wagrALIM

THE AGRO-INDUSTRY'S COMPETITIVE CLUSTER IN WALLONIA

INNOVATION IN FOOD PRESERVATION

Isnes, Oct. 20th 2011

Factors influencing food conservability

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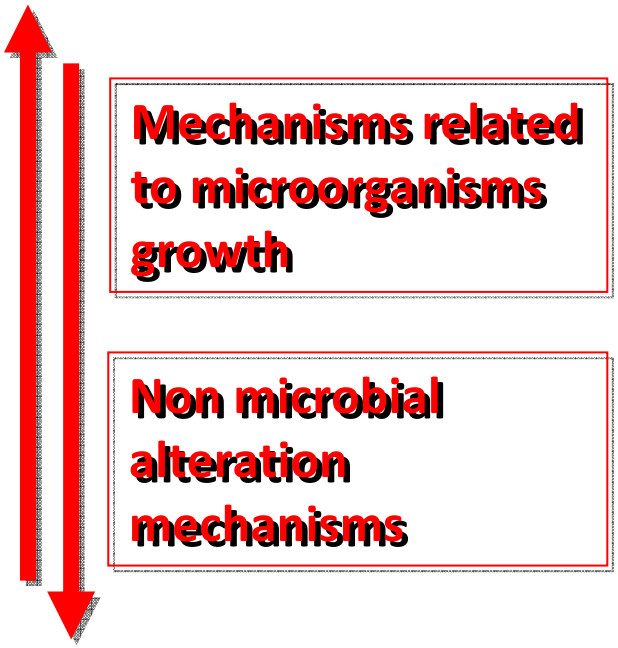
Agenda

- Food conservability
- Mechanisms limiting food shelf life
- Factors influencing food conservability
- Hurdle technology and food preservation
- Conclusions

Mechanisms limiting food shef life

Food conser-vability



Mechanisms related to microorganisms growth

Non microbial alteration mechanisms

Mechanisms limiting food shef life

–Microbial (bacteria, molds, yeasts)

- Ex. :
  - **Spoiling** m.o.
  - **Pathogenic** m.o. (including toxins)

Mechanisms limiting food shef life –Biochemical

- Ex. :
  - **Glycolysis**
  - **Proteolysis**
  - **Lipolysis**

  } ⇒ <u>also by M.O.</u> (or added ingredients)
  - **Enzymatic browning**

⇒ **Enzymes**

- **reaction rate** is function of substrate concentration, temperature, pH, …
- **denaturation** by heat, extreme acidity/alcalinity, high ionic strength, …

Mechanisms limiting food shef life –Chemical

- Ex. :
  - **Lipid oxidation**
  - **Protein oxidation**
  - **Pigment oxidation**
  - **Maillard reactions, …**

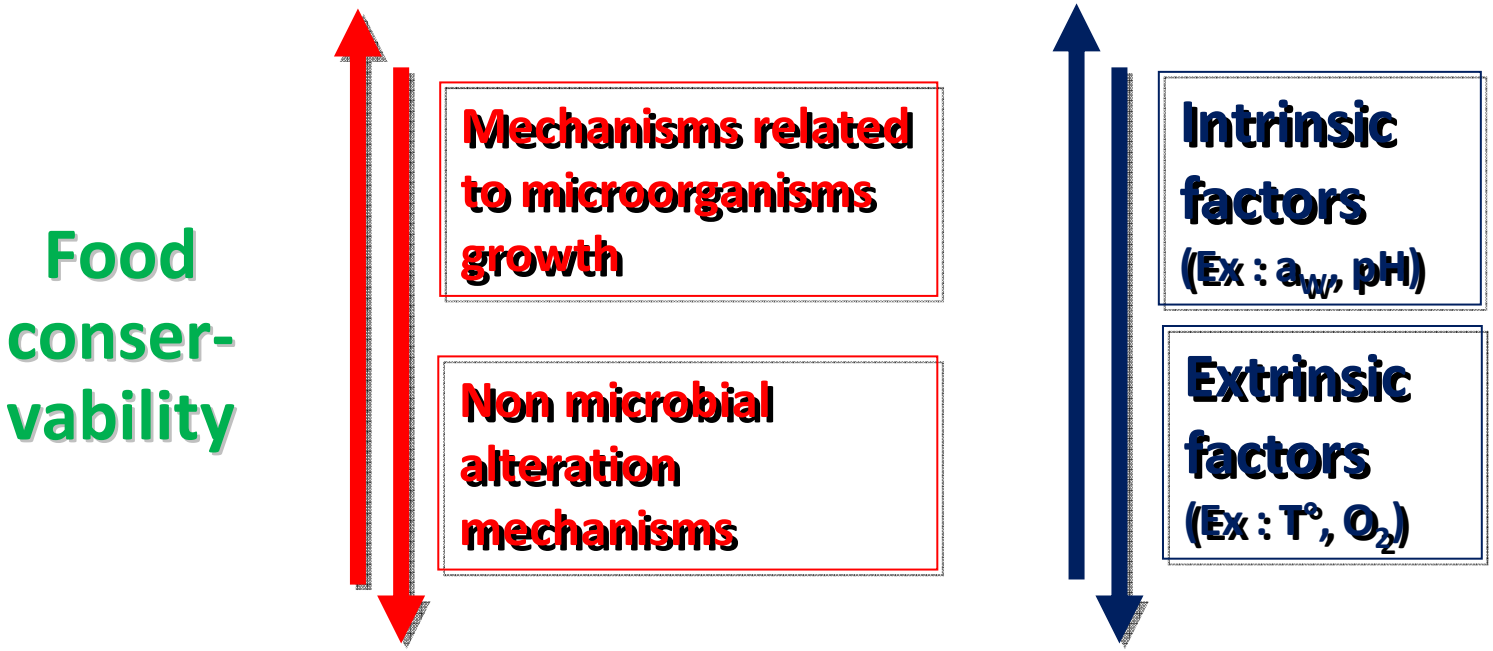
⇒ **non enzymatic**

- **reaction rate** is function of substrate concentration, temperature, pH, …
- ~~**denaturation** by heat, extreme acidity/alcalinity, high ionic strength~~

Mechanisms limiting food shef life
–Physico(-chemical)

- Ex. :
  - **Migration**
  - **Evaporation**
  - **Syneresis**
  - **…**

Factors influencing food conservability



Factors influencing food conservability – pH

Table 3-5—Approximate pH values permitting the growth of selected pathogens in food

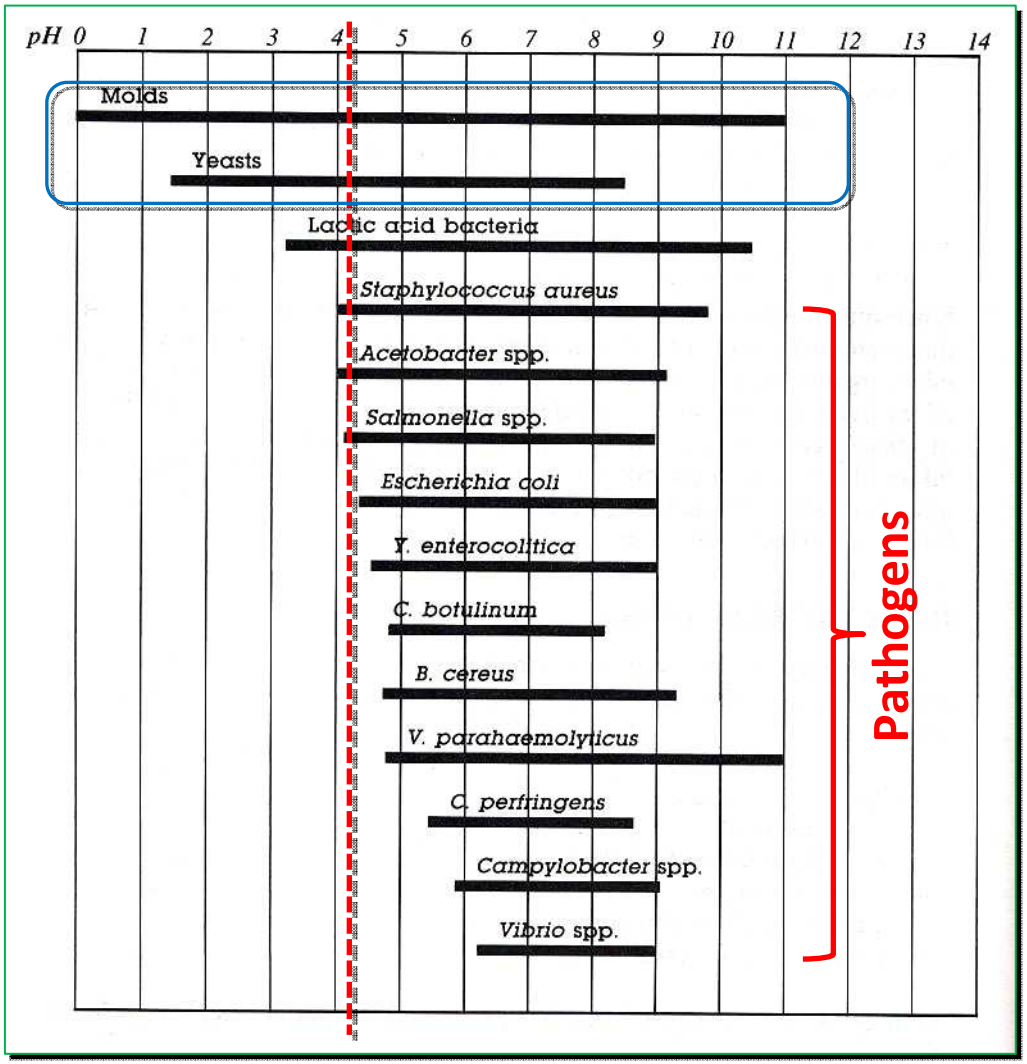
Microorganism	Minimum	Optimum	Maximum
Clostridium perfringens	5.5 to 5.8	7.2	8.0 to 9.0
Vibrio vulnificus	5.0	7.8	10.2
Bacillus cereus	4.9	6.0 to 7.0	8.8
Campylobacter spp.	4.9	6.5 to 7.5	9.0
Shigella spp.	4.9	9.3	
Vibrio parahaemolyticus	4.8	7.8 to 8.6	11.0
Clostridium botulinum			
toxin	4.6	8.5	
growth	4.6	8.5	
Staphylococcus aureus			
growth	4.0	6.0 to 7.0	10.0
toxin	4.5	7.0 to 8.0	9.6
Enterohemorrhagic			
Escherichia coli	4.4	6.0 to 7.0	9.0
Listeria monocytogenes	4.39	7.0	9.4
Salmonella spp.	4.2[1]	7.0 to 7.5	9.5
Yersinia enterocolitica	4.2	7.2	9.6

Sources: Table 5.3 in ICMSF 1980, p 101.
[1]pH minimum as low as 3.8 has been reported when acidulants other than acetic acid or equivalent are used.

[IFT/FDA, 2003]

Factors influencing food conservability – pH

Approximate pH values permitting the growth of selected microorganisms



[Jay, 1986]

Factors influencing food conservability – pH

pH of meat and meat products and comparison with other foods from animal origin

Meat and meat products	pH	Other foods from anim.	pH
Muscle (living animal)	7.0-7.2	Fish (most species)	6.6-6.8
Meat (normal ultimate pH)	5.3-5.8	Salmon	6.1-6.3
« P.S.E. » meat (pH1)	<5.8	Shrimp	6.8-7.0
« D.F.D » meat (pH24)	>6.2	Oysters	4.8-6.3
Poultry	6.2-6.4	Milk	6.3-6.5
Cooked ham	5.8-6.2	Cream	6.5
Dry-cured ham	5.3-5.8	Butter	6.1-6.4
Liver pâté	5.9-6.3	Cheese	>4.5
Francfort sausage	5.8-6.3	Yoghurt	3.7-4.3
Black pudding	6.6-7.1	Egg	7.3-7.6
Dry-fermented sausage	4.8-6.3		
(From Hofmann, 1988)		(From Jay, 1986; Rosenthal, 1991)	

Factors influencing food conservability – pH

pH of some foods from vegetal origin

Vegetables	pH	Fruits	pH
Asparagus	5.7-6.1	Apples	2.9-3.3
Broccoli	6.5	Bananas	4.5-4.7
Brussels sprouts	6.3	Lemon	1.8-2.0
Carrots	4.9-5.2	Melon	6.3-6.7
Cauliflower	5.6	Orange	3.6-4.3
Celery	5.7-6.0	Grapefruit	3.0
Lettuce	6.0	Plum	2.8-4.6
Parsley	5.7-6.0	Grapes	3.4-4.5
Potatoes	5.3-5.6	Tomatoes	4.2-4.3
		Olives	3.6-3.8
(From Jay, 1986)			

Factors influencing food conservability – A_w

The concept of ***water activity*** (A_w) was developed to account for the intensity with which water associates with various non-aqueous constituents and solids.

Water activity is defined as follows :

$$a_w = \frac{P}{P_0} = \frac{ERH}{100}$$

P = partial vapor pressure of food moisture at temperature T ;
P_0 = saturation vapor pressure of pure water at temperature T
$\Rightarrow$ the result is expressed by a number between 0 and 1.

ERH = equilibrium relative humidity at temperature T.

Factors influencing food conservability – A_w

Table 3–2—Approximate a_w values for growth of selected pathogens in food

Organism	Minimum	Optimum	Maximum
Campylobacter spp.	0.98	0.99	
Clostridium botulinum type E*	0.97		
Shigella spp.	0.97		
Yersinia enterocolitica	0.97		
Vibrio vulnificus	0.96	0.98	0.99
Enterohemorrhagic *Escherichia coli*	0.95	0.99	
Salmonella spp.	0.94	0.99	>0.99
Vibrio parahaemolyticus	0.94	0.98	0.99
Bacillus cereus	0.93		
Clostridium botulinum types A & B**	0.93		
Clostridium perfringens	0.943	0.95 to 0.96	0.97
Listeria monocytogenes	0.92		
Staphylococcus aureus			
growth	0.83	0.98	0.99
toxin	0.88	0.98	0.99

ICMSF 1996.
**proteolytic
*nonproteolytic

[IFT/FDA, 2003]

Factors influencing food conservability – A_w

Table 3-4. Approximate minimum a_w values for the growth of microorganisms of importance in foods.

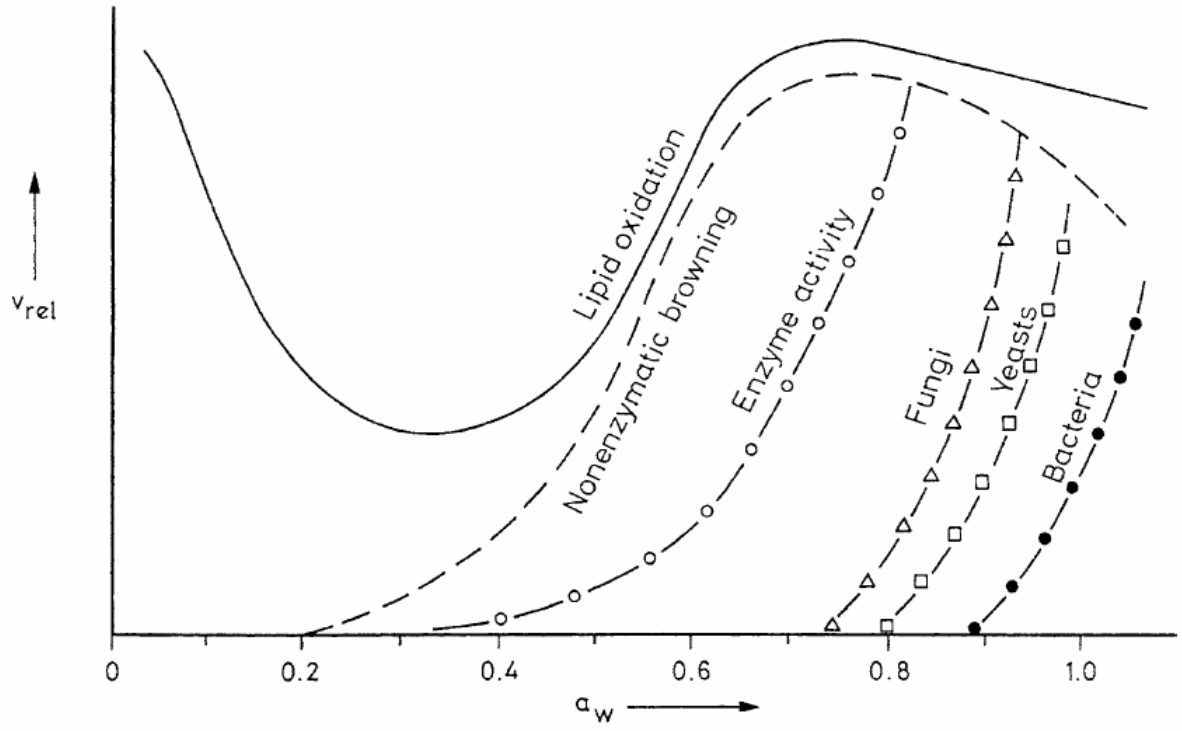
Organisms	a_w	*Organisms*	a_w
GROUPS		GROUPS	
Most spoilage bacteria	0.9	Halophilic bacteria	0.75
Most spoilage yeasts	0.88	Xerophilic molds	0.61
Most spoilage molds	0.80	Osmophilic yeasts	0.60
SPECIFIC ORGANISMS		SPECIFIC ORGANISMS	
Clostridium botulinum, Type E	0.97	*Candida scottii*	0.92
Pseudomonas spp.	0.97	*Trichosporon pullulans*	0.91
Acinetobacter spp.	0.96	*Candida zeylanoides*	0.90
Escherichia coli	0.96	*Endomyces vernalis*	0.89
Enterobacter aerogenes	0.95	*Staphylococcus aureus*	0.86
Bacillus subtilis	0.95	*Alternaria citri*	0.84
Clostridium botulinum,		*Penicillium patulum*	0.81
Types A and B	0.94	*Aspergillus glaucus*[a]	0.70
Candida utilis	0.94	*Aspergillus conicus*	0.70
Vibrio parahaemolyticus	0.94	*Aspergillus echinulatus*	0.64
Botrytis cinerea	0.93	*Saccharomyces rouxii*	0.62
Rhizopus stolonifer	0.93	*Monascus bisporus*	
Mucor spinosus	0.93	(*Xeromyces bisporus*)	0.61

[a] Perfect stages of the *A. glaucus* group are found in the genus *Eurotium*.

[Jay, 1986]

Factors influencing food conservability – A_w

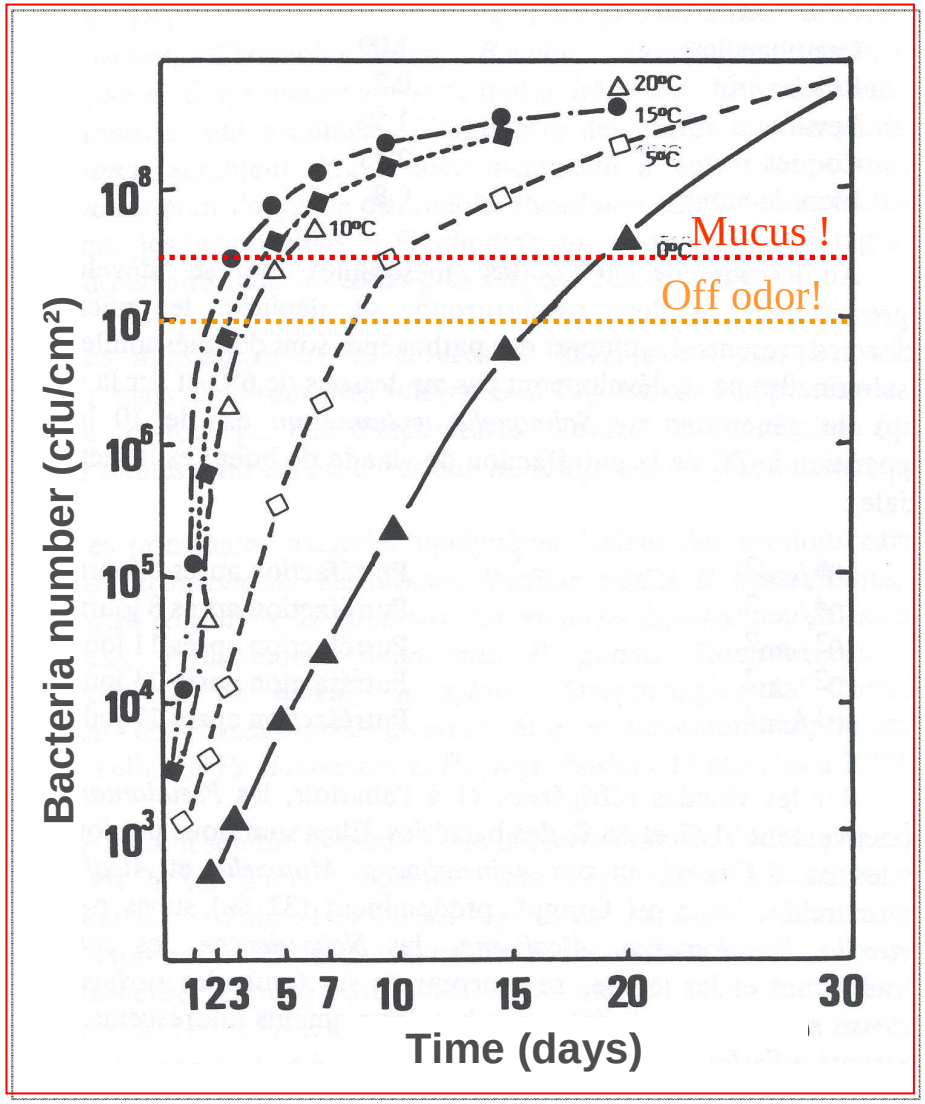
[Belitz *et al.*, 2009]



Food shelf life (storage stability) as a function of water activity (according to *Labuza*, 1971)

Factors influencing food conservability – Temperature

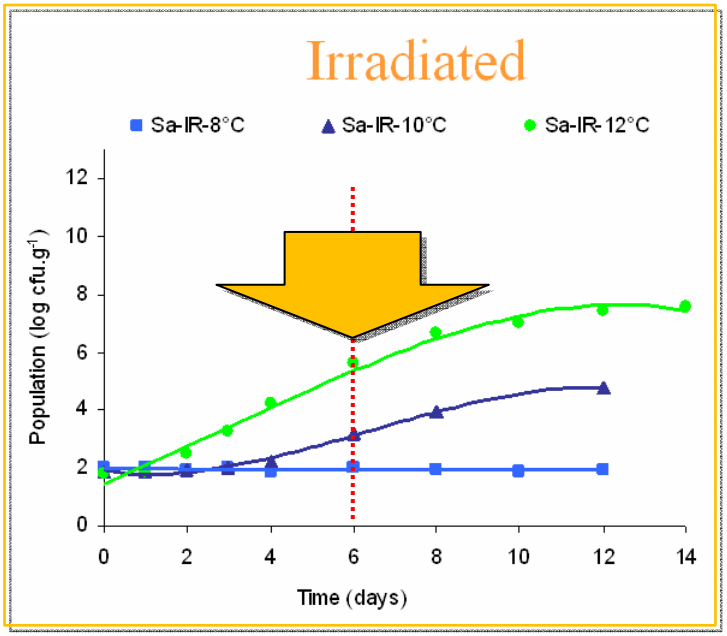
Bacteria growth rate on the meat surface / temperature

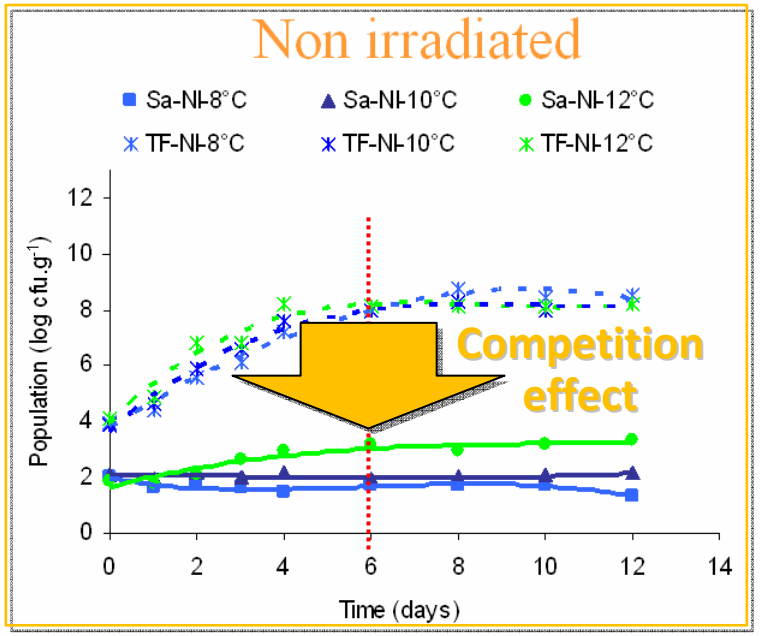


[Larpent, 1992]

Factors influencing food conservability – Temperature

Growth of *Salmonella* spp. (inoculated at 2 $\log_{10}$ cfu/g) in irradiated (= **without natural flora**) *vs* non irradiated (= **with natural flora**) pork minced meat stored under MAP (70%O_2:30%CO_2) during 12 d. at +8/10/12°C.





[Y. Adolphe, L. Delhalle, A. Jasick, G. Boseret, R. Duré, G. Daube, A. Clinquart. Food Micro 2010, Copenhagen]

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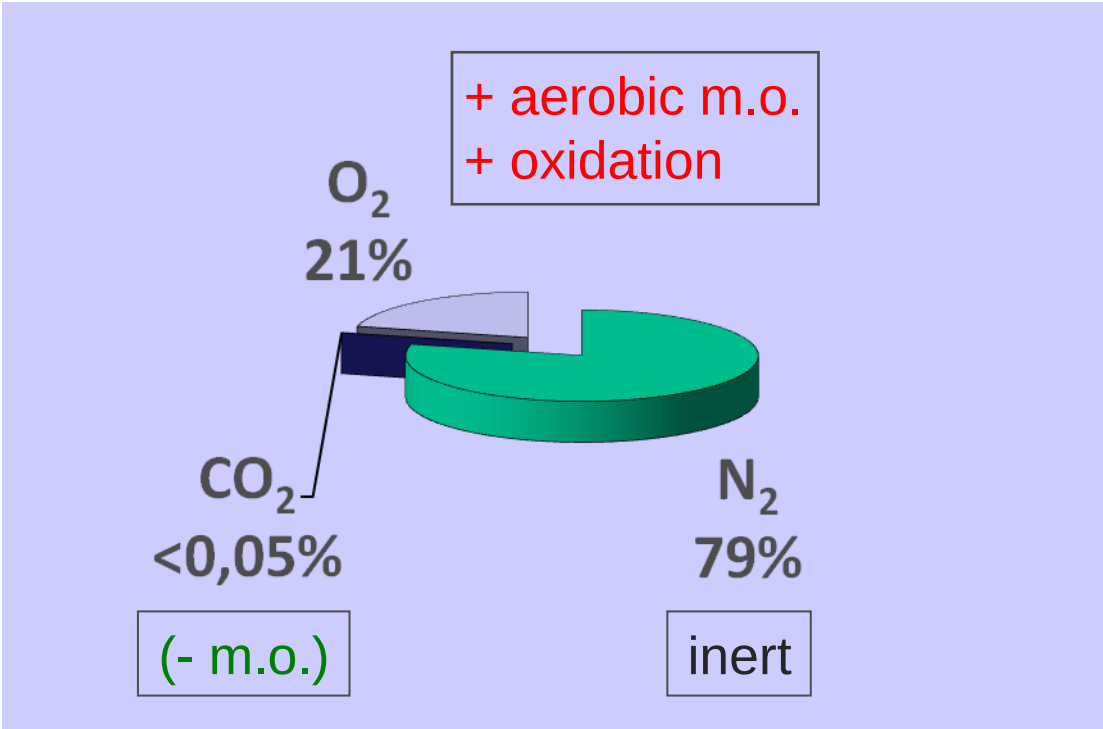
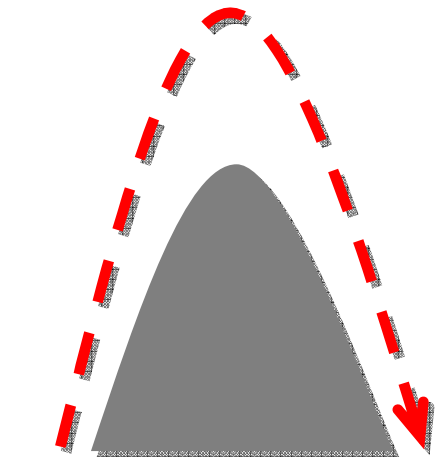
Factors influencing food conservability – Atmosphere

Atmospheric air



Hurdle technology and food preservation

Food preservation is function of « ***hurdle*** » effects



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Hurdle technology and food preservation

Classification *[From Bøgh-Sørensen, 1995]*	*Some « hurdle » values* *[From Labuza and Fu, 1995]*
PHYSICAL	
Heat processing (sterilization, pasteurization, blanching)	
Storage temperature (chilling, freezing)	< 4°C (1)
Radiations (UV, ionizing)	
Electroagnetic energy (microwave, RF, PEF)	
Photodynamic inactivation (light)	
Ultrahigh pressure	
Ultrasonication	
Packaging (active, edible)	
Atmosphère (modified, controlled)	
Hypobaric storage	
Aseptic packaging	
Microstructure	

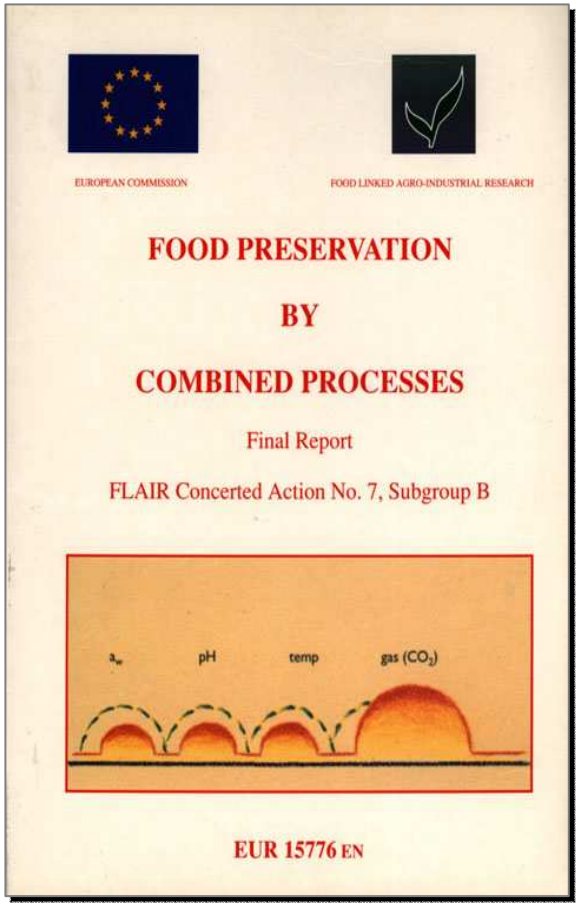
Hurdle technology and food preservation

Classification [From Leistner and Gorris, 1995]	*Some « hurdle » values [From Labuza and Fu, 1995]*
PHYSICO-CHEMICAL	
Water activity (a_w)	< 0,91 (2)
pH	< 4,6 (2)
Redox potential (Eh)	
Salt (NaCl)	> 2-3,5% (2)
Nitrates (NO_3^-), nitrites (NO_2^-)	≥ 120 ppm NO_2 (2)
Carbon dioxide (CO_2)	> 10 – 20% (2)
Oxygen (O_2)	
Ozone (O_3)	
Organic acids (lactic, acetic)	
Ascorbic acid	
Sulphite (SO_2)	
Smoking	
Phosphates	
Glucono-δ-lactone	
Phenols	
Chelators	
Antifongic	
Ethanol	
Propylene glycol	
Maillard reaction products	
Spices, herbs	
Lactoperoxidase	
Lysozyme	

Hurdle technology and food preservation

Classification *[from Bøgh-Sørensen, 1995]*	*Some « hurdle » values* *[From Labuza and Fu, 1995]*
MICROBIALLY DERIVED	
Competitive flora	
Starter cultures	
Bacteriocins	
Antibiotics	

Hurdle technology and food preservation
–Effect of combined factors



Combined processes
(FLAIR 1990-1994)

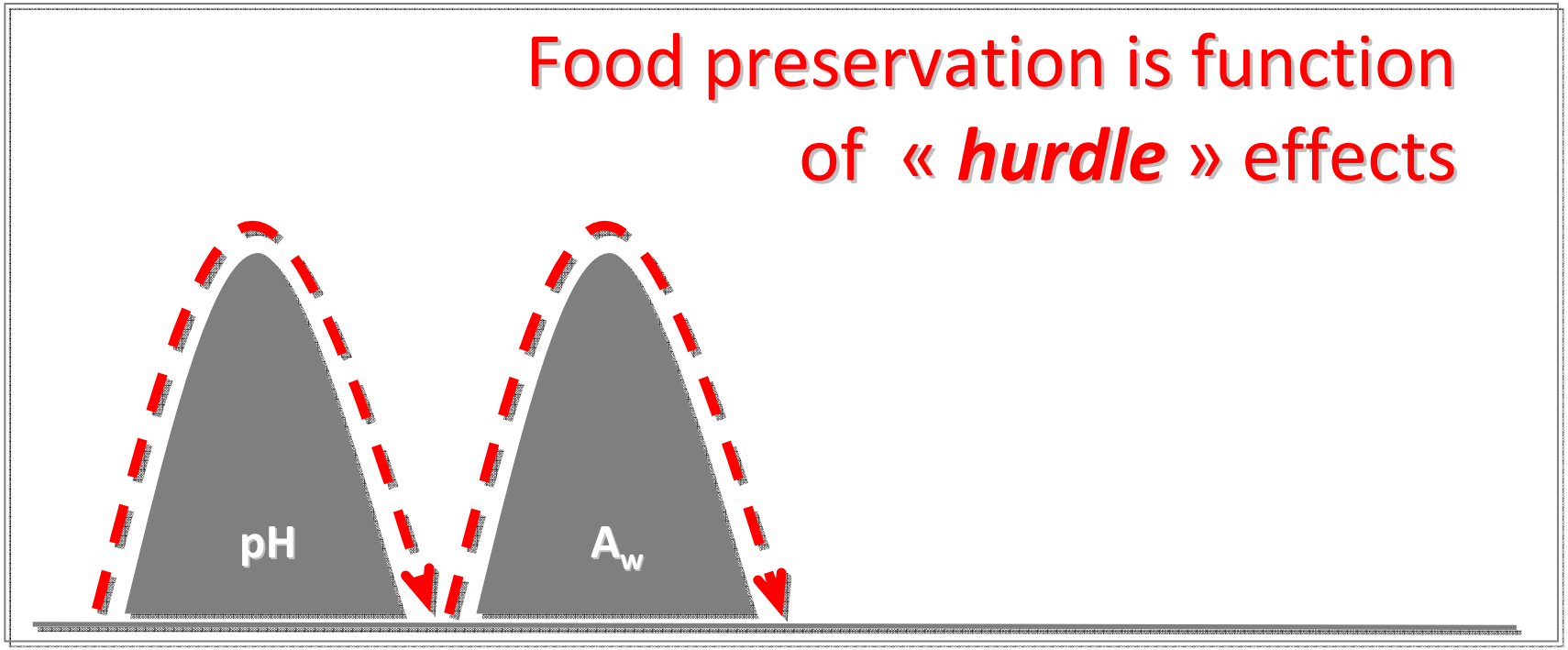
Minimally processed foods
(FAIR 1996-1999)

Hurdle technology and food preservation
–Effect of combined factors

Safety barriers for shelf life extension of **refrigerated** foods (Labuza and Fu, 1995)

Type	*Barrier*
Primary	Refrigeration (<4°C)
Secondary	A_w < 0.91
	pH < 4.6
	High levels of non pathogenic competing microorg.
	> 120 ppm nitrite (meat or poultry products)
	NaCl 2-3.5% (meat or poultry products)
	CO_2 > 10-20%
	Antimicrobial agents (natural or synthetic)
	Scavenger / emitter / active packaging
	Mild pasteurization (heat, µ-waves, irradiation, light)

Food preservation is function of « *hurdle* » effects



Hurdle technology and food preservation

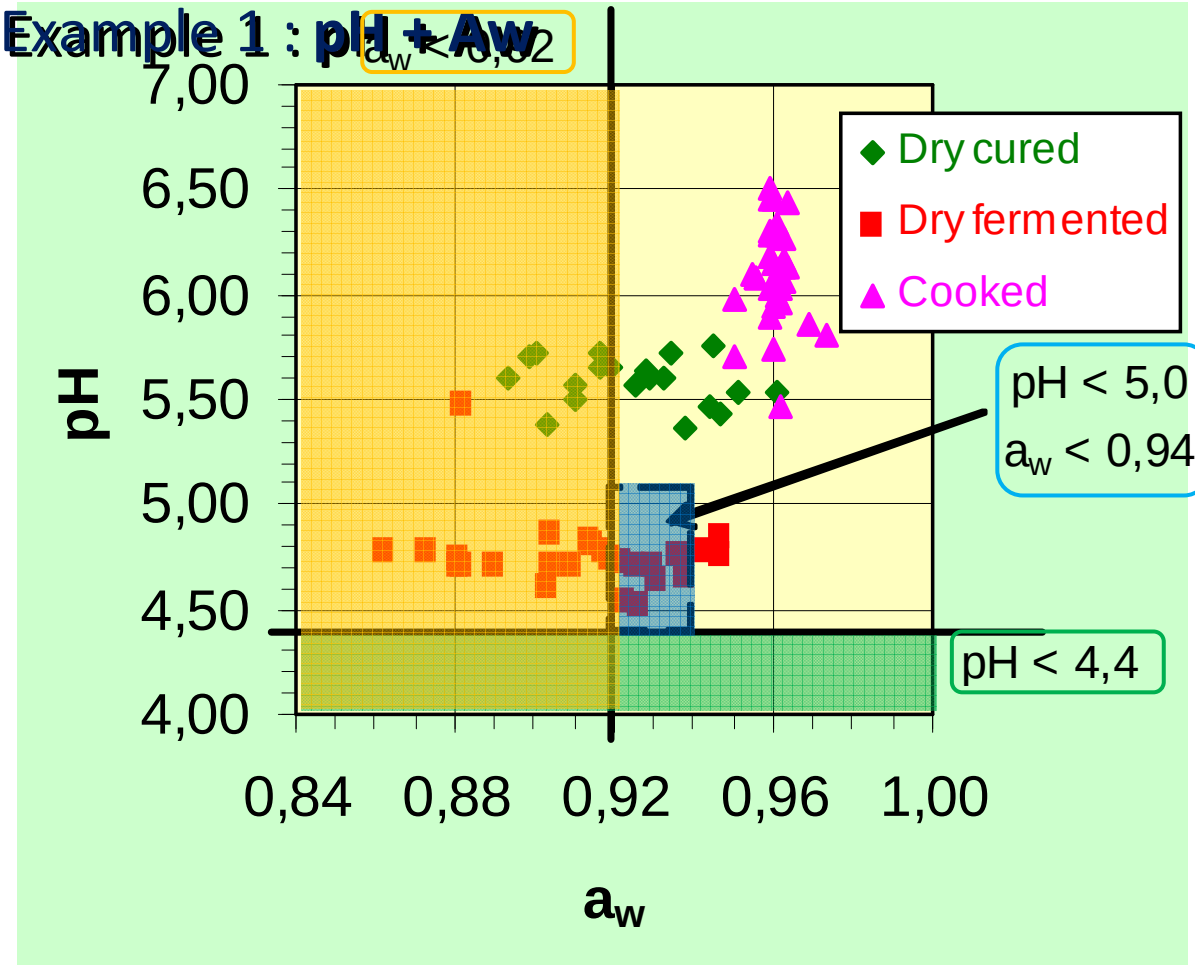
–Effect of combined factors

- Example 1 : pH + Aw

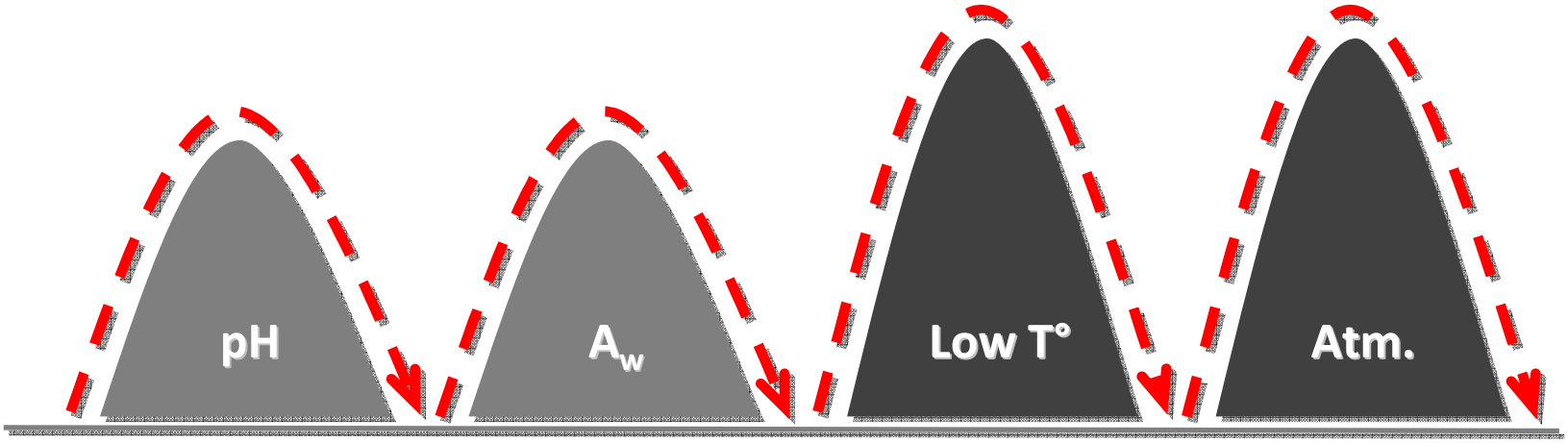
Reg. (EC) N° 2073/2005
L. monocytogenes

Influence of intrinsic physico-chemical characteristics (a_w, pH) on the conservability of meat products (n=79).

(Clinquart *et al.*, 1998)



Food preservation is function of « *hurdle* » effects



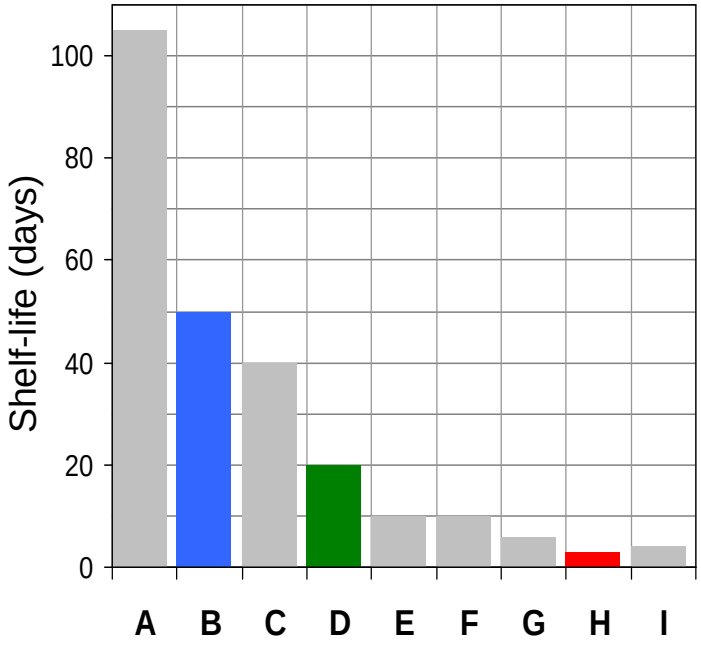
Hurdle technology and food preservation

–Effect of combined factors

- Example 2 : **low t° + atm.**

Shelf-life for beef products as based on microbiological factors obtained with different combinations of gas atmosphere composition and temperature conditions

(Rönner U., 1995. Food Preservation by combined processes, Final Report FLAIR Concerted Action No.7, Subgroup B)



A = 100% CO_2, +1°C

B = Vacuum, +1°C

C = 100% CO_2, +4-5°C

D = Vacuum, +4-5°C

E = 10-20% CO_2 + 2-10% O_2 + N_2, +4°C

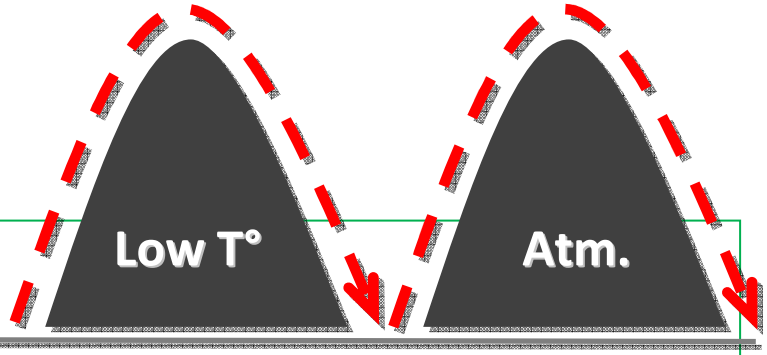
F = 15% CO_2 + 40% O_2 + 45% N_2, +4°C

G = 50-60% CO_2 + 40-50% O_2, +4°C

H = Air, +4°C

I = 100% O_2, 1-3°C

- **Fresh meat**

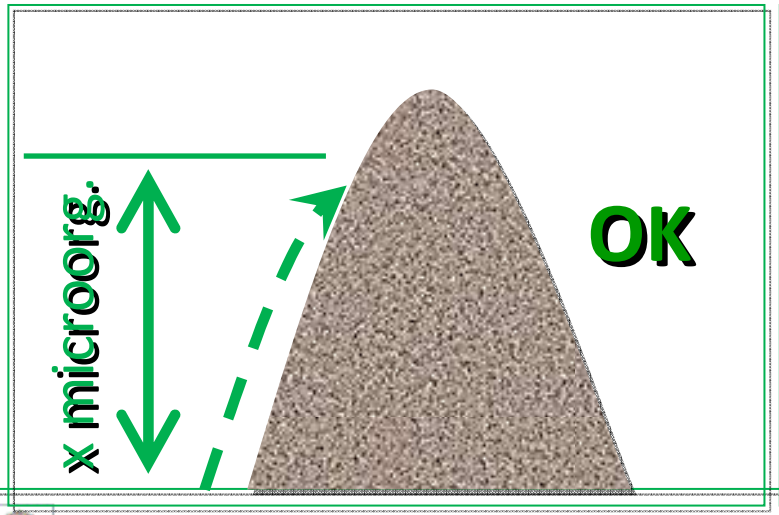


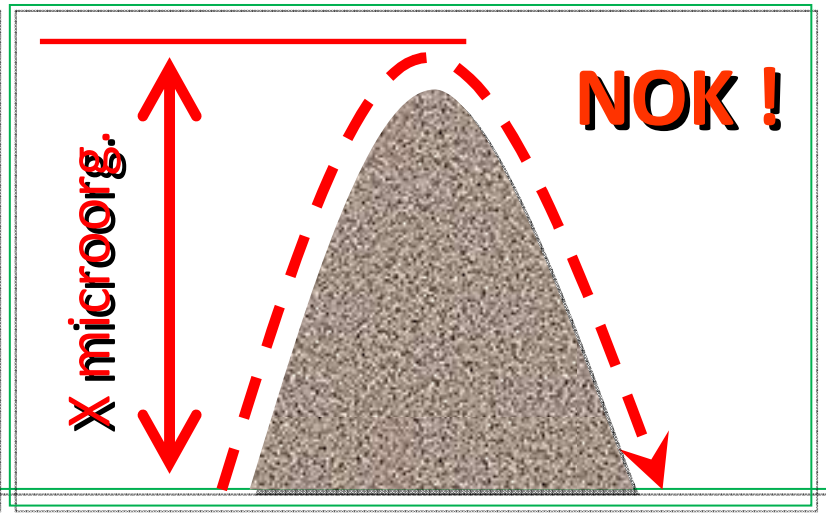
Air	MAP ($70\% O_2 : 30\% CO_2$)	Vacuum	
			
3-4 days at +4°C	1 week at +4°C	Weeks at +4°C	Months at -1°C

Shelf life

Conclusions (i)

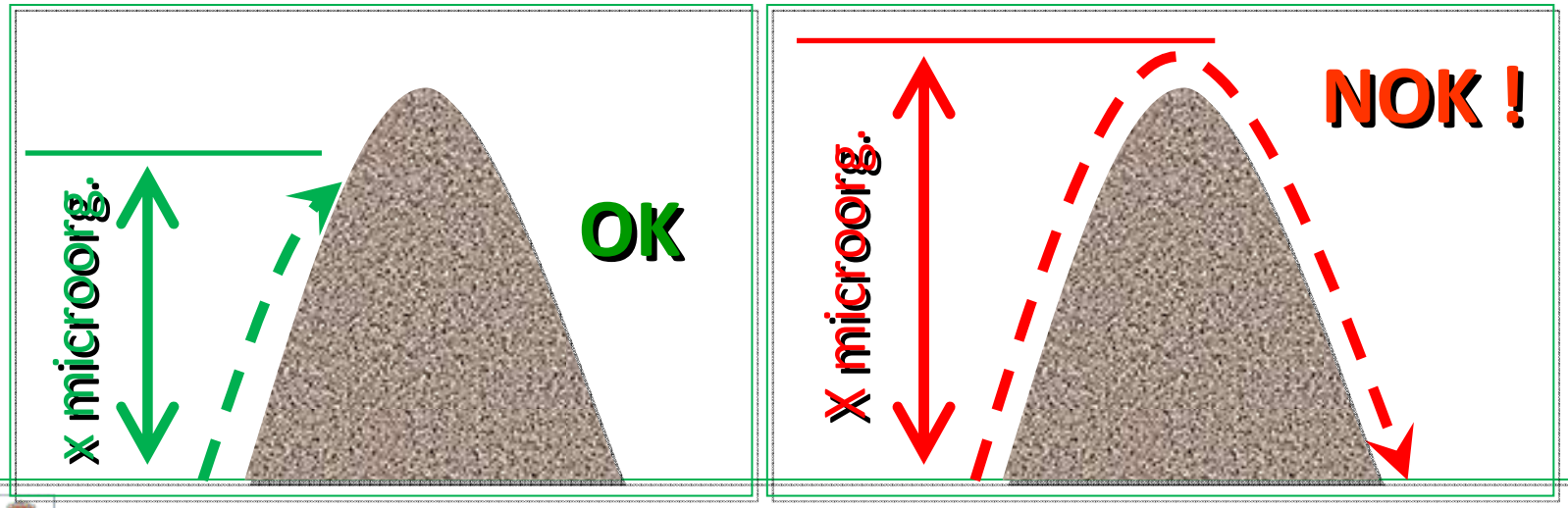
- The « hurdle » technology
  - contributes to a great extent to the food **conservability**,
  - is **not the only way** to control food quality/safety ; to extend food shelf life





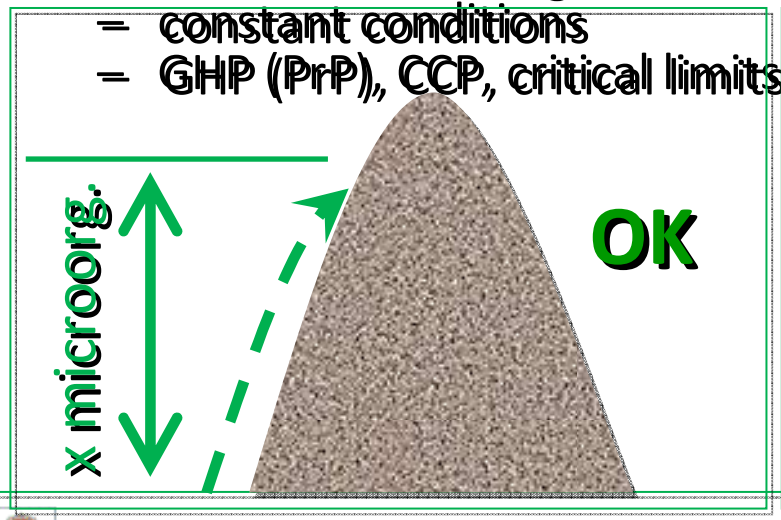
Conclusions (ii)

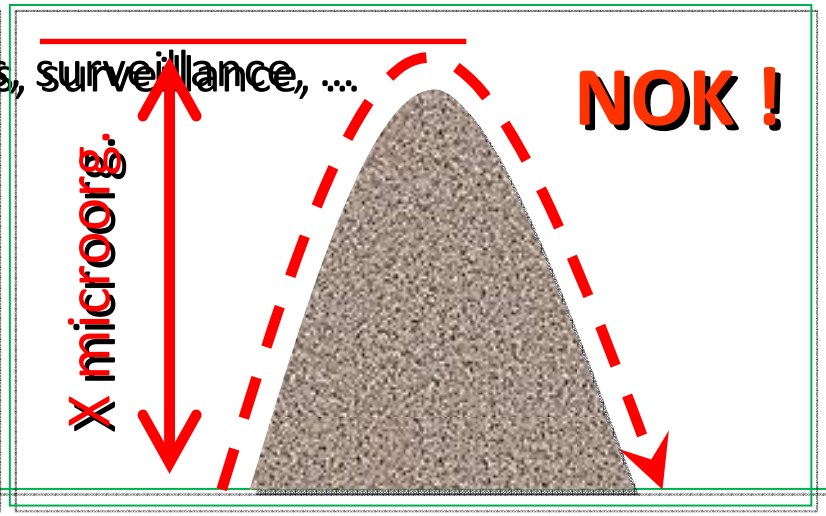
- A « hurdle » effect is **reproducible** only in **reproducible** conditions
  - Intrinsic factors
    - Food : composition, physico-chemical properties, ...
    - Microorganisms : type and number
  - Extrinsic factors
    - Environnemental conditions



Conclusions (iii)

- **A preservation technology has to be validated**
  - predictive microbiology
  - microbiological // physico-chemical durability test (shelf life)
  - challenge test (pathogens behavior)
- **and controlled**
  - raw materials // ingredients quality
  - constant conditions
  - GHP (PrP), CCP, critical limits, surveillance, ...





Acknowledgements

- wagrALIM
- DGO6 and DGARNE (Be)

Wallonie

- Univ. Liège / Dept Food Science (www.dda.ulg.ac.be)
  - P. Imazaki, L. Delhalle, Y. Adolphe, G. Daube




DDA
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- You for your attention …

TARGET AREA 2

INNOVATIVE PRODUCTION OR CONSERVATION TECHNOLOGY

CORE PROJECT

CONSALIM

Extending the shelf life of food by understanding and perfecting the mechanisms responsible for changes in food products

The CONSALIM project was launched after the 2nd project invitation in October 2006.

GOALS

- Imitate the parameters that can change foods and predict their effects
- Offer concrete tools to forecast how products will behave
- Add a competitive edge by introducing healthy products with improved shelf life with a view to reaching a wider market

The research focuses on

- refrigerated products with natural, animal and composite ingredients such as ready meals
- drinks fermented with regional products such as beers and various malts
- live products with lactic acid bacteria and yeast

PARTNERS

BUSINESSES :

Artechno, Beldem, Belourthe, Brasserie du Val Dieu, Brasserie Dubuisson Frères, Brasserie Dupont, Brasserie Lefebvre, Detry, Lutosa, Malterie du Château, Milioni, THT-Research

SCIENTIFIC INSTITUTIONS :

Celabor-Département emballage et agro-alimentaire, Centre wallon de recherches agronomiques (CRA-W), Faculté universitaire des Sciences Agronomiques de Gembloux (FUSAGx), ULg, UCL

For further information about this project, please visit our website: **www.wagralim.be/consalim**