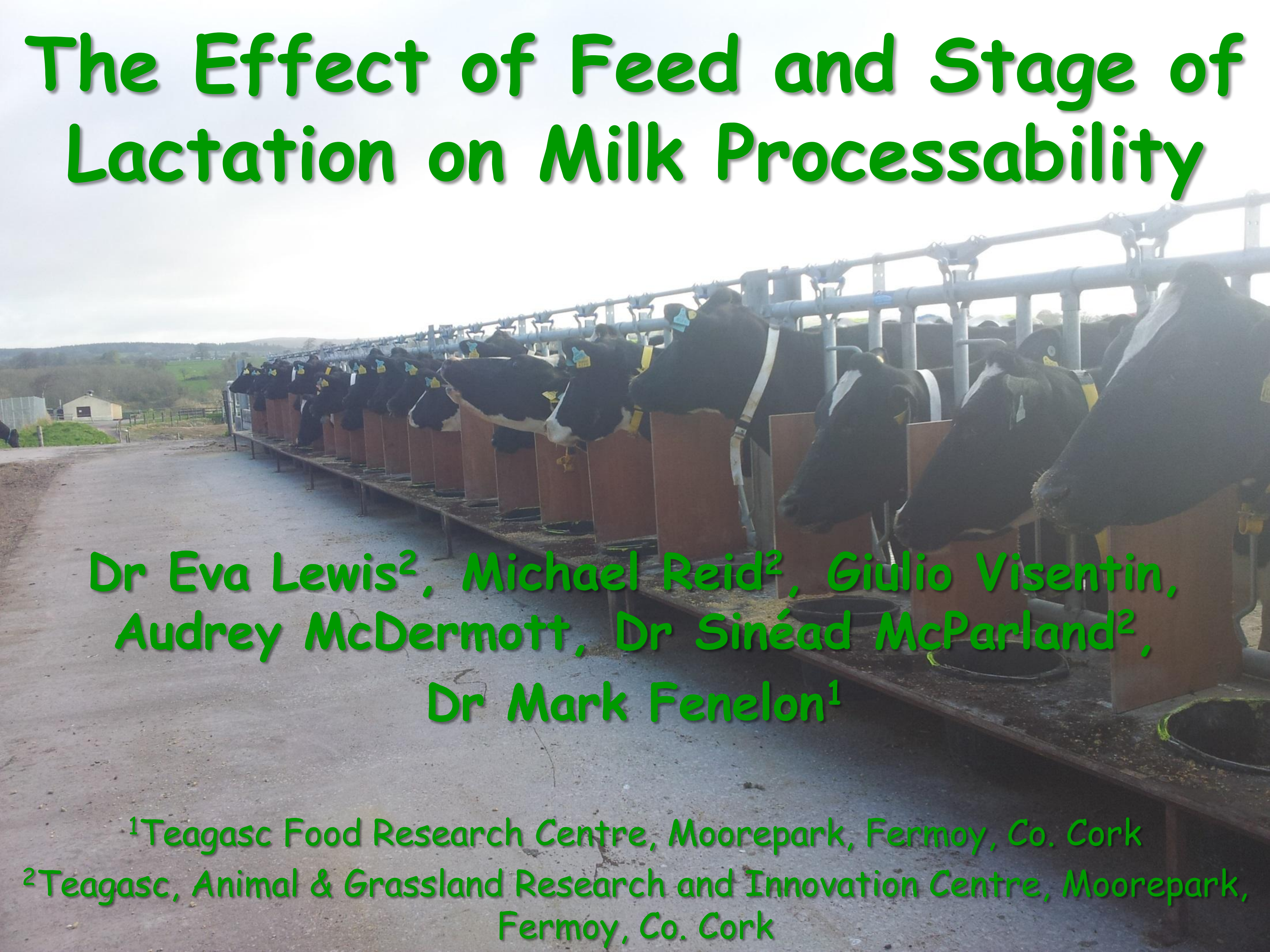
The Effect of Feed and Stage of Lactation on Milk Processability



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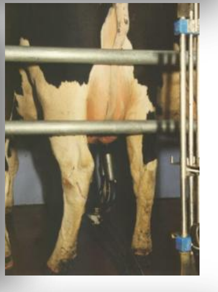
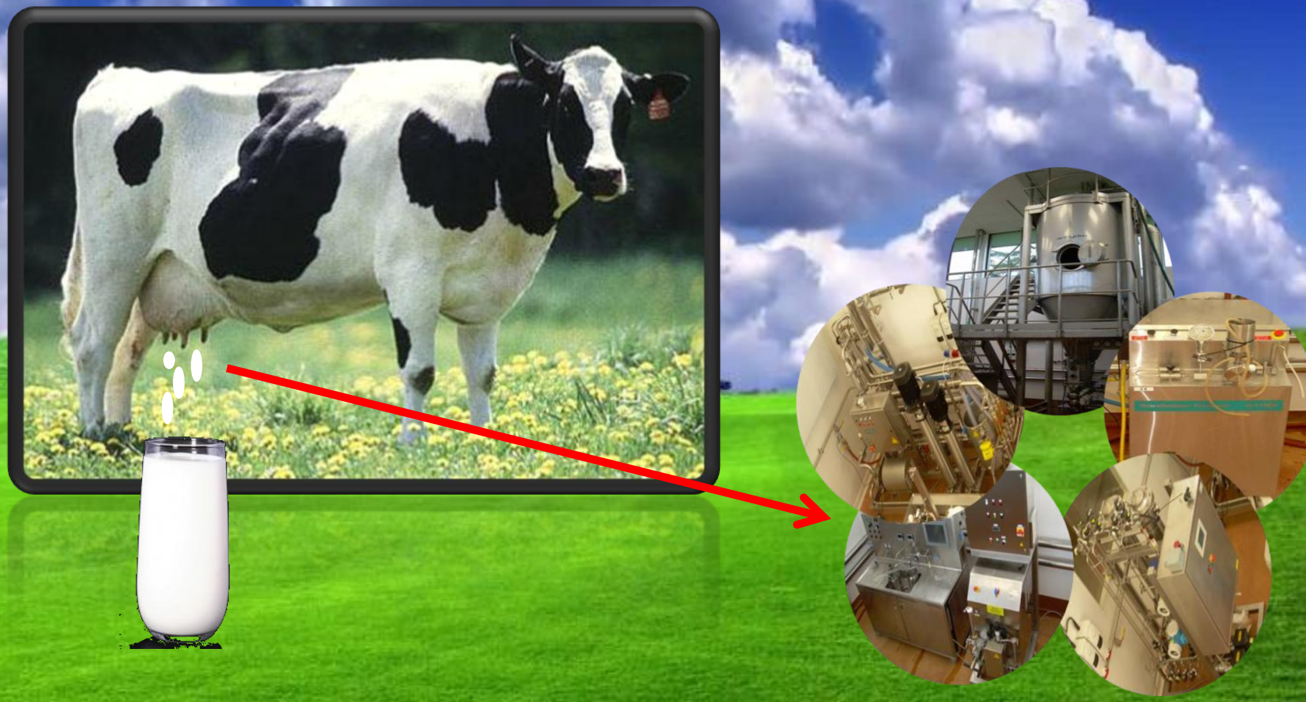
Presentation Guide

- Background
- Research approach
- Milk production
- Milk processability
- Predicting milk processability (MIR)




Milk Quality ‘Processing’!



Why milk processability?

- Milk urea nitrogen (MUN) concentrations very high in spring 2011
- MUN not beneficial from processing cheese perspective

Milk Proteins

<u>Casein: 78-80% of milk protein</u>

- as1, as2, b and k
- Relatively heat stable
- Aggregation, yoghurt / cheese manufacture

<u>Whey Proteins: 17-20% of milk protein</u>

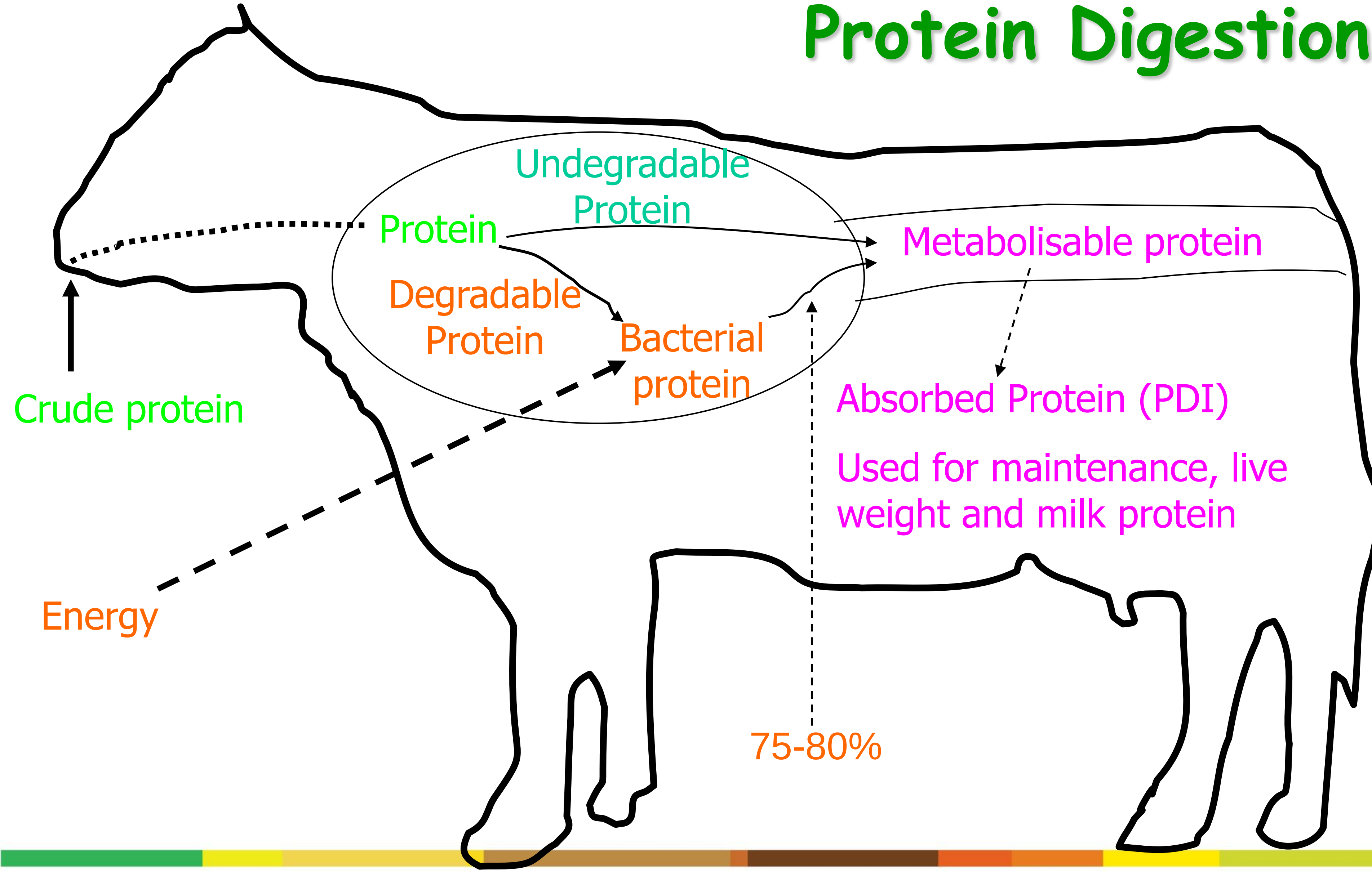
- Globular, highly folded, a-helices, b-sheets
- b-lactoglobulin (~10% total protein)
- a-lactalbumen (3.7%)
- Other serum proteins:BSA,Ig
- Not heat stable: can aggregate (gel)

<u>Non protein Nitrogen: 5%</u>

Why milk processability?

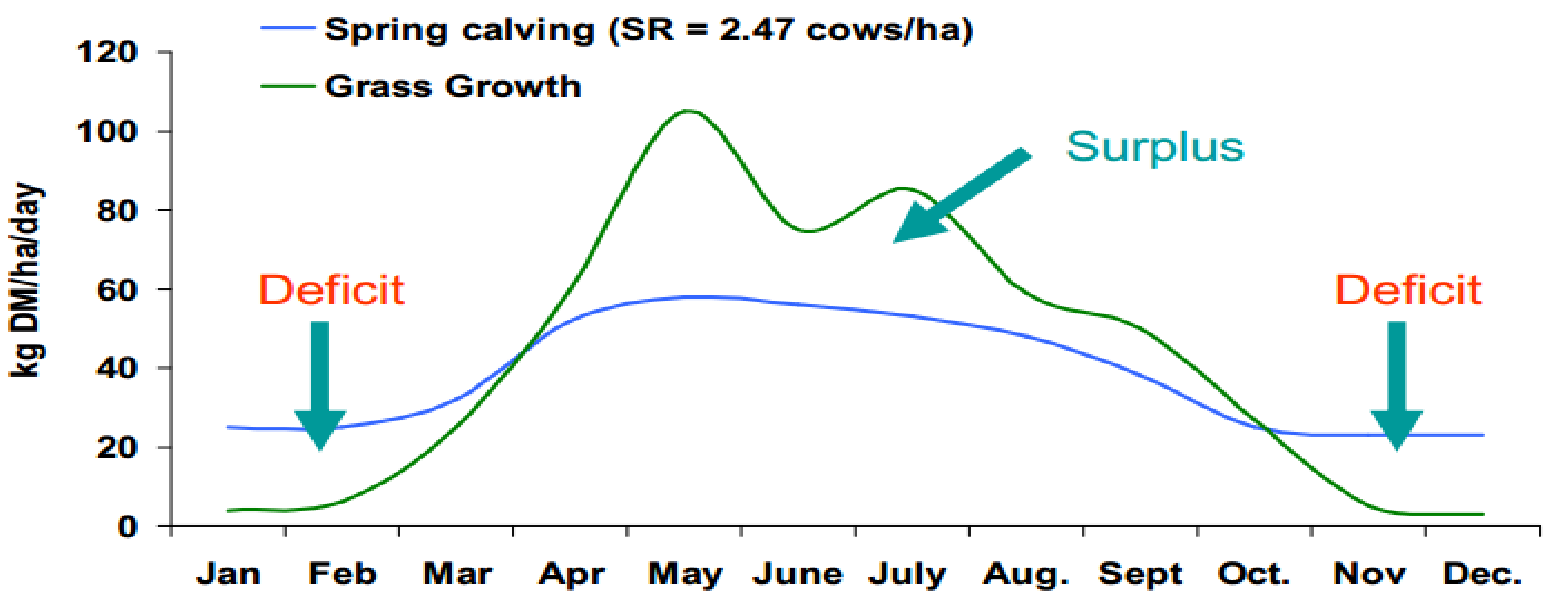
- Milk urea nitrogen (MUN) concentrations very high in spring 2011
- MUN not beneficial from processing cheese perspective
- What factors affect MUN?
  - Diet affects milk composition (Broderick, 2003) and milk processability (of which heat stability is an indicator) (Singh, 2004)
  - Stage of lactation has an important effect on milk processability (Guinee et al., 1999)

Protein Digestion



Ireland and the grass-based system

- Maximum profitability for dairy farms achieved through optimum utilisation of pasture (O'Donovan *et al.*, 2007)
- However, due to grass growth deficits in spring and autumn, and poorer grass quality in autumn, supplementation is required (Burke *et al.*, 2008)



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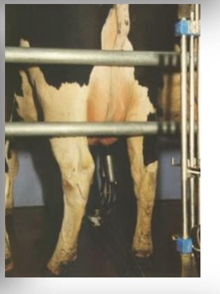


Research Approach

- Teagasc AGRIC and Teagasc FRC joint research
- Impose diets on dairy cows in spring (early lactation) and autumn (late lactation) to
  - Measure milk production
  - Generate milk from different treatments
    - Measure total milk protein, NPN and Non-casein N using Kjeldahl method
  - Remove fat by 'Separator' to make Skim milk
    - Measure protein profile (casein and whey)
  - Measure heat coagulation time on freeze dried samples

Experimental diets

- Spring – early lactation
- Autumn – late lactation
- Grazed grass as the base feed
- With supplementary feed
  - ↓ grazed grass as supplementary feed ↑
- Spring: no grass silage, only concentrate
- Autumn: both feeds considered

- Spring: 4 kg DM high, medium or low CP concentrate feed (+13 kg DM grazed grass)
- Autumn: 13 kg DM grazed grass alone, or with 4 kg DM supplementary feeds – grass, bale silage, pit silage or concentrate

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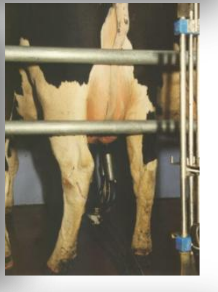
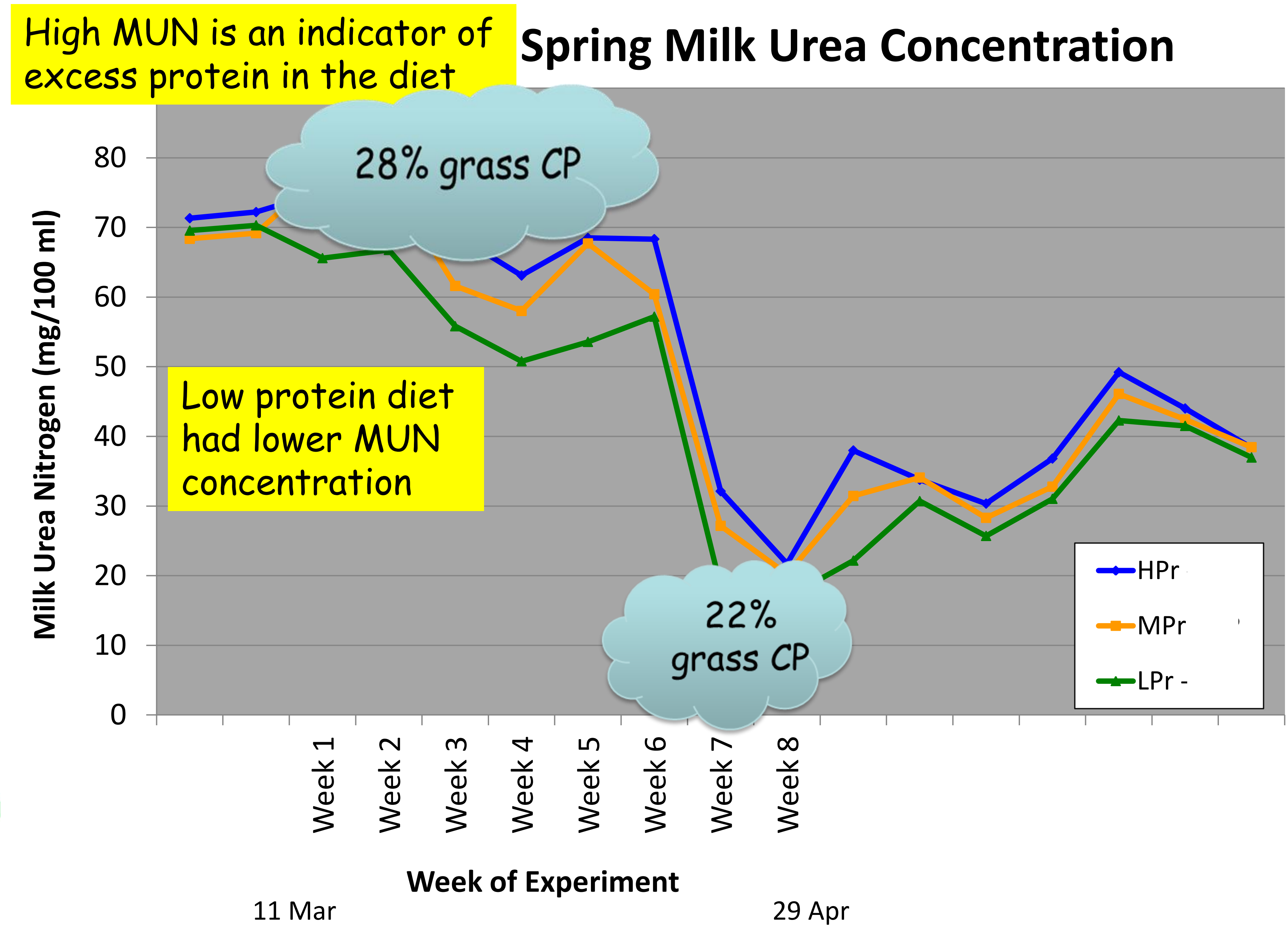


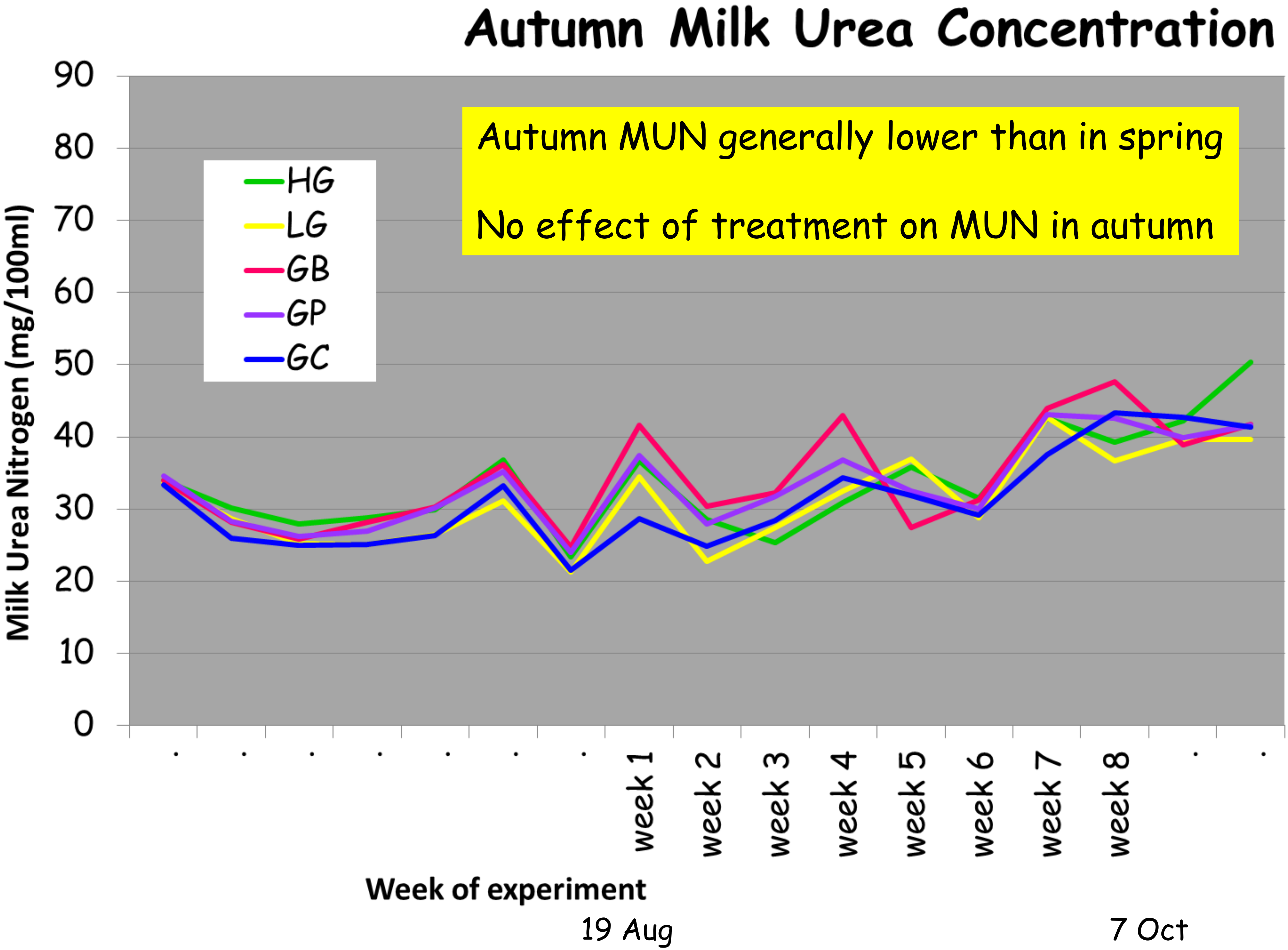

Milk production

13 kg DM grass SPRING 4 kg DM concentrate	High CP	Medium CP	Low CP
Milk Yield (kg/d)	27.6	27.0	26.2
Milk Fat (%)	4.5	4.5	4.6
Milk Protein (%)	3.41	3.36	3.37
Milk Solids (kg/d)	2.1	2.1	2.0

AUTUMN	17 kg DM grass (HG)	13 kg DM grass (LG)	LG + 4 kg DM bale silage (GB)	LG + 4 kg DM pit silage (GP)	LG + 4 kg DM conc (GC)
Milk yield (kg/d)	12.4[a]	11.5[b]	13.3[c]	13.3[c]	15.3[d]
Milk fat (%)	4.91	5.08	4.98	4.67	4.79
Milk protein (%)	3.88	3.76	3.75	3.78	3.88
Milk solids (kg/d)	1.08[a]	1.01[b]	1.12[a]	1.09[a]	1.29[c]

Spring Milk Urea Concentration





Autumn Milk Urea Concentration
Autumn MUN generally lower than in spring
No effect of treatment on MUN in autumn
HG
LG
GB
GP
GC
Milk Urea Nitrogen (mg/100ml)
90
80
70
60
50
40
30
20
10
0
week 1
week 2
week 3
week 4
week 5
week 6
week 7
week 8
Week of experiment
19 Aug
7 Oct

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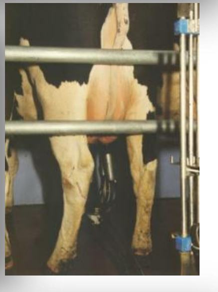


Selecting Milk Composition

…..for Processing!

Spring Milk protein fractions

Caseins account for ~80% of total protein – a higher concentration of casein increases cheese yield (Wedholm et al., 2006)

13 kg DM grass SPRING 4 kg DM concentrate	High CP	Medium CP	Low CP
α_{s1}-Casein (g/l)	11.31[a]	11.69[ab]	12.63[b]
α_{s2}-Casein (g/l)	2.42	2.26	2.36
β-Casein (g/l)	7.25	8.67	8.44
κ-Casein (g/l)	2.86	3.28	3.12
β-Lactoglobulin (g/l)	3.64[a]	4.21[b]	4.20[b]
α-Lactalbumin (g/l)	0.81	0.85	0.83

β-Lactoglobulin is associated with changes in milk heat stability

Autumn Milk protein fractions

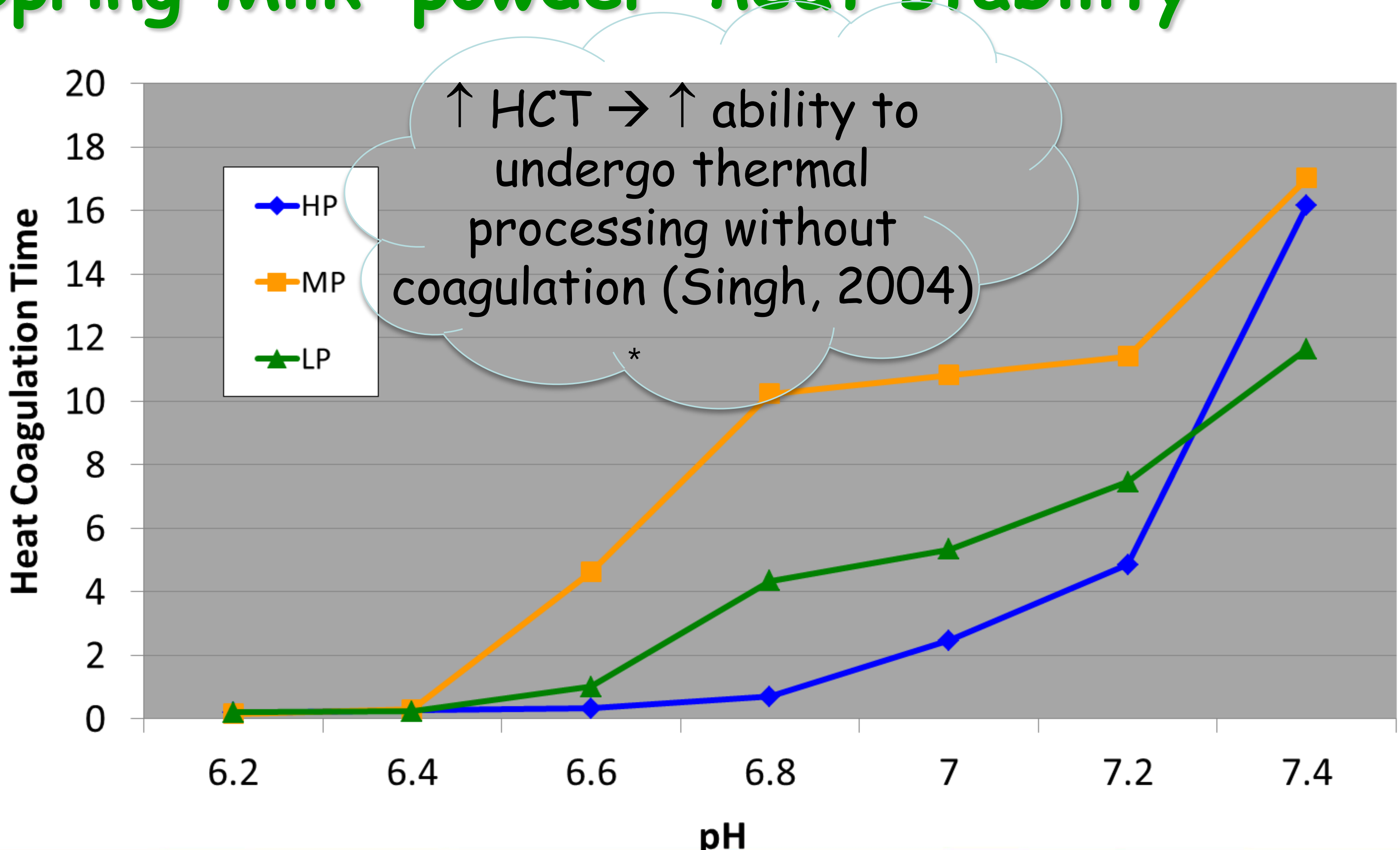
AUTUMN	17 kg DM grass (HG)	13 kg DM grass (LG)	LG + 4 kg DM bale silage (GB)	LG + 4 kg DM pit silage (GP)	LG + 4 kg DM conc (GC)
α_{s1}-Casein (g/l)	14.2	13.6	14.6	14.2	14.8
α_{s2}-Casein (g/l)	2.79	2.74	2.59	2.70	2.92
β-Casein (g/l)	8.63	8.96	10.40	9.20	9.57
κ-Casein (g/l)	4.62	4.26	4.19	4.03	4.27
β-Lactoglobulin (g/l)	4.83	4.58	4.84	4.68	4.81
α-Lactalbumin (g/l)	0.58[a]	0.60[a]	0.67[b]	0.65[b]	0.67[b]

α-Lactalbumin

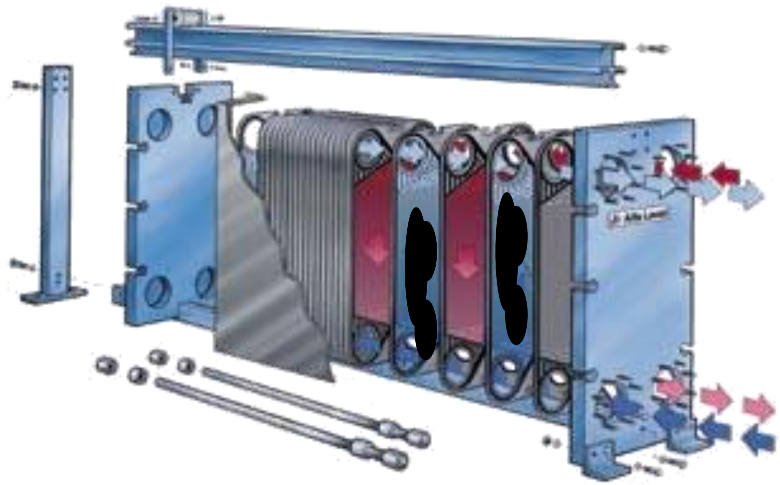
-is major protein of human milk → ↑ in proportion of α-LA in cow's milk helps it more closely mimic human milk (Lien, 2003)

-is related to production of milk lactose, so may be positively associated with milk yield (Farrell Jr et al., 2004) and therefore be reflective of milk yields of treatments

Spring Milk 'powder' heat stability



Consequences of low Heat stability – Fouling / Burn on



Protein (whey protein - denaturation/aggregation)

Protein (casein protein – precipitation, instability)

Increase in viscosity, back pressure on heat exchanger, etc.

Poor processability (protein burn on)

- Manufacturing downtime

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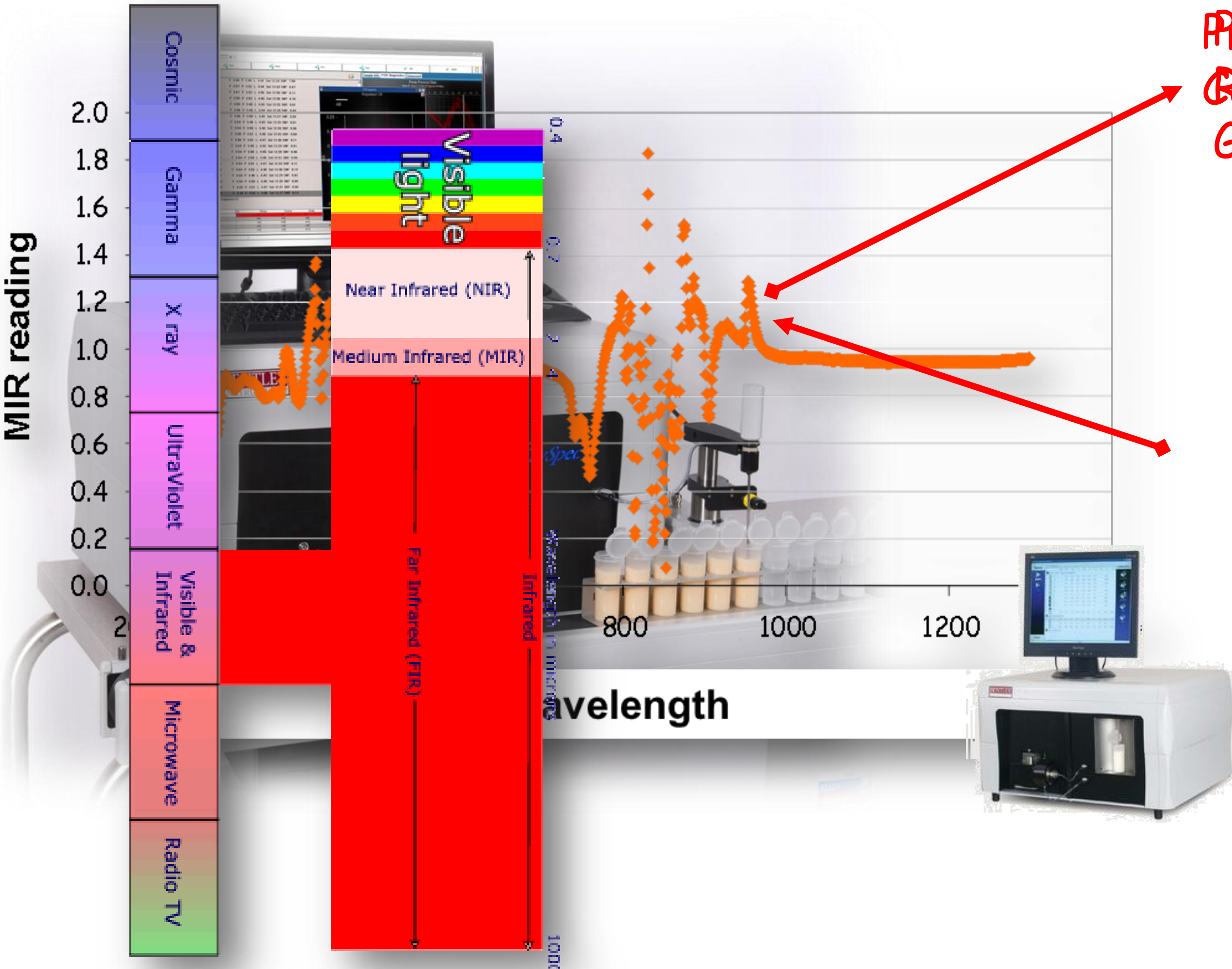
Predicting Processability?



Processability?
Protein, Fat, Lactose
RCT, HMPN Stability,
Casein, BPN
Gelation Properties

Mid-infrared Spectrometry

Breed quality data base (n=730)

Basic Composition

Fat
Protein
Casein
Urea
Lactose
Total Solids

Protein Profile

κ-casein
α-s1-casein
α-s2-casein
β-casein
α-lactablumin
β-lactoglobulin a
β-lactoglobulin b

Amino Acids

Cysteic Acid
Aspartic Acid
Threonine
Serine
Glutamic Acid
Glycine
Alanine
Cysteine
Valine
Methionine
Isoleucine
Leucine
Tyrosine
Phenylalanine
Histidine
Lysine
NH_3
Proline

Physical

Casein Micelle size
Colour
- Lightness
- Blueness
- Yellowness

Functional

Heat stability
Native pH
Coagulation Properties
- Rennet Coagulation time
- Curd firmness

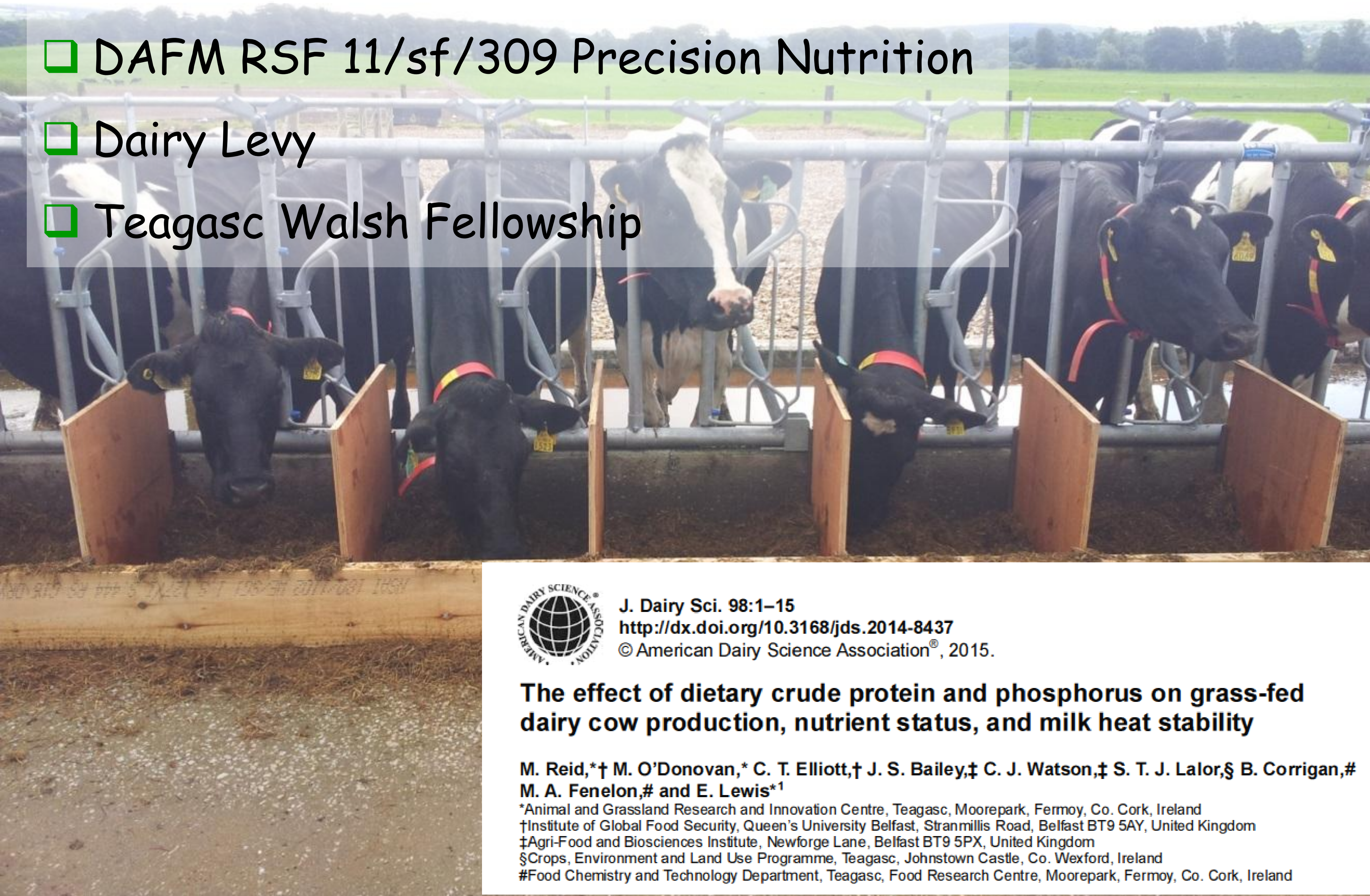
Minerals (n=140)

Full mineral profile

Correlation between gold standard and MIR-predicted traits

- Proteins 0.39 (beta LG a) to 0.69 (total LG)
- Amino Acids 0.22 (Threonine) to 0.75 (Glycine)
- Coagulation time (RCT) 0.74
- Milk pH 0.84
- Heat stability 0.68

Acknowledgements



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The effect of dietary crude protein and phosphorus on grass-fed dairy cow production, nutrient status, and milk heat stability

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