Module 02 - lecture 04, short

Food technologies to render and keep foods safe

Introduction (1)

Historically, objectives of food technologies have been :

- **preservation of food**
- **rendering food more palatable and digestible**

Introduction (2)

In modern times, food technologies are applied with the additional objectives :

- **developing new food products**
- **giving food desired functional properties**
- **improving nutritional and organoleptic quality**
- **ensuring safety**

Food technologies and food safety

Basic knowledge of Food Technology can help to :

- **identify appropriate control measures (may involve application of several technologies)**
- **select parameters which assure their effectiveness**
- **decide how these parameters need to be monitored**

Objective

To understand :

- **how different food technologies can be used to prevent and/or control hazards in foods**
- **the factors (parameters) which influence the process and thus the safety of the final products**
- **how to monitor these factors**

Classes of food technologies

Food technologies can be classified into those that :

- **render food safe**
- **control contaminants i.e. prevent growth of microorganisms or production of toxin(s)**
- **prevent (re)contamination**

Food technologies that may kill certain microbes

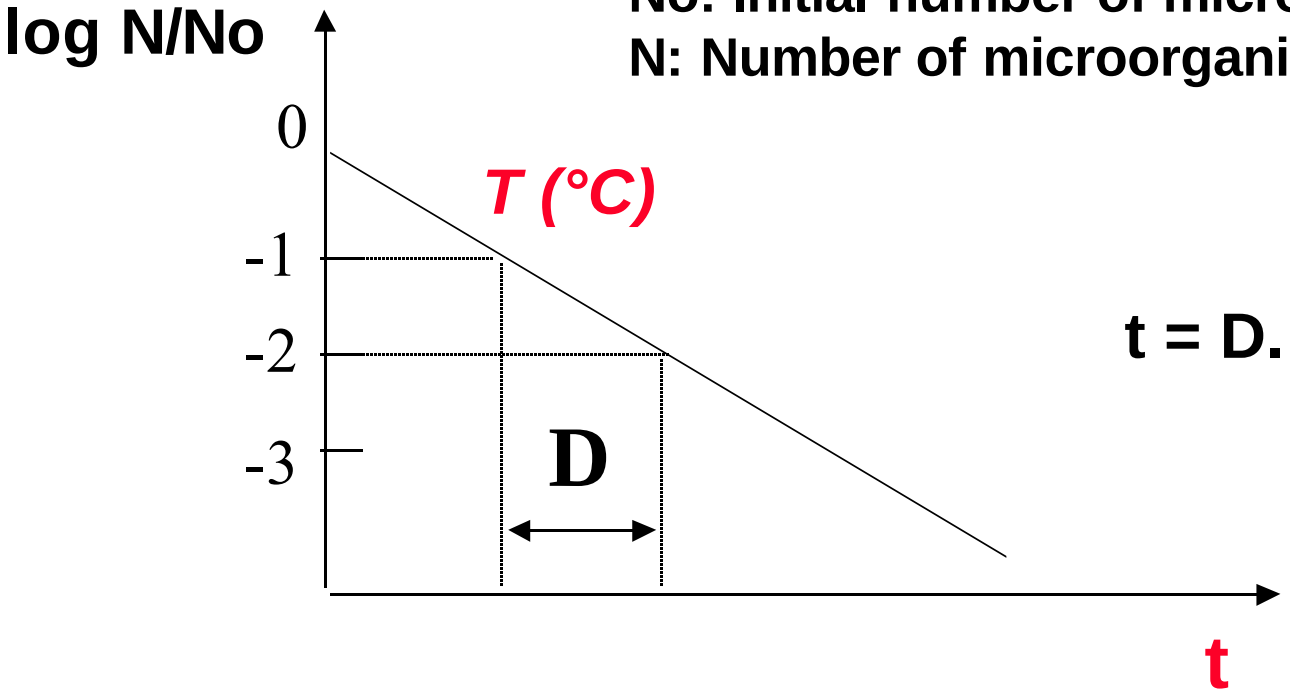
- Heat treatments
- Irradiation
- Disinfection
- Freezing (parasites only)
- High pressure technology

Heat treatments

Method of heating	*Heating medium*
cooking	water
baking / roasting	air
boiling	water
frying	oil
grilling	air
microwave	electromagnetic radiation
pasteurization	heat exchanger / water
sterilization	steam under pressure

D value

Heat resistance is measured by the decimal reduction time D



No: Initial number of microorganisms
N: Number of microorganisms at time *t*

t = D. log No/N

Heat resistance (1)

Vegetative organism	*D values (min)*		
	55°C	*60°C*	*65°C*
Escherichia coli	**4**		**0.1**
***Salmonella* spp.**			**0.02-0.25**
Salmonella typhimurium			**0.056**
Salmonella senftenberg			**0.8-1.0**
Staphylococcus aureus			**0.2-2.0**
Listeria monocytogenes		**5.0-8.3**	
Campylobacter jejuni	**1.1**		

Heat resistance (2)

Bacterial endospores	*D values (min)*		
	100°C	*110°C*	*121°C*
C. botulinum type A and B	50		0.1-0.2
C. botulinum type E		< 1 sec	
C. perfringens	0.3-20		
C. sporogenes			0.1-1.5
Bacillus cereus	5		

Heat resistance (3)

Heat resistance (D value) is influenced by many factors, e.g. :

- **type or strain of microorganism**
- **physico - chemical parameters of the medium e.g. water activity, pH, composition**
- **age of the cells or state of growth**

Pasteurization schemes

Low temperature:

63° C for 30 min

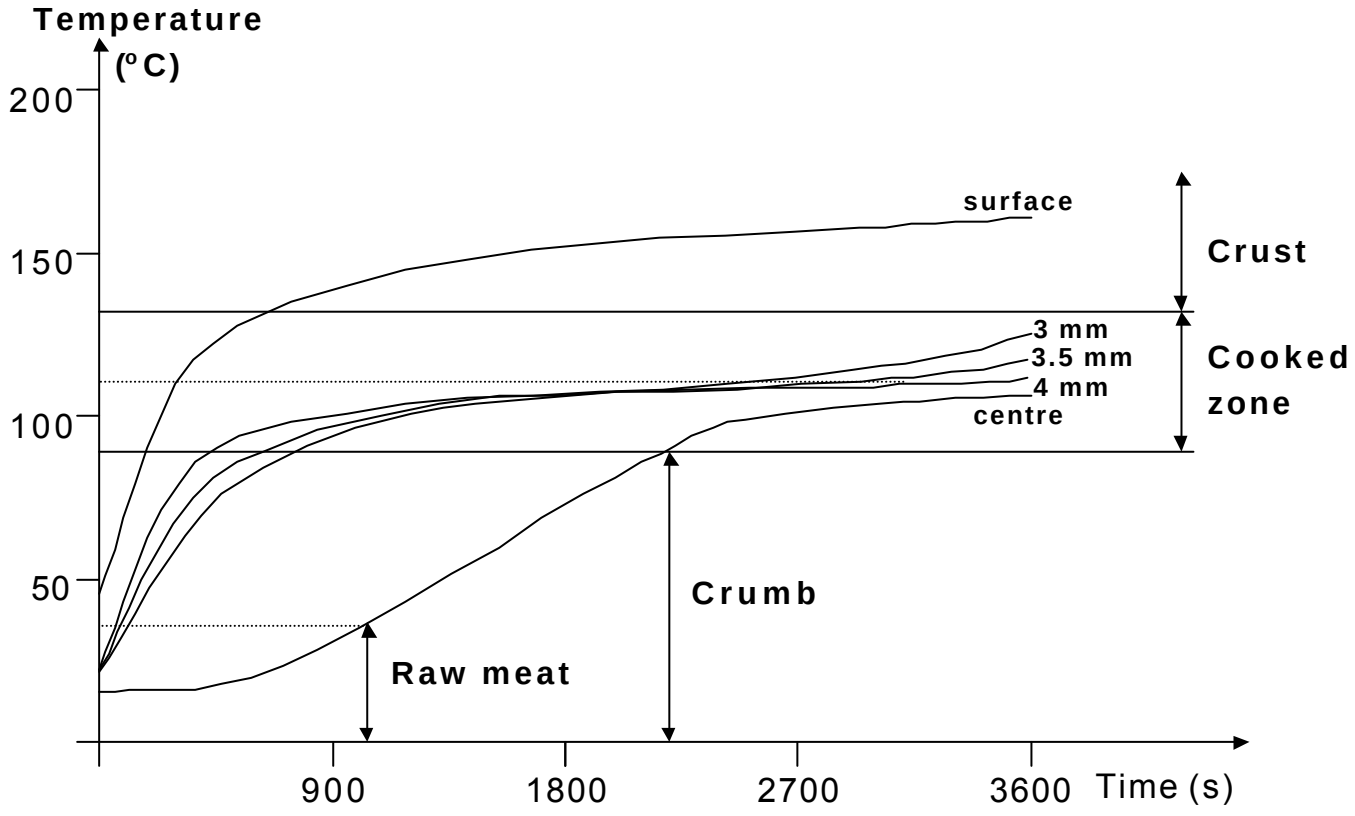
High temperature:

72° C for 15 sec

Ultra-high temperature:

135° C for 1 sec

Temperature gradient in hamburger



Microwave treatment

Heat is generated by friction of water molecules under the influence of electromagnetic waves (500 MHz to 10 GHz)

Rapid but non - uniform heating (cold and hot spots)

Freezing

Effective against parasites

Critical limit:

- 18° C for minimum 24 to 48 h

No or minimal effect on:

- **survival of bacteria and viruses**
- **enzymatic activity (polyphenol oxidase, lipase)**

Food irradiation (1)

Gamma rays

produced during decay of radioactive isotopes Cobalt 60, Caesium 137
Good penetration power

High energy electron beams

produced by accelerators
low penetration

X-rays

highest penetration power

Sensitivity of microorganisms

Necessary dose

Parasites 1.0 kGy

Bacteria 1-7 kGy

(Viruses > 30 kGy)

Food irradiation (2)

Food irradiation at any dose has been assessed by IAEA, FAO and WHO as safe

Macronutrients and essential minerals are not affected by food irradiation

Certain vitamins e.g. thiamine and tocopherols are sensitive, but the loss is small (10 - 20 % or less) and comparable to thermal processing or drying

Chemical disinfection

Example of application	*Example of disinfectant agent*
Water	chlorine
Fruits and vegetables	hypochlorite
Surfaces and equipment	chlorine dioxide
	iodine
	chloramines
	ozone

Chlorination of water (3)

The normal conditions for chlorination :

free resid. chlorine	**> = 0.5 mg / l**
contact time	**minimum 30 minutes**
pH	**< 8**
water turbidity	**< 1 NTU**

Chlorination of water (4)

To eliminate parasites and decrease turbidity, chlorination is combined with :

- **coagulation and flocculation**
- **filtration**

Disinfection of fruits and vegetables

Depending on type of fruits and vegetables some decrease may be obtained

Not fully effective

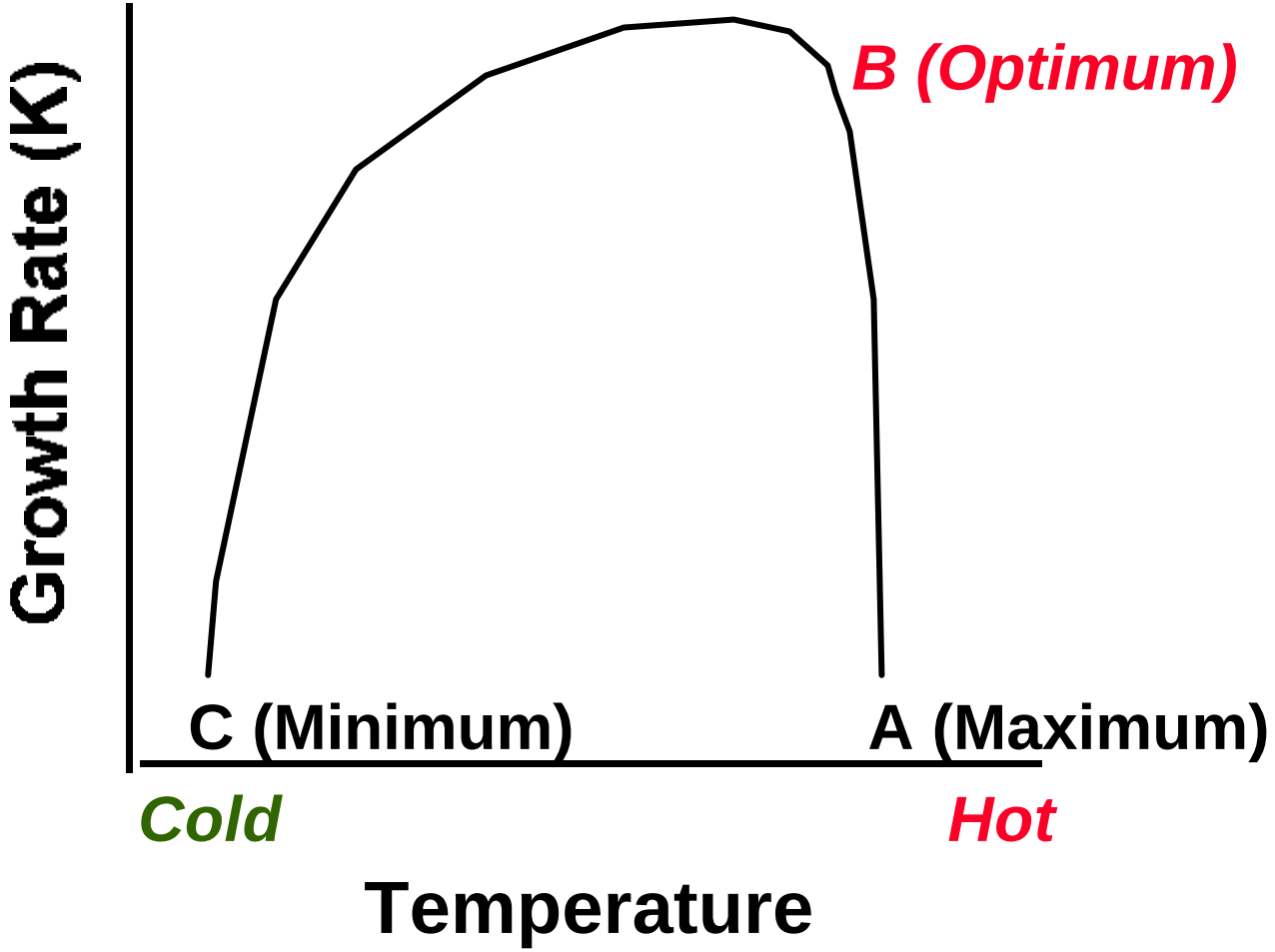
Food technologies to control the development of microbiological hazards

Technologies

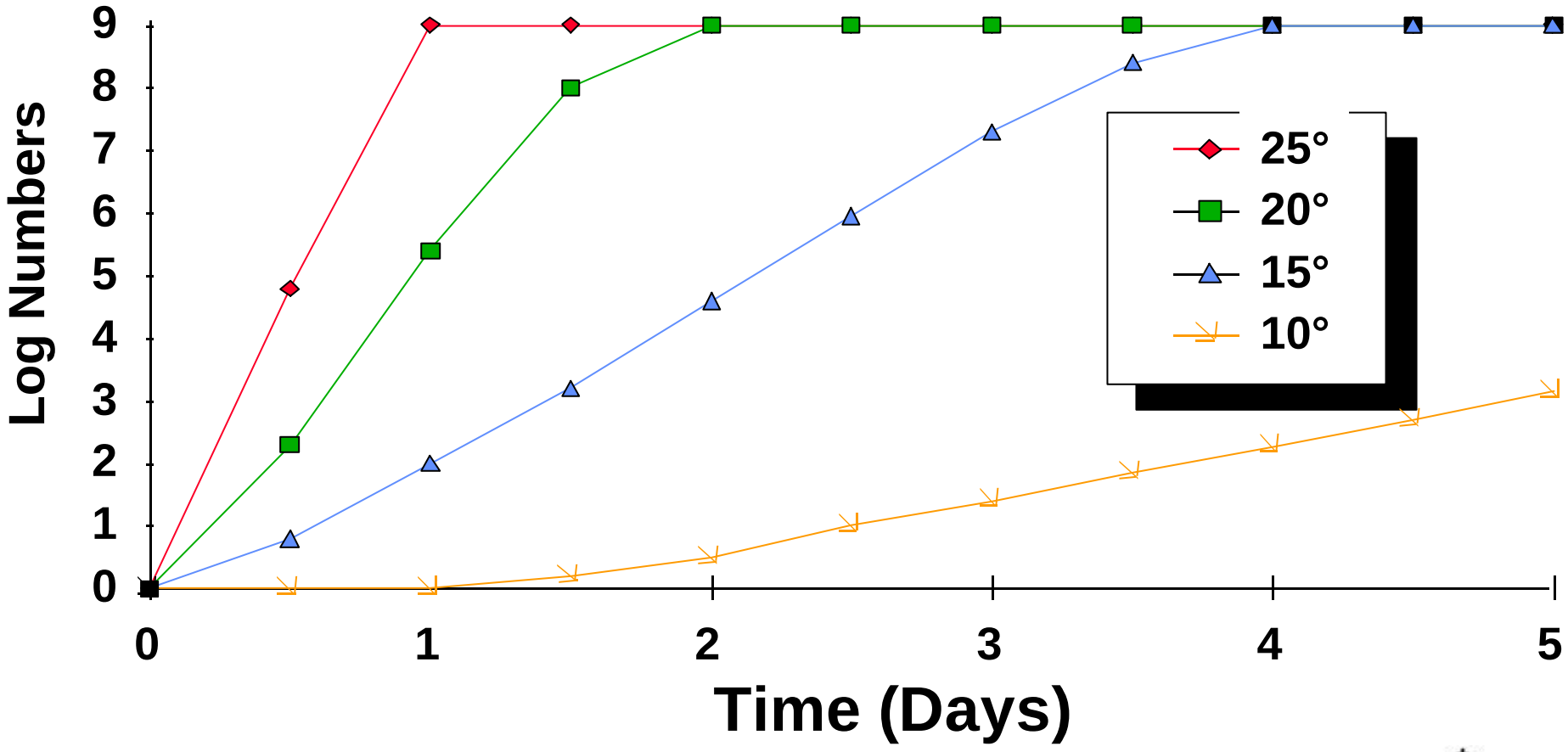
Technologies based on:

- temperature control
- control of water activity
- control of pH
- control of redox potential
- antimicrobial agents

How temperature affects growth rate of a bacterial population



Growth of *S. typhimurium* at different temperatures



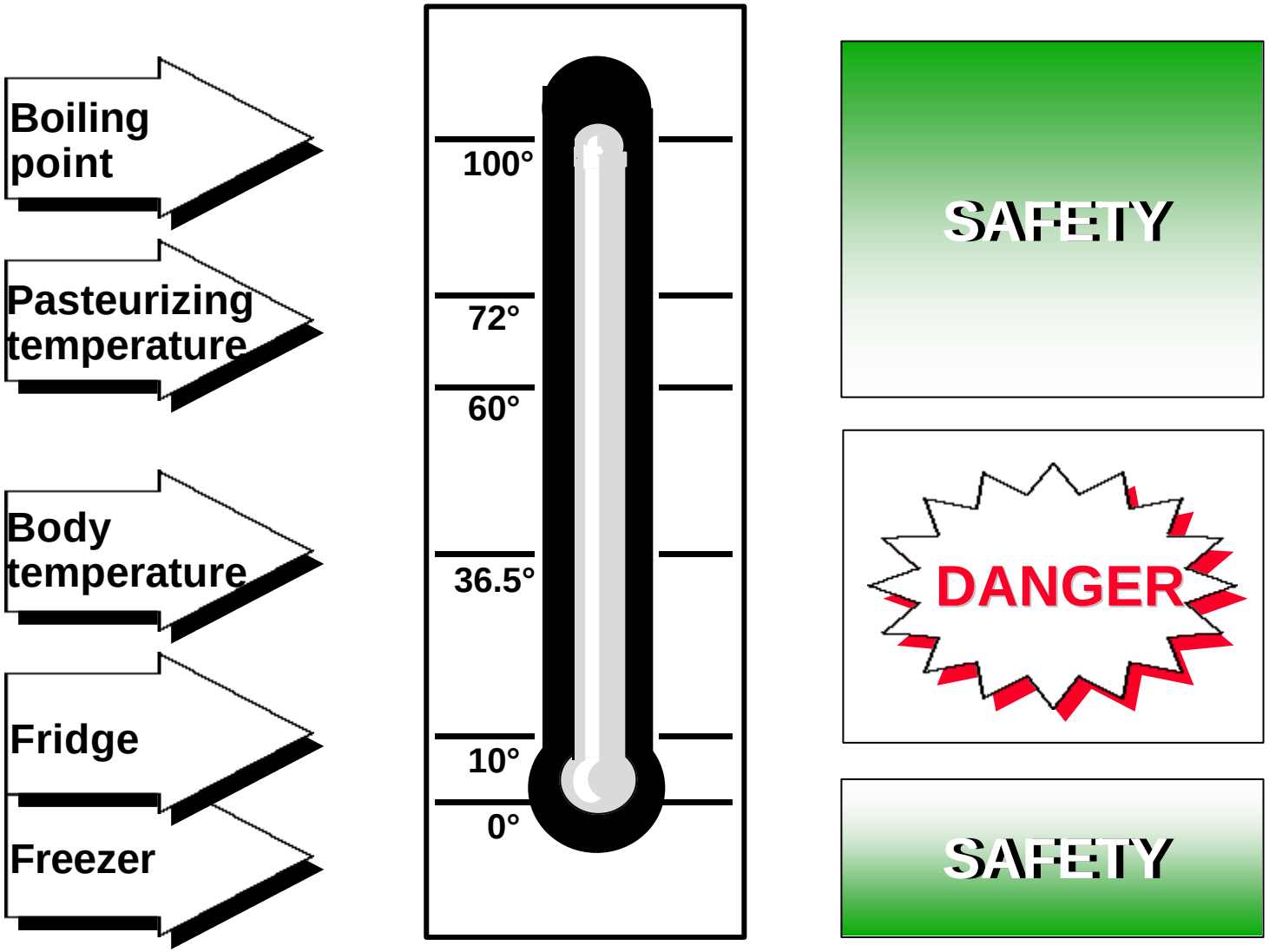
Temperature range for growth of pathogens

	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

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**

Temperature zones



Psychrotrophic pathogens

- ***L . monocytogenes***
- ***Y . enterocolitica***
- ***C . botulinum type***

Water activity

- Water is required for the growth and metabolism of microorganisms
- All the water in foods is not available for microorganisms
- The degree of availability of water is measured by water activity (a_w)
- Chemical and enzymatic reactions are also affected by availability of water

Minimum levels of a_w permitting growth
(at near optimum temperatures)

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

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

Water activity

a_w can be reduced by :

- **Removing water (drying)**
- **Decreasing availability of water by crystalization (freezing)**
- **Decreasing availability by binding water with water binding agents e.g. salt, sugar**

pH values limiting the 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*

pH and other factors

Microorganisms can grow in lab media at a wider range of pH than would occur in foods

Here, other factors come into effect e.g. microbial competition:

- ***oxygen tension***
- ***storage temperature***
- ***reduced a_w***
- ***heat damage to cells during processing***

pH

Acidification

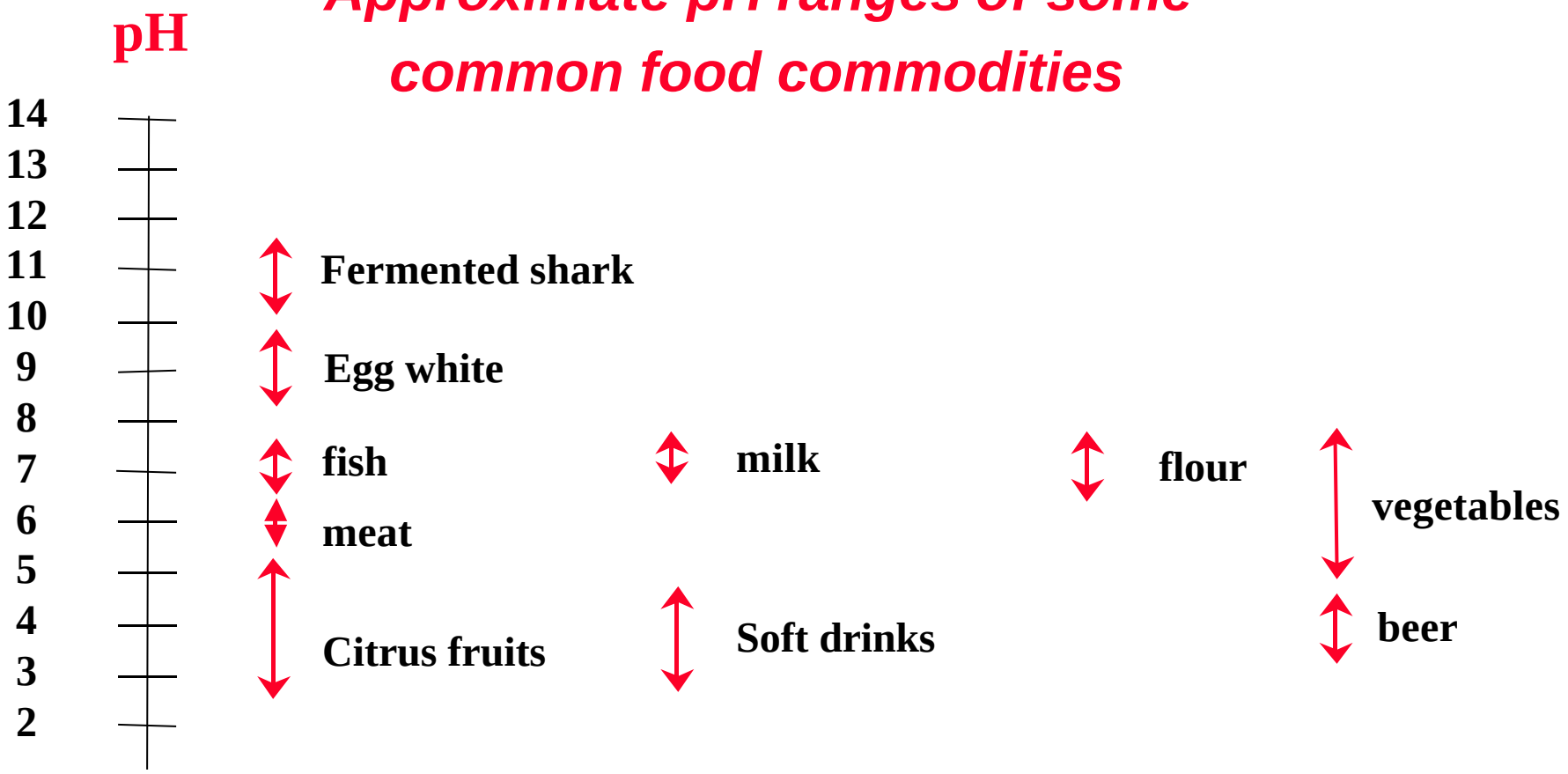
- *addition of vinegar*

Fermentation

- *organic acid*
- *competitive exclusion*
- *antimicrobial agents*

pH of different foods

Approximate pH ranges of some common food commodities



Control of E_h

- **Vacuum packaging**
- **Modified atmosphere packaging by gas flushing: CO_2 , N_2**

Antimicrobial agents

- Curing salts e.g. nitrites
- Bacteriocins e.g. nisin
- Gas: e.g. CO_2
- Organic acids / salts e.g. benzoic, sorbic and propionic acid

Food technologies that prevent contamination

Additional operations and aspects of importance

- Packaging
- Hygienic design of factories, lines and equipment
- Cleaning and disinfection

Packaging

- Prevent recontamination
- Protect solid food against moisture uptake
- Maintain low oxygen atmosphere
- Protect food against light

Packaging - Key messages

- The purpose of packaging is to protect the food from change in quality, including microbiological and physico-chemical alterations
- The major causes of alterations are water vapour or moisture, oxygen, light and chemicals
- Hazards can be associated with packaging material or processes
- Packaging material must be chosen as a function of the preservation process, stability and characteristics of the food