Developing Flavours in Soft Cheeses

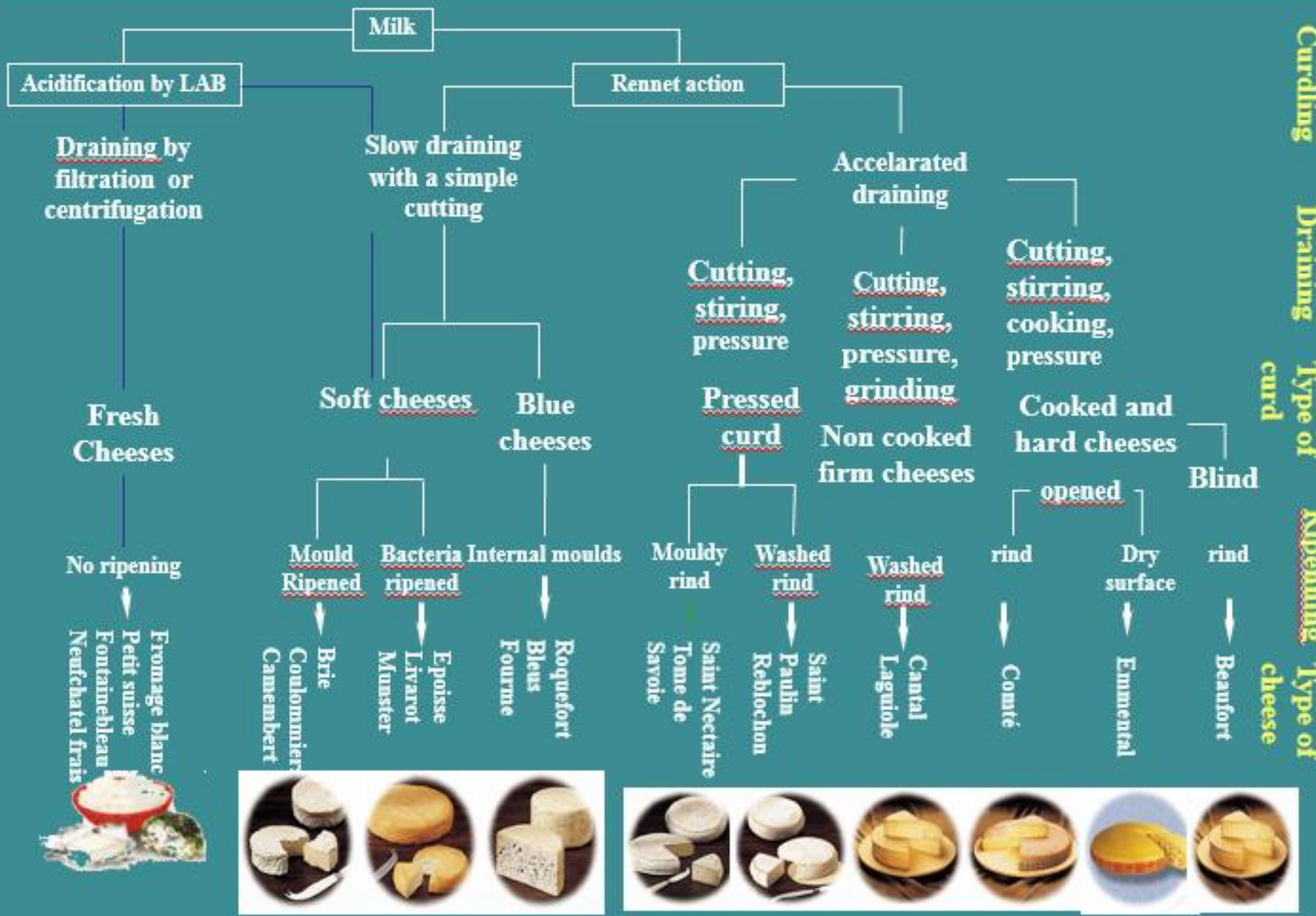
Prof. HE Spinnler,

AgroParisTech / INRA

78850 Thiverval Grignon

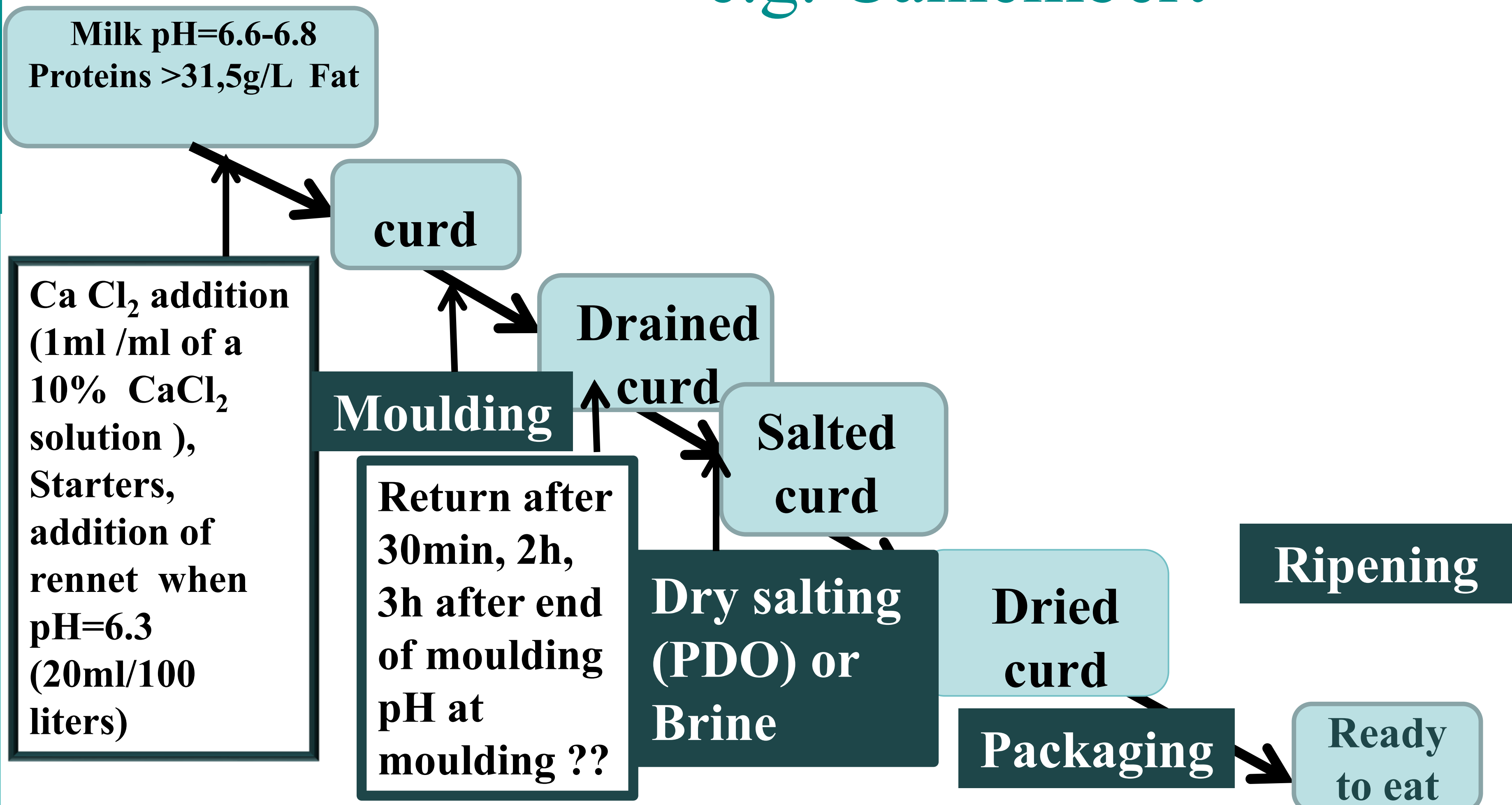
France

spinnler@agroparistech.fr



Milk
Acidification by LAB
Rennet action
Draining by filtration or centrifugation
Slow draining with a simple cutting
Accelarated draining
Cutting, stiring, pressure
Cutting, stirring, pressure, grinding
Cutting, stirring, cooking, pressure
Fresh Cheeses
Soft cheeses
Blue cheeses
Pressed curd
Non cooked firm cheeses
Cooked and hard cheeses
opened
Blind
No ripening
Mould Ripened
Bacteria ripened
Internal moulds
Mouldy rind
Washed rind
Washed rind
rind
Dry surface
rind
Fromage blanc
Petit suisse
Fontainebleau
Neufchatel frais
Brie
Coulommiers
Camembert
Epoisse
Livarot
Munster
Roquefort
Bleus
Fourme
Saint Nectaire
Tome de Savoie
Saint Paulin
Reblochon
Cantal
Laguiole
Comté
Emmental
Beaufort
Curdling
Draining
Type of curd
Ripening
Type of cheese

Technological diagram e.g. Camembert



T° < 37° C in tank, 30° C in air	*T° =34° C 18h for PDO*	T° =14° C, 85% RH	*T° =12-14° C, 13 days , 98% RH*	*T° =8-10° C 2 weeks , 95 HR*

Summary of the differences between lactic curd and rennet curd

Curd mainly lactic

- Acidification and only then draining
- pH 4,5
- Residual Lactose
- Deminéralisation
- Low buffer capacity
- Weak Interactions between proteins
- High moisture level
- Fragile
- Small cheeses

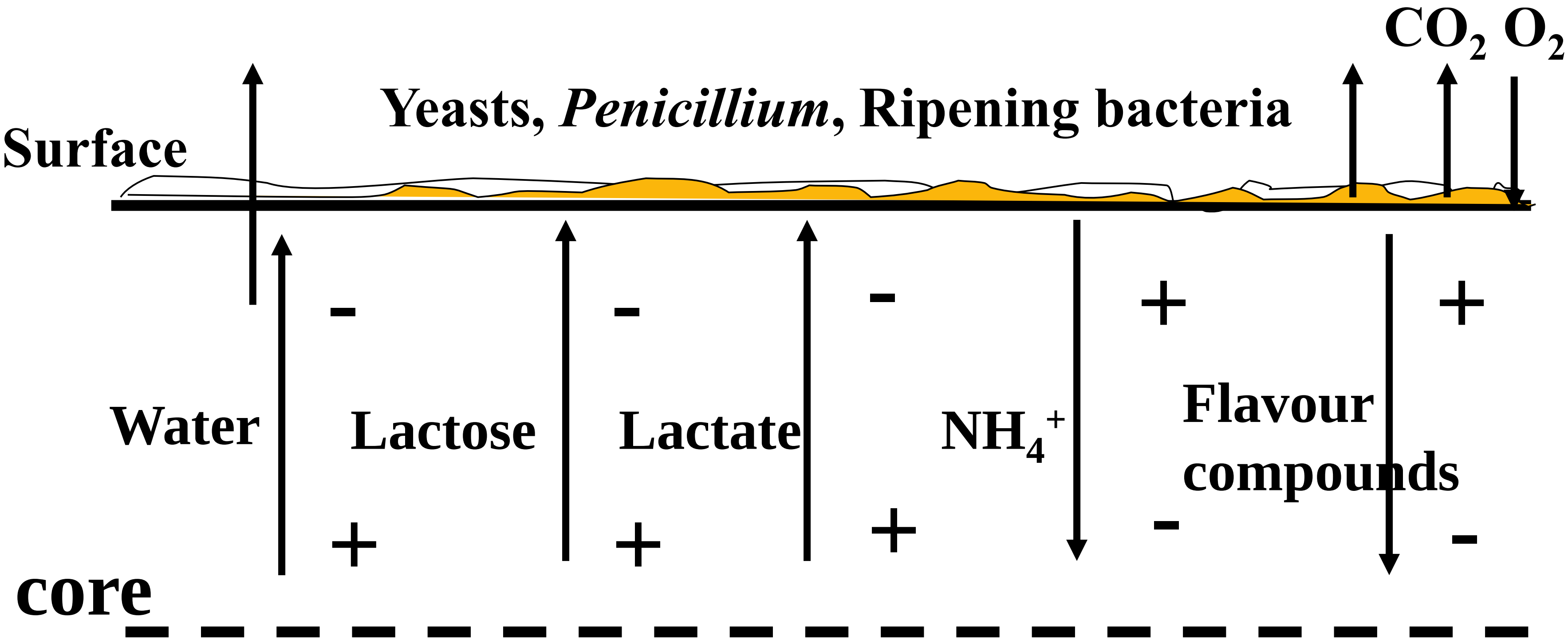
Curd mainly rennet

- Draining and then acidification
- pH 5,2
- No residual lactose
- High minéral concentration
- Strong buffer capacity
- Strong interactions between caseins
- Low moisture level
- Ferm and elastic
- Big cheeses

PLAN

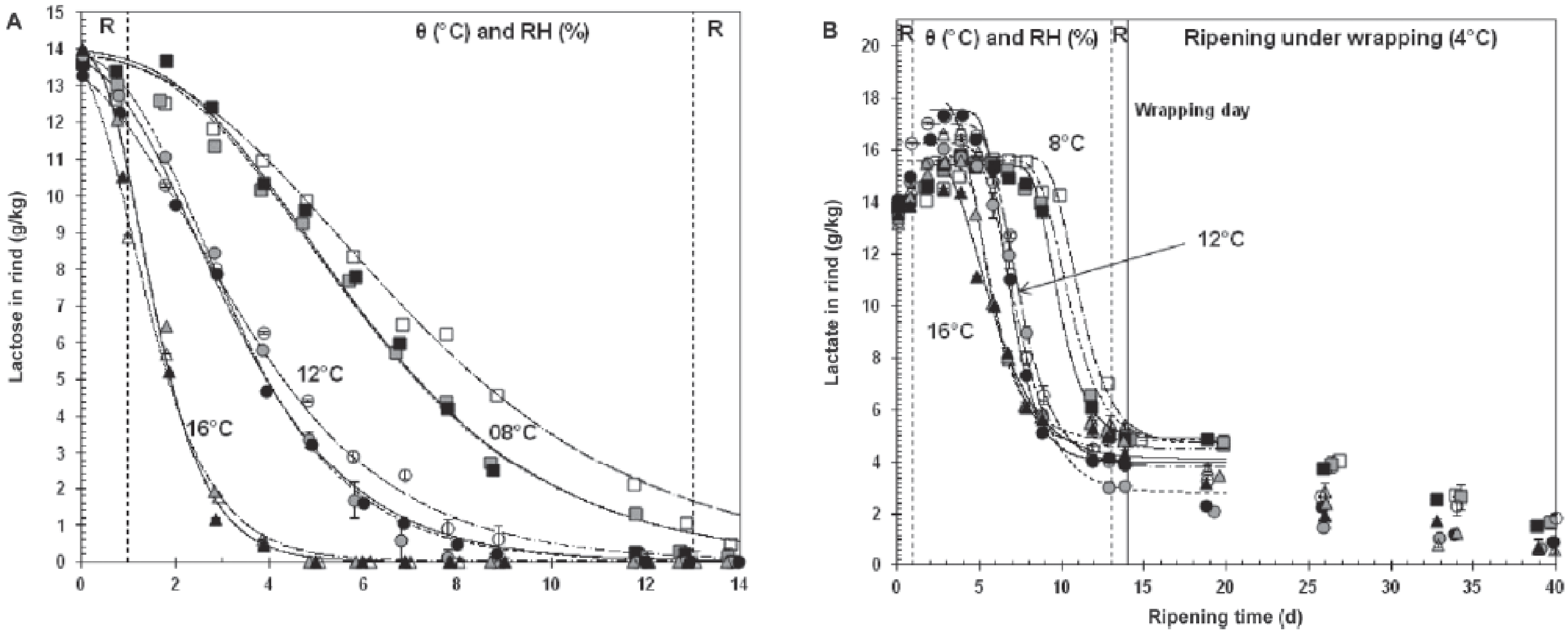
Mass transfer in soft cheese ripening

- Context : Important changes in curd, composition, structure, aspect, texture, colour and taste due to biological activity and transport phenomena.



Leclercq Perlat et al, 2004

Lactose and lactate changes during ripening



Leclercq-Perlat et al, 2012

Microbial growth during ripening

DESACIDIFICATION

MATURATION

SURFACE

Fungi :

-Yeasts
-Geotrichum
-Penicillium

PH=5.8

Fungi + ripening bacteria :

Micrococcinae :
Micrococcus, Arthrobacter, Brevibacterium

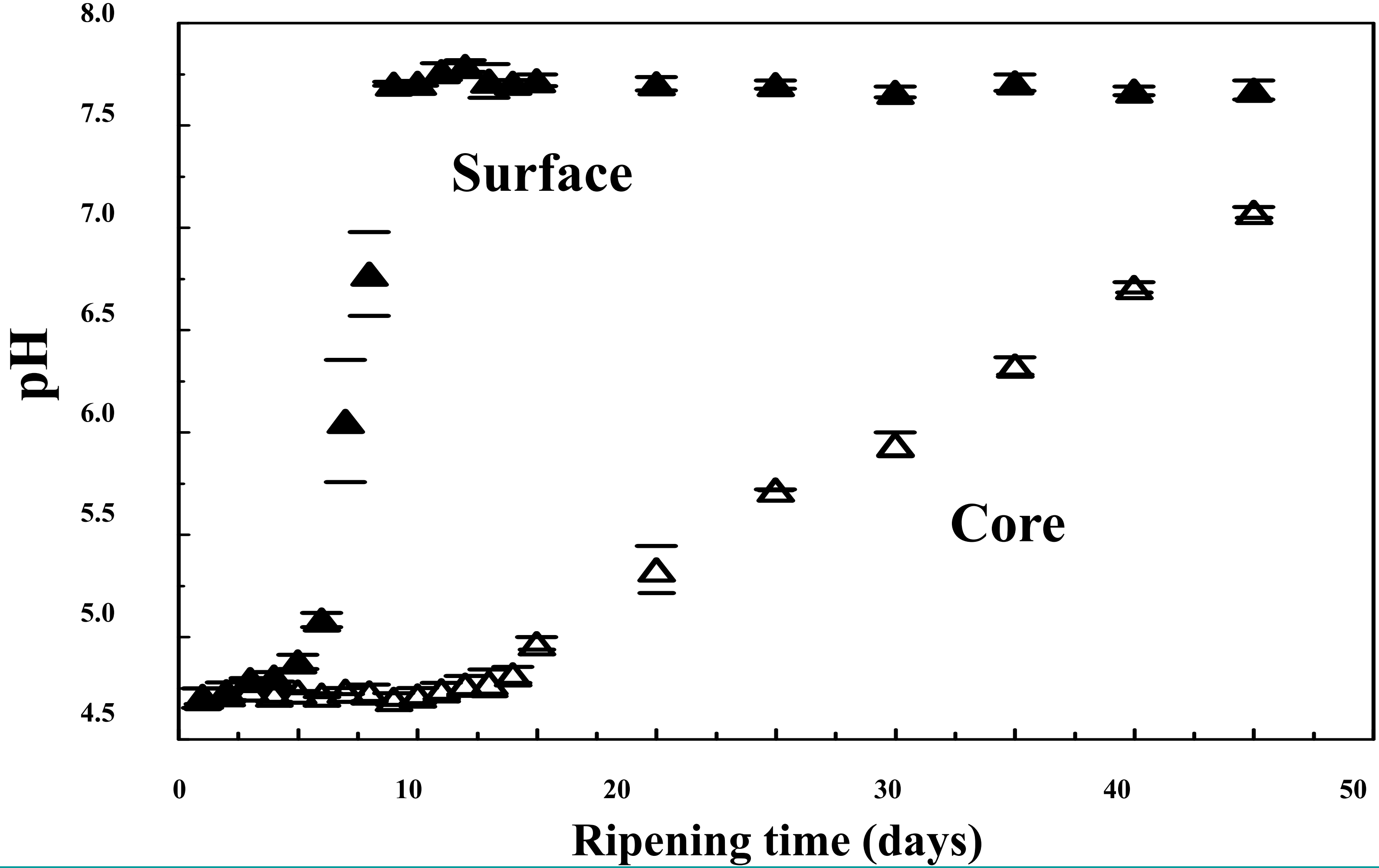
Corynebacterinae :
Corynebacterium

Staphylococci

INSIDE

Time

pH Change at the surface and in the core of a Camembert cheese

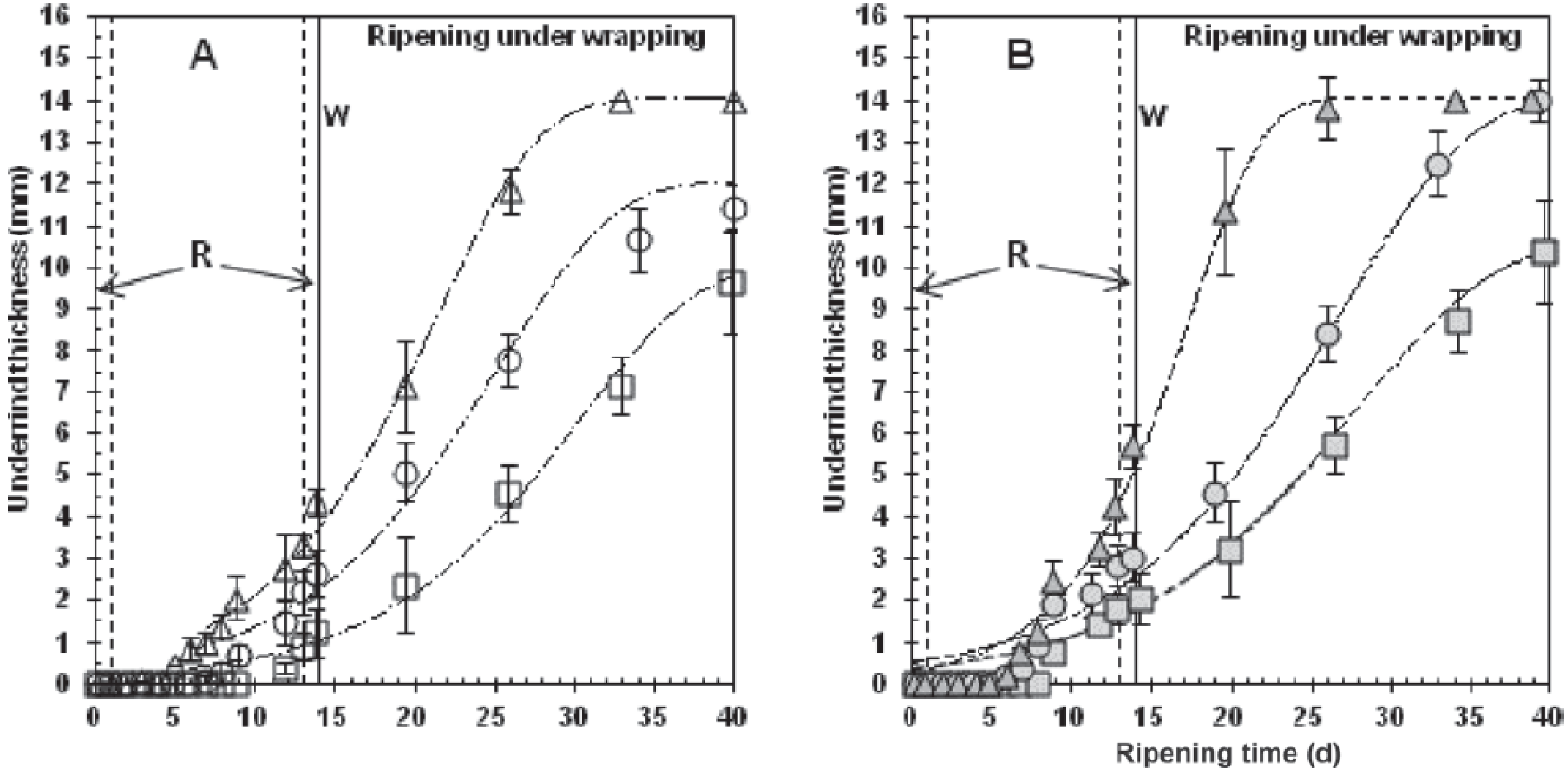


Buffer capacity

- **Buffer capacity can be defined as the resistance to pH change, low pH decrease the buffer capacity with strong consequences on texture**

- **Low pH at moulding (pH= 6.1 (traditional camembert) to 5,2 (lactic washed rind))**
  - Makes easier the pH rise after the *Penicillium* growth, gives creamy underind after a while
  - Makes the cheese center tough and chalky

Evaluation of the ripening efficiency on the base of texture change



RH : 88%

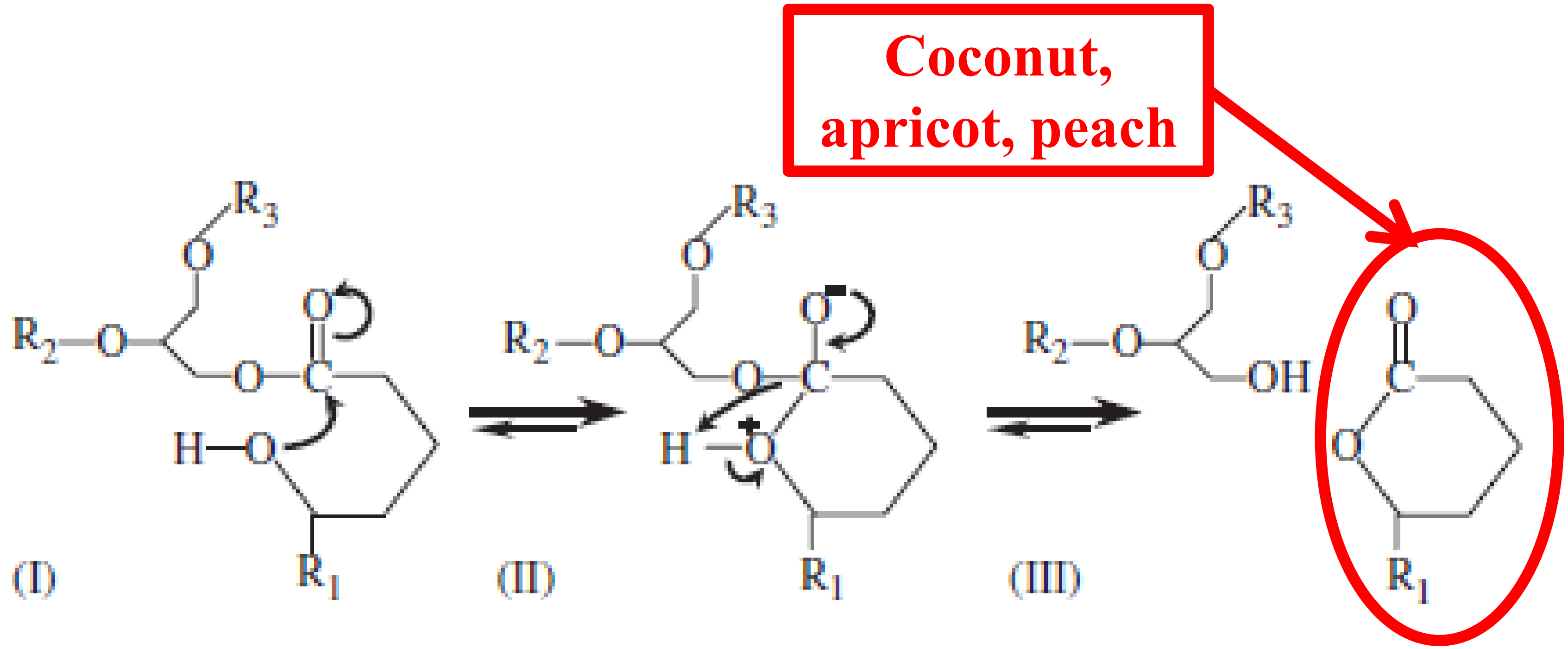
RH : 92%

Triangles : 16° C
Circles : 12° C
Squares : 8° C

Leclercq-Perlat et al, 2012

PLAN

Formation of fruity notes directly from fat



Proposed Mechanism for δ-lactones production from triglycerides containing 5-hydroxy acids. R1=(CH2)n-CH3 ; R2 and R3=CO-(CH2)n-CH3 (Alewijn *et al.* 2007)

Malt and Fruity flavours

They are mainly coming from amino acid breakdown

These flavour compounds are produced early in the ripening process

Yeasts are mainly responsible of these flavours

At the end of ripening, some bacteria may reinforce these flavour notes especially in washed rind cheeses

PROTEINS

↓ *Proteases,*

PEPTIDES

↓ *aminopeptidases, carboxypeptidases*

AMINO ACIDS

↓ *transaminases*

α-ceto acids

↓

Aldehydes, alcools, acides

↓ *decarboxylase*

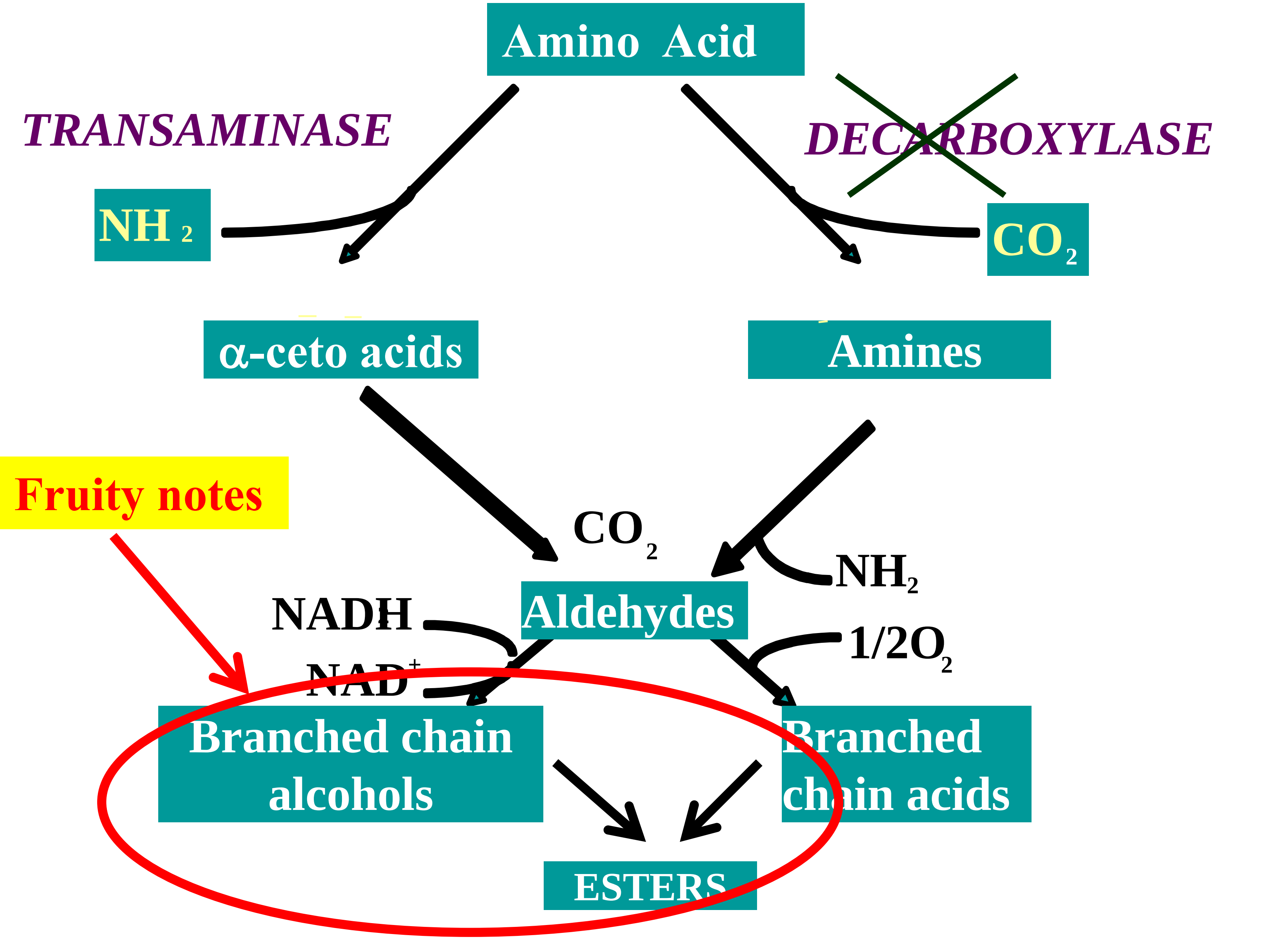
Amines

↓

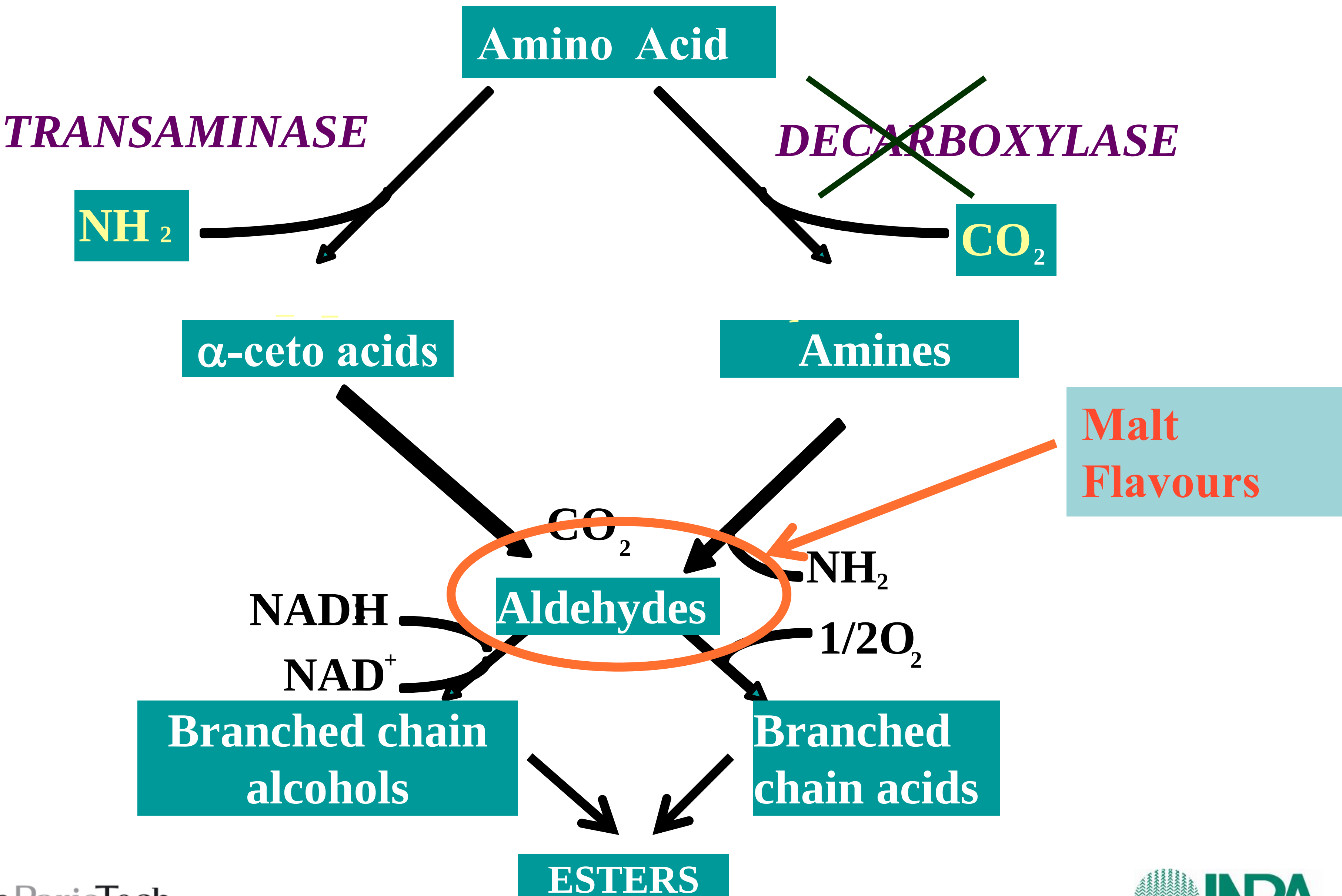
↓ *lyases*

Indole, phenol, styrene sulfur compounds

OXIDATIVE DEGRADATION OF AMINO ACIDS



OXIDATIVE DEGRADATION OF AMINO ACIDS



The amino acids breakdown is the main source of malt and fruity notes :

- aldehydes (malt and chocolate notes),

- alcools, esters, thioesters (fruity notes)

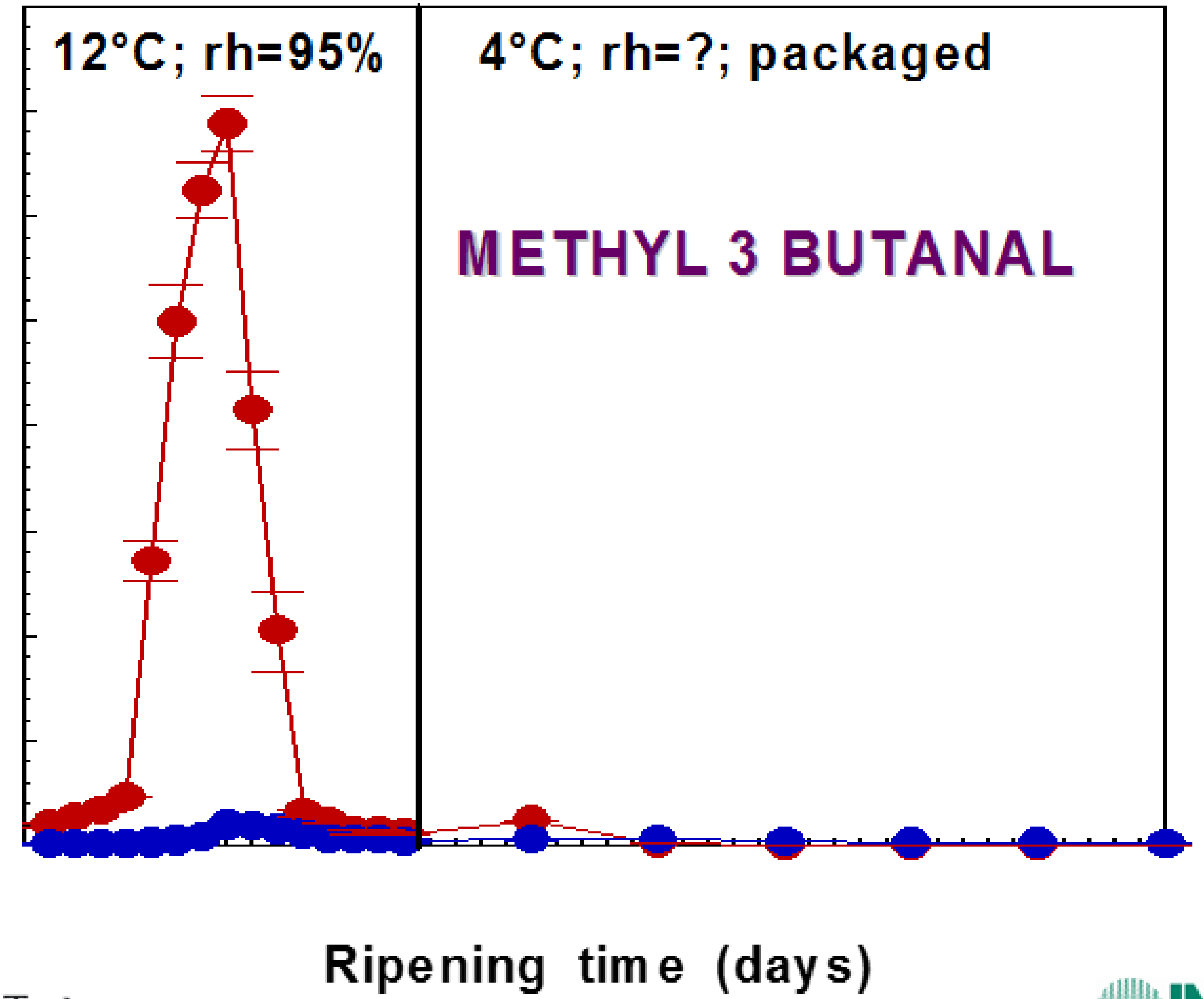
Starters sources of malt and fruity notes

- aldehydes (malt and chocolate notes) :

Debaryomyces hansenii,
Staphylococcus xylosus

- alcools, esters, thioesters (fruity notes) :

Kluyveromyces lactis,
Geotrichum candidum



12°C; rh=95%
4°C; rh=?; packaged
METHYL 3 BUTANAL
Ripening time (days)

Olfactive thresholds of esters

Compounds	Aromatic Notes	perception threshold
Ethyl acetate	Solvent, fruity	5 ppm[a] 22 ppm[b]
Ethyl Propionate	Pineapple	9,9 ppb[a]
Ethyl Butyrate	Pineapple	0,13 à 45.10^4 ppb[a] 0,6 ppm[b]
Ethyl Hexanoate	pineapple, banana	1 ppb[a] 0,85 ppm[b]
Isoamyle acetate	pear, banana	2 ppb[a]
2-phenylethyl acetate	floral, rose	18,5 ppm[c]
2-phenylethyl propionate	floral, fruity	16,8 ppm[c]

a : in water ; b : in oil or butter ; c : in a cheese base.

Thioester formation

AA

↓

CH_3SH

Sugars, FFA, AA

↓

Acyl CoA

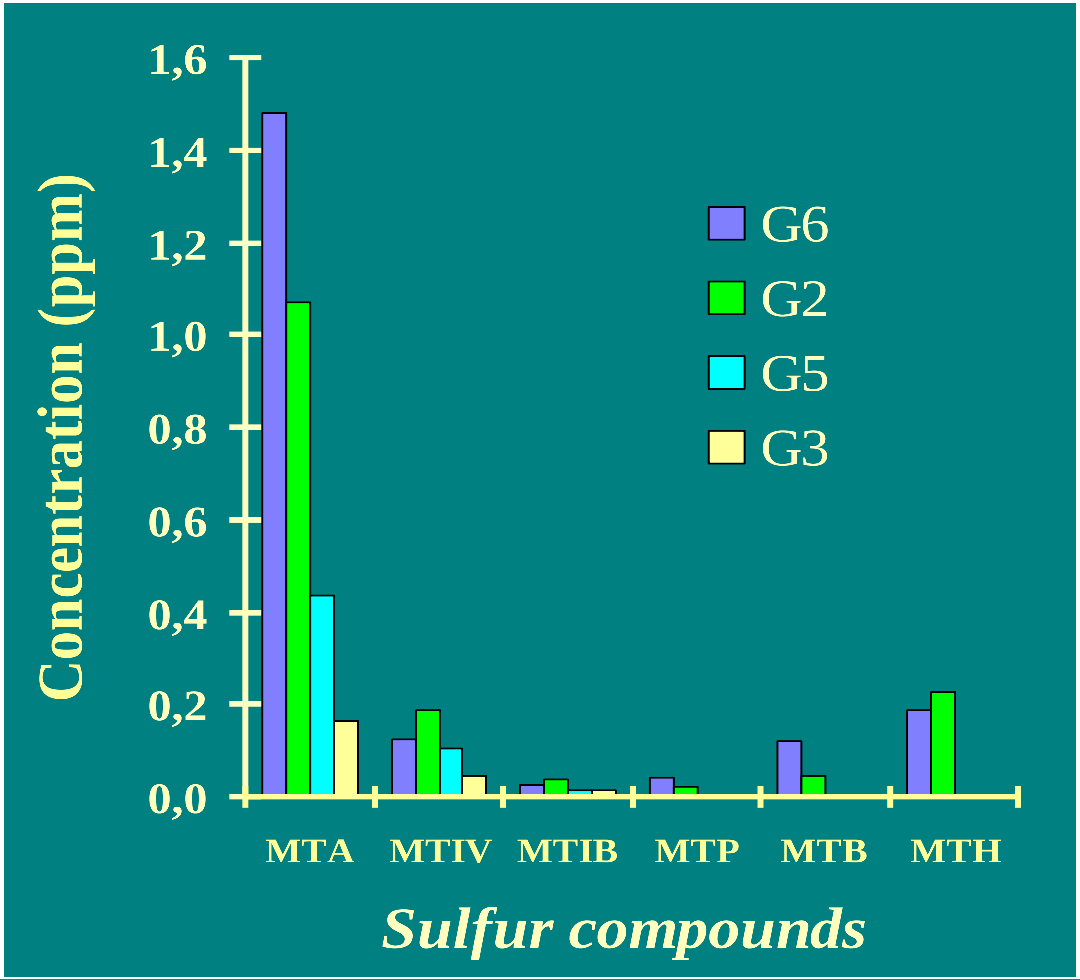
Enzyme?

Acyl S Me + CoASH

AgroParisTech

INRA

Geotrichum candidum is able to produce thioesters *(Berger et al, 1999)*



AgroParisTech

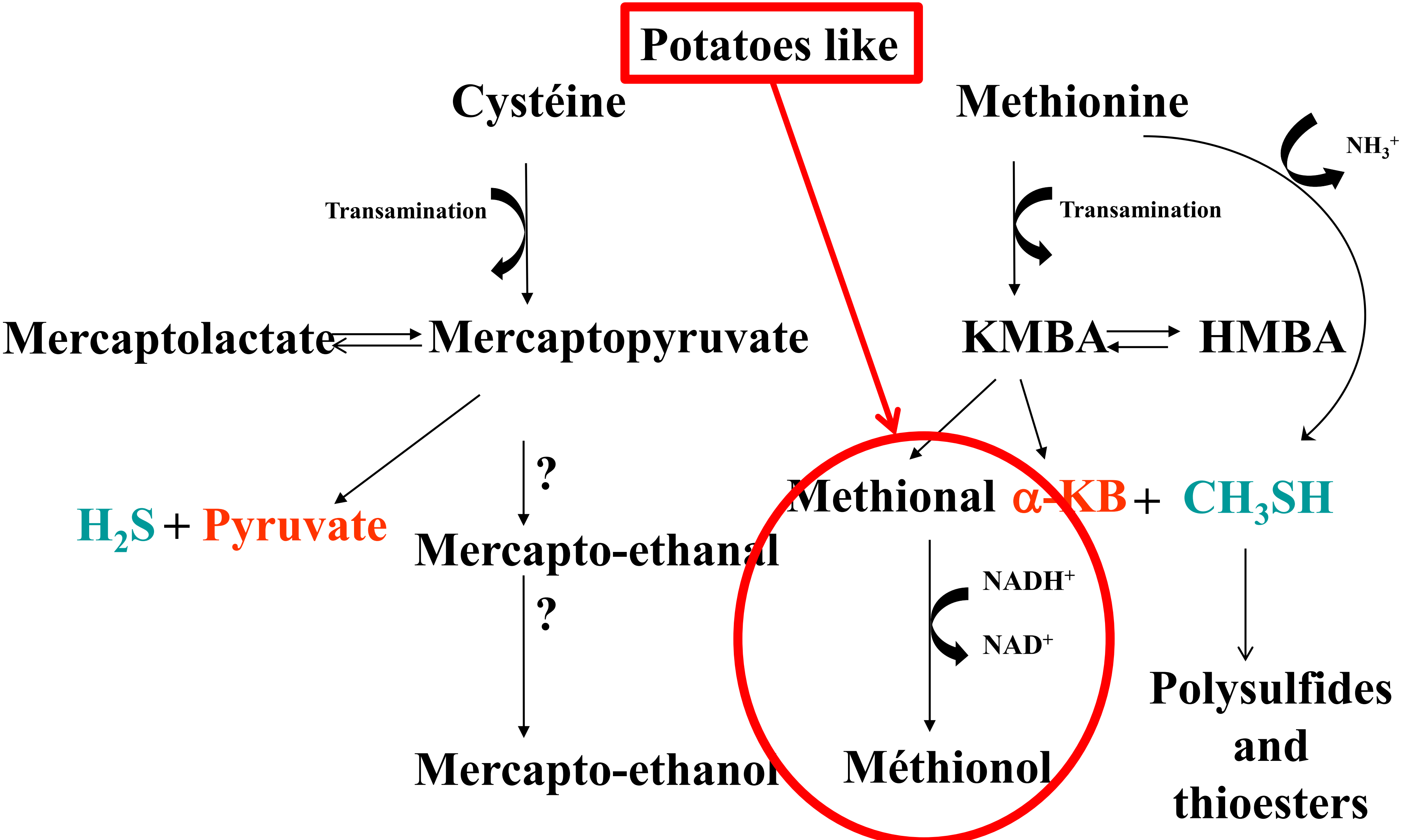
INRA

PLAN

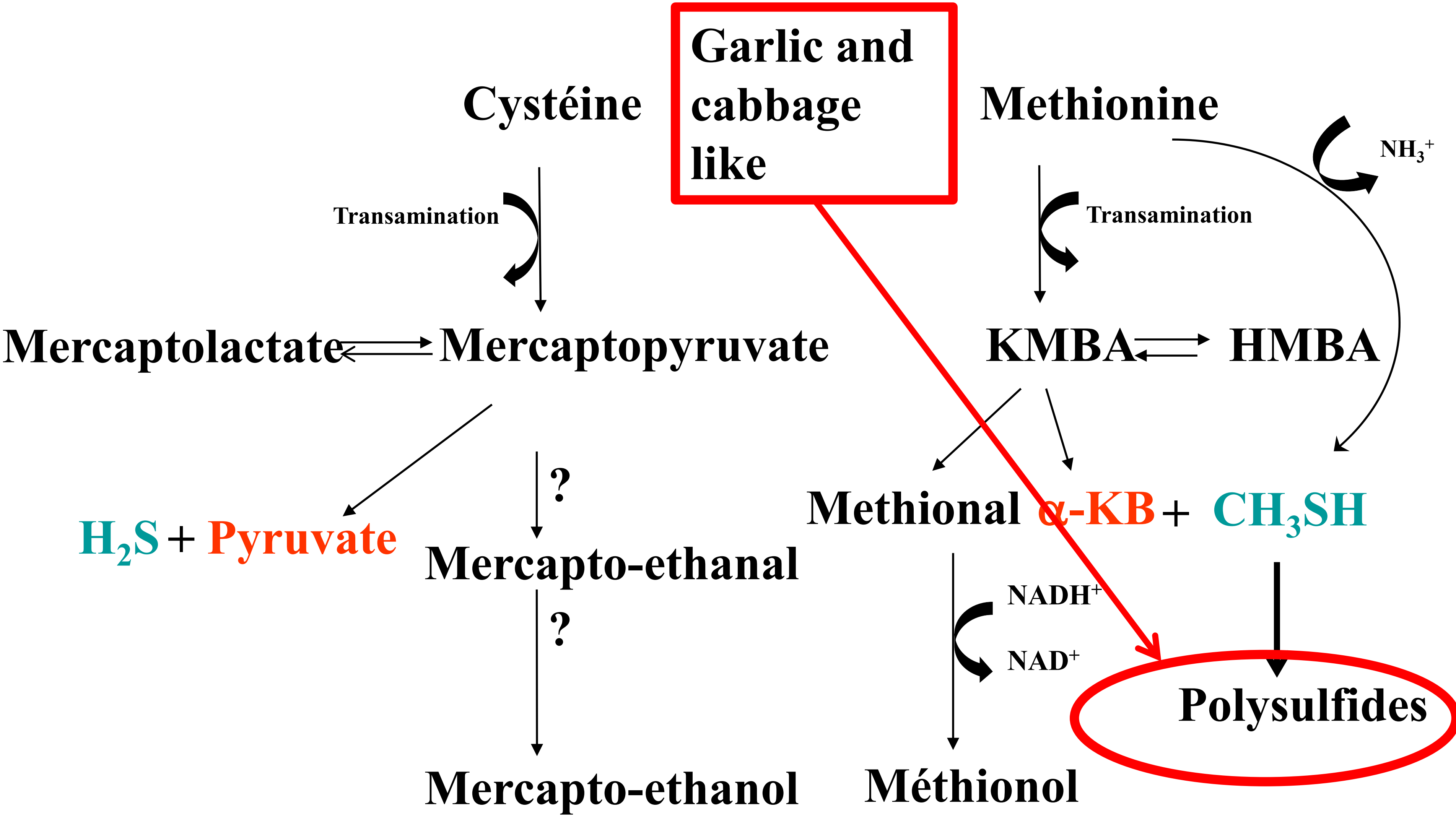
Degradation of amino acids also leads to :

- phenols (animal notes, role in ewes milk cheeses)

- sulfur compounds (garlic and cabbage notes- important especially in smear ripened cheeses)



Relations between sulfur amino acid metabolism and flavour production



Relations between sulfur amino acid metabolism and flavour production

Olfactive thresholds of sulfur compounds

Olfactive thresholds (µg/kg or ppb)

Compounds	In water	In oil
DMS	0.3*	1.2*
DMDS	18.69+	2.5*
DMTS	0.23+	2.5*
DMQS	0.06+	ND*

* Kubickova & Grosch, 1997

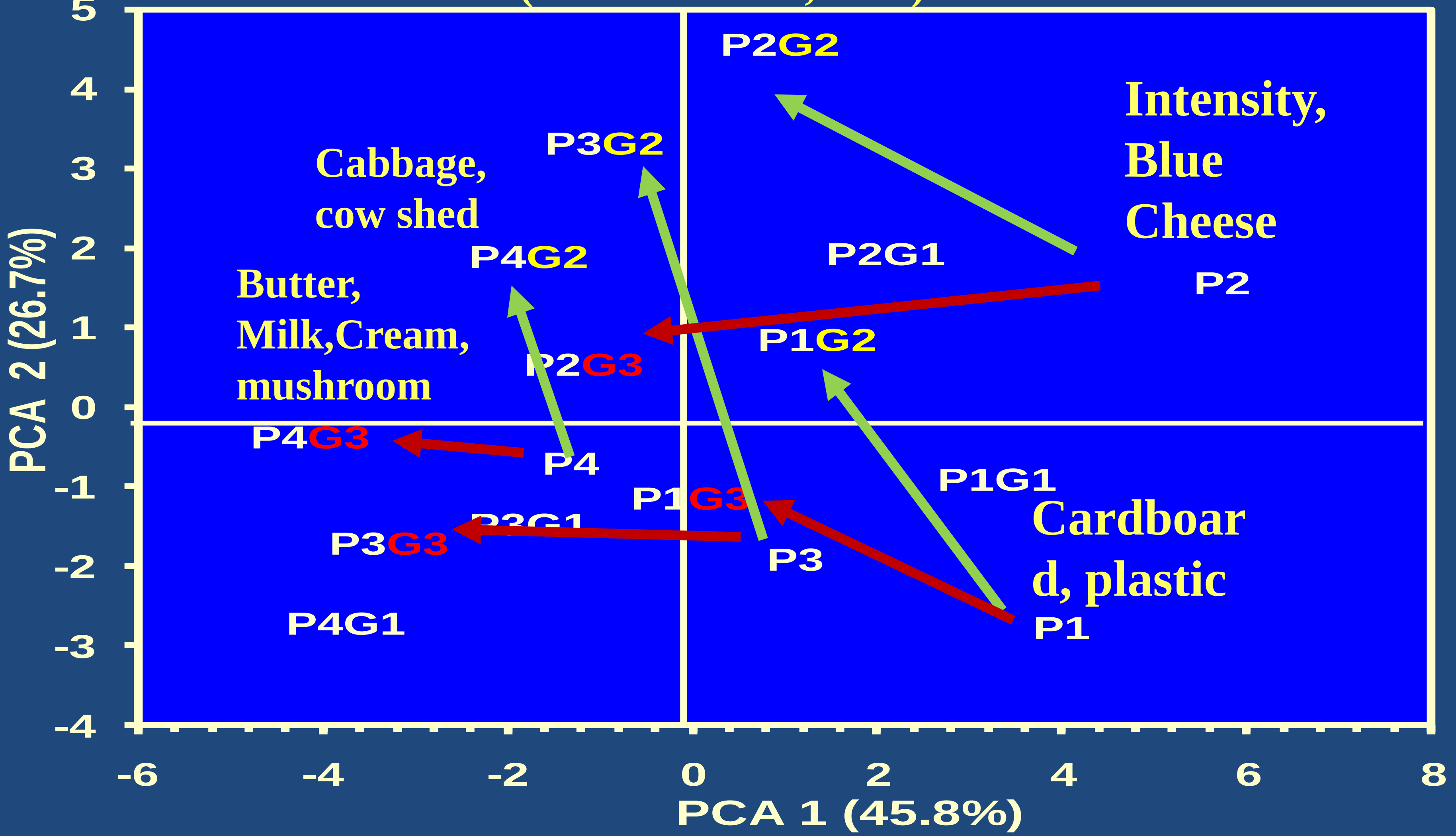
+ Our results

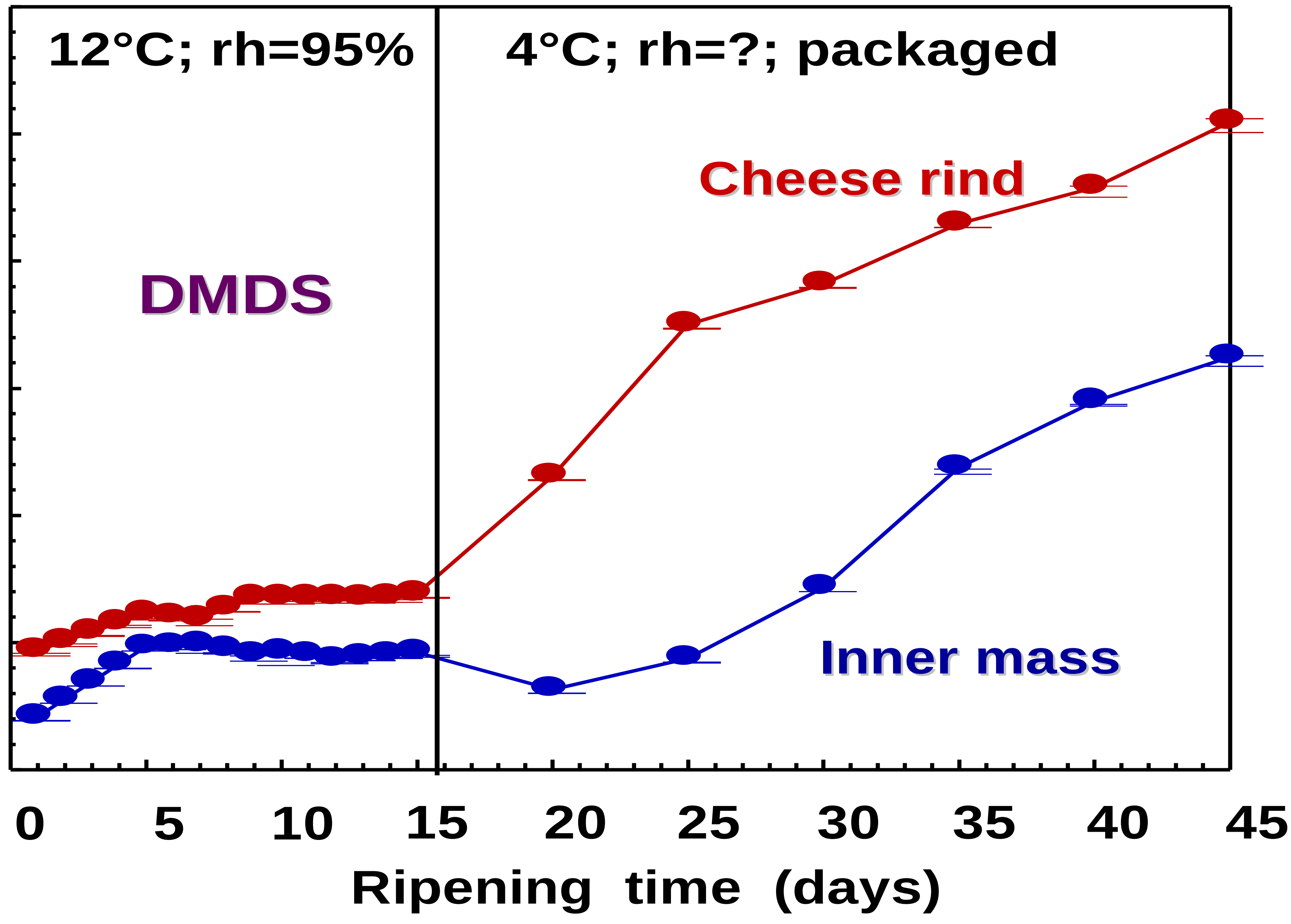
Micro-organisms able to produce sulfur compounds

- ***Geotrichum candidum***
- ***Hafnia alvei***
- ***Coryneform bacteria :***
  - ***Brevibacterium linens, B. aurantiacum***
  - ***Micrococcus sp.***
- ***Staphylococcus equorum and S. lentus***
- ***Lactobacilli***

Propriétés aromatiques de Camembert fabriqués avec *P. camemberti* avec et sans *G. candidum*

(Molimard et al, 1996)




12°C; rh=95%
4°C; rh=?; packaged
DMDS
Cheese rind
Inner mass
0
5
10
15
20
25
30
35
40
45
Ripening time (days)

PLAN

Introduction

1. Texture

2. Malt and Fruity flavours

3. Cabbage and Garlic flavours

4. Goaty, Blue cheese to Soapy flavours

5. Mushroom flavours

6. Plastic

Conclusions

TRIGLYCERIDES

Lipases

SATURATED FATTY ACIDS

UNSATURATED FATTY ACIDS

HYDROXY ACIDS,

OXO-ACIDS,

HYDROPEROXY-ACIDS

AgroParisTech

INRA

Effect of fat on the sensory properties

- **Texture factor (thickener, lubricant, emulsifier,…)**
- **Flavour support**
- **Flavour precursor**

Lipid degradation

Step 1 lipolysis: It can be a limiting step (Goat cheese, Blue cheese)

Step 2 : fatty acid oxidation (usually not the limiting step)

Impact of Fat

	Normal milk	Rancid milk	Cheddar - Emmental	Gouda	Parmesan, Camembert	Roquefort	Bleus
	<0.25%	0.4-0.5	~0.2-1%	~1.5%	~ 4-5%	8-10%	18-25%
Fat acidity (meq/100 g MG)		1.5-2.0	0.8-16*	6-8	20	30-40	60-100
mg of FFA/cheese g			0.4-5	~5	12-15	25-30	50

Level of lipolysis in different cheeses

B- Lipolysis in blue Cheeses compared to other types of cheeses

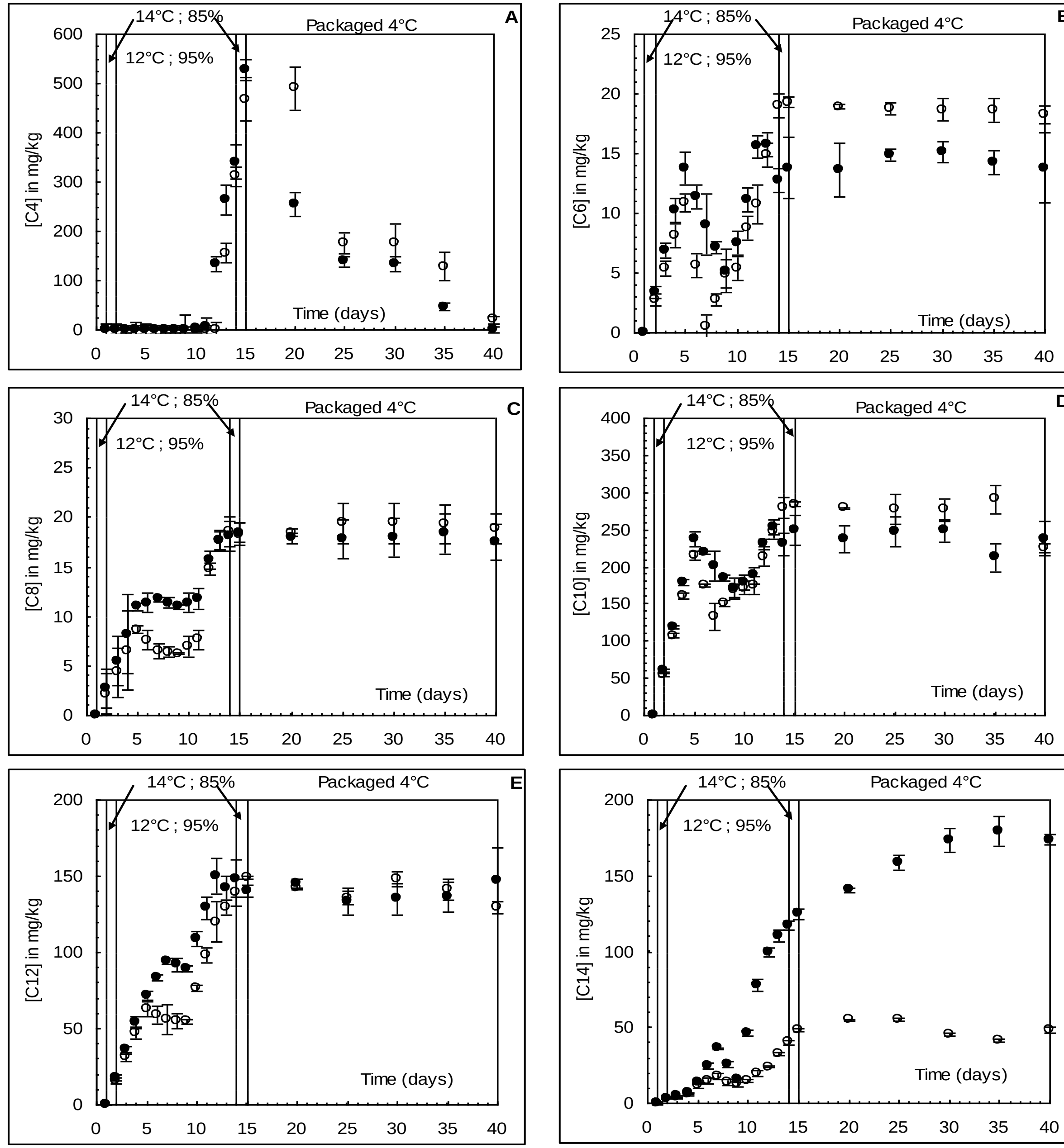
Table 3 Typical concentration of free fatty acids (FFA) in different cheese varieties

Variety	FFA ($mg\ kg^{-1}$)	Variety	FFA ($mg\ kg^{-1}$)
Cabrales	33200	Gruyere	1500
Danablu	32600	Brie	1300
Roquefort	32400	Cheddar	1000
Parmesan	5000	Camembert	700
Provolone	2100	Mozzarella	360

Specific fatty acids are goaty

- 4-ethyl- 2octenoic acid
- 4-Ethyl octanoic acid (threshold 6ppb against 0.9 ppm for decanoic acid)
- 4-methyl octanoic acid (threshold 20 ppb against 3.4 ppm for the decanoic acid)

Free fatty acid changes during camembert cheese ripening

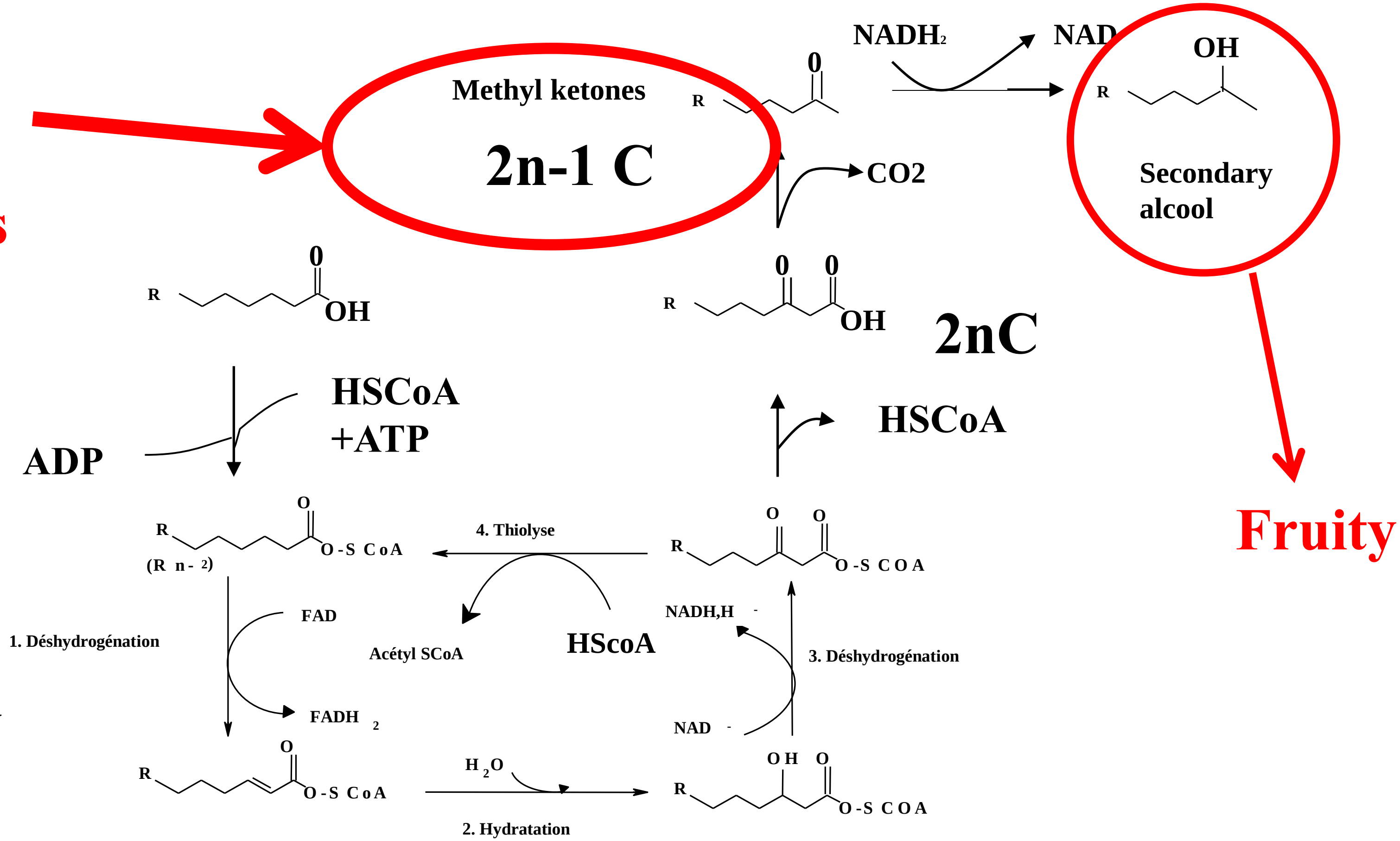


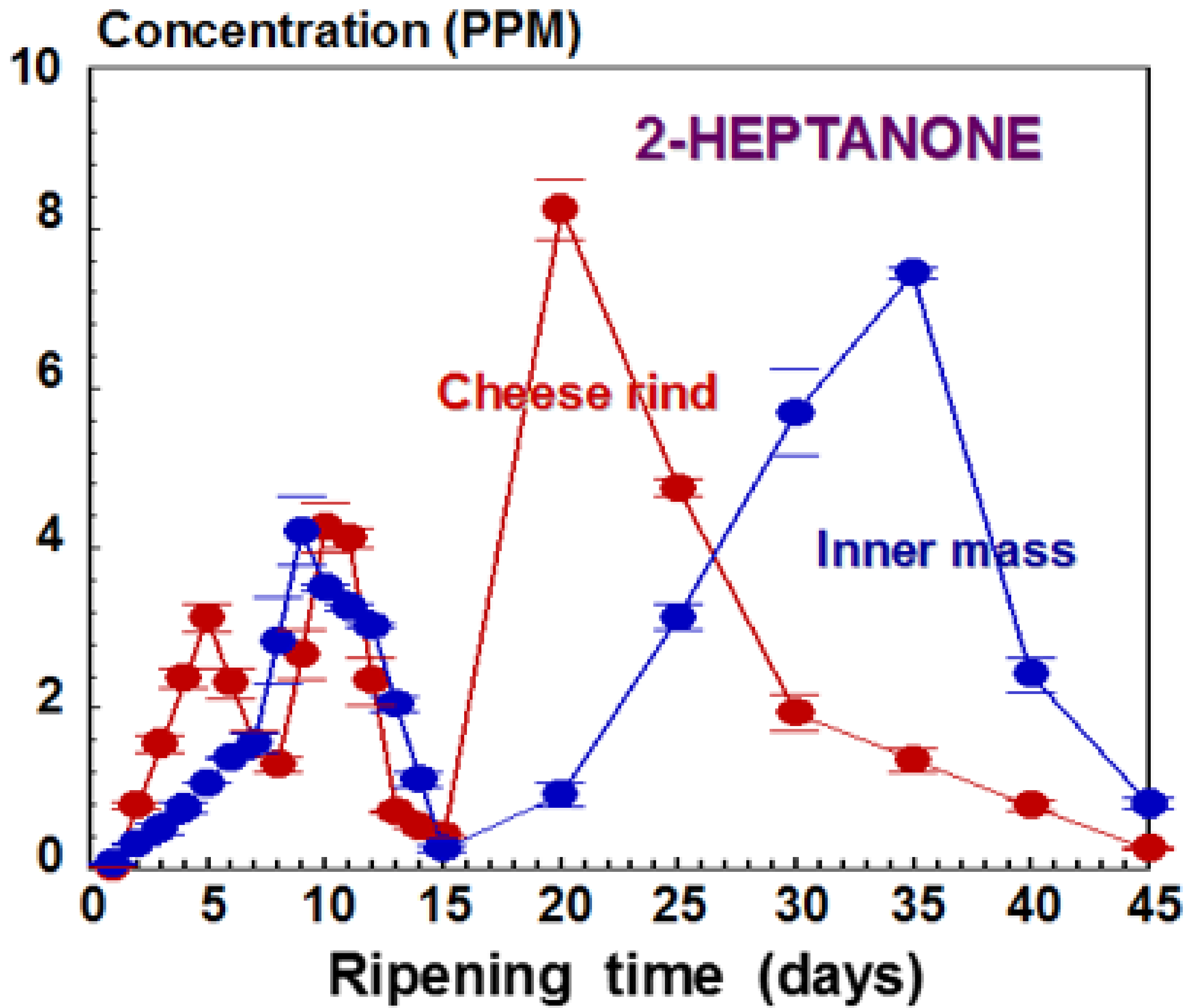
In soft cheeses volatil FFA increase global flavour intensity

BUT too many fatty acids gives soapy flavours

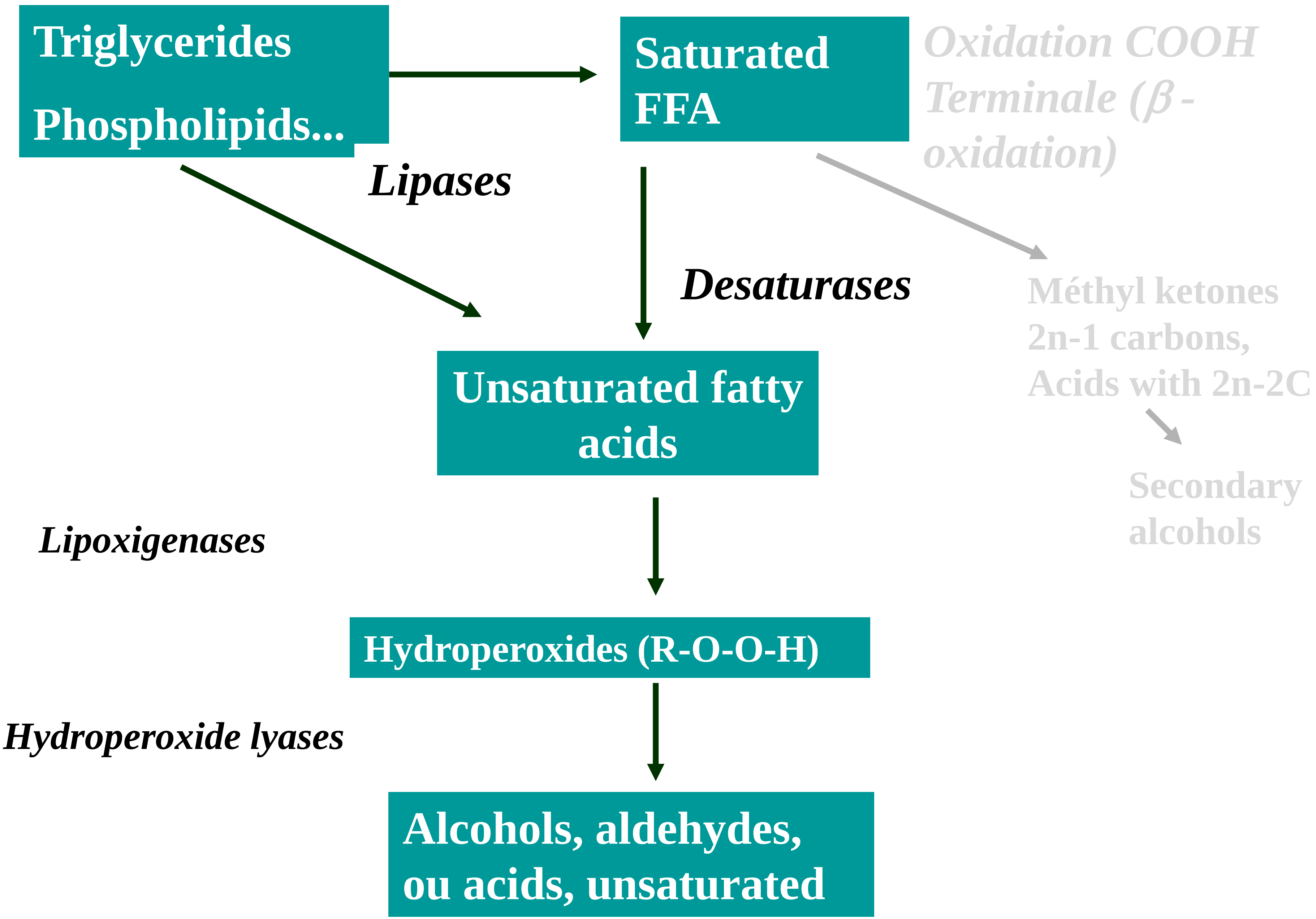
Beta- oxidation

Blue Cheese Flavours – in mould ripened cheese it is giving flavour intensity

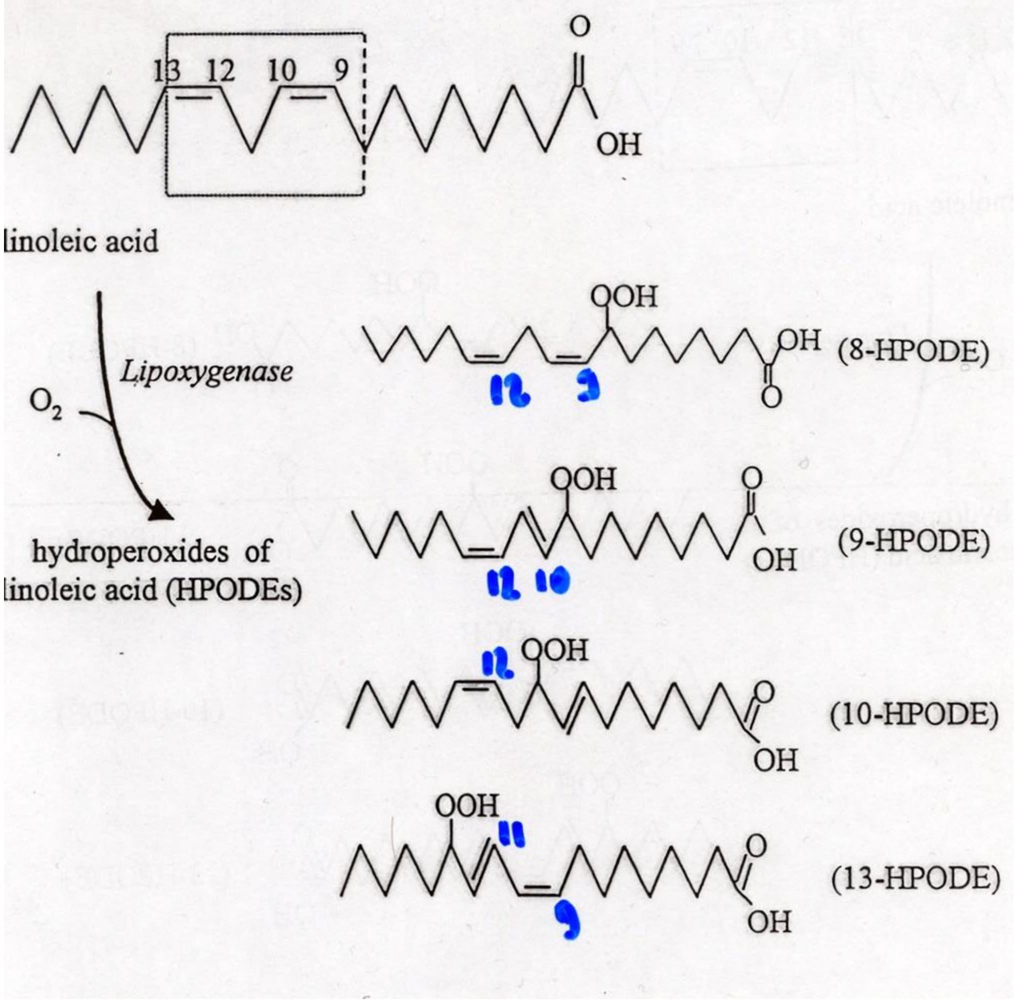



Concentration (PPM)
2-HEPTANONE
Cheese rind
Inner mass
10
8
6
4
2
0
0
5
10
15
20
25
30
35
40
45
Ripening time (days)

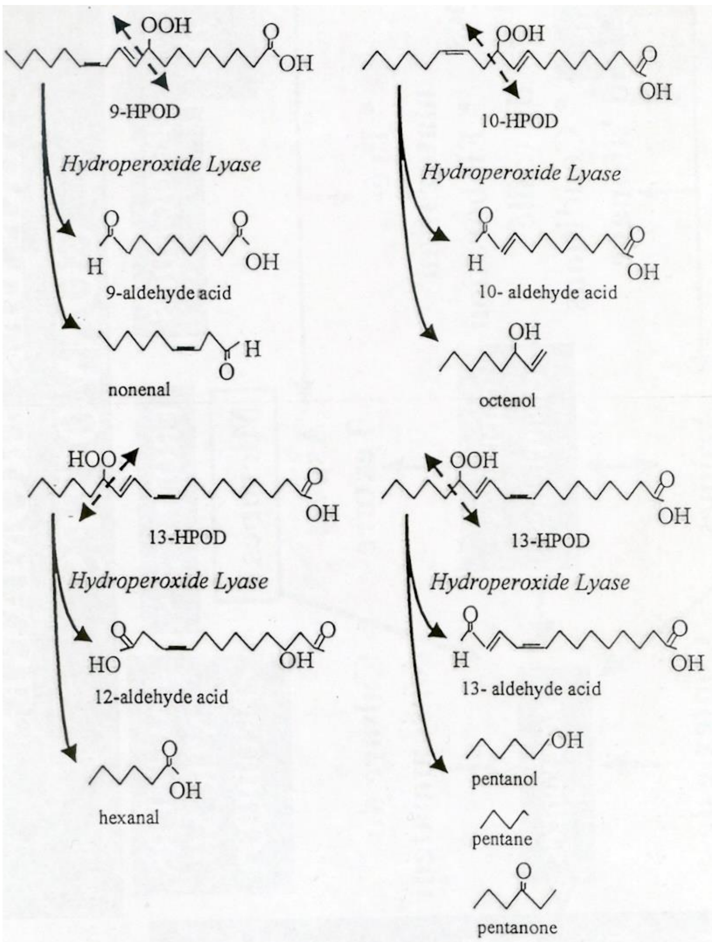
PLAN


Triglycerides
Phospholipids...
Saturated FFA
Oxidation COOH Terminale (β-oxidation)
Lipases
Desaturases
Méthyl ketones 2n-1 carbons, Acids with 2n-2C
Unsaturated fatty acids
Secondary alcohols
Lipoxigenases
Hydroperoxides (R-O-O-H)
Hydroperoxide lyases
Alcohols, aldehydes, ou acids, unsaturated

Oxydation of a pentadiene motive through a Lipoxigenase



Clivage of Hydroperoxy acids through an Hydroperoxide lyase



This pathway gives mushroom, metalic, geranium like, vegetal like flavours

Spontaneous oxydation (rare in cheese) but mainly activated by moulds (*Penicillium camemberti* mainly)

PLAN

Introduction

1. Texture

2. Malt and Fruity flavours

3. Cabbage and Garlic flavours

4. Goaty, Blue cheese to Soapy flavours

5. Mushroom flavours

6. Plastic

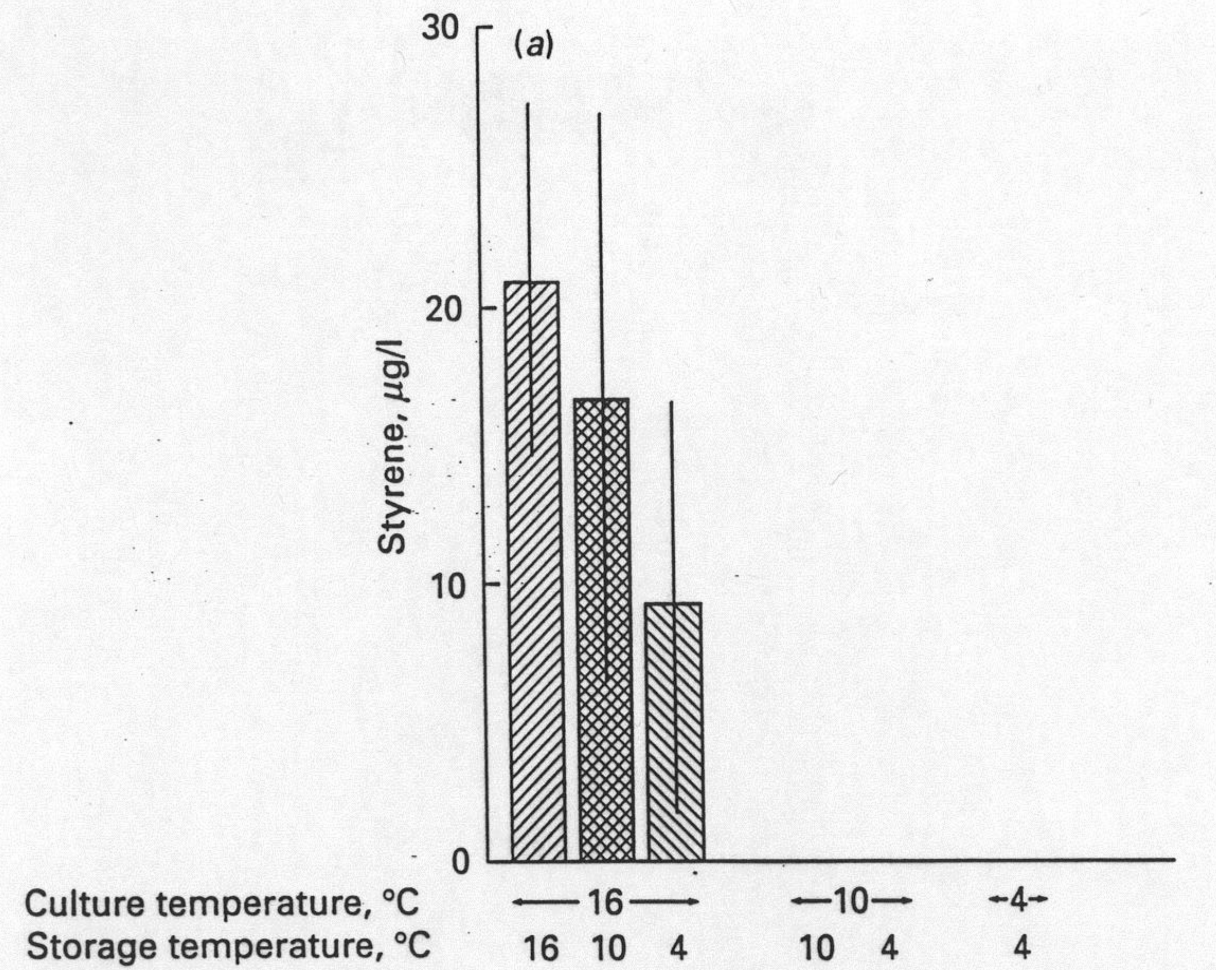
Conclusions

Effect of ripening temperature on the styrene production by *P. camemberti* on a model curd

www.agroparistech.fr

After 1week at the culture temperature

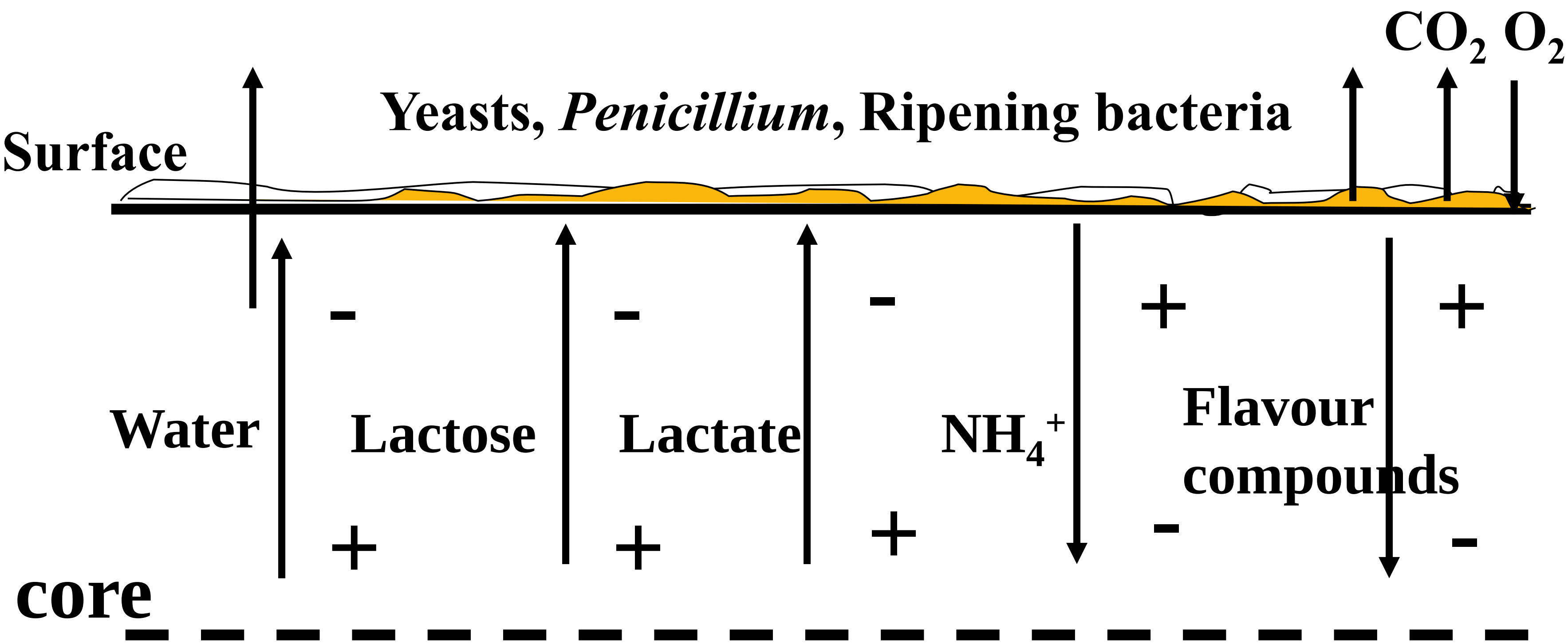
And 3 weeks at the storage temperature



AgroParisTech

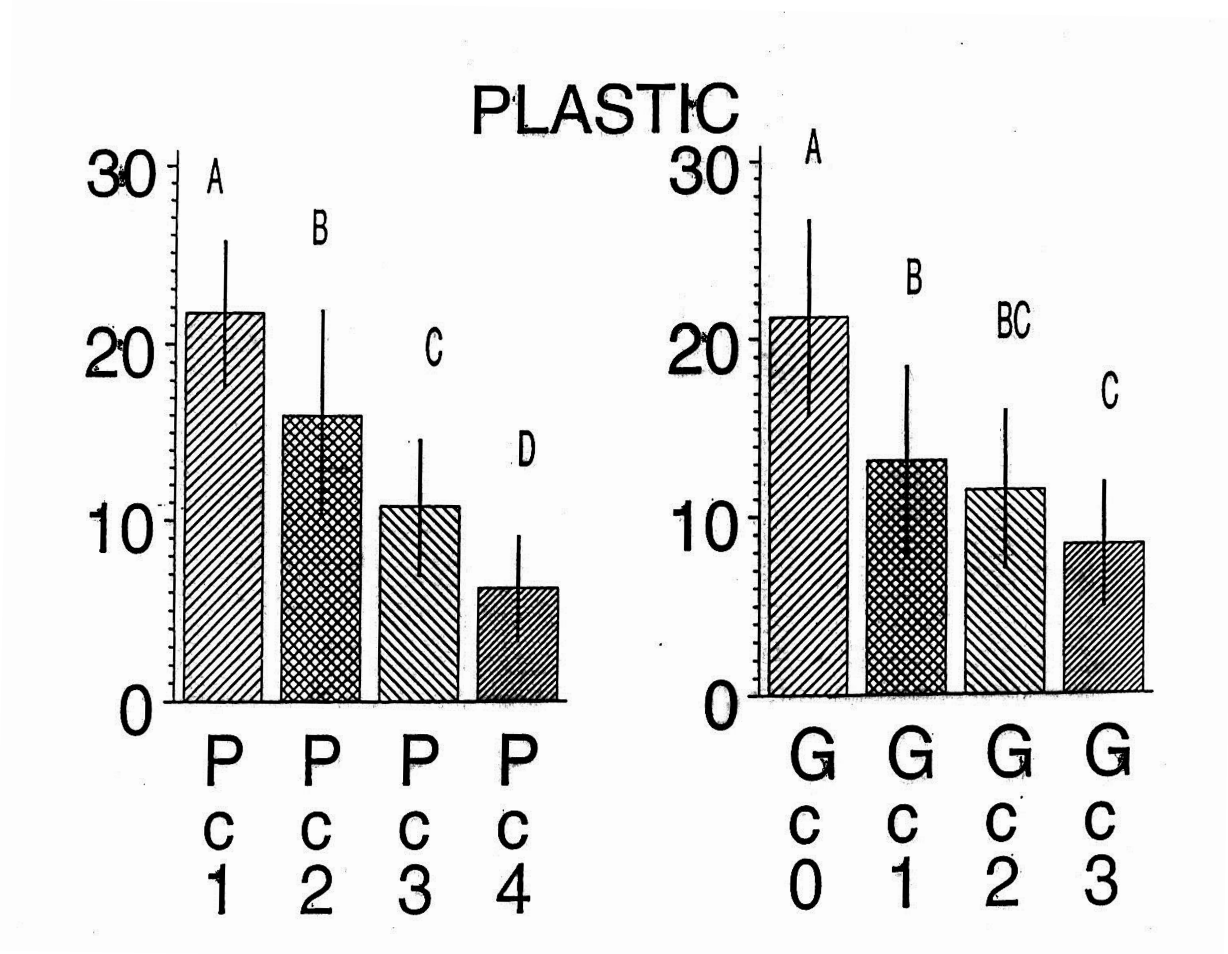
Mass transfer in soft cheese ripening

- Context : Important changes in curd, composition, structure, aspect, texture, colour and taste due to biological activity and transport phenomena.



Leclercq Perlat et al, 2004

Plastic flavour tested with a panel of 20 trained judges (camemberts made with 4 strains of *Penicillium*, with and without strains of *G. candidum*)



PLAN

Introduction

1. Texture

2. Malt and Fruity flavours

3. Cabbage and Garlic flavours

4. Goaty, Blue cheese to Soapy flavours

5. Mushroom flavours

6. Plastic

Conclusions

CONCLUSIONS

SURFACE

DESACIDIFICATION

Uptake :
- residual sugars, citrate and lactate
- proteolysis, lipolysis
- flavours (alcohols, aldehydes, esters)

pH=5.8

MATURATION

Proteins → amino-acids

↓

Flavours (sulfurs, thioesters, phénols)

Triglycerides → FFA

↓

Flavours (methyl ketones , alcohols, sulfur compounds, unsaturated carbonyles)

INSIDE

Time

CONCLUSIONS

- **Fungi and Bacteria are able to produce a large diversity of flavour compounds which will determine the cheese flavour notes perceived**

- **Understanding the origin of the flavour notes**
  - **Understanding may help to manage flavor defects**
  - **May help to choose the starters**

- **The parameters used in the technology (management of the relative humidity, temperature, ventilation) will not only change the growth of the different species of the microbial ecosystem but also the physiology of some of the micro-organisms**