Improving phosphorus efficiency using infrared predicted milk phosphorus

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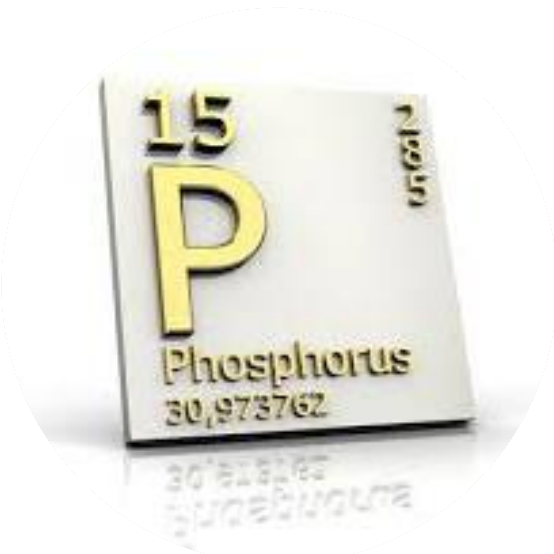
1) Animal Breeding and Genetics
2) Animal Nutrition



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Background

- Phosphorus is a non-renewable resource and 90% of the demand for P is for food production.
- At the current rate, the global commercial phosphate reserve will be depleted in 50–100 years.
- The excess of P is detrimental to the environment.

Phosphorus use in agriculture needs optimization.

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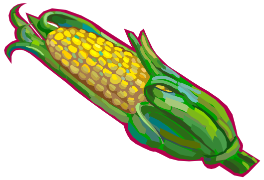
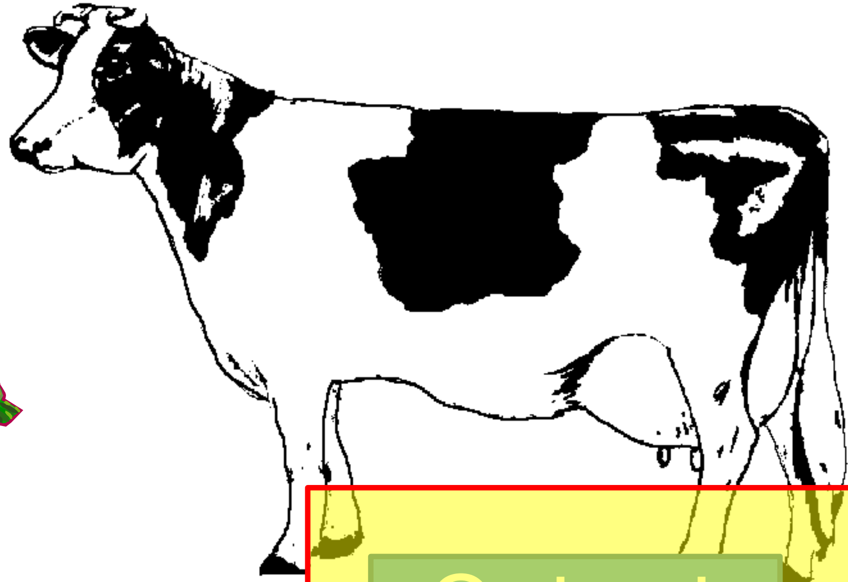
Phosphorus utilization

Input



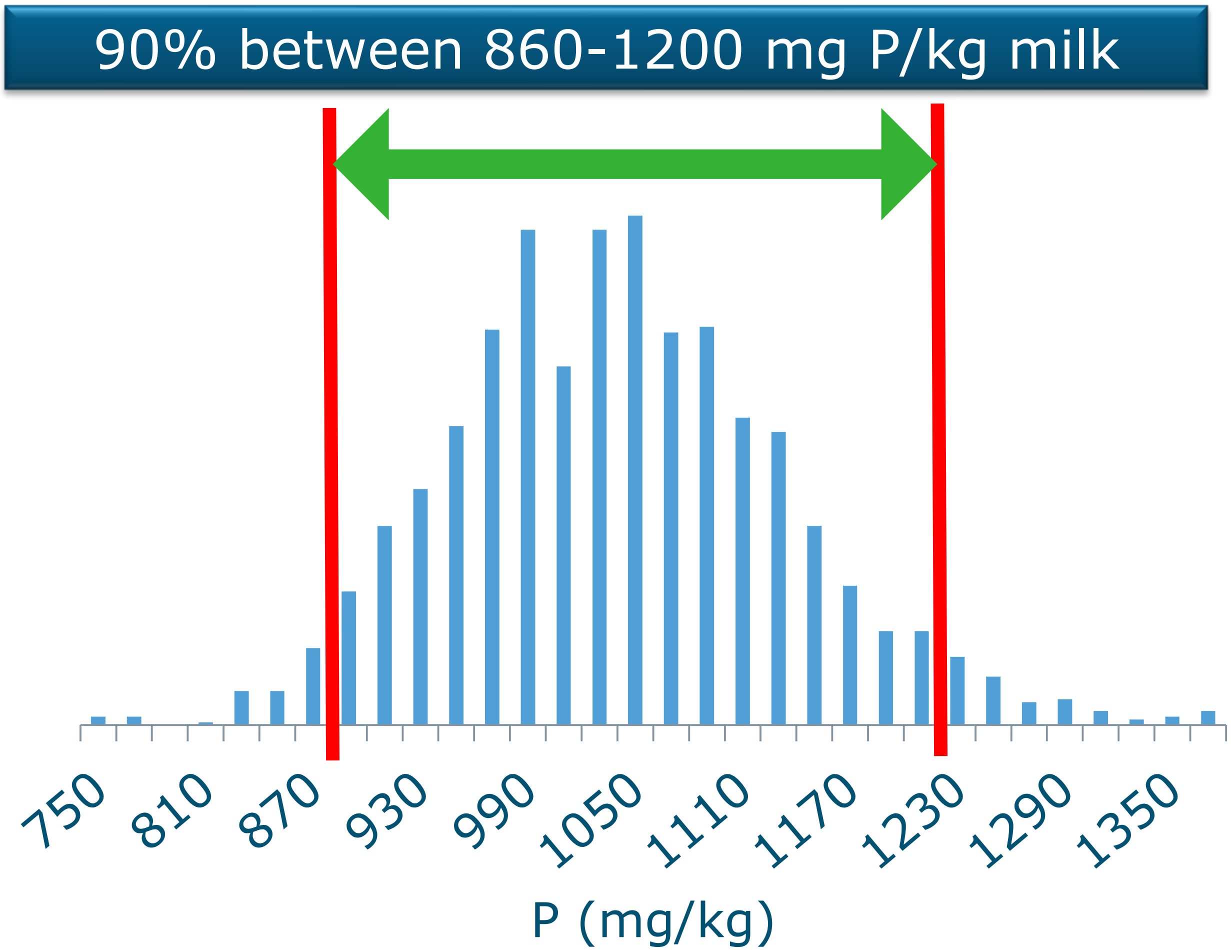


"Output"

Output

P content of milk is assumed to be **constant**:
NL 970 mg P/kg milk

Phosphorus excreted in milk



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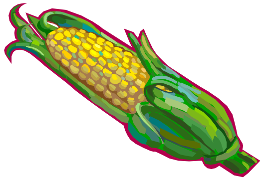
n= 1894
first parity HF cows

Phosphorus utilization

Input



P input should take into account variable P content of milk

"Output"

Output

P content of milk is highly variable but assumed to be **constant**

Can milk P content be accurately estimated based on milk IR measurements?

Material and Methods

Data

- 1379 1st parity HF cows
- 63 to 282 DIM
- 398 herds

Fourier Transformed Infrared (FTIR) spectra

- MilkoScan FT 6000
- 1,060 wavenumbers ranging from 925 to 5,008 cm−1.

P in milk – gold standard

Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES)

Material and Methods

Prediction milk P content

- Routinely recorded milk production traits
  - fat%, protein%, lactose%
- Infrared spectrum
  - Excluding wavenumbers water absorption region
- Genotypes DGAT1 and rs29019625 (SLC37A1)

Model building

- The Partial Least Square Regression (PLSR) procedure in SAS (Proc PLS)
- Cross validation

Results – routinely recorded traits

Variable	R^2 val (%)
Fat%	18.4
Protein%	41.1
Lactose%	0.3

Results – routinely recorded traits

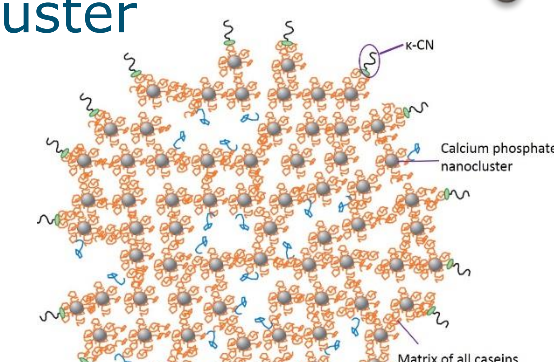
Variable	R^2 val (%)
Fat%	18.4
Protein%	41.1
Lactose%	0.3
Fat, protein, and lactose%	43.1

58% of milk P associated with caseins

1. Caseins are phosphoproteins e.g.

α_{s1}-CN -8P
α_{s1}-CN -9P
α_{s2}-CN -10P
……..

2. Calcium phosphate nanocluster



Casein micelle

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Results – Genotypes

Variable	R^2 val (%)
Protein%	41.1
DGAT1	8.7
SLC37A1	4.7

DGAT1 and SLC37A1 are genes with major effects on milk P content.

Results – Full IR spectrum

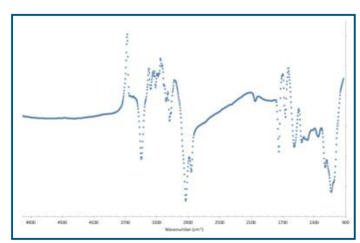
Variable	R^2 val (%)
Protein%	41.1
Infrared spectrum	83.8

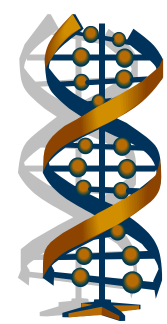
Full IR spectrum gives much better prediction than based on protein% only

Results – Full IR spectrum

Variable	**R^2 val (%)**
Protein%	41.1
Infrared spectrum	83.8
Infrared spectrum + DGAT1+SLC37A1	83.7

No added value of the two genotypes – info of genotypes is captured by IR spectrum





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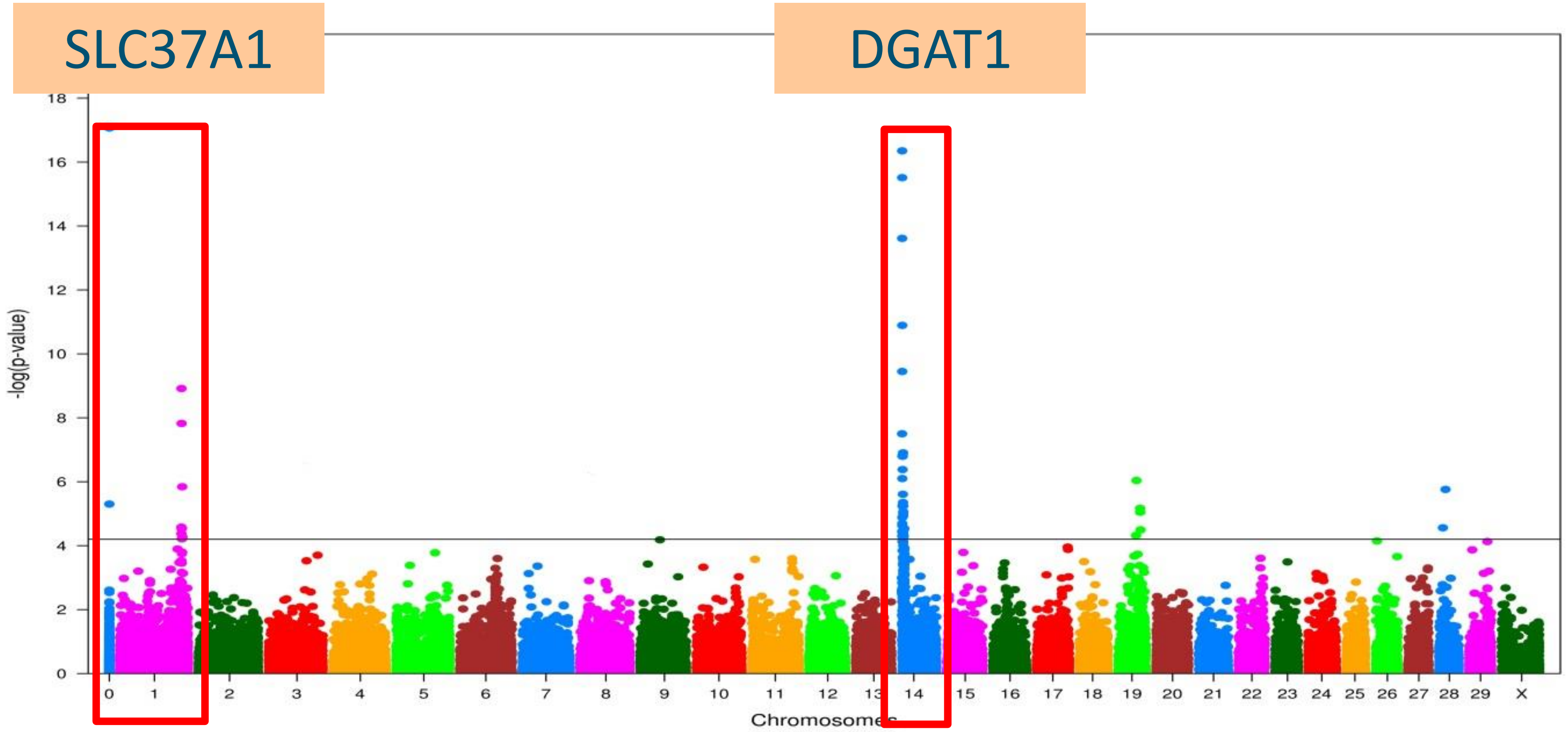
GWAS IR Wavenumber 432



Wang and Bovenhuis (2018)

Conclusions

Phosphorus in milk can be predicted using milk Infrared based on

- Relation P with protein%
- "Direct" information on P

Literature

- Soyeurt et al. (2009)
  62 milk samples, many breeds
  ICP-AES
  $r_{cv}^2 = 0.83$

- Toffanin et al. (2015)
  208 HF, Italy
  ICP-OES
  $r_{cv}^2 = 0.72$

- Bonfatti et al. (2016)
  689 Simmental, Italy
  ICP-OES
  $r_{cv}^2 = 0.43$

- Visentin et al. (2016)
  251 milk samples , 4 breeds, Italy
  ICP-OES
  $r_{cv}^2 = 0.62$

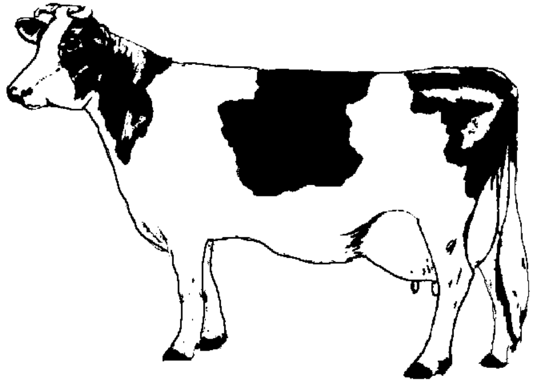
Conclusions

Phosphorus in milk can be predicted using milk Infrared based on

- Relation P with protein%
- "Direct" information on P

Milk P content can be accurately predicted based on the milk IR spectrum

Implications



New

Old: P requirement

Milk Yield * (970mg)
+ **"safety margin"**

New: P requirement

Milk Yield * (IR predicted milk P)
+ (2*PE)

Feeding cows according P requirements savings in P of up to 17% can be realised……….or 3.6 kg phosphorus/cow/lactation