Preservation of Products
The Control of Microbial Growth

Growth

Absolute Factors

- Nutrients
- pH
- Temperature
- Oxygen

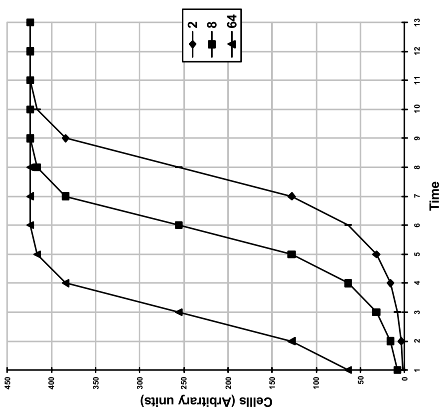
Rate-Determining Factors

- Mass transfer rate
- Energy transfer rate

The Microbial Growth Curve

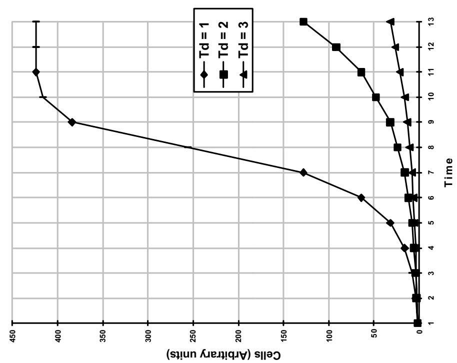
- The microbial growth curve is a record of cell numbers over a time period.
- Absolute and rate-determining factors determine the shape of the microbial growth curve.

Effect of the Microbial Load



The time period to maximal population size is dependent on the initial microbial load or inoculum size.

Effect of Opportunity



- Opportunity for growth is determined environmental factors.
- Unfavorable conditions prolong the lag phase and slow the growth rate.

Microbiological QA & the Microbial Growth Curve

Microbiological QA is centred around obtaining an *appropriate shape* in the *growth curve*

Microbiological Quality Assurance

Assuring a wholesome product

- **Food safety**
  Requires assuring minimal numbers of specific microrganisms.
- **Spoilage**
  Requires the control of microbial proliferation.

Both aspects are allied and mutually supportive.

Physicochemical Properties of the Product & Microbial Growth

a. Hydrogen-Ion Concentration

- **pH; optimal enzymatic activity; optimal growth**
- **Buffering capacity**

b. Oxidation-Reduction Potential (*Eh*)

- **Positive *Eh* (mV): Aerobic conditions**
  Negative *Eh* (mV): Anaerobic conditions
- **Influenced by the**
  - **nature of the product**
    Eh characteristic
    Poising capacity
  - **gaseous environment the product**

Oxygen tension and access to the atmosphere

c. Water Activity (A*w*)

- **Without water, no growth can occur.**
- **A solution's A_w is the**
  Ratio of the vapor pressure of the solution to the vapor pressure of water.
- **Solute concentration determines the A_w of a solution.**
- **A*w* can also be determined by the amount of water present.**

d. Content of Nutrients & Chemical Inhibitors, and Structure

- **Type of nutrient** — Carbohydrates; Proteins; Fats
- **Complexity of the nutrient** — Polymers; monomers
- **Naturally occuring inhibitors** — *e.g.* Lysozyme; benzoic acid
- **Nature of the

substrate** — *e.g.* Fat layers; fish scales; size

Preservation of Product in Perspective

a. Control of Microbial Growth

- Exclusion of microbial load
- Removal of microbial load
- Inhibition of growth
- Destruction

b. Prevention or delay of self-decomposition

- Destruction or inactivation of food enzymes
- Prevention or delay of chemical reactions

c. Prevention of mechanical, pest and other damage

Methods of Product Preservation 1

Mode of action	Preservation factor	Mode of achievement
Inactivation of microorganisms	Heat	Pasteurization Sterilization
	Chemical	Gaseous Liquid
	Radiation	Radicidation Radurization Radappertization
Restriction of access of microorganisms to product	Filtration	Membrane filters
	Decontamination	Ingredients Packaging materials
	Aseptic or clean handling	Clean processing Aseptic processing Aseptic or clean packaging
	Packaging	

After Frazier & Westhoff (1988)

Methods of Product Preservation 2

Mode of action	Preservation factor	Mode of achievement
Inhibition of growth rate	Cool	Chill Freeze
	Restrict water	Dry Add solutes
	Restrict oxygen	Vacuum pack Nitrogen pack
	Increase carbon dioxide	CO_2 pack
	Acidify	Add acids Acidic fermentation
	Alcohol	Fermentation Fortification
	Chemicals	Add inorganic or organic preservatives Add antibiotics Use smoke

After Frazier & Westhoff (1988)

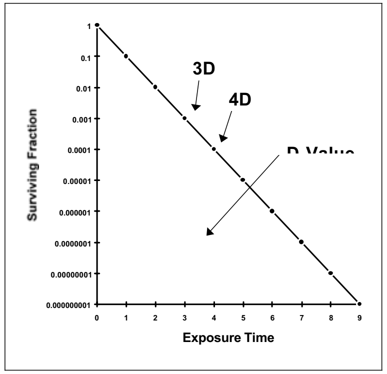
Methods of Product Preservation 3

1. Inactivation of Microorganisms by Heat

a. Kinetics of Microbial Inactivation

The *D*-Value

$$D = \frac{t}{\mathrm{Log}_{N0} - \mathrm{Log}_{Nt}}$$



The exposure time required for the number of survivors to change by a factor of 10 or the population to be reduced by 90%.

Kinetics of Microbial Inactivation 1

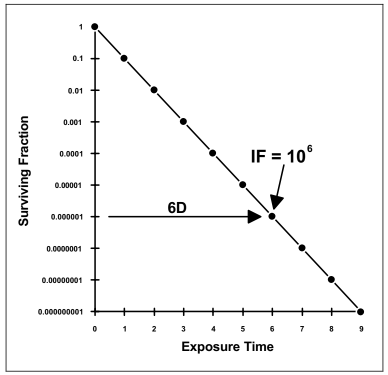
ii. The Inactivation Factor

The reduction in the number of viable microorganisms brought about by the process.

$IF = 10^{t/D}$

Where t = Exposure time
D = *D*-Value for the microorganism under the exposure conditions.

A process that achieves 12D has an IF of 10^{12}.

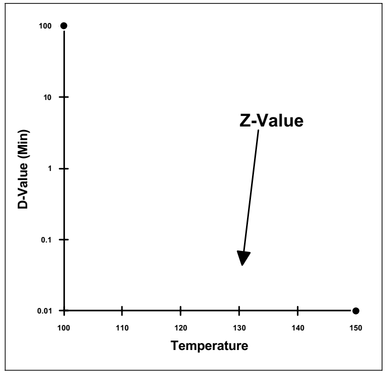


Kinetics of Microbial Inactivation 2

iii. The *Z*-Value

The increase in temperature required to reduce the *D*-Value of a microorganism by one log cycle or 90%.

$$Z = \frac{T_2 - T_1}{\text{Log}\,D_1 - \text{Log}\,D_2}$$



Kinetics of Microbial Inactivation 3

iv. Sterilization Efficiency: The *F*-Value

- **Is a measure of the total lethality of a sterilization process.**
- **Defined as the *capacity to destroy a particular microorganism which is equivalent in minutes of heat at 121°C.***

$$F_0 = D_{121}\,\text{lF}$$

Where F_0 is the value when temperature = 121°C
Z-Value = 10°C

Methods of Preservation 4

b. Sterilization by Moist Heat

- **Saturated steam is an efficient heat transfer medium**
- **Condensation on cooler surface ⇒ release of latent heat**
- **Temperatures above 100°C are used. This is achieved by containing the heat treatment in a pressure vessel**
- **The pressure within the vessel must be raised by steam alone. Presence of air will contribute to pressure but not to temperature of the steam**
- **"Wet steam" and "dry saturated steam"**

Sterilization by Moist Heat 2

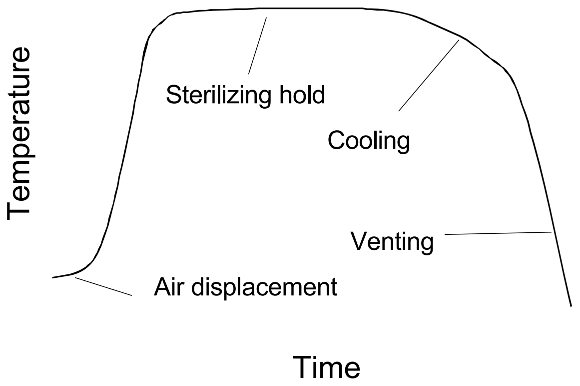
Satisfactory sterilizing conditions (U.K. Dept. of Health, 1981)

Temperature (°C)	Hold Time (Min)	Pressure	F_o Value
134	3	30 p.s.i.; 207 Kpa	59
126	10	20 p.s.i.; 138 Kpa	31
121	15	15 p.s.i.; 103 Kpa	15
115	30	10 p.s.i.; 69 Kpa	8.1

The highest temperature compatible with the product to be sterilized should be used
⇒ Highest assurance of sterility + short cycle time.

Sterilization by Moist Heat 3

Stages of a Steam Sterilization Cycle



Sterilization by Moist Heat 4

Sterilization of Liquids

- **Steam heats the container**
- **The use of pressure helps to counteract the pressure rise in a heated, sealed container**
- **Lethality of the process includes the heating up and cooling down periods. This effect depends on the volume of the liquid**

Sterilization by Moist Heat 5

Porous Load Sterilization

- **Wrapped goods and porous materials *e.g.* dressings; linen**
- **Trapped air is an insulator**
- **Air removal is required to ensure contact between product and steam**
- **Air removal is achieved by cyclic application of vacuum evacuation and steam injection at the start of the sterilization cycle**

Methods of Preservation 5

c. Sterilization by Dry Heat

- **Method of choice for heat stable but moisture-sensitive items**
  e.g. thermostable powders; non-aqueous liquids; corrosion-sensitive equipment
- **Temperatures and times required are significantly greater than moist heat**

Temperature (^{o}C)	Time (min)	
	DH (1980)	BP (1988)
150	60*	-
160	60	120
170	40	60
180	20	30

DH: U.K. Dept. of Health; BP: British Pharmacopoeia
*only for fixed oild, ethyl oleate, liquid paraffin, glycerol

Methods of Preservation 6

d. Pasteurization

- **Heat treatment which kills part but not all microorganisms present**
- **Used when**
  1. More rigorous heat treatment is incompatible with product quality
  2. One aim is to kill specific microorganisms
  3. The main spoilage microorganisms are not very heat resistant
  4. Other treatments are used in conjunction *e.g.* refrigeration
  5. Followed by desired fermentation *e.g.* preparation of yogurt

Pasteurization 2

Time-Temperature Regimes in Pasteurization

Times and temperatures used depend on the method and the product to be treated

- **Low-Temperature-Long-Time Method (LTLT)**
  Milk: 62.8 oC for 30 min
- **High-Temperature-Short-Time Method (HTST)**
  Milk: 71.7°C for 15 s
  88.0°C for 1 s
  90.0°C for 0.5 s
  96.0°C for 0.05 s
- **Ultra-High-Temperature Method (UHT)**
  Milk: 137.8°C for 2 s
  Approaches sterilization