Feed4Foodure
Phosphorus utilization in dairy cattle

26 November 2013

Geronda Klop

WAGENINGEN UR
For quality of life

Contents

- Reducing Phosphorus (**P**) excretion by dairy cows
- P metabolism: Dairy cows ≠ pigs
- Research aspects that provide the most interesting opportunities to improve P utilization in dairy cattle
- Modelling P utilization

WAGENINGEN UR
For quality of life

Reducing P excretion by dairy cows

No mineral element with more known biological functions than P *(NRC, 2001)*, but...

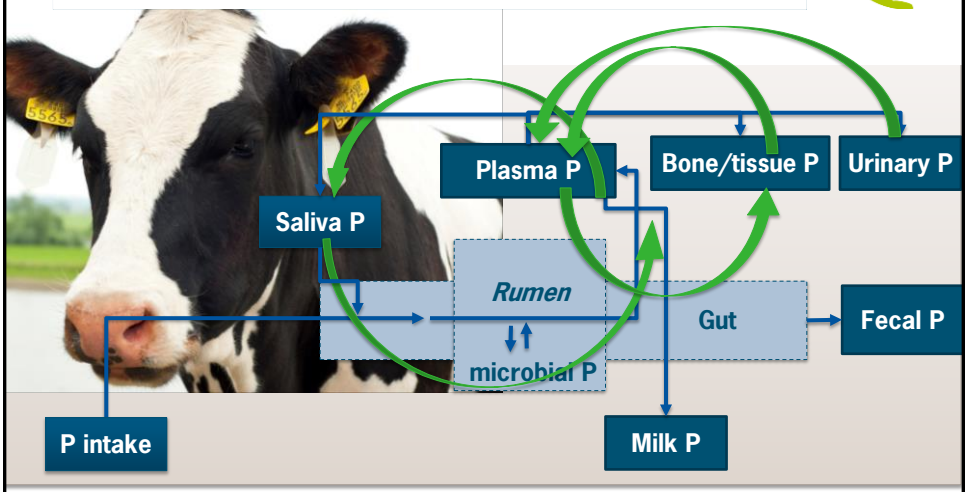
- Increased environmental concerns related to P
  - Nutrient leaching from agricultural soils (eutrophication risks)
- Stringent legislation on nutrient management (*EU, USA*)
  - Costs of manure disposal
- Expected scarcity of mineral P resources (*Cordell et al. 2009*)
  - P recycling and efficient use of P

P utilization: A dairy cow is not a pig...

Important aspects regarding P utilization in pigs	Relevance in dairy cattle
P intake	=
Phytate/phytase	✖
Ca:P ratio in diet	= ✖
P absorption in the GI tract	✖
Urinary P excretion	✖

Because P metabolism in dairy cows is **different**

Major P flows in dairy cattle



WAGENINGEN UR
For quality of life

P utilization lactating dairy cows

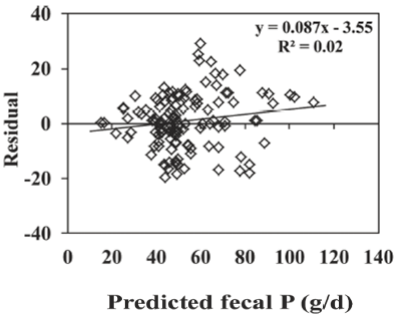
- Example P efficiency based on data from 6 balance trials (*Valk et al., 2002*)
  - Average FCM yield 33 kg/d
  - Average DMI 23 kg/d (3.4 g P/kg DM)

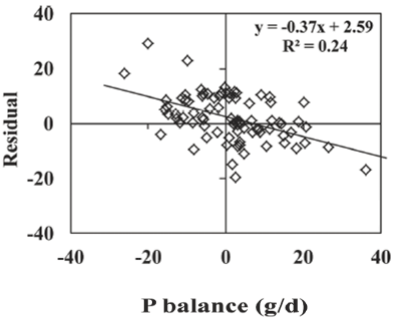
P flow	g/d (% of intake)
P intake	78 (100)
P in feces	38 (49)
P in milk	34 (43)
P in urine	1 (1)
P balance	5 (6)

Importance of P dynamics bone/tissue

Meta-analysis (25 studies, 130 treatments)

P in feces (g/d) = -3.8(±3.45)+0.64(±0.038) x P intake (g/d)





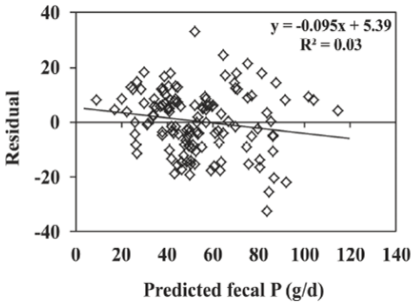
P balance data from 14 studies (n=81)

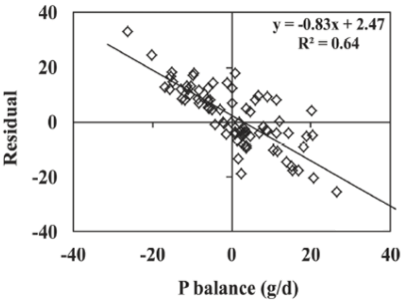
Klop et al., 2013 – JDS 96:3936-3949

Importance of P dynamics bone/tissue

Meta-analysis (25 studies, 130 treatments)

P in feces (g/d) = 19.9(±5.07)+0.79(±0.060) x P intake (g/d)
-1.04(±0.127) x milk production (kg/d)





P balance data from 14 studies (n=81)

Klop et al., 2013 – JDS 96:3936-3949

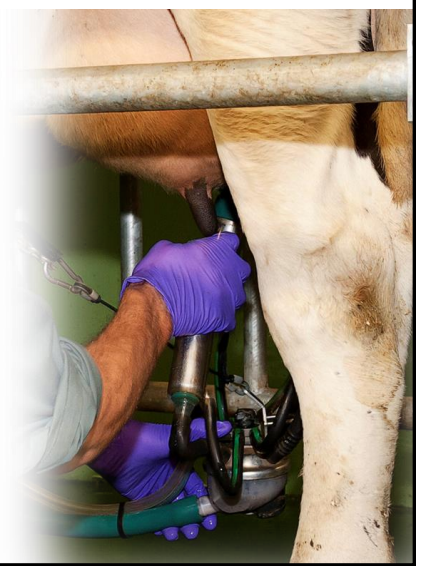
Long term effects of lower dietary P?

- Dairy cattle rations in the NL → difficult to feed far below P requirements
- Influence of lactation stage/P balance?
- Need for **accurate** 'tools' to monitor P status and P utilization efficiency in dairy cows…

Parameter	Sampling constraints	Indicator for
Saliva	Differences between glands	Plasma P/P supply to gastro-intestinal tract
Blood	Simple, but still invasive	?
Milk	None	P use efficiency
Feces	Diurnal variation	P use efficiency/P status

P in milk

- Comprises a major fraction of total P requirements *(CVB, 2005; NRC, 2001)*
- Concentration of P in milk is **NOT** constant *(Lenstrup, 1926; Bannink et al., 2010)*
- Milk P (g/kg) is partly related to milk composition *(Klop et al., 2013)*
- What are other reasons for variation?



P requirements and milk production

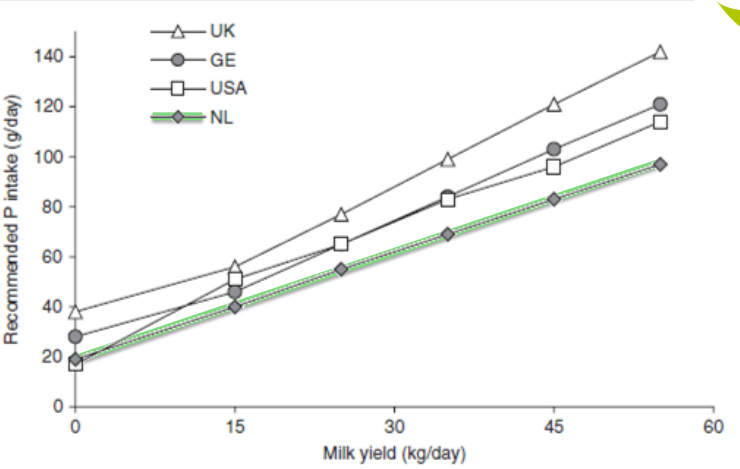
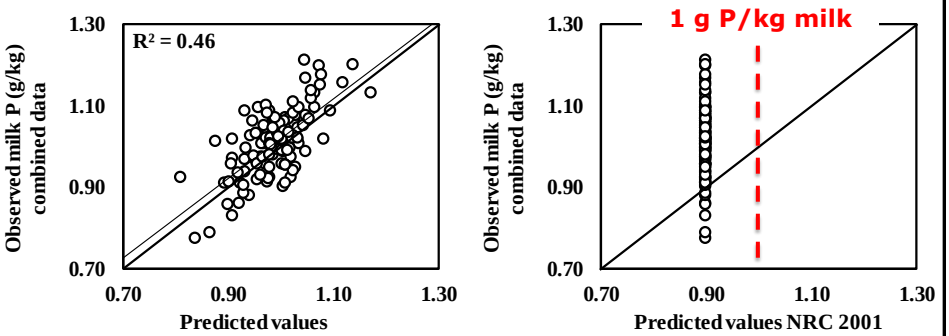


Fig. 10.4. Dependency of recommended P allowance on milk yield of (dry and lactating) cows in various countries: UK (AFRC, 1991); GE (GfE, 1993); USA (NRC, 2001); NL (CVB, 2005).

Bannink et al., 2010

P in milk - Empirical relationships (1)

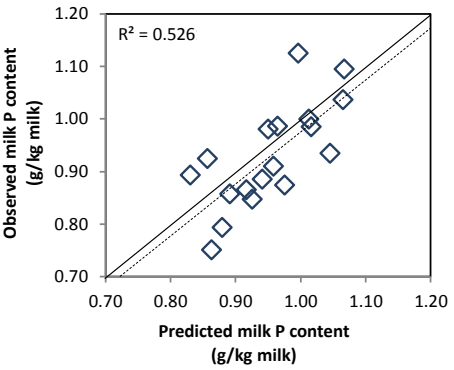
- Protein and lactose and P content of milk
- Empirical relationship, but also physiological mechanism
- Explains more of the observed variation than fixed value of either 0.9 or 1.0 g P/kg milk



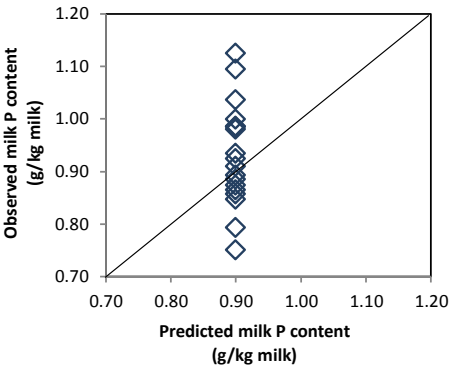
Klop et al., J Agric. Sci., *accepted*

P in milk - Empirical relationships (2)

Independent prediction based on protein and lactose content of milk



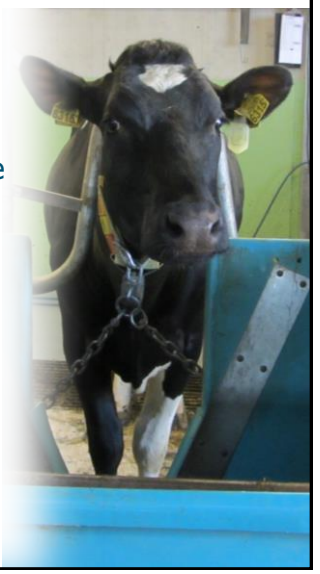
Fixed value (NRC, 2001)

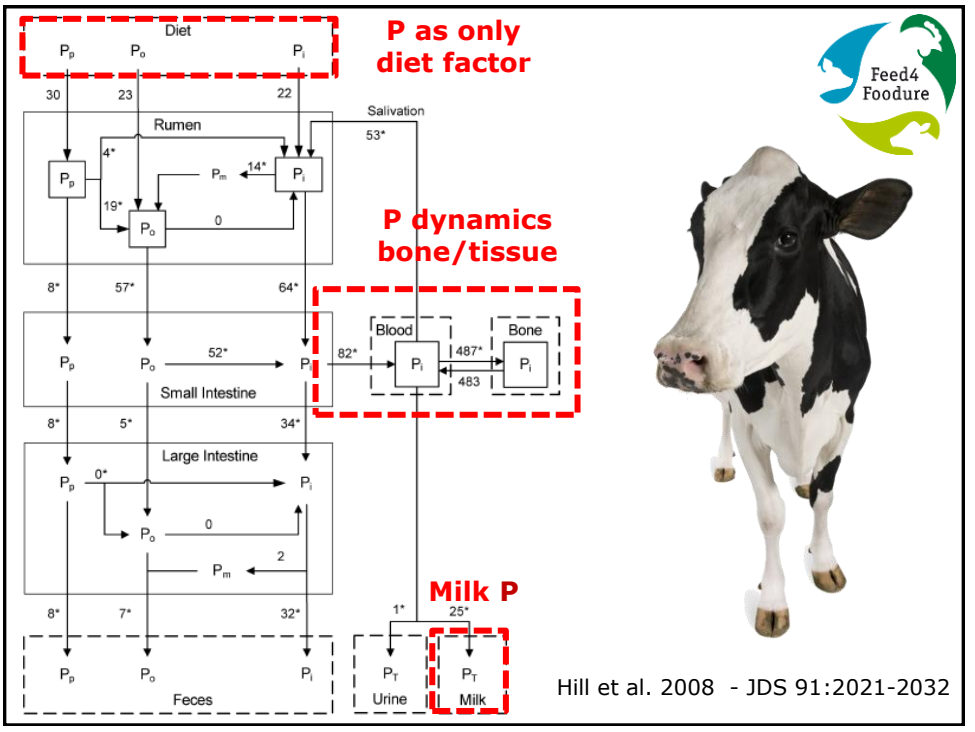


Klop et al., *unpublished data*

Mechanistic modelling of P

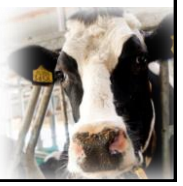
- Better understanding of P dynamics
  - Response based
  - Variation in milk P content
  - Influence P dynamics bone/tissue
- Input data from reliable *in vivo* experiments
- Extant mechanistic model on P metabolism in dairy cows needs to be improved





Take home message

- P metabolism in dairy cows differs from non-ruminant species → **different research questions**
- Most important areas for further research
  - P in milk
  - P dynamics bone/tissue i.r.t. P utilization
  - Biomarkers in feces, saliva, milk as simple tools?
  - Mechanistic modelling of P metabolism in dairy cows



WAGENINGEN UR
For quality of life

Thank you

geronda.klop@wur.nl