Hurdle Technology

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Introduction

Hurdle technology is a concept developed to meet the consumer demand for more natural and fresh food products. It is a preservation method that combines multiple preservation techniques to inhibit microbial growth and extend the shelf life of food products. By using various "hurdles" such as temperature control, pH adjustment, reduction of water activity and preservatives. The overall effectiveness of preservation is enhanced due to the combined effect of the overall hurdles. Hurdle technology also known as combined methods, combined processes, combination preservation, or combination techniques was developed to produce safe, stable, nutritious, tasty, and affordable foods. The core idea is to use a combination of existing and novel preservation techniques "hurdles" to eliminate microbial growth. This technology is designed to reduce the use of preservatives in food and aims to establish an additional antimicrobial effect through the combined impact of hurdles, thereby improving the quality of food products. The minimally processed fruits and vegetables have a large market share, due to increased consumer preference by the virtue of added advantages of convenience of the minimally processed fruits and vegetables for preparation of fresh salads and healthy foods (Valverde *et al*., 2010; De Corato, U. 2020).

Aspects of Hurdle Technology

Hurdle technology influences the physiology and growth of microorganisms in food. Primarily, it works through four major mechanisms to impact microbial growth:

a. Homeostasis: Homeostasis is a process that maintains the internal stability of living cells in response to changes in their external environment. Examples of homeostasis in organisms include temperature regulation and balancing acidity and alkalinity. Disrupting microbial homeostasis through various hurdles eventually causes the death of microorganisms responsible for food spoilage, thus protecting food from microbial degradation (Gould, G. W. 1988).

b. Metabolic Exhaustion: This aspect of hurdle technology relates to the auto-sterilization of food. Studies have shown that the number of spores in hurdle-treated food products decreases during storage, particularly at ambient temperatures. Microorganisms in hurdle-treated stable products use their energy to maintain homeostasis, which leads to metabolic exhaustion. This results in the auto-sterilization of food products, making microbiologically stable products safe for storage at normal room temperatures. (Leistner, L.1995).

c. Stress Reactions: Some microorganisms develop resistance or become more toxic under stressful conditions as they synthesize stress-shock proteins. The synthesis of stress-shock proteins is influenced by factors such as water activity, ethanol, and heat. Microbial responses to stress conditions can hinder food preservation. Exposure to multiple stresses simultaneously activates the energy-intensive synthesis of multiple stress-shock proteins, leading to the metabolic weakening of the microorganisms. Thus, multi-targeted preservation of food can reduce the synthesis of stress-shock proteins, making it an effective strategy for food preservation (Leistner, L.1995).

d. Multi-Targeted Preservation of Food: This is a critical aspect of the efficient and effective preservation of targeted food items. The hurdles applied to targeted food not only influence microbial stability but also work concurrently. A synergistic effect can be achieved if the hurdles simultaneously affect different targets like pH, water activity (aw), Eh, and enzymatic systems within microorganisms. This disrupts the homeostasis of microorganisms, making it challenging for them to synthesize stress-shock proteins and maintain homeostasis (Leistner, 1978).

Types of Hurdles

Hurdles used for food preservation are broadly categorized into physical, physico-chemical, and microbiological types:

1. Physical

Ionizing radiation, low temperatures, aseptic packaging, high temperatures, modified atmospheres, UV radiation, electromagnetic energy, ultrasonification, packaging films, ultra-high pressures and photodynamic inactivation.

2. Physico-Chemical

Sodium nitrate, potassium sulfite, phosphates, salts, spices, herbs, carbon dioxide, ozone, organic acids, surface treatment agents, lactic acid, low redox potential, reduced water activity, smoking, Maillard reaction products.

3. Microbiological

Bacteriocins, protective cultures, competitive flora, antibiotics.

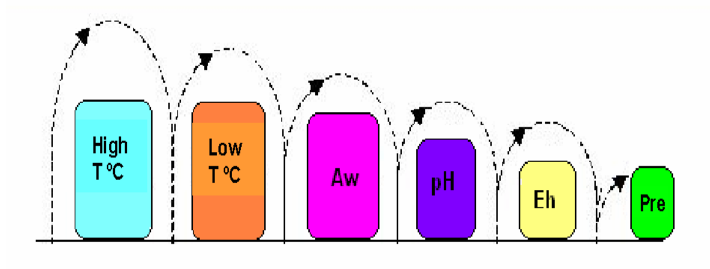

Fig. 1. Pictorial representation of Hurdle Technology

Mechanism

Microorganisms respond to stress factors through homeostatic reactions. When stress factors disrupt their environment, microorganisms usually react by stabilizing certain key elements of their physiology. They undergo several important homeostatic responses. Some key homeostatic responses to stress factors are as follows:

Stress Factor	Homeostatic Response
Reduced nutrient availability	Searching for nutrients; 'stationary-phase response'
Decreased pH level	Proton efflux across the cell membrane; transmembrane pH gradient
Decreased water activity	Accumulation of 'compatible solutes'; prevention of water loss
Lower growth temperature	'Cold shock' response; alteration in membrane lipids for fluidity
Higher growth temperature	'Heat shock' response; alteration in membrane lipids
Increased oxygen level	Enzyme protection from free radicals produced by H_2O_2 and oxygen
Presence of biocides	Reduced permeability of the cell wall/membrane
High hydrostatic pressure	Unclear; potentially reduced spore water content

Applications of Hurdle Technology in Different Products

Hurdle technology is an innovative concept used for preserving various food products:

i. Dairy Products

- Hurdle technology extends the shelf life of many dairy products.
- Shelf-stable cheese can be prepared using hurdles like pH, water activity (aw), preservatives and modified atmosphere packaging.
- Brown peda, a traditional Indian milk-based product, can also be prepared and preserved through hurdle technology.

ii. Fruits and Vegetables

- Hurdles are essential in preserving various fruits and vegetables like carrots, pineapples, coconuts and papayas, enhancing their stability and shelf life.
- Shelf-stable ready-to-eat intermediate-moisture pineapple can be developed using hurdle technology, extending its shelf life.
- Osmotic dehydration, infrared drying, and gamma irradiation have successfully reduced microbial load in pineapple slices, extending shelf life up to 40 days.
- Hurdle technology has been used for preserving fresh coconut through humectants, acidulants, and preservatives.
- Minimally processed shelf-stable high-moisture grated papaya can also be prepared using hurdles like mild heat treatment, reduced aw and pH and the addition of preservatives.

iii. Fruit-Based Products

- Both traditional and novel hurdle strategies are effectively used for preserving various fruit products.
- Hurdles like UV light, pulsed light, ultrasound and high hydrostatic pressure are employed in fruit processing.
- This technology is based on combining heat treatment and antimicrobials for preserving high-moisture fruit products like peaches, pineapples, papayas, mangoes and bananas.

iv. Meat and Meat Products

- Hurdle technology is used in several meat products.
- In pork sausages, hurdles like pH, aw, vacuum packaging and post-packaging treatment are applied at refrigerated temperatures.
- Shelf-stable ready-to-eat pickle-type spiced buffalo meat products are prepared and preserved by controlling hurdles like pH, water activity, FFA,

soluble hydroxyl proline, TBA value, nitrite content and protein solubility.

Conclusion

The use of hurdle technology in food preservation has transformed how foods are preserved in recent years. It allows for the consumption of more natural foods with minimal nutrient and sensory quality loss. Food safety has improved, and the storage period of many perishable foods has been extended. Resistant microorganisms are being tackled and many can be eliminated through smart combinations of preservatives. Exploring new hurdles and understanding their properties in combination with existing preservation techniques will open new research avenues.

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