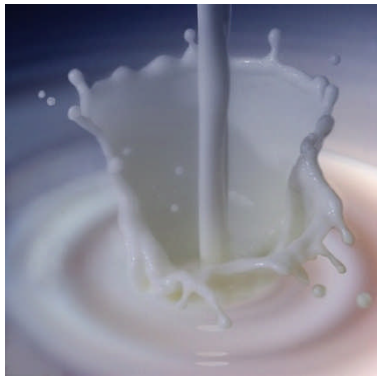
Cheese diversification & the IDB-Teagasc cheese programme: A milk quality perspective



Diarmuid Sheehan

Overview

- Expanding milk pool
- The importance of cheese
- Role of cheese diversification
- IDB-Teagasc as part of cheese diversification programme
- Importance of milk quality for cheese diversification
  - Microbial perspective
  - Enzymatic perspective
  - Curd formation and quality perspective
- Conclusions

Increased Milk Pool

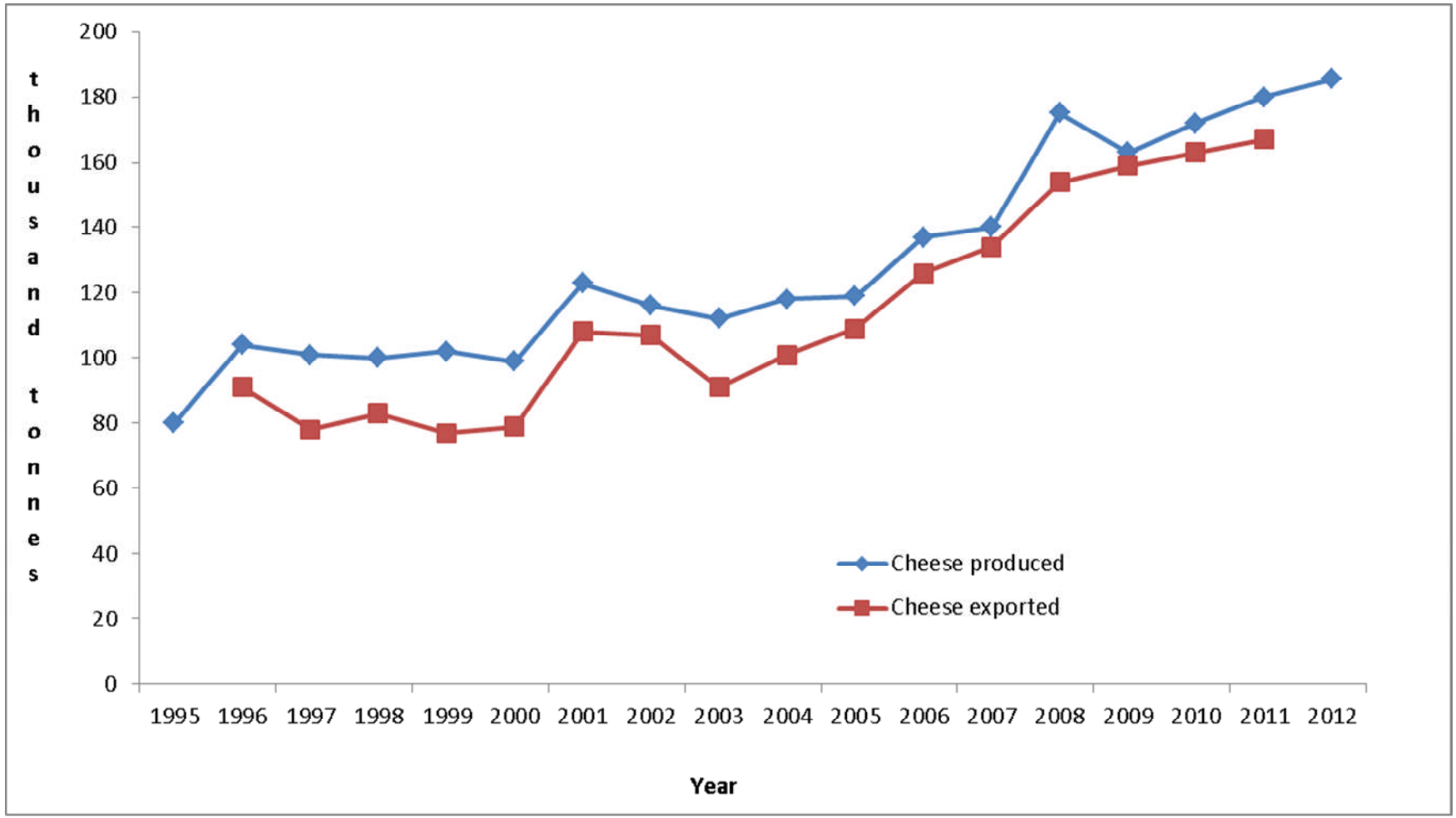
- Abolition of EU milk quotas in 2015
  - Projected 2.75 billion litre increase in Irish milk by 2020
  - Equivalent to an increase of approximately 50% (Food Harvest 2020).
  - Significant processing challenges
    - Capacity
    - Seasonality of supply
    - Products and Markets: Diversification for
    - Consistency and quality

Why Cheese ?

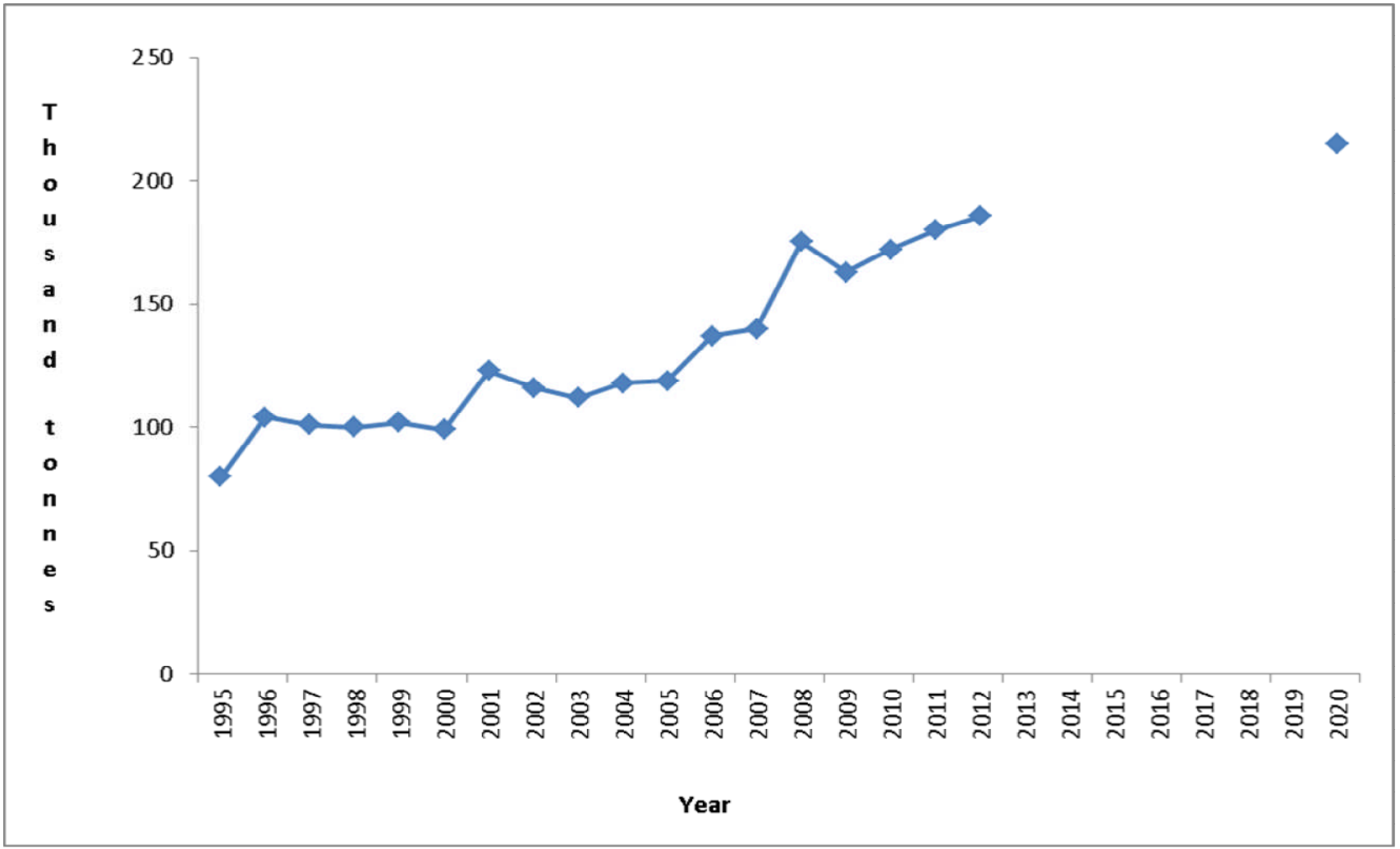
- Cheese has been targeted as a vital end-product
  - Continued increases in global cheese consumption,
  - High end-use versatility,
  - Potential for significant added value,
  - Potentially profitable outlet for surplus milk fat

- Historically not a major component of the Irish dairy product mix
- Share in milk utilisation has always lagged well behind that of European competitors.
- Changing…

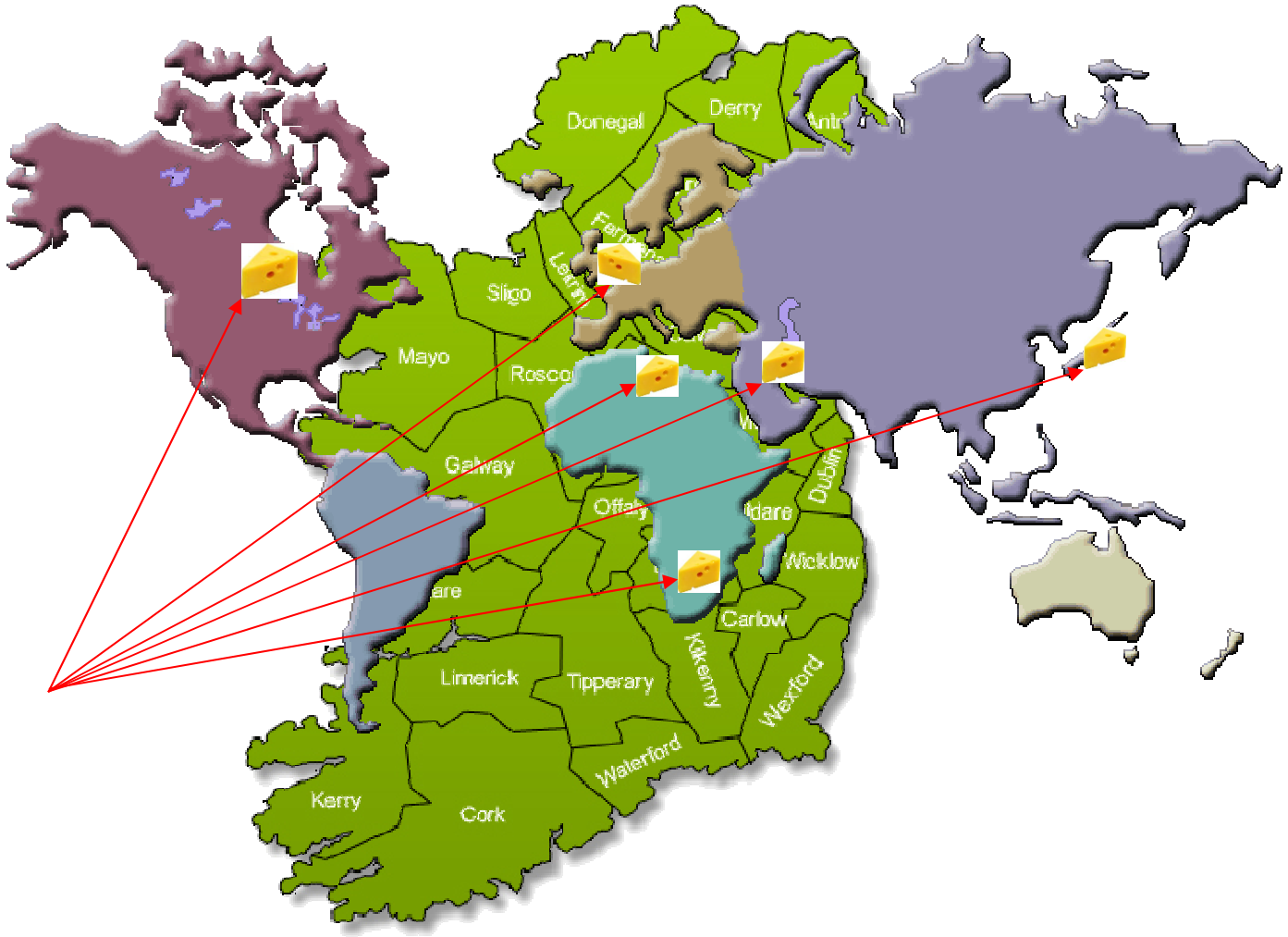
Irish Cheese production and exports (000 tonnes)



Projected Irish Cheese production to 2020



Irish cheese exports



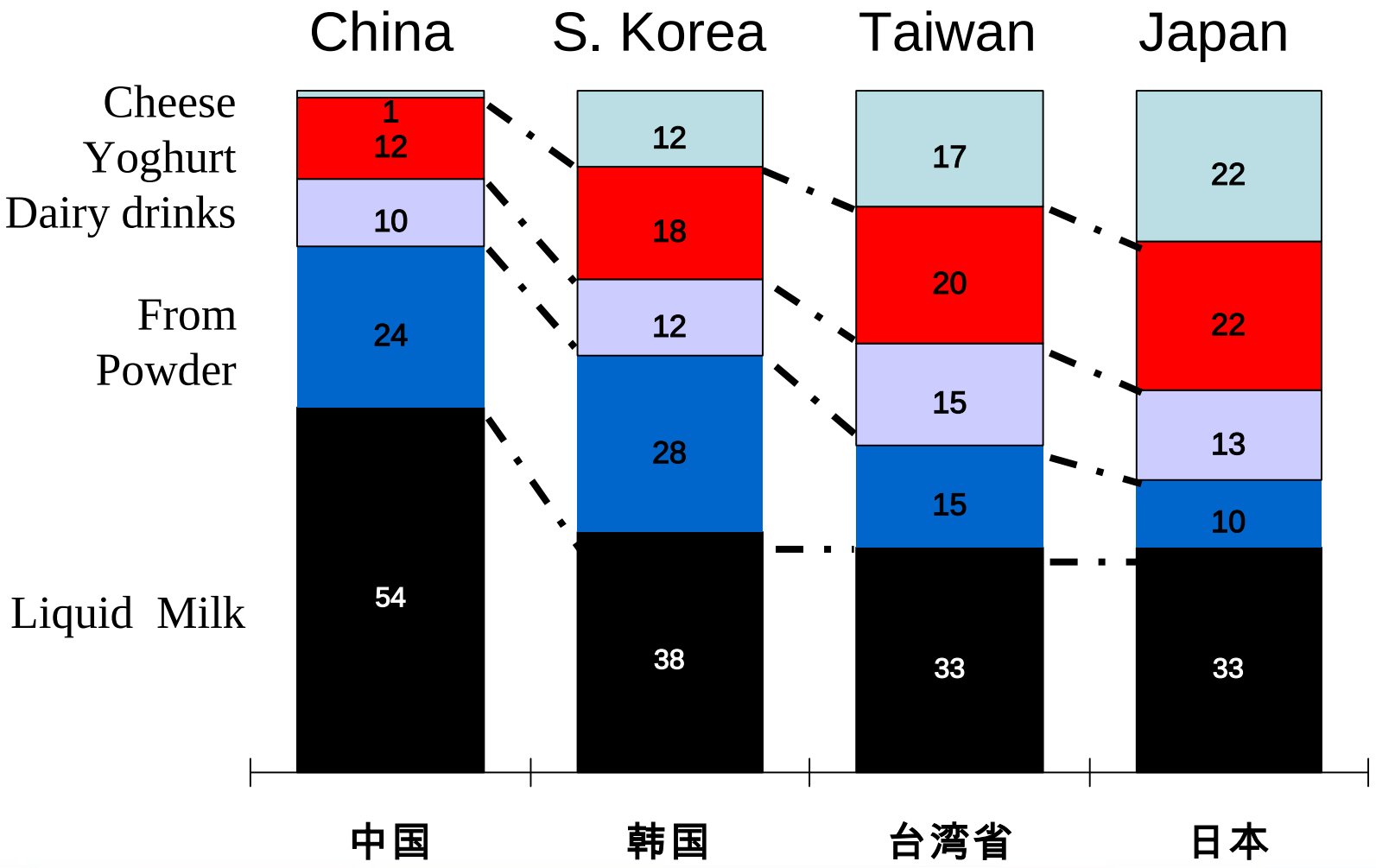
Irish cheese exports by destination

UK 114, 000 tonnes

EU (-uk) 39,700 tonnes

Partner Country	Tonnes 2012
World	**191,494**
United Kingdom	**113,978**
France	9,382
Germany	8,988
Algeria	7,232
United States	6,980
Netherlands	6,127
Belgium	5,239
Bahrain	4,137
Spain	3,634
Greece	3,237
Italy	3,089
South Africa	2,841
Japan	2,076
Saudi Arabia	1,803
Turkey	1,629
Libya	1,534
Egypt	1,245
China	**65**

Dairy Consumption trends in Asia (%)



Source: Prof G Huo, Key Lab Dairy Science, NEAU, Harbin, China

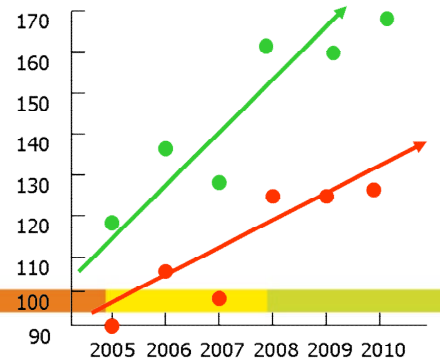
Growth, but diversity necessary

Traditional cheese markets such as Cheddar changing

- UK cheese retail market- 415,000 tonnes (Ref: G. Paul, Bradburys & IDB)
- 100, 000 tonnes imported , 90, 000 tonnes from Ireland
  - 1950 – 95 % Cheddar
  - 2013- 50 % Cheddar
- Areas of double digit growth: Artisan cheese, Continental/soft and Ing.

Diversification already in train in Irish cheese production:

- Continental type cheeses (Emmental, Jarlsberg, others under dev.)
- Dubliner cheese
- Regatto and other higher salt cheeses
- Growing interest in salt reduction



The IDB-Teagasc cheese programme

- Public private partnership – Dairy Innovation Centre
- Research capability & expertise of Teagasc:
  - Dairy chemistry and technology
- IDB's market and distribution infrastructure and global reach.
- Develop a pipeline of new innovative products to meet specific consumer and customer needs in key global markets

- Milk protein ingredient- recombined in market, to produce fresh cheese types common to markets within the Middle East.
- European/continental-style cheese for retail markets
- Cheddar (reduced- fat, reduced-salt content) for retail markets

Diversification requires change:

- Cultures: Thermophillic and/or heterofermentative mesophilic
- Temp: Max scald temperatures (≥ 50 °C)
  Ripening temperatures (> 20°C)
- Salt Elevated contents (Regatto, Grana types)
  Reduced salt cheeses (Continental type, low salt)
- Openness Eye type: Aesthetic quality
  Propionic and Citric acid fermentations
  Curd quality
- pH/Acid Acidification profiles, curd pH (Vs Cheddar)
  Curd washing
  Curd drainage characteristics

How does milk quality interact with these changes ?

Milk Quality

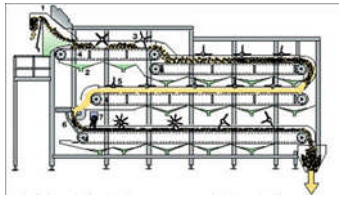
- Milk quality can be defined under many headings:
  - Microbial (both pathogenic and non pathogenic bacteria);
  - Chemical
  - Compositional
  - Physicochemical
  - Enzymatic
  - Stage of lactation

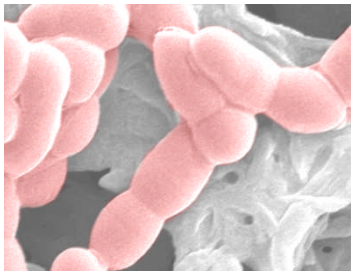
Milk Microbial Safety & Quality

- Microbial Safety
  - Raw milk can potentially contain pathogenic bacteria e.g. Salmonella spp, Listeria spp, *E coli*, Campylobacter spp., *Mycobacterium bovis* and Brucella spp.
  - (Jayarao and Hennin, 2001; Rea, Cogan and Tobin, 1992)
  - Industrial scale diversification – pasteurisation
    - No greater safety threat than standard Cheddar types

Milk Microbial Quality

- Microbial populations in raw milk can influence cheese quality dependant on
  - Microbial profile and microbial load of the raw milk,
  - Ability to survive pasteurisation
  - Build-up of microflora within the cheese manufacture plant
  - Starter culture activity and acidity profiles,
  - Cheese type, composition and manufacture technology
  - Ripening temperature/environments.





Milk Microbial Quality

Coliforms ***(****Enterobacter, Escherichia, Citrobacter*, and *Serratia)*

- P.P.C. (or use of unpasteurized milk)
- First 24- 48 h of manufacture - numerous small holes possible off-flavours
- H_2 and/or CO_2 gas as a by-product of lactose utilization.
- H_2 is poorly soluble in the aqueous phase of curd and therefore even small quantities can cause serious gas problems (Sheehan, 2011).

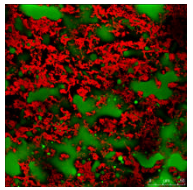
Yeasts (*Debaryomyces hansenii, Candida versatilis, Torulaspora delbrueckii*)

- Heat sensitive & killed by pasteurisation.
- Contamination of equipment surfaces and by air
- Gas blowing in hard, semi-hard and soft cheeses.
- Some resistance reported to commercial sanitisers
  - (Sheehan, 2011; Tudor and Board, 1993; Welthagen and Viljoen, 1998)

Milk Microbial Quality

NSLAB Non-Starter Lactic Acid Bacteria

- Facultatively heterofermentative (mesophilic) lactobacilli (FHLs), Pediococci, Enterococci, and Leuconostocs



- Cell densities of 10^6 - 10^8 cfu/g during cheese ripening (Swearingen et al., 2001). (Beresford et al., 2001; Beresford and Williams, 2004; Thierry et al, 1998)
- Capable of growth at pH 5.5 to 6.2, in 4–6% salt and from 2 to 54 °C (Lynch et al., 1996).

- *L. paracasei, L. plantarum, L. rhamnosus* and *L. brevis* in Swiss-type cheese
- As cheese ripened *L. paracasei* began to dominate (Demarigny, 1996)

Milk Microbial Quality

- NSLAB affect quality of cheese: flavour defects, biogenic amine (BA) formation, gas formation, and secondary fermentations

- Gas production by FHLs such as *L. brevis* and *L. fermentum* *(O'Sullivan et al, 2013)*

- NSLABs capable of BA formation include *L. casei, L curvatus, L. buchneri, (O'Sullivan et al, 2013)*

- Controlling the strains, and the proportions thereof, is emerging as a key issue to minimize cheese defects (McSweeney, 2007)

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Milk Microbial Quality

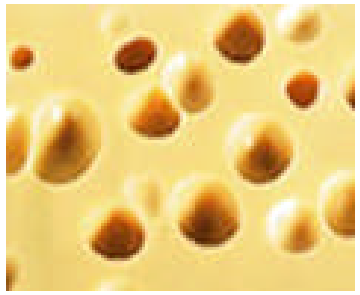
- The ability of NSLABs and FHLs to survive pasteurisation important
  - Lactabacilli are generally not described as thermoduric , but
  - Some thermo resistance reported when assays involve milk

    (Jordan and Cogan, 1999).
  - Strains of *Lactobacillus brevis* did not survive pasteurisation
  - Strains of *Lb. buchneri* and curvatus were partially resistant showing a reduction on treatment of ~ 2 logs

    (Sanchez-Llana, Fernanadez & Alvarez, 2011)
- Cells injured by pasteurisation Vs total inactivation (non culturable)
  - but still capable of metabolic activity
  - Thus capable of generating defects in diverse cheese types during ripening
- Thus the importance of NSLAB profile/counts in milk

Milk Microbial Quality

- Swiss or Dutch-type cheese manufacture
  - Milk from Silage fed herds contain spores
- *Clostridium tyrobutyricum* or *C. butyricum C. sporogenes*, *C. beijerinckii*
  - Germination of spores and growth of clostridia during ripening
- Fermentation of lactate to acetate, butyrate, CO_2 and H_2
  - Late gas blowing defect in the cheeses.
- Due to anaerobic environment , higher ripening temps
- Low salt and acid content



Milk quality and microbiota

- Non–molecular methods (plate counts) selecting only specific strains - may introduce a degree of inherent bias
- Molecular methods - total DNA is extracted directly from the cheese overcoming any selective bias.
- Molecular methods - also functional analysis (active metabolic pathways).
  - Can also target specific defect causing strains/genes (decarboxylase genes)

frontiers in MICROBIOLOGY

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Nucleic acid-based approaches to investigate microbial-related cheese quality defects

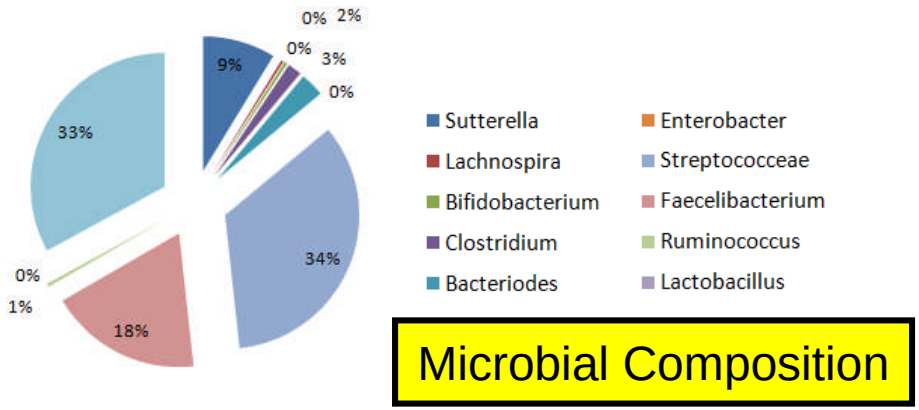
*Daniel J. O'Sullivan[1,2], Linda Giblin[1], Paul L. H. McSweeney[2], Jeremiah J. Sheehan[1] and Paul D. Cotter[1,3]**

[1] Food Bioscience Department, Teagasc Food Research Centre, Fermoy, Ireland
[2] School of Food and Nutritional Sciences, University College Cork, Cork, Ireland
[3] Alimentary Pharmabiotic Centre, University College Cork, Cork, Ireland

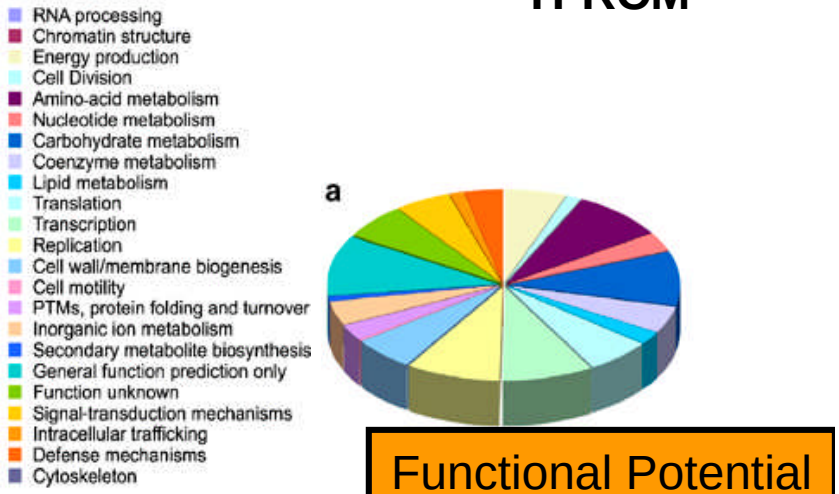
Next Generation Molecular Techniques

- Pyrosequencing:16S rRNA analysis (16S used for typing bacteria to genus level)
- Allows for microbial composition to be determined

Ref: Paul Cotter group TFRCM



Microbial Composition



Functional Potential

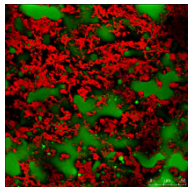
- Illumina Sequencing: Used for Shotgun/Meta-genome sequencing
- Data generated allows for compositional and functional analysis

Milk Microbial/enzymatic Quality

Psychrotrophic bacteria (*Pseudomonas fluorescens* and *P. putrefaciens*)

- Activity of proteinases (Lemieux and Simard, 1991; McSweeney, 2007)
- Heat stable (unaffected by pasteurization)
- bitter hydrophobic peptides from C-terminal region of β-casein and in α_{s1}-casein
- accumulate during cheese ripening (Lemieux and Simard, 1991).
- Lipases leading to lipolysis of fat negative flavour attributes

Milk quality: enzymes



- Plasmin content of milk varies with advancing stage of lactation (Richardson and Pearce, 1981).
- Milk and cheese plasmin levels influence cheese ripening & quality
  - High levels of plasmin in milk
    - Longer rennet gelation times
    - Lower gel firmness, more porous, open structured rennet gel
    - Less connectivity between the particles and clusters making up the gel matrix (Guinee and O'Brien, 2010).
- Addition of plasmin or of mastitic milk
  - increased rates of primary proteolysis & overall quality of smear ripened cheese (O'Farrell, Sheehan, Wilkinson, Harrington, and Kelly, 2002).
- Poorer eye formation in cheeses manufactured from early lactation milk partly attributed to a lower concentration of plasmin

(Lawrence, Heaps and Gilles, 1984)

Milk quality: enzymes

- Plasmin has a relatively high heat stability (Kaminagowa, Mizobuchi, & Yamauchi, 1972) and a pH optimum of 7.5 (Grufferty & Fox, 1988).
- The contribution of plasmin to primary hydrolysis of caseins is more pronounced in cheeses where high cooking temperatures are used during manufacture (Steffen, Flueckiger, Bosset, & Ruegg, 1993; Sousa et al., 2001)
- Due to
  - increased plasminogen activation resulting from inactivation of plasmin inhibitors and
  - inhibitors of plasminogen activators being lost in the whey during cheesemaking (Farkye & Fox, 1990; Somers & Kelly, 2002).
- Implications for Swiss, Swiss Cheddar-hybrid types and Grana type cheeses

Milk quality: Physico-chemistry and curd structure

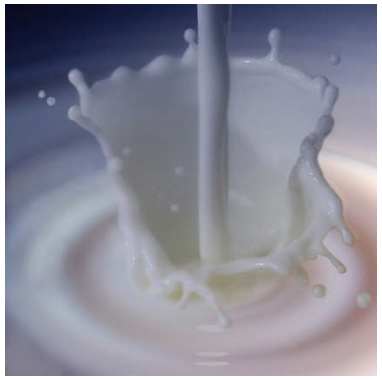
- Cheddar and late lactation milk (Guinee and O'Brien, 2010)
  - Poor rennet coagulability
  - Impaired curd syneresis
  - Higher moisture
  - Lower fat recovery to cheese

- Eye-type cheeses (Akkermann et al, 1996)
  - During manufacture, flow of whey through interconnected pores between curd grains-important for eye quality
    - Geometry of drainage column
    - Moisture content of curd grains — Stage of Lactation
    - Amount of curd fines — Stage of Lactation

Conclusions

- Cheese is a key dairy product for “Ireland Inc.” Whey for IMF.
- Markets are changing….Diversification…. IDB- Teagasc PPP.
- Milk quality impacts hugely on cheese quality esp. diverse types
- Microbial quality - Non culturable but metabolically active
- Enzymatic quality- Higher temp profiles implication for enzymes
- Stage of lactation- Continental types equally/ more demanding..
- Milk quality and cheese quality are inextricably linked …..
  ……. cheese consistency work in progress

The IDB-Teagasc cheese programme: A milk quality perspective



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