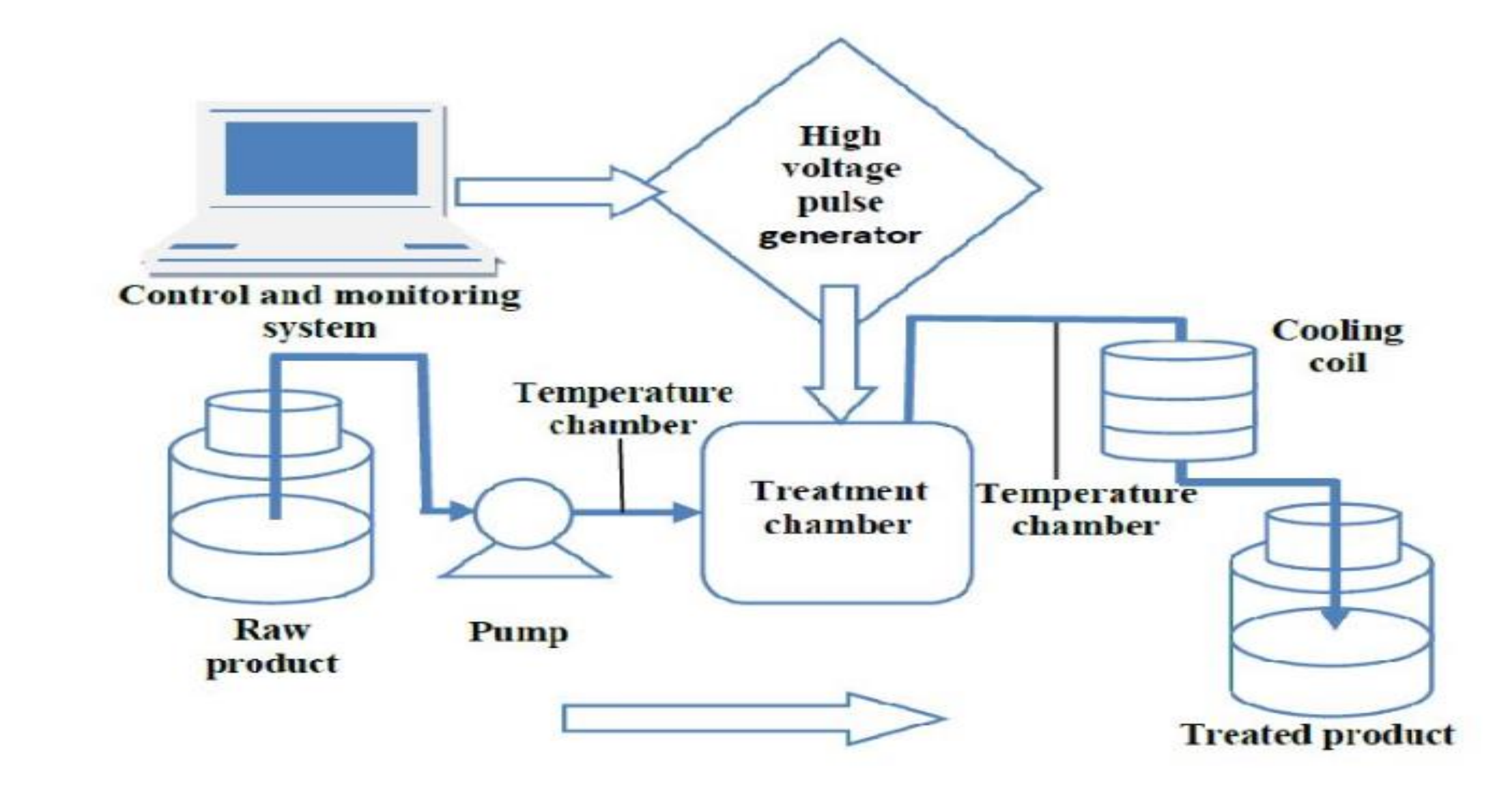
- Affects on bacteria, yeasts and moulds.
- Main sites of damages: nucleic acid and the lipids of the cell membrane
  - *Membrane lipid degradation*
  - *Change the permeability of the cell membrane*
  - *Leach out of cell components and*
  - *Inhibition of the DNA replication*
- Indirect effect: inhibitory effects of free radicals produced by the radiolysis of water.

PULSED ELECTRIC FIELD (PEF) TECHNOLOGY

PEF is a non-thermal food preservation technology that involves the discharge of high voltage electric pulses (up to 70 kV/cm) into the food product, which is placed between two electrodes for a few microsec.

- Pulsed electric field is also called High Electric Field Pulses (HELP)
- It is the application of very high field electric strength for a very short time to foods placed between electrodes.
- It uses short electric field pulses to preserve food.
- It works in intensity of 10-80 kV/cm with duration of micro to milli seconds.

Food is capable of transferring electricity because of the presence of several ions. So, when an electric filed is applied, electric current flows into the liquid food and is transferred to each point in the liquid because of charged molecules present. The food product experiences a force per unit charge called electric field, which is responsible for the cell membrane breakdown in microorganisms and interact with the charged molecules of food.



PULSED ELECTRIC FIELD (PEF) TECHNOLOGY

Advantages:

- Providing microbiologically safe food.
- Minimal processing of food.
- Enhance extraction of sugars and cellular contents, metabolites from plant cells.
- It helps in drying plant tissues.
- It helps in enzyme activity modification.
- Can be used synergistically with pre heat method, HPP and with antimicrobials like Nisin and lysosyme is under investigation.
- Useful for processing of semisolid and liquid foods.
- Since PEF kills cells and impairs water retention, it can aid in filtration methods.
- Can also be used for the extraction of sugars and starches from root vegetables.
- Continuous processing is possible.
- Applicable for acid foods, as spores will not germinate in acid foods.

Disadvantages:

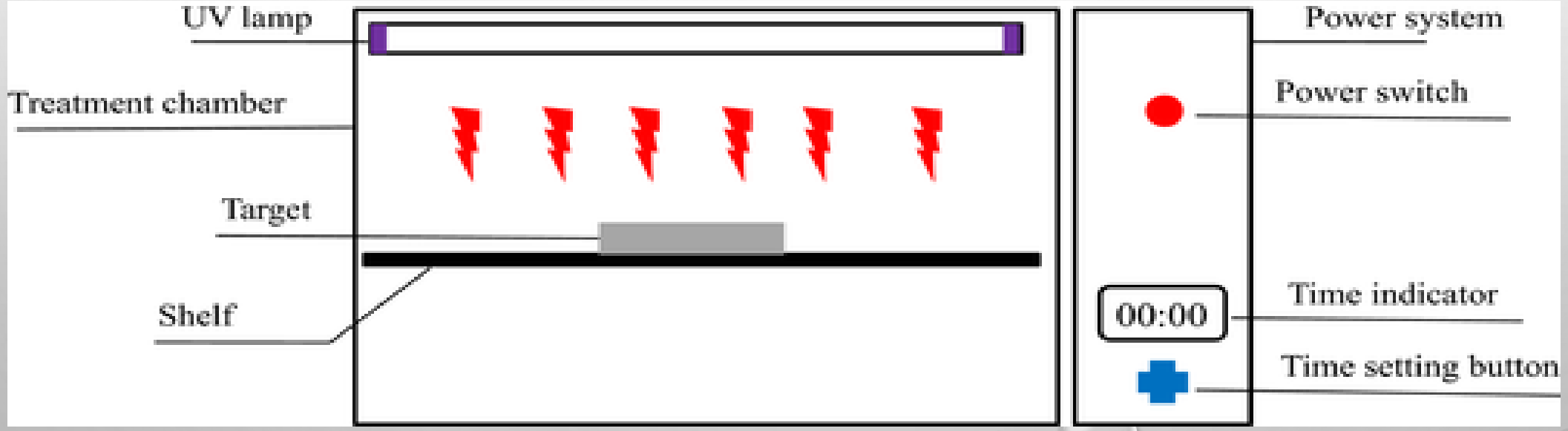
- It is an Expensive method.
- Still under research and development.
- Availability of commercial units is less.
- The method of inactivation is still theoretical and not clearly studied.
- Effectively depends on electrical conductivity of food.
- Not useful for solid foods.
- A reduction in electrode lifetime because of the release of particles and heavy metals from electrode may cause toxicity.

PULSED LIGHT (OR) HIGH INTENSITY LIGHT TECHNOLOGY

- High Intensity Light Technology can be used for the rapid inactivation of micro organisms on food surfaces, equipment's and food packaging materials.
- High intensity white light and UV light food preservation methods employ light wave lengths ranging from ultra violet to near infra-red in short intense pulse.
- Pulses of light used for food processing applications typically emit one to twenty flashes per second of electromagnetic energy
- It is generally accepted that UV plays a critical role in microbial inactivation.
- The treatment is most effective on smooth, nonreflecting surfaces or in liquids that are free of suspended particulates.
- In surface treatments, rough surfaces hinder inactivation due to cell hiding.

Pulsed UV-light

Pulsed UV-light is a technique to inactivate surface microorganisms using short pulses of an intense broad spectrum of ‘white light’ in the spectral band between 200 and 280 nm. Each pulse or flash of light lasts only a few hundred million or thousands of a second, but the intensity of each flash light is 20 000 times that of sunlight at sea level and contains some ultraviolet light. Under such conditions, the deoxyribonucleic acid (DNA) in the cells absorbs the UV light to form photoproducts in the DNA which interrupt both DNA transcription and translation, and then leads to the cell death.



Pulsed UV light system for treating foodstuffs

Mode of action

Photochemical effect	Photothermal effect

- **Pulsed Light**
  - rich broad spectrum ultraviolet content,
  - short duration,
  - high peak power and
  - the ability to regulate the pulse duration and frequency output
- **Ultraviolet** plays a vital role in the microbial cell inactivation.
- **The lethal effect** of pulsed light can be due to
  - Photochemical or
  - Photothermal mechanism or
  - Both may exist simultaneously.

- As DNA is the target cell for ultraviolet wavelengths so Primary target -nucleic acid

- Dimers inhibit the formation of new DNA chains in the process of cell replication resulting in the chologenic death of affected microorganisms by ultraviolet.

HIGH PRESSURE PROCESSING (HPP)

- High Pressure Processing is also known as “High Hydrostatic Pressure” or “Ultra High Pressure” processing. HPP uses up to 900 MPa to kill many of the micro organisms found in foods even at room temperature without degrading vitamins, flavor and colour molecules in the process.

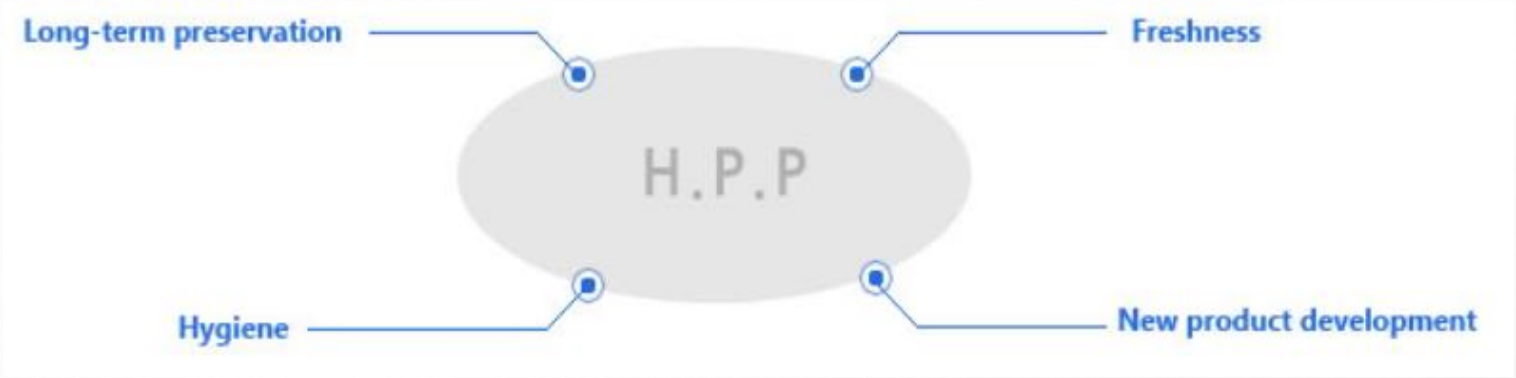
- Food packages are loaded onto the vessel and the top is closed.

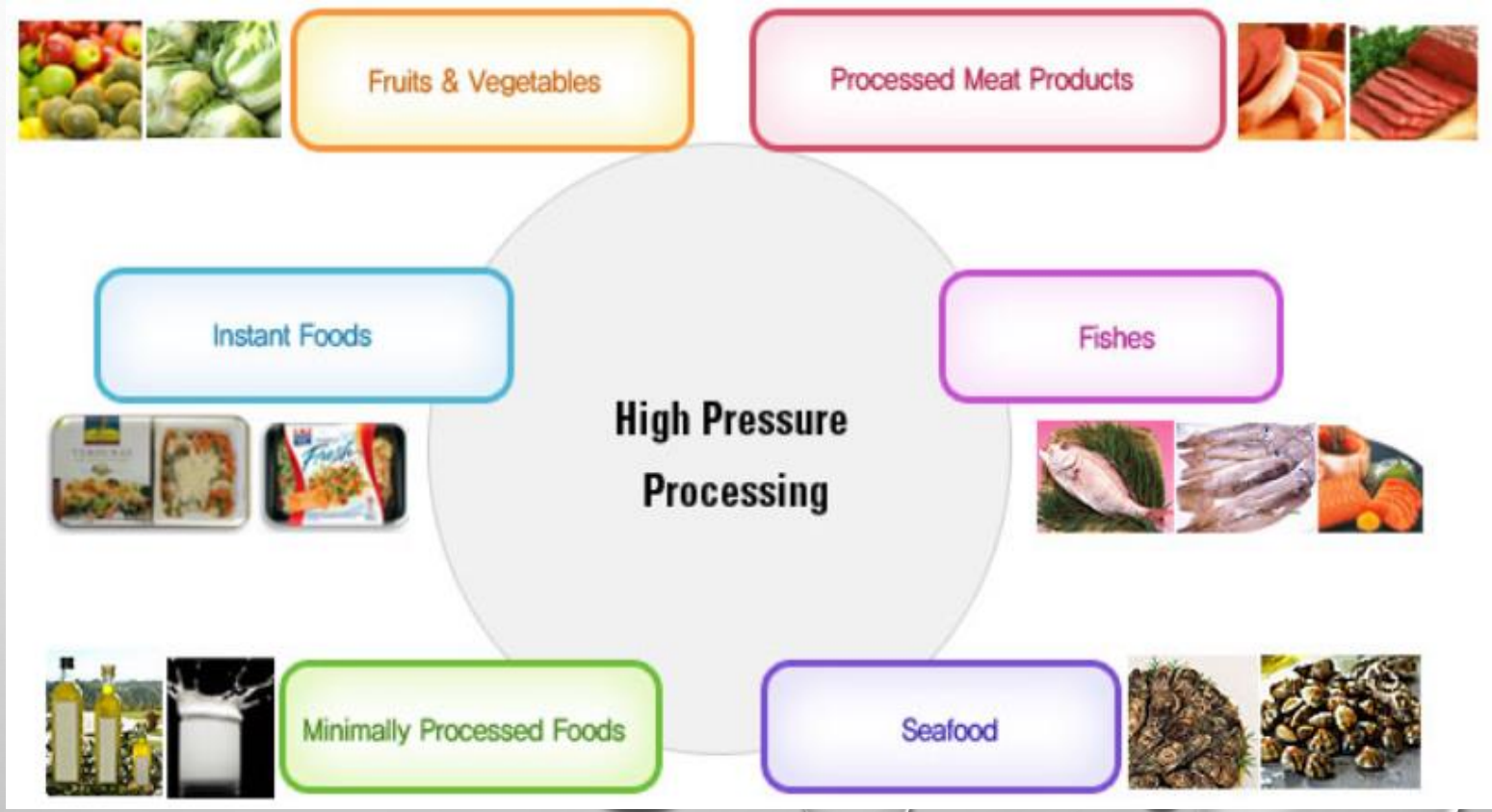
- The pressure medium usually water is pumped into the vessel from the bottom.

- Once the desired pressure is reached, the pumping is stopped, valves are closed, pressure can be maintained without further need for energy input.

Principle: A principle underlying HPP is that the high pressure is applied in an “isostatic” manner such that all regions of food experience a uniform pressure, unlike heat processing.

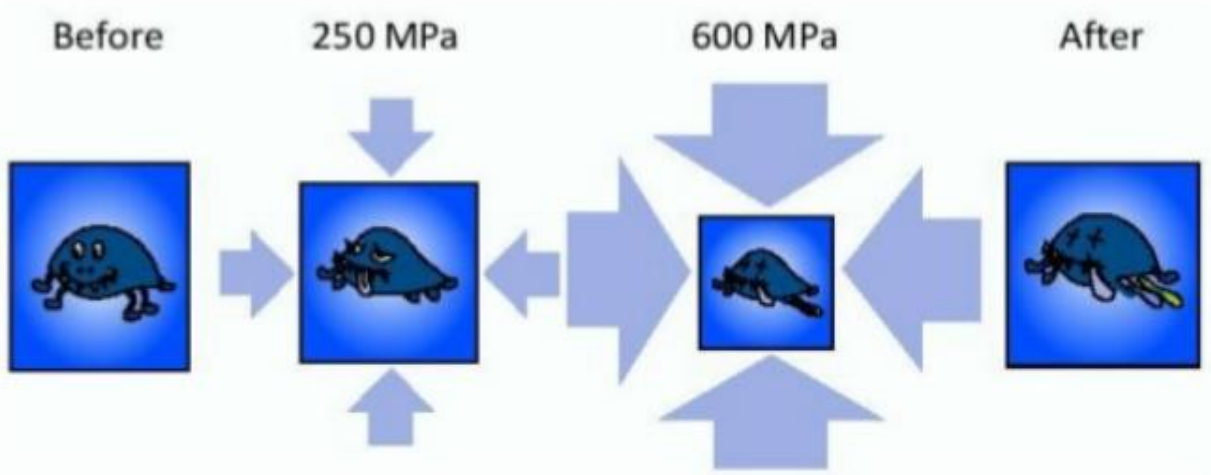
High Pressure Processing (HPP) is a cold pasteurization technique by which products, already sealed in its final package, are introduced into a vessel and subjected to a high level of isostatic pressure (300–600MPa / 43,500-87,000 psi) transmitted by water.



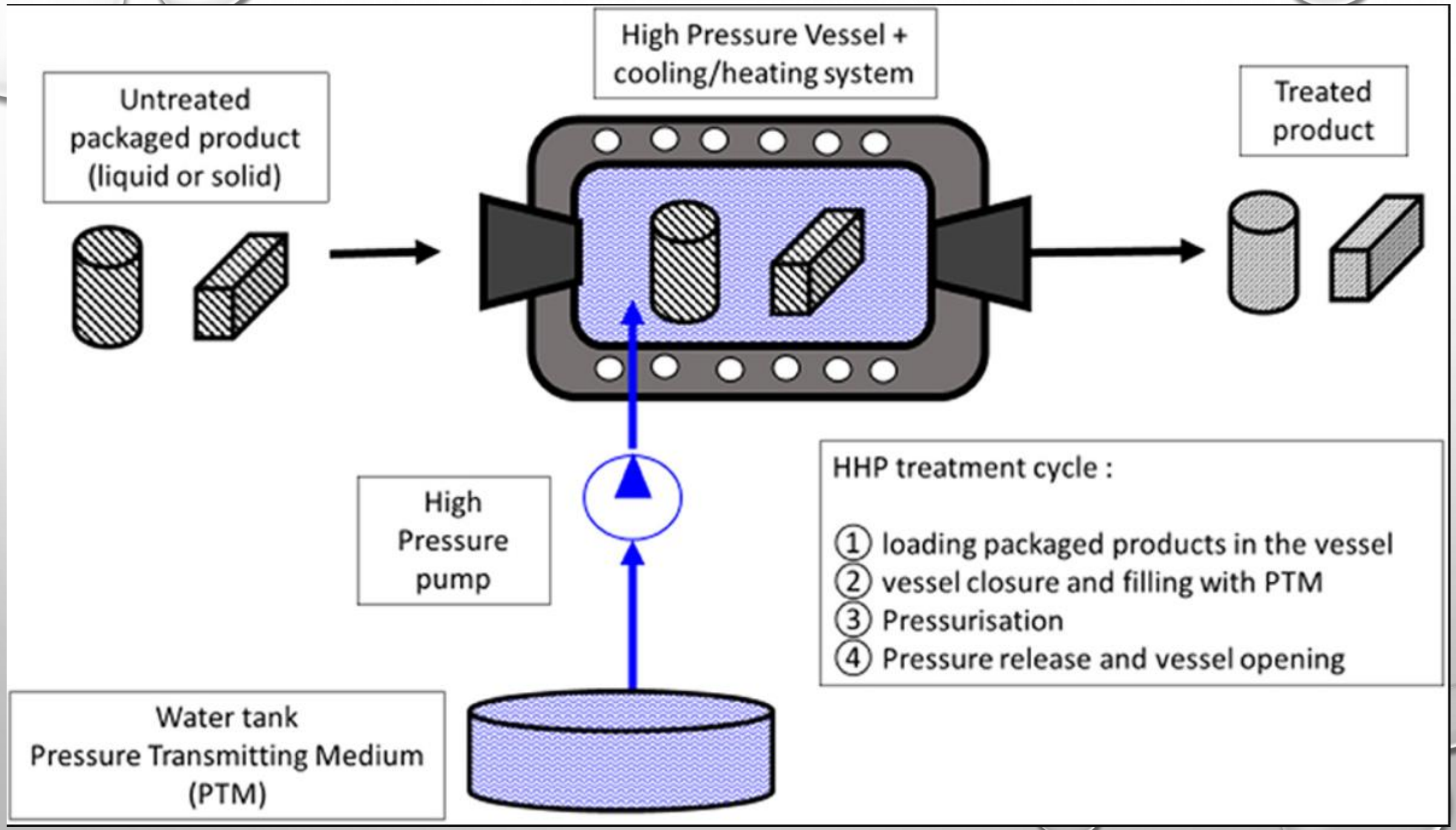


Features:

- Application of high pressures can cause:
  - Inactivation of Parasites, Plant cells.
  - Vegetative micro-organisms.
  - Some fungal spores.
  - Many food borne viruses.
  - Enzymes are selectively inactivated.
  - Macro molecules can change conformation.
  - Small molecules (eg: flavors) are generally unaffected
- High pressure is instantaneously and uniformly applied to the sample.
- Compression is fully reversible.



High pressure can kill microorganisms by interrupting their cellular function without the use of heat that can damage the taste, texture, and nutrition of the food.


High Pressure Vessel + cooling/heating system
Untreated packaged product (liquid or solid)
Treated product
High Pressure pump
HHP treatment cycle :
① loading packaged products in the vessel
② vessel closure and filling with PTM
③ Pressurisation
④ Pressure release and vessel opening
Water tank
Pressure Transmitting Medium (PTM)

What is the effect of HPP on microorganisms?

In HPP operations, (400-600 Mpa) pressure is normally used for two minutes or greater. the high pressure applied to foods at room temperature will reduce numbers of most vegetative bacteria by up to 4 log units or greater and inactivate certain enzymes with only a small change in the organoleptic properties of the food. However, the resistance of bacteria and other microorganisms to HPP is highly variable, e.g. some gram positive bacteria such as *Listeria monocytogenes* can exhibit higher resistance than gram negative bacteria such as *Salmonella*. Spores of both bacteria and molds are largely resistant to inactivation by HPP. Viruses have a wide range of pressure resistance, depending on their structural diversity.

The effectiveness of HPP treatments will be dependent on the pressure applied, the holding time, temperature, the type of food matrix and the target organism.

THANK YOU