

# iFBM

THE REFERENCE IN THE BARLEY TO THE BEER



A large white arrow pointing to the right, set against a dark red background.

# Relationship between polyphenols and beer flavour stability

**Dr Patrick BOIVIN**

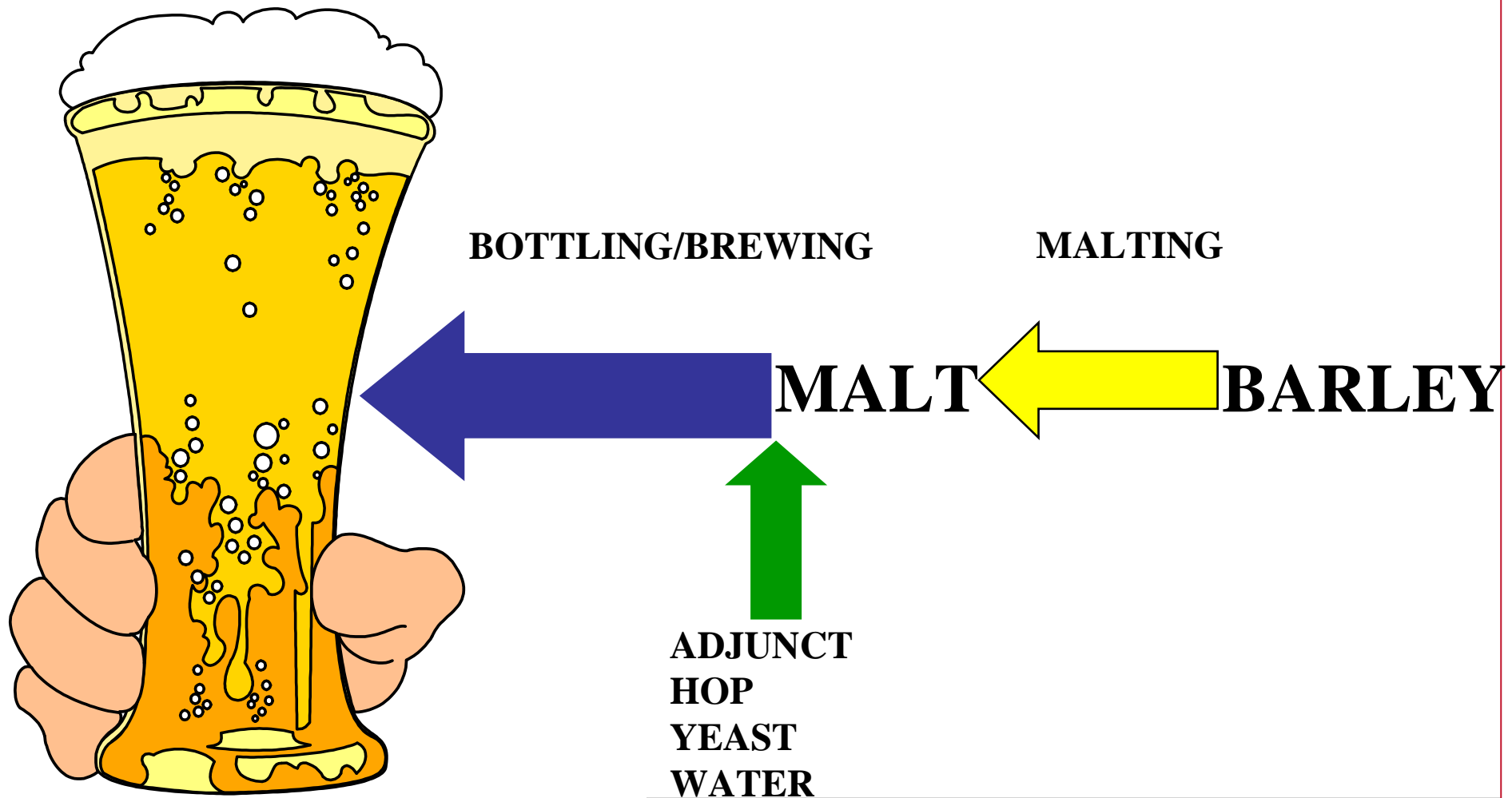
**Scientific Director of IFBM**



# Overview

- ⇒ **Flavour instability of beer**
- ⇒ **Polyphenols in raw materials and beer**
- ⇒ **Antioxidant activity of polyphenols**
- ⇒ **Polyphenols and beer flavour stability**
- ⇒ **Conclusion**

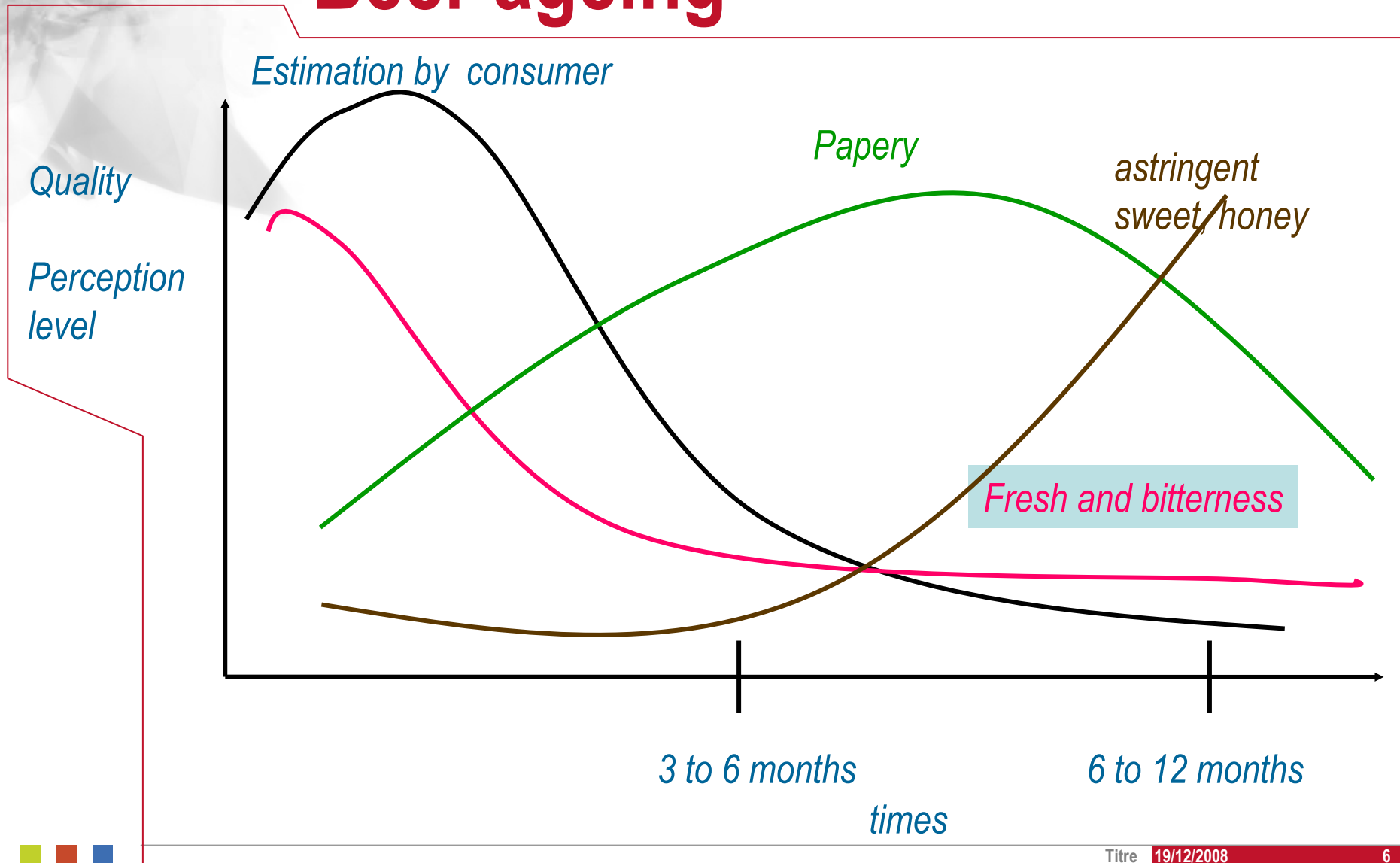
# Beer quality



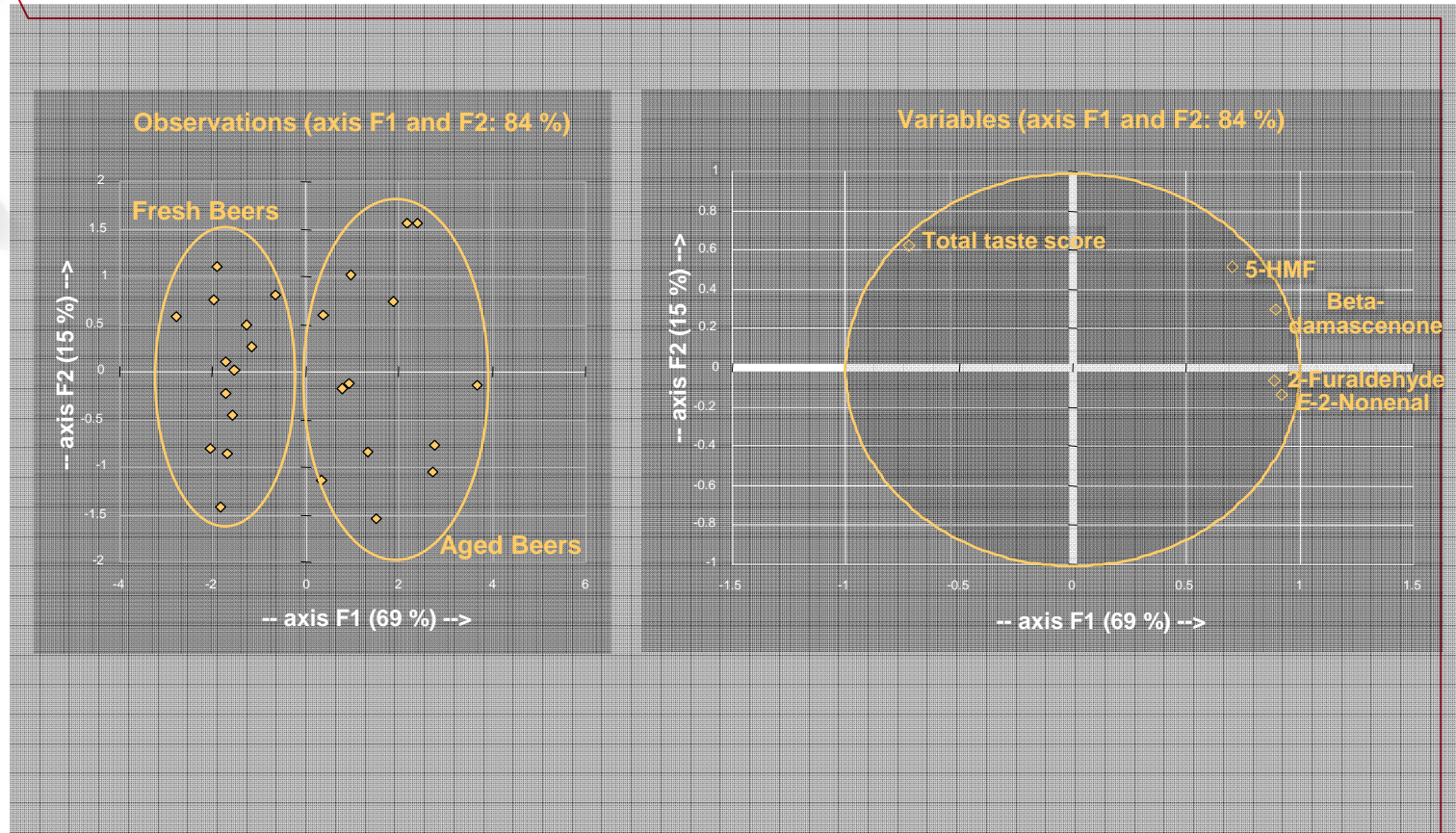
# Beer ageing

Beer	Aroma	Taste
<b>Fresh</b>	Floral, light, sweet, nutty, roasted	Nutty, roasted cereal, grainy, smooth, not very bitter or astringent
<b>One year, Room t°</b>	stale, fatty acid, burnt, medicinal, ash	Sour, stale, foul, watery, burnt, bitter, astringent, no pleasant flavour

# Beer ageing



# Indicators of beer ageing

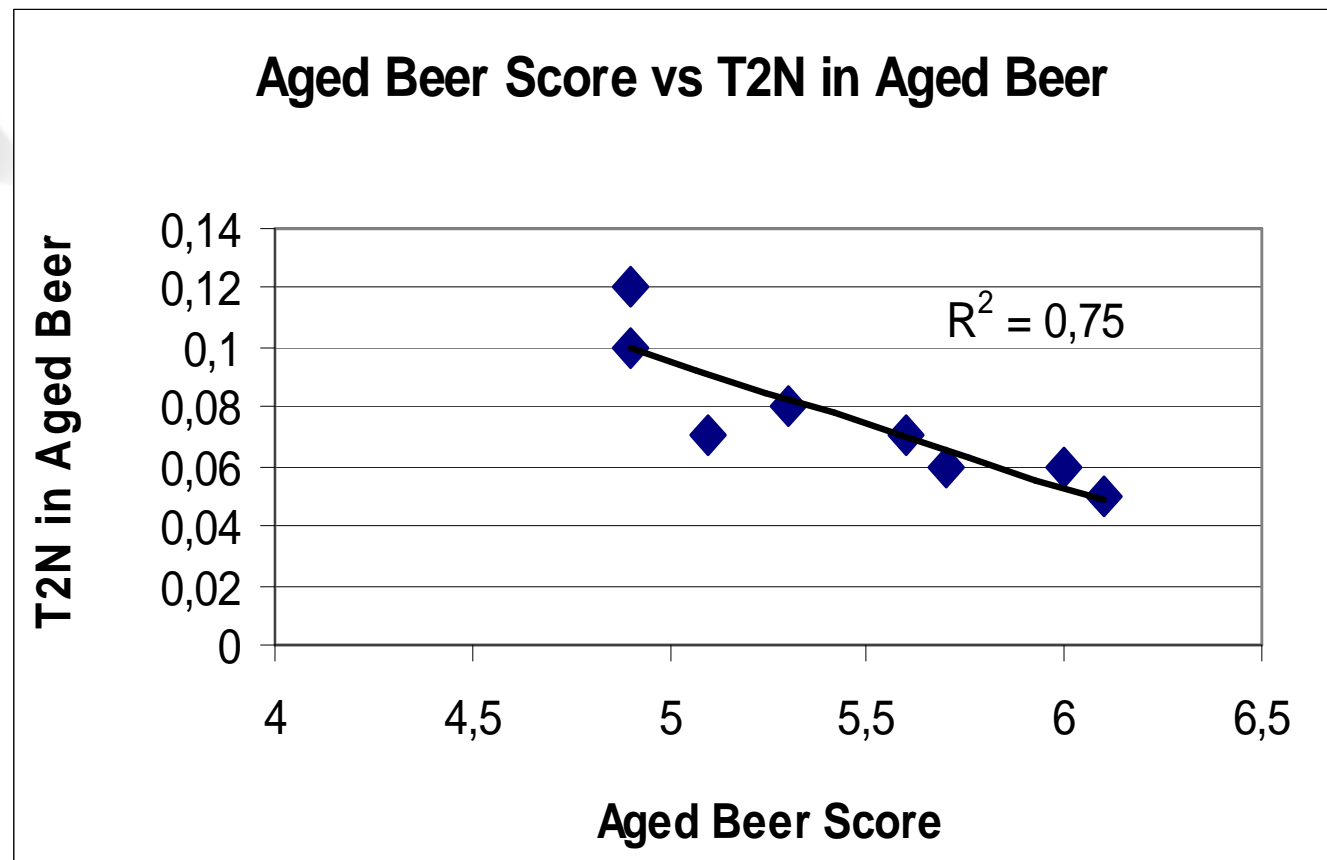


**BEER CHEMICAL INDICATORS**

Guido and al. EBC symposium 2005

- E-2-NONENAL (1<sup>st</sup>)
- 2-FURALDEHYDE (2<sup>nd</sup>)
- β-DAMASCENONE (3<sup>rd</sup>)
- 5-HMF (not correlated)

# Aged beer & Trans-2-Nonenal



Williams and al. EBC symposium 2001

# Beer ageing indicator

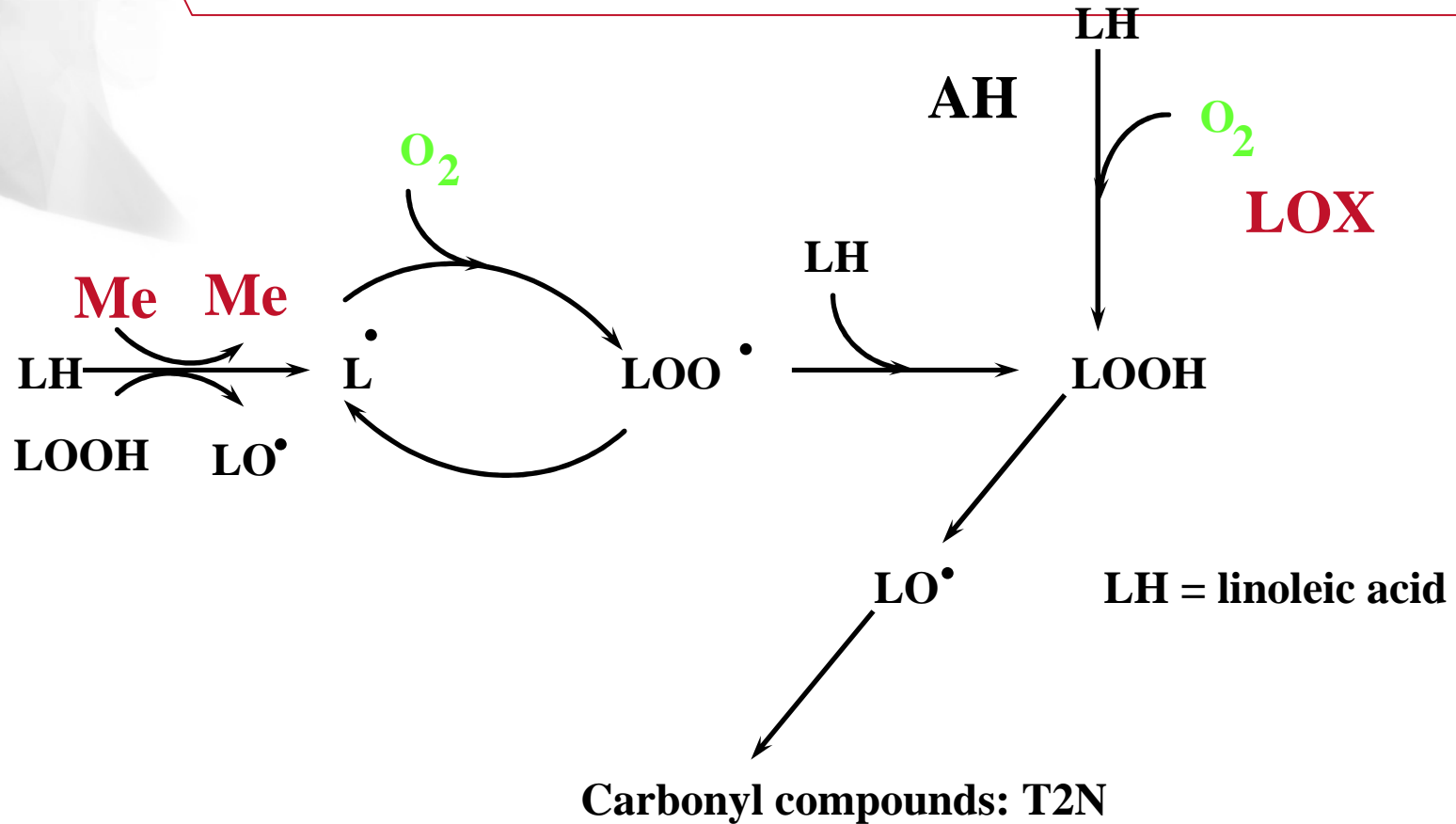
TRANS-2-NONENAL:T2N



CARBOARD-LIKE FLAVOUR

# Off flavour in beer

## Oxidation reaction



# Oxidised flavours

## TWO MECHANISMS

### ◆ CHEMICAL OXIDATION

- ◆ Malting
- ◆ Mashing, filtration, Boiling, Whirlpool

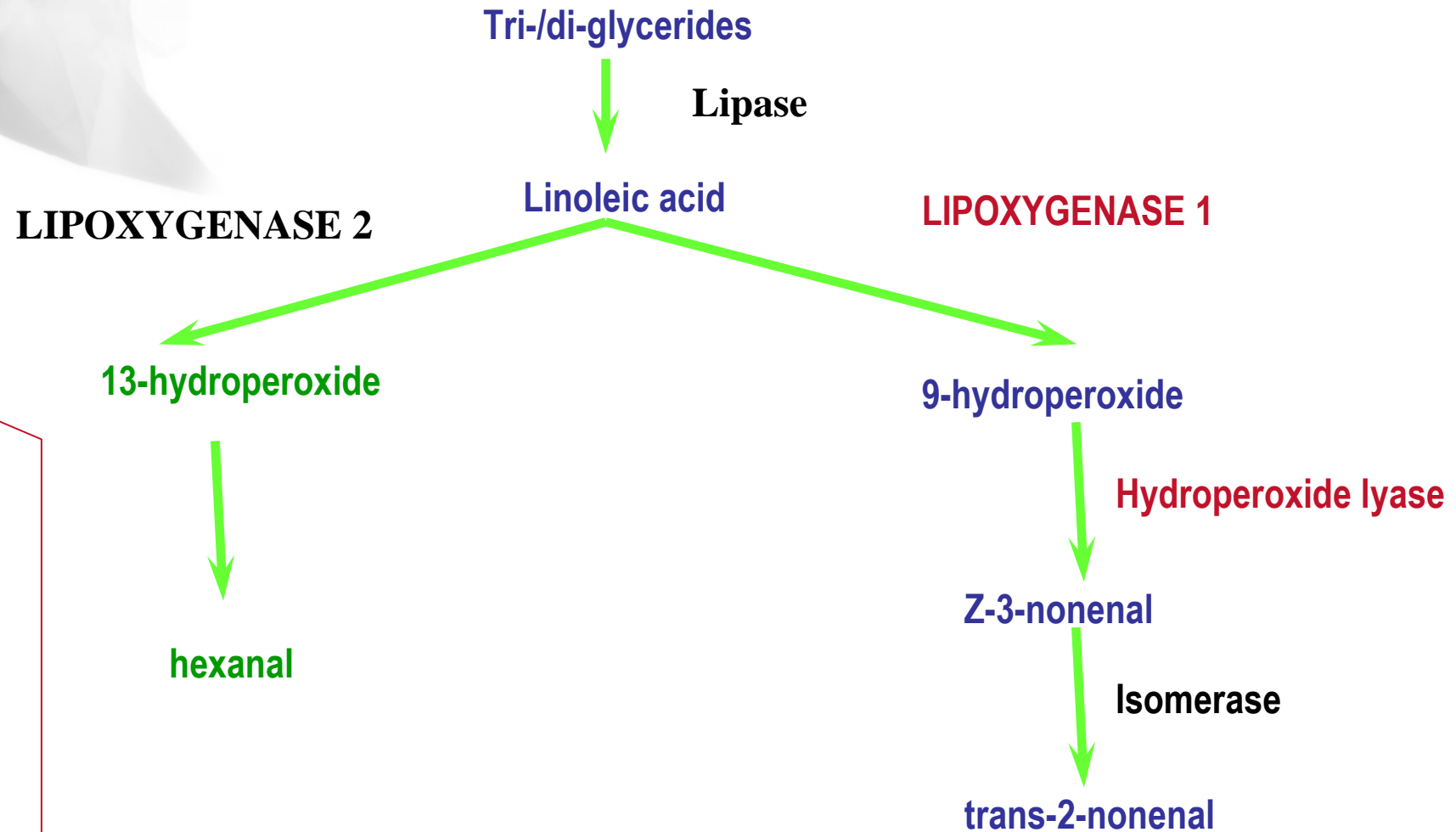
M<sup>+</sup>, O<sub>2</sub>, T° [ $>60^{\circ}\text{C}$ ], time

### ◆ ENZYAMTIC OXIDATION

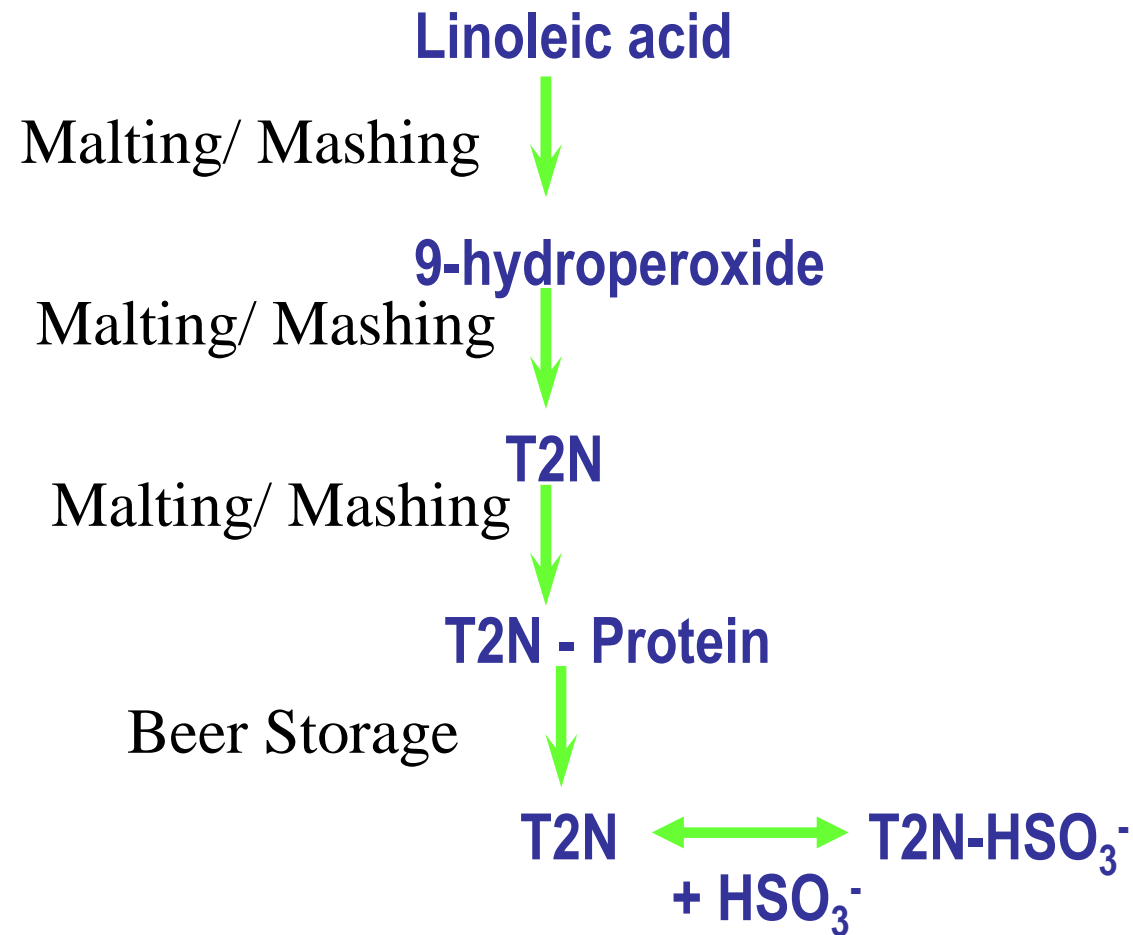
- ◆ malting
- ◆ mashing

Lox, O<sub>2</sub>, T° [35-55], time, pH

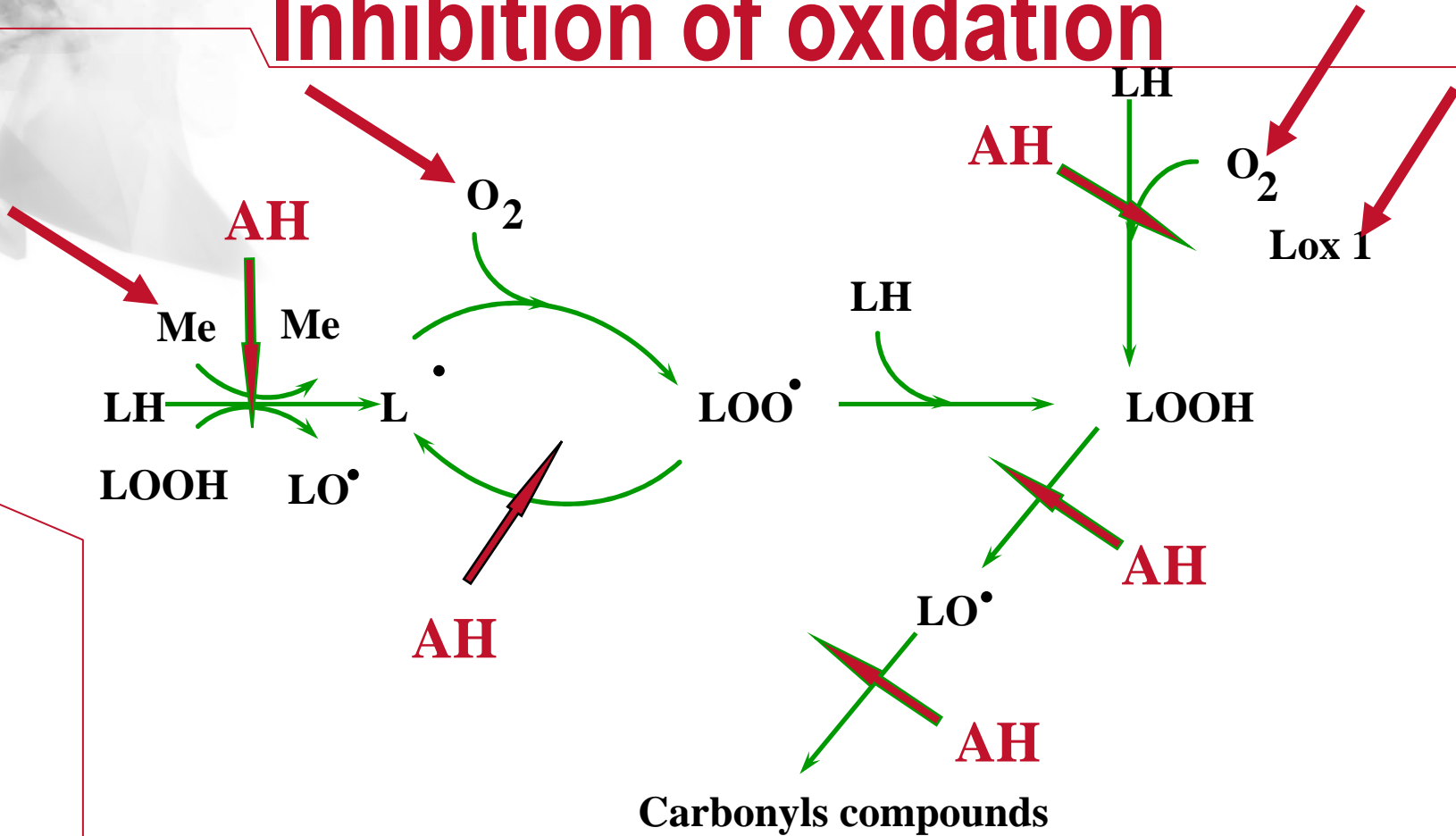
# Enzymatic oxidation of lipids



# Flavour stability of beer



# Inhibition of oxidation



Off flavour

LH = linoleic acid  
AH: antioxidant



# Improvement of Beer flavour stability

## ⇒ Enzyme

### ⇒ Barley

- low Lox 1: Frilox (1/10)
- no Lox 1: null-Lox 1
- no Hydroperoxide lyase

### ⇒ Malting process

- Curing at high temperature

### ⇒ Brewing process

- Mashing in at High temperature
- Mashing at low pH

# Improvement of Beer flavour stability

## ⇒ Substrate

### ⇒ Linoleic acid

- Large amount

### ⇒ Oxygen

- Avoid oxygen from mashing to wort cooling

# Improvement of Beer flavour stability

⇒ Inhibition of oxidation

⇒ Maillard Reaction Product

⇒ Polyphenols

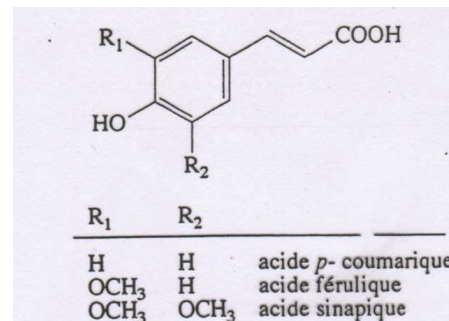
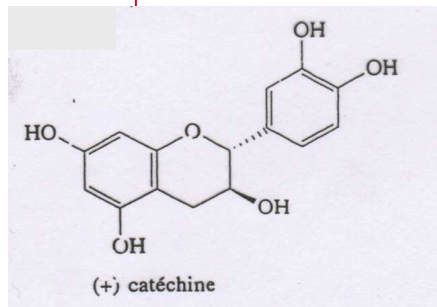
# Polyphenols in beer raw materials

⇒ Malt: 70 to 80%

⇒ Hop: 20 to 30%

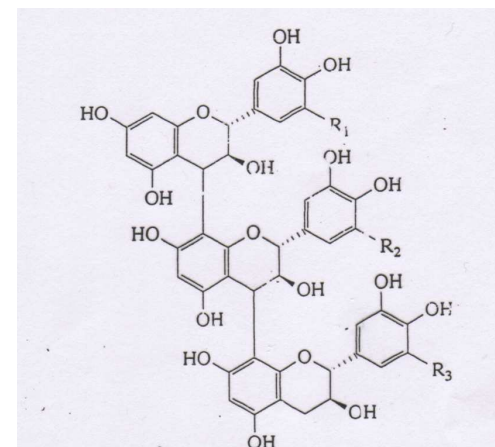
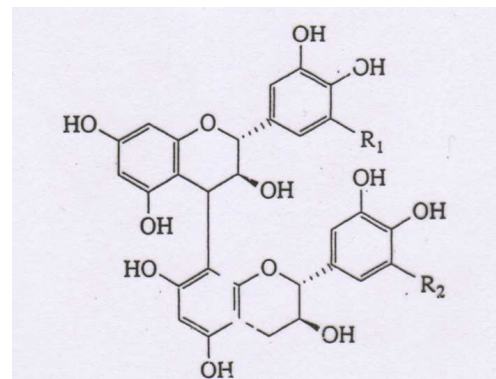
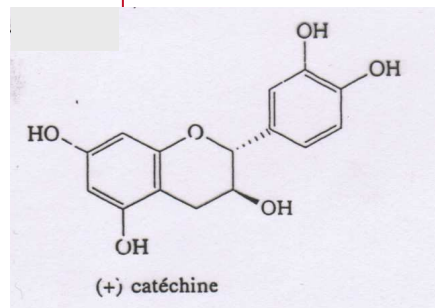
# Phenolic composition of iFBM Barley

	<i>Flavanols</i>	<i>Flavonols</i>	<i>Phenolic Acids</i>	<i>Apolar compounds</i>	<i>tocopherol</i>	<i>Carotenoid</i>
Alexis	157.3	23.7	8.1	3.6	0.01	0.5
Plaisant	186.8	59.2	12.1	2.4	0.02	0.3
Esterel	231.4	49.4	9.2	4.3	0.03	0.3
Caminant	12.4	10.9	1	2.9	0.01	0.2

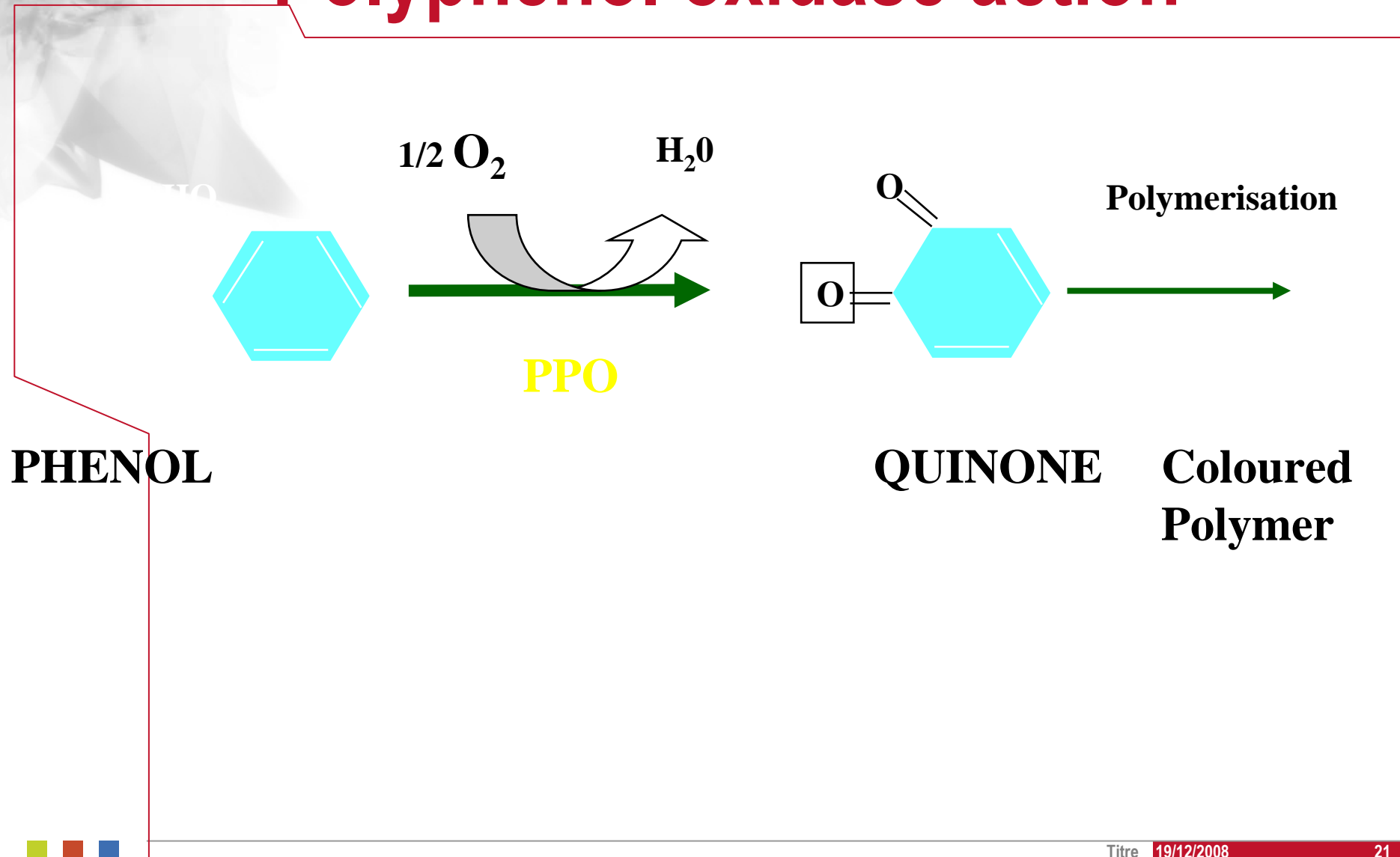


# Phenolic composition of Barley

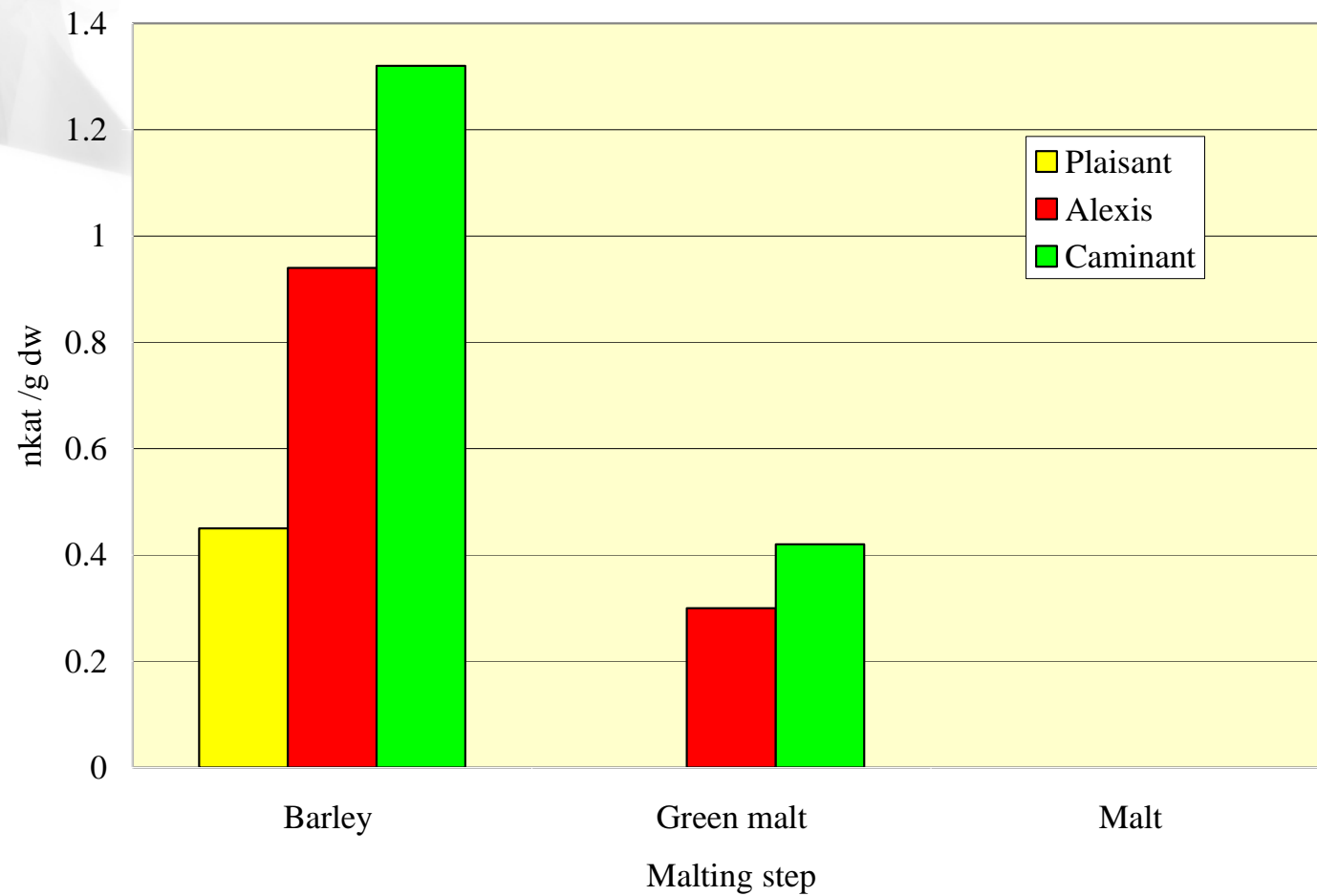
Barley	Flavan-ols					Total flavanols	Flavonols	Phenolic acid
	Catechin	PcB3	PdB3	PCC2	Trimers			
Plaisant	25	82	52	20	7	<b>185</b>	<b>59</b>	<b>12</b>
Alexis	30	55	51	14	7	<b>157</b>	<b>24</b>	<b>8</b>
Caminant	5	2	3	2	1	<b>13</b>	<b>11</b>	<b>1</b>



# Polyphenol oxidase action



# Polyphenol oxidase activity <sup>i</sup>FBM during malting



# Antioxidant activity of polyphenol

- ⇒ Free radical method: DPPH
- ⇒ Co-oxidation of  $\beta$ -carotene in linoleate model system
- ⇒ Inhibition of Lox 1 Activity
- ⇒ ABTS radical cation scavenging activity
- ⇒ Reducing power
- ⇒ Metal chelating activity
- ⇒ ESR
- ⇒ ...

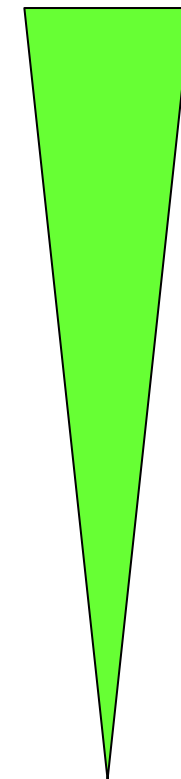
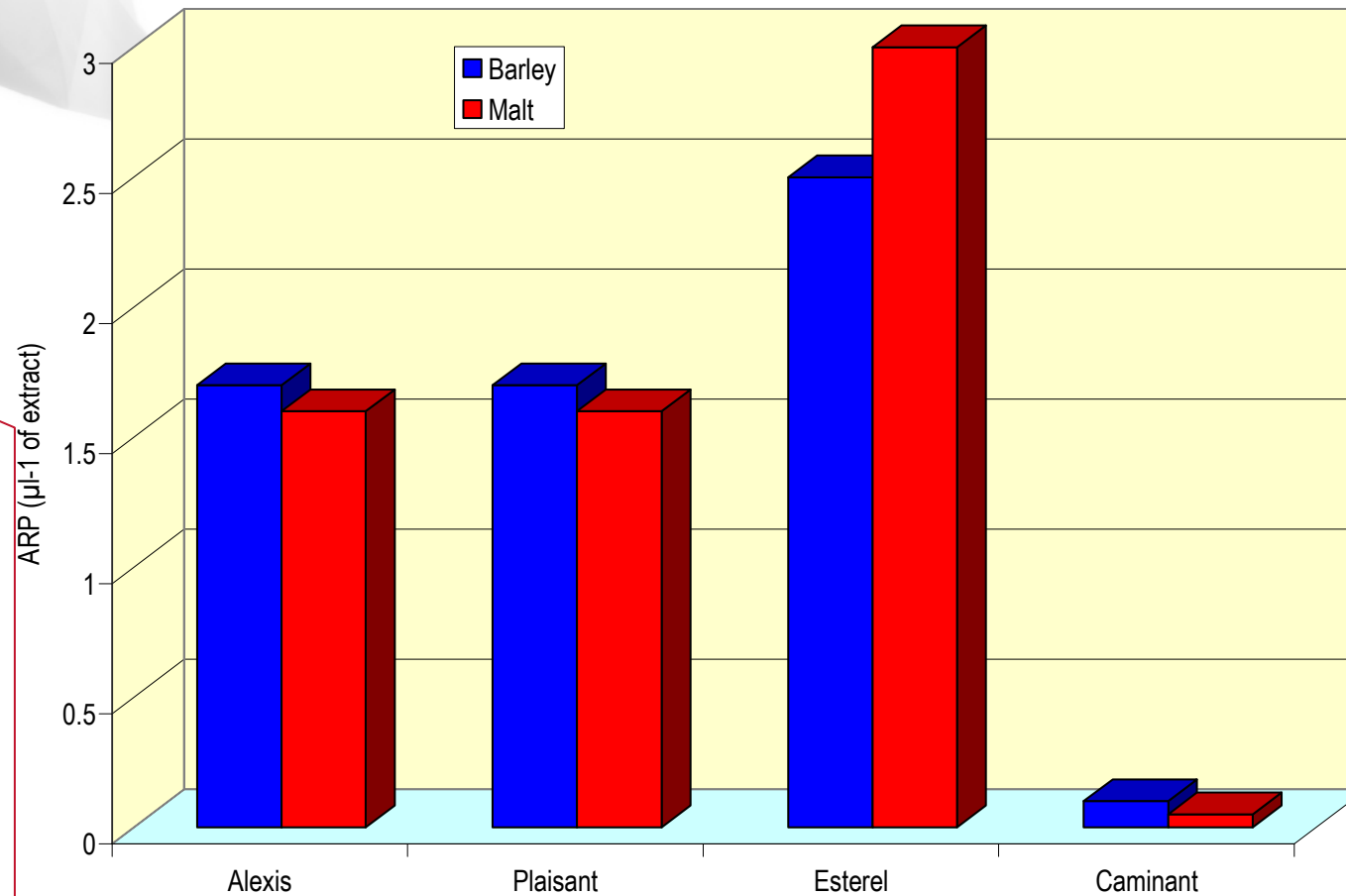
# Antioxydant activity of barley phenolic compounds



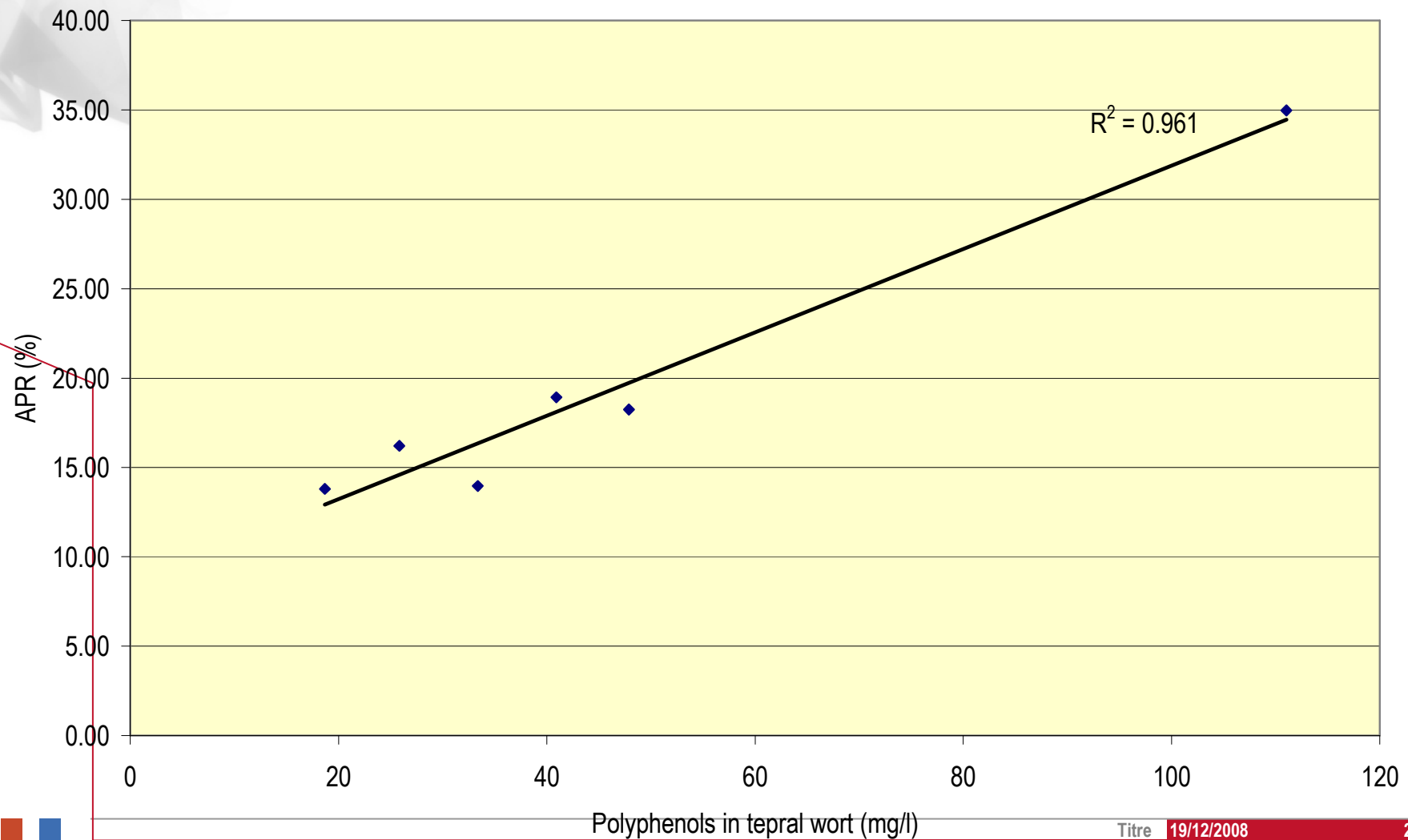
<b>Compounds</b>	<b>1 mg/ml</b>	<b>ARP (<math>\mu\text{l}^{-1}</math> of extract)</b>	<b>AOP (%)</b>	<b>Loxl (%)</b>
(+)-catechin		0.59	48.5	32.2
(-)-epicatechin		0.60	16.4	24.8
(-)-epigallocatechin		0.67	26.5	51.5
Procyanidin B3		0.88	55.1	46.8
Prodelphinidin B3		1.04	56.9	52.3
Procyanidin C2		0.98	65.5	65.4
Ferulic acid		0.34	31.2	2.9
p-coumaric acid		nd	23.2	5.0
Vanillic acid		nd	12.0	10.8

# Antioxidant of barley and malt extract

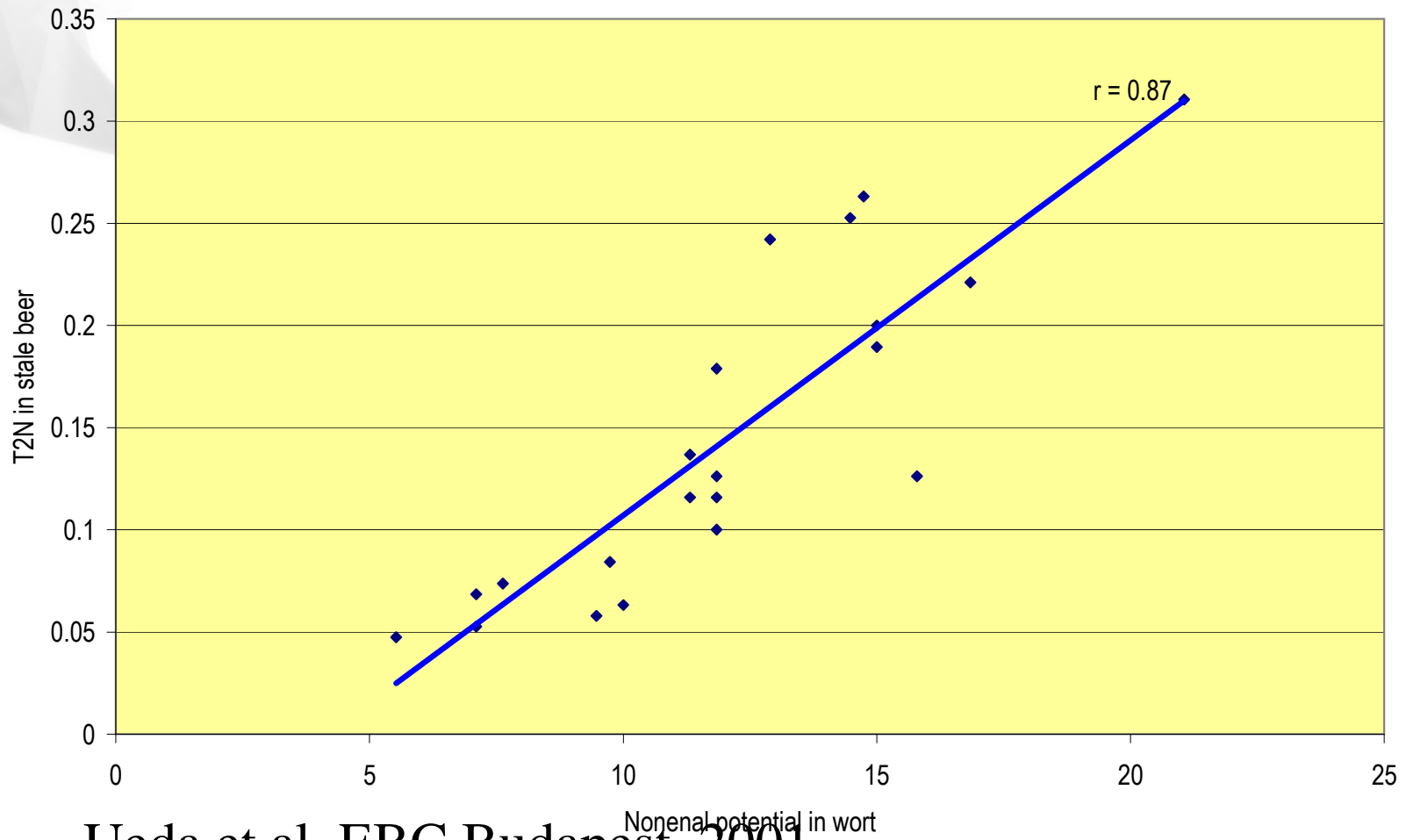
Antioxidant activity



# Antioxidant activity of wort & polyphenols content

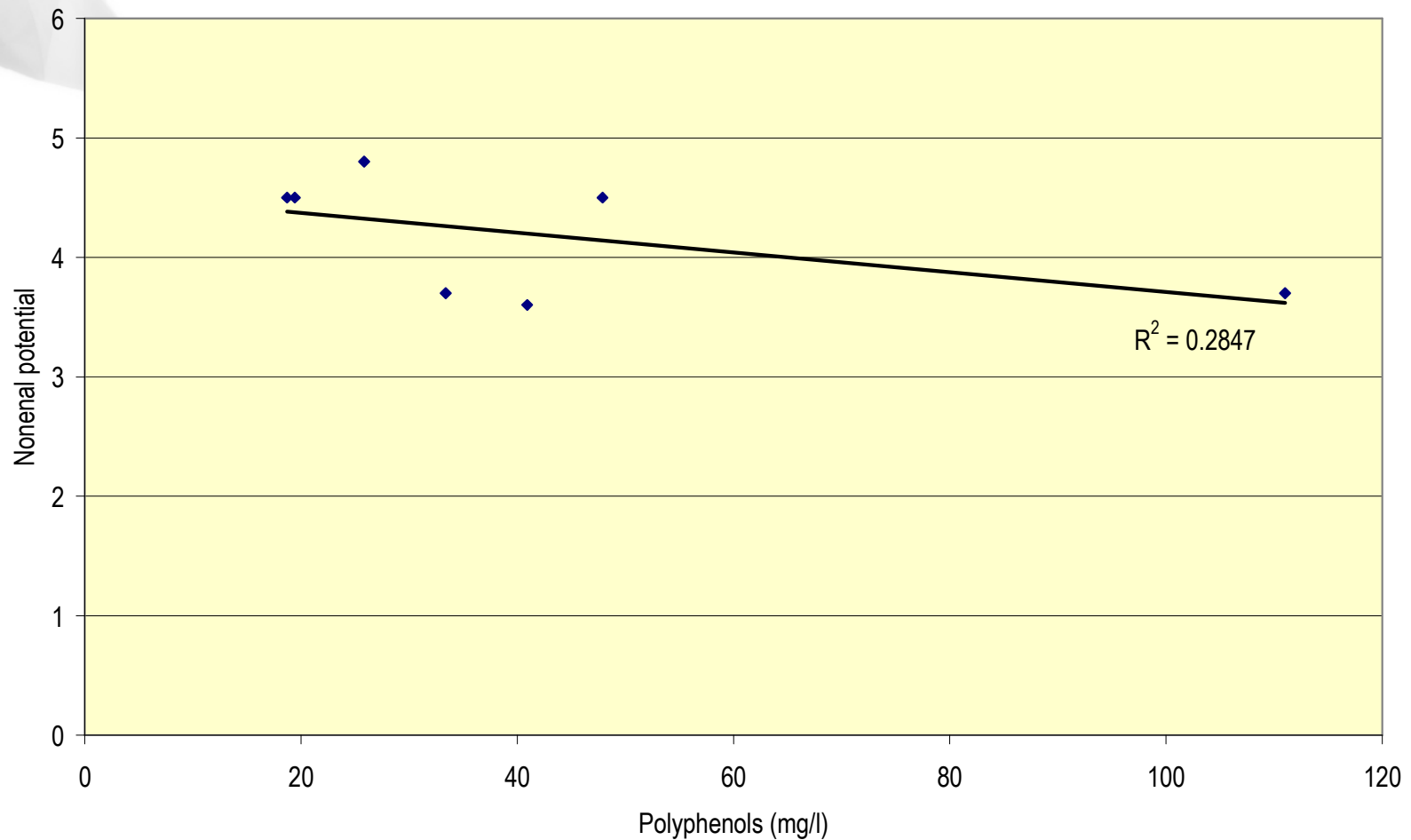


# Nonenal potential of wort and T2N in stale beer



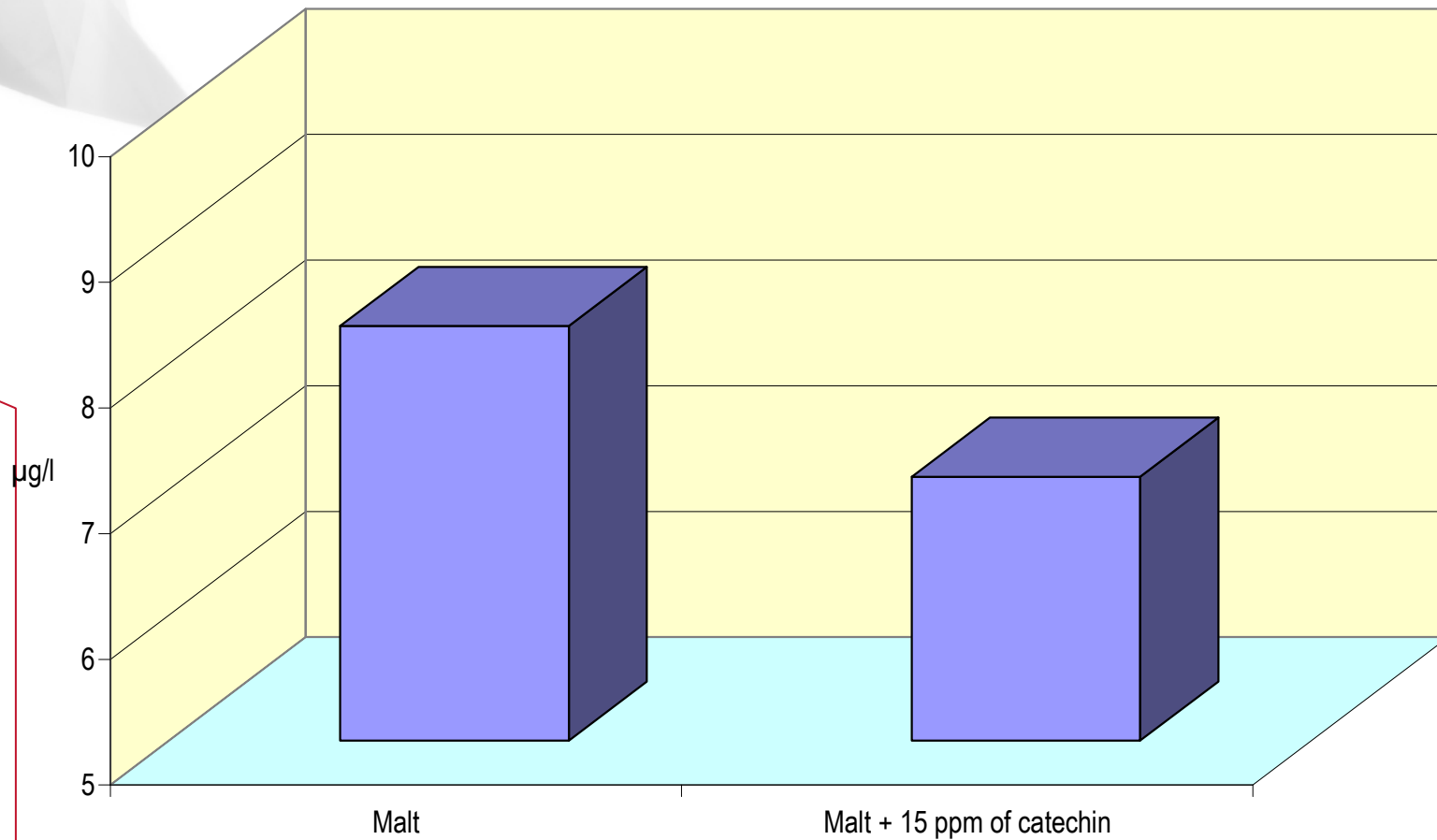
Ueda et al, EBC Budapest, 2001

# Nonenal potential and Polyphenols content in wort

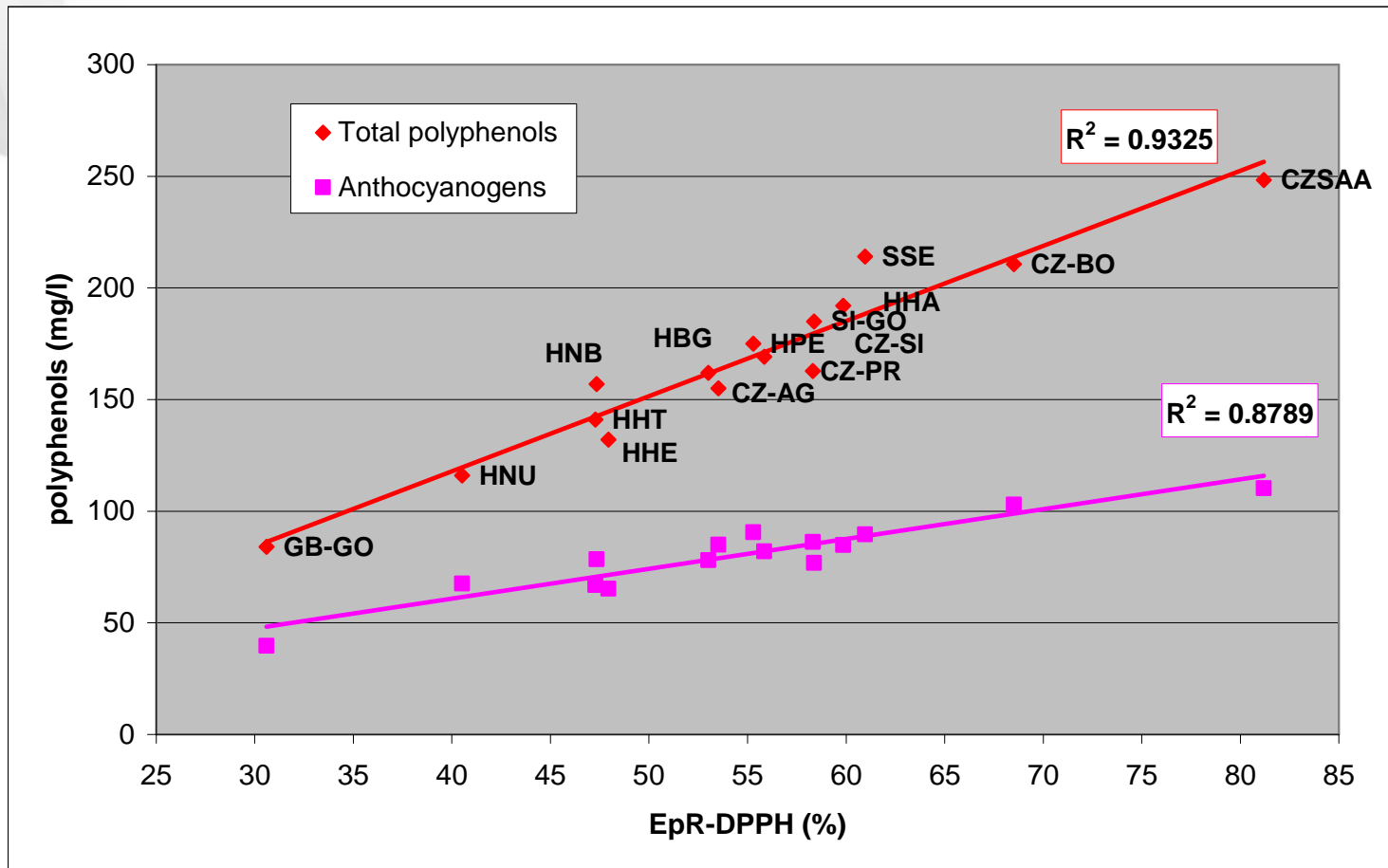


# Impact of exogenous polyphenol

Nonenal potential in Tepral wort

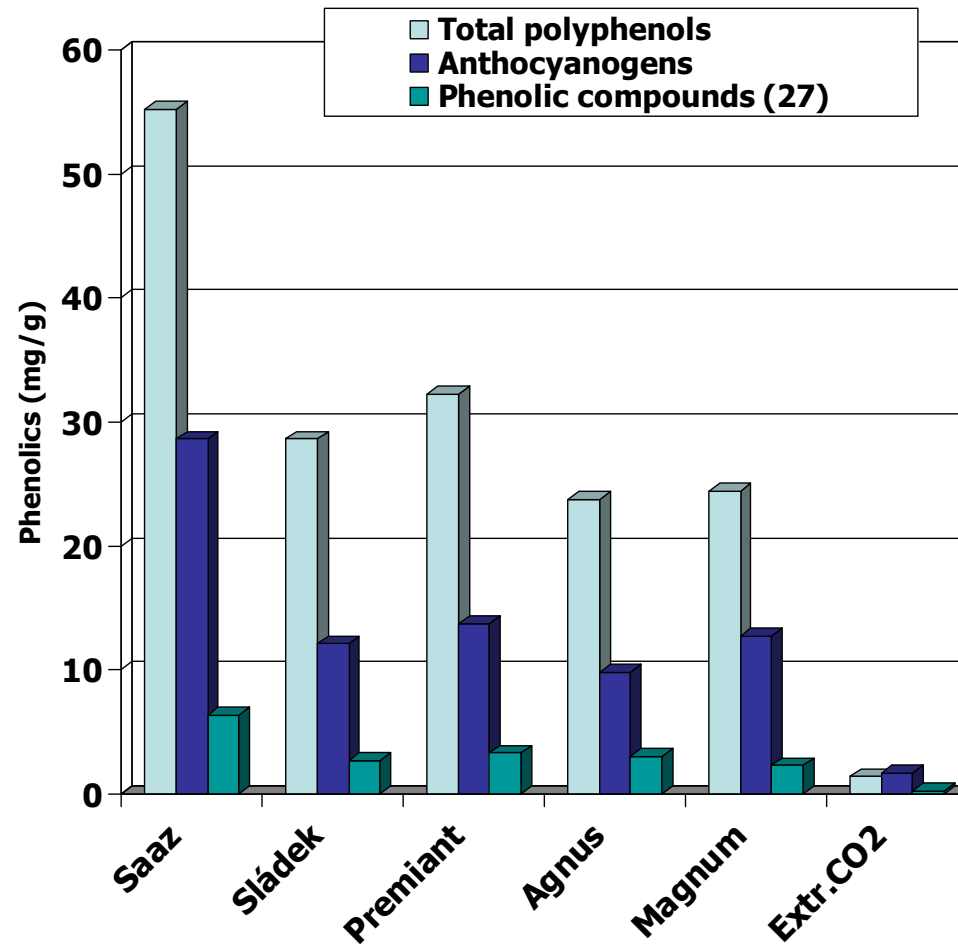


# Antiradical activity and hop varieties & polyphenols



Mikyška and al. EBC symposium 2005

# Polyphenols compounds of Hop and Hop extract



Mikyška and al. EBC symposium 2005

# Hop boiling & nonenal potential

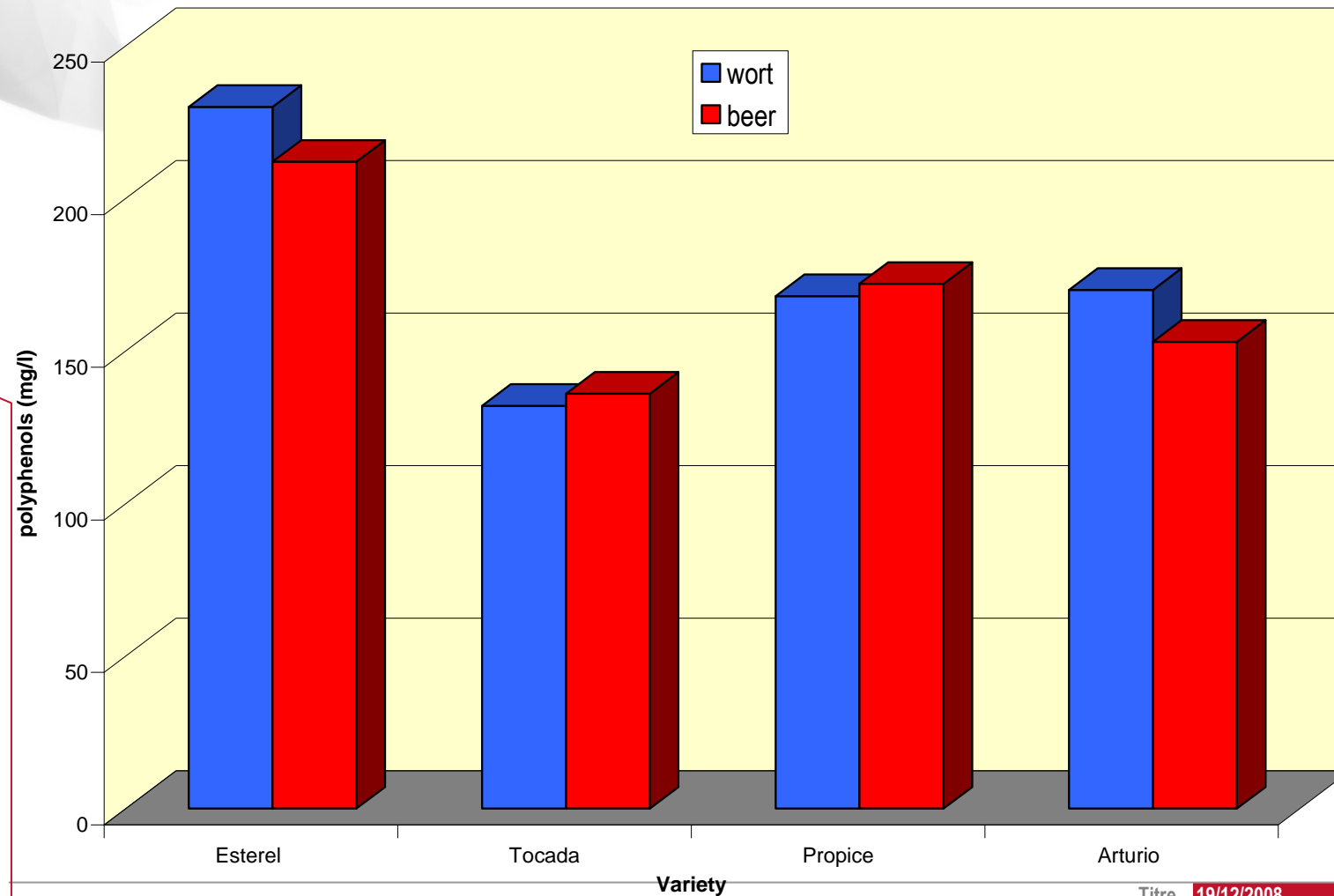
Boiling	Increase of reducing power	Nonenal Potential
Without hop		3.2
Pellets Saaz	+ 36%	2.5
CO2 extract	+ 4%	3.0

Lermusieau & al. Chair de Clerk 2000

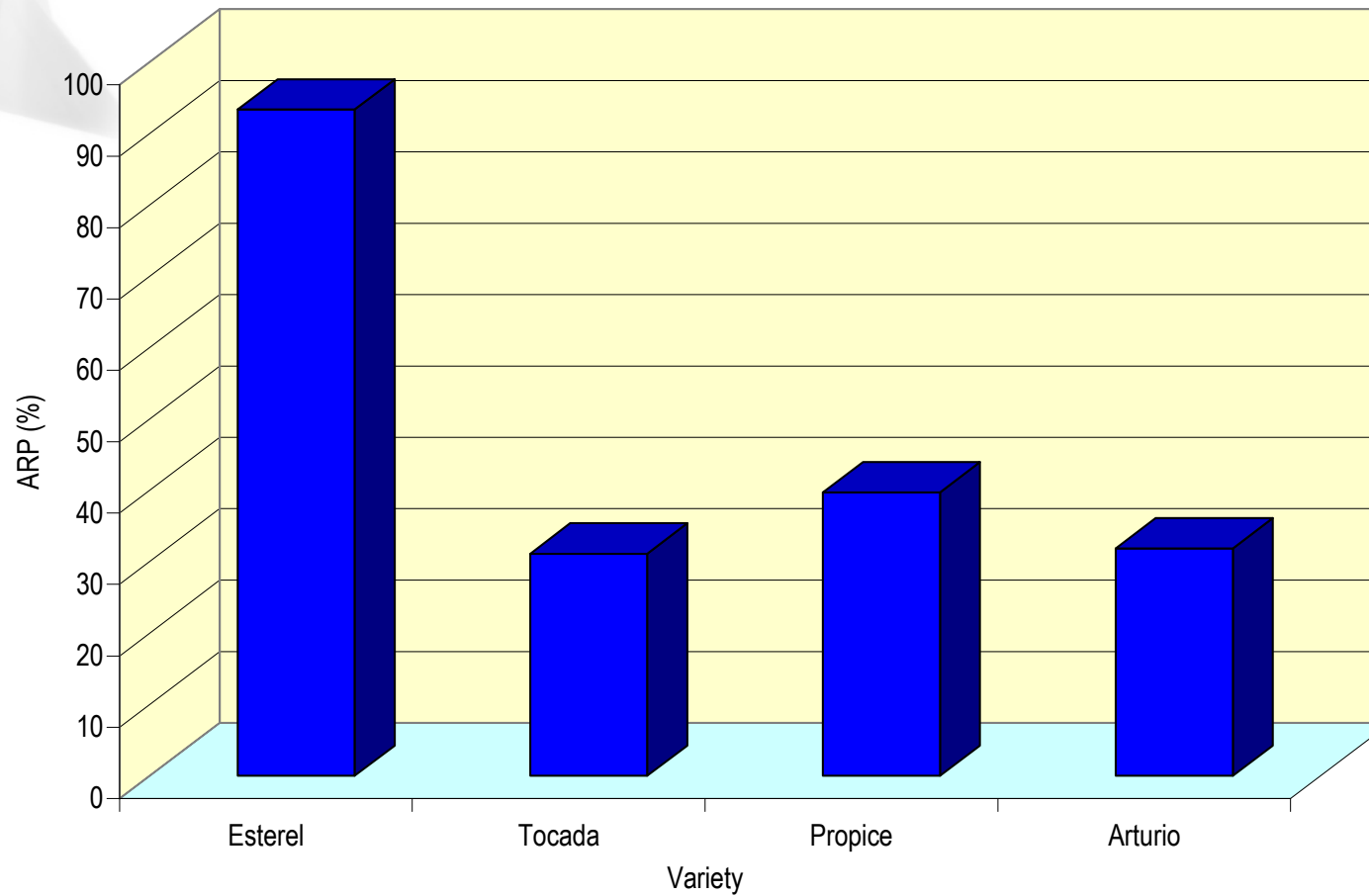
# Polyphenols and cold wort

- ⇒ Antioxidant activity of cold wort is mainly due to malt and hop polyphenols
- ⇒ Nonenal potential of wort could be decrease by polyphenols

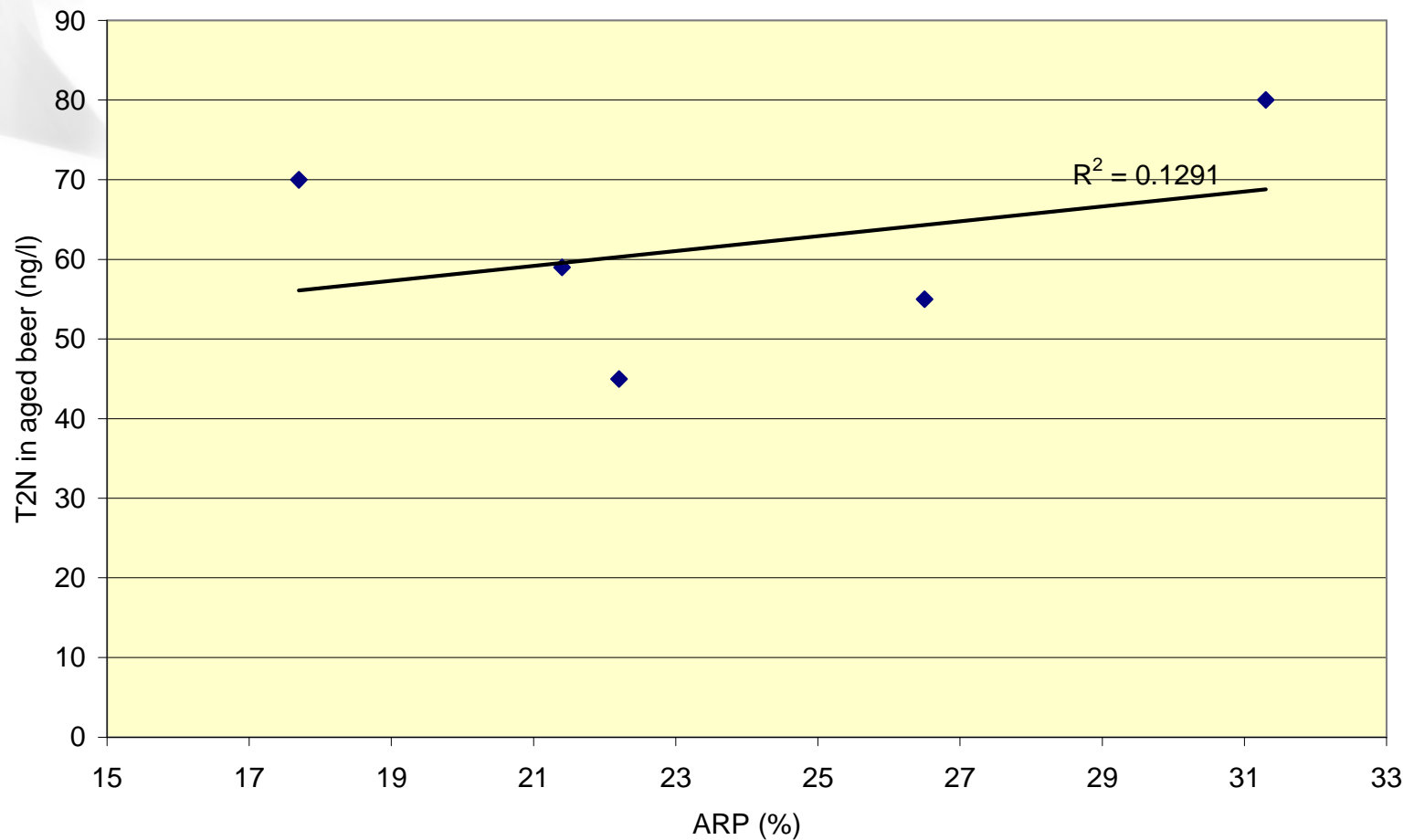
# Polyphenols content of beer



# Antioxidant activity of beer



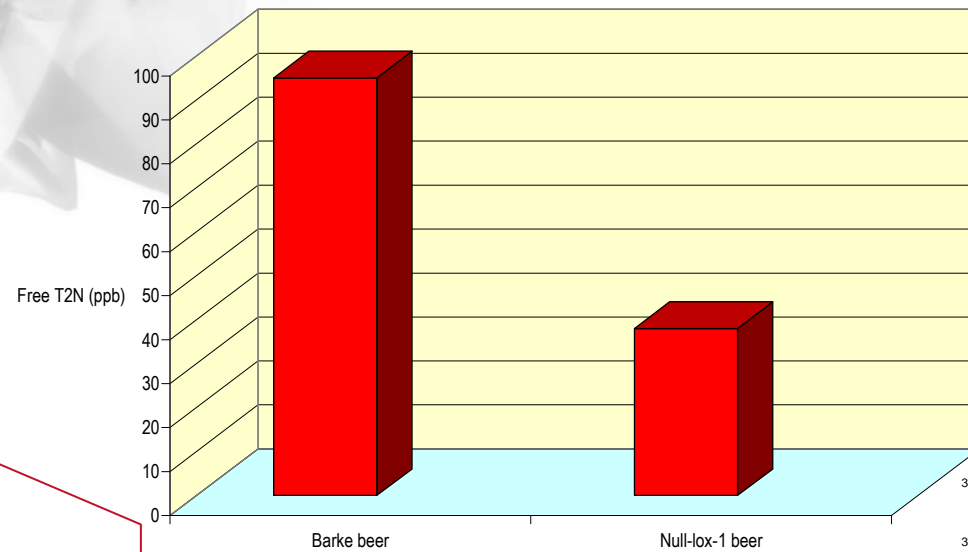
# Polyphenol in malt & Flavour stability of beer



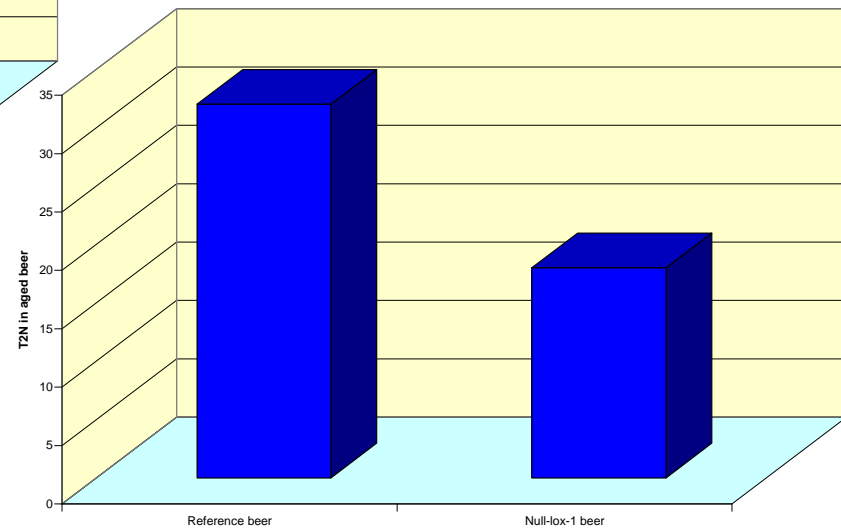
# Impact of Beer stabilisation on Flavour stability of beer

	Beer stabilisation		
	<i>PVPP</i> 30 g/hl	<i>Prolyl endoprotease</i> 1.25 u/kg malt	<i>Prolyl endoprotease</i> 2.5 u/kg of malt
Polyphenol content (mg/l)	124	202	217
ARP (%)	30	48.5	50.9
Nonenal in fresh beer (µg/l)	0.08	0.12	0.08
Nonenal in after ageing (µg/l)	0.21	0.12	0.08

# Flavour stability of beer and Lox-1 activity



Skadhauge et al. EBC congress 2005



Doderer et al. EBC congress 2007

# Conclusion

## ⇒ Flavour instability of beer

⇒ mainly due to Lox 1 (40 to 60% of Beer T2N )

## ⇒ Polyphenols

⇒ exhibit an antioxidant activities

- Lox-1 inhibition,
- chelating agent,
- free radical scavenger

⇒ Effect in brewhouse (10 to 20%)

⇒ Effect on beer storage

## Conclusion

BEER WITH HIGH CONTENT OF POLYPHENOLS

A GOOD IMAGE FOR THE CONSUMER