ΠΡΟΓΡΑΜΜΑ ΔΙΑ ΒΙΟΥ ΜΑΘΗΣΗΣ ΑΕΙ ΓΙΑ ΤΗΝ ΕΠΙΚΑΙΡΟΠΟΙΗΣΗ ΓΝΩΣΕΩΝ ΑΠΟΦΟΙΤΩΝ ΑΕΙ (ΠΕΓΑ)

«Οι σύγχρονες τεχνικές βιο-ανάλυσης στην υγεία, τη γεωργία, το περιβάλλον και τη διατροφή»

APPLIED FOOD MICROBIOLOGY

MICROBIAL GROWTH IN FOOD

Dr. George Boskou
Assistant Professor
Dep. Dietetics-Nutrition
Harokopio University
Athens, Hellas

INTRINSIC FACTORS

- ACIDITY (pH)
- WATER ACTIVITY (a_w)
- REDOX POTENTIAL (Eh)
- THE COMPOSITION OF THE FOOD PRODUCT
- PRESENCE OF NATURAL ANTIMICROBIAL SUBSTANCES
- BIOLOGICAL STRUCTURES

ARE RELATED TO THE FOOD PROPERTIES

EXTRINSIC FACTORS

- TEMPERATURE
- RELATIVE HUMIDITY
- PRESENCE OF GASES
- UV-LIGHT

ARE RELATED TO ENVIRONMENTAL FACTORS

IMPLICIT FACTORS

- COMPETITION
- GROWTH STIMULATION
- SUCCESSIONS - ASSOCIATIONS

ARE RELATED TO THE MICROFLORA

TIME

BECAUSE TIME IS ALWAYS RUNNING

IT IS AN INDEPEDENT VARIABLE IN GROWTH STUDIES

IT IS A DEPENDENT VARIABLE IN PREDICTIVE MICROBIOLOGY

INTRINSIC FACTORS

- ACIDITY (pH)
- WATER ACTIVITY (a_w)
- REDOX POTENTIAL (Eh)
- THE COMPOSITION OF THE FOOD PRODUCT
- PRESENCE OF NATURAL ANTIMICROBIAL SUBSTANCES
- BIOLOGICAL STRUCTURES

ARE RELATED TO THE FOOD PROPERTIES

ACIDITY (pH)

Micro-organisms are able to grow in an environment with a specific pH.
Their growth is characterised by a minimal, an optimal and a maximal pH-value.
Those values are different for bacteria, yeasts and moulds.

Microbial growth as a function of pH

micro-organisms	pH-value (min.)	pH-value (opt.)	pH-value (max.)
Bacteria	4.4	7.0	9.8
Yeasts	1.5	4.0-6.0	9.0
Moulds	1.5	7.0	11.0

exceptions

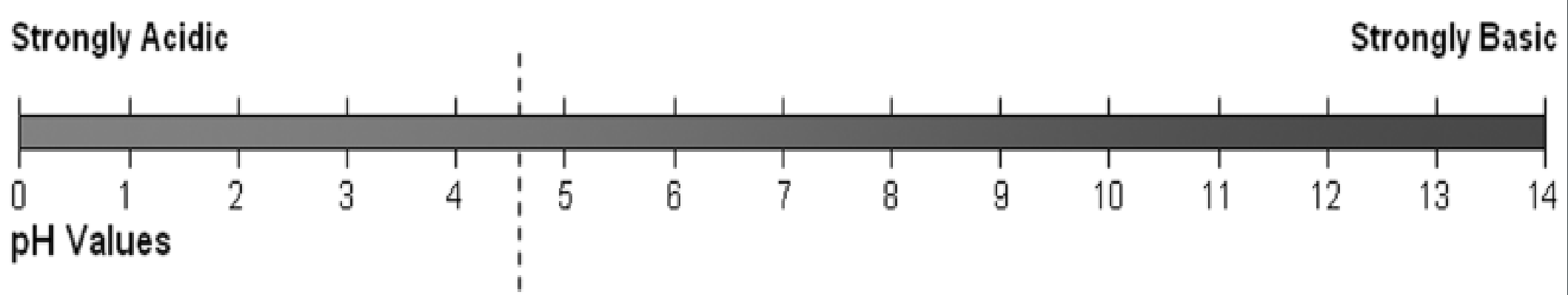
lactic acid bacteria
(min. pH = 3.3 and max. pH = 7.2)
acetic acid bacteria
(min. pH = 2.8 and max. pH = 4.3)
basophilic bacteria

- *Vibrio parahaemolyticus*
  (min. pH = 4.8 and max. pH = 11.0)
- *Enterococcus*
  (min. pH = 4.8 and max. pH = 10.6).

pH-values of some food products

food	pH-value
Meat*	5.6-6.2
Fish*	5.2-6.8
Shellfish*	6.8-7.0
Poultry*	5.9-6.3 (turkey)
	6.2-6.4 (chicken)
Eggs	6.8 (yolk)-9.3 (white)
Milk	6.3-6.5
Cheese	4.9-7.4
Vegetables	4.2 (tomato)- 6.5 (beans)
Fruit	1.8 (lemon)-6.7 (melon)
Cereal products	5.3-8.0

**the pH depends on the "rigor mortis"*



Most Fruits:
e.g. *Apples*
Berries
Cherries
Citrus
Peaches
Plums

Bananas
Dates
Melons
Persimmons
Papayas
Pineapples
Tomatoes

Most Vegetables:
e.g. *Beans*
Beets
Carrots
Corn
Cucumbers
Onions
Peppers
Potatoes

Pickled Vegetables
Most BBQ Sauces, & Salsas
Yogurt
Vinegar

Meat & Poultry
Milk
Most Cheeses

High acid foods | *Low acid foods*

4.6

(pH value dividing high-acid from low-acid foods)

WATER ACTIVITY (a_w)

The water activity is a measure for the availability of water for microorganisms

$$a_w = P/PO$$

P= water vapour pressure of the solution,
PO = water vapour pressure of pure water

Min. a_w values for microbial growth

Microorganisms	Min. a_w values
Bacteria Gram -	0.95
Gram +	0.91
Yeasts	0.88
Moulds	0.80

Exceptions:
halophilic bacteria (min. aw = 0.75),
xerophilic moulds (min. aw = 0.60)
osmophilic yeasts (min. aw = 0.60).

The a_w of raw unprocessed food is higher than 0.98, cereals and nuts: 0.60-0.70, depending on the dehydration.

REDOX POTENTIAL (Eh)

Reduced and oxidised substances in food can act as electron donors or acceptors

Redox potential, expressed in mV, is the difference between reduction potential and oxidative potential

$$Eh = Er - Eo \ (+/- \ mV)$$

If Eh positive => reductive state

If Eh negative => oxidative state

The more oxidised substances, the lower the Eh;

The more reduced substances, the higher the Eh.

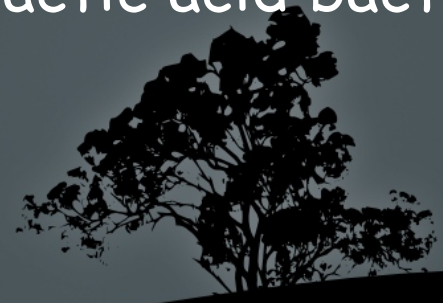
REDOX POTENTIAL (Eh)

Micro-organisms that grow at high Eh
are called **aerobes**

and those that grow at low Eh
are **anaerobes**

Micro-organisms that grow both at high and low Eh
are **facultative anaerobes**

Micro-organisms growing at low Eh, such as lactic acid bacteria,
are **micro-aerophilic**



REDOX POTENTIAL (Eh)

Fresh plant and animal tissues have low internal Eh and a high Eh on the surface.
Diffusion of oxygen causes a rise in Eh.

The Eh in the interior of fresh meat amounts to -200 mV.
Cominuted meat on the other hand has an Eh of +200 mV due to the expose to air as a result of grinding.

The Eh of fresh meat "pre-rigor" is + 250mV;
this value decreases "post-rigor" to -130 mV
and further to -205 mV because of microbial growth.

COMPOSITION OF FOOD

- Energy source (carbohydrates, proteins)
- Nitrogen source for synthesis (amino acids, proteins, nucleotides, urea, ammonia)
- Minerals for various cell functions
- Vitamins, certain auxotrophic microorganisms are unable to produce theirs.

(e.g. Gram+ bacteria need more vitamin B than Gram-).

NATURAL ANTIMICROBIALS

- Fresh milk contains lactenin and an anticoliform factor.
- Cranberries contain benzoic acid.
- Spices contain some essential oils with antimicrobial effect (eugenol in clove).
- Cinnamon contains cinnamon aldehyde.
- Albumin in egg contains lysozyme

BIOLOGICAL STRUCTURES

Certain food structures offer protection against microbial invasion, e.g.

- the skin of fish, and carcasses,
- the testa of seeds,
- the peel of fruit and vegetables,
- the shell of eggs and nuts.

EXTRINSIC FACTORS

- TEMPERATURE
- RELATIVE HUMIDITY
- PRESENCE OF GASES
- UV-LIGHT

ARE RELATED TO ENVIRONMENTAL FACTORS

TEMPERATURE

Microbial growth is possible from - 18 °C to 70 °C.
Microorganisms can be divided into three groups, depending on the temperatures at which they are able to multiply.
Microorganisms that are able to grow at low temperatures but that do not necessarily need those low temperatures for their growth are called psychrotrophes e.g. some mesophiles.

Group	T° Min.	T° Opt.	T° Max.
Psychrophiles	-18	10	20
Mesophiles	5	30-37	50
Thermophiles	37	55	70

RELATIVE HUMIDITY

Relation between the a_w of a food product and the R.H. of the environment in which it is stored.

$$a_w \times 100 = \% \text{ R.H.}$$

If this condition is fulfilled, there will be a balance between the food product and its environment,
in other words, the food will not take up liquid or dehydrate.

PRESENCE OF GASES

The replacement of air by one or more gases influences microbial growth.
Controlled atmosphere storage
Modified atmosphere packaging

USE OF RADIATION

IR rise in temperature.
UV-rays
higher frequency ionising rays e.g. X- and l-rays

IMPLICIT FACTORS

- COMPETITION
- GROWTH STIMULATION
- SUCCESSIONS - ASSOCIATIONS

Implicit factors are the results of mutual interactions in mixed microbial populations.

ARE RELATED TO THE MICROFLORA

COMPETITION

a) Nutrient depletion. depletion of O_2 by aerobes, depletion of CHO

b) Change of intrinsic factors. 3.5 % NaCl causes a decrease in a_w

c) Production of antimicrobial substances

Lactic acid and acetic acid bacteria decrease the pH

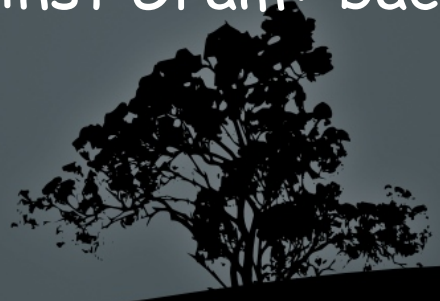
some organic acids have an antimicrobial activity.

CO_2 depletes O_2 and lowers the pH

Peroxides, formed by some bacteria, show antimicrobial activity.

Some microorganisms are capable of producing antibiotics and/or bacteriocins in the food product itself;

(e.g. nisin by *Streptococcus lactis* is active against Gram+ bacteria).



GROWTH STIMULATION

a) Metabolites. Yeasts produce vit.B that stimulates the growth of lactic acid bacteria. Hydrolysis of starch by moulds, providing mono- and disaccharides as source of energy.

b) Changes in pH. Lactic acid fermentation lowers the pH. The surface growth of moulds, which will raise the pH.

c) Change in Eh or a_w:

Eh; growth of Clostridium perfringens in meat lowers Eh hence a stimulation of the growth of Clostridium botulinum.

a_w; due to lipolytic activity, xerophilic moulds can liberate H_2O, causing a rise in a_w.

GROWTH STIMULATION

d) Hydrolysis. Hydrolysis of polymers in plant and animal tissues facilitates the invasion of tissues by spoilage organisms.
e) Inhibitors. Microbially formed inhibitors can be broken down again by other microorganisms, and as a result they lose their inhibitory or lethal effect. (H_2O_2 that is broken down by catalase+ bacteria).
f) Symbiosis. Growth is not possible unless both species are present. *Lactobacillus bulgaricus* in yoghurt produces valine, histidine and glycine, which are important for the growth of *Streptococci thermophilus*. The latter produces formate which is an important for *Lactobacillus bulgaricus*.

SUCCESSIONS - ASSOCIATIONS

In meat, poultry and fish, the initial flora consists of *Pseudomonas* and *Acinetobacter-Moraxella*.
During spoilage, *Pseudomonas* will dominate as a result of mutual interactions.
Numerous other successions and associations may occur in food. This is determined by internal and external flora and by the ecology of the food product.

TIME

BECAUSE TIME IS ALWAYS RUNNING

IT IS AN INDEPEDENT VARIABLE IN GROWTH STUDIES

IT IS A DEPENDENT VARIABLE IN PREDICTIVE MICROBIOLOGY

TIME

IS ALWAYS RUNNING

and this is
favorable *for the* ***micro-organisms***

but ***not favorable*** *for the* ***macro-organisms***
*if they are "****bad****"*

and ***favorable*** *for the* ***macro-organisms***
*if they are "****good****"*