Module 02 - lecture 04a

Food technologies to render 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 HACCP

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**

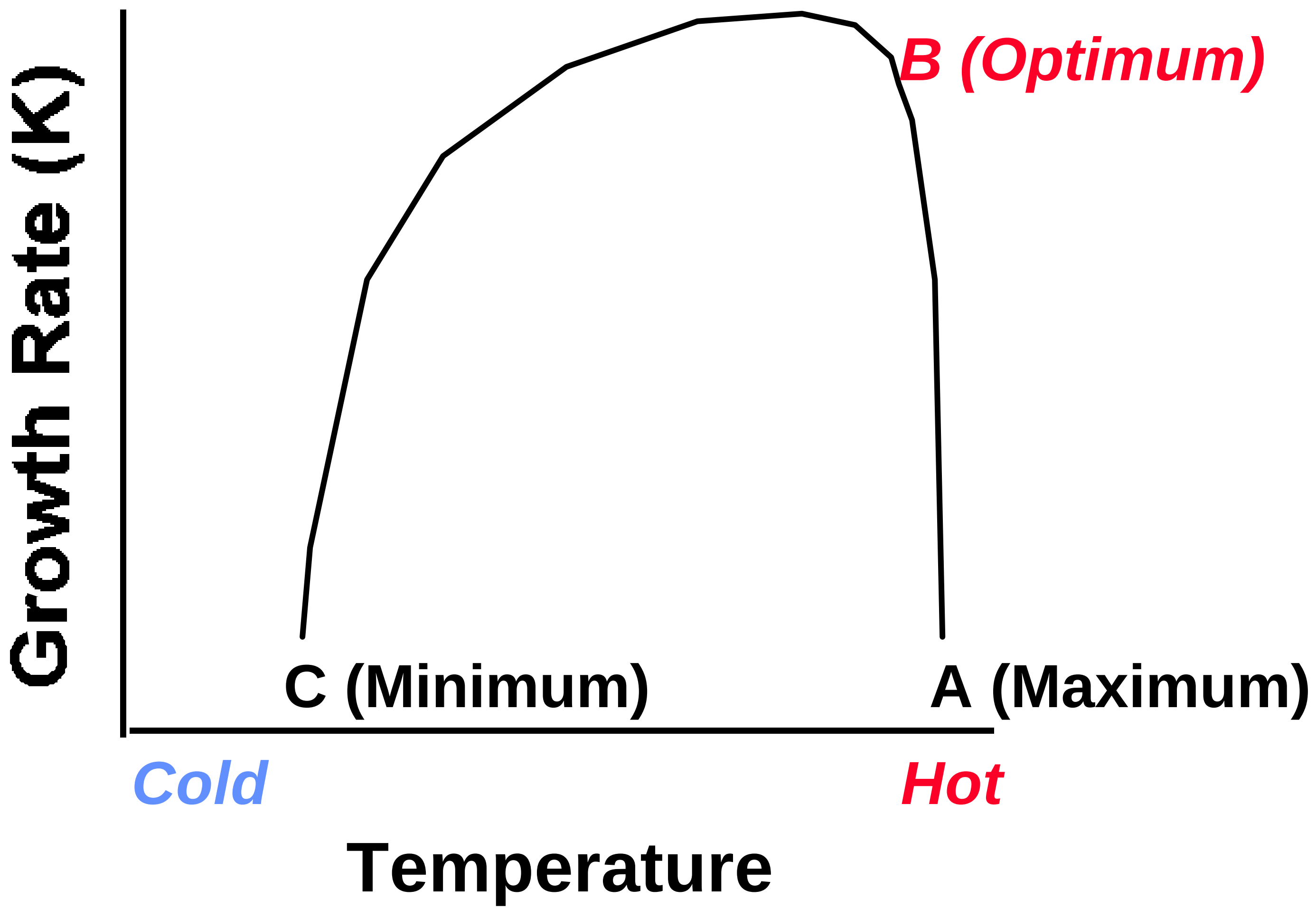
Food technologies that may kill certain microbes

- 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

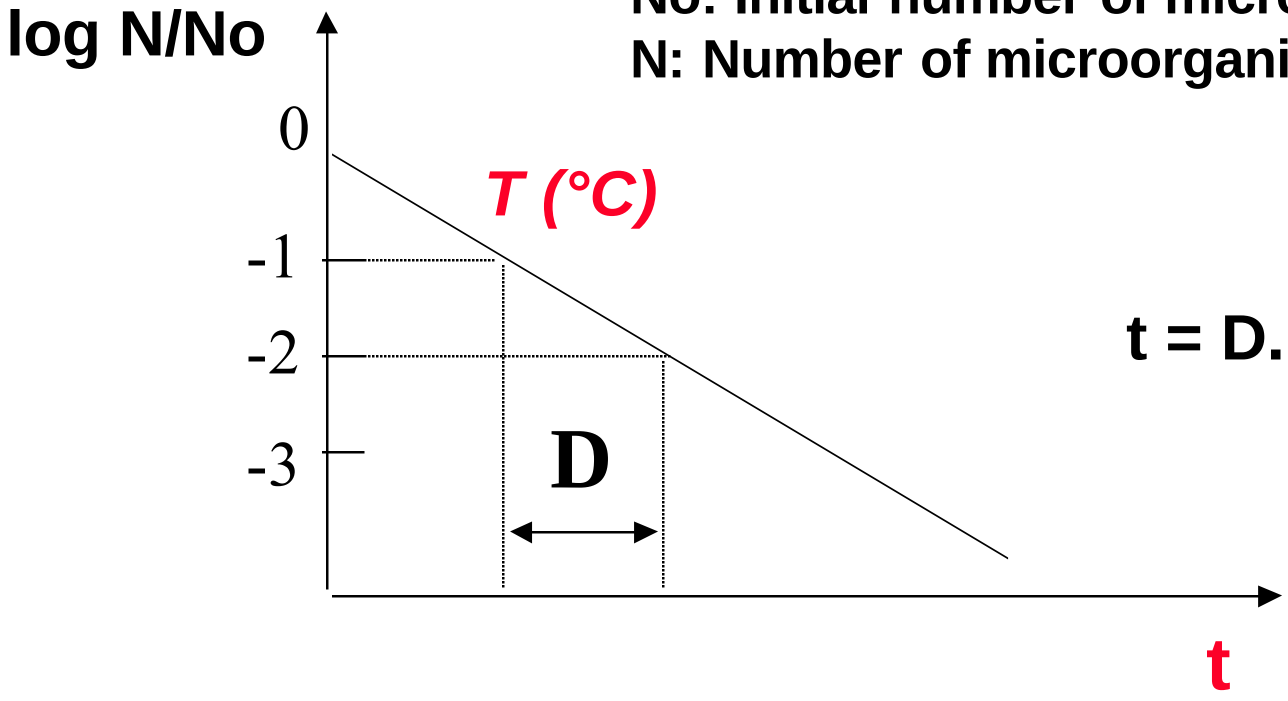
Effect of temperature on growth rate



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)

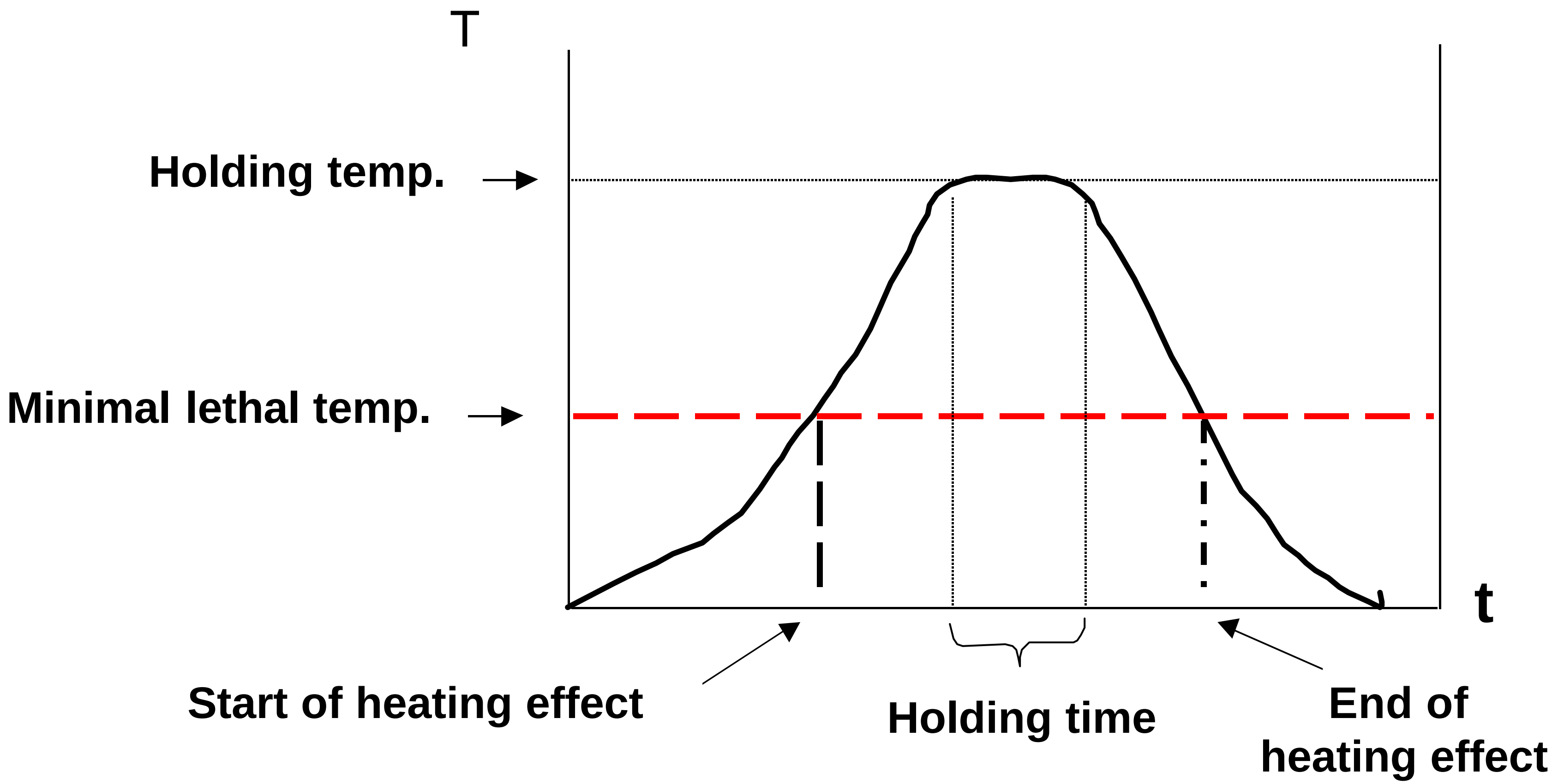
Heat resistance (D value) is influenced by many factors, e.g. :

- **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**

Heat resistance (4)

Medium	*D_{60} value Salmonella senftenberg*
Heart infusion broth (pH = 7.4; a_w = 0.99)	**6.1**
Heart infusion broth + NaCl (pH = 7.4; a_w = 0.90)	**2.7**
Heart infusion broth + Sucrose (pH = 7.4; a_w = 0.90)	**75.2**

Heat treatment (1)



Effects on proteins and vitamins

	D_{121} (min)
Protein degradation	**5**
Non - enzymatic browning	**0.4 - 40**
Lipase	**1.2 - 1.7**
Thiamin	**38 - 380**
Vitamin C	**245**
Betamin	**48**

Pasteurization schemes

Low temperature:

63° C for 30 min

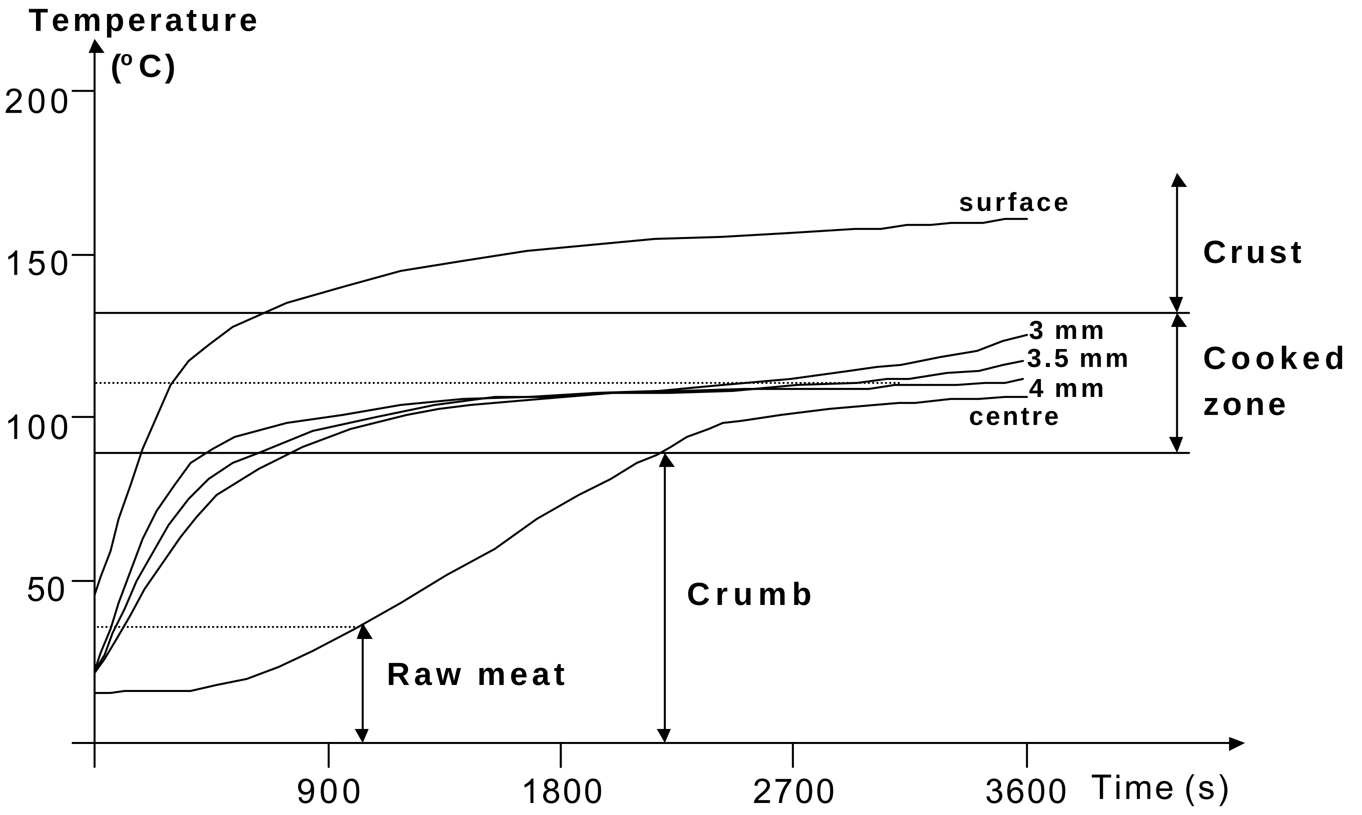
High temperature:

72° C for 15 sec

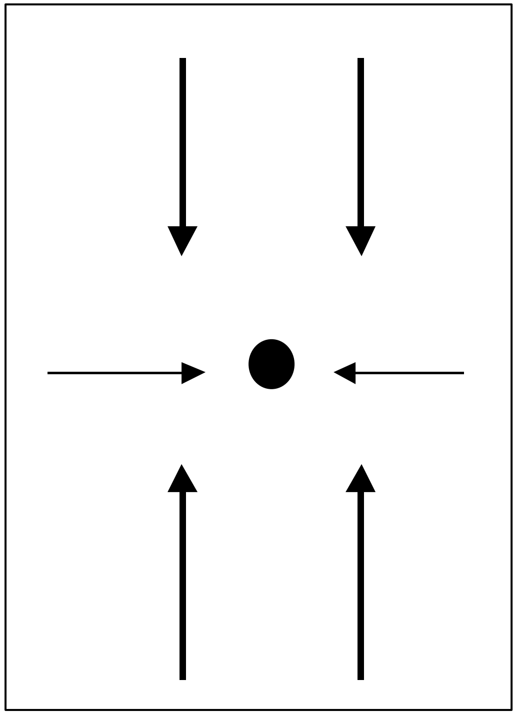
Ultra-high temperature:

135° C for 1 sec

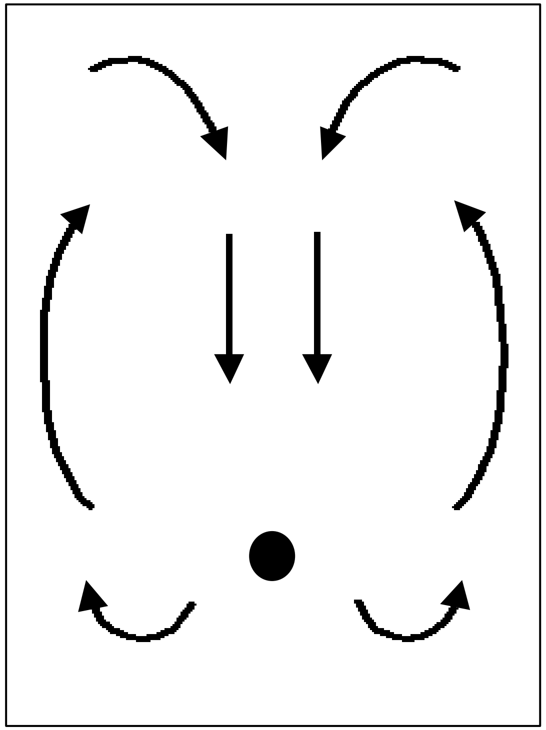
Temperature gradient in hamburger



Types of heat transfer



Conduction



Convection

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

Low - dose irradiation

Low - dose (up to 1 kGy)	*Dose (kGy)*	*Products irradiated*
Inhibition of sprouting	0.05 - 0.15	Potatoes, onions, garlic, etc.
Insect disinfestation and parasite disinfection	0.15 - 0.5	Cereals and pulses, fresh and dried fruits, dried fish and meat, fresh pork
Delay of physiological processes (e.g. ripening)	0.5 - 1.0	Fresh fruits and vegetables

Medium - dose irradiation

Medium-dose 1-10 kGy	*Dose (kGy)*	*Products irradiated*
Extension of shelf-life	**1.0 - 3.0**	**Fresh fish, strawberries, etc.**
Elimination of spoilage and pathogenic microorganisms	**1.0 - 7.0**	**Fresh and frozen seafood, raw or frozen poultry and meat, etc.**
Improving technological properties of food	**2.0 - 7.0**	**Grapes (increasing juice yield), dehydrated vegetables (reduced cooking time), etc.**

High - dose irradiation

High-dose (10-50 kGy)	*Dose (kGy)*	*Products irradiated*
Sometimes industrial sterilization (in combination with mild heat treatment)	**30 - 50**	**Meat, poultry, seafood, prepared foods, sterilized hospital diets**
Decontamination of certain food additives and ingredients	**10 - 50**	**Spices, enzyme preparations**

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

+

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

UV radiation

Produced by mercury lamps

Limited penetration

Useful for destroying microorganisms in air, surfaces and in thin liquid films

Most effective against vegetative bacteria >yeast > bacterial spores > mould spores

Chemical disinfection

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

Disinfection of water

Disinfection processes i.e. reduction of the number of micororganisms with time, obey Chick's law:

$$No / N = e^{-k\,t}$$

k = death rate*

t = time

No = initial number or nicroorganisms

N = number of microorganisms at time t

* k (death rate) is determined by the Watson's empirical dilution law:

$$k = C^{n} . t$$

n = dilution exponent (for water: n ~ 1)

C = concentration in mg / l

Disinfection of water

Efficacy of different disinfectants on pathogens is measured by the C . t value required to achieve 99 % reduction or inactivation of microorganisms

Chlorination of water (1)

Organism	*C.t value (mg.min/l) for 99% inactivation by chlorine at 5°C and pH 6-7*
E . coli	**0.034 - 0.05**
Hepatitis A virus	**1.8**
Poliovirus type 1	**1.1 - 2.5**
Rotavirus	**0.01 - 0.05**
***G . lamblia* cyst**	**47 - 150**
C . parvum	**7200**

Chlorination of water (2)

Efficacy depends on purity :

Median < 1 NTU

Maximum in single sample: 5 NTU

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

High pressure technology

- Hydrostatic pressure 1000 MPa
- Destruction of bacteria and fungi (90 % by 400 MPa for 5 min)
- Resistance depends on pH and T
- Acts uniformly and instantaneously
- Spores are resistant and tolerate pressure up to 1200 MPa