

# Redox potential Scale-up

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# Scale-up criteria

- Geometric similarity
- Power input ( $P/V$ ),
- Oxygen transfer in the liquid phase,
- Stirrer speed velocity,
- Gass hold up

# Redox potential

## Nernst Equation

$$E_h = E_0 + \frac{RT}{nF} \ln \frac{\sum a_{\text{oxidants}}}{\sum a_{\text{reductants}}}$$

Redox potential of standard calomel electrode

$$E_{\text{calomel}} = 244 \text{ mV } E_0$$

## Clark rH definition

$$rH = 0.0343 E_h + 2 \text{ pH} ;$$

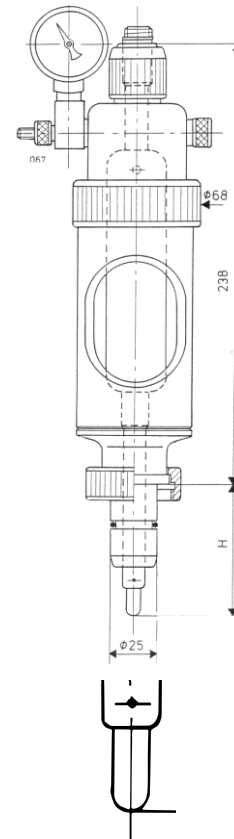
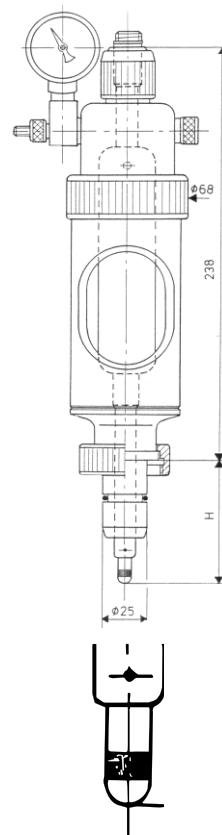
$$rH = - \log p\text{H}_2 ; \text{ pH} = - \log a\text{H}_2$$

**Redox electrode**

**pH electrode**

Pt / calomel

glass/calomel



$$E_h = E^{\circ} + \frac{RT}{zF} \ln \left( \prod_i a_i \right)$$

# Redox potential

$$E_h = E^{\circ} + \frac{RT}{zF} \ln \frac{\sum a_{ox}}{\sum a_{red}}$$

$$E_h = E^{\circ}_{O_2/H_2O} + \frac{RT}{4F} \ln a_{O_2} - \frac{RT}{F} \cdot 2,303 \cdot pH$$

For more complex systems

$$E_h = E^{\circ} + \frac{RT}{zF} \ln \left( \frac{\prod_i a_{ox}^{v_{ox}}}{\prod_i a_{red}^{v_{red}}} \right)$$

$$\prod_i a_i^{v_i} \equiv a_{S_1}^{v_1} \cdot a_{S_2}^{v_2} \cdot \dots \cdot a_{S_n}^{v_n}$$

# Redox potential scale-up

- Maintenance of the same optimized course of redox potential in all of the applied scales
- Using
- Regulation of mixing
- Regulation of aeration
- Regulation of temperature
- Application of CO<sub>2</sub> fluxes
- Application of additional oxydants/reductants
- Application of low galvanic current

# Key studies

- Citric acid,
- Wine technology,
- Xylanase production

# Scale-up methods

- Dimension analysis,
- Analysis of kinetics and transport regime,
- Mixing in reactor Reynolds and Freud number

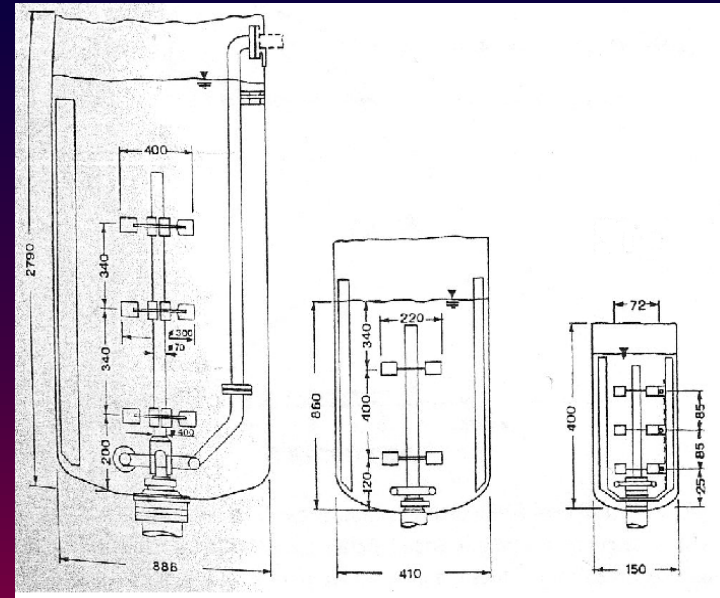
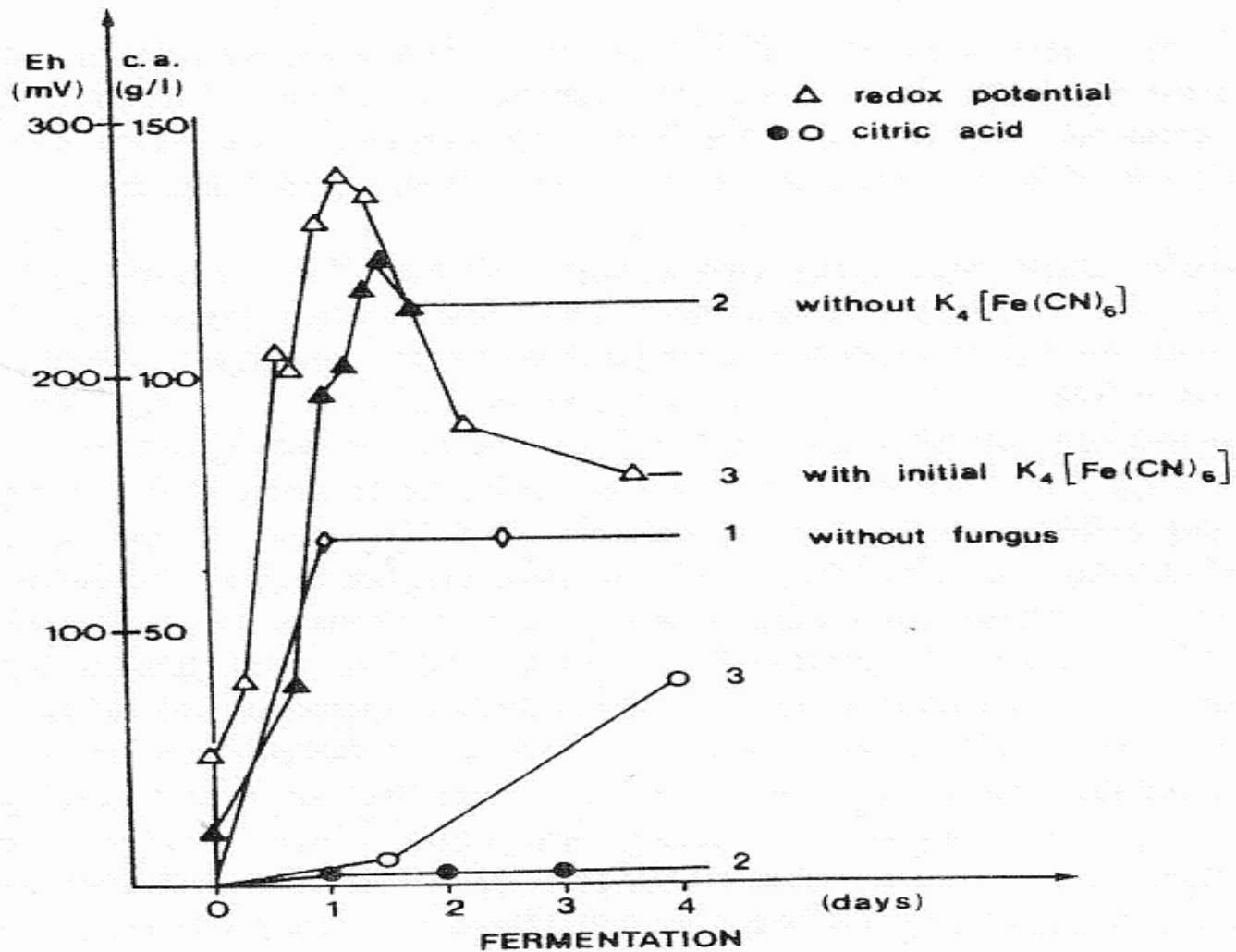


Table I. Stirred-tank reactor characteristics.

	10 L	100 L	1000 L
Impeller diameter (mm)	72	220	400
Reactor diameter (mm)	150	410	888
Liquid height (H) (mm)	310	860	2700
H/D (/)	2.06	2.10	3.14
Impeller tip speed, $v_T$	1.13–2.26	3.40–5.75	6.90–11.15

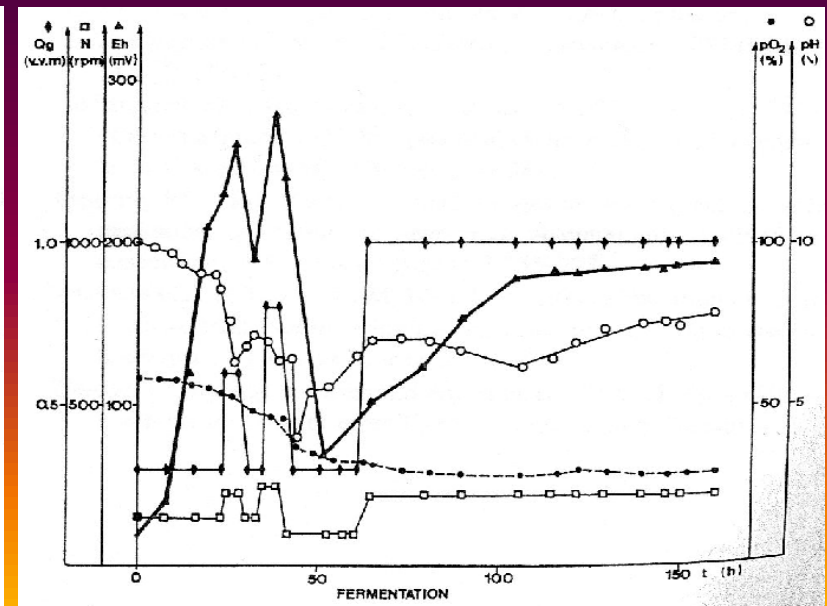
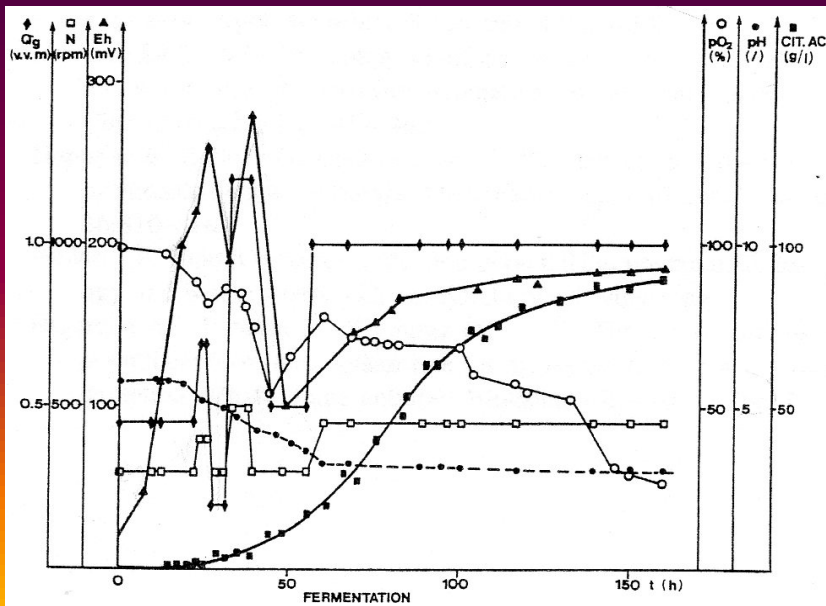
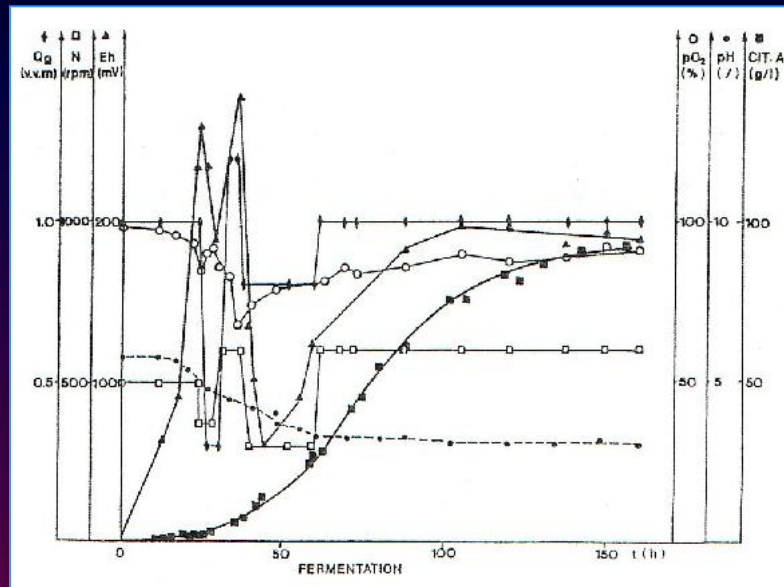
# Citric acid

## *Aspergillus niger*

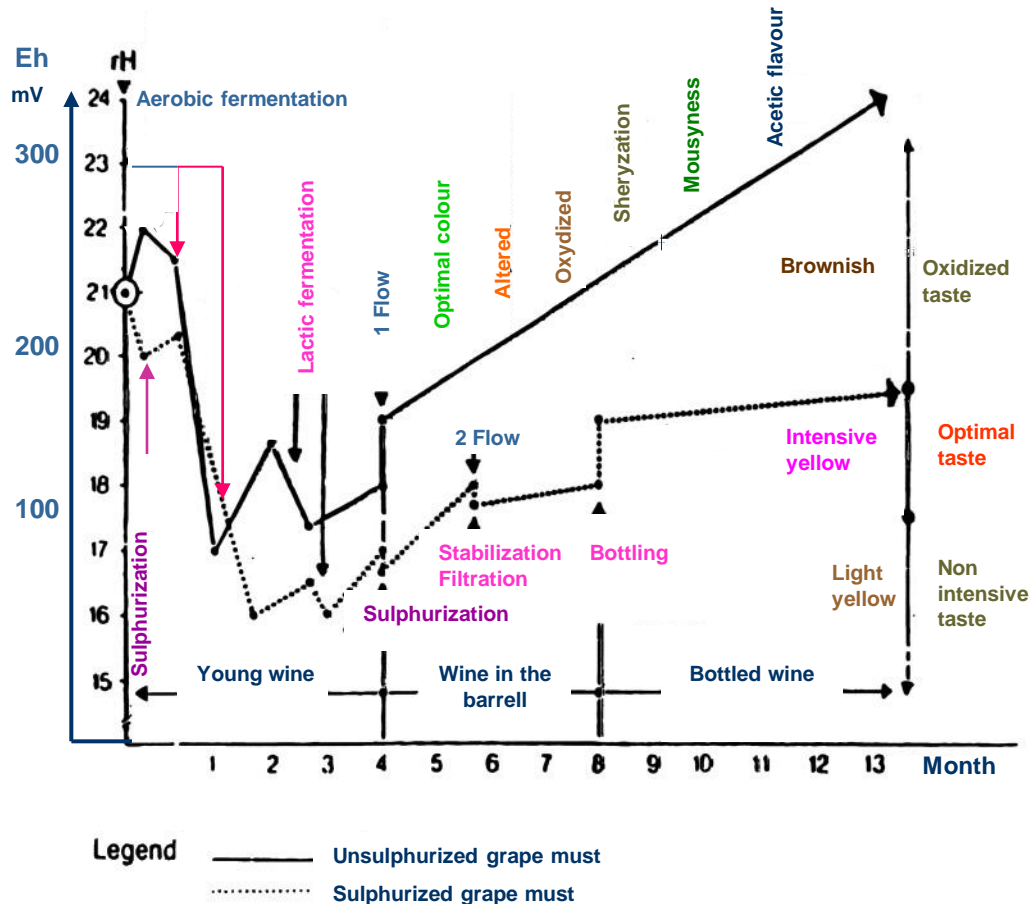


# Citric acid

*Aspergillus niger*



# Redox potential and sensorial analysis in wine fermentation



Reductive non-oxdyzed wines Eh = 100 - 180 mV ; rH=18 do 20    Oxdyzed wines Eh = 268 - 300 mV ; rH=24 do 25

White bottled wines : Eh = 275 - 300 mV

Red bottled wines : Eh = 100 - 223 mV

# REDOX POTENTIAL in WINE

Wine represent complex oxydo-reductive system composed by :

→ **Chemical oxydo – reductive compounds :**

alcohols, aldehydes, organic (oxo & keto) acids polyphenols,  
kinons, ascorbic & dehydroascorbic acid,

→ **Ion couples**  $\text{Fe}^{2+} / \text{Fe}^{3+}$  ;  $\text{Cu}^{+} / \text{Cu}^{2+}$

Redox potential in wine express intensivity and the rate of the  
sum of all oxydo - reductive processes

**Metabolic activity of microbial culture and its metabolism  
play the main role**

→ Sugars (glucose) → alcohols + biomass

# REDOX CHARACTERISTICS of WINES

Premium quality wines are characterized by the lowest redox potential values  
Reductive and close character wines are disposed to oxidation

Reductive non-oxydized wines  $Eh = 100 - 180 \text{ mV}$  ;  $rH=18 \text{ do } 20$

Oxydized wines  $Eh = 268 - 300 \text{ mV}$  ;  $rH=24 \text{ do } 25$

White bottled wines :  $Eh = 275 - 280 \text{ mV}$

Red bottled wines :  $Eh = 100 - 223 \text{ mV}$

## REDUCTANTS

SO<sub>2</sub>, ascorbic acid, cell products (cysteine , glutatione) are parameters that are decreasing redox potential and express reductive character

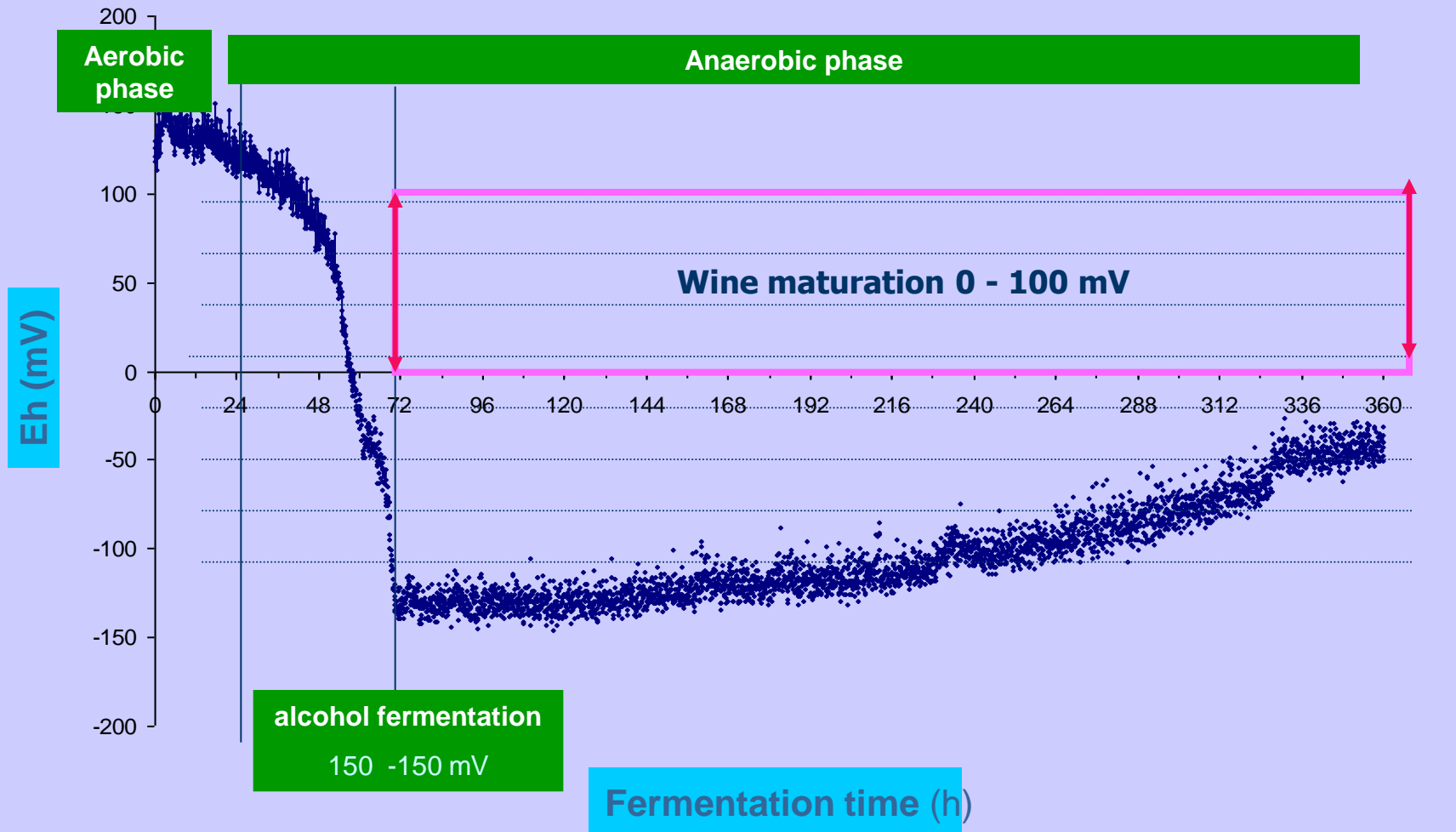
## OXIDANTS

Air oxygen, bentonites, mineral adsorbents, peroxyde

## PROTECTORS AND ANTIOXIDANTS IN FERMENTATION

Carbone dioxyde, gaseous nitrogen are protective agents  
in the pipes and fermentor head space

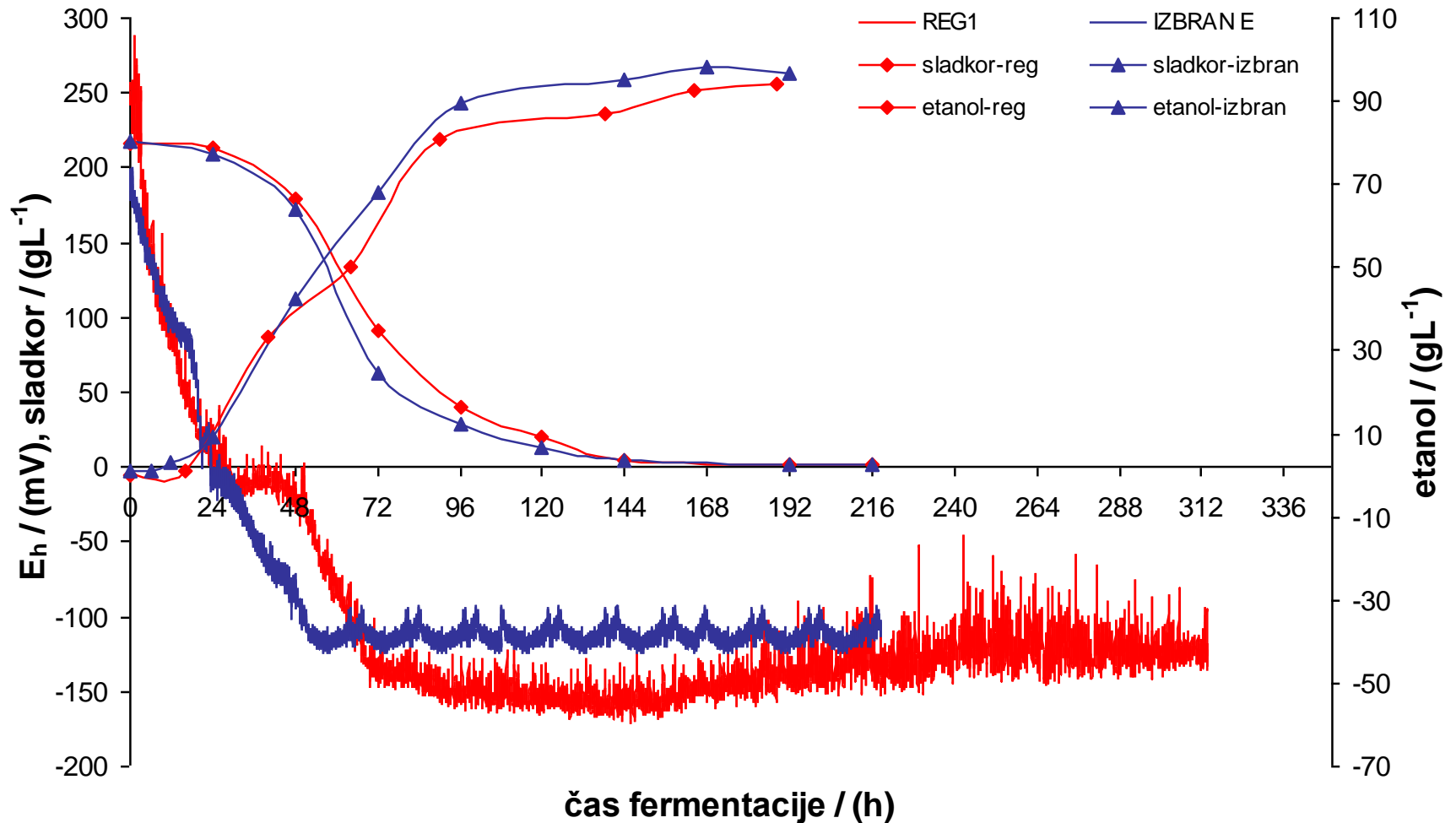
# Redox potential of unsulfurized *Sauvignon blanc* must alcohol fermentation

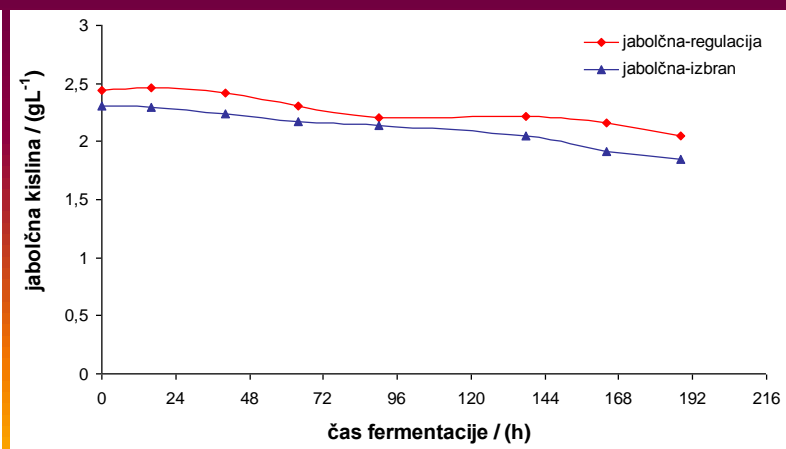
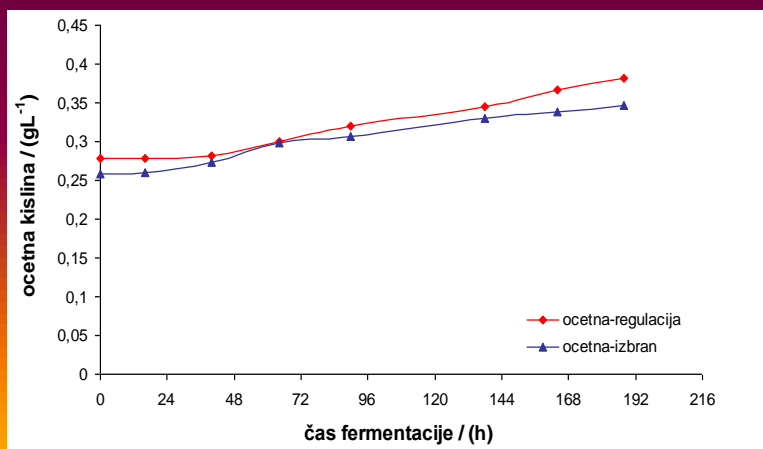
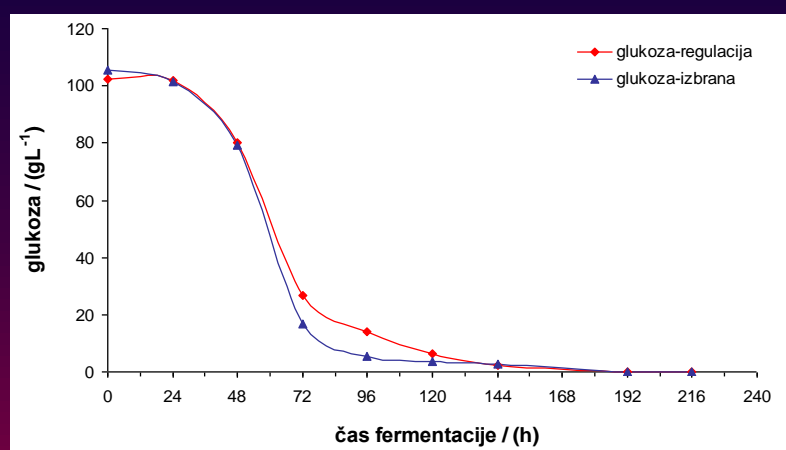
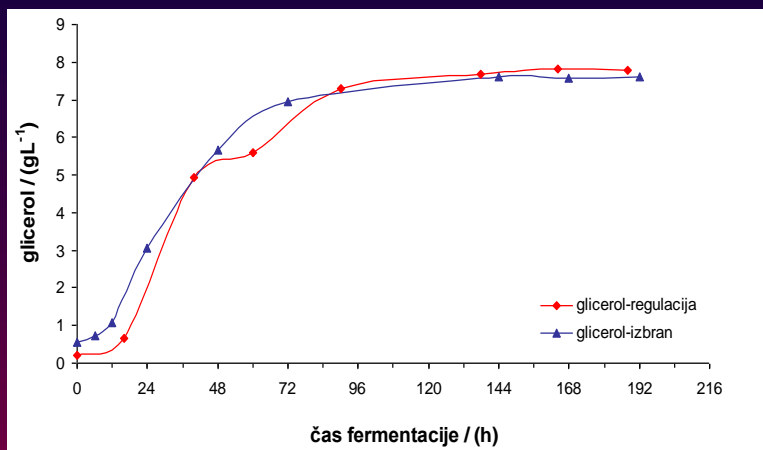
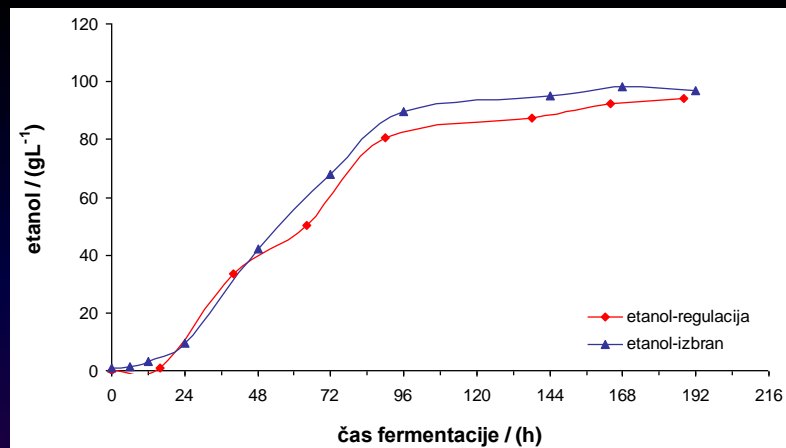
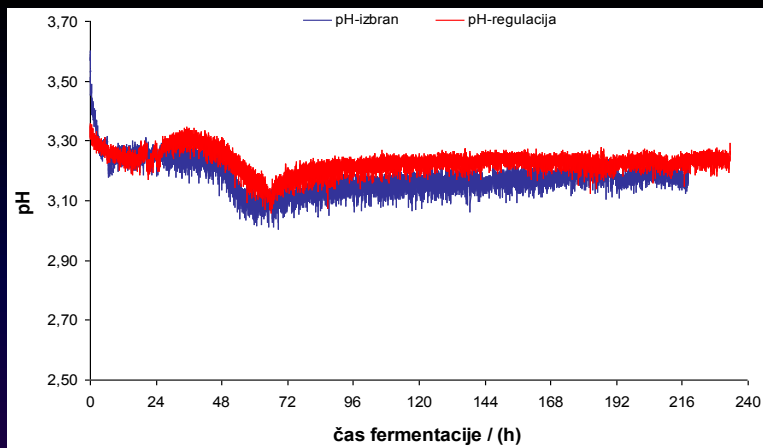


Fermentation temperature 18°C

# Wine Technology

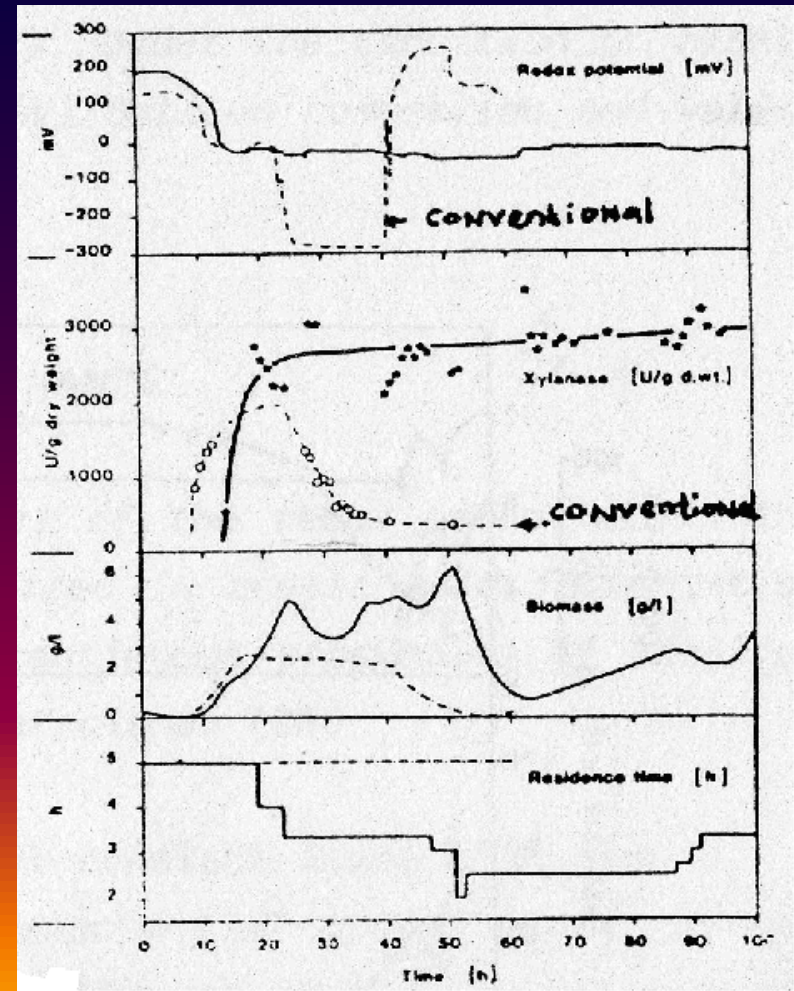
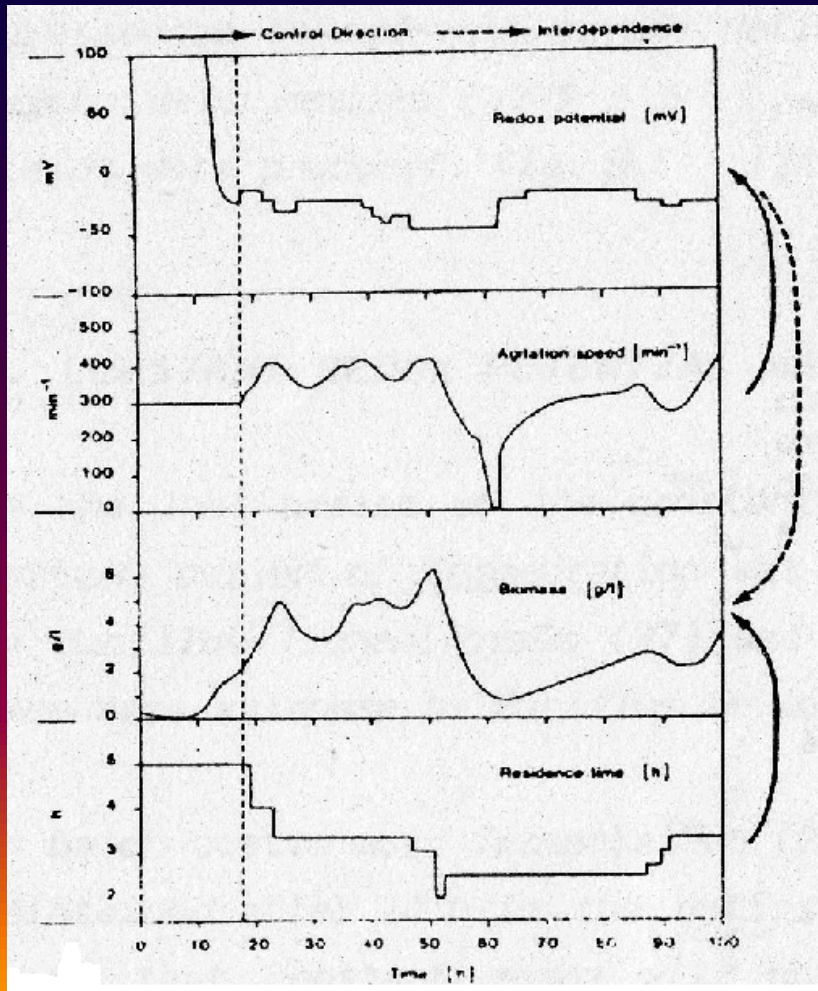
*Saccharomyces cerevisiae*





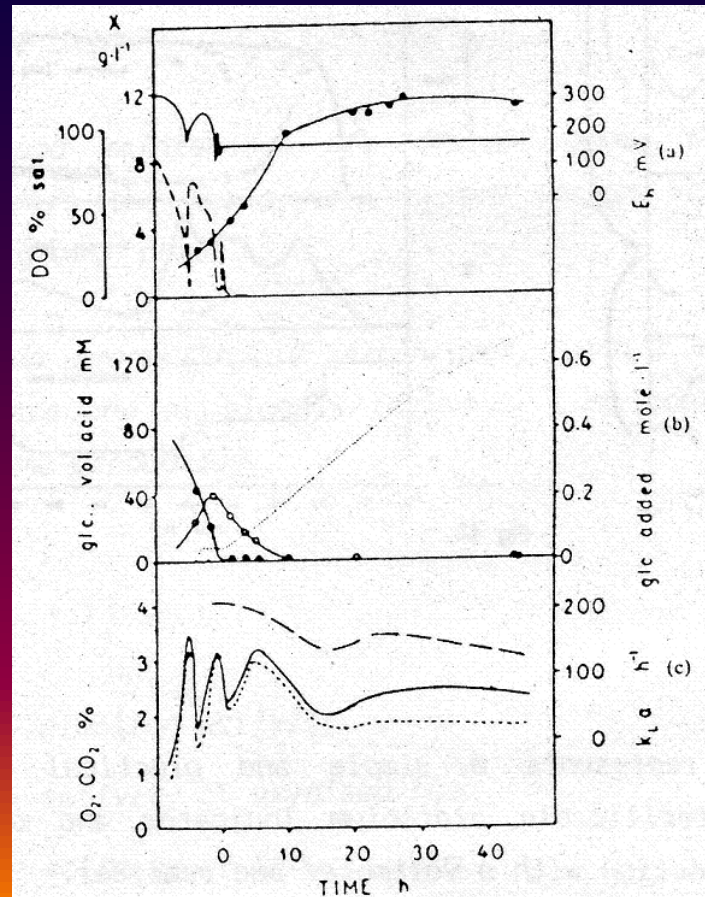
# Xylanase production

## *Bacillus licheniformis*



# Xylanase production

## *Bacillus licheniformis*



# Wine Technology

*Saccharomyces cerevisiae*

