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Routine FTIR Phosphorous Determination in Ex-farm Milk for Better Insight in the Phosphorous Cycle on Dairy Farms

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ICAR Conference, Prague (CZ), 20 June 2019

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Background

ENVIRONMENT

European Commission

The Nitrates Directive

What's new ?

Latest Commission Report and Staff Working Document on the implementation of the Nitrates Directive

The Commission published its report on the implementation of the Nitrates Directive for the period 2012–2015. The report is accompanied by a Staff Working Document including detailed information on nutrient pressures from agricultural sources, water quality and designated nitrate vulnerable zones, both at EU level and at Member State level.

Commission Report - Staff Working Document - Press release - Questions and answers

The Nitrates Directive (1991) aims to protect water quality across Europe by preventing nitrates from agricultural sources polluting ground and surface waters and by promoting the use of good farming practices.

The Nitrates Directive forms an integral part of the Water Framework Directive and is one of the key instruments in the protection of waters against agricultural pressures.

More information on the aims, implementation and impact of the Nitrates Directive can be found in the Factsheet on the Nitrates Directive and on the following infographics:

- Nitrates Directive in a nutshell
- Nitrates Directive - solutions
- Nitrates Directive - nitrogen cycle
- Nitrates Directive - water quality

THE NITRATES DIRECTIVE IN A NUTSHELL

Nitrogen is a vital nutrient that helps plants and crops grow, but high concentrations are harmful to people and nature.

Pure, clean water is vital to human health and to natural ecosystems.

Excess nitrogen from agricultural sources is one of the main causes of water pollution in Europe.

The EU wants to reduce water pollution caused by nitrates used in agriculture and sets out steps for EU countries to take

Monitoring of water bodies with regard to nitrate concentrations

Establishing codes of good agricultural practices and measures to prevent and reduce water pollution from nitrates

EU Nitrates Directive (1991) aims to protect water quality across Europe by preventing nitrate from agricultural sources polluting ground and surface waters and by promoting good farming practices

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Background

Since 2006 the Dutch animal husbandry sector operates under EU derogation from the EU Nitrates Directive:

Allowance for farms with at least 80% grassland to spread up to 230 to 250 kg N (instead of 170 kg N) with manure from grazing animals per hectare per year

As a consequence, national quota on production of:

- Nitrogen
- **Phosphate**

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Imposed Measures by Dutch Government

Phosphate Reduction Plan 2017

The Dutch animal husbandry sector had to decrease her phosphate production in 2017 to preserve her EU derogation. On February 3rd 2017, the State Secretary informed the Dutch Parlement of the measures to achieve this.

The Phosphate Reduction Plan 2017 enforced a reduction in dairy cattle and decrease of P in concentrate feed. As a result, phosphate production was reduced with 4 million kilograms.

Phosphate Production Rights from 2018

Subsequent to the Phosphate Reduction Plan 2017 Dutch dairy farms are from 1 Janury 2018 only allowed to produce phosphate from dairy cattle manure corresponding to the phosphate production rights they hold.

Initial phosphate rights were awarded corresponding to the number of animals on 2 July 2015 with an overall deduction of about 8%. Phosphate rights are tradable.

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Role of Phosporous in Milk Production

- Essential element for a healthy milk production
- Excretion through milk and manure: **Pmanure = Pintake - Pmilk**
- Milk production largely determines P requirement
- Storage in bones (P buffer) and unborn calve

- P shortage:
  - Lowered feed intake, interest in ‘strange’ feed
  - Decrease in body weight
  - Lower milk production
  - Muscle weakening, blood watering, liver malfunctioning
- P surplus:
  - Little effect on animal health
  - Higher risk of milking disease around parturation
  - **Environmental burden**

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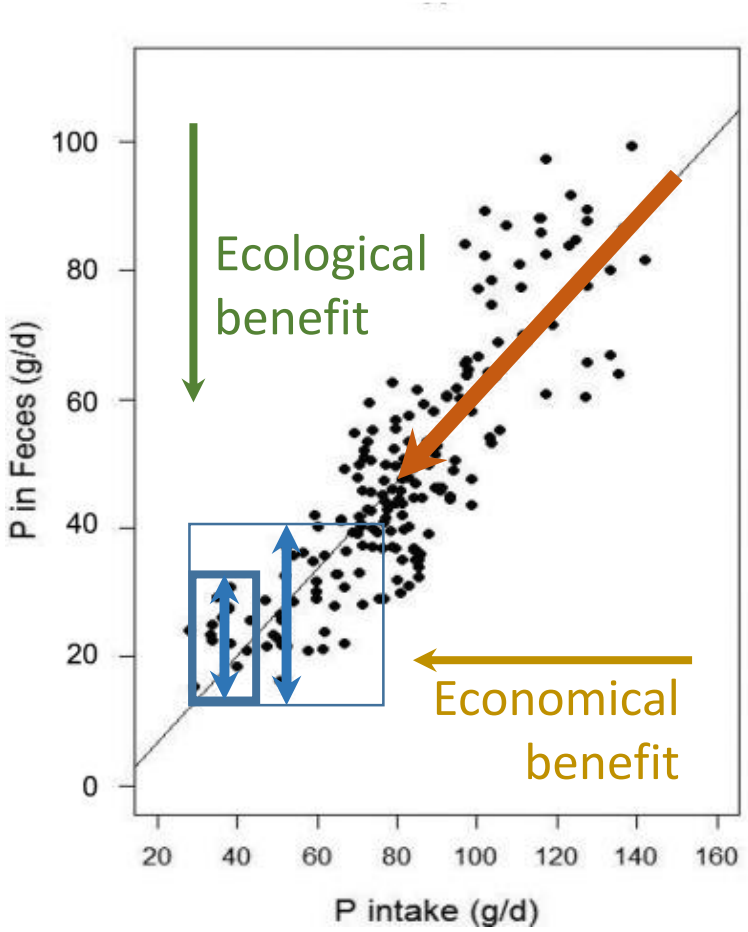
Towards a Better Management of the P Cycle



Pmanure = Pintake - Pmilk :

➔ optimize P intake, otherwise it is *wasted*

- **Ecological** cost: burden on environment
- **Economical** cost: cost of P supplementation

Information on P in milk promotes awareness, gives insight in the P- cycle and provides means for finetuning (reduce uncertainty in the intake-manure relationship)

Alvarez-Fuentes et al. 2016

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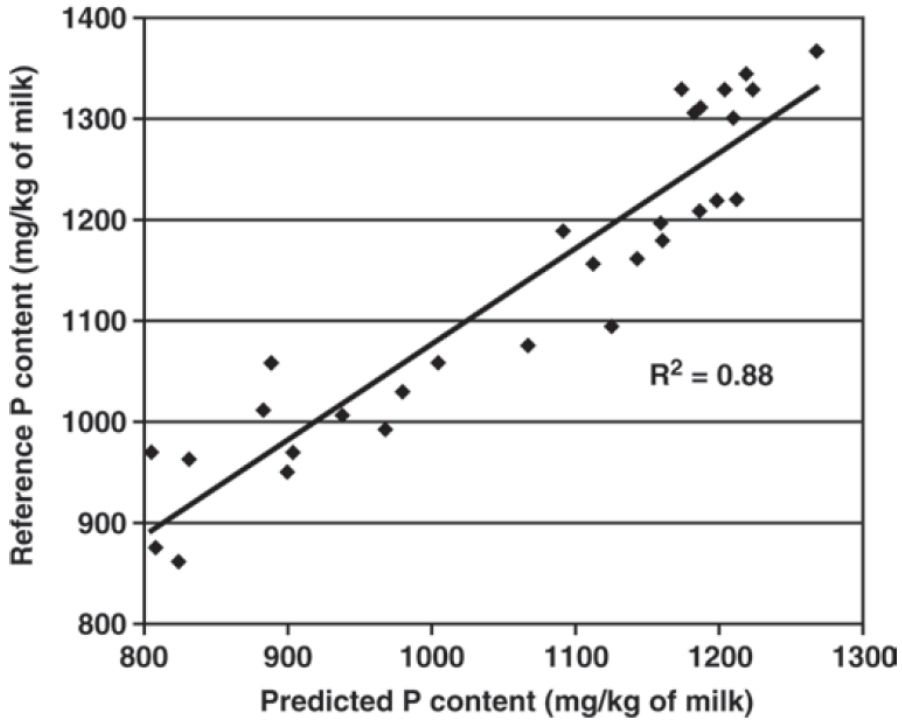
Feasibilility of Milk FTIR Application

J Dairy Sci. 2009 Jun;92(6):2444-54. doi: 10.3168/jds.2008-1734.

Potential estimation of major mineral contents in cow milk using mid-infrared spectrometry.

Soyeurt H[1], Bruwier D, Romnee JM, Gengler N, Bertozzi C, Veselko D, Dardenne P.



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In-house Development of FTIR Calibration Model

Selection of 210 samples (median = 103 mg P/100 g milk, range = 64 – 192 mg P/100 g milk)

- 105 herd bulk milk samples (spectra from 4 FTIR instruments)
- 105 individual cow milk samples (spectra from 11 FTIR instruments)

Samples were selected:

- Randomly (N = 40)
- Based on fat/protein/lactose/urea dimensions
- Based on expected P content
- Throughout 2018: January, February, April, June, August, October
- Different breeds, including Jersey cows

Reference method: ICP–MS (ISO 21424|IDF 243)

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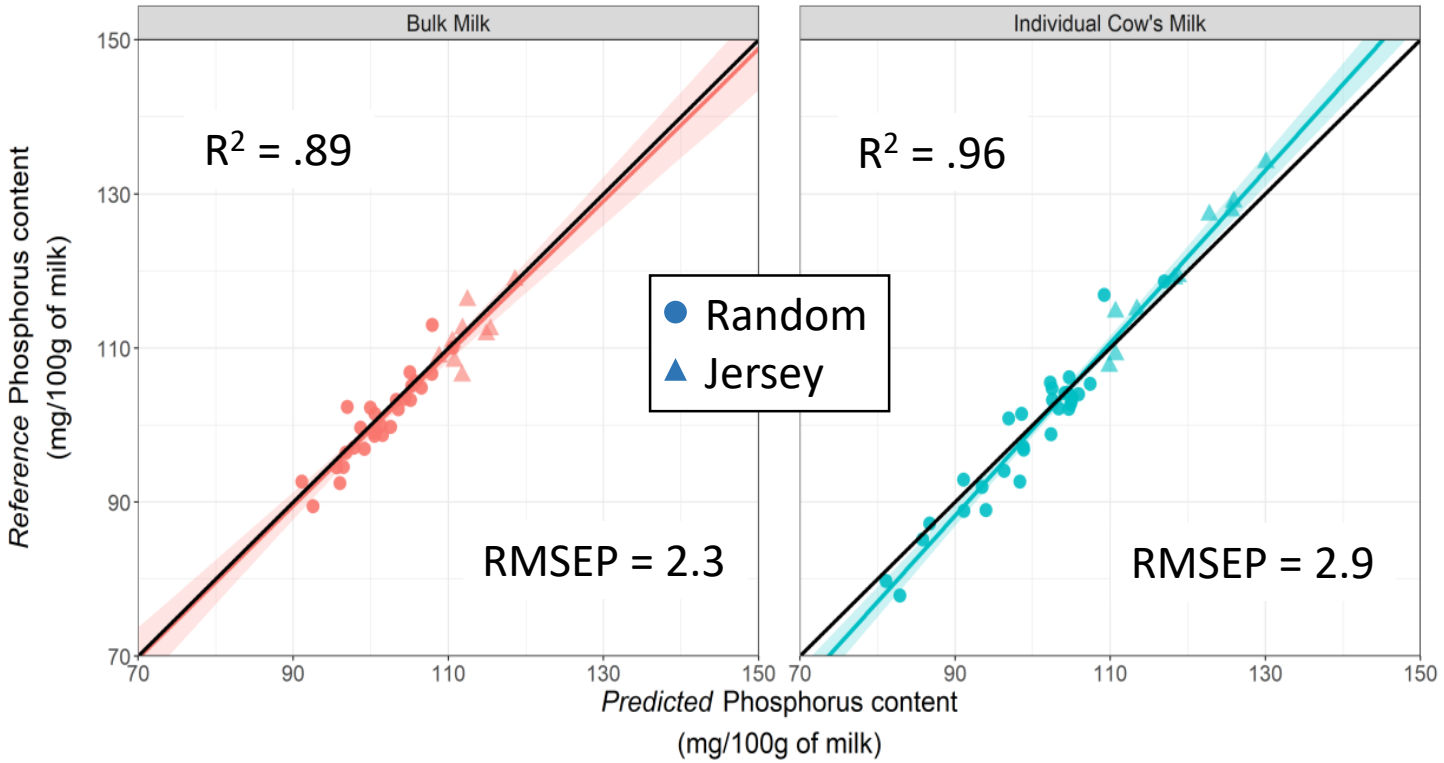
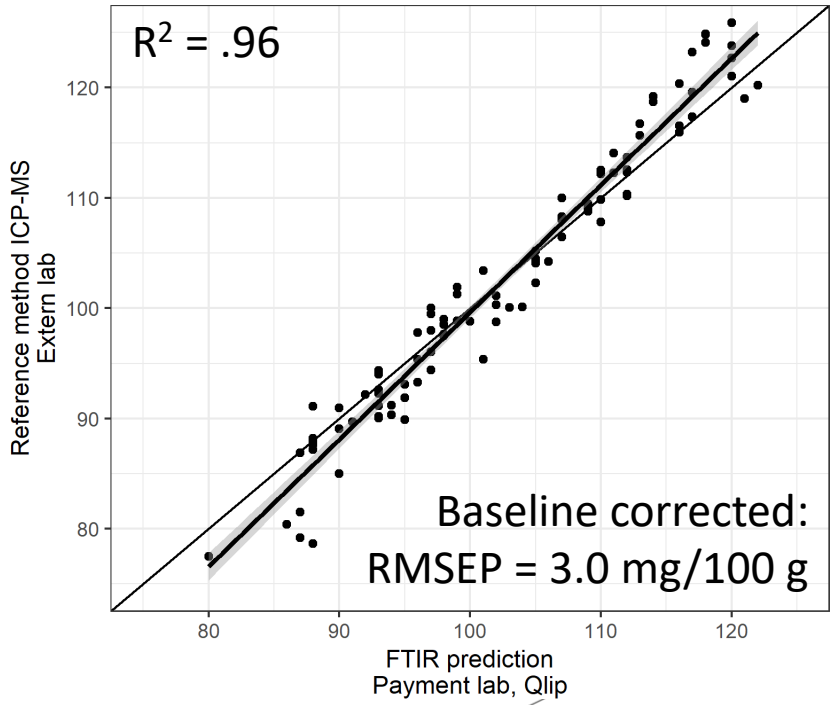
Validation of the Calibration Model

Validation on independent set of random samples
Validation plot: P content (mg/100 g milk)



External lab validation on 12 February 2019
Validation plot: P content (mg/100 g milk)



No significant difference between herd bulk milk and individual cow milk:
Overall for 60 random samples: R^2 = .90 and RMSEP = 2.6 mg/100 g

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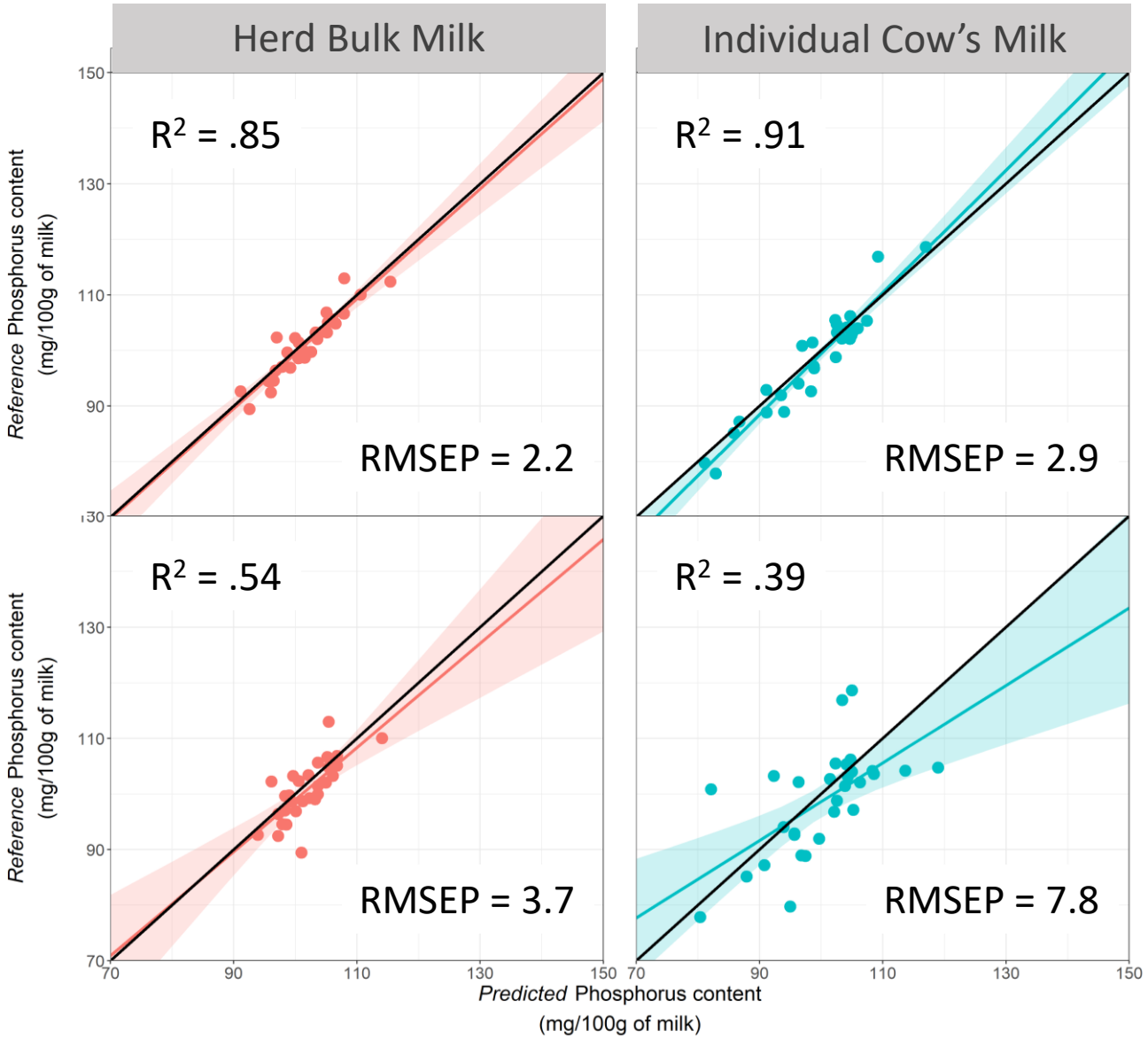
Direct vs Indirect Prediction from Protein Content



Direct prediction

✓ **Direct FTIR prediction model performs considerably better than a protein-based model**

Indirect P prediction
based on protein content

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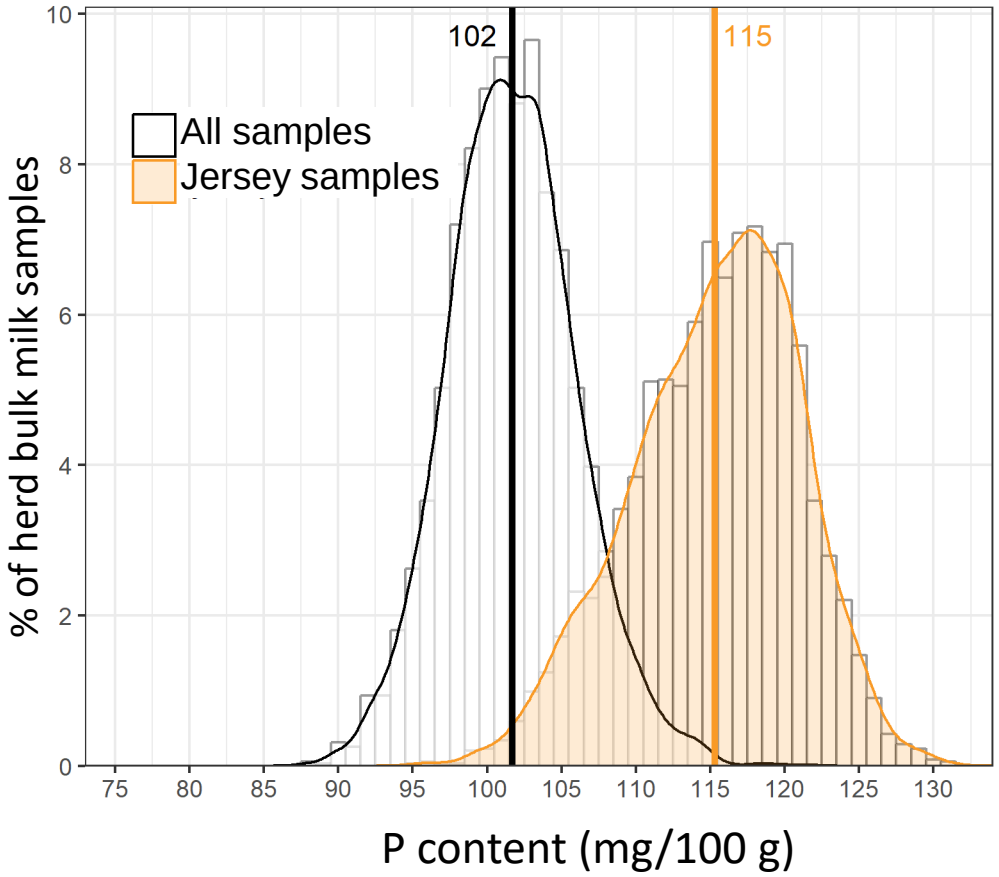
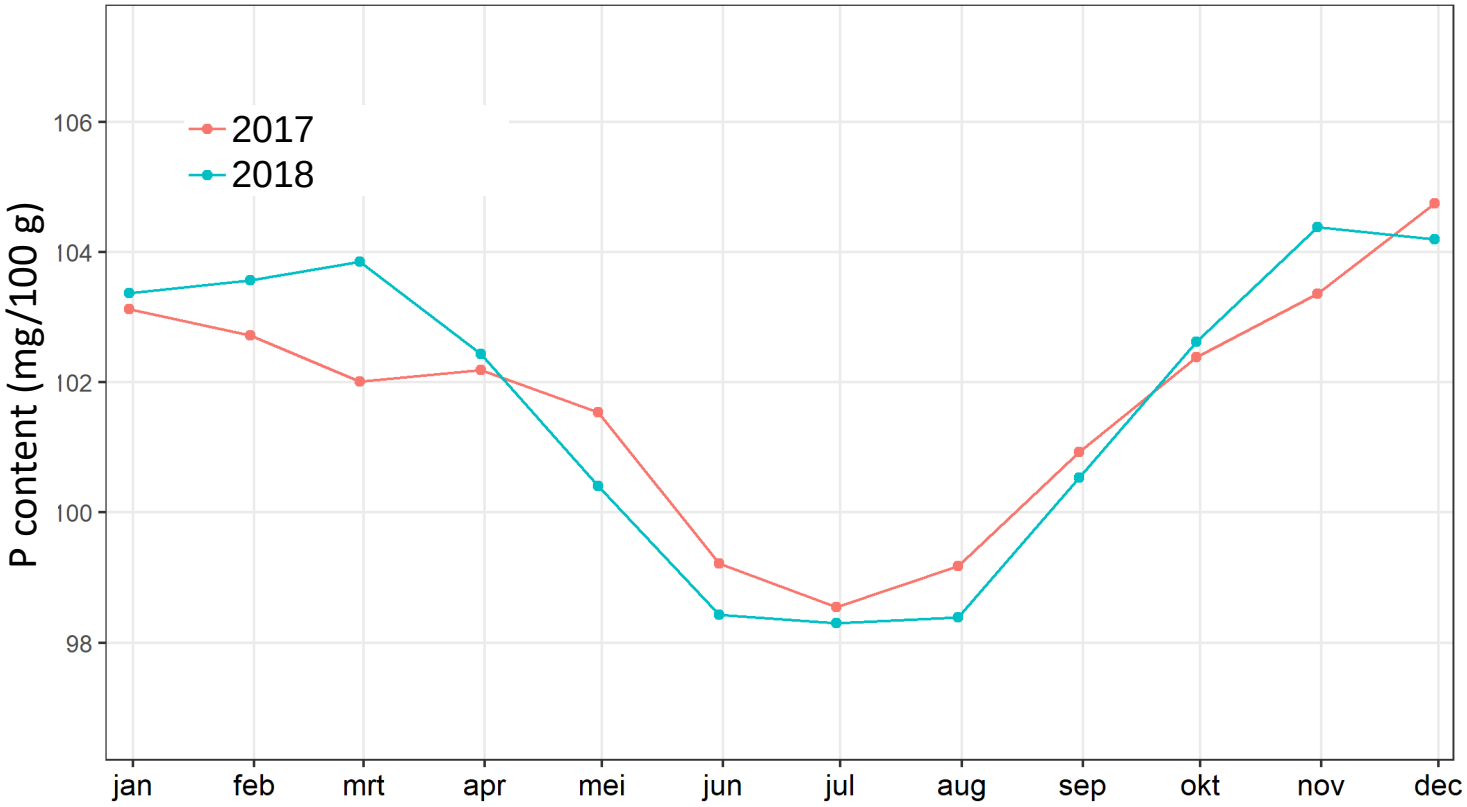
Some Statistics for Herd Bulk Milks 2017-2018





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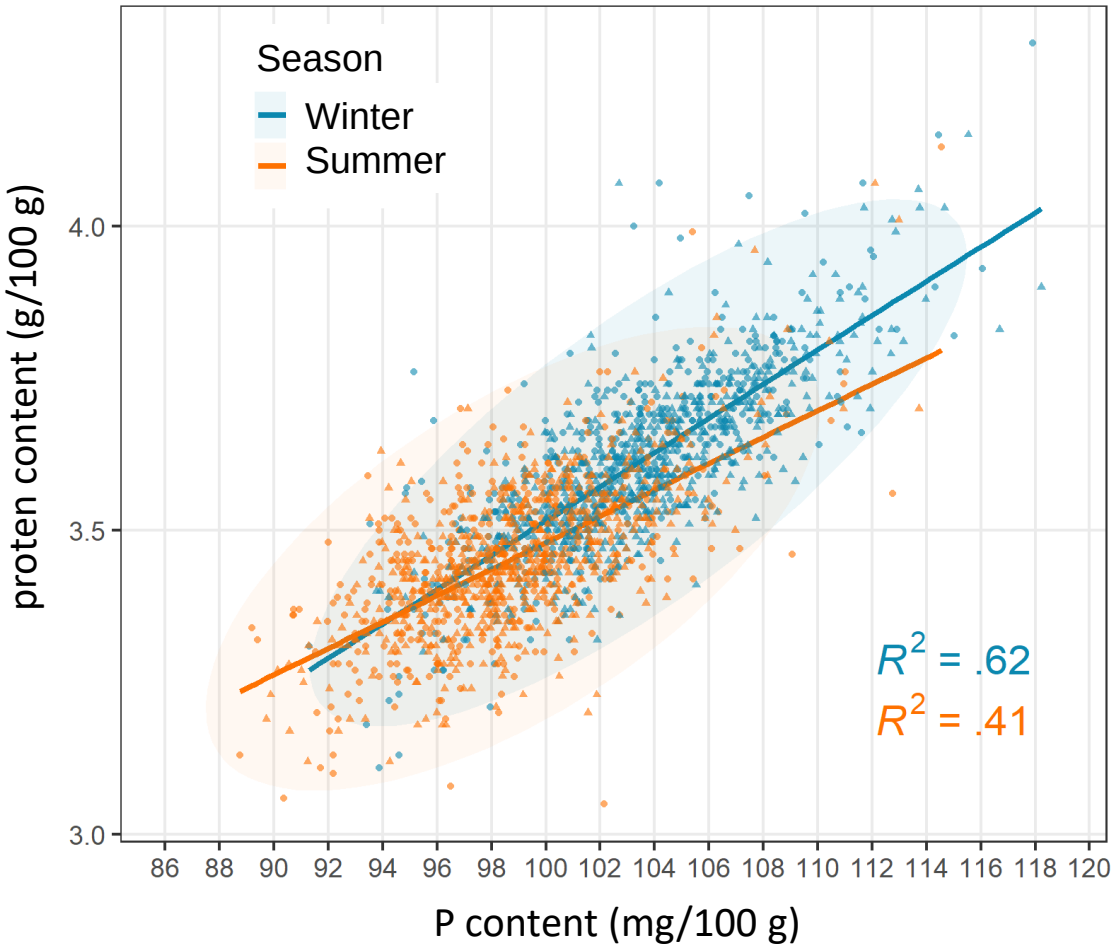
Correlation with Protein in Different Seasons



Correlation with protein content varies with seasons:
it is stronger in winter than in summer

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Reporting of Herd Bulk Milk Results
(since January 2019)

Message:
Focus on trend!

Datum	Tijd	Kg melk	Temp	Vet%	Eiwit%	Lac%	Ureum	Ber	Vries punt(ir)	Zuurgr vet(ir)	Vet%/Eiwit%	Bact. groei	Fosfor	Myristinezuur	Palmitinezuur	Stearinezuur	Oliezuur
													mg/100gr melk	C_14	C_16	C_18	C_18_1
11-06-2019	01:35	4.662	3,7	4,21	3,58	4,46	28		0,513-	0,2	1,176	-	98	10,9	26,6	11,9	24,9
08-06-2019	13:15	4.799	3,3	4,19	3,59	4,50	25		0,515-	0,2	1,167	-	98	11,0	28,6	11,0	24,6
06-06-2019	02:05	5.569	3,8	4,07	3,60	4,50	26		0,515-	0,2	1,131	-	100	11,1	30,0	10,3	23,1
03-06-2019	05:41	2.699	3,7	4,23	3,54	4,48	22		0,511-	0,2	1,195	-	98	11,4	29,1	10,6	23,4
01-06-2019	11:32	5.590	7,1	4,17	3,59	4,46	25		0,512-	0,2	1,162	-	100	11,3	28,8	10,6	24,0
29-05-2019	09:56	3.632	3,6	4,17	3,61	4,50	20		0,513-	0,2	1,155	-	97	11,3	29,3	10,6	23,7
27-05-2019	12:49	5.625	3,7	4,06	3,65	4,44	18		0,512-	0,2	1,112	-	101	11,8	27,3	10,3	23,2
24-05-2019	12:04	5.499	3,7	4,20	3,66	4,49	26		0,516-	0,2	1,148	-	98	11,2	29,3	10,5	24,3
21-05-2019	13:00	5.549	3,7	4,14	3,63	4,49	25		0,517-	0,2	1,140	-	98	11,1	27,8	10,6	24,4
18-05-2019	14:26	3.674	3,8	4,17	3,65	4,52	27		0,519-	0,3	1,142	-	99	11,3	28,8	11,0	24,5
16-05-2019	12:49	5.469	3,7	4,17	3,60	4,47	24		0,514-	0,2	1,158	-	99	11,5	28,1	10,8	24,0
13-05-2019	12:49	5.464	3,7	4,28	3,60	4,49	21		0,514-	0,3	1,189	-	95	11,0	28,5	10,1	24,8
10-05-2019	12:40	5.452	3,7	4,37	3,66	4,49	21		0,515-	0,2	1,194	-	96	11,2	27,9	10,8	24,7
07-05-2019	12:18	3.251	3,6	4,27	3,67	4,46	20		0,515-	0,2	1,163	-	99	11,0	26,9	11,2	24,8
07-05-2019	04:28	2.305	3,6	4,44	3,68	4,47	21		0,513-	0,2	1,207	-	98	10,8	28,2	10,8	25,0
04-05-2019	13:50	1.933	3,5	4,39	3,66	4,50	24		0,517-	0,3	1,199	-	96	10,7	28,3	10,9	25,5
03-05-2019	10:29	1.920	3,4	4,32	3,67	4,45	21		0,514-	0,2	1,177	-	100	11,1	28,7	10,7	24,1
02-05-2019	12:43	3.682	3,6	4,45	3,66	4,45	25		0,515-	0,2	1,216	-	97	10,6	29,0	10,3	25,4
30-04-2019	11:47	1.900	3,6	4,39	3,66	4,46	24		0,515-	0,2	1,199	-	100	10,9	29,2	10,0	24,4
29-04-2019	13:30	3.723	3,7	4,43	3,67	4,46	22		0,514-	0,2	1,207	-	98	10,8	28,2	10,6	24,8
27-04-2019	12:17	1.916	3,5	4,25	3,68	4,48	20		0,514-	0,2	1,155	-	100	11,1	27,5	10,6	24,9
26-04-2019	12:38	1.819	3,5	4,25	3,65	4,48	21		0,513-	0,2	1,164	-	98	11,1	30,1	10,1	23,3
25-04-2019	10:50	3.838	3,6	4,28	3,65	4,46	21		0,511-	0,2	1,173	-	99	11,0	27,6	10,3	25,2
23-04-2019	13:04	1.808	2,7	4,25	3,62	4,47	19		0,510-	0,2	1,174	-	98	10,8	28,2	10,4	24,7
22-04-2019	10:56	3.790	2,9	4,42	3,57	4,46	22		0,511-	0,2	1,238	-	96	11,5	30,1	9,5	23,1
20-04-2019	13:29	1.824	4,1	4,31	3,62	4,50	18		0,514-	0,2	1,191	-	100	11,4	28,5	10,9	23,9
19-04-2019	12:33	1.889	4,0	4,28	3,62	4,48	16		0,513-	0,2	1,182	-	100	11,5	31,1	10,3	22,7
18-04-2019	11:37	3.942	4,1	4,37	3,65	4,47	16		0,514-	0,2	1,197	-	102	11,4	29,3	10,3	23,3
16-04-2019	07:49	1.786	7,4	4,32	3,67	4,44	17		0,514-	0,2	1,177	-	100	11,6	29,9	9,5	22,7

Recap (1)

- Need to control mineral losses poses severe challenges to dairy farming in NL

- Intentions with reporting milk P content to dairy farmers:
  - Creating awareness, bringing insight in the P – cycle on dairy farms
  - Providing means to improve P - utilization on dairy farms
  - To explore options for underpinning farm-specific registration of phosphate production

- Developed direct milk FTIR calibration model with robust performance
  ➔ RMSEP = 2.5-3 mg P/100 g milk

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Recap (2)

- P content in NL raw milk varies with:
  - Season
  - Breed
  - Region (results not shown)
- Correlation of P content and protein content is strongest in winter
- New perspective for other FTIR mineral applications
- Implementation in routine always needs a driver!

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Thank you for your attention!

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