



Process evaluation

Lethality

- Containers do not heat instantaneously
- All temp. have a lethal effect above 93°C
- Contributes to the destruction of m.o.
- Mechanism to determine the relative effect of a changing temperature is necessary
- **z value** helps to calculate the lethal effect of various temperature

Lethal Rate (L)

- The relative effect of temp. on microbial destruction with respect to a certain reference temp. (T_{ref})
- Equivalent time in min at reference temp / time in min at temp. (T)
- $L = 10^{(T-T_{ref})/z}$

Lethal Rate (L)

Temp (oC)	Lethal rate (min at 121.1oC/ min at T)	Time (F_T) req. for 12 D
101.1	0.01	4 h
111.1	0.1	24 min
121.1	1	2.4 min
131.1	10	15 s
141.1	100	1.5 s

Change in processing temp by one z value requires
10-fold change in processing temp

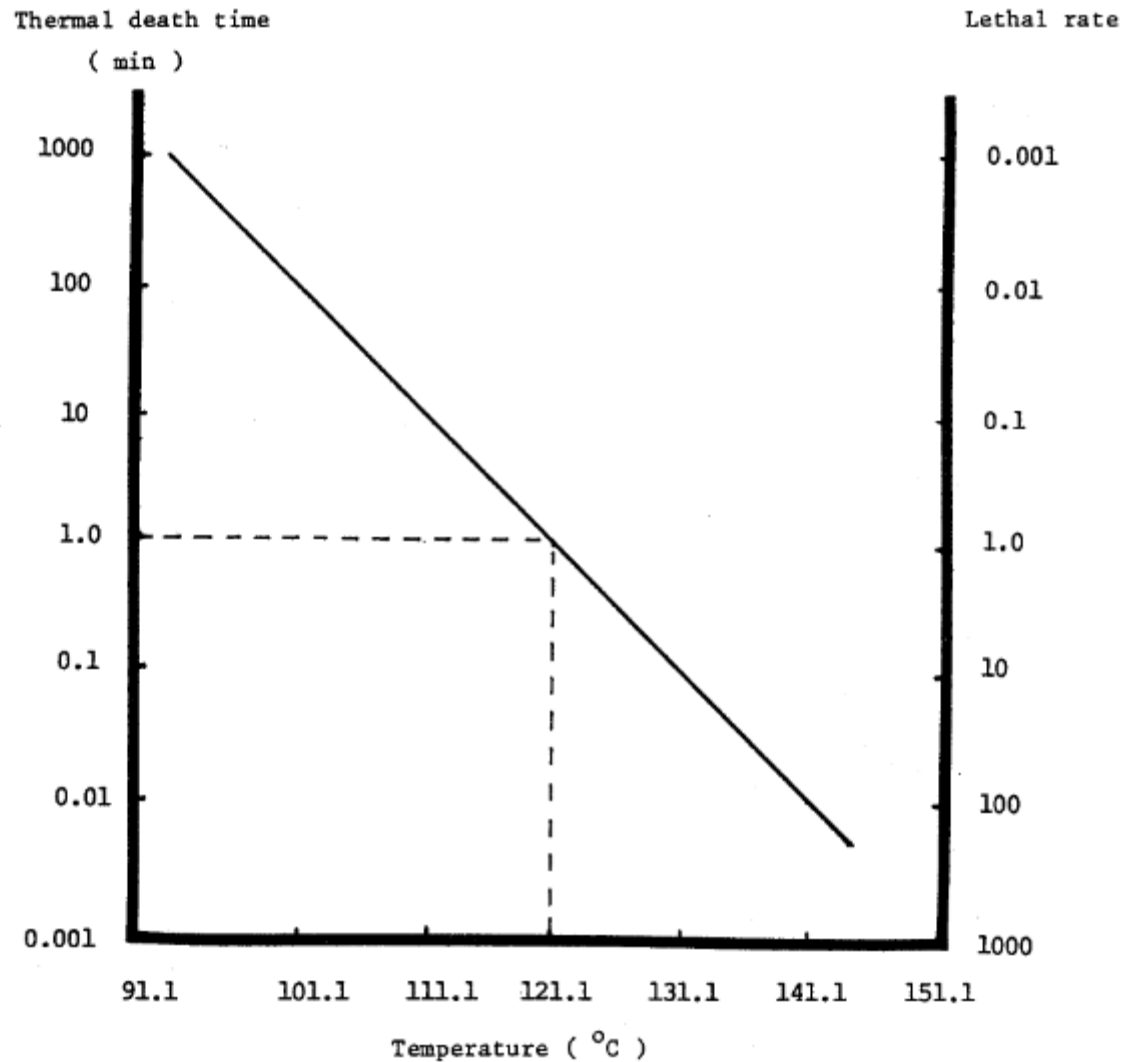


Figure 2 Thermal death time curve passing through 1 min at 121.1 °C.

Sterilization value

- Lethal effect as a function of time (t) during the thermal process
- $F_{T_{ref}} = \int_0^1 10^{(T-T_{ref})/z} dt$
- $F_{T_{ref}} = \sum L \Delta t$
- When T is the cold point temp. and when ref. temp and z value are 121.1°C and 10°C, then, the sterilization value is known as **Fo value**
- Fo value of 3 min is acceptable.

Commercial Sterility

- **Application of heat that render the food free from viable forms of m.o of public health significance as well as any m.o of non PHS capable of reproducing under non-refrigerated conditions of storage and distribution.**

Process evaluation

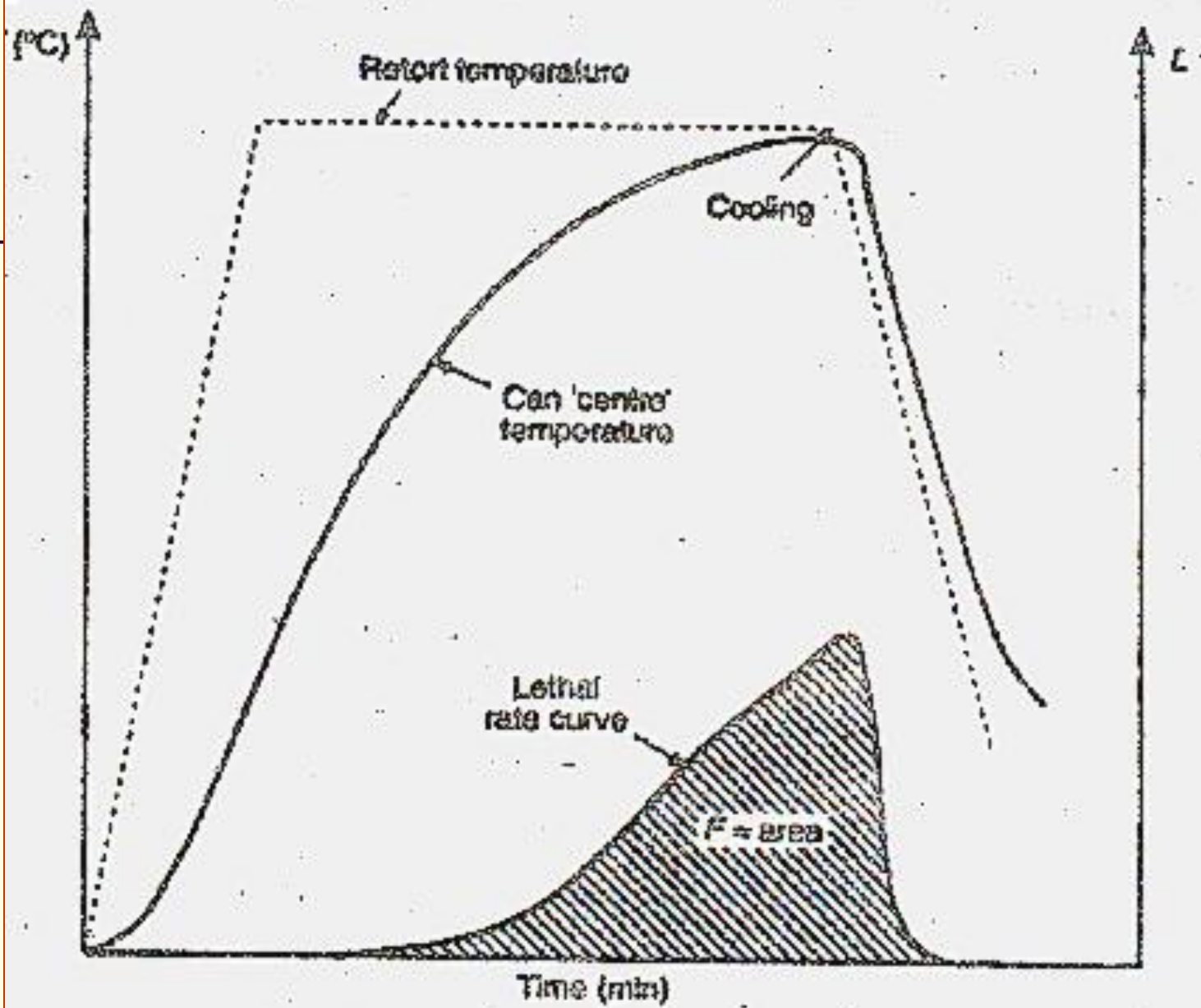
- **Sterilizing effect** : Starts at temp. above their maximum growth temp.
- **Lethal effect** on bacterial spores commence at 93°C
- **Process time** - Time theoretically required to destroy any specific spore in **food can** at any given temp is calculated from
 - **Lethal rate of the temperature**
 - **TDT curve**
 - **Heating and Cooling curves**

Thermal process evaluation

- **Determination of thermal process, F_0 involves**
 - **Measurement of temp. at SHP**
 - **Integration of lethal effect at this point**

Lethality

- **Lethal rate** - Rate of destruction of an organism per min at any given lethal temp. is the reciprocal of the time in min required to completely destroy it at that temp. $LR = \text{Antilog} [(T-121.1)/z]$
If z value is 10°C, the LR for 111.1°C is 0.1



Lethal Rate curve

Integration of lethal effects

- *C. botulinum* spores requires F_0 of 2.52 min
- Heat the food at 121.1°C hold for 2.52 min instantaneously, and cool below lethal temp.
- **Integrated lethal value equivalent to 2.52 min sufficient**
- F_0 at 121.1°C is unity
- So, for every temp. change of 10°C, there is 10-fold change in death rate of organisms
- Work out F_0 equivalent at that time-temp combinations
- If processing at 111.1°C, needs 10 times more heating to attain sterilization effect
- If processing at 131.1°C, needs 1/10th of time

Methods

- **Methods of estimating process lethality**
 - **Classical calculation method**
 - **General method**
 - **Formula method**
 - **Integrated lethality method**
 - **Nomogram method**

Classical calculation method

- Simplest method
- Record SHP temp/ min
- Obtain LR rate for temp. from LR table or calculate LR
- Integrate lethal values of heat for all time-temp combinations at this point
- **Cumulative F_0 value** - Add LR of temp after steam cut off also

General method (Bigelow, 1920)

- Graphical method - each point of H & C curve represent lethal value for the organisms
- Construct TDT, H&C curves and lethality curve with LR against time (min)
- Area under lethality curve gives the **total lethality of the process** i.e summation of all lethal rates obtained during CUT, retorting and cooling.
- Measure area by counting squares or using planimeter

General method (Graphical method)

- **If area under lethality curve is unity (1) – process adequate – complete destruction achieved**
- **If total lethality < 1 – under processing**
- **If total lethality > 1 – over processing**
- **Process value (F_0)**
 - = Area under LR curve x lethality/square**
 - = $117 \times 0.1 = 11.7$ min**
- **Cannot predict F_0 of shorter or longer process, change in retort temp. or can size**

Mathematical method (Ball and Olson, 1928)

- **Applicable to convection and conduction packs of any can size and retort temp**
- **Construct HP curve by plotting values representing differences between retort temp. and product temp. on a log scale and time on linear scale**
- **Zero time taken when the steam is turned on**
- **After an initial lag, the graph becomes a straight line**

Mathematical method

- **Slope is fh**
- **CUT sterilizing effect is 42% of COT**
- **Corrected zero time is 52% of COT**
- **Extend straight line of graph to meet 'y' axis**
- **The corresponding temp is theoretical initial temp (I)**
- **Ratio of j/I is referred to as 'j'**
 - **jI = diff. between retort temp. and theoretical initial temp**
 - **I = diff. between retort temp and actual initial temp**
 - **j = lag factor or time before which there is no increase in temperature at SHP**

Mathematical method

- The basic equation is

$$B \text{ process time (min)} = fh \log (j|g)$$

g = diff. in oF bet. retort temp and max. temp at SHP

- From above, g is calculated

- Value of g is related to the ratio of fh/U

$$U = F_o F_i$$

F_i = Time in min at the retort temp equivalent to F_o process at 250oF

$$F_i = \log^{-1} (250-t)/z \quad (t - \text{process temp; } z-18\text{oF})$$

- From above, F_i is calculated

- From U and F_i , F_o is calculated

Integrated lethality method

- In convection pack, heating at SHP (F_c) is equal to the effective mean through out the container (F_s)

$$F_c = F_s = D (\log a - \log b)$$

$D = \text{DRT at reference temp}$

$a = \text{initial no of spores}$

$b = \text{no of survivors}$

- For conduction pack, integration of lethal values of heat received at SHP is more accurate
 - Determine survival ratios for small volume
 - Integrate over the whole volume

Nomogram method (Olson and Stevens, 1939)

- **American Can Co – Quick method**
- **Not accurate**
- **Applicable to straight line and broken curve lines**
- **Knowledge on Ball method necessary**
- **Calculate process value (F_0)**
- **Predict F_0 values for similar products under changed conditions ie. can size, retort temp or filling temp.**



Verification of the Process

Microbiological methods

- Most reliable
- Two methods
 - **Inoculated pack method** – Spores are directly added to the food
 - **Spore bulb method** – Spores suspended in a buffer and contained in a small bulb or capillary tube are placed in the food in the can

Inoculated pack method

- **Place heat resistance spores (gas former) in SHP**
- **Subject to normal heat treatment**
- **Presence of blown can**
- **Estimate survival by culture or incubation tests**

Spore bulb method

- **Similar to capillary bulb method**
- **Capillaries containing spores implanted in solid pieces of food at SHP**
- **In convection packs, placed using special device**
- **Compare no. of survivors with the initial no. of spores**
- **Evaluate the lethality of the process**