A TRADITION OF INDEPENDENT THINKING

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Mastering cheese texture and flavour during ripening

PLH McSweeney
University College Cork, Ireland

University College Cork (1845)

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

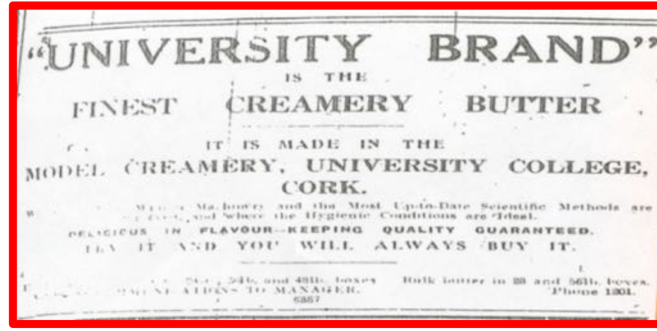
Food in…

BEES/ERI
History, Geography
Food Business and Development (CUBS)
Management and Marketing (CUBS)
APC
Microbiology
Process and Chemical Engineering
Medicine

Food: *the* strategic priority for UCC

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

3—MR. W. T. COSGRAVE, PRESIDENT OF THE EXECUTIVE COUNCIL, LAYING THE FOUNDATION STONE OF THE DAIRY SCIENCE BUILDING, 20th JULY 1928



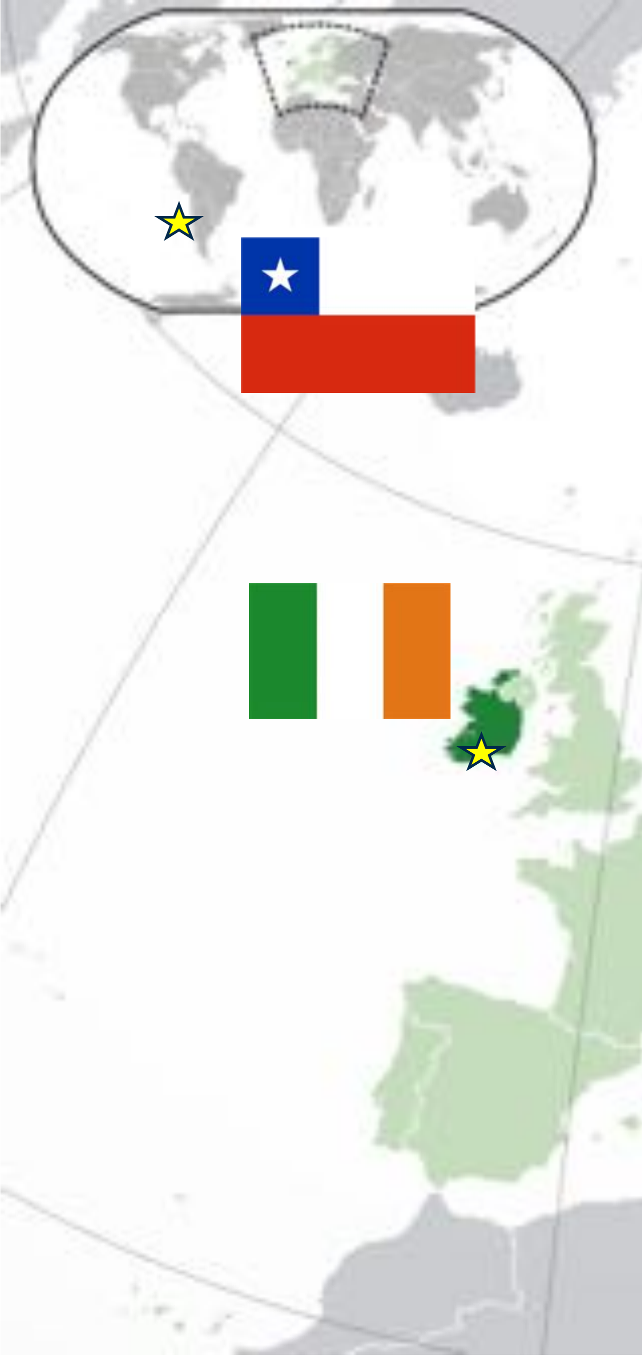
DEGREE DAY, OCTOBER 30th, 1928.

Number 32 of 1926.

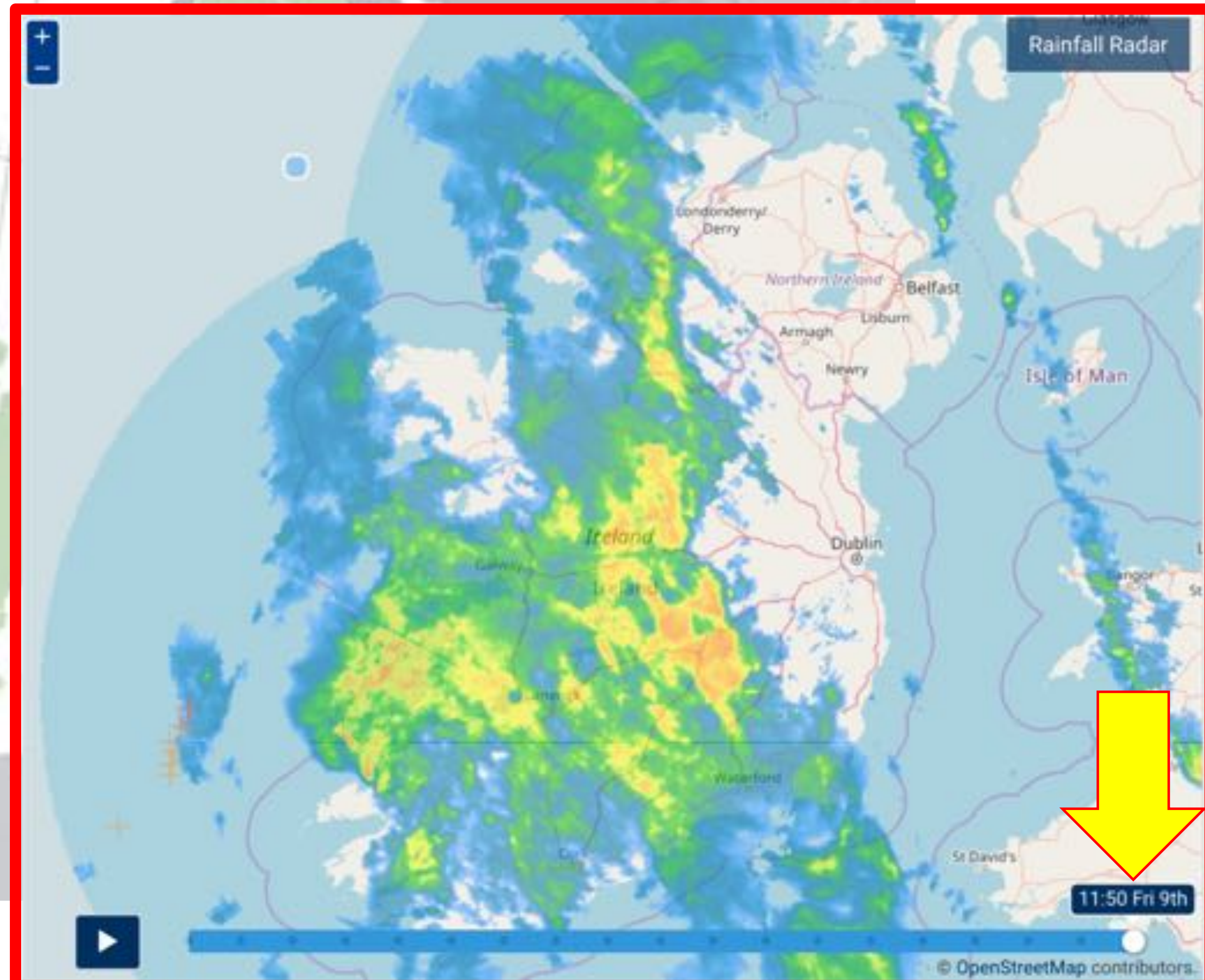
UNIVERSITY EDUCATION (AGRICULTURE AND DAIRY SCIENCE) ACT, 1926.

AN ACT TO TRANSFER THE COLLEGE OF SCIENCE AND THE ALBERT AGRICULTURAL COLLEGE TO UNIVERSITY COLLEGE, DUBLIN, TO MAKE FINANCIAL AND OTHER PROVISION FOR THE ESTABLISHMENT AND MAINTENANCE OF A FACULTY OF AGRICULTURE IN UNIVERSITY COLLEGE, DUBLIN, AND THE PERFORMANCE BY THAT COLLEGE OF THE FUNCTIONS HERETOFORE FULFILLED BY THE COLLEGE OF SCIENCE AND THE ALBERT AGRICULTURAL COLLEGE RESPECTIVELY, TO MAKE FINANCIAL AND OTHER PROVISION FOR THE ESTABLISHMENT OF A FACULTY OF DAIRY SCIENCE IN UNIVERSITY COLLEGE, CORK, TO MAKE BETTER PROVISION FOR THE ACCOMMODATION OF THE NATIONAL UNIVERSITY OF IRELAND, AND FOR THOSE AND OTHER PURPOSES TO AMEND THE IRISH UNIVERSITIES ACT, 1908. [*17th July*, 1926.]

BE IT ENACTED BY THE OIREACHTAS OF SAORSTÁT EIREANN AS FOLLOWS:—



Ireland: the dairy island
Irlanda: la isla lechera



The dairy industry in Ireland

KERRY Market capitalisation US$18.5 bn

Irish owned multinationals

1.4 m dairy cows. Approx 16,500 dairy farmers in Ireland. Average herd size 80 cows (and growing). Average cow produces 5,000 litres milk per annum. Average farm output is *ca*. 11,000 L/Ha

7,300 m litres of milk
But we consume <10%.
Export 80% of production.
Growing!

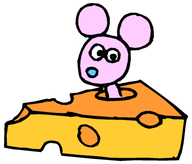
205,000 tonnes of cheese (mainly Cheddar ☹)

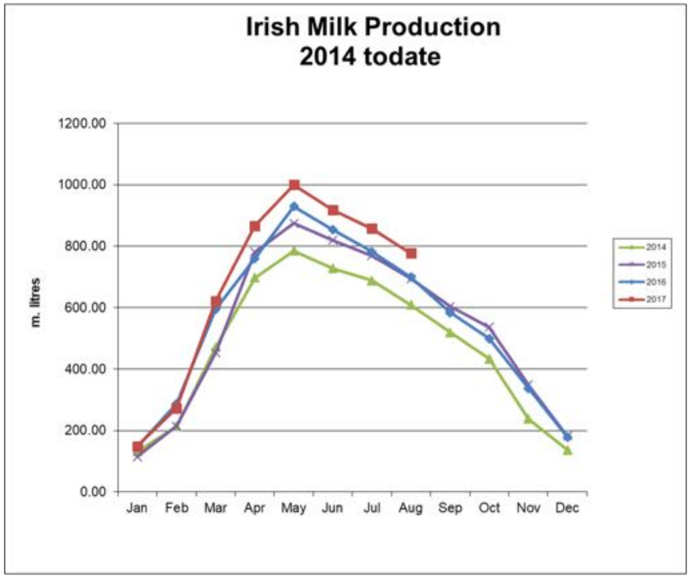
Ingredients…

glanbia Dairygold CARBERY TIPPERARY

Make 11% of the world's trade in infant formula

Nestlé DANONE





Product mix determined by seasonality of milk supply

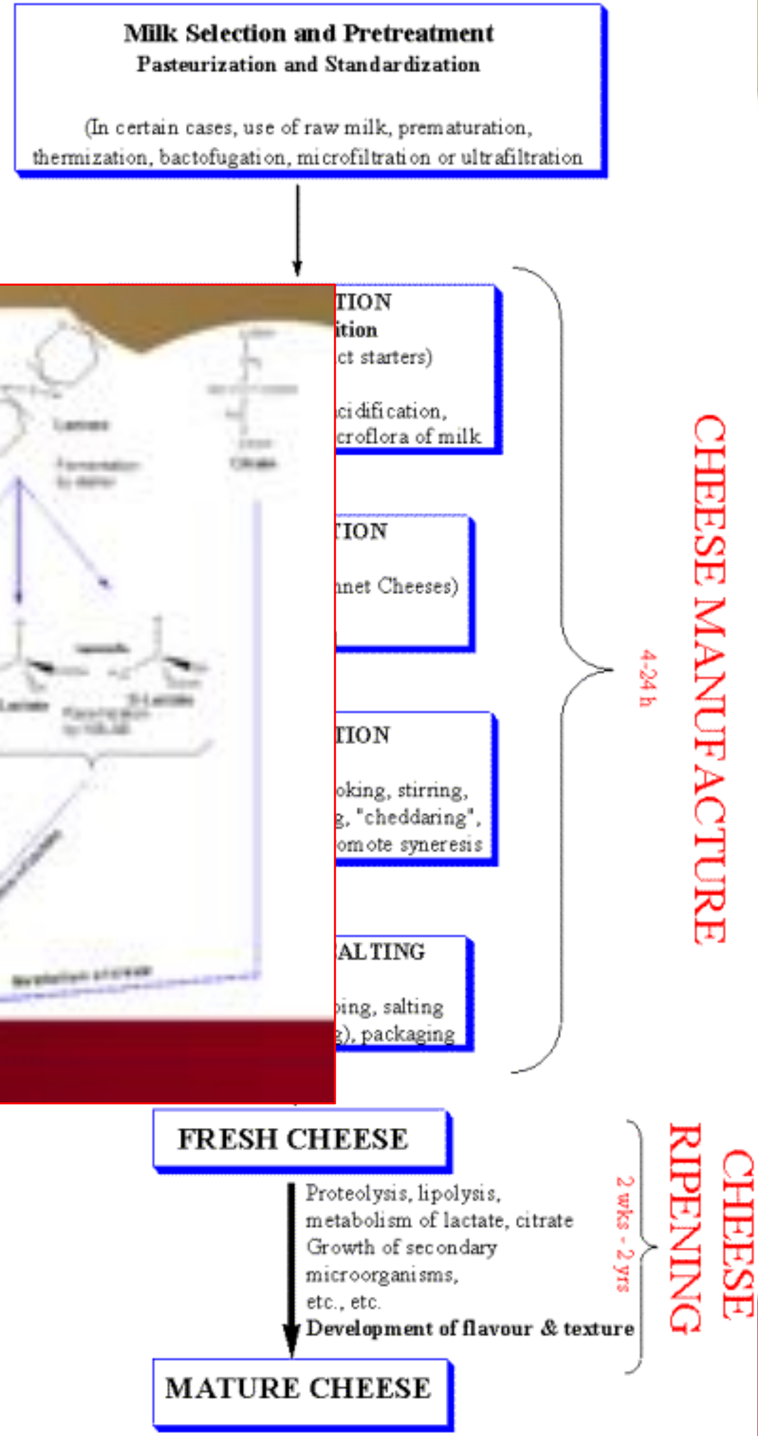
Outline…

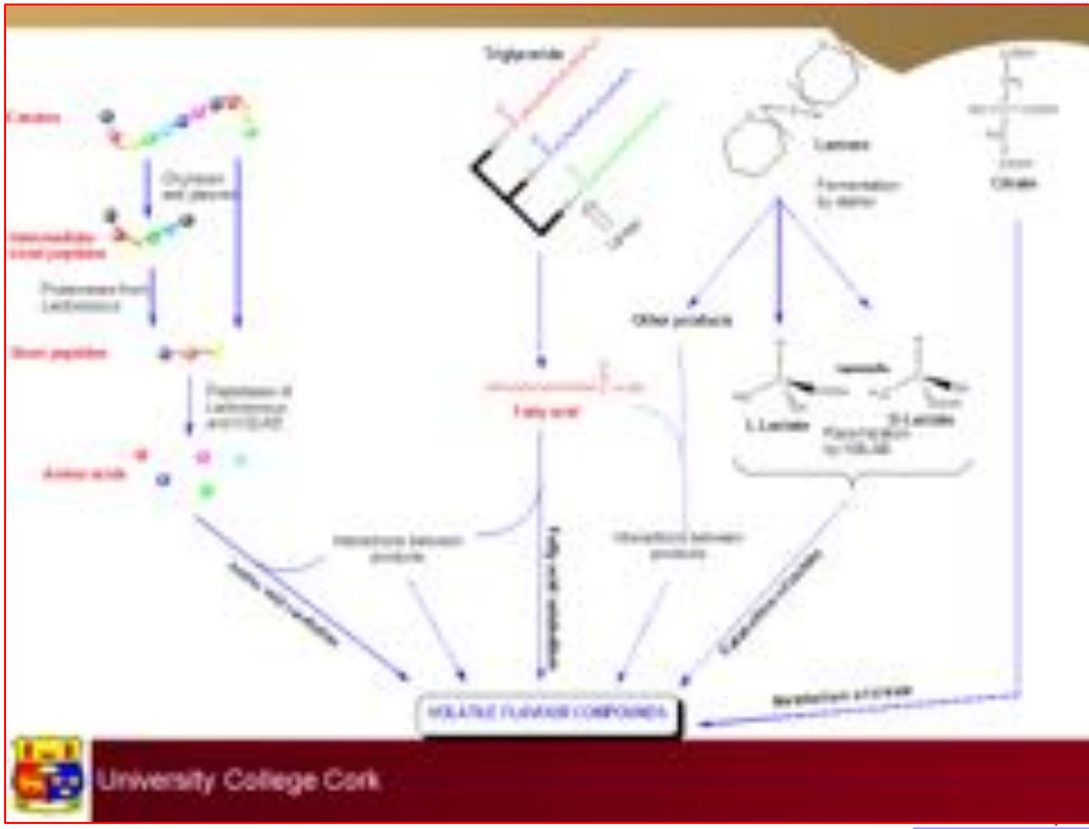
- Overview of cheese ripening, coagulants
- Calcium equilibrium and cheese texture
- Optical properties of low-fat cheese
- Redox potential and cheese

Outline…

- Overview of cheese ripening, coagulants
- Calcium equilibrium and cheese texture
- Optical properties of low-fat cheese
- Redox potential and cheese

Stages of manufacture

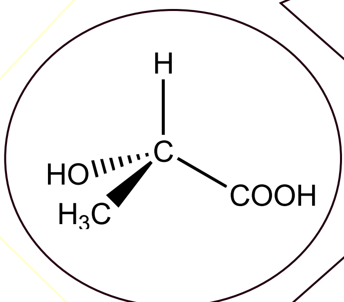




Metabolism of lactate…

Butyrate, CO_2, H_2
***Clostridium* sp.**

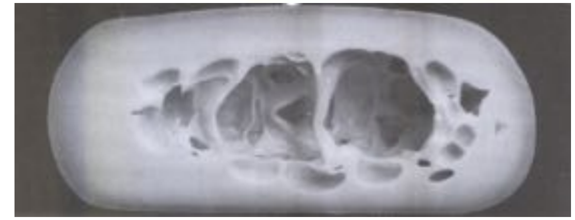
Ca lactate crystals

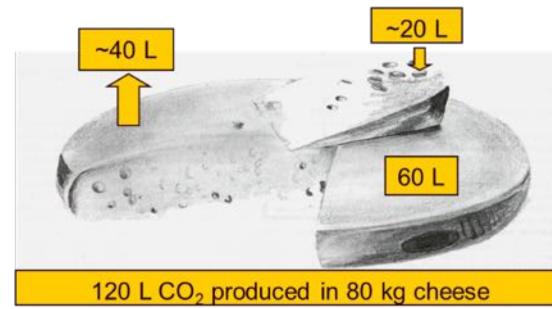


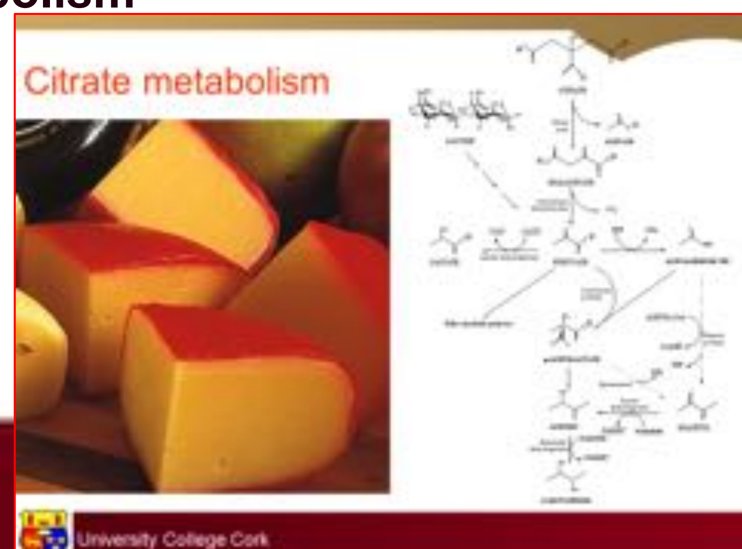
Propionate, Acetate, CO_2
Propionibacterium freudenreichii

Oxidative metabolism

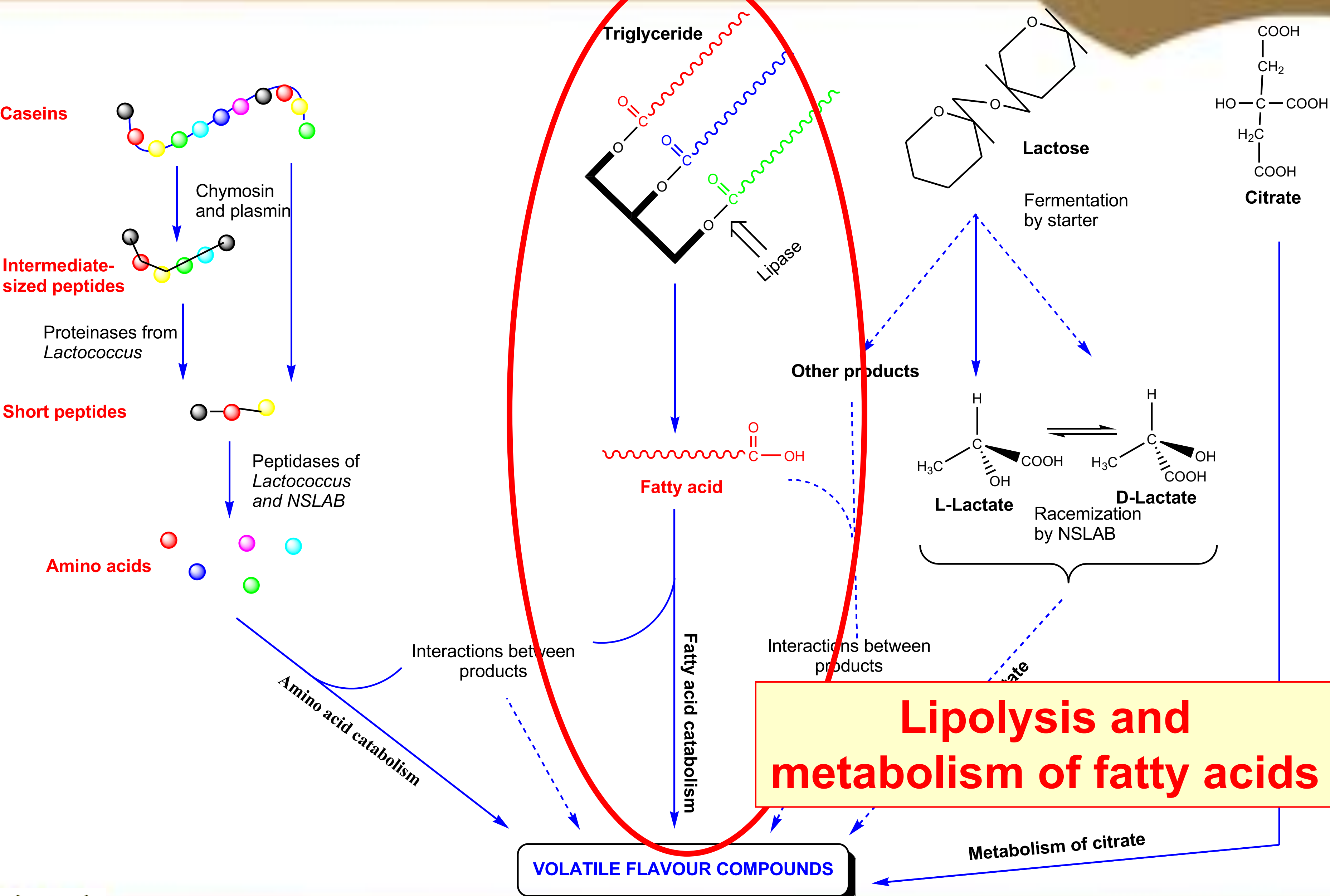
Oxidation to formate, ethanol and acetate
LAB?

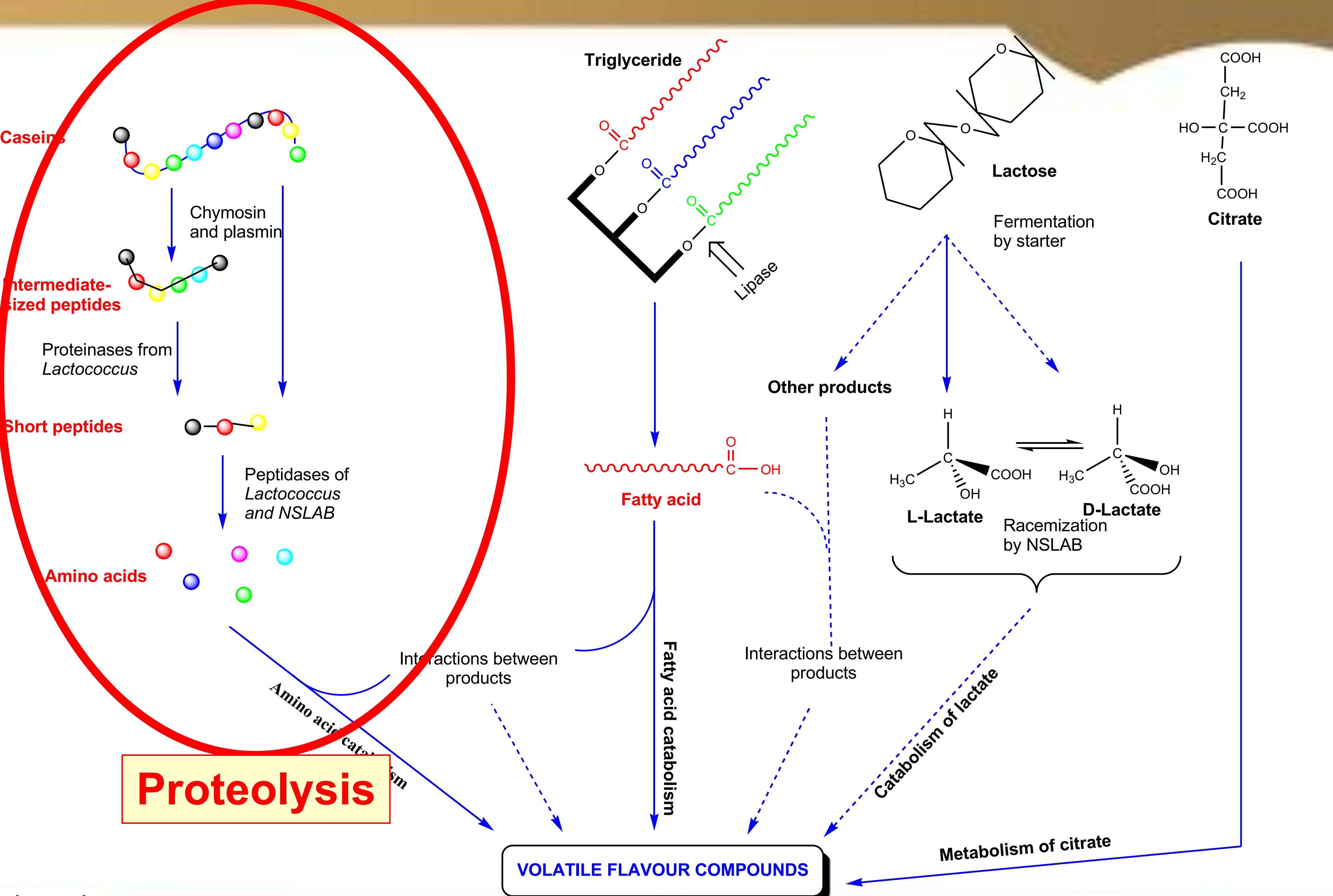


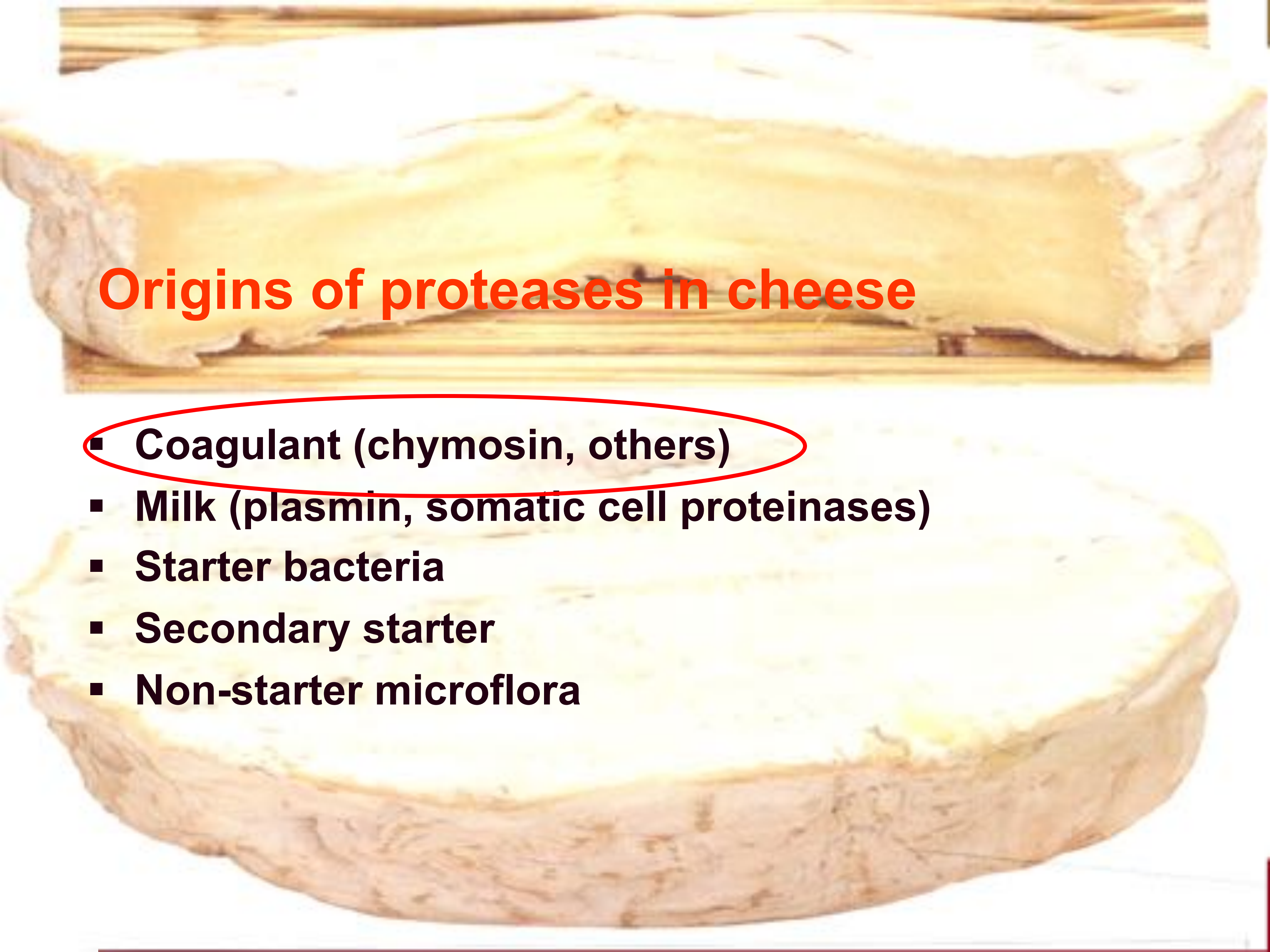




Lipolysis and metabolism of fatty acids



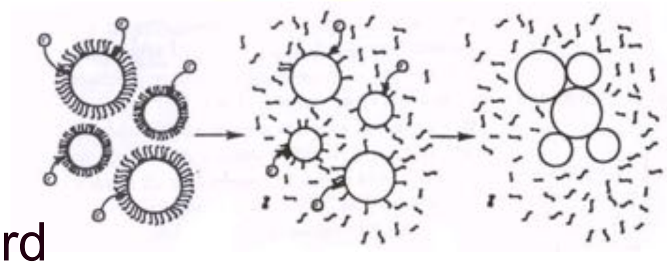

Caseins
Chymosin
and plasmin
Intermediate-
sized peptides
Proteinases from
Lactococcus
Short peptides
Peptidases of
Lactococcus
and NSLAB
Amino acids
Triglyceride
Lipase
Fatty acid
Lactose
Fermentation
by starter
Citrate
Other products
L-Lactate
D-Lactate
Racemization
by NSLAB
Interactions between
products
Interactions between
products
Amino acid catabolism
Fatty acid catabolism
Catabolism of lactate
Metabolism of citrate
VOLATILE FLAVOUR COMPOUNDS
Proteolysis



Origins of proteases in cheese

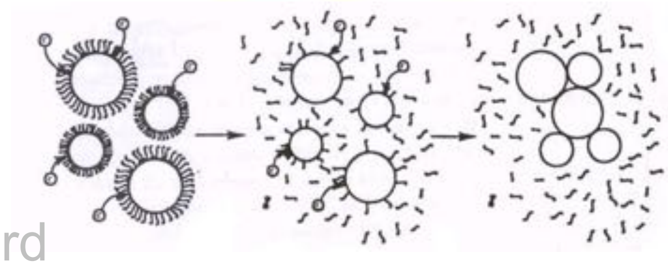
- Coagulant (chymosin, others)
- Milk (plasmin, somatic cell proteinases)
- Starter bacteria
- Secondary starter
- Non-starter microflora

Coagulant



- Rennet coagulation of milk…
- Proportion of added rennet *activity* retained in curd
- Little hydrolysis of β-casein in cheese due to hydrophobic interactions of hydrophobic C-terminal region
- Principally responsible for primary hydrolysis of α_{s1}-casein

Coagulant



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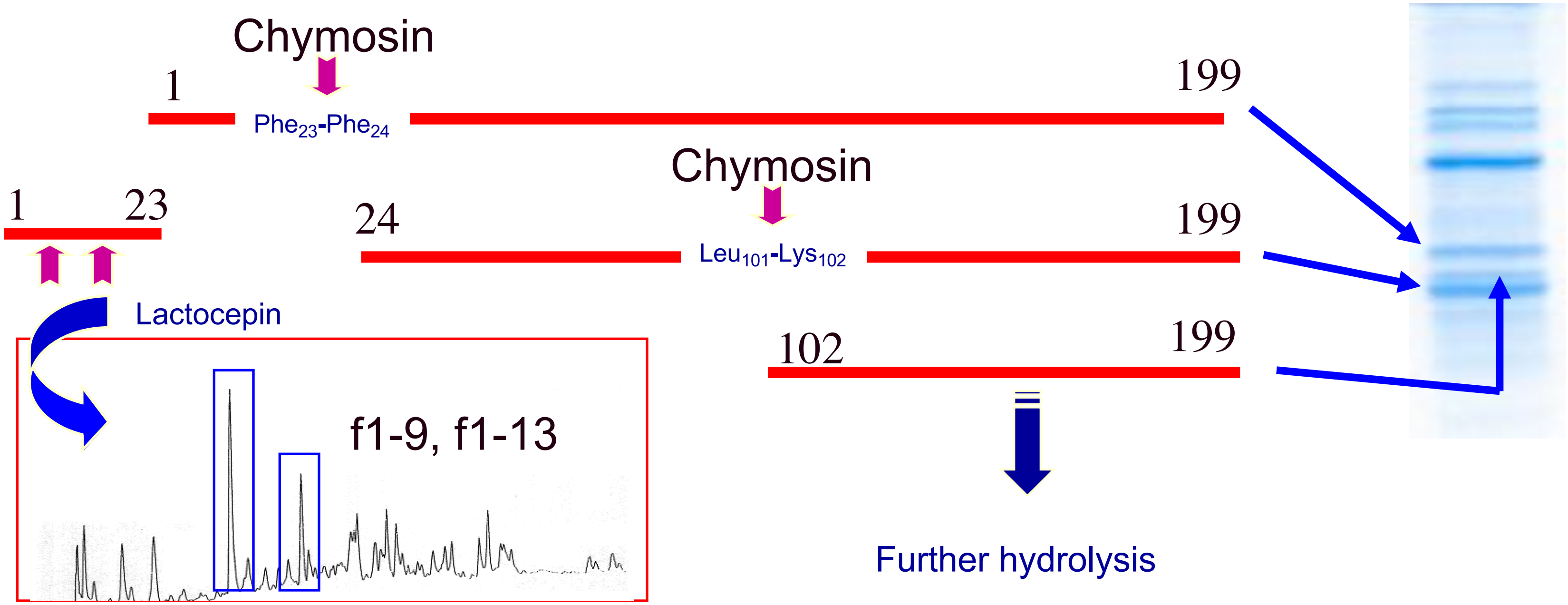
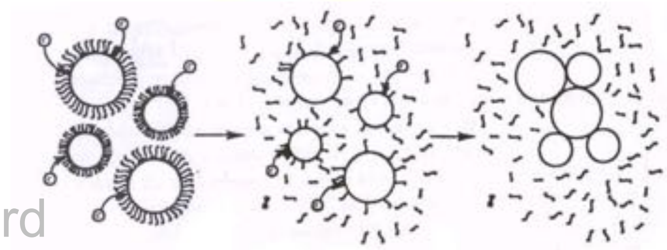
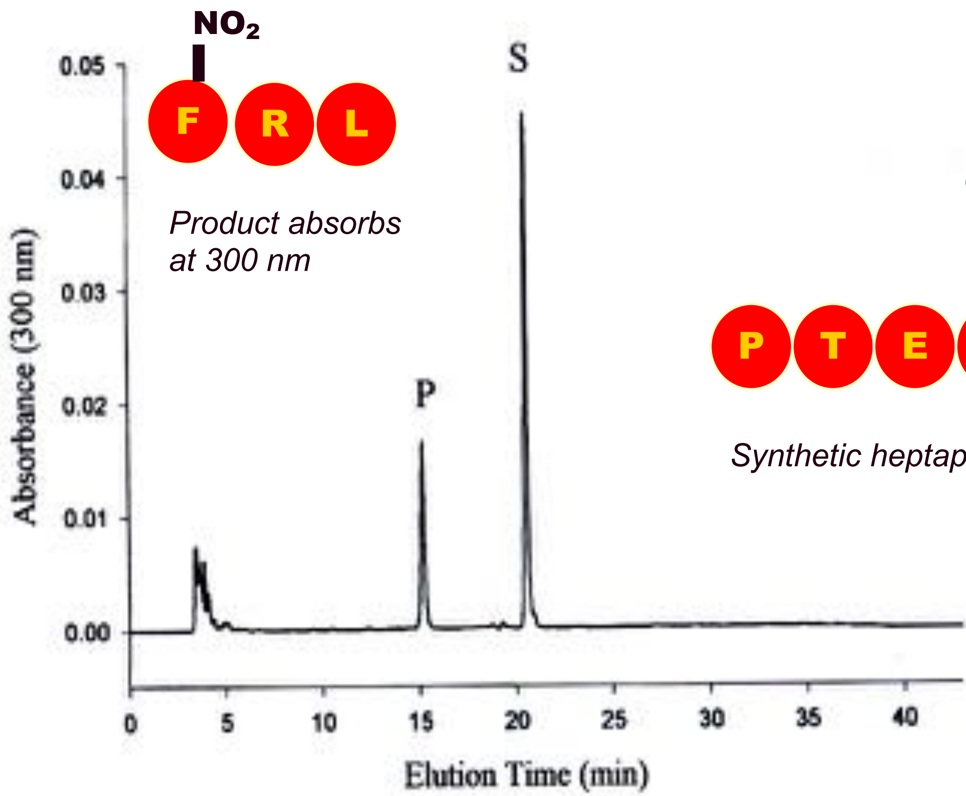
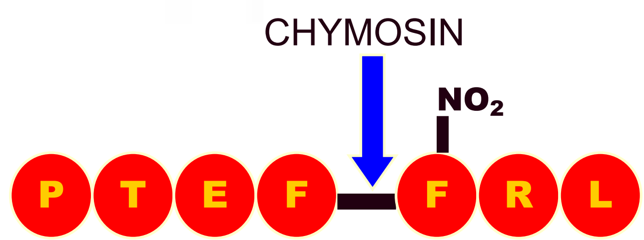


Coagulant



- Rennet coagulation of milk…
- Proportion of added rennet *activity* retained in curd
- Little hydrolysis of β-casein in cheese due to hydrophobic interactions of hydrophobic C-terminal region
- Principally responsible for primary hydrolysis of α_{s1}-casein
- Chymosin assay…





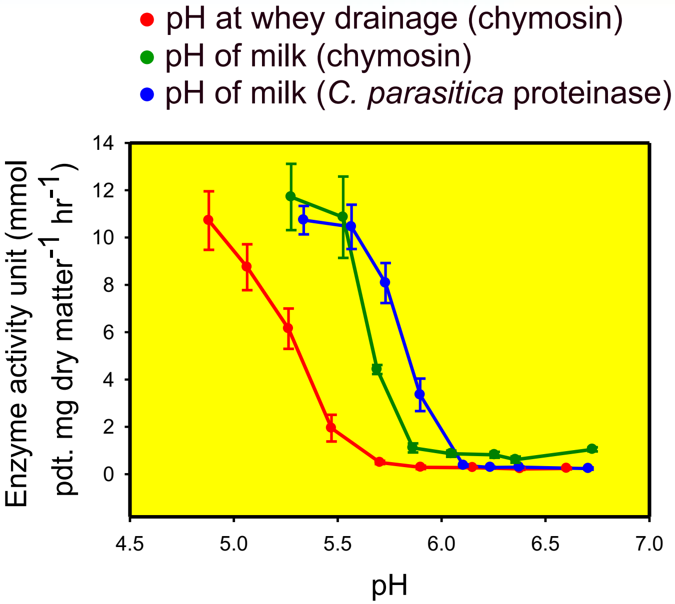
Synthetic heptapeptide substrate

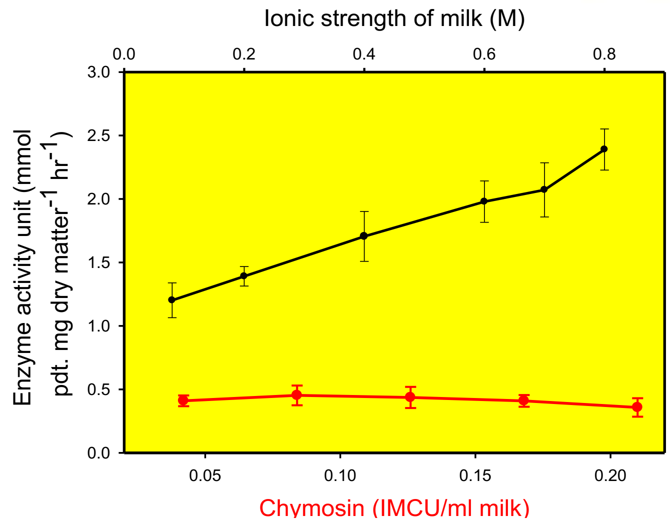

ELSEVIER

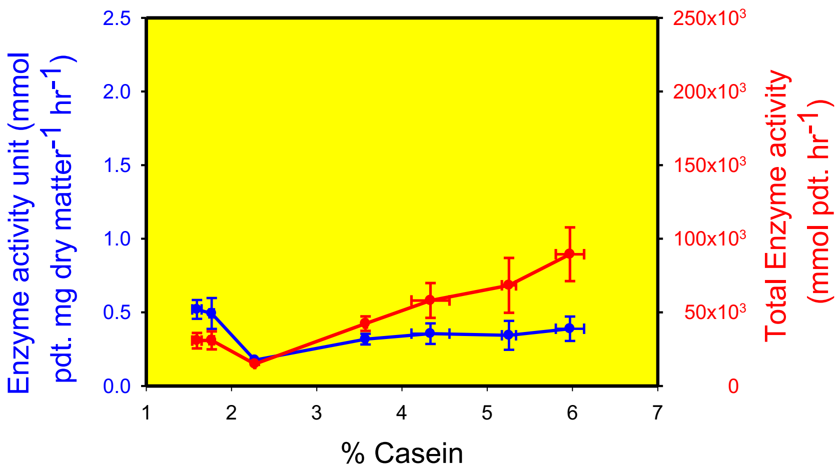
INTERNATIONAL DAIRY JOURNAL

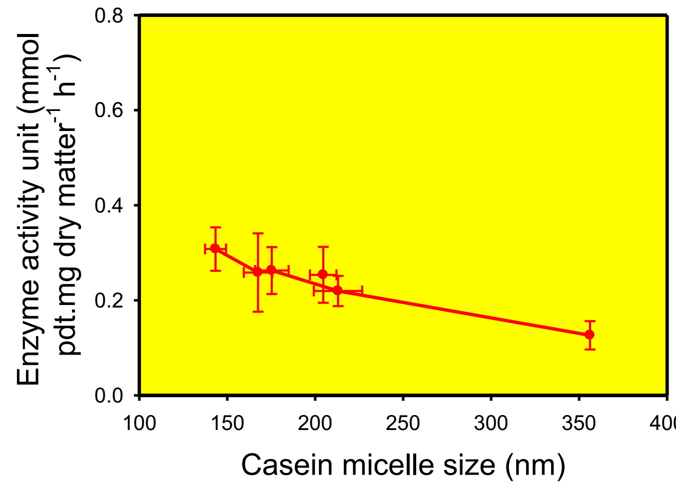
Novel assay for the determination of residual coagulant activity in cheese

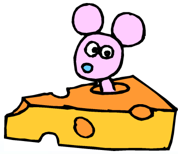
M.J. Hurley, B.M. O'Driscoll, A.L. Kelly*, P.L.H. McSweeney











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JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY

J. Agric. Food Chem. 2007, 55, 9219–9225 9219

Factors Affecting the Retention of Rennet in Cheese Curd

Nidhi Bansal, Patrick F. Fox, and Paul L. H. McSweeney*

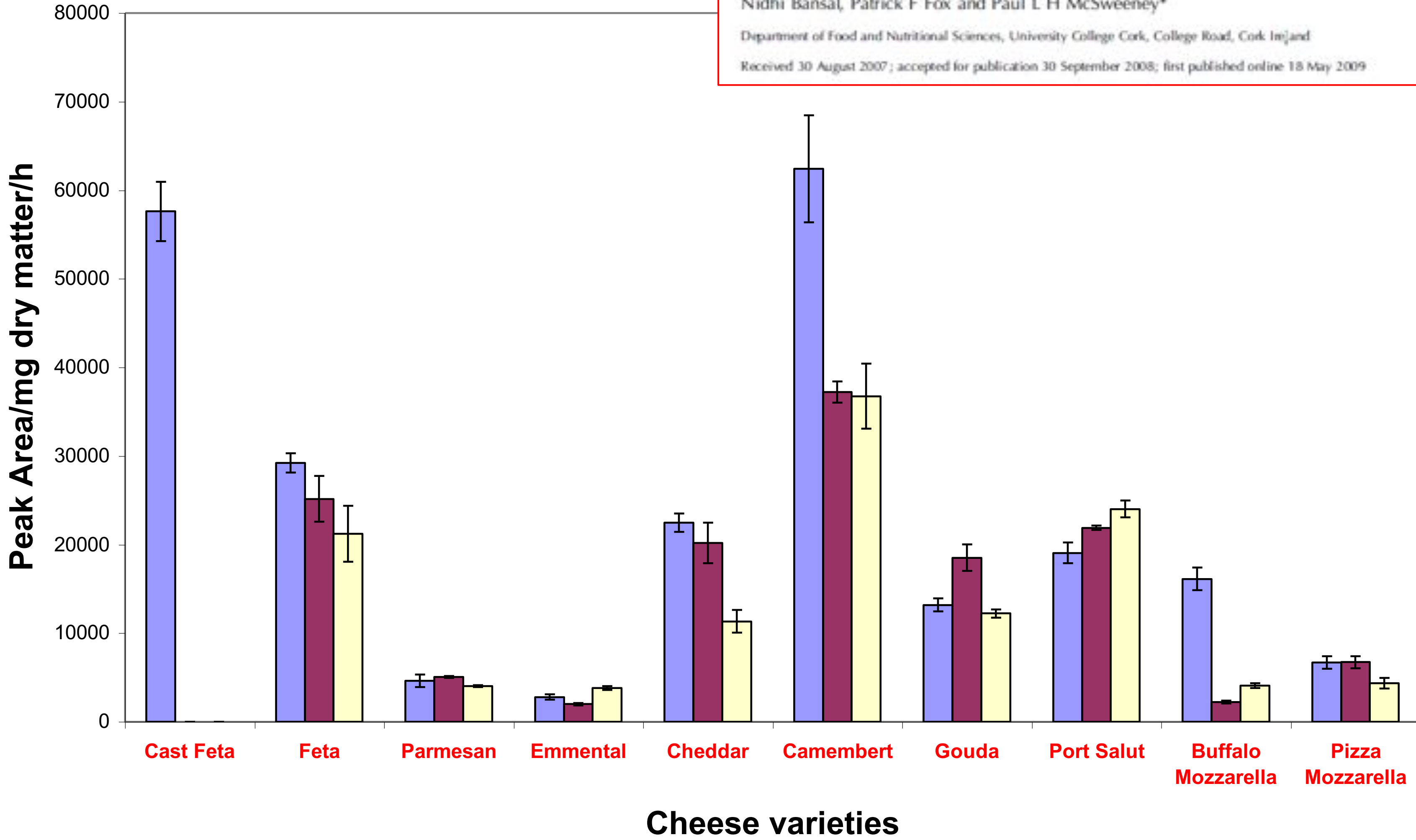
Journal of Dairy Research (2009) **76** 290–293. © *Proprietors of Journal of Dairy Research 2009*
doi:10.1017/S0022029909004075 *Printed in the United Kingdom* 290

Comparison of the level of residual coagulant activity in different cheese varieties

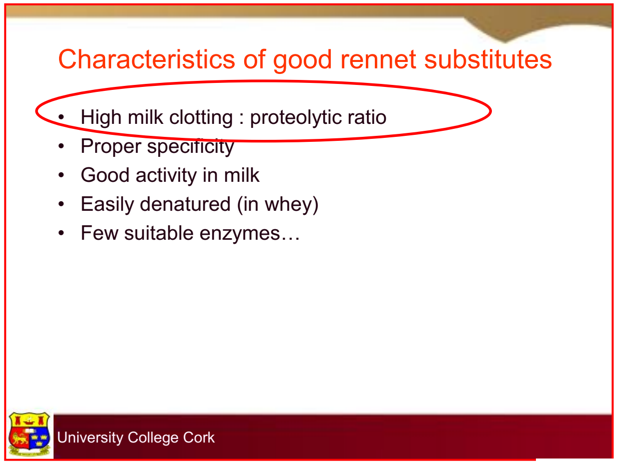
Nidhi Bansal, Patrick F Fox and Paul L H McSweeney*

Department of Food and Nutritional Sciences, University College Cork, College Road, Cork Ireland

Received 30 August 2007; accepted for publication 30 September 2008; first published online 18 May 2009



A interesting coagulant…


Characteristics of good rennet substitutes

- High milk clotting : proteolytic ratio
- Proper specificity
- Good activity in milk
- Easily denatured (in whey)
- Few suitable enzymes…

University College Cork

- No significant differences in composition and pH; suggestion of increased yield
- Primary proteolysis was significantly lower in camel chymosin cheeses large quantitative differences between the peptide profiles of cheeses; however, the levels of amino acids were similar
- Flavour differences
- Camel chymosin can be used successfully to make Cheddar cheese with lower levels of proteolysis but with good flavour.

Camel chymosin

CHY-MAX^{TM} M

CHR HANSEN


Contents lists available at ScienceDirect

International Dairy Journal

journal homepage: www.elsevier.com/locate/idairyj

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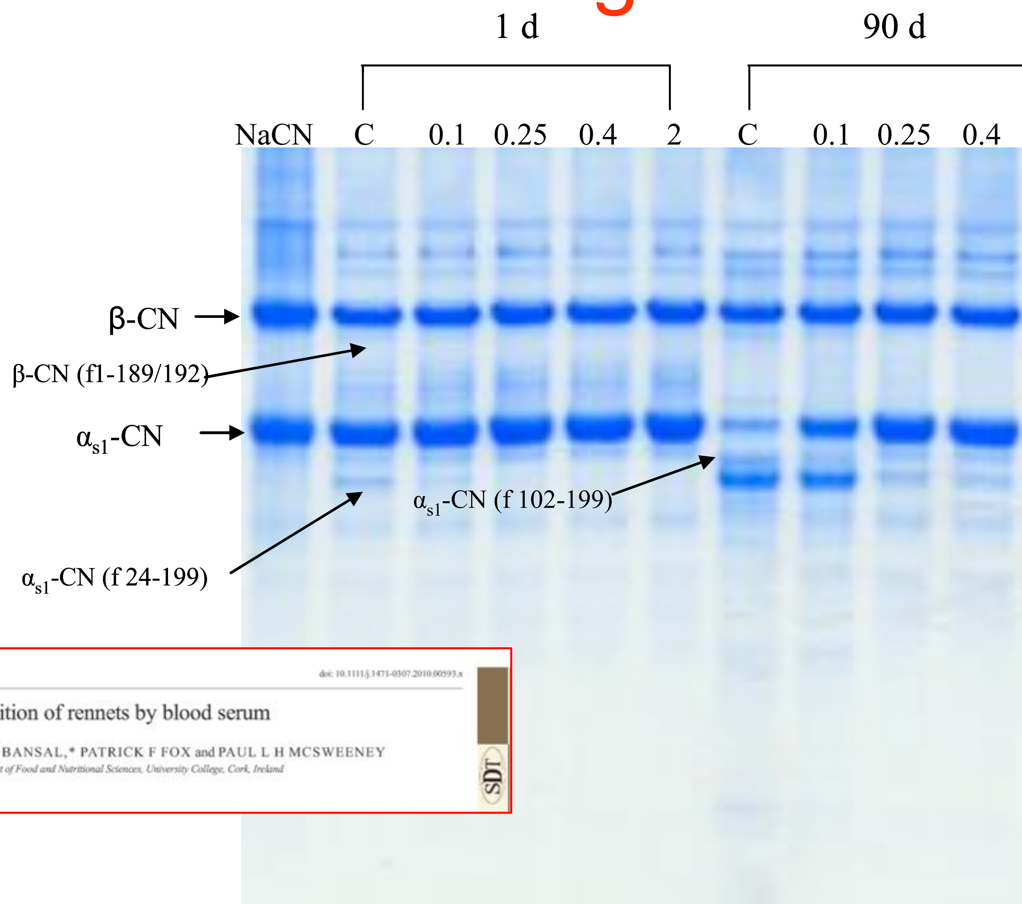
Suitability of recombinant camel (*Camelus dromedarius*) chymosin as a coagulant for Cheddar cheese

N. Bansal[a], M.A. Drake[b], P. Piraino[c], M.L. Broe[d], M. Harboe[d], P.F. Fox[a], P.L.H. McSweeney[a,*]

Inhibition of coagulant

Bansal *et al.*



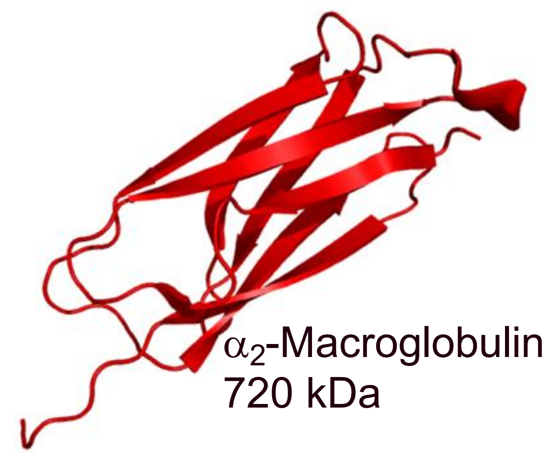
ORIGINAL RESEARCH

doi: 10.1111/j.1471-0307.2010.00593.x

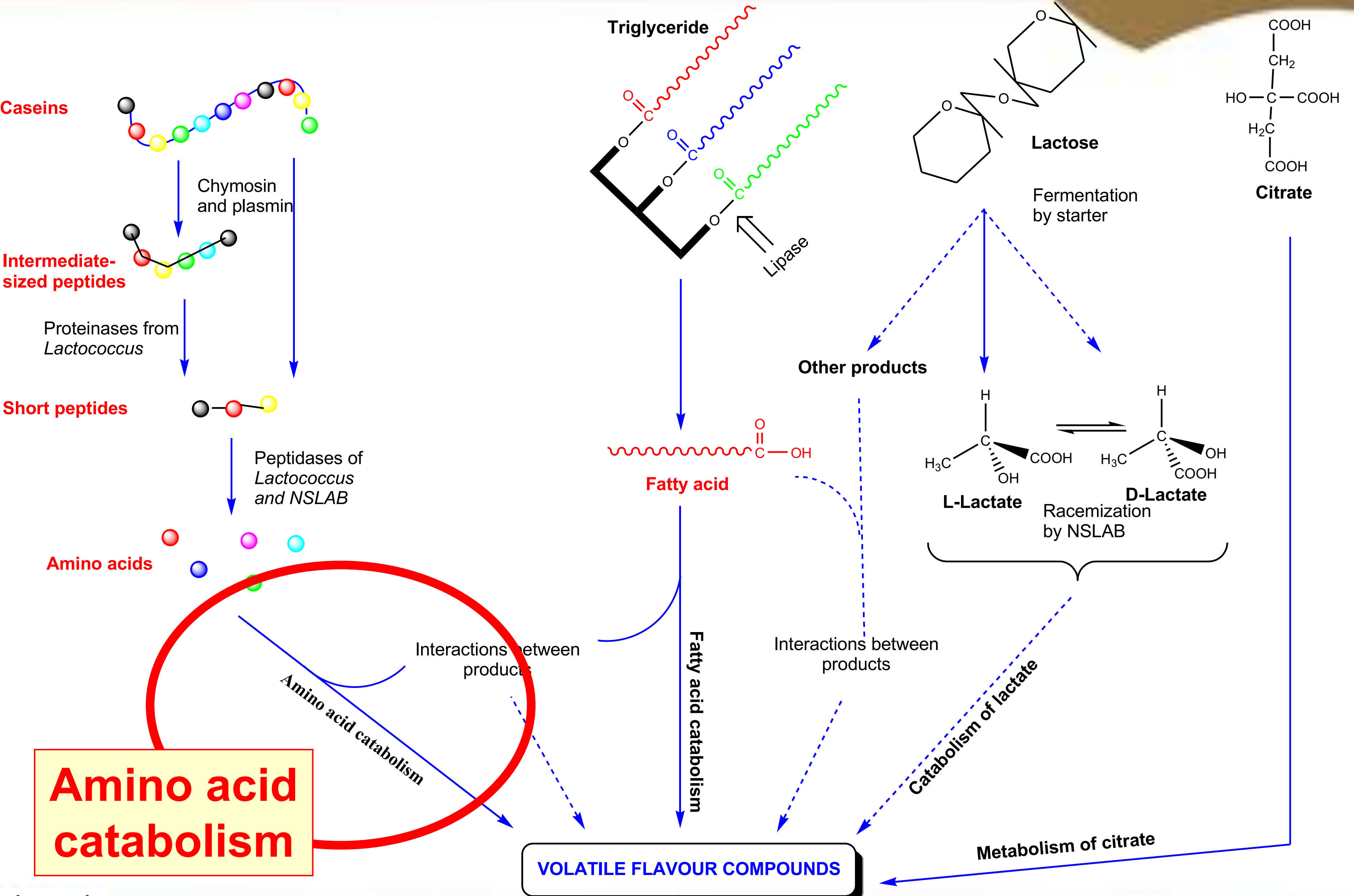
Inhibition of rennets by blood serum

NIDHI BANSAL,* PATRICK F FOX and PAUL L H MCSWEENEY
Department of Food and Nutritional Sciences, University College, Cork, Ireland

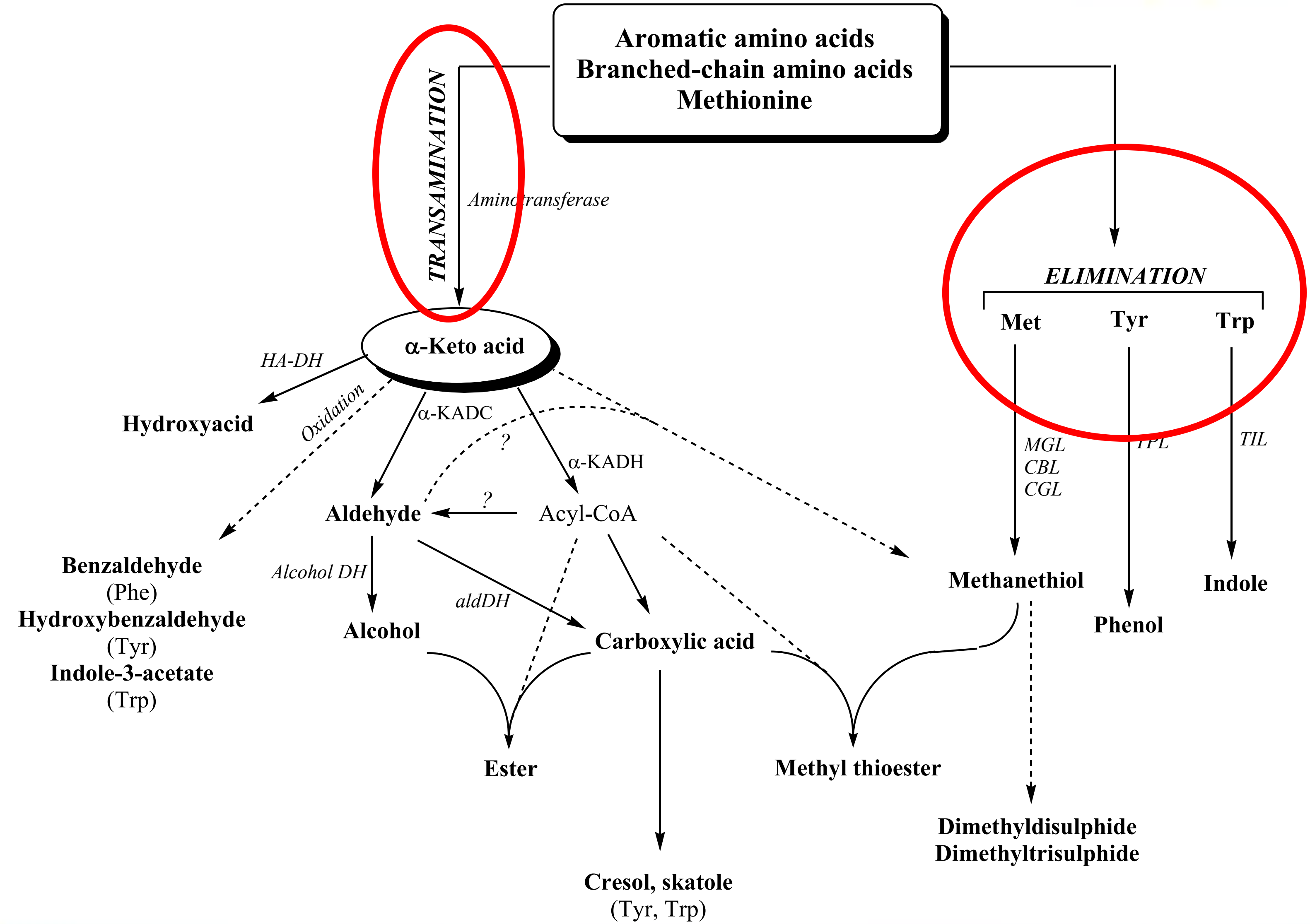
SDT



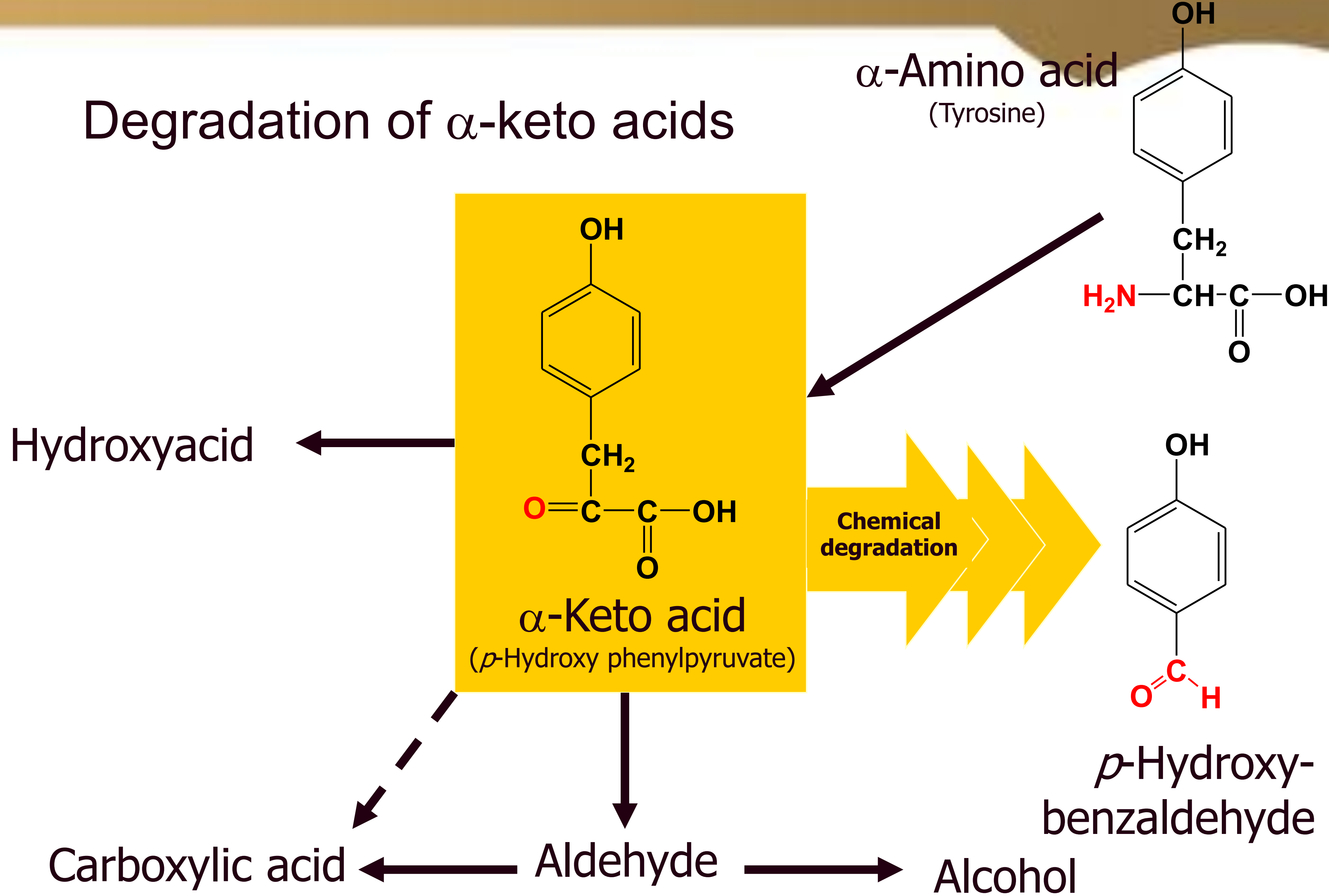
Urea-polyacrylamide gel electrophoretograms (12.5% T, 4% C, pH 8.9) of bovine sodium caseinate (CN) and the Cheddar cheeses manufactured from milk containing 0 (C), 0.1, 0.25, 0.4 or 2% equine blood serum after 1, 90 and 180 d of ripening.


Caseins
Chymosin
and plasmin
Intermediate-
sized peptides
Proteinases from
Lactococcus
Short peptides
Peptidases of
Lactococcus
and NSLAB
Amino acids
Amino acid catabolism
Interactions between
products
Triglyceride
Lipase
Fatty acid
OH
Fatty acid catabolism
Lactose
Fermentation
by starter
Other products
Interactions between
products
COOH
CH_2
HO
COOH
H_2C
COOH
Citrate
H_3C
COOH
OH
L-Lactate
H_3C
OH
COOH
D-Lactate
Racemization
by NSLAB
Catabolism of lactate
Metabolism of citrate
VOLATILE FLAVOUR COMPOUNDS
Amino acid
catabolism

Catabolism of amino acids



Degradation of α-keto acids



Outline…

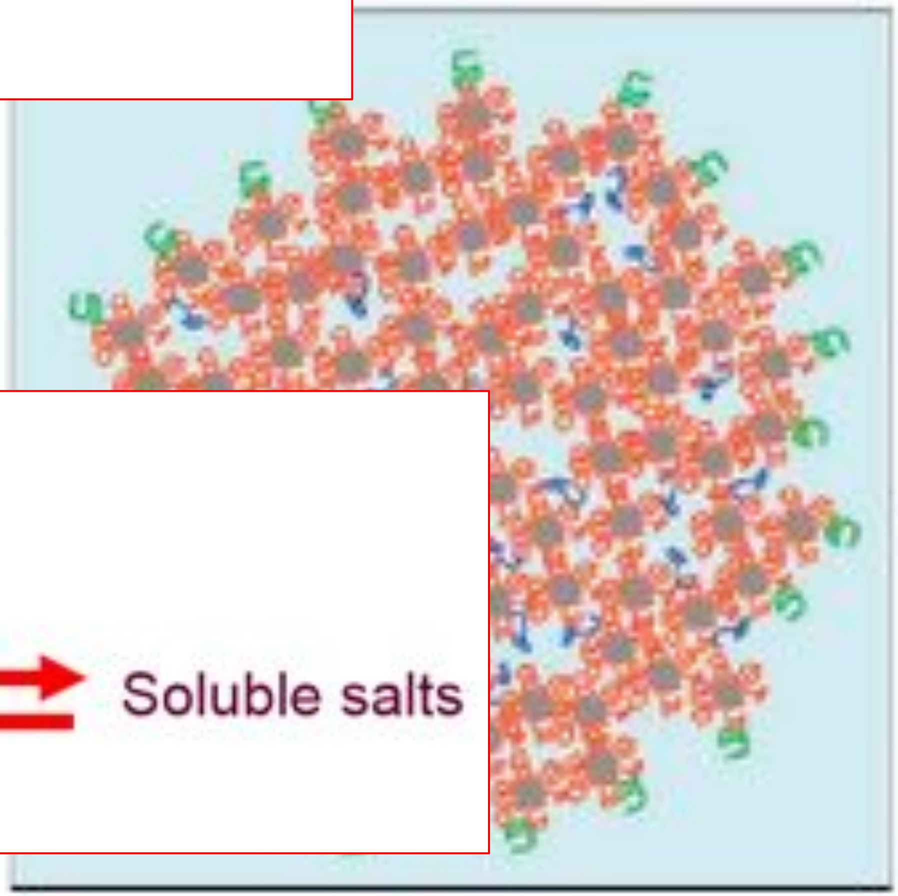
- Overview of cheese ripening, coagulants
- Calcium equilibrium and cheese texture
- Optical properties of low-fat cheese
- Redox potential and cheese

REVIEW www.rsc.org/softmatter | Soft Matter

On the structural models of bovine casein micelles—review and possible improvements

Douglas G. Dalgleish*

Received 11th August 2010, Accepted 12th November 2010
DOI: 10.1039/c0sm00806k



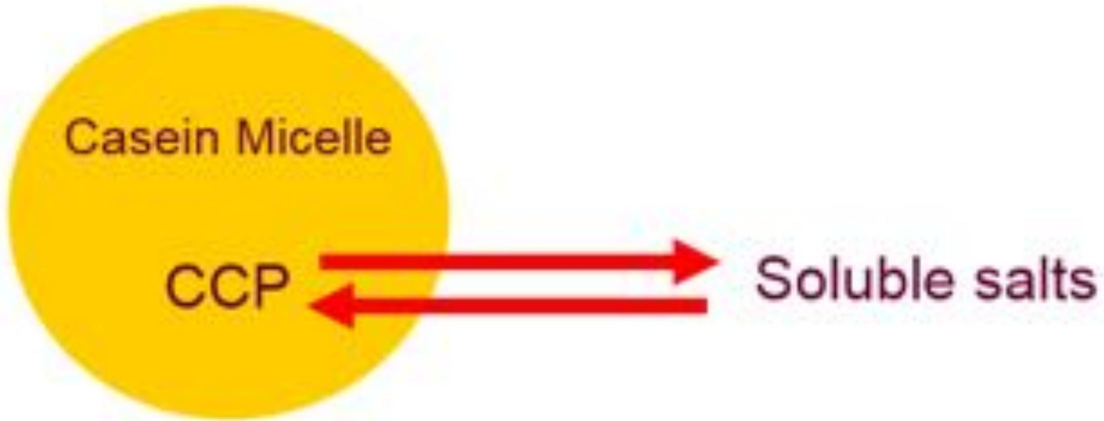
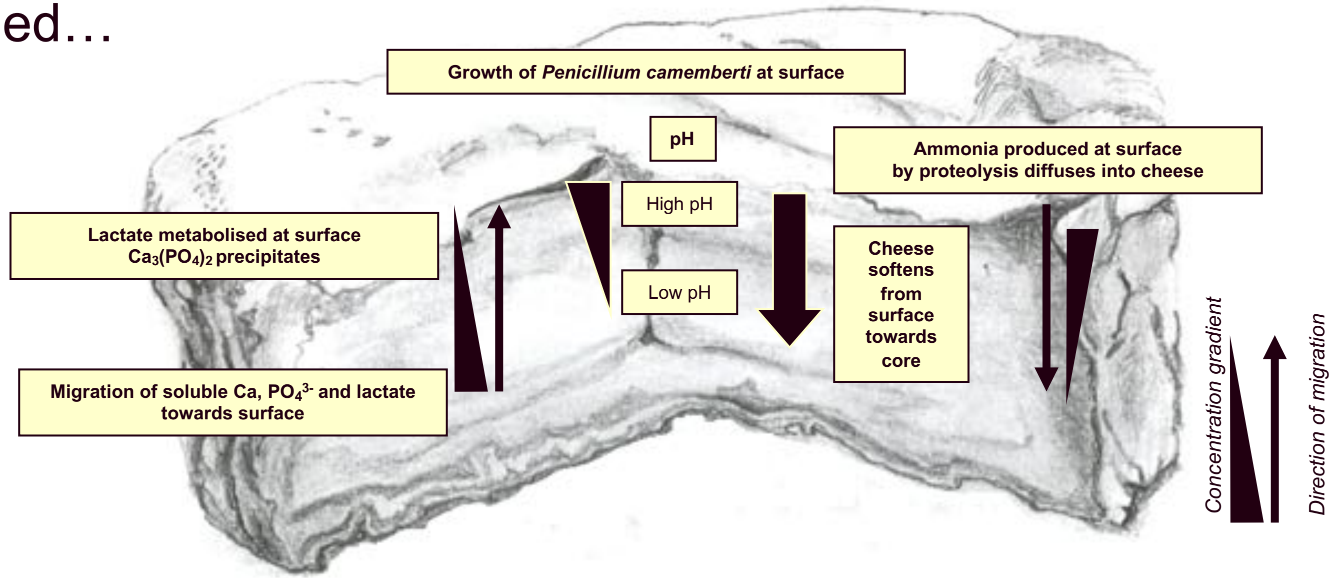


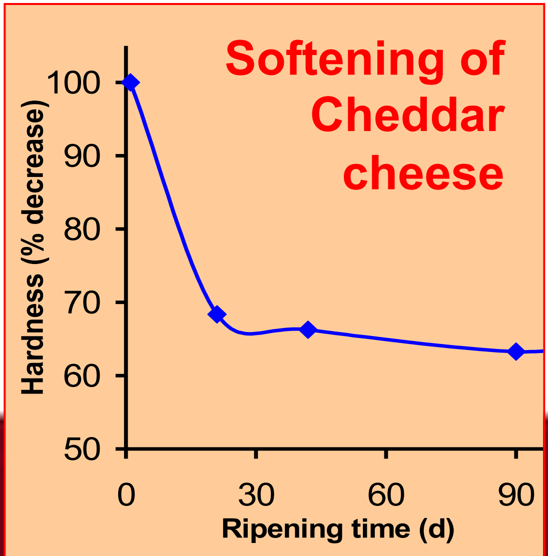
Fig. 5 Schematic structure of the casein micelle, incorporating calcium phosphate nanoclusters (grey) with their attached caseins (red) and the surface-located κ-casein (green). The "hydrophobically bound" mobile β-casein is shown in blue, within the water channels inside the micelle. For clarity, the relative sizes of the individual components are not to scale.

Textural changes during ripening…

- Role of calcium, pH in softening of Camembert-type cheeses is well established…



- What is the role of calcium in softening of Cheddar cheese?
  Biochemical and physicochemical processes…
  Role of α_{s1}-casein?

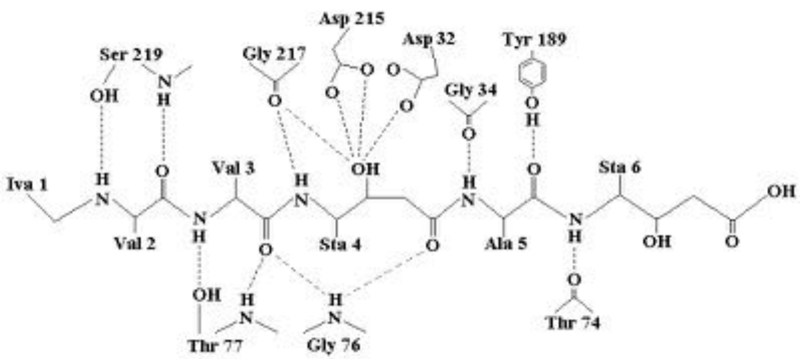


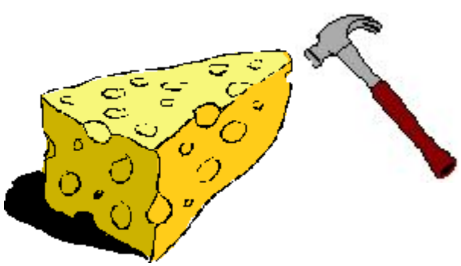
Creamer, L. K., and N. F. Olson. 1982. Rheological evaluation of maturing Cheddar cheese. J. Food Sci. 47:631–646.

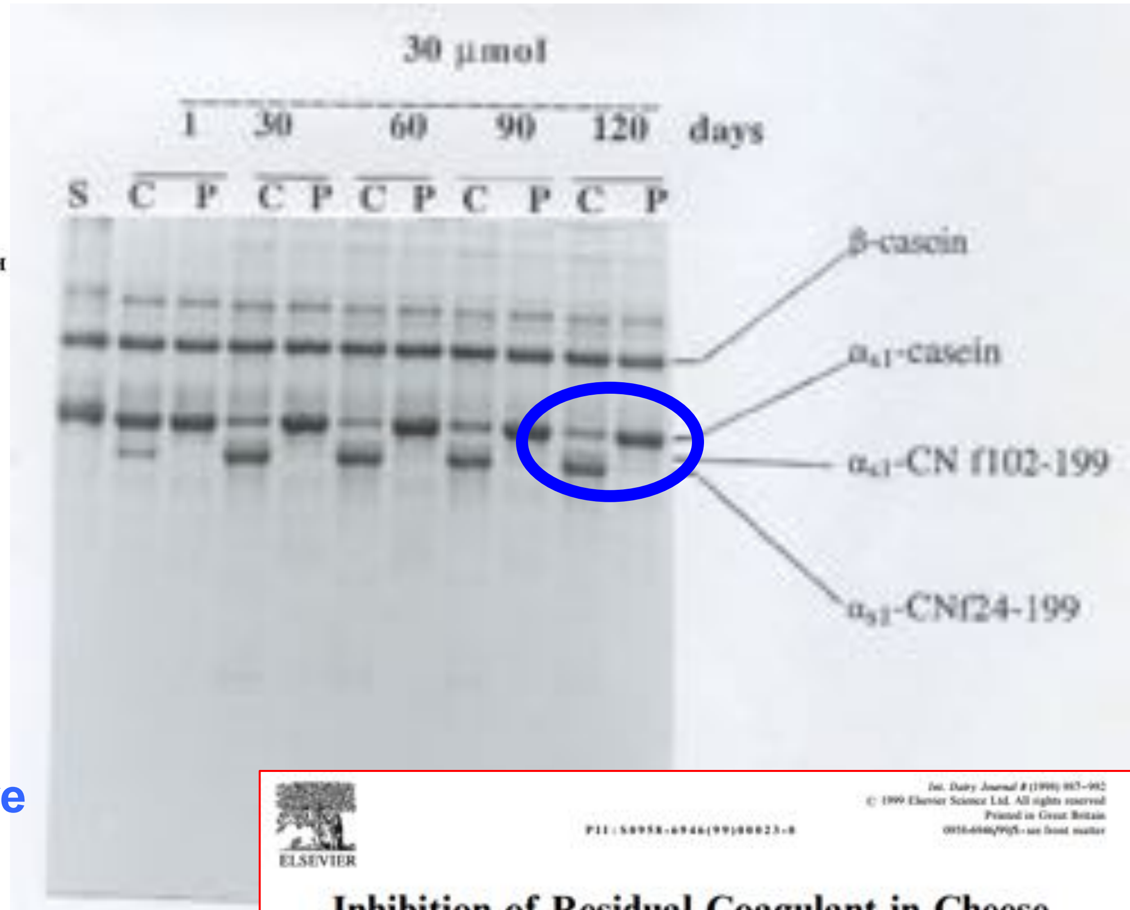
Creamer, L. K., H. F. Zoerb, N. F. Olson, and T. Richardson. 1982. Surface hydrophobicity of α_{S1}-I, α_{S1}-casein A and B and its implications in cheese structure. J. Dairy Sci. 65:902–906.

Role of chymosin in cheese texture development?

- Chymosin inhibited by pepstatin
  (IsoVal-Val-Val-Stat-Ala-Stat)





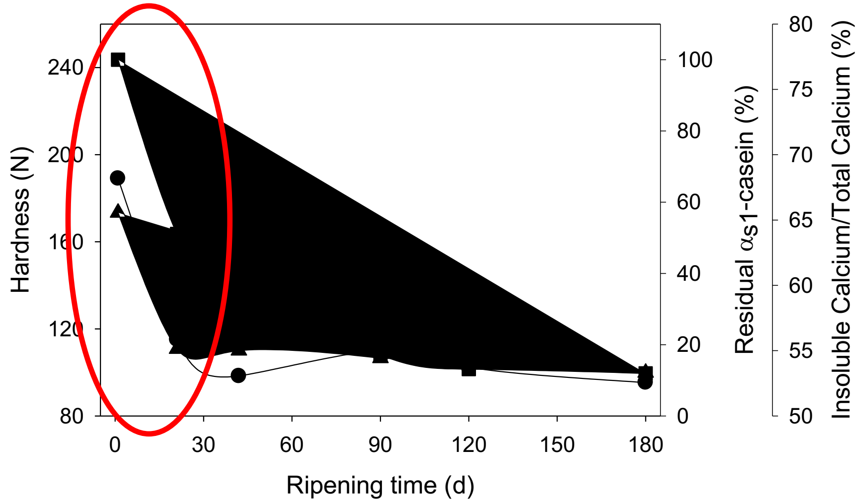


Useful tool to study cheese texture

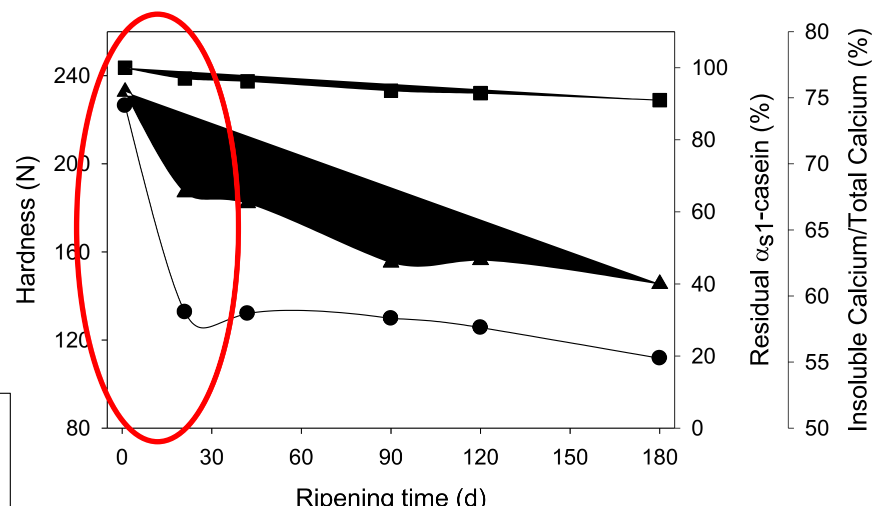
Inhibition of Residual Coagulant in Cheese using Pepstatin

Shakeel-Ur-Rehman, Esther P. Feeney, Paul L. H. McSweeney* and Patrick F. Fox
Department of Food Science and Technology, University College, Cork, Ireland

Control (100% residual chymosin activity)



Pepstatin (16% residual chymosin activity)



- Hardness
- Residual α_{s1}-casein
- Insoluble Calcium

Hardness decreased significantly (p<0.001) irrespective of α_{s1}-casein hydrolysis

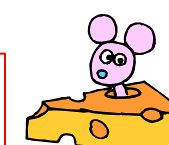
Calcium solubilization most closely related to initial softening

Hydrolysis of α_{s1}-casein plays a role but not as important as solubilization of Ca

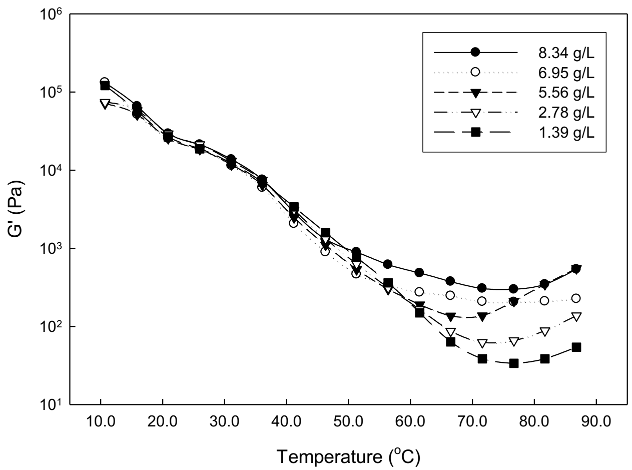
J. Dairy Sci. 88:JDS5070 TakeB130

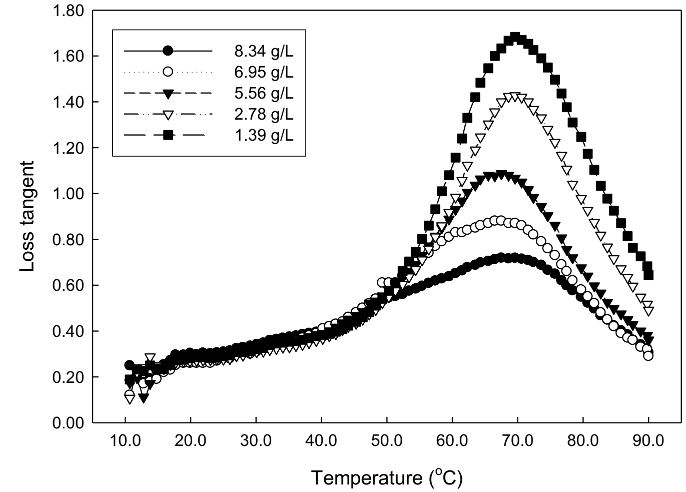
Chymosin-Mediated Proteolysis, Calcium Solubilization, and Texture Development During the Ripening of Cheddar Cheese

J. A. O'Mahony,[1,2] J. A. Lucey,[2] and P. L. H. McSweeney[1]
[1]Department of Food and Nutritional Sciences, University College, Cork, Ireland
[2]Department of Food Science, University of Wisconsin-Madison, 1605 Linden Drive, Madison 53706



Variation in CCP levels using synthetic Cheddar cheese aqueous phase





Storage modulus

[CCP] had no significant effect on G′ at 20°C

G′ at 70°C increased significantly with increasing [CCP]

Loss tangent

LT_{max} increased significantly with decreasing [CCP]

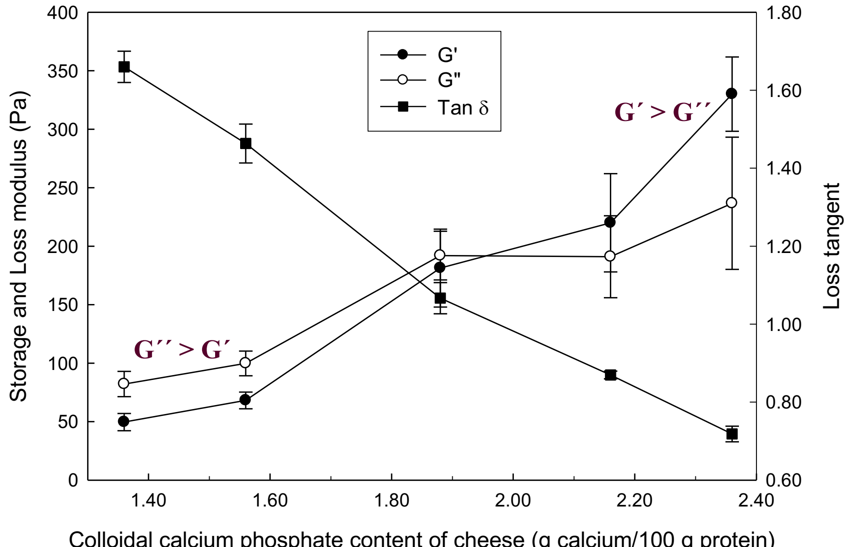
[CCP] had no significant effect on temperature of LT_{max}

Rheological properties at 70°C

J. Dairy Sci. 89:892–904

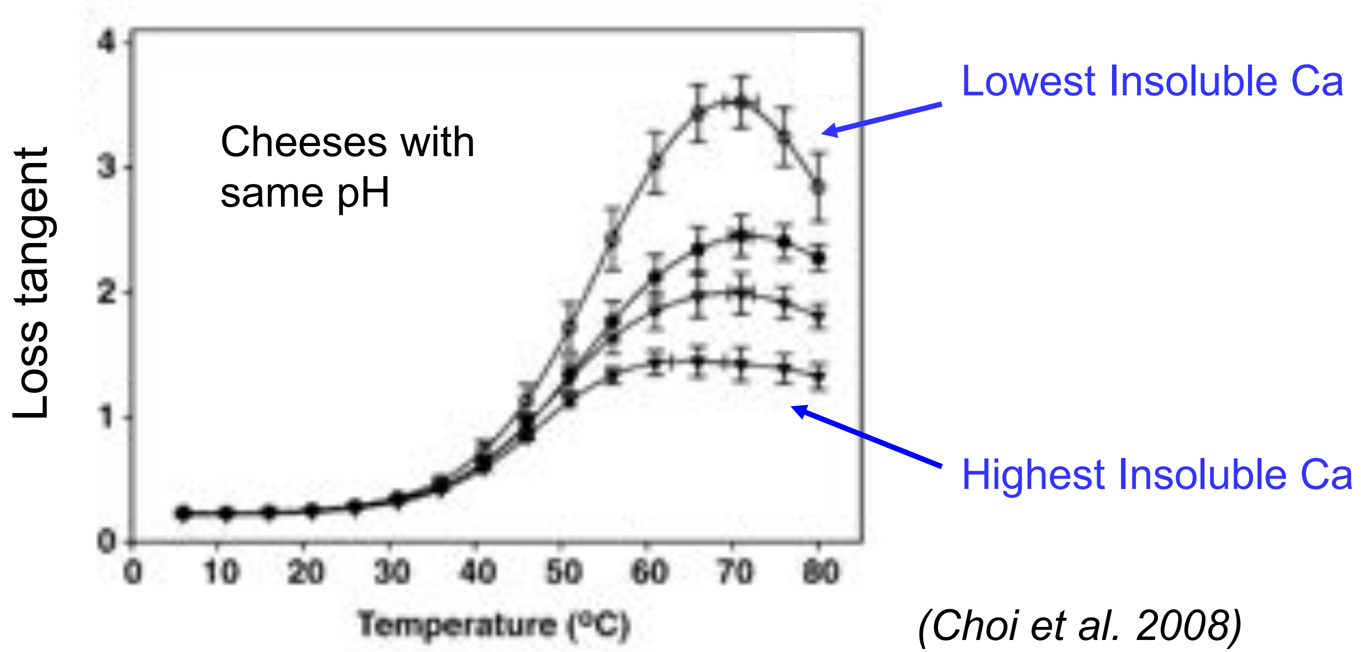
A Model System for Studying the Effects of Colloidal Calcium Phosphate Concentration on the Rheological Properties of Cheddar Cheese

J. A. O'Mahony,*† P. L. H. McSweeney,* and J. A. Lucey†[1]
*Department of Food and Nutritional Sciences, University College, Cork, Ireland
†Department of Food Science, University of Wisconsin, Madison 53706-1565



Influence of Ca equilibrium on melt

- Insoluble Ca decreases during ripening and is responsible for increased melt during early ripening
- Cheeses with lower insoluble Ca have increased meltability



(Choi et al. 2008)

Varying the texture of Cheddar cheese by controlling levels of soluble Ca using trisodium citrate or $CaCl_2$ added at salting

Five vats of Cheddar cheese manufactured –

Control (100% NaCl)

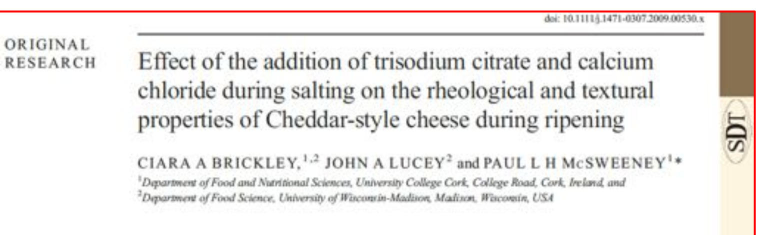
Experimental 1 (90% NaCl, 10% TSC)

Experimental 2 (70% NaCl, 30% TSC)

Experimental 3 (90% NaCl, 10% $CaCl_2$)

Experimental 4 (70% NaCl, 30% $CaCl_2$)

Levels of NaCl were varied to maintain a constant ionic strength to avoid different moisture levels

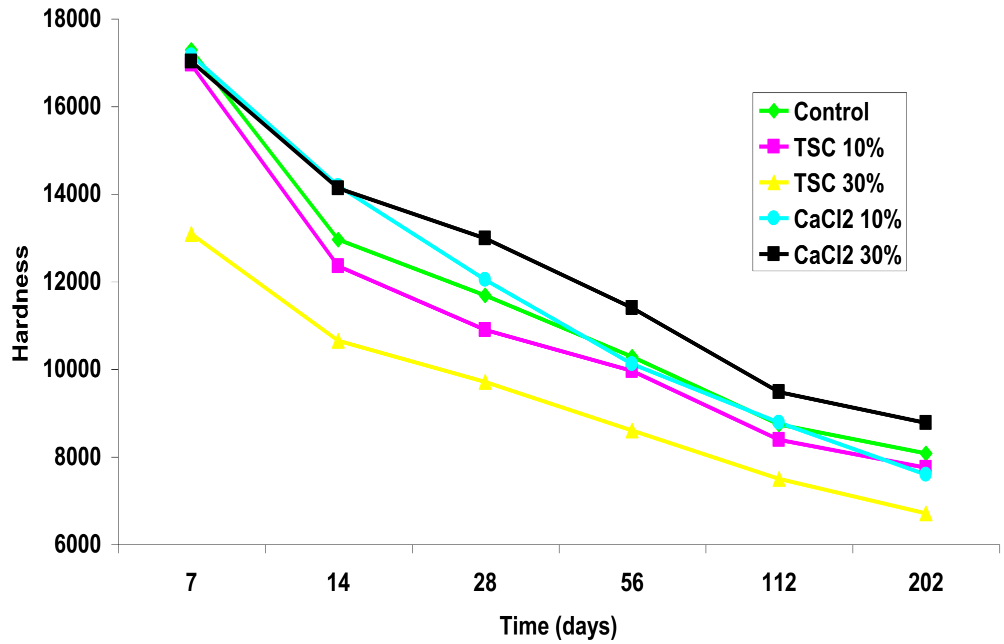

doi: 10.1111/j.1471-0307.2009.00530.x

ORIGINAL RESEARCH

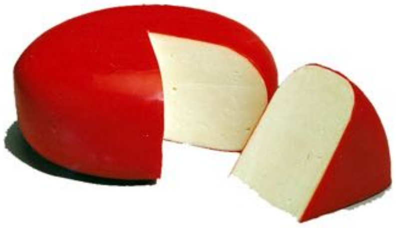
Effect of the addition of trisodium citrate and calcium chloride during salting on the rheological and textural properties of Cheddar-style cheese during ripening

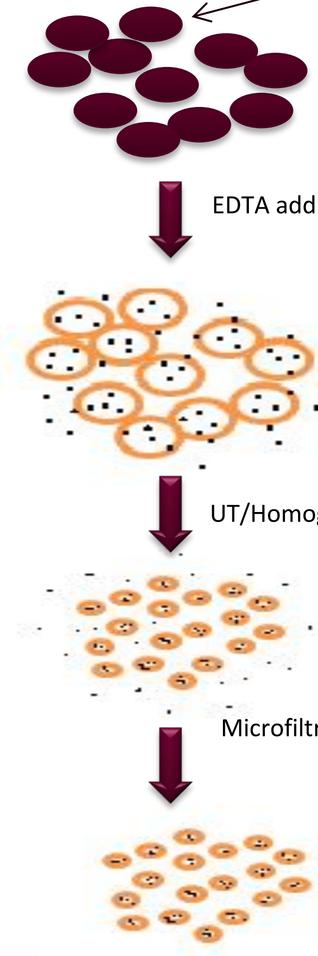
CIARA A BRICKLEY,[1,2] JOHN A LUCEY[2] and PAUL L H McSWEENEY[1]*
[1]Department of Food and Nutritional Sciences, University College Cork, College Road, Cork, Ireland, and
[2]Department of Food Science, University of Wisconsin-Madison, Madison, Wisconsin, USA

SDT



1. Manufacture of Gouda-type cheeses containing a Ca-sequestering agent (EDTA) encapsulated in liposomes
2. Determine the effect of EDTA on the *textural* and *rheological* properties of Gouda-type cheeses **without** affecting composition



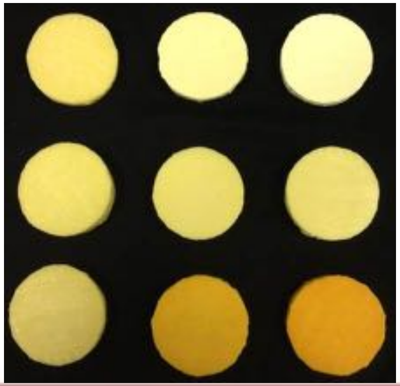


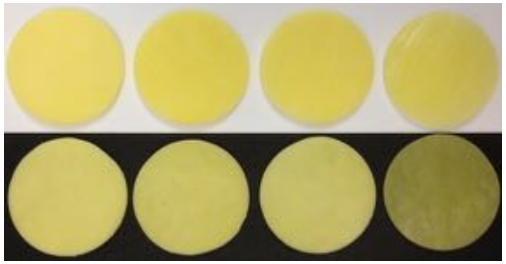
Outline…

- Overview of cheese ripening, coagulants
- Calcium equilibrium and cheese texture
- Optical properties of low-fat cheese
- Redox potential and cheese

Translucency in low-fat Cheddar Cheese

- Colour is considered the most important attribute to food appearance.
- Importance of fat content and temperature in cheese colour:
  - Fat increases light scatering, affecting whiteness. (L* values)
  - Fat reduction on cheese increases translucency (decreases L* values) and hence acceptability
  - High temperatures increases whiteness. However, it is Influenced by fat content (melting effect)
- Other parameters that affect colour in cheese:
  - Salt content
  - Calcium content
  - Homogenisation of cheese-milk
  - Addition of annatto
  - Addition of titanium dioxide





Translucency of low-fat Cheddar Cheese

- L* value used as an indicator of translucency (the higher the value, the lower the translucency).
- The study of translucent materials has also been studied by means of the reflectance of a thin layer of a sample under a black and a white background.
- Based on this relation, the Kubelka-Munk index (K/S) has been developed (Judd and Wyszecki, 1975)

$$\frac{K}{S} = \frac{1 - {R_\infty}^2}{2R_\infty}$$

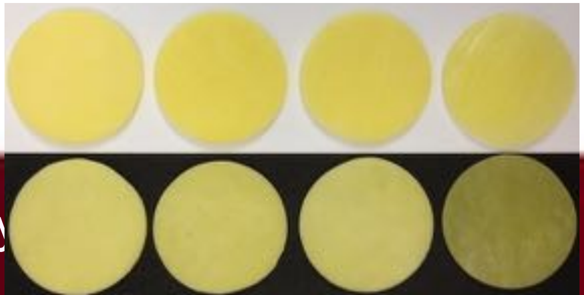
Where

$$R_\infty = a - b$$

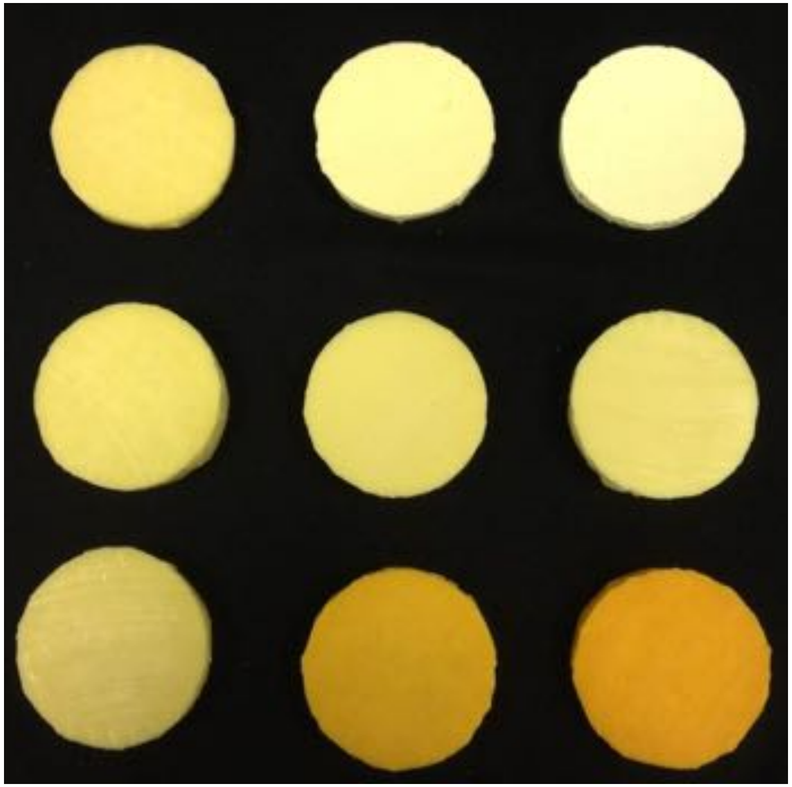
$$a = \frac{1}{2}\left(R + \frac{R_0 - R + R_g}{R_0 R_g}\right)$$

$$b = \sqrt{(a^2 - 1)}$$

R_∞:reflectance of a layer of infinite thickness.
R: reflectance of the sample layer above a white background with a known reflectance R_g
R_0: reflectance of the sample with an ideal black background.



Effect of titanium dioxide, annatto and homogenisation on Kubelka-Munk index in half fat Cheddar Cheese



Titanium Dioxide	0, 20 and 40 (g TiO_2/100 kg cheesemilk)
Homogenisation	0, 10 and 20 (MPa)
Annatto	0, 8.25 and 16.5 (ml/100 kg cheesemilk)

Outline…

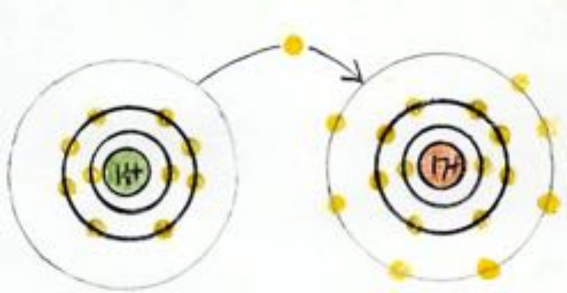
- Overview of cheese ripening, coagulants
- Calcium equilibrium and cheese texture
- Optical properties of low-fat cheese
- Redox potential and cheese

Physicochemical parameters influencing cheese ripening…

- pH, a_w (≈[NaCl]), T well understood and controlled…
- Oxidation-reduction potential largely ignored…

- ORP: measure of ability of chemical species to oxidize or reduce

- ORP of milk ≈ +250 to +350 mV, cheese varies (but very reducing)
- Affects microbial growth, production of aroma compounds by amino acid catabolism



Oxidation-reduction potential and cheese

- ORP affects the type of microorganisms that grow in and on cheese…



- Evidence that ORP influences which species or strains of NSLAB proliferate (Boucher *et al*., 2006).
- ORP contributes to the creation of conditions necessary for balanced flavour development and influences compounds formed…

Journal of Appli

ORIGINAL ARTICLE

Addition of oxidizing or reducing agents to t medium influences amino acid conversion to a compounds by *Lactococcus lactis*

A. Kieronczyk[1], R. Cachon[2], G. Feron[2] and M. Yvon[1]

1 Unité de Biochimie et Structure des Protéines, INRA, Jouy-en-Josas, France
2 Laboratoire de Microbiologie UMR UB/INRA 1232, INRA, Dijon, France

Figure 1 Amino acid catabolism pathways in *Lactococcus lactis*. ArAAs, aromatic amino acids; BcAAs, branched-chain amino acids; Met, methionine; α-KG, α-ketoglutarate; Glu, glutamate; AT, aminotransferases; HADH, hydroxyl acid dehydrogenase; KADH, keto acid dehydrogenase; KADC, keto acid decarb-

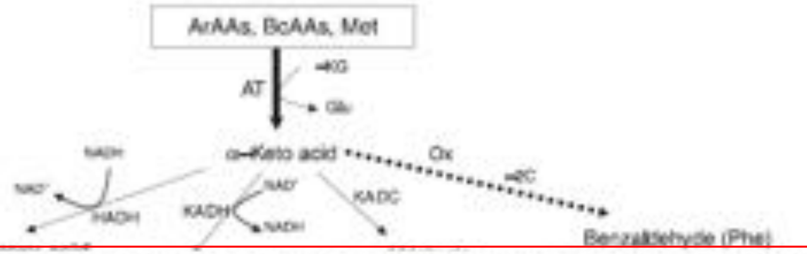


Table 1 Percentages of radioactivity associated with the metabolites produced from phenylalanine, leucine and methionine by *Lactococcus lactis* NCDO 763 and *L. lactis* NCDO 1867 under the three different E_h conditions. The results are means from at least three experiments

Strain	Average E_h (mV)	α-Keto acid	Hydroxy acid	Carboxylic acid	Aldehyde −1C	Aldehyde −2C	Alcohol	Other metabolites	Total
Phenylalanine		Phenyl pyruvate	Phenyl lactate	Phenyl acetate	Phenyl acetaldehyde	Benzaldehyde	Phenyl ethanol		
L. lactis NCDO763	+370	0·0[a]	0·0[a]	6·7[a]	0·0[a]	9·3[a]	0·0	18·2[a]	34·2[a]
	+270	6·0[b]	2·0[a]	16·4[b]	0·0[a]	6·2[b]	0·0	13·7[b]	44·3[b]
	−170	11·0[c]	7·8[b]	22·8[c]	4·4[b]	0·0[c]	0·0	0·0[c]	46·0[b]
L. lactis NCDO1867	+330	1·4	0·0[a]	5·2[a]	0·0[a]	2·4[a]	4·1	16·8[a]	29·9[a]
	+180	0·8	2·4[b]	7·4[a]	2·0[a]	0·3[b]	6·6	6·5[b]	26·0[a]
	−220	0·5	4·6[c]	11·6[b]	5·6[b]	0·0[b]	5·0	16·6[a,a]	44·1[b]
Leucine		Keto-isocaproic acid	Hydroxy-isocaproic acid	Isovaleric acid	3-Methyl butanal	2-Methyl propanal	3-Methyl butanol		
L. lactis NCDO763	+370	33·1[a]	1·7[a]	8·9	0·0	0·0	0·0	2·9	46·6[a]
	+200	25·1[a]	7·0[b]	18·3	0·0	0·0	0·0	0·7	51·1[a]
	−190	12·6[b]	44·0[c]	10·4	0·0	0·0	0·0	2·3	69·3[b]
L. lactis NCDO1867	+340	4·8	0·0[a]	2·9[a]	12·8[a]	0·0	12·9[a]	9·7[a]	43·1
	+270	6·6	6·7[b]	2·4[a]	5·9[b]	0·0	10·4[b]	0·3[b]	32·3
	−200	6·4	13·0[c]	7·4[b]	5·2[b]	0·0	6·9[c]	0·0[b]	38·9
Methionine		KMBA	HMBA	Methylthiopropionic acid†	Methional	Methylthioacetaldehyde†	Methionol		
L. lactis NCDO763	+340	10·2	1·8[a]	6·0[a]	0·0	12·9[a]	0·0	14·9[a]	45·8[a]
	+170	9·4	10·7[b]	15·1[b]	0·0	10·5[b]	0·0	4·7[b]	50·4[a]
	−210	5·8	17·7[c]	30·4[c]	0·0	3·8[c]	0·0	4·2[b]	61·9[b]
							2·2[a]	7·6[a]	37·1
							2·7[a]	2·1[a]	27·1
							4·6[b]	0·7[b]	21·9

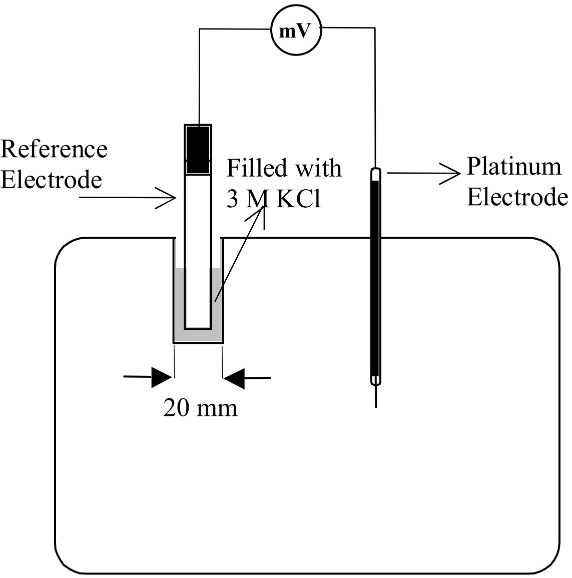
… to the calculated percentage of each compound

Table 2 Production of volatile sulfur compounds from methionine by *Lactococcus lactis* NCDO763 and *L. lactis* NCDO1867 under different E_h conditions. Data are means of duplicate ± deviations from the mean

	Average E_h (mV)	Methanethiol*	Dimethyldisulfide*	Dimethyltrisulfide*
L. lactis NCDO763	+340	43 ± 12	10 861 ± 2274	11 ± 2
	+170	45 ± 9	1312 ± 14	82 ± 69
	−210	36 ± 12	1339 ± 634	43 ± 16
L. lactis NCDO1867	+320	863 ± 205	11 089 ± 860	84 ± 2
	+200	828 ± 244	736 ± 89	69 ± 2
	−220	463 ± 98	482 ± 136	256 ± 6

*Peak area values divided by 1000.

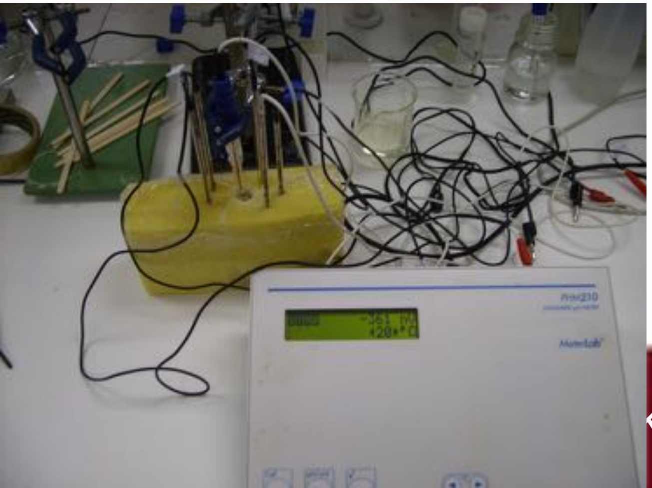
Measurement of ORP in mature hard cheese

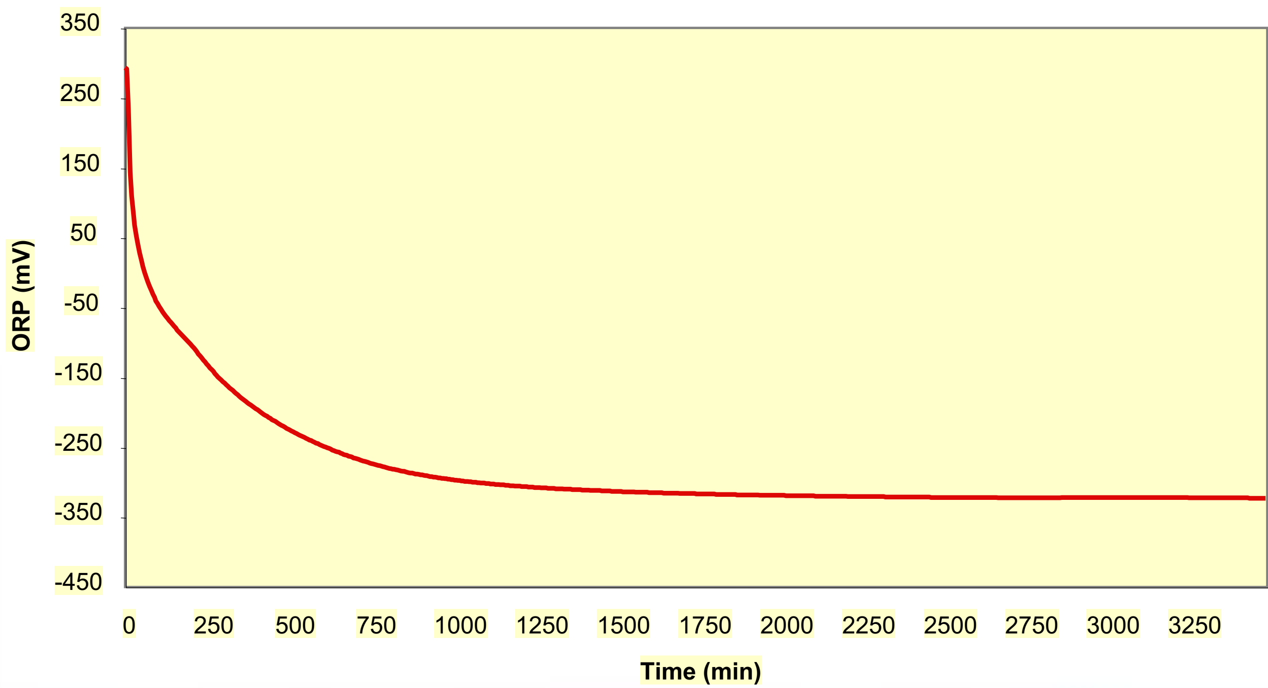


JFS C: Food Chemistry

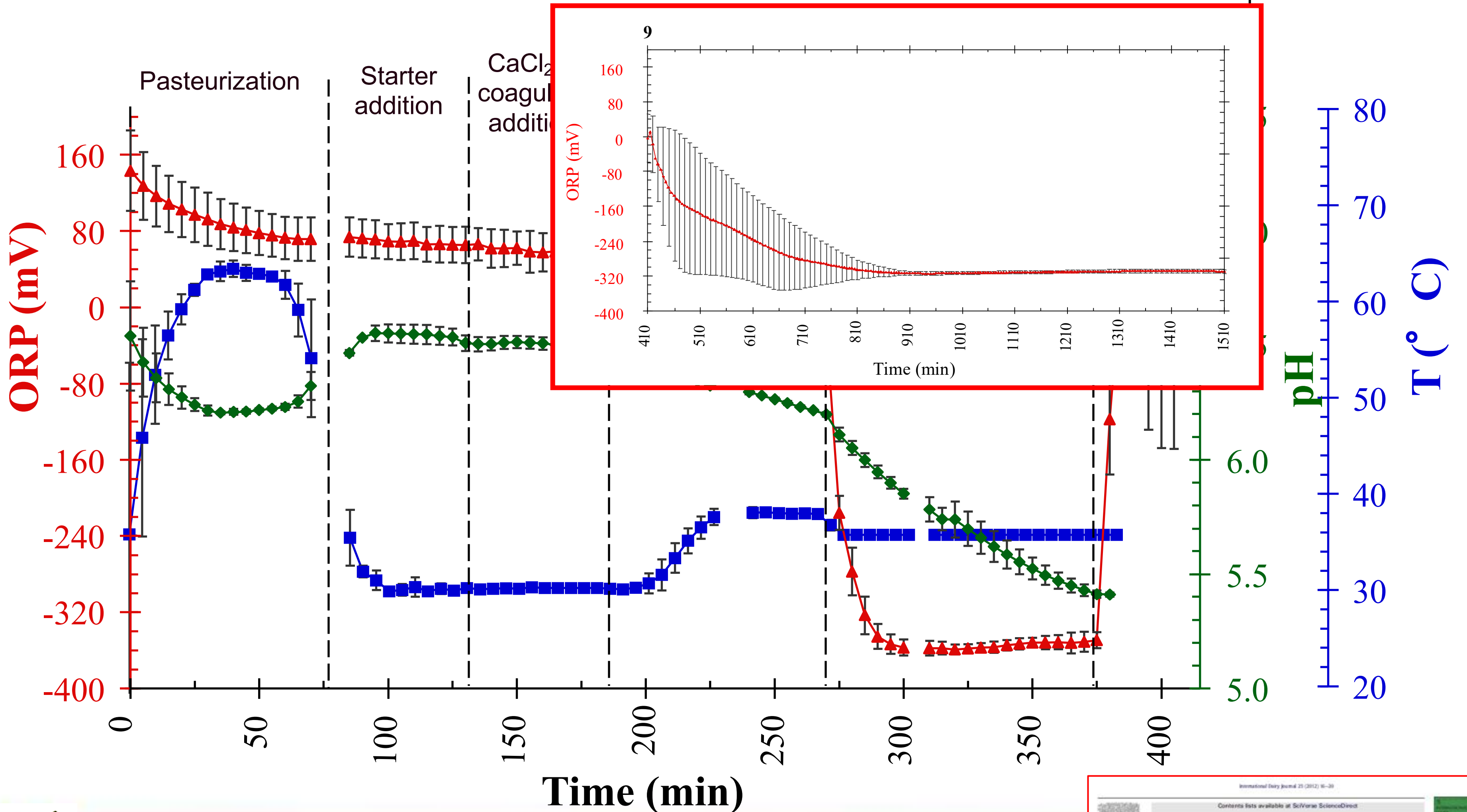
Measurement of the Oxidation–Reduction Potential of cheddar Cheese

A. Topcu, I. McKinnon, and P.L.H. McSweeney





Cheddar cheesemaking



University College Cork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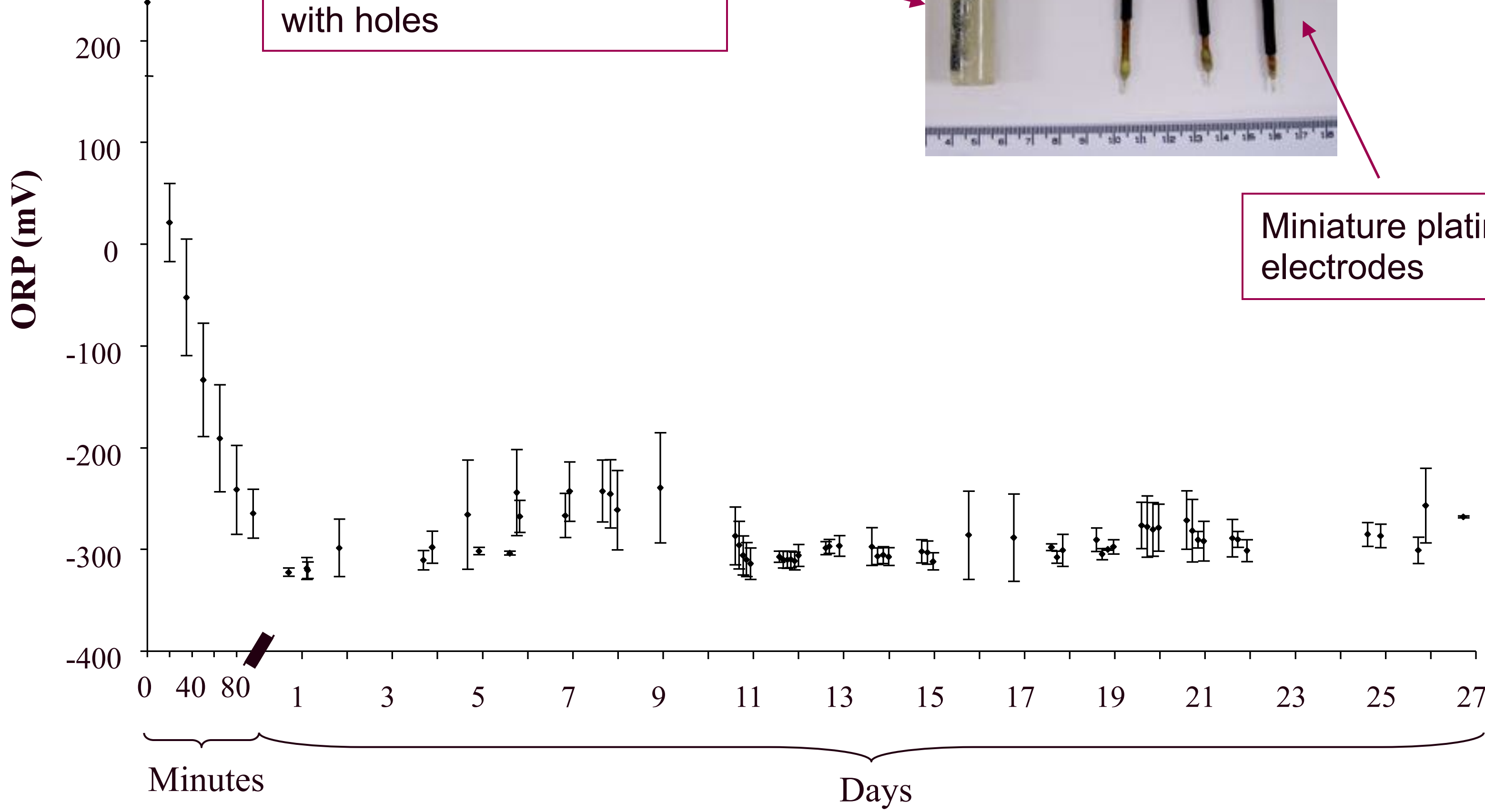
Changes in oxidation-reduction potential during the simulated manufacture of different cheese varieties

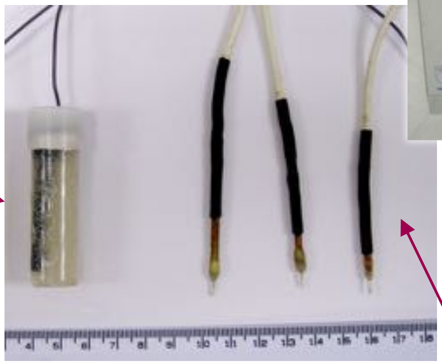
V. Caldeo, P.L.H. McSweeney*

School of Food and Nutritional Sciences, University College Cork, Cork, Ireland

Changes during ripening

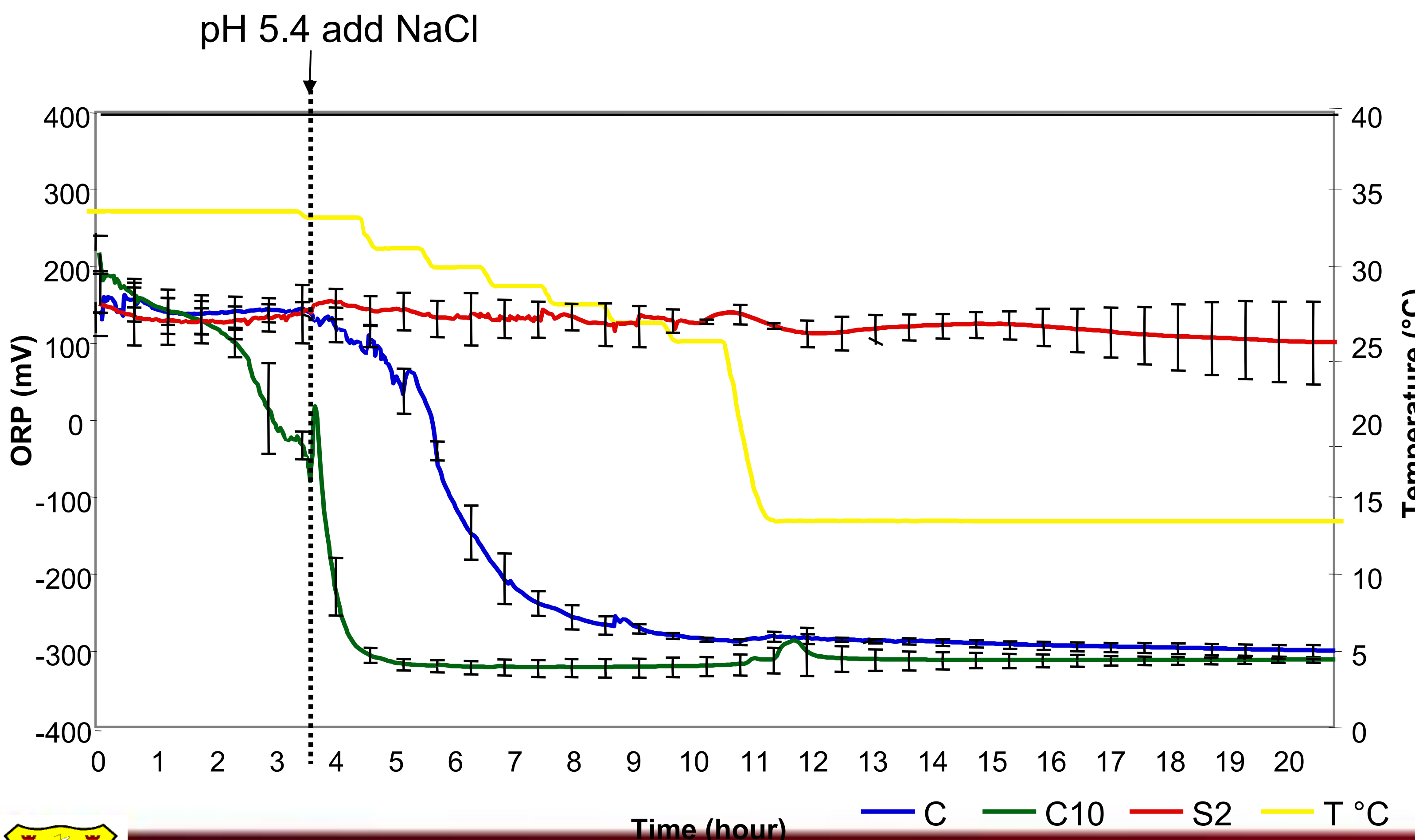


Reference electrode in agar containing saturated KCl gelled in plastic tube with holes



Miniature platinum electrodes

Influence of microbial growth on ORP in Cheddar cheese extract during simulated cheese pressing



Strain			
L.	l.	lactis	C10
L.	l.	lactis	DL16
L.	l.	lactis	ATCII454
L.	l.	lactis	ML3
L.	l.		MM510
L.	l.	lactis	ATC29146
L.	l.	lactis	M70
L.	l.	Crem,	Z8
L.	l.	Crem	HP
L.	l.	Crem	45P+
L.	l.	Crem	SW224
L.	l.	Crem	SK11 04
L.	l.	Crem	UC317
L.	l.	Crem	E
L.	l.	Crem	R
L.	l.	Crem	EB7
L.	l.	Crem	D
L.	l.	Crem	W
L.	l.	Crem	G
L.	l.	Crem	S2
L.	l.	lactis	C2
L.	l.	lactis	26-2
L.	l.		SCO213
L.	l.	Crem	A
L.	l.	Crem	B
L.	l.	Crem	C
L.	l.	Crem	F
L.	l.	Crem	I
L.	l.	Crem	J
L.	l.	Crem	Q

ORP control during Cheddar ripening

- Cheddar is a dry salted variety
- Redox agents added to the salted curd before pressing

- Reducing agents:
- Cysteine (2%)
- Sodium hydrosulfite (0.05%,0.1%)
- Oxidizing agent:
- Potassium iodate (0.05%,0.1%,1%)

Journal of Dairy Research, Page 1 of 8. © Proprietors of Journal of Dairy Research 2016 1
doi:10.1017/S002202991600056X

Control of oxidation-reduction potential during Cheddar cheese ripening and its effect on the production of volatile flavour compounds

Veronica Caldeo[1*], John A Hannon[2], Dara-Kate Hickey[3], Dave Waldron[1], Martin G Wilkinson[3], Thomas P Beresford[2] and Paul L H McSweeney[1]

[1] School of Food and Nutritional Sciences, University College Cork, Cork, Ireland
[2] Teagasc Food Research Centre, Moorepark, Fermoy, Cork, Ireland
[3] Department of Life Sciences, University of Limerick, Castletroy, Limerick, Ireland

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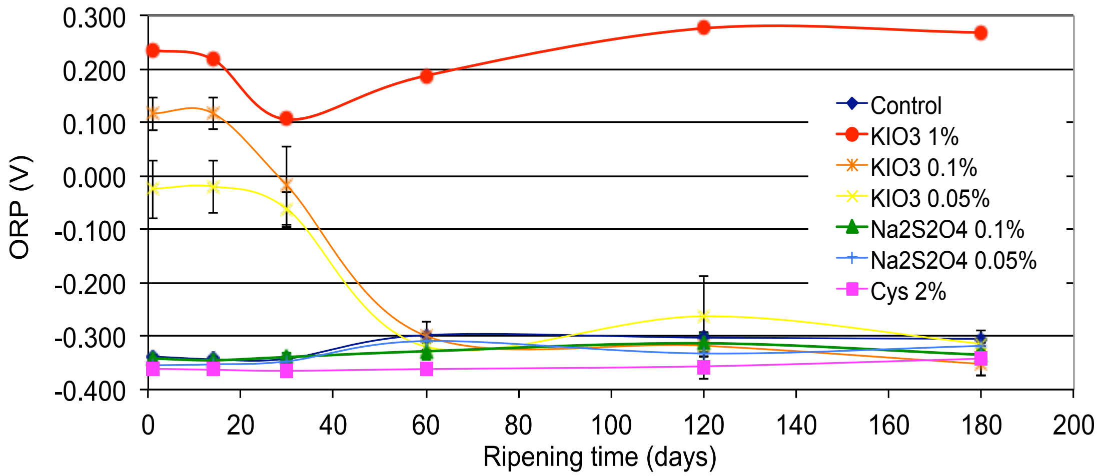
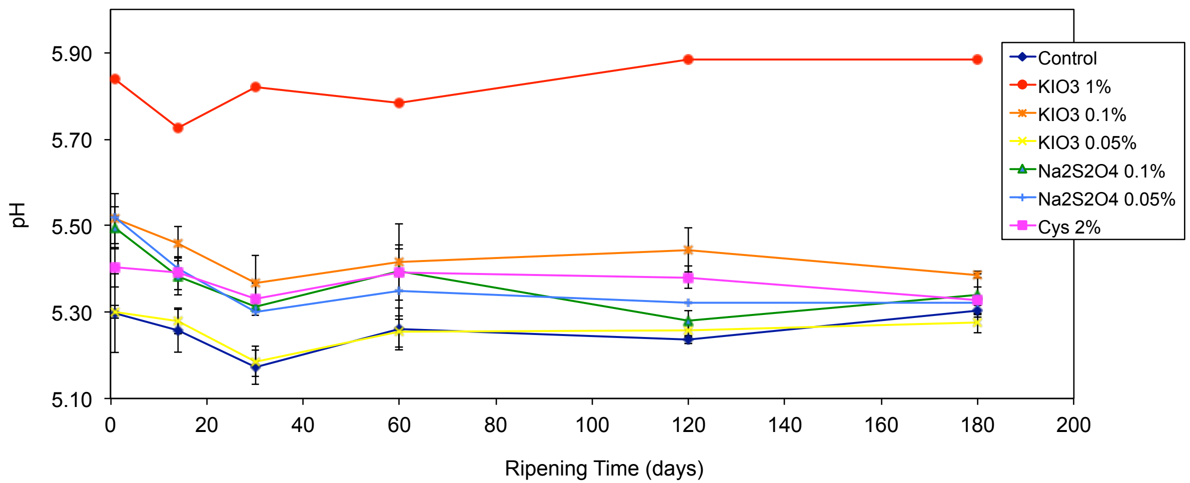
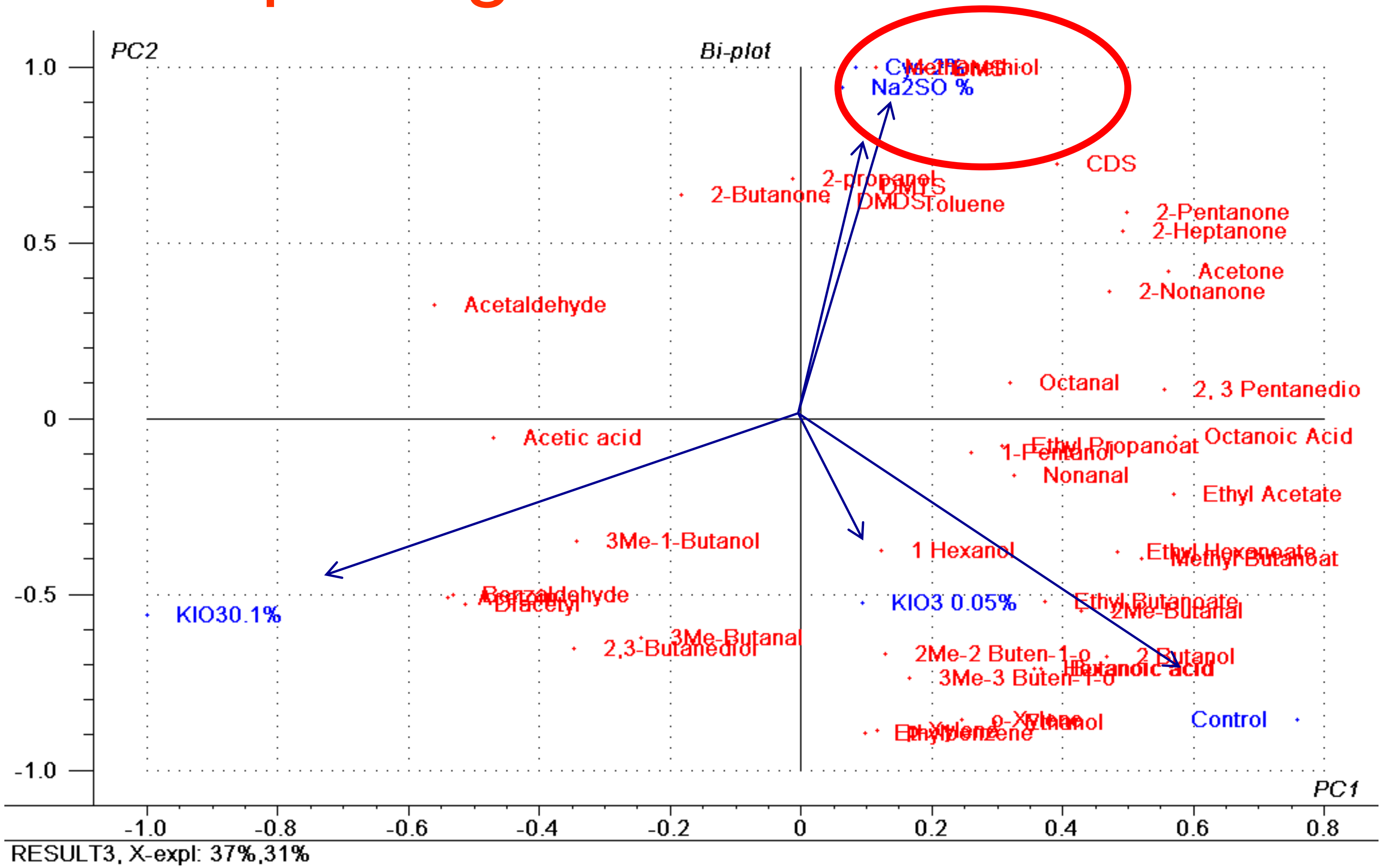
ORP and pH during ripening





PCA of volatile compounds at 2 month ripening



Thank you!
¡Gracias!

Department of Agriculture, Food and the Marine

NDP National Development Plan 2007 - 2013

Food Institutional Research Measure (FIRM)