Microbial inactivation during superheated steam drying of fishmeal

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Microbial Inactivation during Superheated Steam Drying of Fish Meal

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Microbial inactivation during superheated steam drying (SSD) of fish meal was investigated in a pilot scale fluidized bed dryer. The exposure times required for 90% reduction in population (D-values) of the surrogate organisms *Clostridium sporogenes* (spores) and *Escherichia coli* at 300°C were 0.33 and <0.10 min,

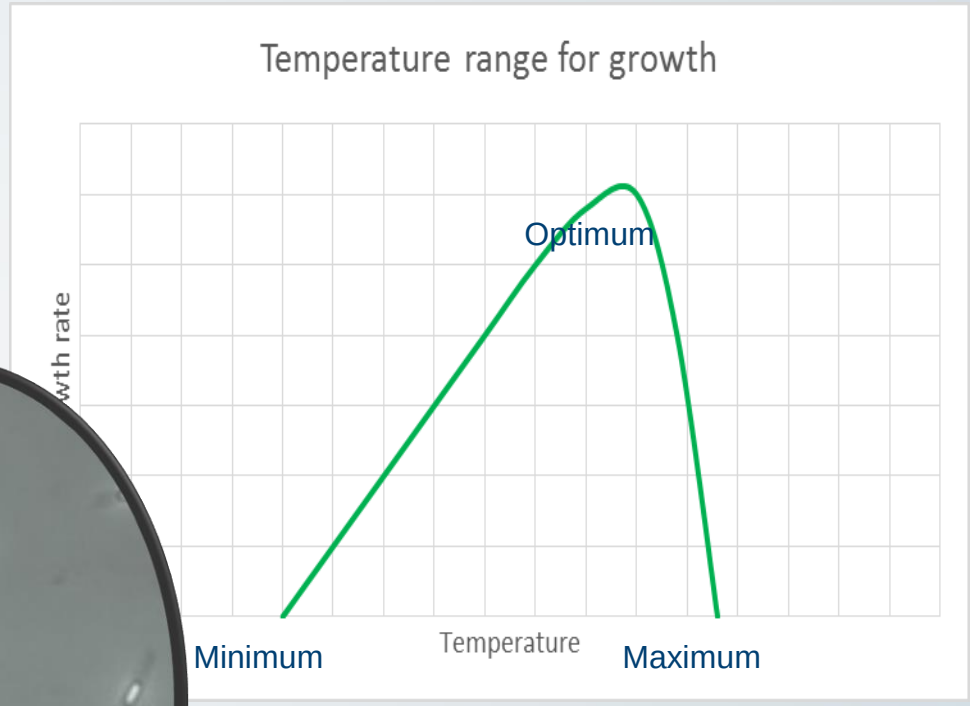
mechanism described also applies to similar processes, such as feed mills.[3] Recontamination occurring prior to drying may have an adverse effect on product hygiene if effective inactivation is not provided during drying. Hence, the ability of dryers to inactivate bacteria may have considerable

Temperature range for growth of bacteria

Bacteria varies in relationship to heat

	Min	Opt	Max
Typical marine bacterium	-2 C	20 C	25 C
Human pathogens	5 C	37 C	43 C
Typical thermophile	30 C	65 C	75 C

- Below minimum temperature, bacteria will be inactive
- Above maximum temperature, bacteria will die, faster the higher the temperature
- Some bacteria form highly resistant resting structures; «spores»



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Thermal inactivation of bacteria

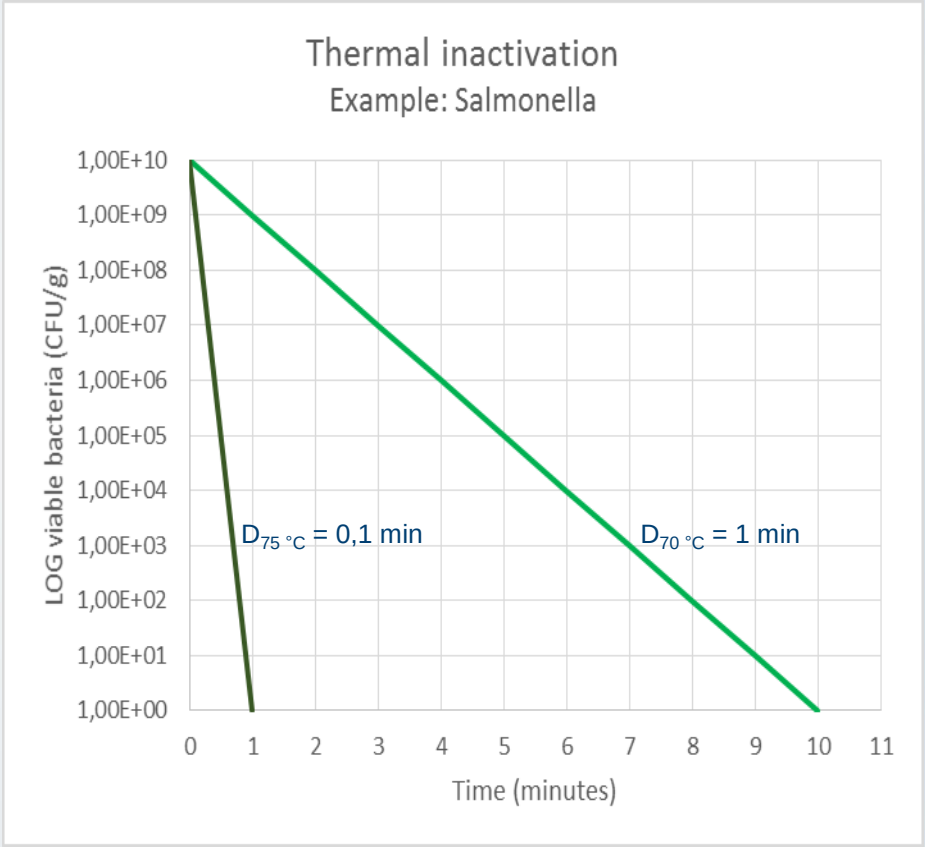
The heat-resistance of bacteria can be described by «D-values» and «z-value»

D-value:

Time required at a certain temperature to kill 90 % of the organisms (1 Log reduction)

z-value:

Temperature increase required to reduce D-value by a factor of 10



(z-value = 5 °C)

Influence of product composition

- Heat resistance of bacteria is primarily influenced by moisture and fat contents
- Most literature data relates to high moisture products that are not valid for dry products
- The significance of product moisture and fat content must be kept in mind when considering the effect of drying conditions on microbial inactivation

Examples:

Salmonella in high moisture products (Aw > 0,95):

$D_{70\,°C}$ = 1 min z = 5 °C

Salmonella in a low moisture peanut paste (Aw = 0,23):

$D_{70\,°C}$ = 110 min z = 25 °C

Inactivation is determined by moisture and temperature in product during initial and constant rate period

Hot air drying:

Temperature reach and is maintained at 50-60°C (wet bulb temp)

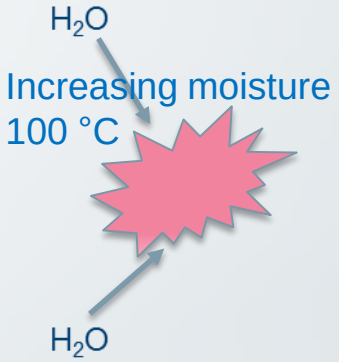
Moisture decreases, temperature is maintained at 50-60°C

Superheated steam drying:

Moisture increases due to water vapor condensation

Temperature reach 100°C

Moisture decreases, temperature is maintained at 100°C



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Drying experiments in pilot scale fluidized bed dryer

Microorganisms added to moistened fishmeal:

Escherichia coli

- E.coli was used as surrogate for Salmonella
- Both are members of Enterobacteriaceae family
- Salmonella is a common human and animal pathogen

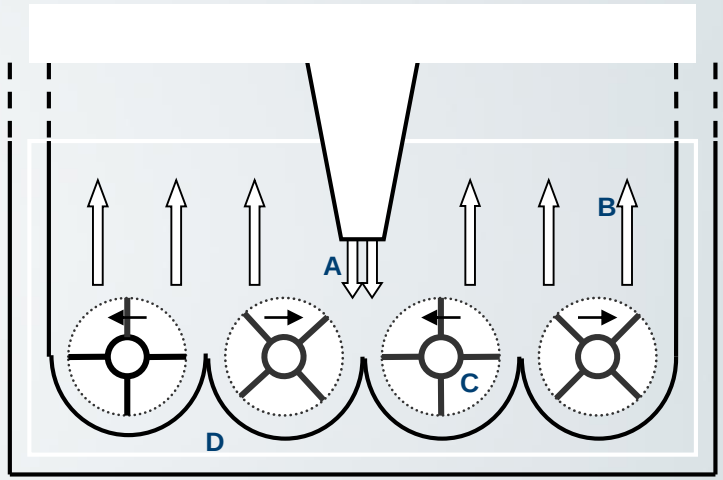
Clostridium sporogenes (spores)

- C.sporogenes was used as surrogate for C.perfringens
- C.perfringens cause the most common food poisoning in human

Geobacillus stearothermophilus (spores)

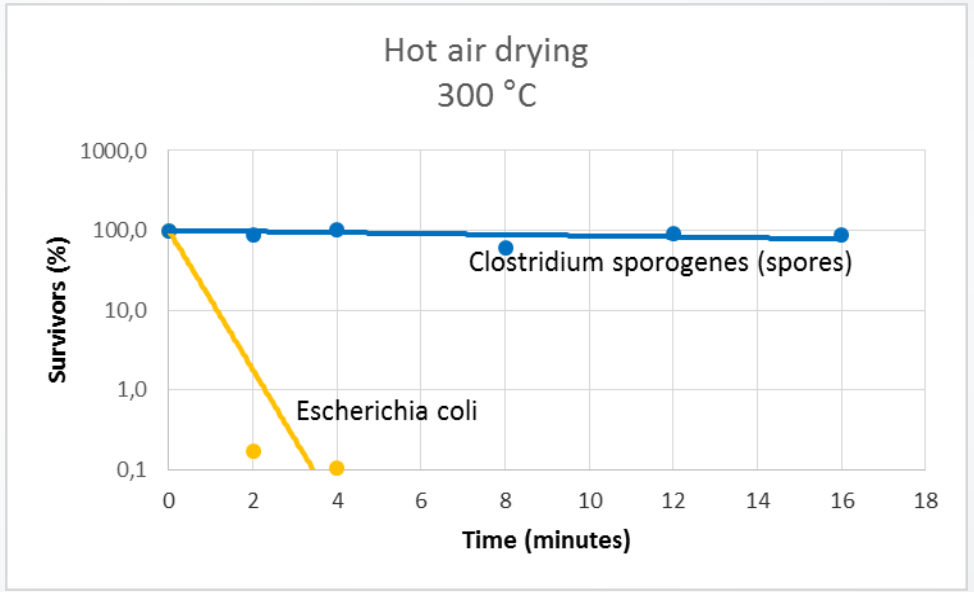
- G.stearothermophilus is extremely heat resistant
- G.stearothermophilus is non-pathogenic

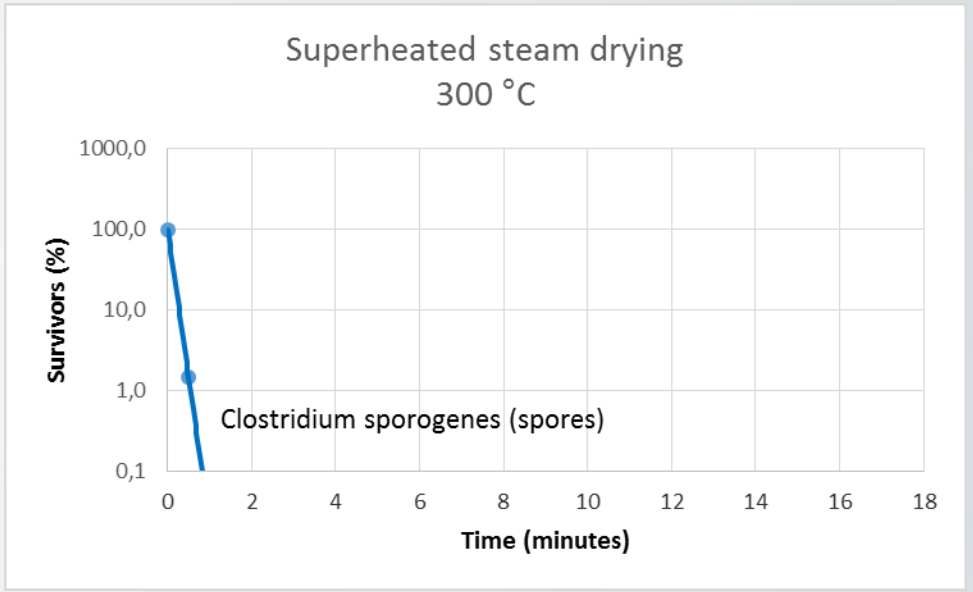
Schematic diagram of drying chamber



A: Drying gas in
B: Drying gas out
C: Shaft with paddles
D: Insulated chamber

Inactivation curves –
hot air drying vs superheated steam drying





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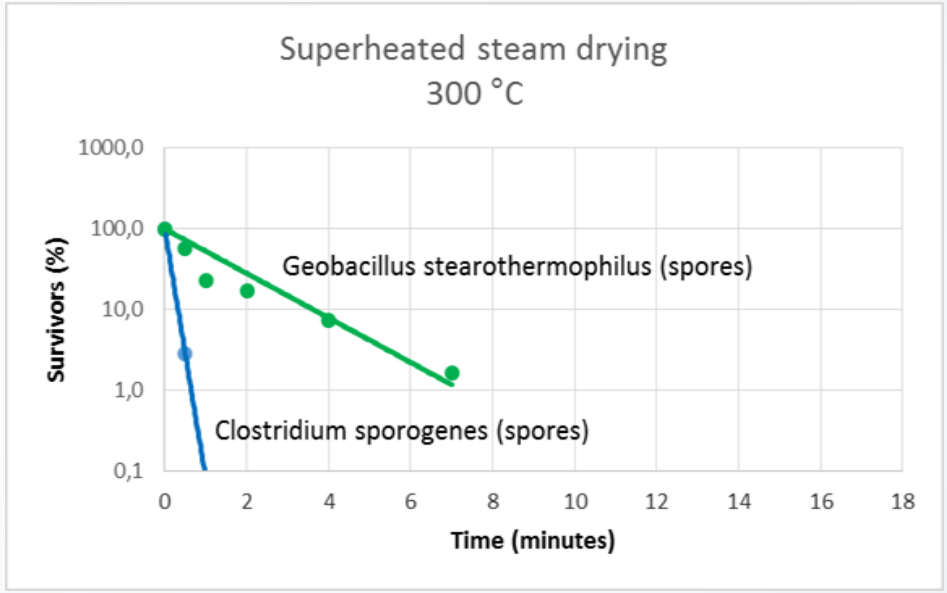
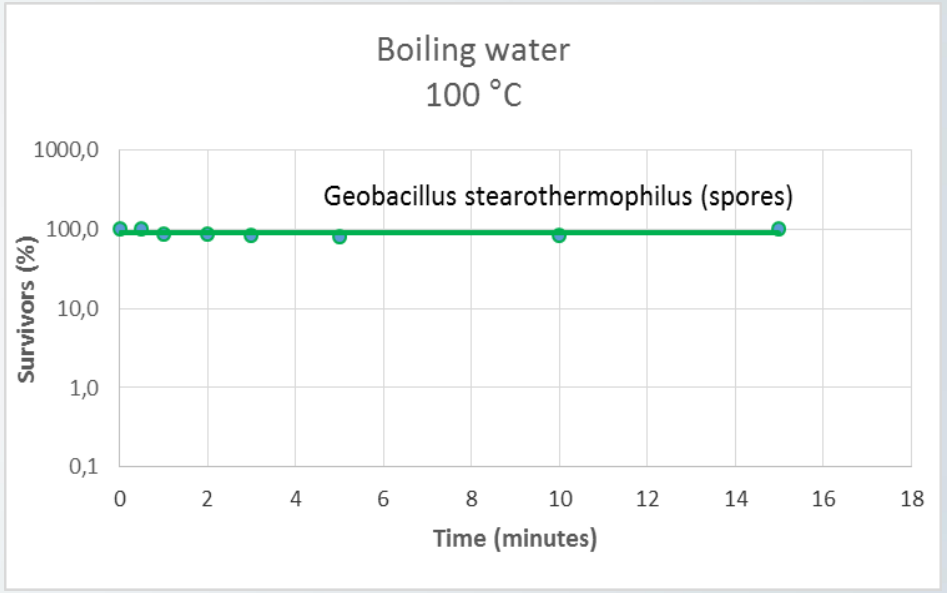
Inactivation curves –
superheated steam drying vs boiling water





- Superheated steam provided **65 times** faster inactivation of G.stearothermophilus spores than boiling water, even if temperature and moisture in the product was expected to be similar.
- The superiority of steam is explained by release of latent heat and by easier heat penetration into spores

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D-values calculated from inactivation curves

Average $D_{300°C}$ values for surrogate organisms during drying of fishmeal

Drying gas	Temperature	E.coli	C.sporogenes	G. stearothermophilus
Hot air	300 °C	1,1 min	54,2 min	
SHS	300 °C	< 0,1 min	0,3 min	3,5 min

Conclusion

Superheated steam drying provide effective inactivation of even the most heat resistant bacteria of relevanse to the food and feed industry