Schothorst Feed Research

Action of different phytase types & doses in different segments of the broiler digestive tract

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Ingredients of this talk about phytase

- Introduction and a brief history
- Efficacy and economy
- ANF effect of phytate
- Interaction Ca, P and N
- DuPont SFR experiment
- Conclusions
- Take Home Messages

Introduction

Phytase has become an indispensable ingredient in feeds for poultry and pigs:

- To diminish P-excretion and improve P-utilisation
- To improve animal performance
- To make extra money

Brief history phytase development

Started in the eighties in The Netherlands by:

- Gist Brocades
- Dutch Board for Animal Feeds

Because of excessive emission of phosphorous (P) to the environment

- First generation: Aspergillus 3-phytase, Natuphos
- Second generation: E.Coli 6-phytases
- Third generation: Buttiauxella, Axtra® PHY

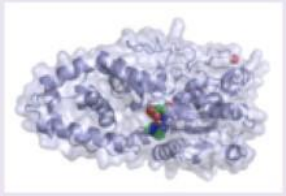
Improvement in efficacy

1.98 Kg

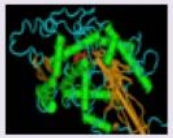
2.19 Kg

2.77 Kg

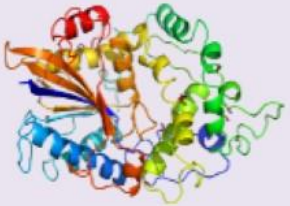
1980 1990 2000 2010 2015



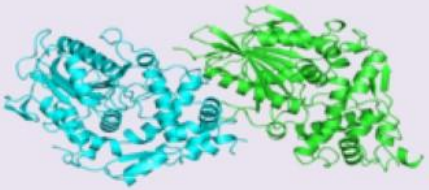
Aspergillus-3



Peniophora lycii



Citrobacter braakii



E.Coli-6

E. Coli (Trichoderma reesei)

Buttiauxella spp (Trichoderma reesei)

Based on Rauw 1998 and Ross info

Economic benefits of phytase above animal performance and environmental benefits

	1991	2014
Price of a 5,000 FTU phytase product	~ 25 USD/kg	~ 9 USD/kg
Cost of using 500 FTU	2.50 USD/ton	0.90 USD/ton
Price of inorganic phosphorus (as MCP)	~ 200 USD/ton	~ 650 USD/ton
Typical phytase "P contribution" at 500 FTU dose	0.10% av.P	0.13% av.P
MCP replacement in the formulation	4.42 kg	5.75 kg
Savings from MCP replacement in feed	0.88 USD/tonne	3.74 USD/tonne
Net profit	**- 1.62 USD/ton**	**+ 2.84 USD/ton**

Phytate: Anti-Nutritional Factor (ANF)

- Contains P and binds minerals as Ca, Mg, Fe, Cu and Zn
- More endogenous losses of amino acids
- Reduces sodium pump activity (Ha)
- Suggested to form complexes with proteins
- More protein and energy used to compensate for endogenous losses
- ANF-effect mostly related to IP-6 and IP-5, but impact from IP-3 and IP-4 also important

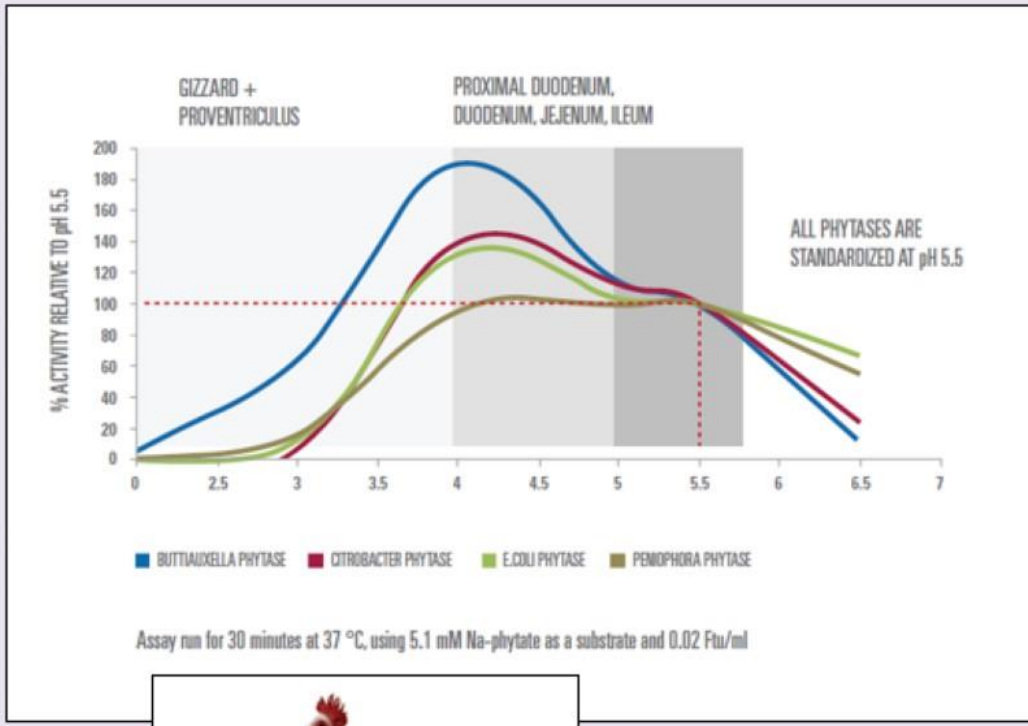
Criteria for a “highly effective” phytase

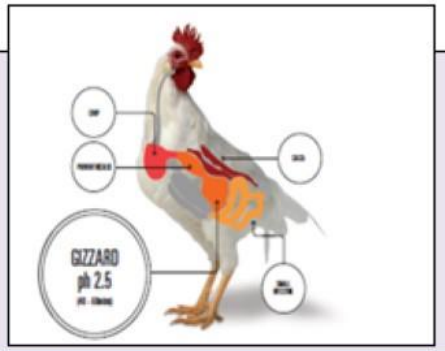
Need to hydrolyze phytate (IP6) in the stomach and upper part of the small intestine:

- As completely as possible
- As quickly as possible

A good phytase needs to have the following attributes:

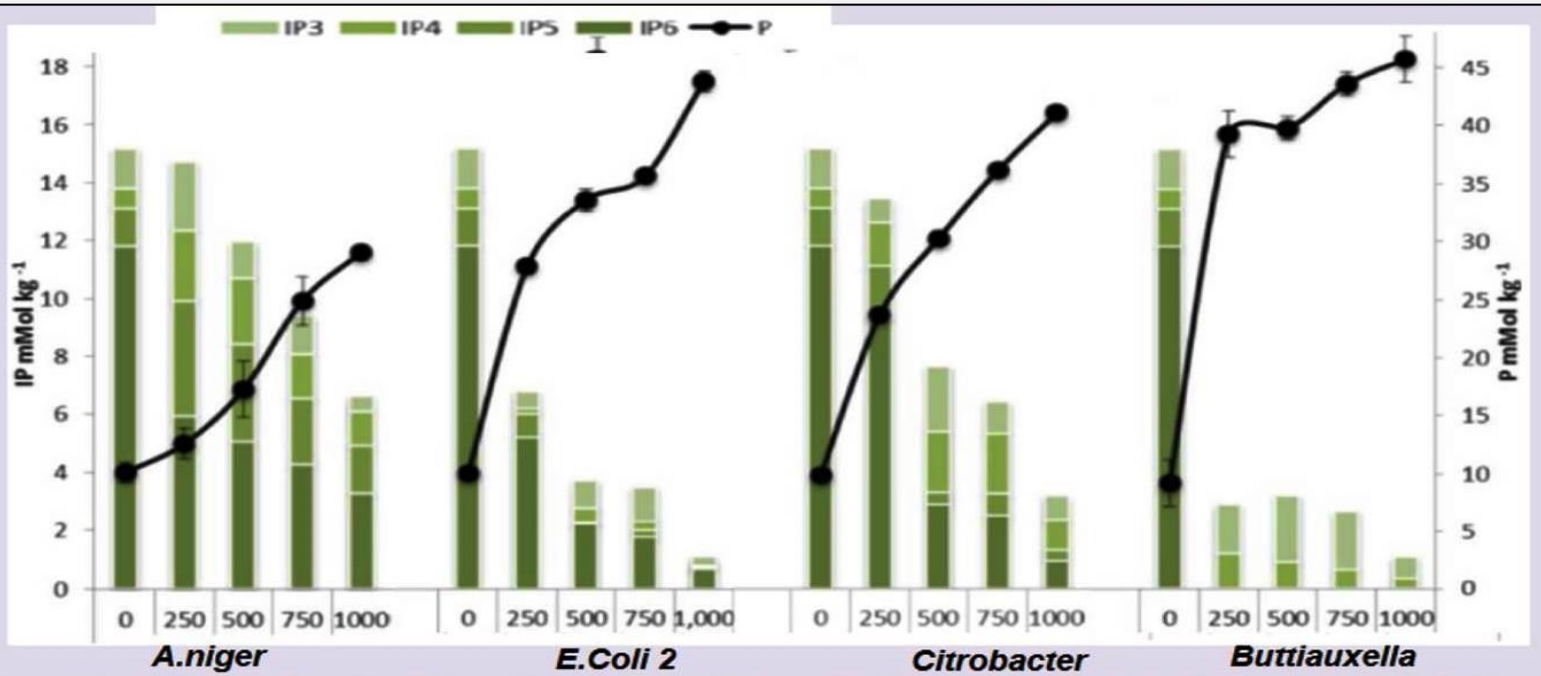
- Highly active in low and wide pH range
- Resistance to protease
- High affinity for and fast degradation of IP6
- Heat stable





Differences in enzyme kinetics and pH optima of phytases result in very different phytate de-phosphorylation patterns and phosphate release during *in vitro* simulation of digestion

Intestine — **Menezes-Blackburn *et al.*, 2015**

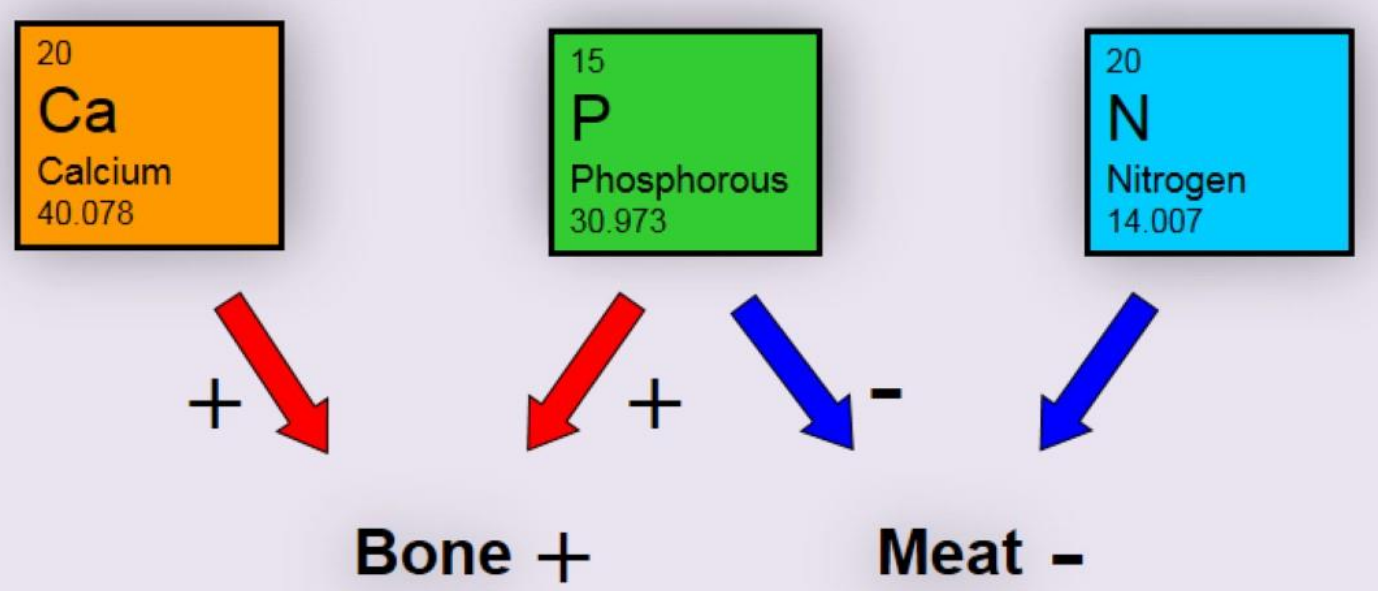


Enzymatic phytate dephosphorylation of wheat during in vitro simulation of poultry digestive tract in a high buffer system

Interaction between Ca, P and N

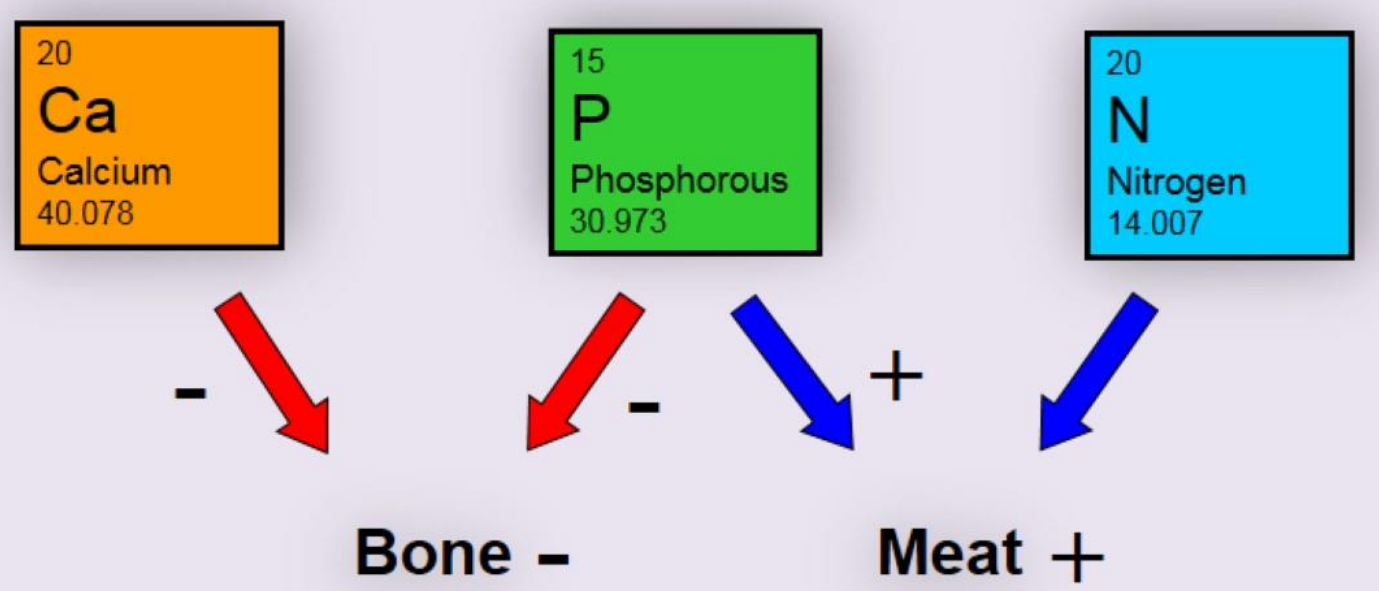
- Calcium: most abundant mineral in the body; 75 - 95% is found in the skeleton and also plays a major role in many enzyme systems, e.g. control of nerve impulses, muscle contractions.
- Phosphorus: predominantly present in the skeleton (50 - 80%) also occurs in soft tissues: phosphoproteins, nucleic acids, phospholipids in animal cell walls; plays a vital role in energy metabolism
- Ca & P stored in bone (mineral hydroxy-apatite) at constant ratio of 2.1 to 1.
- N is stored mainly in the soft tissues as meat

Interaction of Ca and P with N/protein



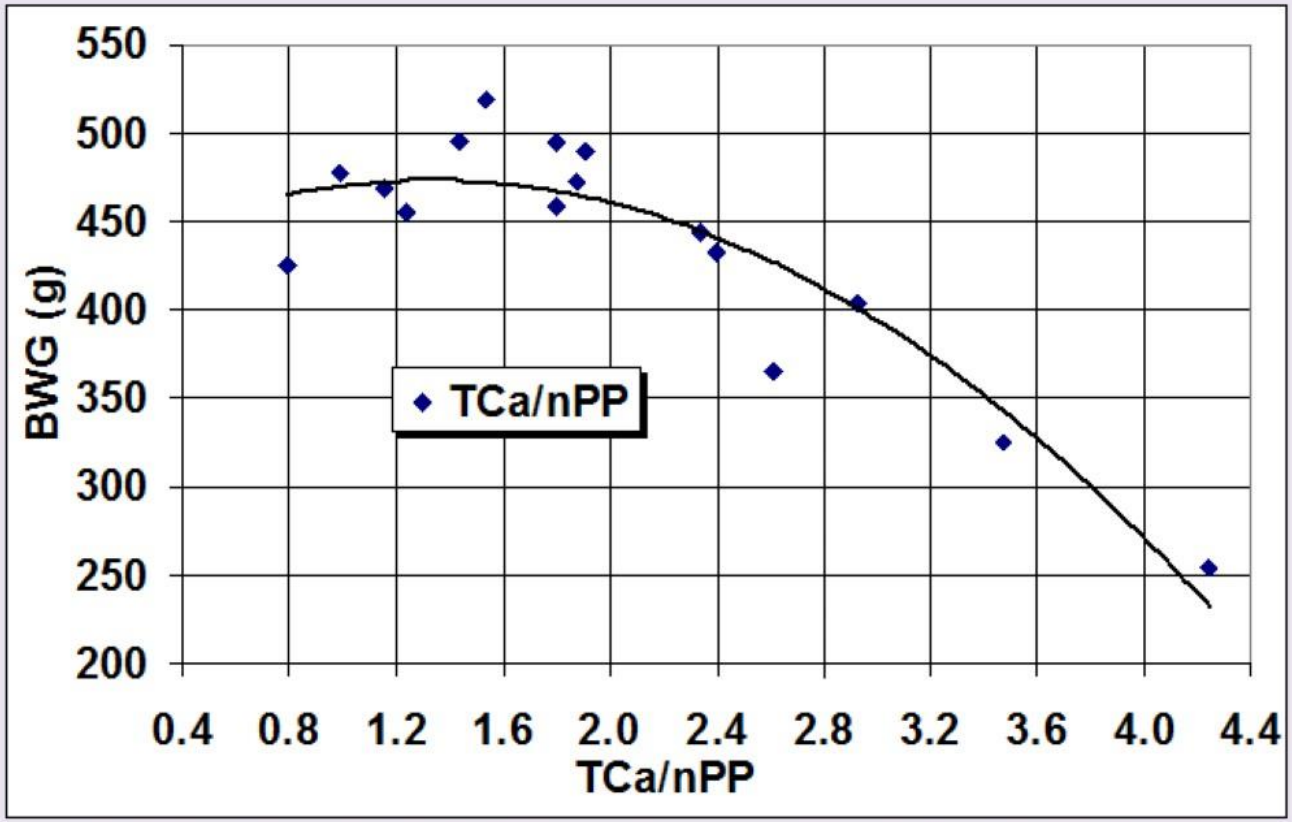
P-requirements are also related to protein-requirements

Interaction of Ca and P with N/protein



Less calcium can result in more meat and changed P-deposition

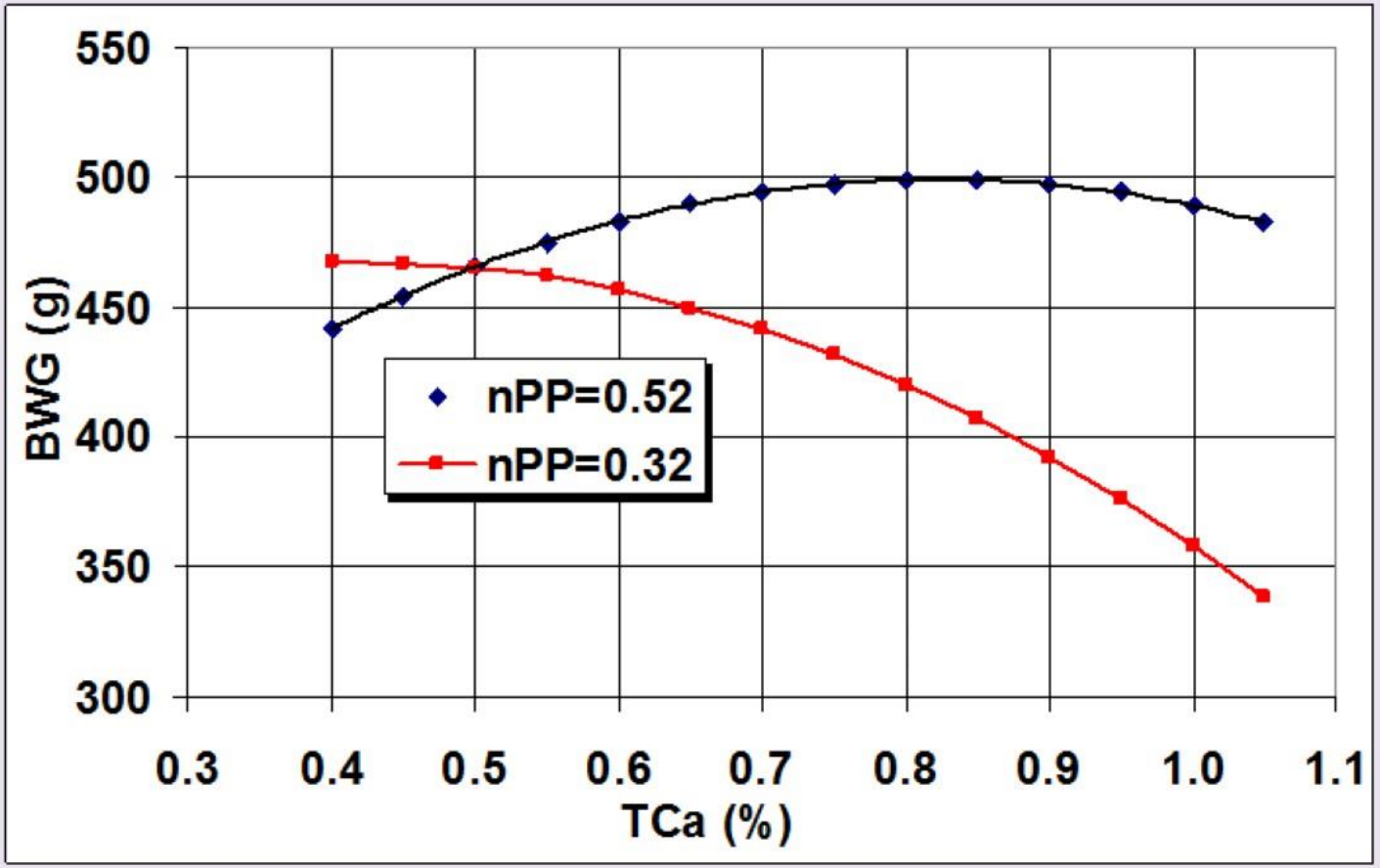
Interaction between Ca and P
Effect of Ca/nPP ratio on BWG day 1-16 in broilers



- A high ratio Ca/nPP has a negative effect on BWG

Driver *et al*, 2005

Interaction between Ca and P
Effect of Ca on BWG day 1-16 at low and high P-supply



Calculations from mathematical broiler model Driver, 2005

- At a low P-supply, the effect of extra Ca on BWG is negative

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Digestion and metabolism of Ca and P in broilers

- Uptake of Ca is regulated at intestinal level depending on supply / requirements

Ca in feed	Ileal dig. Ca (%)
Low	51.0
Standard	34.5
High	31.3

Krimpen *et al*, 2013

- Excess of P is mainly excreted via urine

Dose and type: set up experiment DuPont at SFR

(LPH-51)

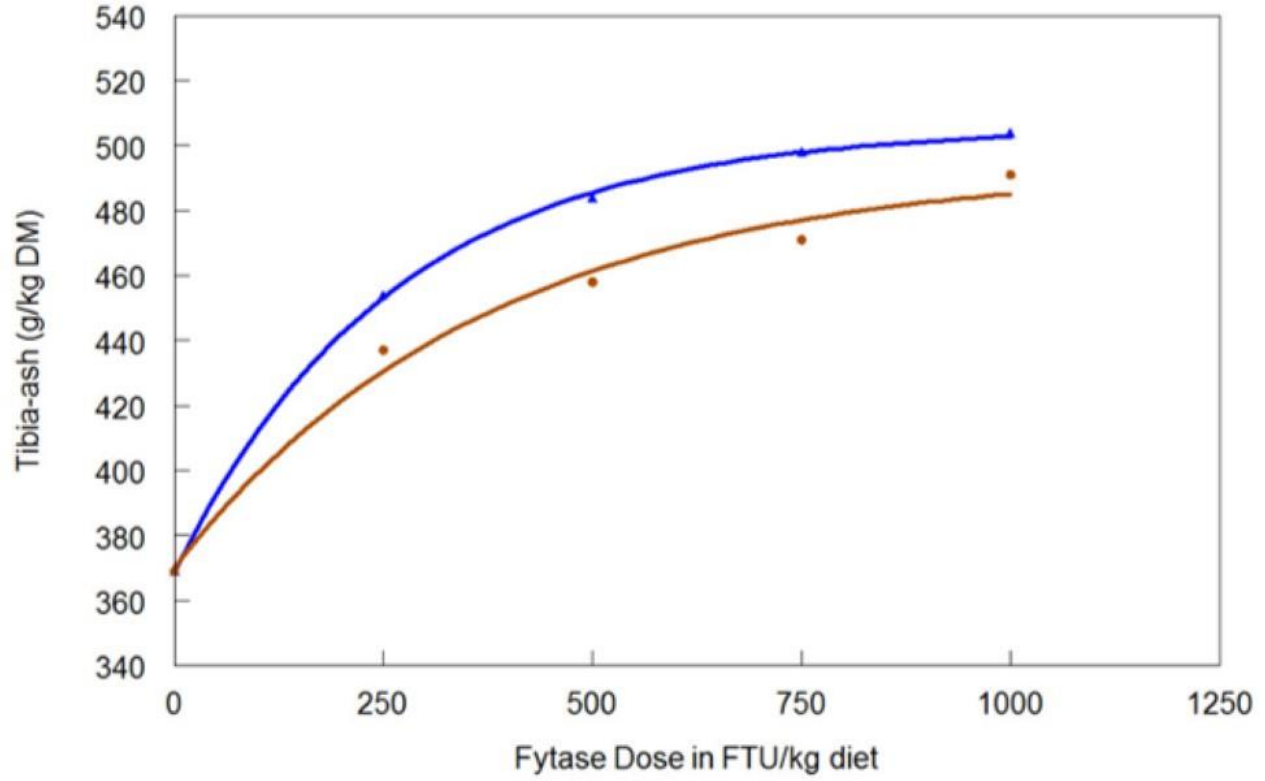
Product	Phytase FTU/kg	Calc P	Calc Ca
NC	0	4.8	7.5
Buxiauxella	250	4.8	7.5
	500	4.8	7.5
	750	4.8	7.5
	1000	4.8	7.5
E.Coli phytase	250	4.8	7.5
	500	4.8	7.5
	750	4.8	7.5
	1000	4.8	7.5
PC0.6	+0.6 g P	5.4	7.5
PC1.2	+1.2 g P	6.0	7.5
PC1.8	+1.8 g P	6.6	7.5

Observations:

- FI, BWG and FCR from day 5 till day 20
- Retention of Ca and P at days 7/8, 13/14 and 18/20
- Ileal absorption of Ca and P at day 21
- Tibia ash at day 14 and day 21

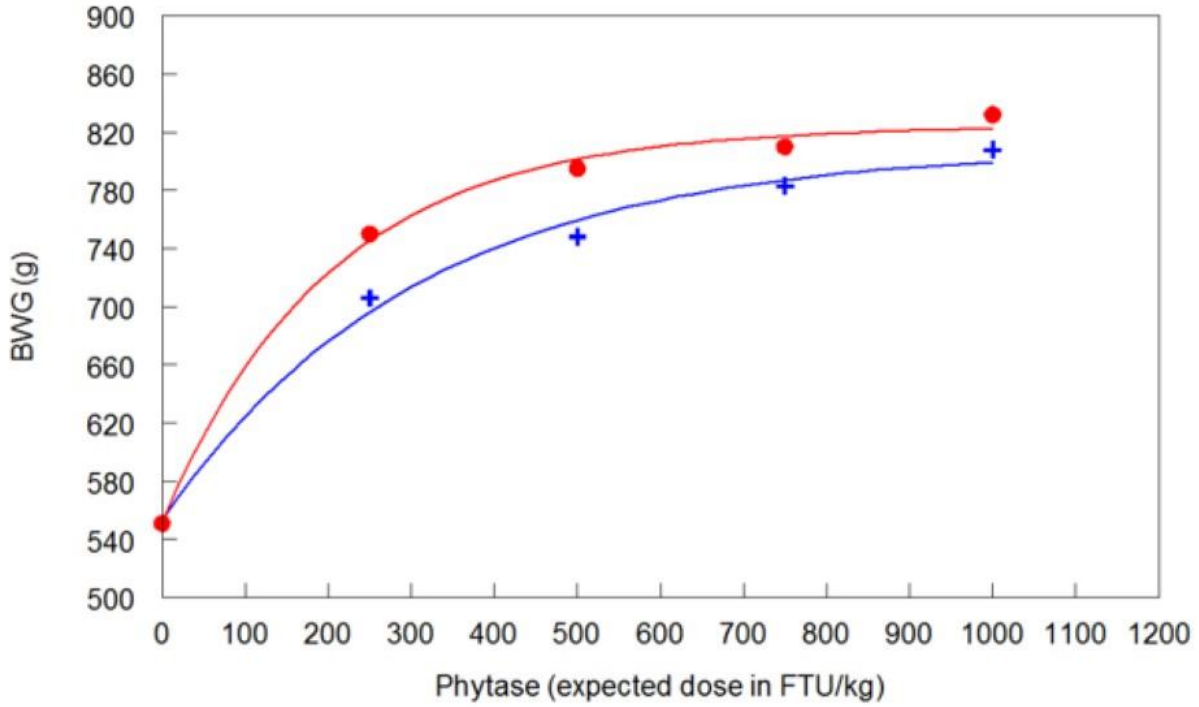
Effect of dose and phytase source on tibia ash at day 21

Phytase from Buttiauxella is more effective on tibia ash than from E. Coli

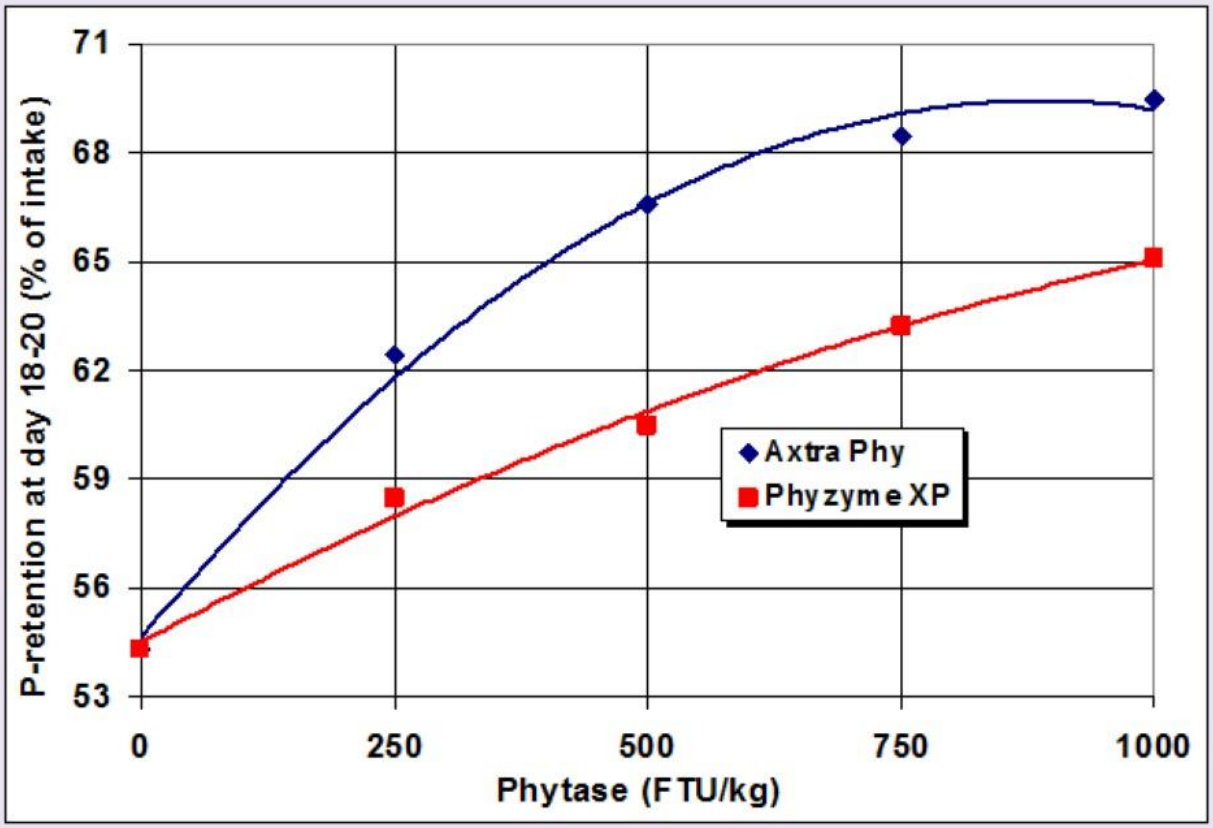


Effect of dose and phytase source on BWG day 5 - 20

Phytase from Buttiauxella is more effective on BWG than from E. Coli



Effect of dose and phytases on P-retention

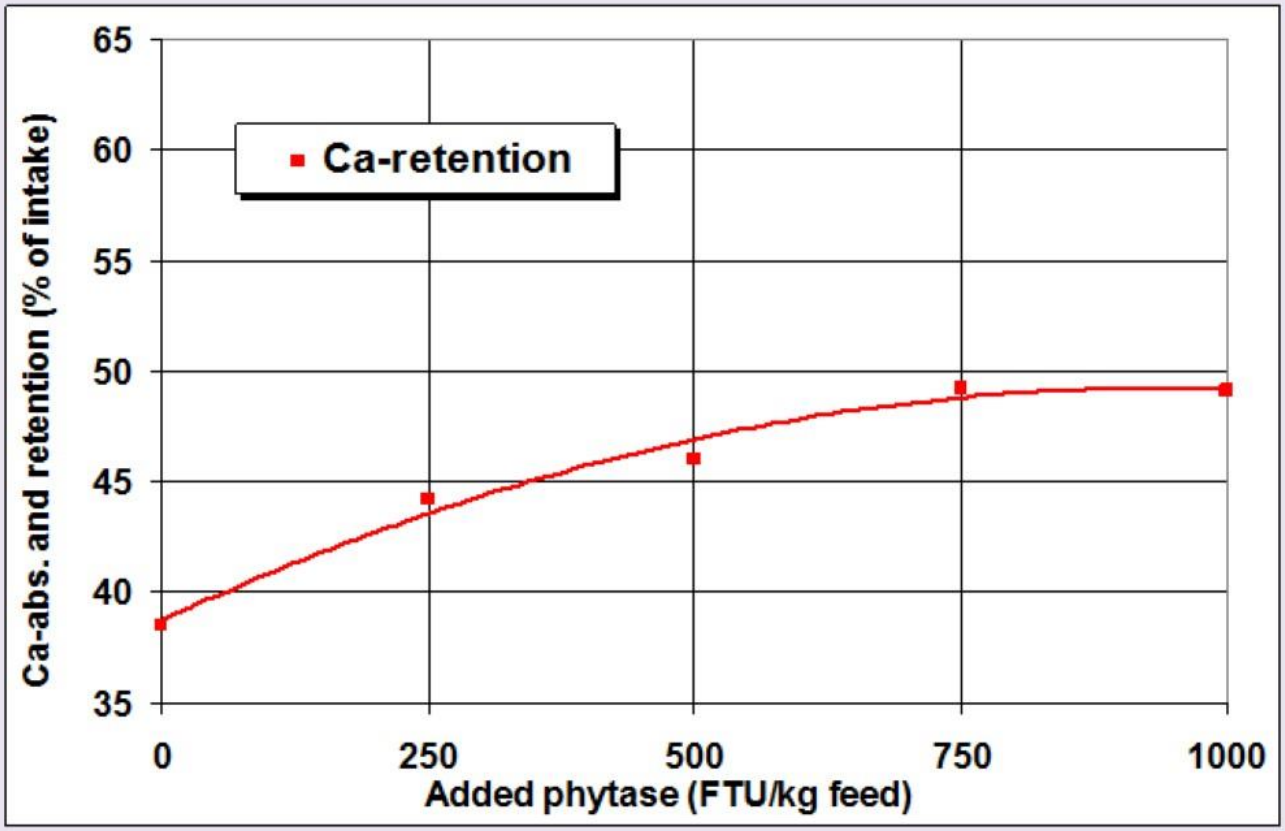


Phytase from Buttiauxella is more effective on P-retention then from E. Coli

Conclusions on dose and phytase source

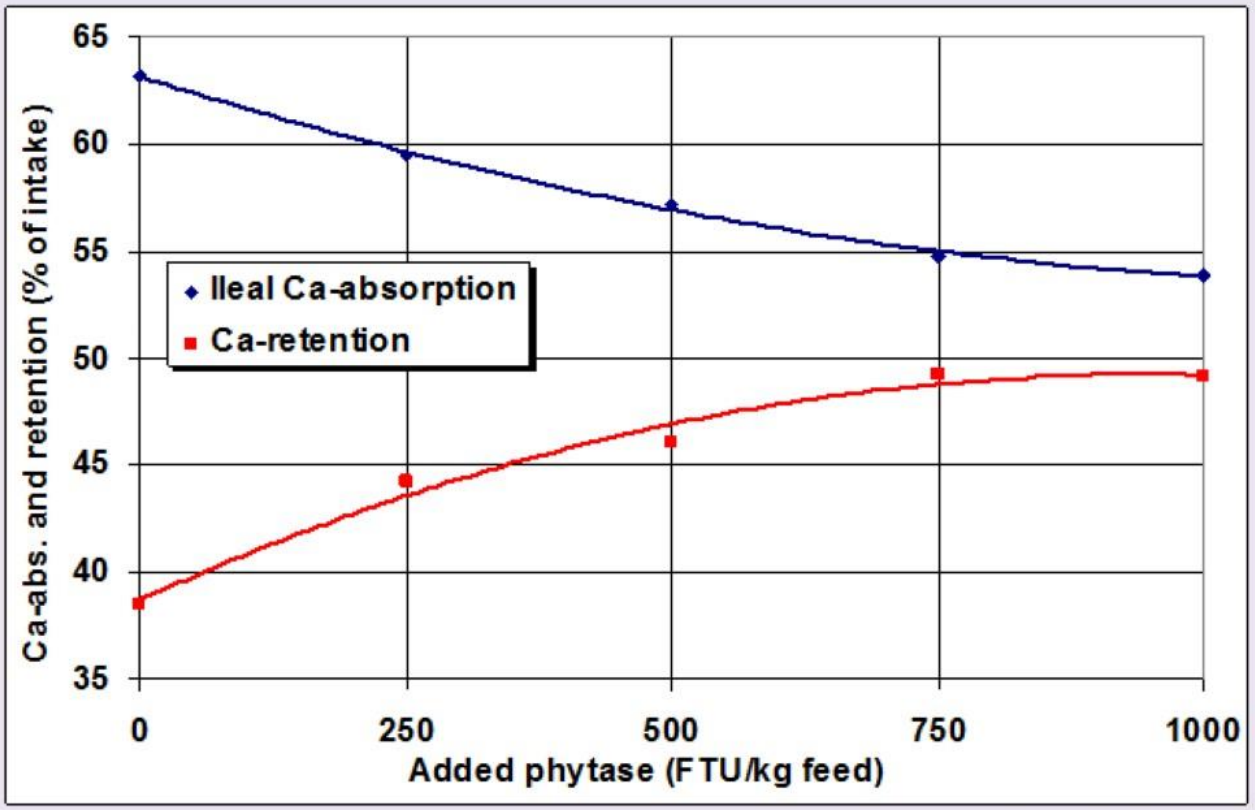
- Butiauxella phytase is more effective than E. Coli phytase regarding bone formation, BWG and P-retention
- Optimal dose: 500 => 1000 FTU/kg ?!

Effect of phytase on Ca-retention



SFR LPH-51;
All feeds: 7.5 g Ca per kg feed
Retention: day 18-20

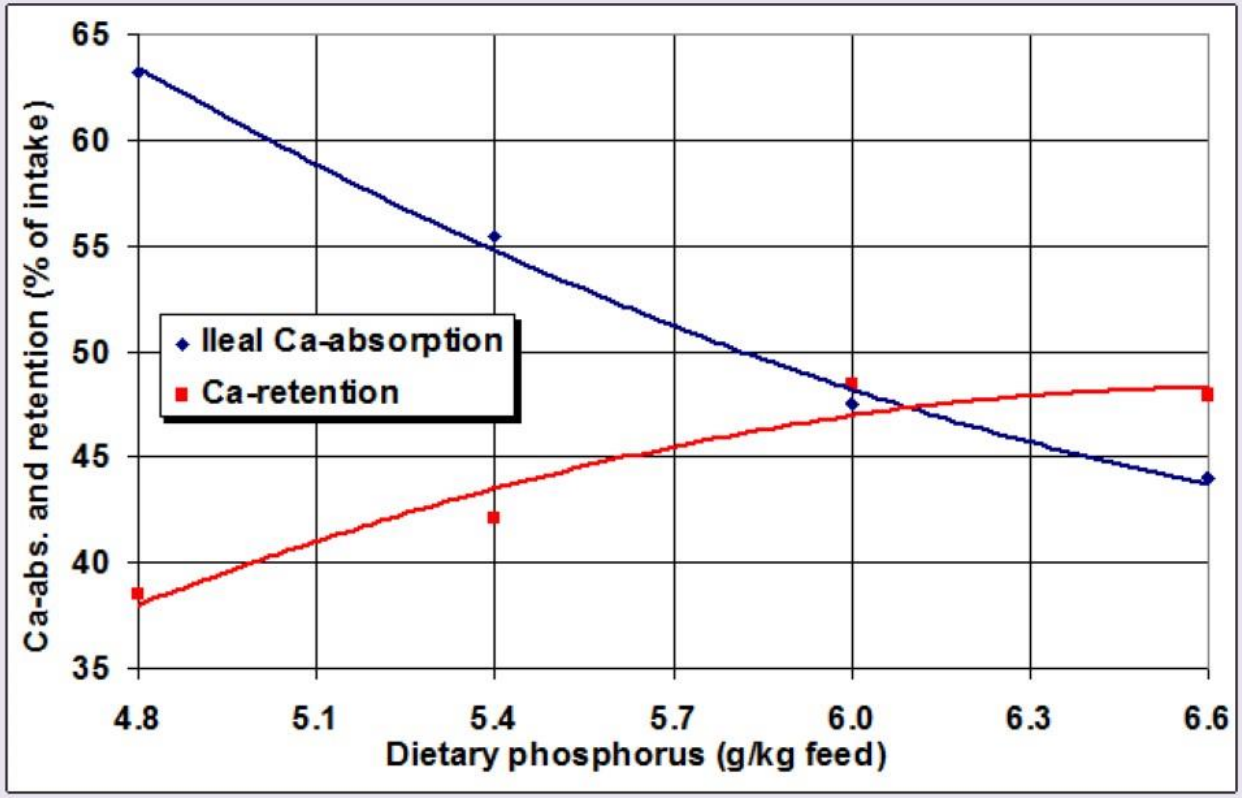
Effect of phytase on ileal Ca-absorption and -retention



SFR LPH-51;
All feeds: 7.5 g Ca per kg feed
Retention: day 18-20
Absorption: day 21

Phytase has ***not*** a positive effect on ileal Ca-absorption, but has a positive effect on Ca-retention!

Effect of mineral P on ileal Ca-absorption and -retention



SFR LPH-51;
All feeds: 7.5 g Ca per kg feed
Retention: day 18-20
Absorption: day 21

Also extra mineral phosphorus from MCP, partly replacing lime stone, has a negative effect on ileal Ca-absorption and a positive effect on Ca-retention!

Why decreases mineral P and phytase ileal Ca-absorption and increases Ca-retention?

- Formation complexes of Ca and phosphates in intestinal tract. Ca-source???
- Increased P-supply below P-requirements increases bone formation and requirements for Ca, and so increase Ca-retention!!!

Conclusions

- The third generation of phytases are more effective per FTU than the older ones, probably related to a high activity at a low and wide pH range
- To reduce the ANF effect, phytate needs to be degraded rapidly and thoroughly in the upper part of GIT
- The optimal phytase dose tends to increase depending on source, age, animal performance and economy
- Requirements for Ca, P and protein are related:
  - Extra Ca at low P-supply seems to reduce P-absorption and Body Weight Gain
  - Extra mineral P and phytase at a low P-supply do not increase ileal Ca-absorption, but increase retention of Ca

Take Home Messages

- Use higher phytases doses than in the past depending on economy and age
- Try to develop a new standard phytase measurement *in vitro* at a pH that is better correlated with *in vivo* efficacy than the common standard at pH 5.5, but validation with *in vivo* trials is still necessary
- Try to reduce the Ca-supply and find out the effect of the phytase on Ca-absorption and -retention
- Always compare efficacy of phytases in animal trials with graded levels of mineral P from MCP