Module 05 Lecture 01

Factors affecting survival and growth

Traditional food preservation

• Stored in cool caves	Cheese, fruits, vegetables
• Frozen / freeze-dried at high latitudes and altitudes	Meat (Switzerland), potato (Peru)
• Dried in the sun	Tomato (Italy), fish, meat (South America), Biltong (South Africa)
• Smoked / dried over fires	Kipper (UK, smoked herring)
• Salted and dried	Bacalhau (Portugal - dried cod)
• Fermented	Tempeh, cheese, wine, beer, yoghurt, kefir

Pasteur's germ theory

Traditional methods work by

- Preventing contamination
- Destroying microorganisms
- Inhibiting growth of undesirable microorganisms

Traditional food preservation

Traditional preservation sometimes fails to preserve the food, or to kill the pathogens. In these cases, spoilage or food poisoning may occur.

Examples: salmonellosis from dried beef (*Salmonella St. Paul*) and poisoning from *tempeh bonkrek* in Indonesia.

Traditional food preservation

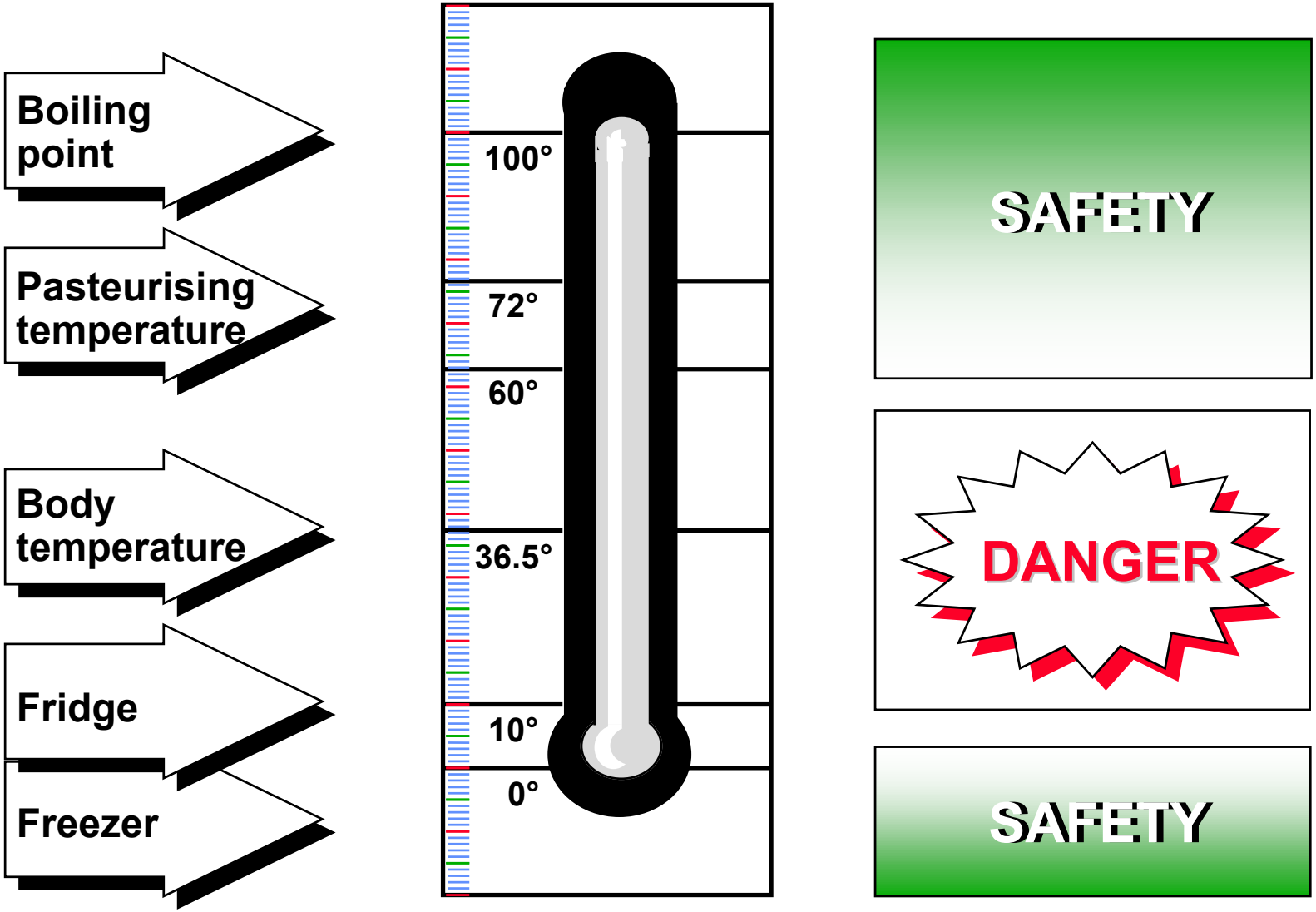
Certain “traditional” foods can be manufactured using industrial processes

Example: Soy sauce

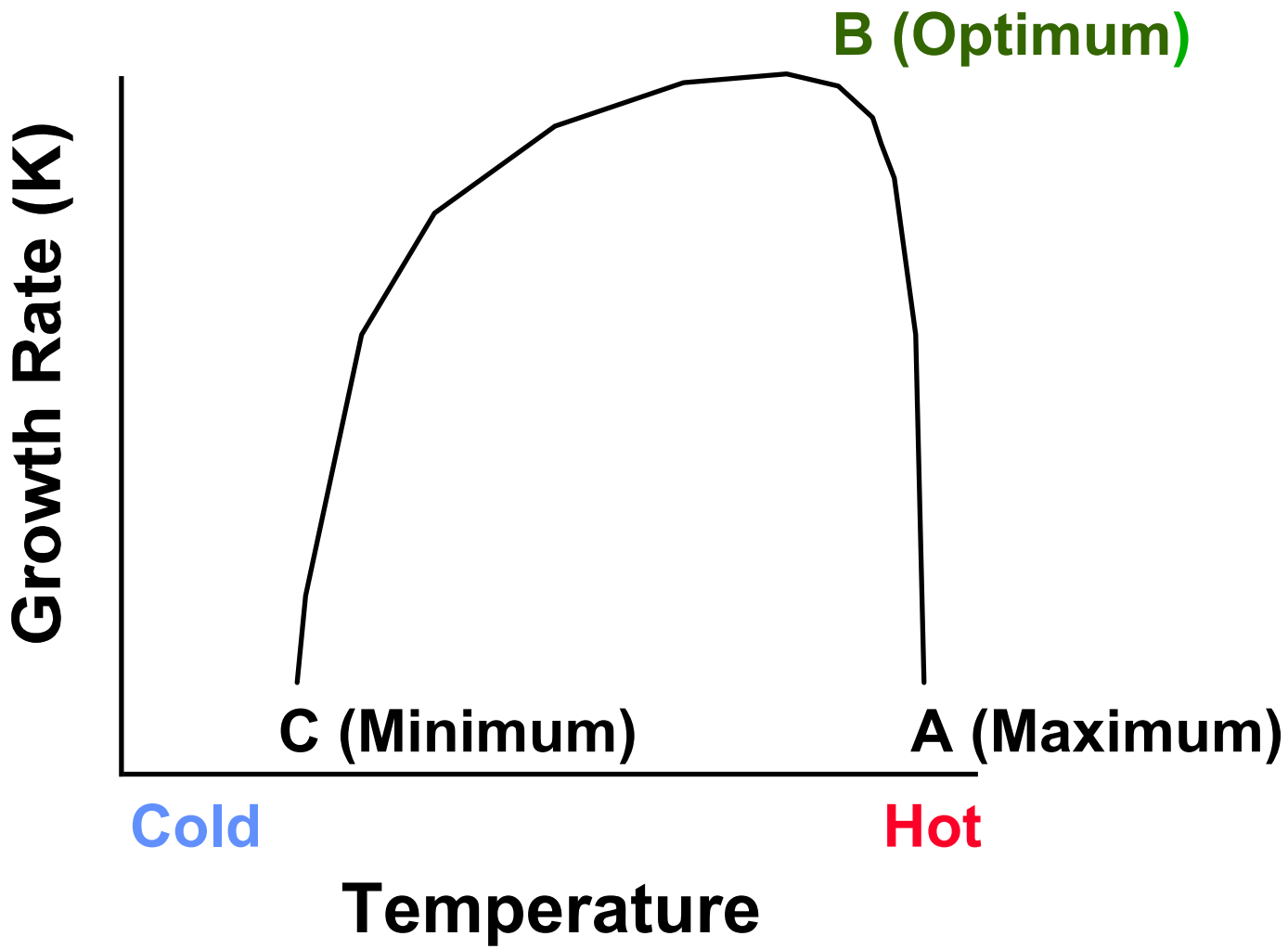
Factors affecting growth of bacteria in food

- Temperature
- Time
- pH
- Water activity (a_w)
- Oxygen tension
- Preservatives
- Microbial interactions

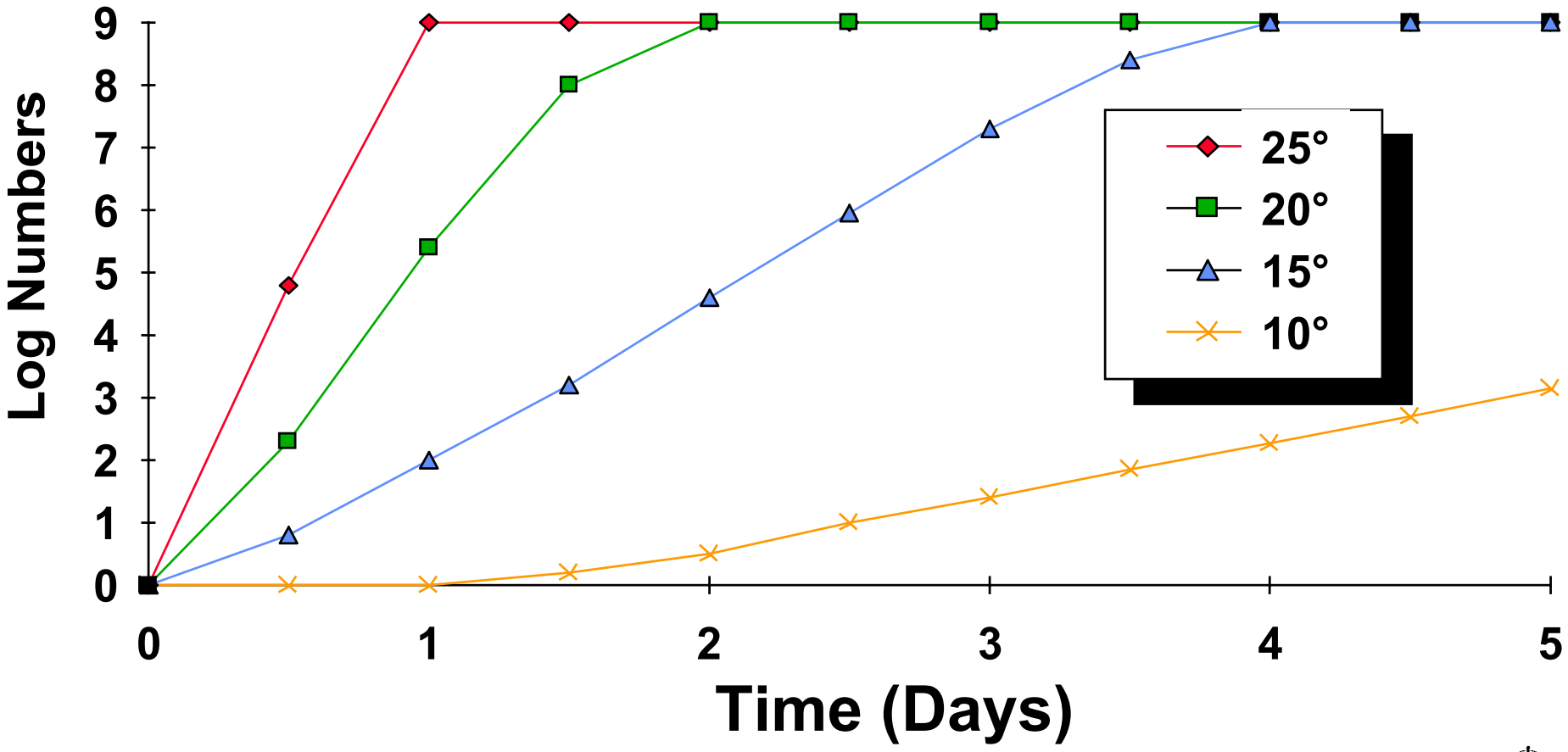
Temperature



How temperature affects growth rate of a bacterial population



Growth of *S. typhimurium* at different temperatures



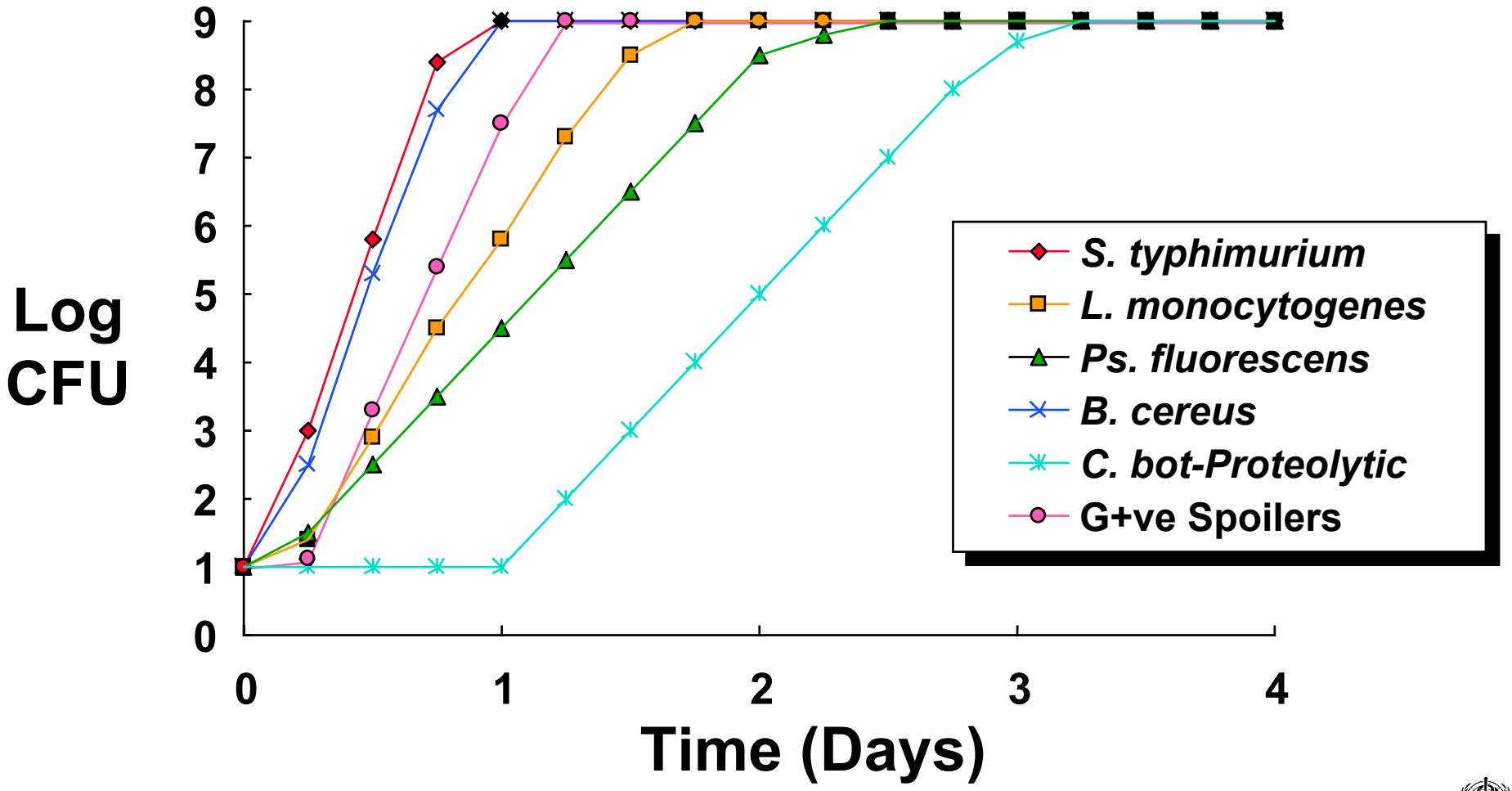
Temperature range for growth of pathogens

	Temperature°C		
	Min.	Opt.	Max.
Salmonella	5	35 - 37	47
Campylobacter	30	42	47
E. coli	10	37	48
S. aureus	6.5	37 - 40	48
C. botulinum (proteolytic)	10		50
C. botulinum (non-proteolytic)	3.3		25 - 37
B. cereus	4	30 - 35	48 - 50[1] 43[2]

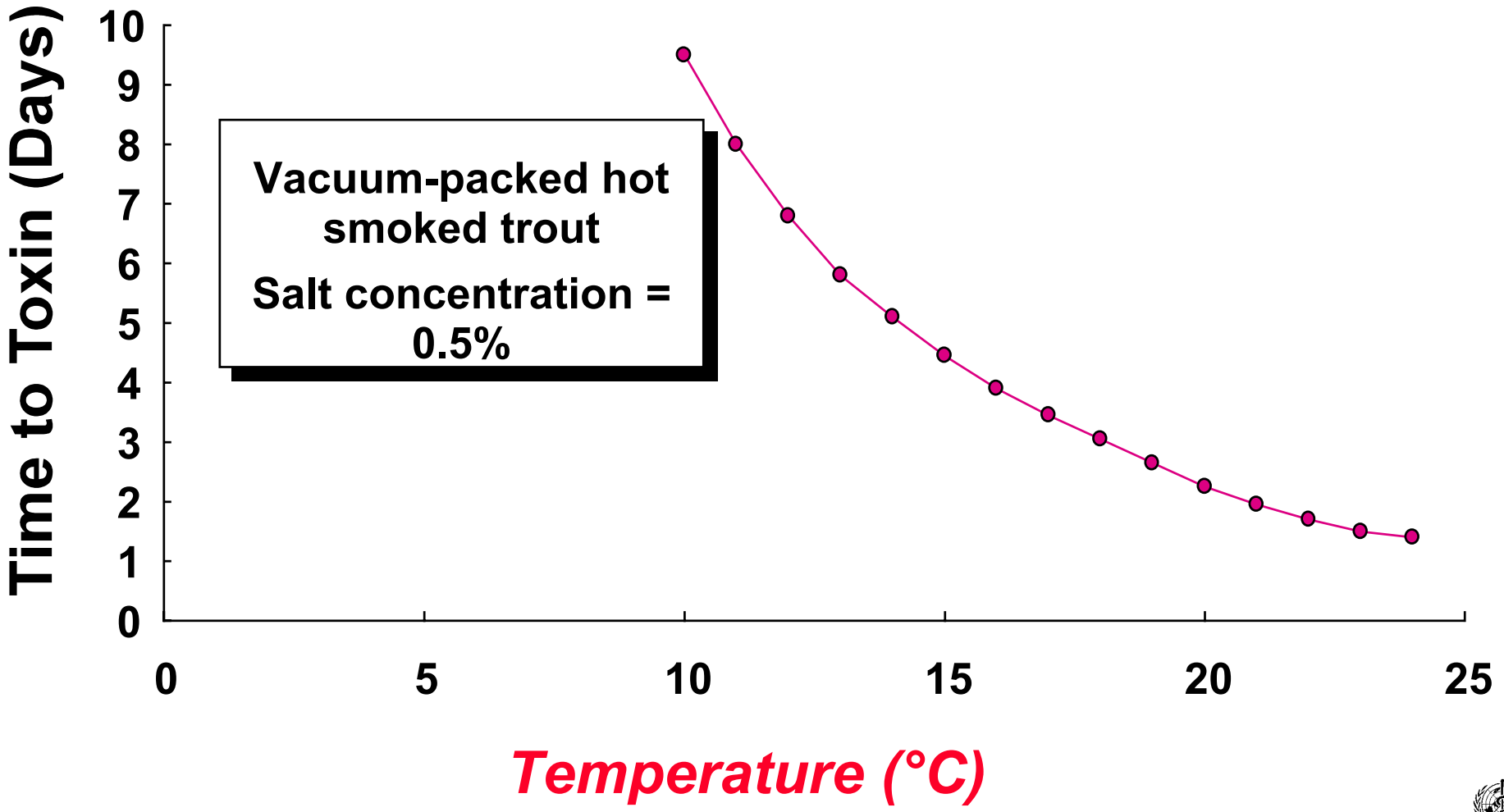
Temperature range for growth of toxigenic moulds

	Temperature °C		
	Min.	Opt.	Max.
Penicillium verrucosum	0	20	31
Aspergillus ochraceus	8	28	37
Aspergillus flavus	10	32	42
Fusarium moniliforme	3	25	37

Growth of different bacteria at 25°C



Effect of temperature on time to botulinum toxin production



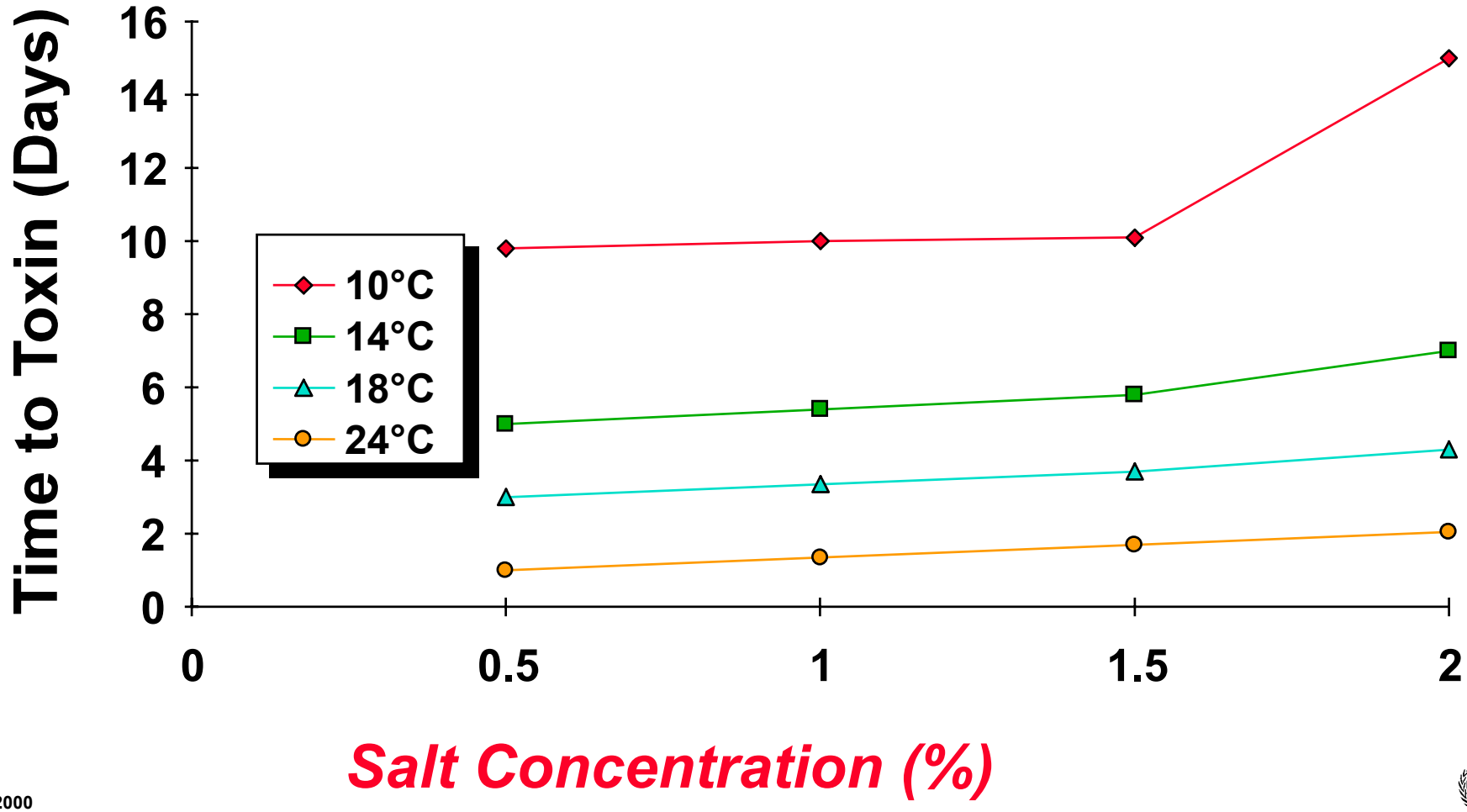
Temperature affects bacteria

- Lag phase
- Growth rate
- Final cell numbers

through the change in

- Enzymatic and chemical composition of cells
- Nutritional requirements
- Limits for other factors influencing growth

Effect of salt concentration on time to botulinum toxin production



Limits of pH for growth of pathogens

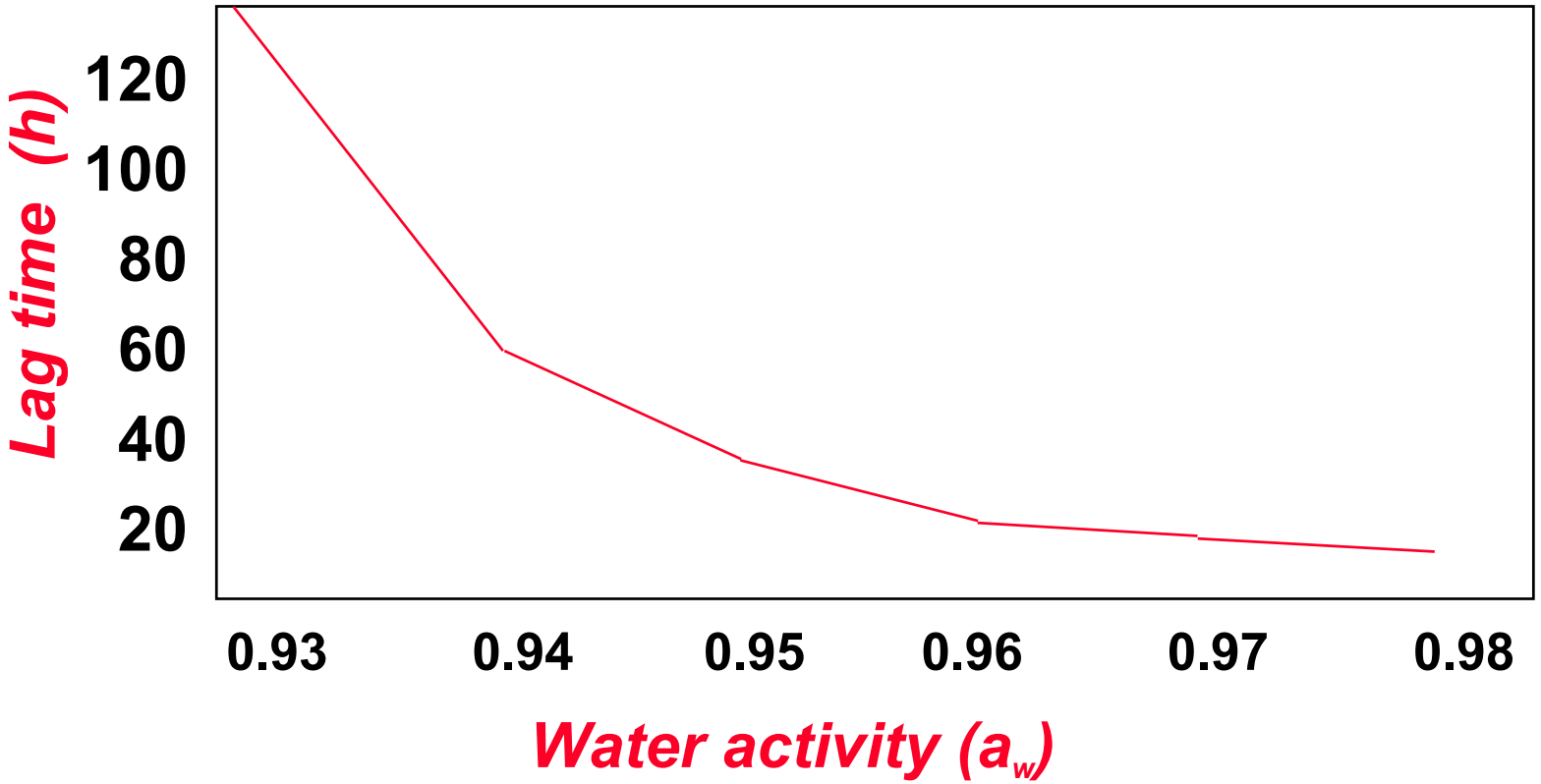
	pH	
	Min	Max.
Escherichia coli	4.4	8.5
Salmonella typhi	4 - 4.5	8 - 9.6
Bacillus cereus	4.9	9.3
Clostridium botulinum	4.6	8.5
Staphylococcus aureus	4	9.8
Saccharomyces cerevisiae	2.3	8.6
Aspergillus flavus	2.0	11.2
Fusarium moniliforme	2.5	10.7
Penicillium verrucosum	2.0	10.0

Definition of water activity (a_w)

$$a_W = p / p_o$$

a_w is the ratio of the water vapour pressure of the food (p) to that of pure water (p_o) at the same temperature.

Effect of water activity on lag time of *S. aureus* in UHT milk at 12°C



NaCl and glucose concentrations and corresponding a_w values at 25°C

a_w	% w/w NaCl	% w/w Glucose
1.00	0.00	0.00
0.99	1.74	8.90
0.98	3.43	15.74
0.96	6.57	28.51
0.94	9.38	37.83
0.92	11.90	43.72
0.90	14.18	48.54
0.88	16.28	53.05
0.86	18.18	58.45

Minimum levels of a_w permitting growth at near optimum temperatures

		a_w
Moulds	*Aspergillus chevalieri*	0.71
	Aspergillus ochraceus	0.78
	Aspergillus flavus	0.80
	Penicillium verrucosum	0.79
	Fusarium moniliforme	0.87
Yeasts	*Saccharomyces rouxii*	0.62
	Saccharomyces cerevisiae	0.90
Bacteria	*Bacillus cereus*	0.92
	Clostridium botulinum (proteolytic)	0.93
	Clostridium botulinum (non-proteolytic)	0.97
	Escherichia coli	0.93
	Salmonella	0.95
	Staphylococcus aureus	0.83

Range of a_w in foods and their microbial flora

a_w range	*foods*	*microbial flora*
> 0.98	Fresh meats Fresh fish Fresh fruits Fresh vegetables	*(C. perfringens, Salmonella)*
	Canned vegetables in brine	
	Canned fruit in light syrup (<3.5% salt, 26% sugar)	*(Pseudomonas)*
0.93 - 0.98	Fermented sausages Processed cheese Bread Evaporated milk Tomato paste	*(B. cereus, C. botulinum, Salmonella)* lactobacilli, bacilli and micrococci
	(10% salt, 50% sugar)	

Range of a_w in foods and their microbial flora

a_w range	*foods*	*microbial flora*
0.85 - 0.93	Dry fermented sausages Raw ham (17% salt, saturated sucrose)	*S. aureus* Mycotoxin producing moulds Spoilage yeasts and moulds
0.6 - 0.85	Dried fruit Flour Cereals Salted fish Nuts	Xerophilic fungi Halophiles Osmophilic yeasts
< 0.6	Confectionery Honey Noodles Dried egg, milk	No growth but may remain viable

Factors affecting microbial growth
Key messages

- Temperature, pH, water activity and oxygen tension are the principal factors affecting microbial growth
- There are optimum ranges for these parameters
- These optima are interdependent
- They can be selected to inhibit the growth of certain organisms within limits related to the palatability of food
- Certain foods are suited for the growth of certain flora