UNIT IV – TOPIC 4

Blanching, Pasteurization, Sterilization

Understanding thermal processing in food preservation

Thermal processing refers to the application of heat to food products to eliminate or reduce microorganisms, inactivate enzymes, and extend shelf life. These processes work by disrupting cellular structures, denaturing proteins, and halting biological activities that lead to food spoilage. The selection of an appropriate thermal process depends on several factors, including the food's pH, water activity, initial microbial load, and desired shelf-life.

In the Indian context, thermal processing has particular significance given the tropical climate that accelerates food spoilage and the need for effective preservation methods to reduce post-harvest losses, which can reach up to 40% for some produce. Let's explore the three main thermal processes used in food preservation: blanching, pasteurization, and sterilization.

Blanching: The crucial first step

Blanching is a mild heat treatment typically applied to fruits and vegetables before freezing, canning, or drying. This pre-processing step serves several important functions that help maintain food quality during subsequent processing and storage.

The science behind blanching

Blanching involves briefly immersing food in hot water (82-100°C) or exposing it to steam for a short period (usually 1-10 minutes). This process primarily targets enzymes like polyphenol oxidase, peroxidase, and lipoxygenase, which are responsible for enzymatic browning, off-flavor development, and texture degradation. By denaturing these enzymes, blanching helps preserve the color, flavor, and nutritional value of foods.

Additionally, blanching reduces the initial microbial load on food surfaces, removes trapped air from plant tissues (important for canning), and helps maintain the natural bright color of vegetables by setting chlorophyll. For leafy greens like spinach and fenugreek (methi), blanching can reduce their volume significantly, making them easier to package and store.

Blanching methods

Several blanching methods are employed in food processing:

- **Water blanching:** Food is immersed in hot water (typically 75-95°C). This method provides uniform heating but can lead to leaching of water-soluble nutrients.
- **Steam blanching:** Food is exposed to steam, which reduces nutrient loss compared to water blanching but may require longer processing times.
- **Microwave blanching:** A newer method that uses microwave energy for rapid heating, offering quicker processing times and better nutrient retention.
- **Hot air blanching:** Food is exposed to heated air, which is less common but useful for certain applications.

For home preservation, water blanching remains the most accessible method. Common examples include blanching green beans for 3-4 minutes or spinach for 2 minutes before freezing. In industrial processing, continuous steam blanchers are often preferred for their efficiency and reduced nutrient loss.

Testing blanching effectiveness

In commercial operations, the effectiveness of blanching is typically assessed through the peroxidase test. Peroxidase is one of the most heat-resistant enzymes naturally present in plant foods. If peroxidase is inactivated, it generally indicates that other less heat-resistant enzymes have also been adequately destroyed. A simple test involves adding a few drops of hydrogen peroxide and guaiacol to blanched tissue – a color change indicates residual enzyme activity, suggesting inadequate blanching.

Pasteurization: Balancing safety and quality

Named after Louis Pasteur, who first demonstrated the process in the 1860s, pasteurization involves heating food to a specific temperature for a defined period to kill pathogenic microorganisms while minimizing changes to the food's nutritional and sensory qualities.

The principles of pasteurization

Unlike sterilization, pasteurization is a relatively mild heat treatment that aims to destroy pathogenic microorganisms and reduce the number of spoilage microorganisms to extend shelf life. The process does not eliminate all microorganisms but reduces them to levels that are safe for consumption and allows for a reasonable shelf life under proper refrigeration.

Pasteurization is particularly important for dairy products, fruit juices, and liquid egg products. In India, where the unorganized sector handles about 80% of milk production, the implementation of proper pasteurization techniques is crucial for public health.

Time-temperature combinations

Pasteurization relies on specific time-temperature combinations to achieve the desired microbial reduction. The two primary approaches are:

- **Low-temperature long-time (LTLT) or batch pasteurization:** Food is heated to 63-65°C and held for 30 minutes. This method is less energy-intensive but more time-consuming.
- **High-temperature short-time (HTST) or continuous pasteurization:** Food is heated to 72-75°C for 15-20 seconds. This is the most common method used in modern dairy processing.
- **Ultra-high temperature (UHT) processing:** Food is heated to 135-150°C for 1-5 seconds. While technically closer to sterilization, UHT is often considered an extended pasteurization method that produces commercially sterile products with extended shelf life without refrigeration.

For milk pasteurization in India, the HTST method is widely used in organized dairy processing plants, while small-scale operations might still use the LTLT method. The selection depends on available technology, energy costs, and product specifications.

Pasteurization's impact on nutrition

One common misconception is that pasteurization significantly reduces the nutritional value of foods. While there is some loss of heat-sensitive vitamins (primarily vitamin C and some B vitamins), the impact is relatively minor compared to the safety benefits. Proteins, carbohydrates, fats, minerals, and most vitamins remain largely unaffected.

In the context of milk, pasteurization causes minimal changes to protein quality, calcium bioavailability, or overall nutritional profile. Studies have shown that pasteurized milk retains approximately 80-90% of its vitamin content, with the exception of more significant losses in thiamine and vitamin C.

Sterilization: Ensuring long-term stability

Sterilization represents the most intense thermal process and aims to eliminate all microorganisms, including spores, to achieve commercial sterility. This level of treatment allows food to be shelf-stable at room temperature for extended periods.

Commercial sterility vs. absolute sterility

"Commercial sterility" refers to a condition where all pathogenic and toxin-forming microorganisms have been destroyed, along with other microorganisms that could grow under normal storage conditions. This differs from "absolute sterility" (used in medical applications), as commercially sterile foods may still contain some extremely heat-resistant bacterial spores that cannot grow under normal conditions.

The target microorganism for sterilization processes is typically *Clostridium botulinum*, which produces highly heat-resistant spores and potentially fatal toxins. The sterilization process is designed to achieve a 12-log reduction of *C. botulinum* spores (known as the "botulinum cook").

Sterilization methods

Several sterilization methods are employed in food processing:

- **In-container sterilization:** Food is filled into containers (cans, retort pouches, glass jars) which are then hermetically sealed and heat-processed in pressure vessels called retorts. This is the traditional canning process, operating at temperatures of 116-121°C for varying times (20-40 minutes).
- **Aseptic processing:** Food is sterilized continuously through a heat exchanger and then packaged in pre-sterilized containers under aseptic conditions. This allows for faster heating and cooling, resulting in better product quality.
- **Ultra-high temperature (UHT) processing:** Food is heated to 135-150°C for very short times (seconds) and then aseptically packaged. This method is commonly used for liquid products like milk and fruit juices.

In India, both traditional canning and newer aseptic processing technologies are used. UHT milk has gained popularity due to its ambient storage stability, which is particularly valuable in regions with limited cold chain infrastructure.