

Module 05 Lecture 02

**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

cooking

baking / roasting

boiling

frying

grilling

microwave

pasteurisation

sterilisation

Heating medium

water

air

water

oil

air

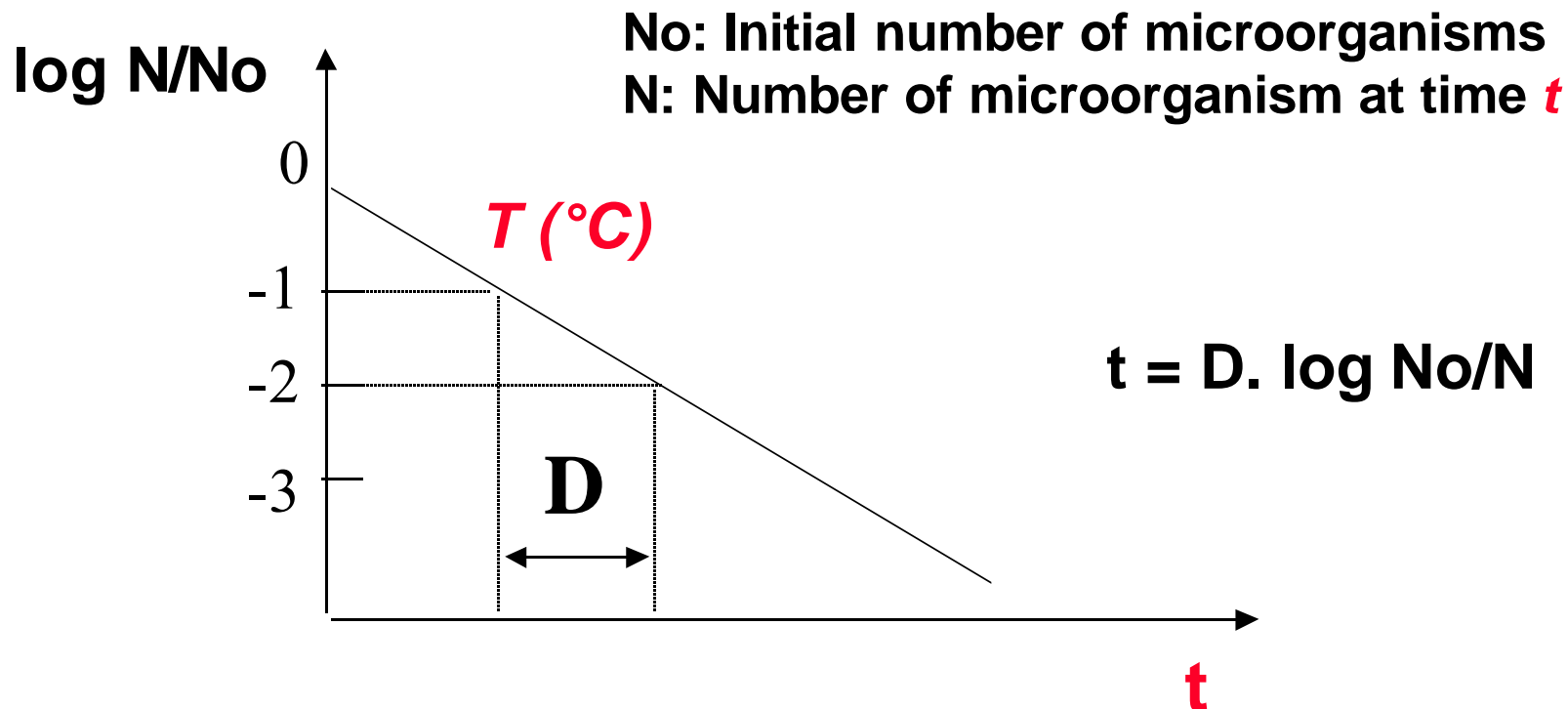
electromagnetic radiation

heat exchanger / water

steam under pressure

D-value

Heat resistance is measured by the decimal reduction time D



Heat resistance (1)

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

Heat resistance (2)

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

Pasteurisation schemes

Low temperature

63° C for 30 min

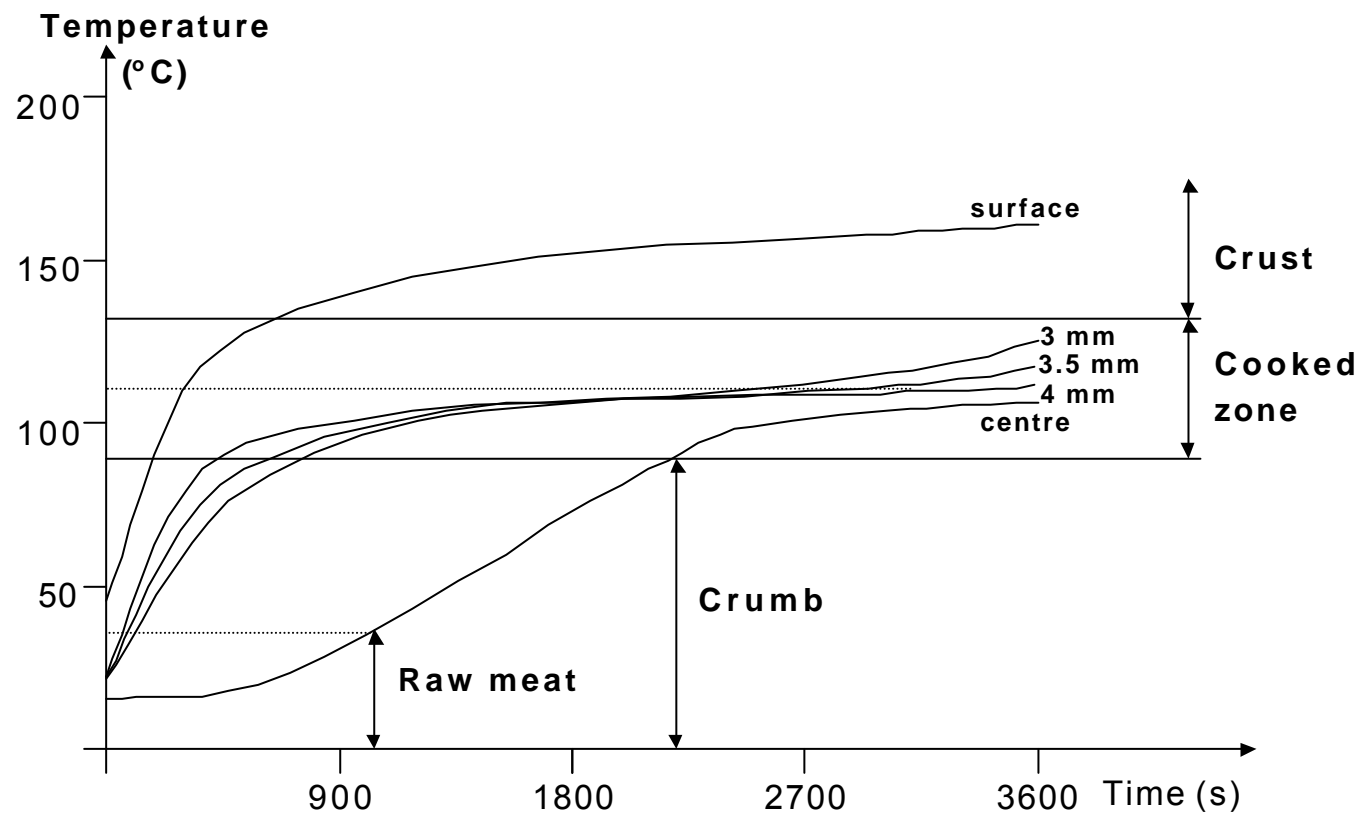
High temperature

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

- **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**

Sensitivity of microorganisms

Necessary dose

Parasites 1.0 kGy
Bacteria 1-7 kGy
(Viruses > 30 kGy)

Parasites

G - Bacteria

G + Bacteria, moulds

Spores, yeasts

Viruses

+

Chemical disinfection

Example of application

Water

Fruits and vegetables

**Surfaces and
equipment**

Example of disinfectant agent

chlorine

hypochlorite

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

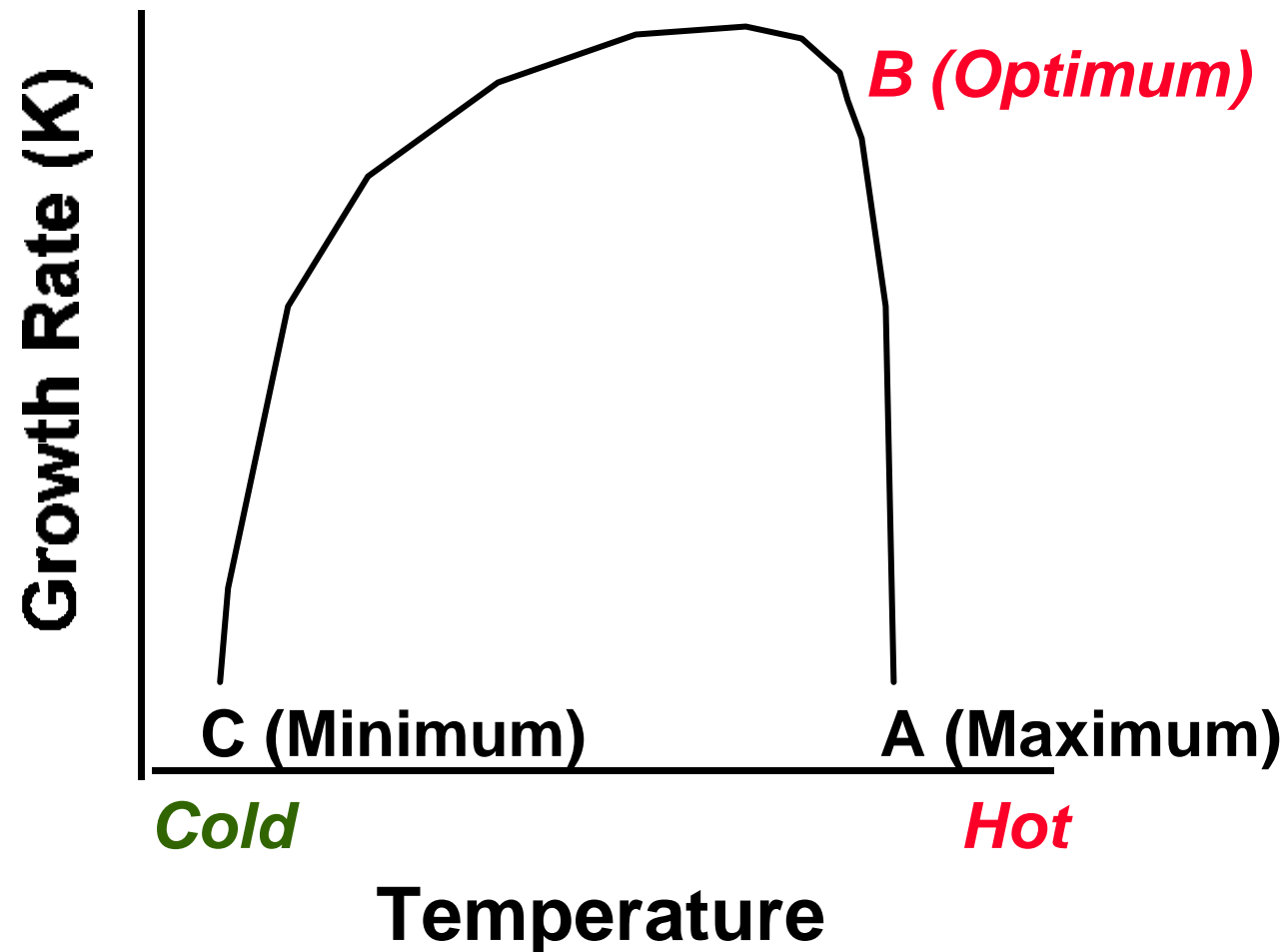
Food technologies to control the development of microbiological hazards

Technologies

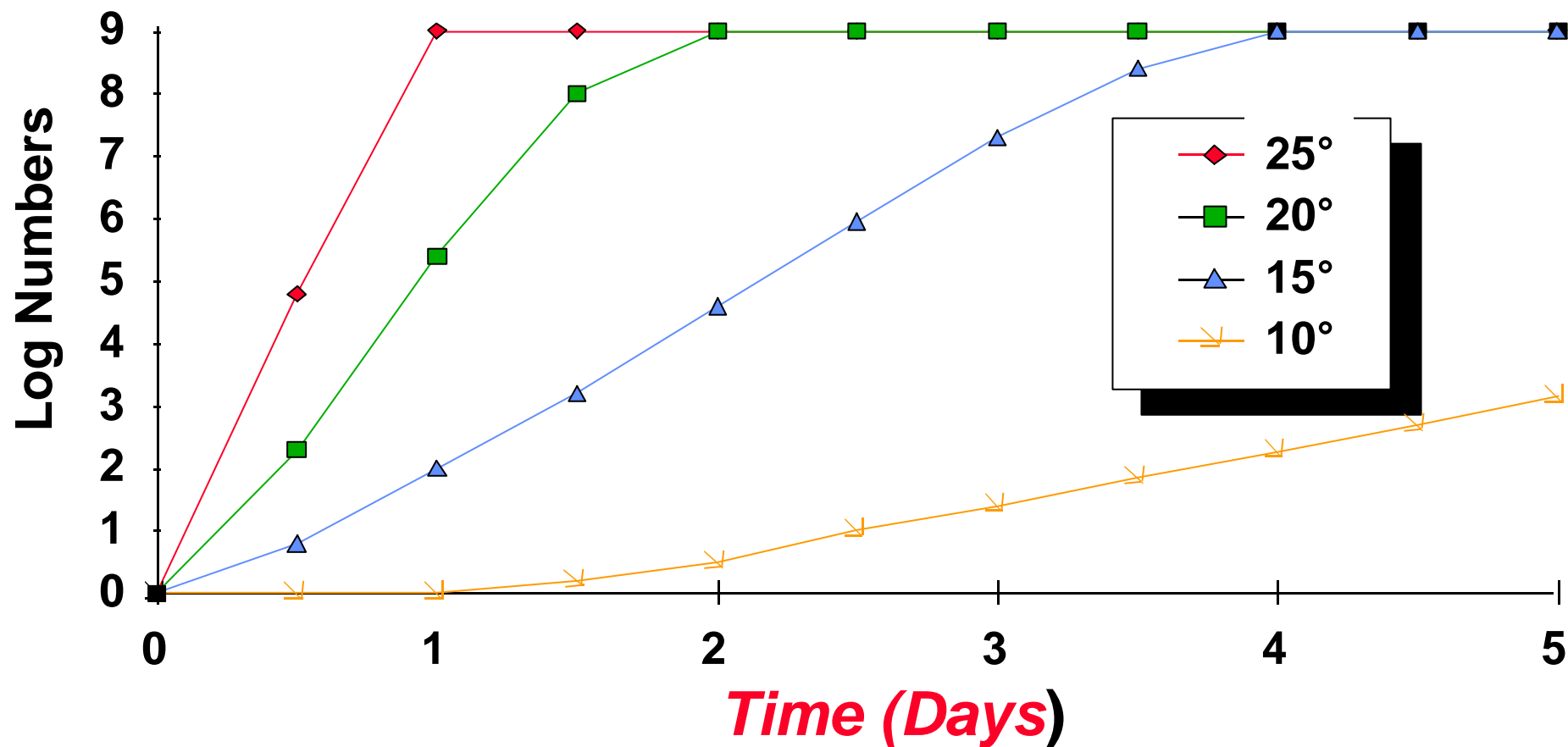
Technologies based on

- ◆ **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

	<i>Temperature °C</i>		
	<i>Min.</i>	<i>Opt.</i>	<i>Max.</i>
<i>Salmonella</i>	5	35 - 37	47
<i>Campylobacter</i>	30	42	47
<i>E. coli</i>	10	37	48
<i>S. aureus</i>	6.5	37 - 40	48
<i>C. botulinum</i> (proteolytic)	10		50
<i>C. botulinum</i> (non - proteolytic)	3.3		25 - 37
<i>B. cereus</i>	4	30 - 35	48 - 50

Temperature range for growth of toxigenic moulds

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

Temperature zones

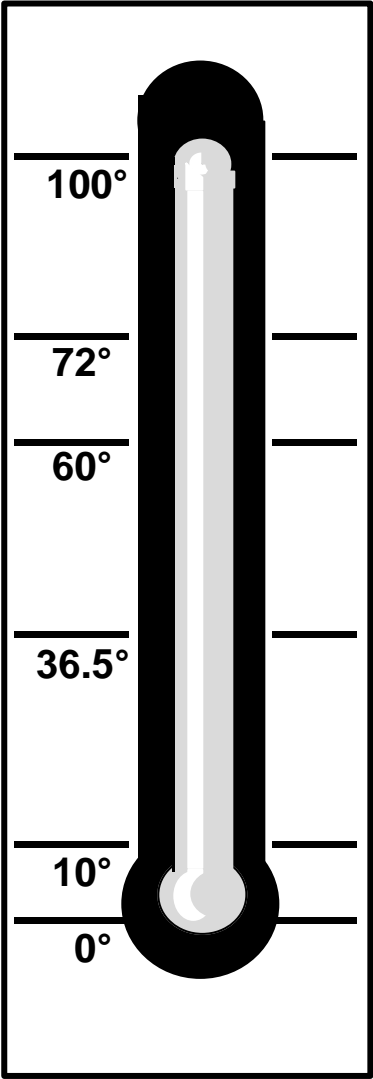
Boiling point

Pasteurising temperature

Body temperature

Fridge

Freezer



SAFETY

DANGER

SAFETY

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

0.85 - 0.93

Foods

Dry fermented sausages
Raw ham (17% salt, saturated sucrose)

Microbial flora

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 (4)

a_w can be reduced by

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

pH values limiting the growth of pathogens

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

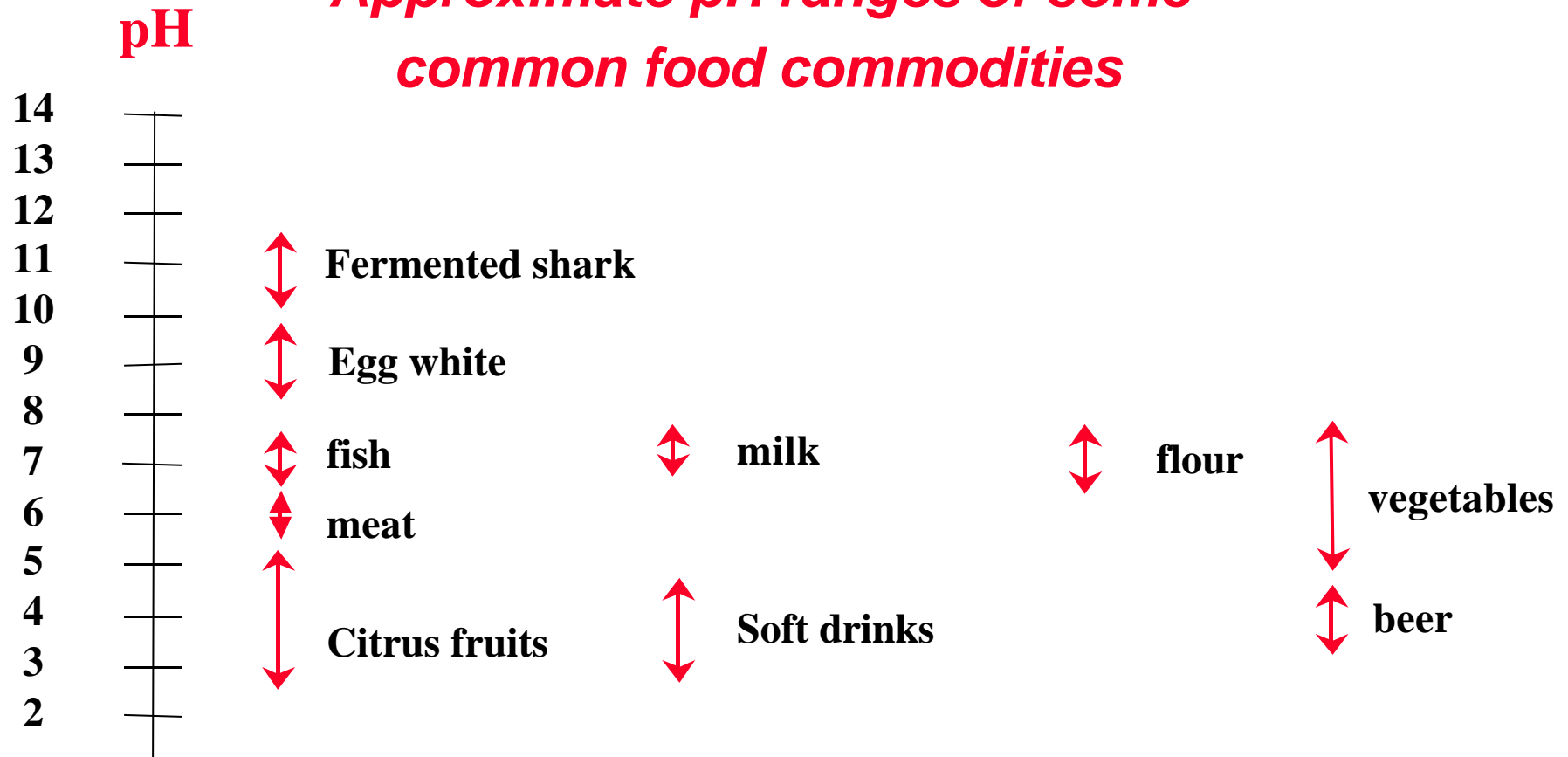
- ***addition of vinegar***

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 CO₂**
- **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 re-contamination**
- **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 cause 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**