Seasonal variation in composition and chemistry of milk from the national milk pool

Moorepark Milk Quality Workshop

December, 2014

B. O'Brien, N. Galvin, E. Lewis

Teagasc
Agriculture and Food Development Authority

The Irish Agriculture and Food Development Authority

Introduction

Important to get a snapshot of the composition, quality and processability of national milk pool

Changes in milk production methods have changed significantly since the previous database was set up (1999)

Calving date; feeding practises; seasonality

Particularly important to establish mineral content of milk - critically important to the infant feed formula industry

Objective:

To determine the composition, processing characteristics and mineral level of the national milk pool and variation over the season

Procedures and methodologies

- Milk samples were collected from 8 milk processors/ co-ops in different geographical locations in order to get a representative sample of the national milk pool
  - *Co-ops/ Processors*:
  - Arrabawn, Aurivo, Carbery, Dairygold, Glanbia, Kerry, Lakelands, Tipperary

- Milks were collected on alternate weeks during the main lactation period, i.e. commencing in February and continuing until volumes of milk decreased in November -2013

- Milk samples were taken from the 'Manufacturing milk' supplies.
- Milks for mineral analysis were stored frozen until tested

Milk quality measurements:

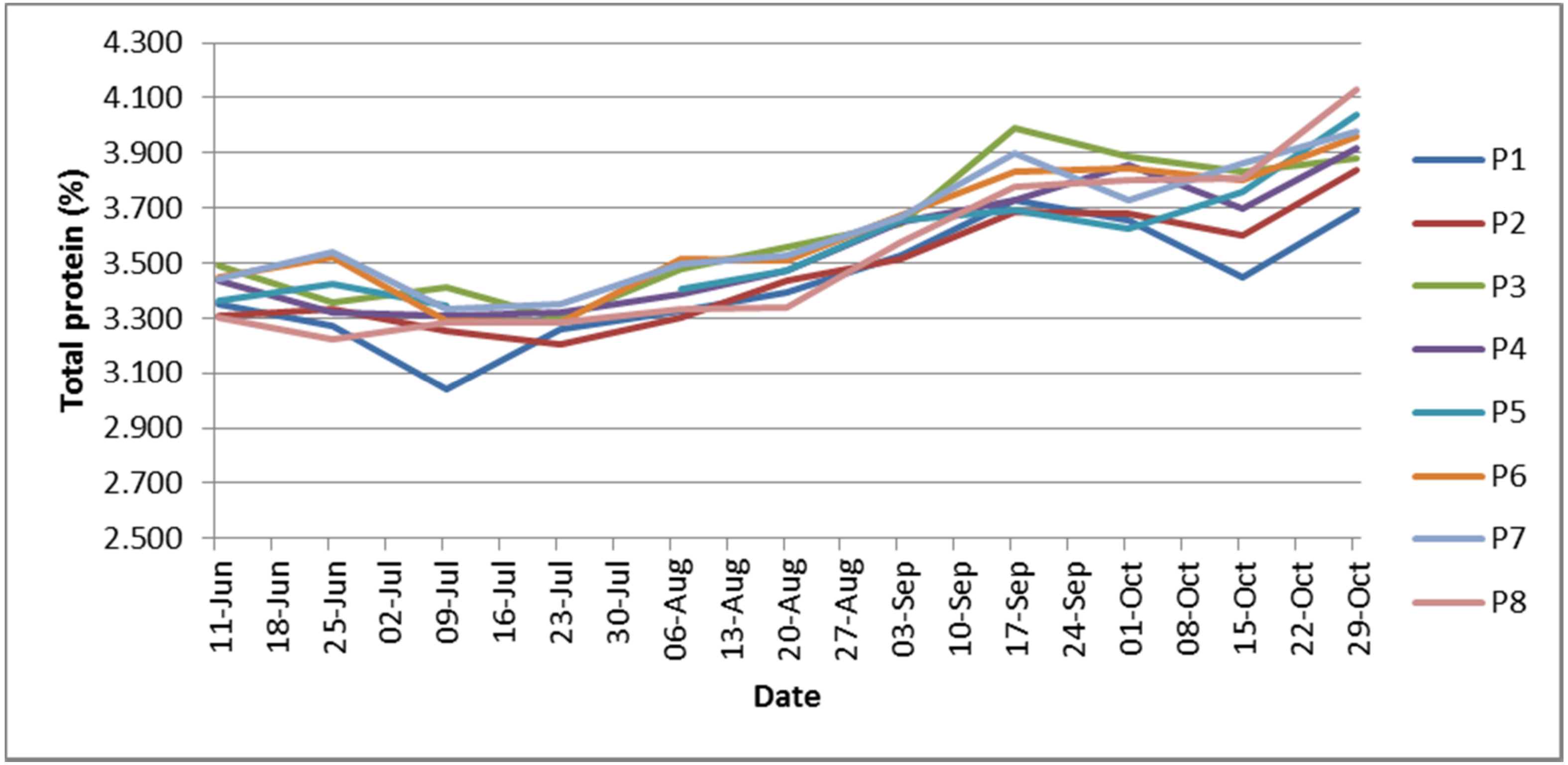
Nitrogen fractions – total protein, NPN, casein number

pH, SCC

lactose content

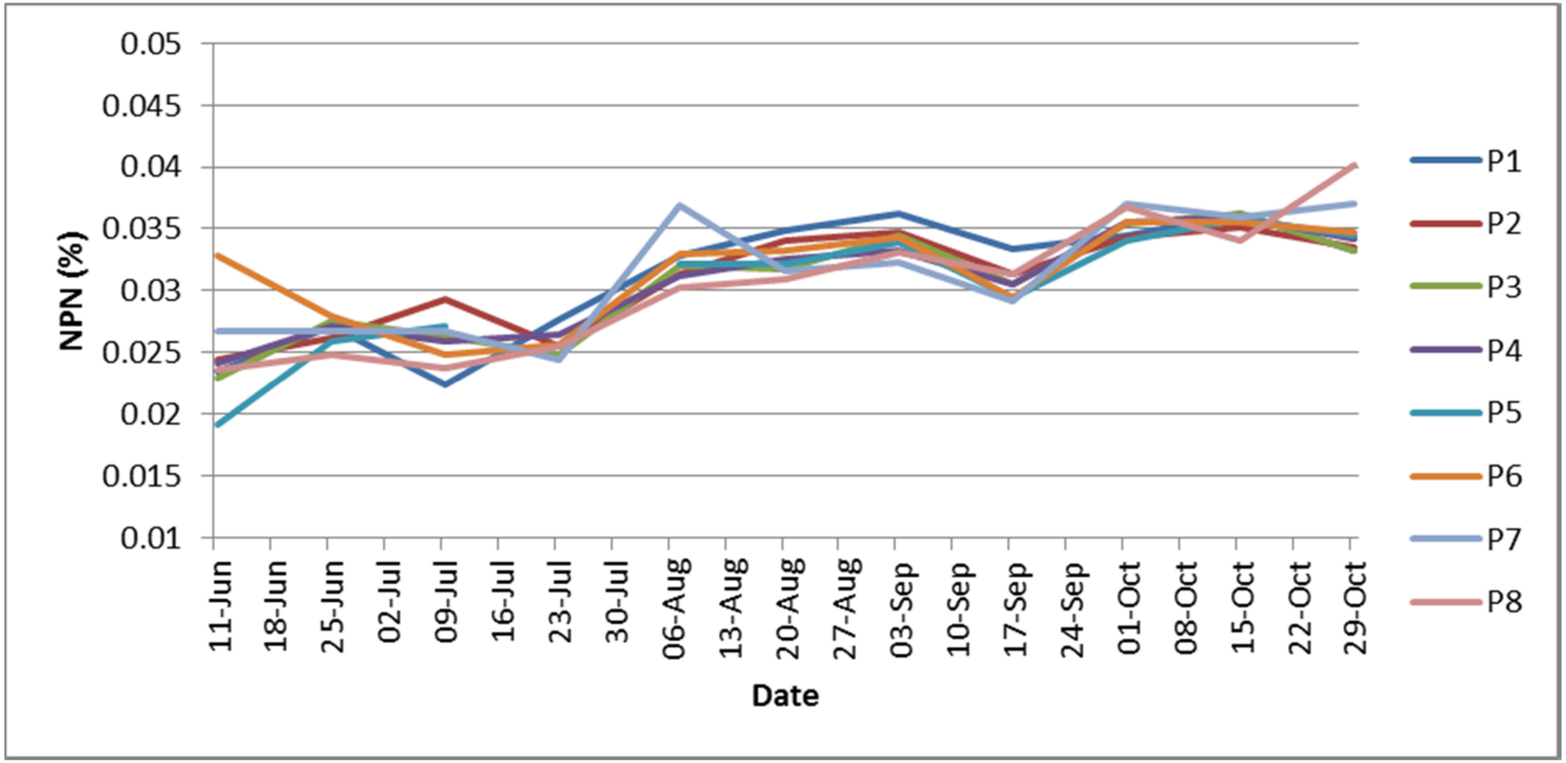
Mineral and trace element levels

Milk total protein %



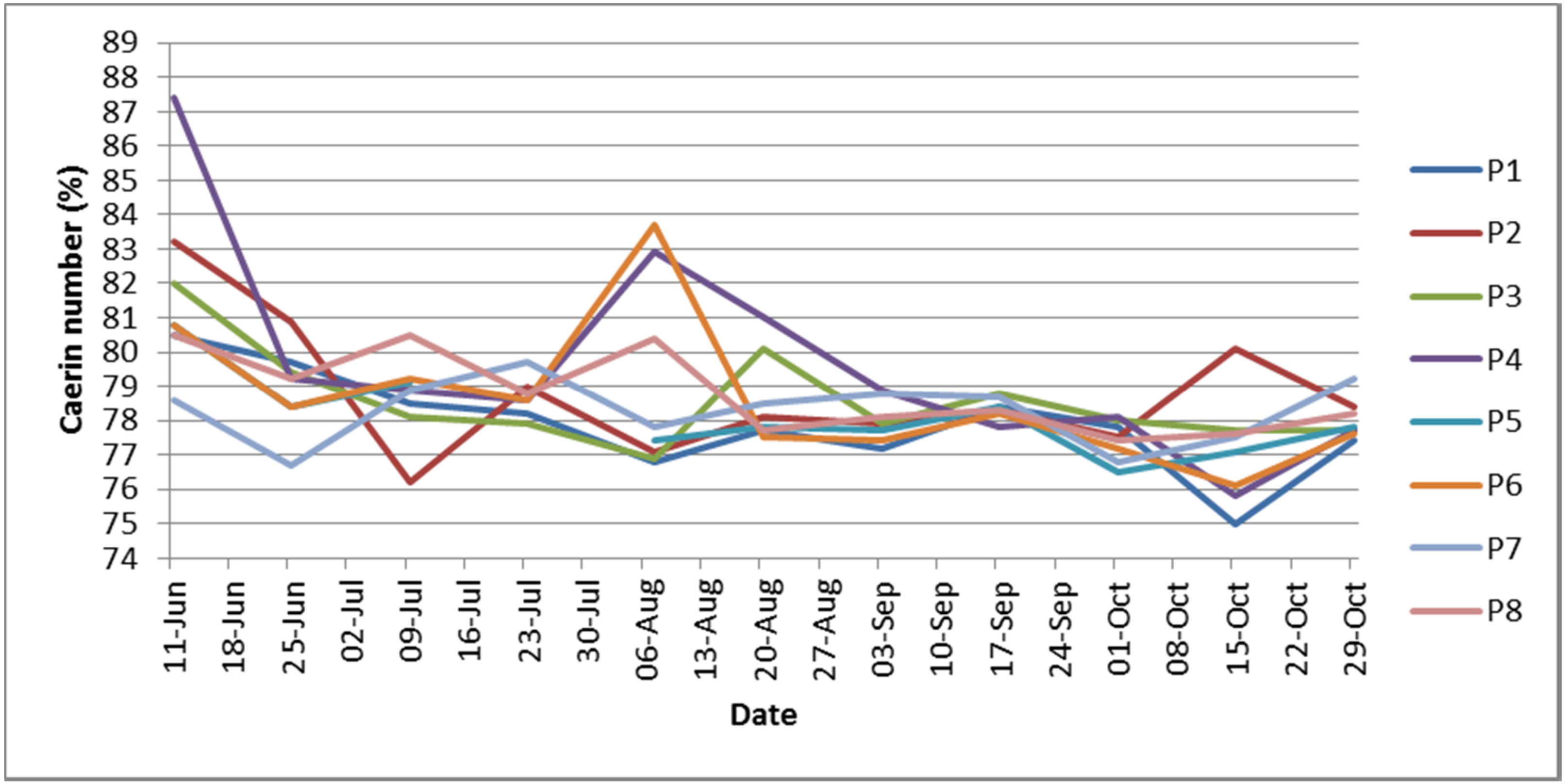
Av = 3.55%; range 3.39% - 3.93%

Milk NPN %



Av = 0.031%; range 0.025% - 0.035%

Milk casein number %



Av = 78.6%; range 81.7% - 78.0%

N fraction trends

- Casein number is defined as (Casein /Total protein)*100
  - Large increase in milk protein concentration
  - Proportionally smaller increase in the milk casein
  - Then lower casein number
- Not just level of protein but quality of the protein as well
- The NPN level important. High protein levels in grass in spring time – very high milk protein - Payment on this BUT high NPN as well. Milk urea represents about ~50-60% of the NPN fraction of milk protein.

Effect of year on average nitrogen fractions in milk on two Moorepark farms in Feb 2010 (average of values of weeks ending 7, 14, 21, 28 Feb) and Feb 2011 (average of values of weeks ending 6, 13, 20, 27 February) (978 Feb records used)

Farm	Year	Milk Protein %	Milk Casein %	Casein no. %	Milk Urea mg/100ml
1	2010	3.42	2.62	78.0	43.5
	2011	3.74	2.83	75.5	73.4
2	2010	3.49	2.76	79.5	44.7
	2011	3.67	2.78	75.6	68.0
Average 1	2010	3.46	2.69	78.8	44.1
Average 2	2011	3.70	2.81	75.5	70.7

Higher Milk Protein % in 2011 compared to 2010
Higher Milk Casein % in 2011 compared to 2010

Lower Casein Number in 2011 compared to 2010
Higher Milk Urea in 2011 compared to 2010

Grass crude protein levels

Crude protein concentration (CP %) of grass samples from 2010 were compared to grass samples from 2011. These grass samples were cut from grazing paddocks at Teagasc Moorepark and were cut, dried (40oC for 48 hours), milled and scanned by NIR

Year	Number samples	Dates	Mean CP %	Min	Max	St dev
2010	7	1 – 12 Mar	21.8	20.0	23.7	1.48
2011	6	10 Feb – 2 Mar	26.8	25.2	30.0	1.76

It is clear that the crude protein concentration is considerably higher (by 5% units) in 2011 than it was in 2010.

High dietary CP levels resulted in an increase in the NPN proportion of milk protein and a decrease in the Casein No.

Why was dietary CP in 2011 higher than in 2010?

- Increase in grass CP
- Coupled with an increase in grass intake

Why did this occur ?

No over-winter growth in 2011 → the grass takes up N in preparation for new growth, but if there is no growth then the increased N just remains.

Why was grass intake higher in 2011 than in 2010?

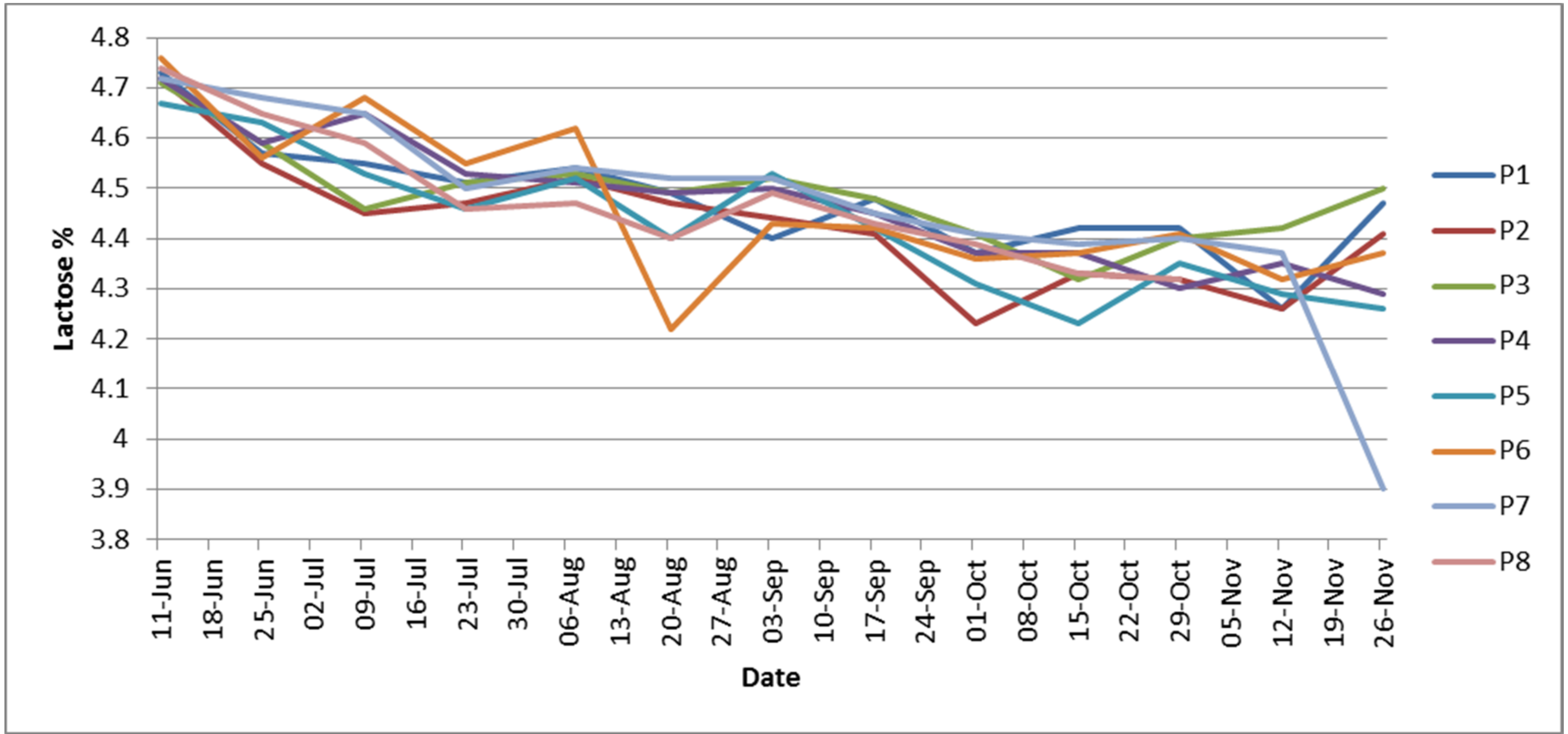
- Good grazing conditions
- Good availability of grass
- Teagasc advice
  Importance of grass in the early lactation diet
  Importance of getting to grass early to condition sward for subsequent grazings
  Reduces requirements for supplementation

Solutions

Decrease the CP concentration of the diet

- as grass growth increases, the concentration of N in grass will decrease
- change the diet mix / supplementation
  - supplement: low protein, high energy

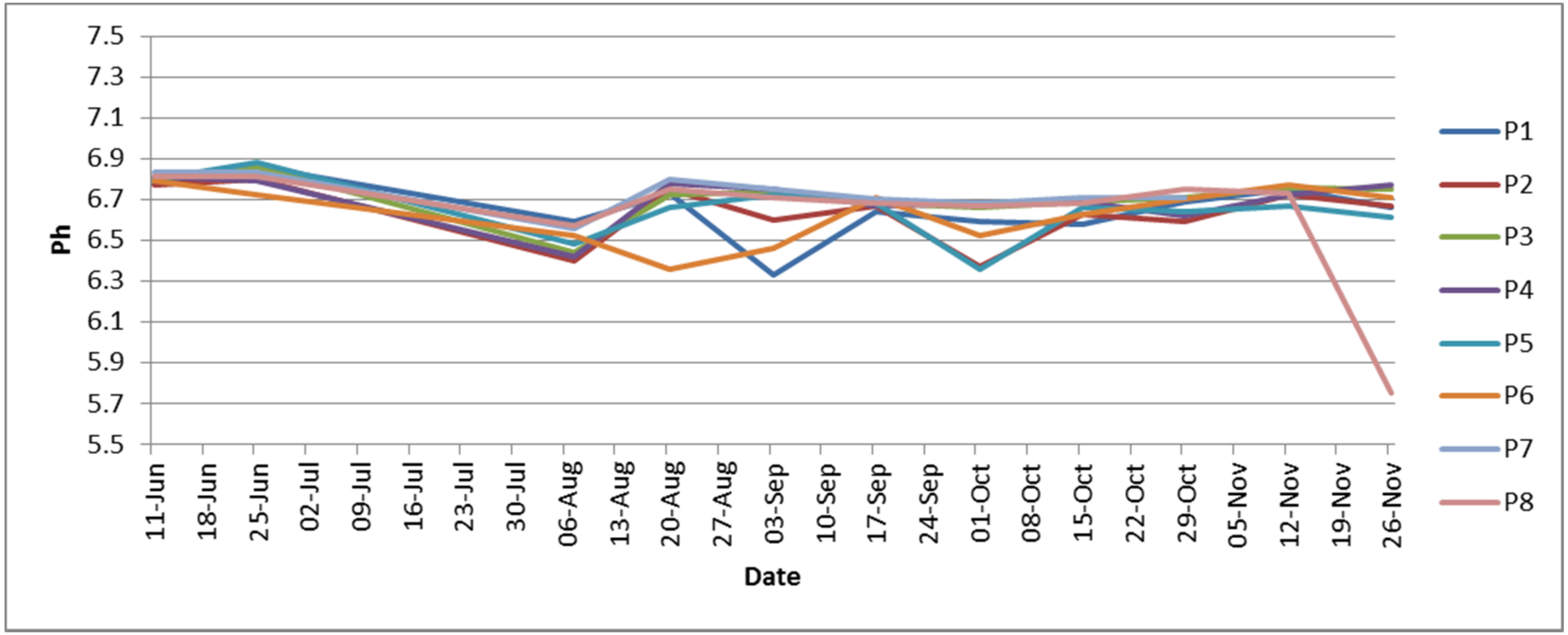
Milk Lactose %



Av = 4.46%; range 4.72% - 4.31%

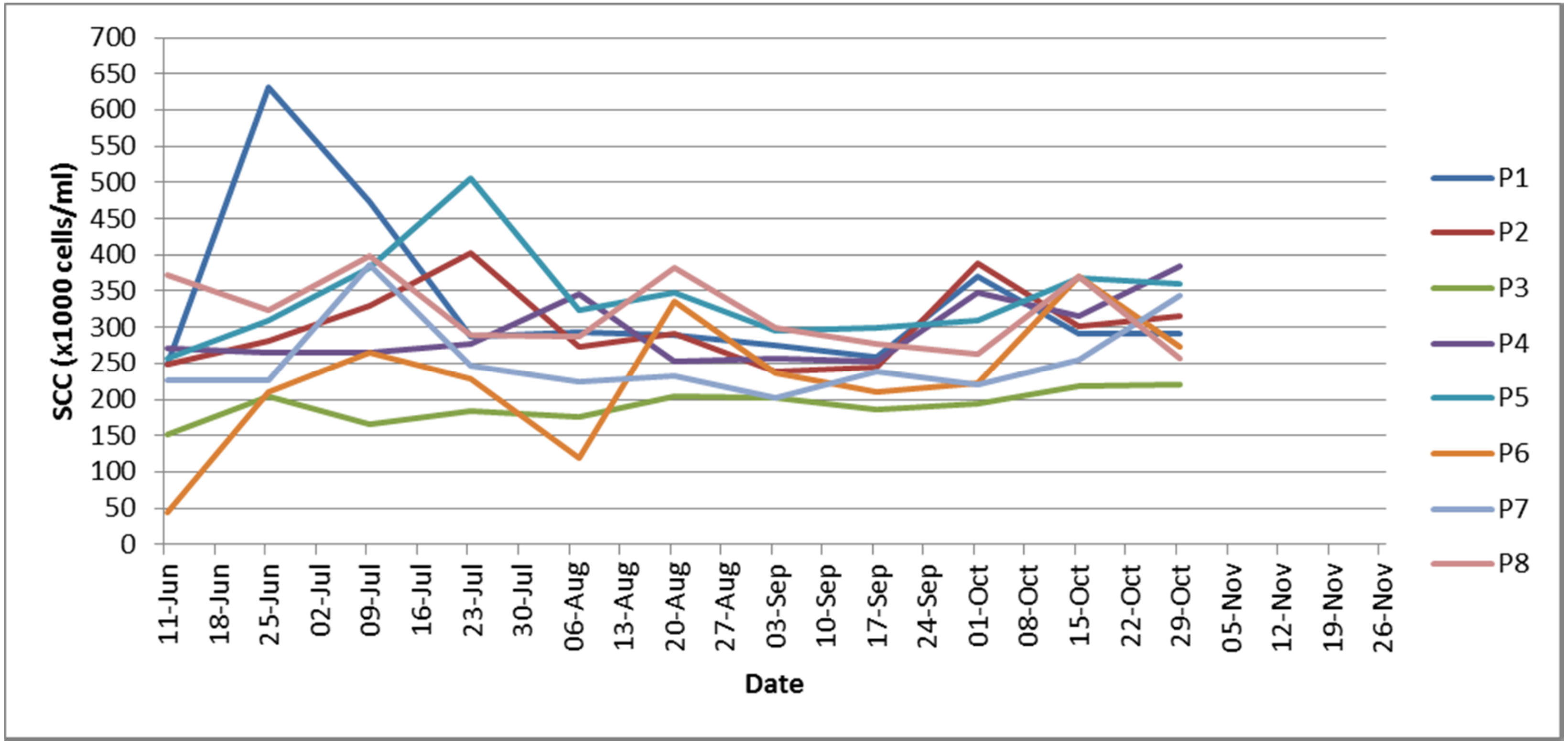
Max 4.21% (1999)

Milk pH



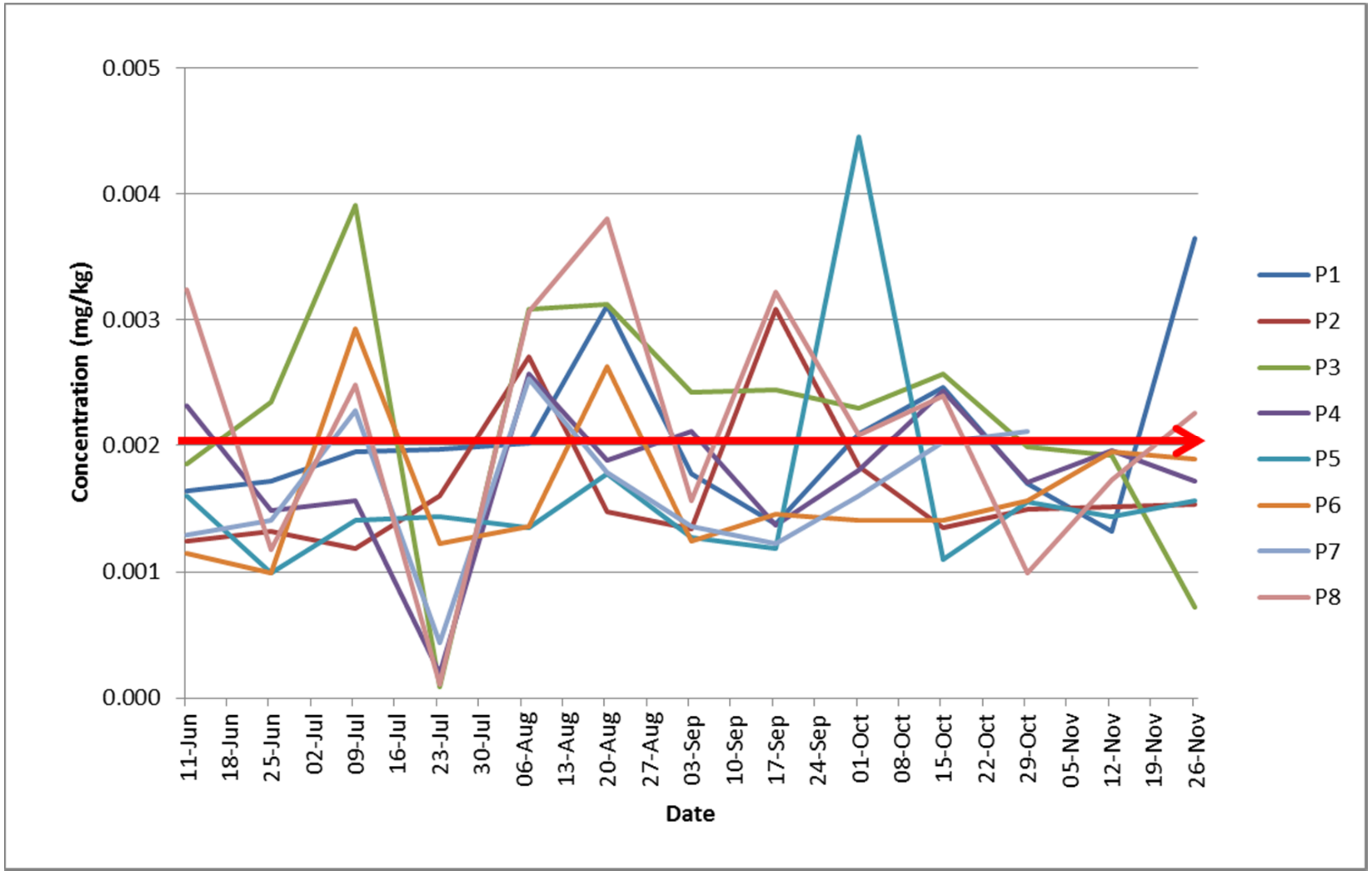
7.5
7.3
7.1
6.9
6.7
6.5
6.3
6.1
5.9
5.7
5.5
Ph
11-Jun
18-Jun
25-Jun
02-Jul
09-Jul
16-Jul
23-Jul
30-Jul
06-Aug
13-Aug
20-Aug
27-Aug
03-Sep
10-Sep
17-Sep
24-Sep
01-Oct
08-Oct
15-Oct
22-Oct
29-Oct
05-Nov
12-Nov
19-Nov
26-Nov
Date
P1
P2
P3
P4
P5
P6
P7
P8

Milk SCC



SCC (x1000 cells/ml)
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
11-Jun
18-Jun
25-Jun
02-Jul
09-Jul
16-Jul
23-Jul
30-Jul
06-Aug
13-Aug
20-Aug
27-Aug
03-Sep
10-Sep
17-Sep
24-Sep
01-Oct
08-Oct
15-Oct
22-Oct
29-Oct
05-Nov
12-Nov
19-Nov
26-Nov
Date
P1
P2
P3
P4
P5
P6
P7
P8

Milk TCM



0.005
0.004
0.003
0.002
0.001
0.000
Concentration (mg/kg)
11-Jun
18-Jun
25-Jun
02-Jul
09-Jul
16-Jul
23-Jul
30-Jul
06-Aug
13-Aug
20-Aug
27-Aug
03-Sep
10-Sep
17-Sep
24-Sep
01-Oct
08-Oct
15-Oct
22-Oct
29-Oct
05-Nov
12-Nov
19-Nov
26-Nov
Date
P1
P2
P3
P4
P5
P6
P7
P8

Mineral and trace element analysis

- Iodine
- Magnesium
- Phosphorus
- Calcium
- Zinc
- Manganese
- Iron
- Cobalt
- Copper
- Selenium
- Molybdenum

Analysis

ICP-MS

Induction Coupled Plasma Mass Spectrometry

General points on minerals and trace elements

- **Minerals and trace elements contribute to the buffering capacity of milk, the maintenance of milk pH, the ionic strength of milk, and milk's osmotic pressure**
- **Some, such as Zn, Mg, Fe, Cu, Mn and Mo, are required by enzymes as cofactors**
- **Ca, P – major minerals found in milk. Required by young - mostly associated with the casein micelle structure**
- **Fe in milk is bound to lactoferrin, xanthine oxidase (an enzyme associated with the cell membrane) and some to caseins**
- **Zn in cow's milk is mostly bound to casein, but some is bound to lactoferrin**
- **Cu is bound to the caseins, to ß-lactoglobulin, to lactoferrin, and some to the milk fat membranes**
- **Mo is bound to xanthine oxidase and inner surface of the milk fat globule membranes**
- **Mn is associated with the milk fat membranes**
- **Co is an essential part of vitamin B12**

Should not be significant problem in Ireland

Originate from cows grazing on land or from contaminated feed stuffs

Land can naturally contain high levels of certain metals or may be contaminated by industry;

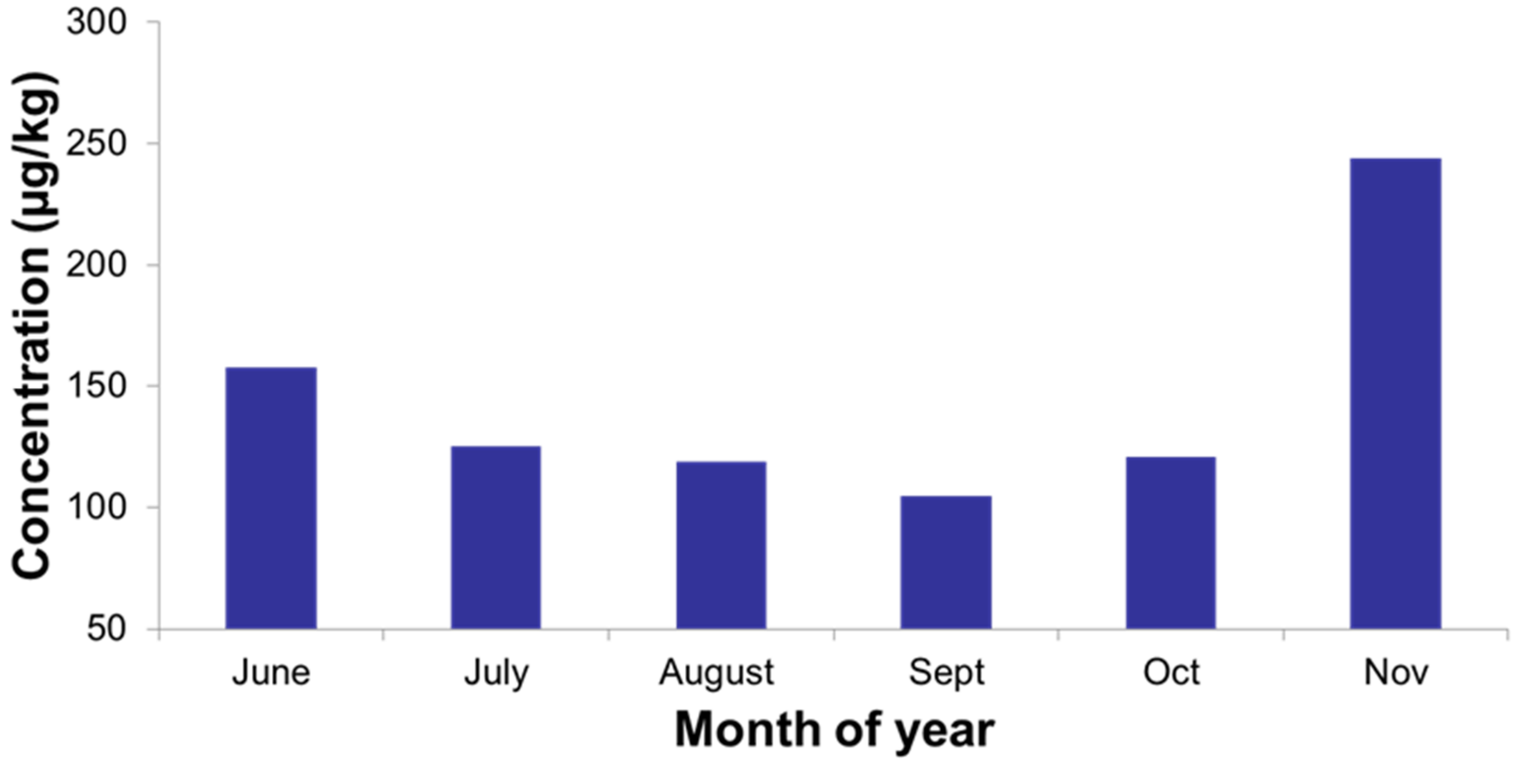
Research study (Simsek *et al*., 2000) - highest heavy metal content was found in the milk samples collected from industrial region followed by traffic intensive region and rural region

In the Irish scenario

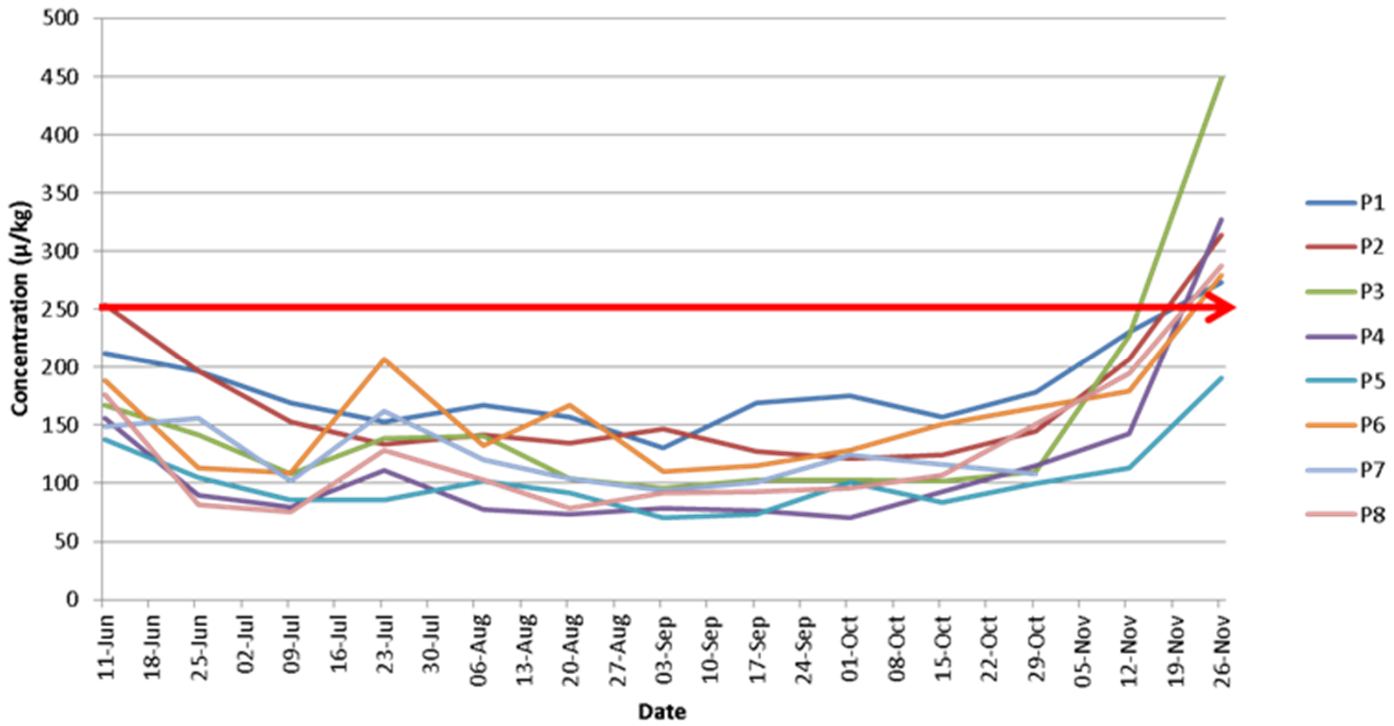
- grass an unlikely source in the Irish scenario due to the rural nature of milk production
- 90% of milk in Ireland is produced from forage - little opportunity for concentrate feedstuff to be a serious source - maximum of approximately 400-500kg of meal to be fed per cow during the full course of the lactation

BUT variation in content may be an issue

Average monthly Iodine concentrations for 8 processor milks-2013



Iodine concentrations for 8 processor milks at 13 dates -2013



Av = 143ppb; range 102 – 302ppb
Av = 280ppb; range 180 – 510ppb (1999)

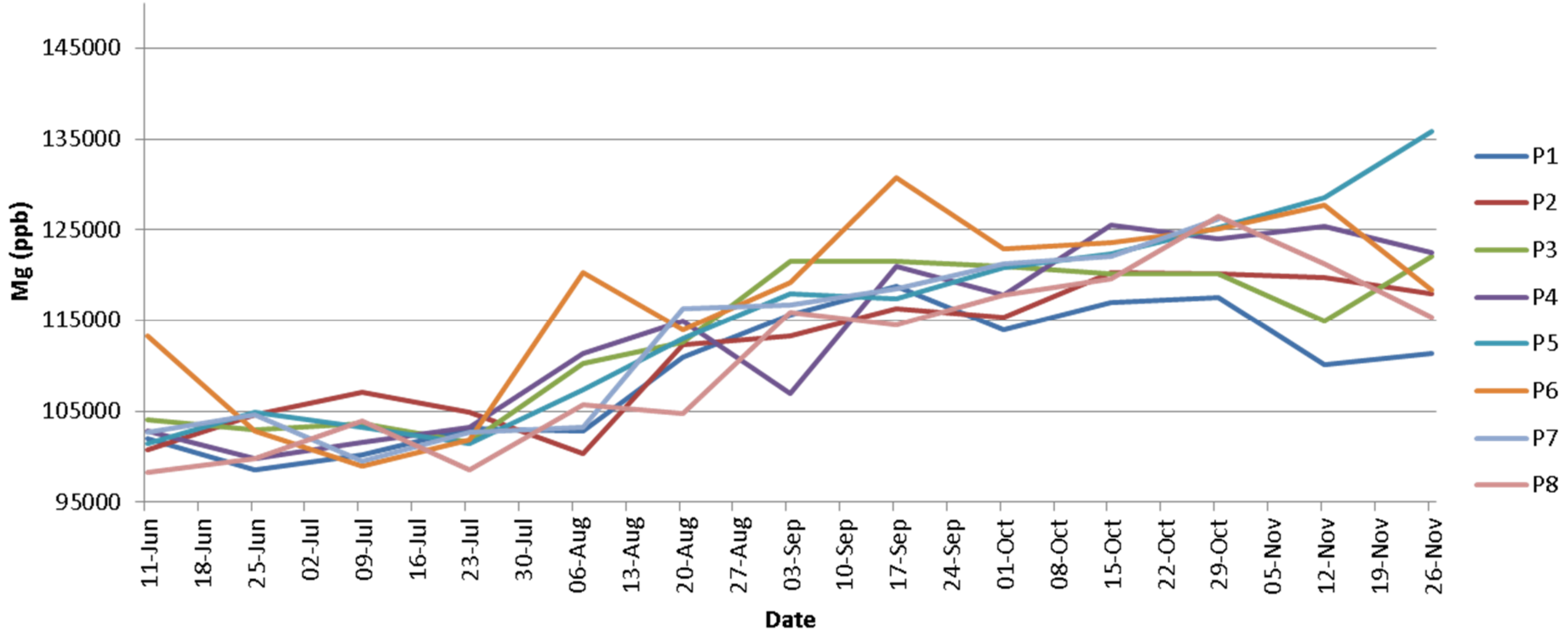
Milk iodine is a quality issue

- Infant formula industry is important in Ireland – necessary to have correct levels and balance of minerals including iodine
- Target for iodine in milk powder as an ingredient in IMF :
  - 100 μg iodine/ 100g powder; equates to <250 μg iodine/kg milk
- Difficult to source at times of year, e.g. - concentrations of >500 μg/kg recorded for December (O'Brien *et al*. 1999)
- Higher Iodine levels observed during winter period – when concentrate levels may be significant proportion of diet – pre-milking teat disinfection
- Lower Iodine concentrations observed in milk compared to previously
- More use of non-iodine teat dips; iodine levels reduced in concentrates ? or less concentrates fed in autumn 2013 ?

Iodine continued

- From Nov the iodine content of Valio Premier plus protein enriched milk will be detailed on the front and back of cartons in Finland and Sweden
- By May 2015 the 16 micrograms/100 ml iodine content of all Valio basic, lactose free and protein enriched milk and milk powder will be detailed beneath calcium on the nutrition label of each package
- The EU recommends that adults consume 150 micrograms of iodine per day
- Drinking half a litre a day of Valio milk with its 16 micrograms of iodine/100 ml would give an adult more than half of their EU recommended daily intake of 150.

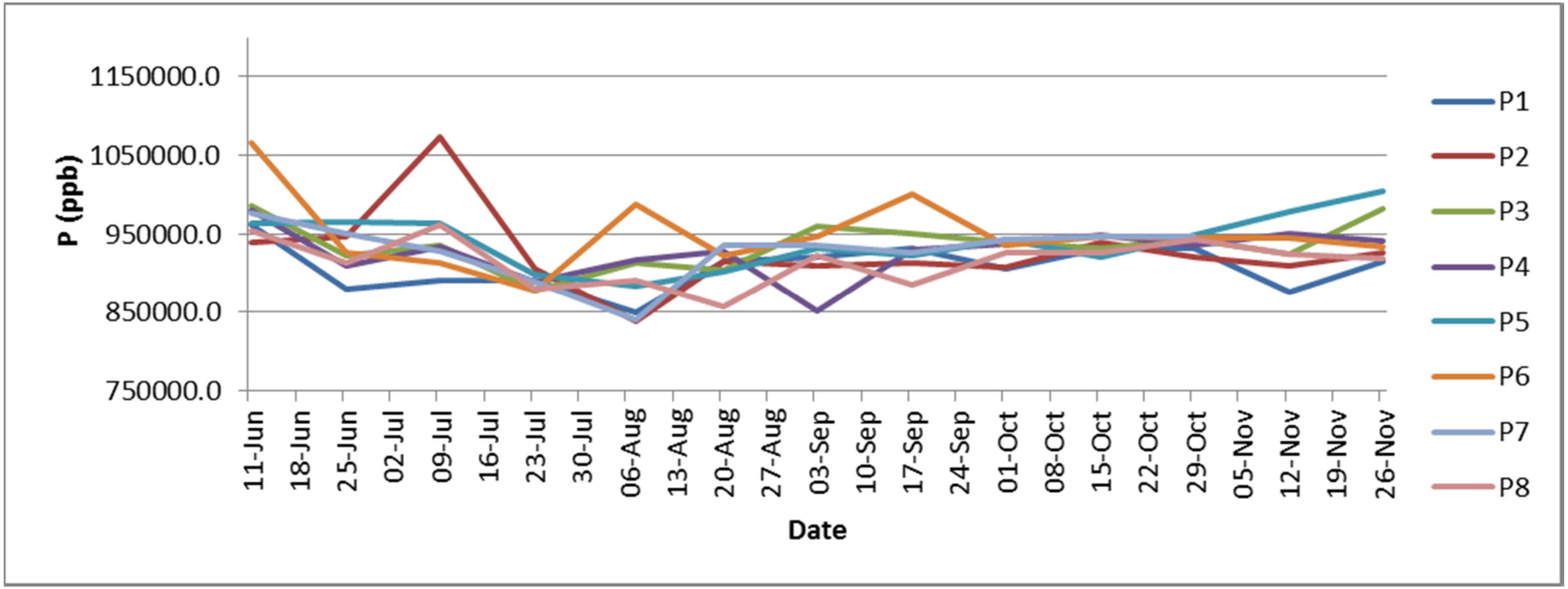
Milk Mg concentration



Av = 113,124ppb; range 102,149 - 123,130ppb

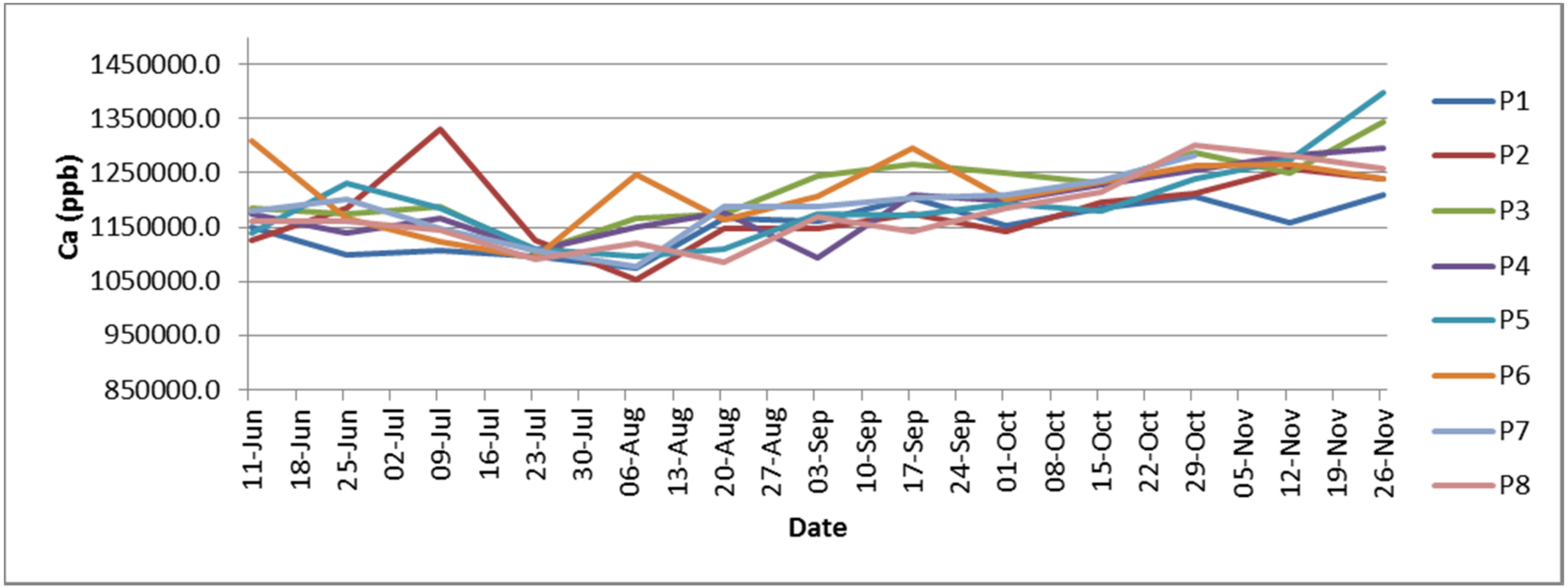
Av = 110,000ppb; range 96,000 – 117,000ppb (1999)

Milk P concentration



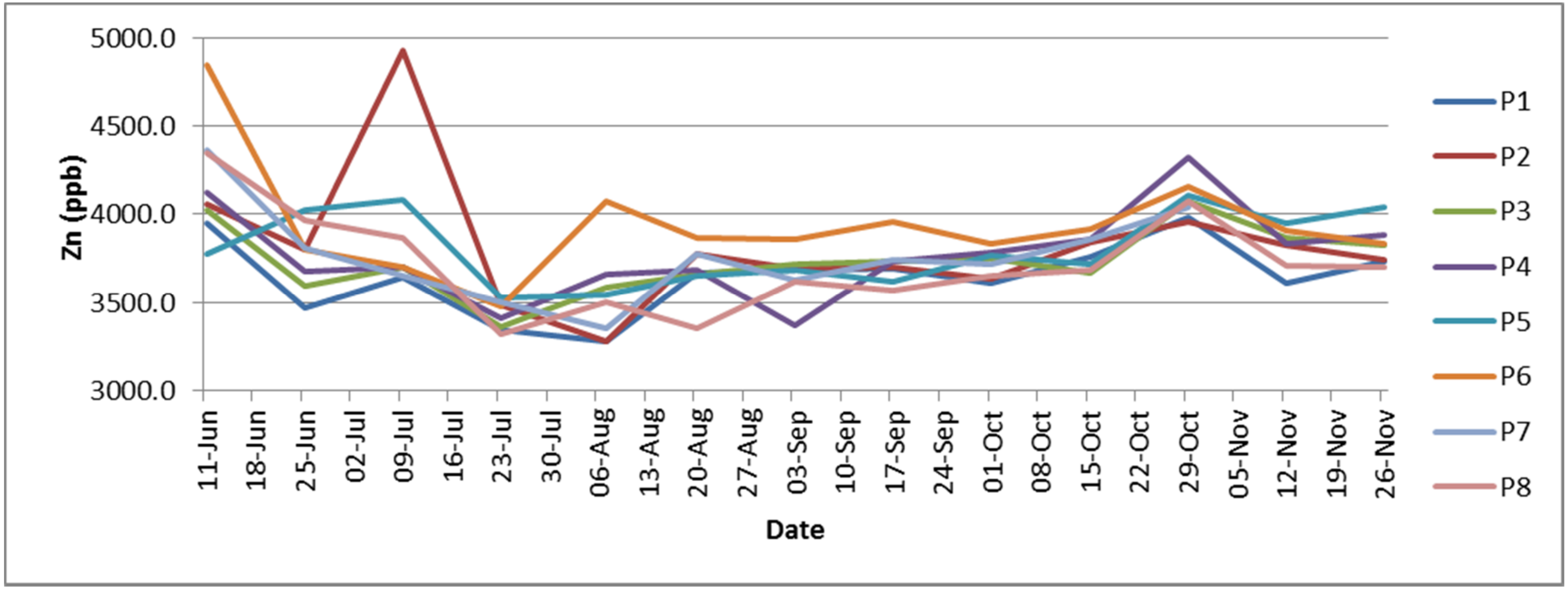
Av = 929,254ppb; range 888,781 - 978,579ppb

Milk Ca concentration



Av = 1190,838ppb; range 1104,458 - 1283,386ppb

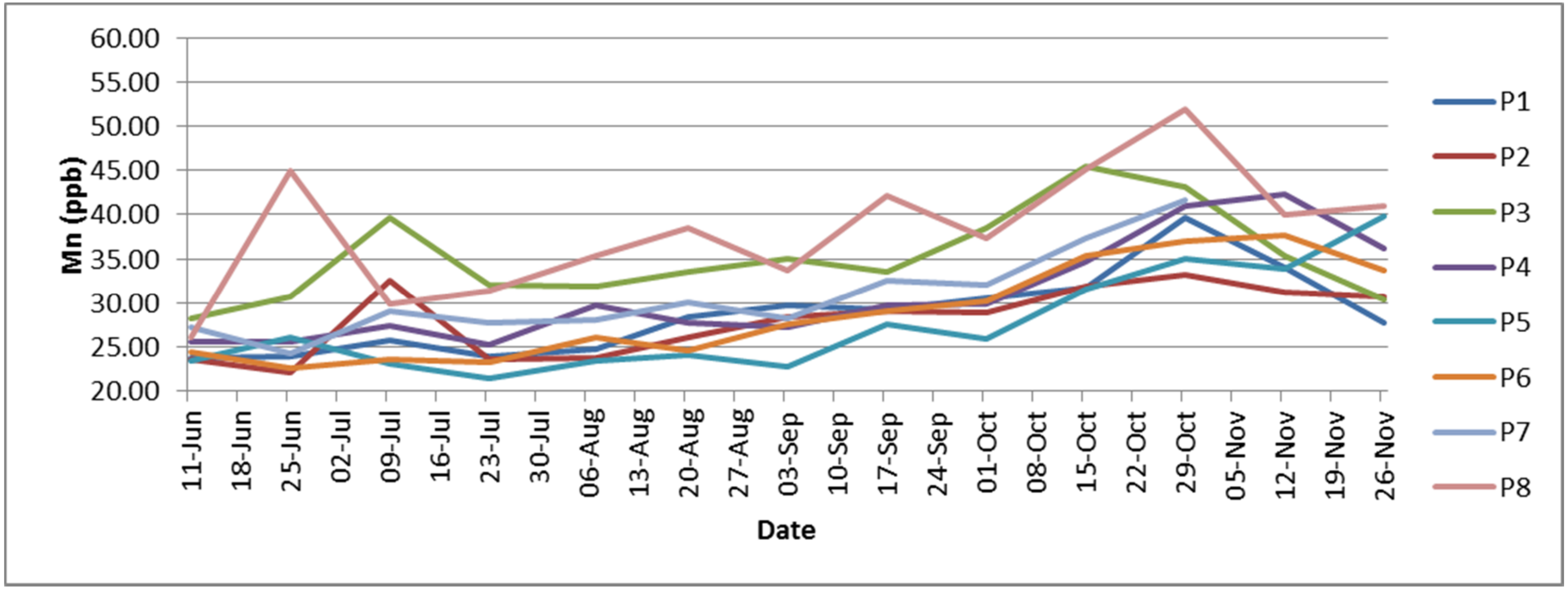
Milk Zn concentration



Av = 3,777ppb; range 3,428 - 4,185ppb

Av = 3,950 ppb; range 3,650 – 4,540ppb (1999)

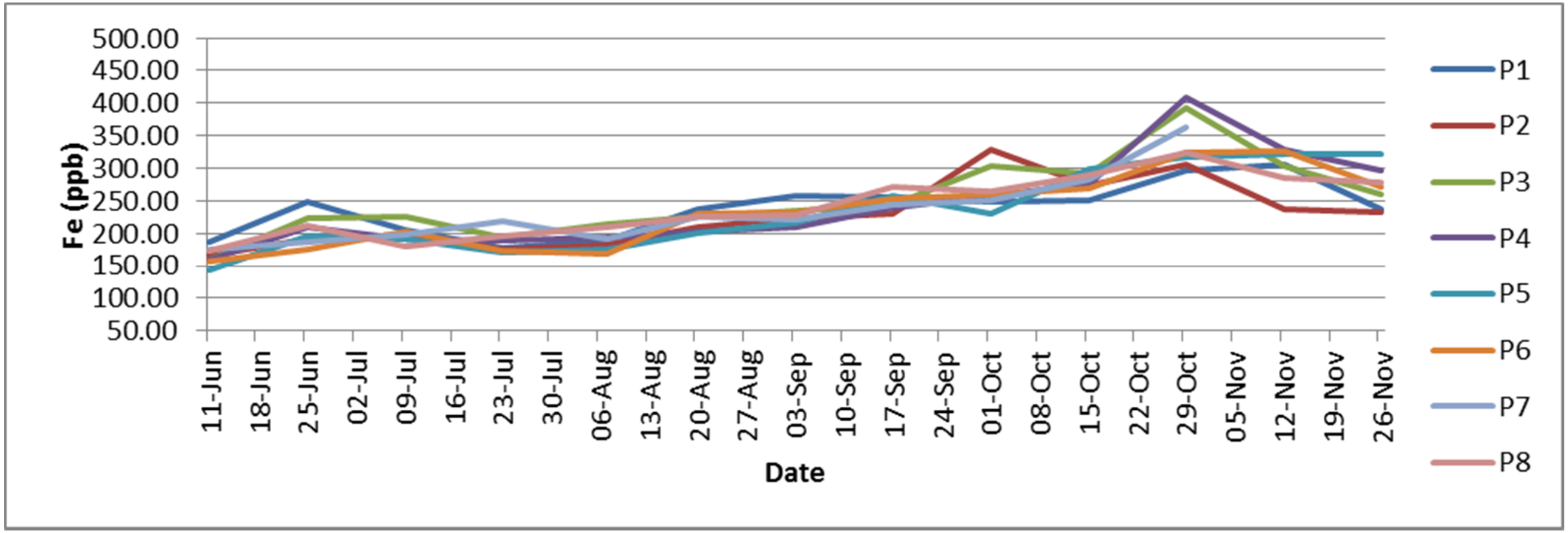
Milk Mn concentration



Av = 31ppb; range 25 – 40ppb

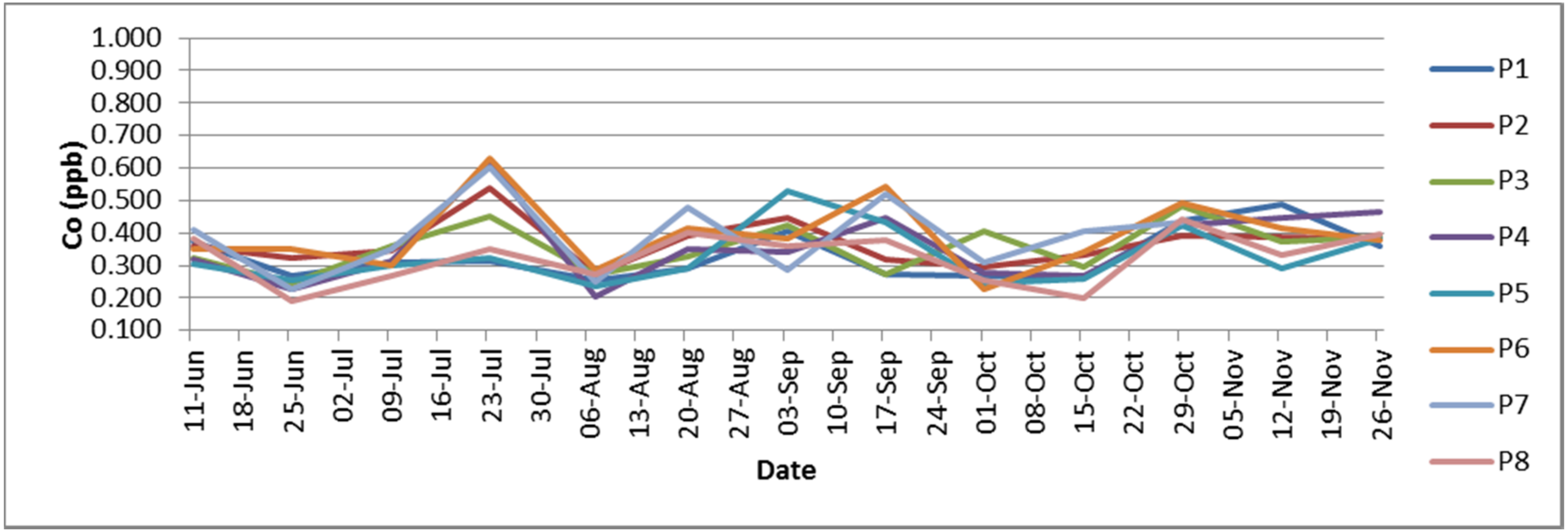
Av = 30ppb; range 21 – 61ppb (1999)

Milk Fe concentration



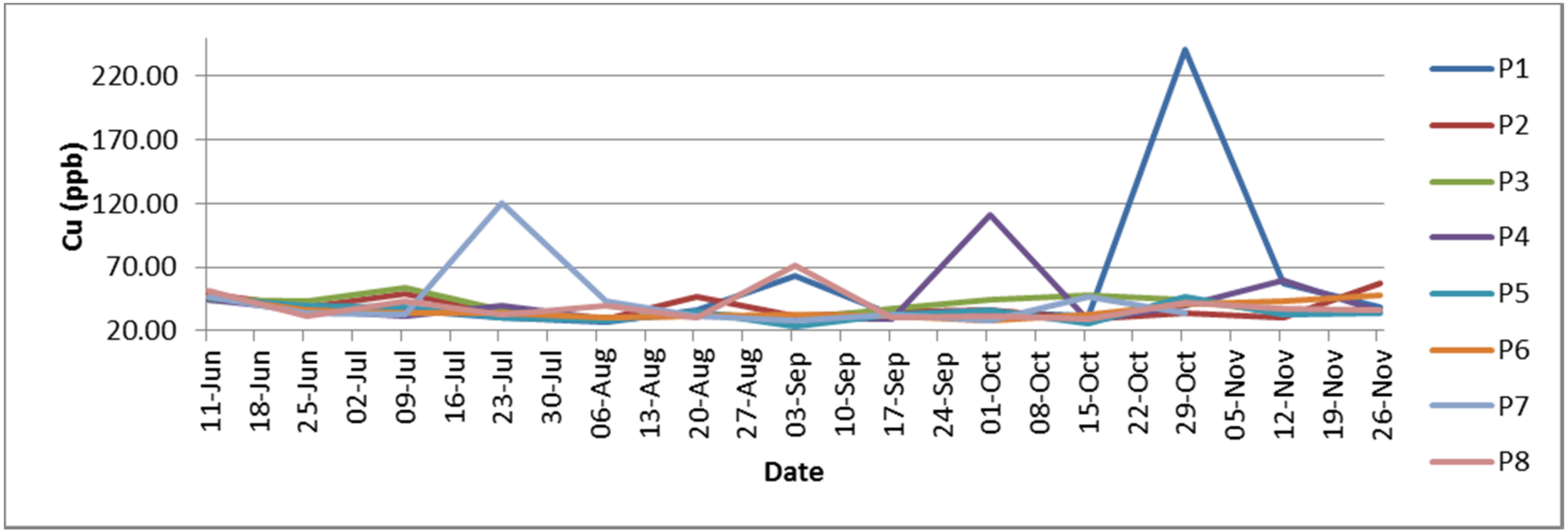
Av = 239ppb; range 165 – 342ppb

Milk Co concentration



Av = 0.36ppb; range 0.26 – 0.48ppb

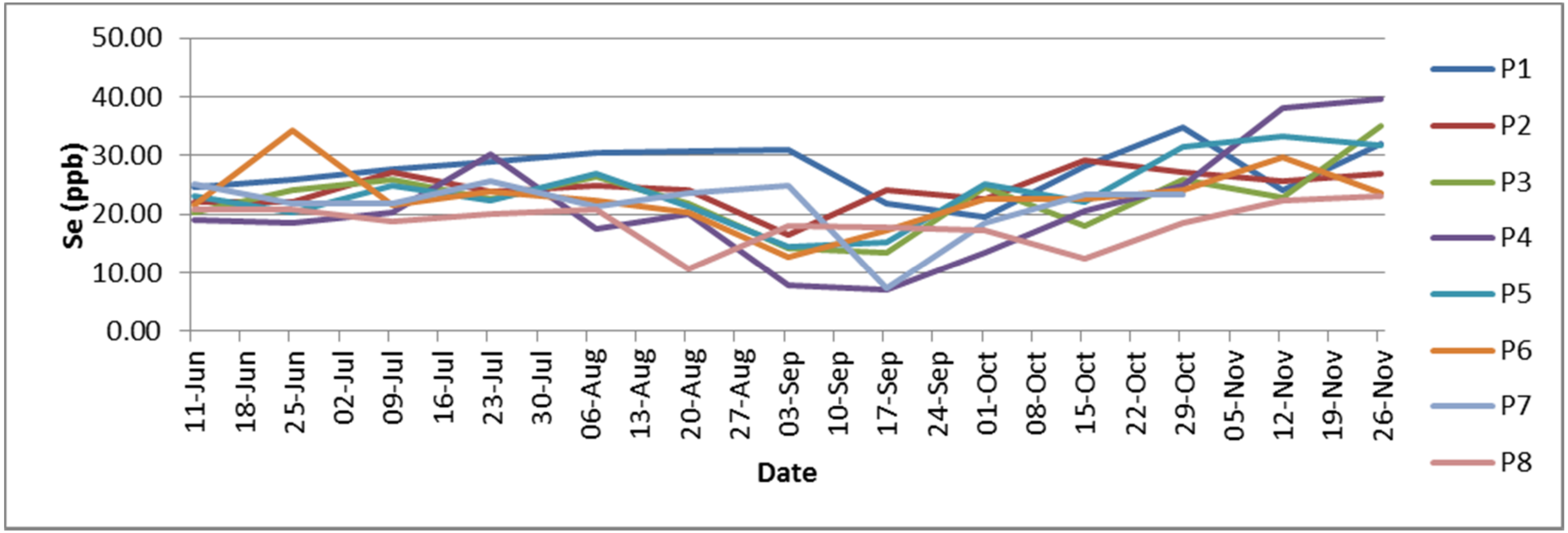
Milk Cu concentration



Av = 41ppb; range 32 – 65ppb

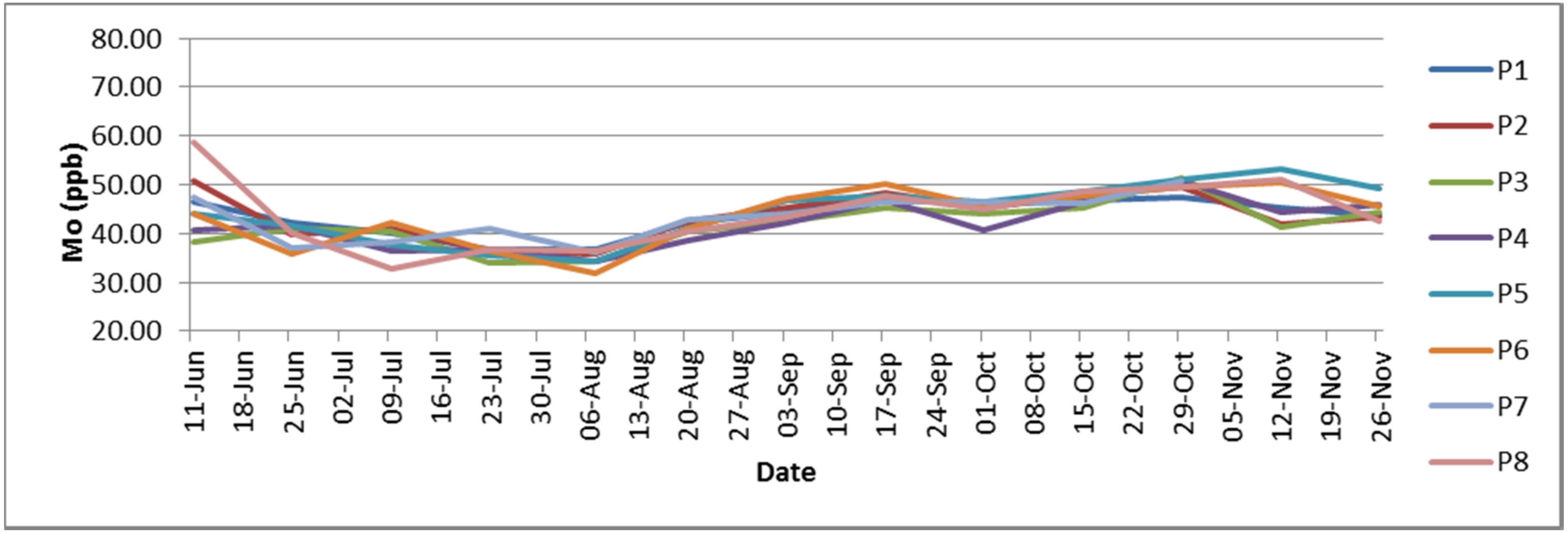
Av = 70 ppb; range 38 – 116ppb (1999)

Milk Se concentration



Av = 23ppb; range 15 – 30ppb

Milk Mo concentration



Av = 43ppb; range 35 – 50ppb

Av = 38 ppm; range 27 – 52ppb (1999)

Summary

Mg – mainly influenced by stage of lactation – shown by Keogh et al (1982); O'Brien et al. (1999); current study

P – little change over the lactation – not measured in Irish milk previously

Ca - studies differ in relation to Ca content of Irish milk. Keogh et al (1982) found it increased significantly in late lactation. Such a pattern was not observed in the 1999 study; but some increase observed here

Zn – some variation observed in current study – also found but P>0.05 in 2012 study - in 1999 study were consistent over time - Zn does not normally vary with season and is only marginally affected by the level of Zn in the diet (Flynn and Power, 1985; IDF, 1992)

Mn – was affected by stage of lactation (increased with advanced lactation); was not affected by lactation stage in 1999 study. However, other studies have reported changes - Mn concentration of Finnish milk was 30% higher in winter than in spring

Summary

Fe – increase observed with advance in lactation – no such change seen in recent study of 2012 – Murthy (1974) indicated that milk Fe concentration is not affected by changes in dietary Fe intake while Coni et a!. (1995) found higher Fe levels in winter milk compared to summer milk

Co – some variation but no consistent effect of stage of lactation; fluctuated also in 1999 study

Cu – content low and consistent in current study, except for 2 peaks of 2 different processors on 1-2 occasions; previously indicated that Cu content is very much influenced by feeding of cow (can be low in grass but high in feeds). Also recent study (2012) found Cu value from summer higher than winter period. Herbicide application – industrial emissions

Se – some slight increase with stage of lactation evident

Mo - some increase with stage of lactation evident

Initial investigation – variation – methodology - impact – further study


Thank you