Winning with phytase

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Winning Strategy Requires Key Decisions To Be Made

Which Phytase? What dose?

How much AvP / Ca^{2+} contribution?

Energy & Amino Acids from Phytase?

Table 1. Some examples of currently commercially available 3- and 6-phytases and their characteristics

Type†	Protein origin	Expression	pH optima	Temperature optima (°C)	Trade name
3	*A. niger**	*A. niger*	2; 5–5.5	65	Natuphos®
3	*A. niger**	*A. niger*, non-recombinant	6.0	–	Allzyme® SSF
3	*A. niger**	*Trichoderma reesei*	2.5	–	Finase® P/L
6	*Escherichia coli**	*Schizosaccharomyces pombe* (ATCC 5233)	4.5	55	Phyzyme® XP
6	*Escherichia coli**	*Pichia pastoris*	4.5	–	Quantum®
6	*Escherichia coli*	*Trichoderma reesei*	–	–	Quantum Blue®
6	*Escherichia coli**	*Pichia pastoris*	3.4, 5.0	58	OptiPhos®
6	*Peniophora lycii**	*Aspergillus oryzae*	4–4.5	50–55	Ronozyme®
6	*Citrobacter braakii*	*Aspergillus oryzae*	–	–	Ronozyme Hiphos®
6	*Buttiauxella* spp.	*Trichoderma reesei*	3.5–4.5#	60#	Axtra® PHY

*Adapted from Lei *et al.*[1] with modifications;
†3- or 6-phytase; —, no information available;
#personal communication (C Evans).

Dersjant-Li et al, 2015

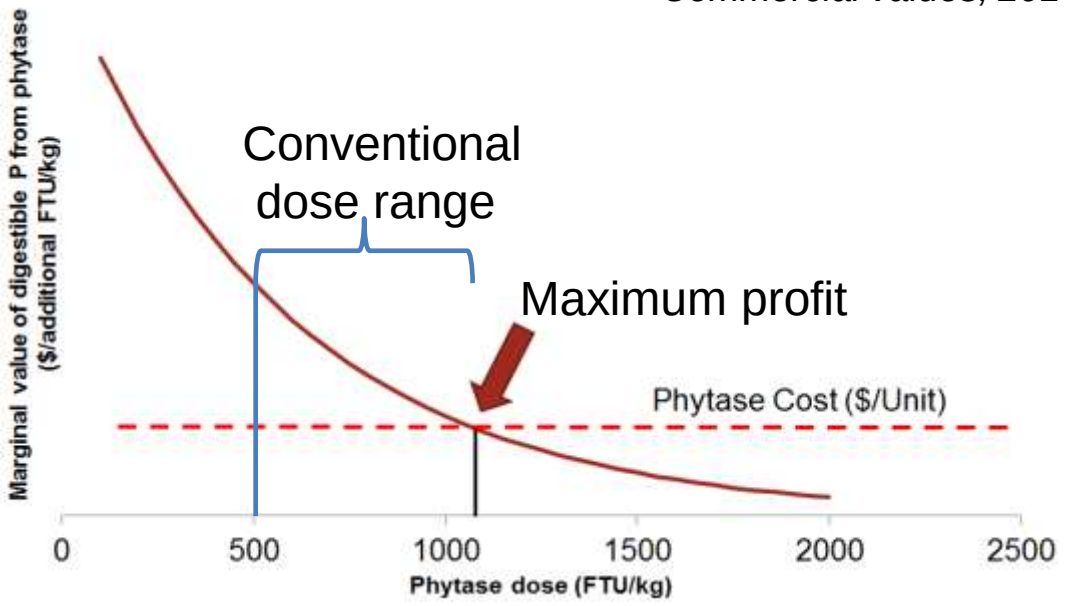
Supplier Recommended Nutrient Contributions From Standard Dose Of Phytase

	E.Coli 1	E.Coli 2	E.Coli 3	Citrobacter	E.Coli 4	Buttiauxella
FTU/kg feed	500 FTU	250 OTU	500 FTU	1000 FYT	500 QU	500 FTU
Digestible P%	0.11	0.11	0.13	0.117	013	0.134
Av.P %	0.12	0.13	0.13	0.146	0.15	0.15
Ratio of Dig. P:AvP	0.92	0.85	100	0.80	100	0.92
Calcium %	0.11	0.13	0.14	0.18	0.165	0.134

Commercial values, 2014

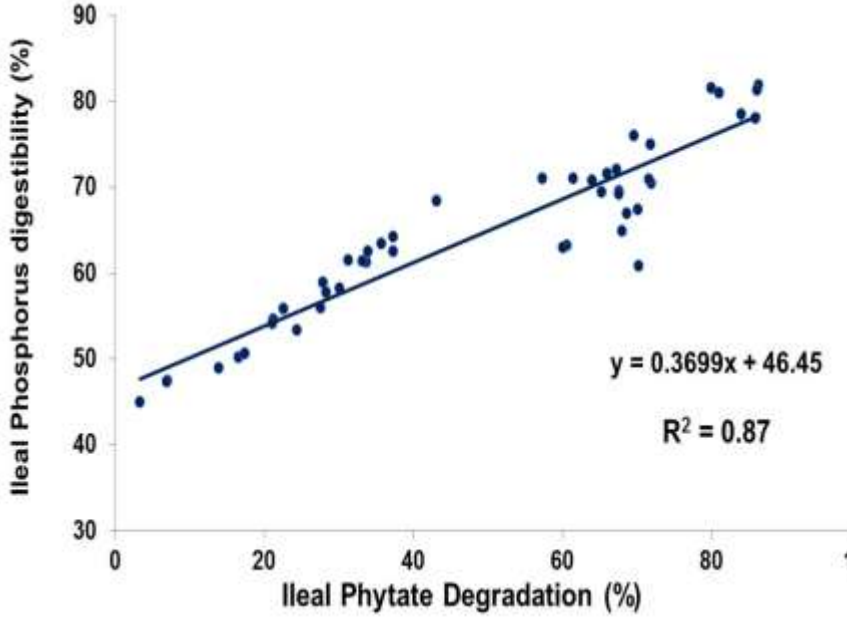
In practice, decisions of phytase source and dose are frequently determined on phytase cost /0.10% AvP release

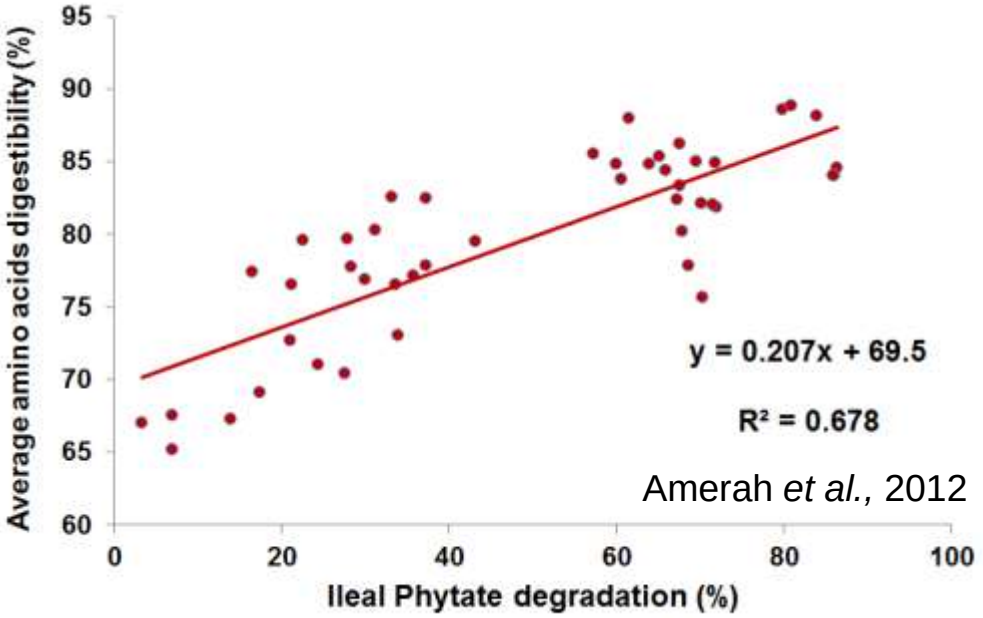
Dose is usually < Max. profit from P replacement to ↓ risk



Barnard *et al*., 2014

Phytate not only affect phosphorus digestibility, but also amino acid digestibility, starch digestibility, endogenous losses, and live-performance





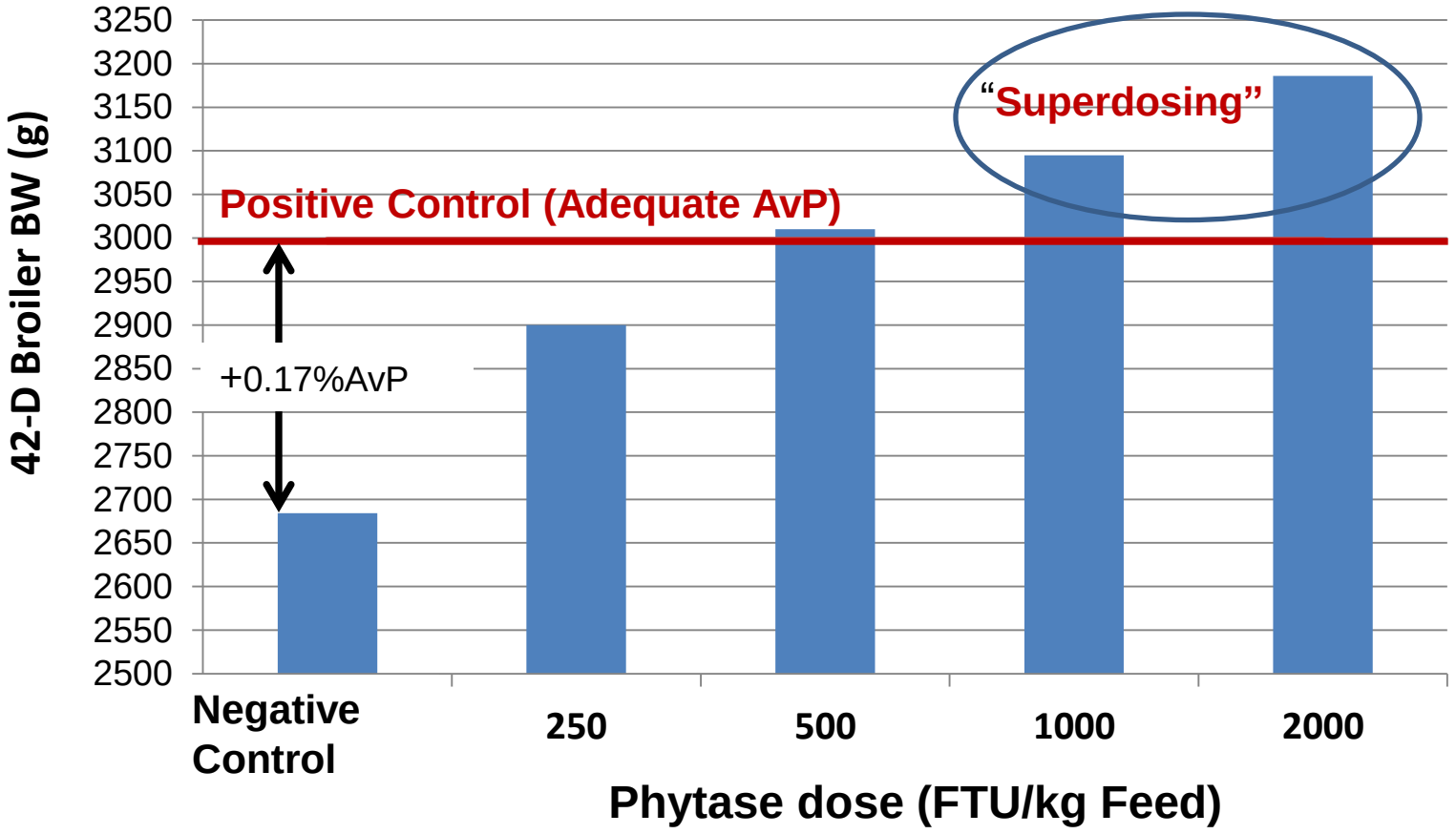
Amerah *et al.*, 2012

Higher phytate has also been shown to decrease live performance

Woyengo *et al.*, 2014

Animal type	Initial age (d)	PA[z] content in control diet (%)	PA content in PA diet (%)	Response criterion[y]	Decrease in performance due to PA (%)	Reference
Broiler	0	0.78	1.57	BWG	3	Liu et al. (2009)
Broiler	0	0.78	1.57	BWG	3	Liu et al. (2008a)
Broiler	0	0.78	1.57	BWG	7	Liu et al. (2008b)
Broiler	7	1.04	1.57	BWG	7	Cabahug et al. (1999)
Broiler	8	0.00	1.65	BWG	28	Onyango and Adeola (2009)

High Doses Of Phytase Have Also Been Shown To Improve Performance Beyond What Can Be Explained By Phosphorus



Unpublished, 2015

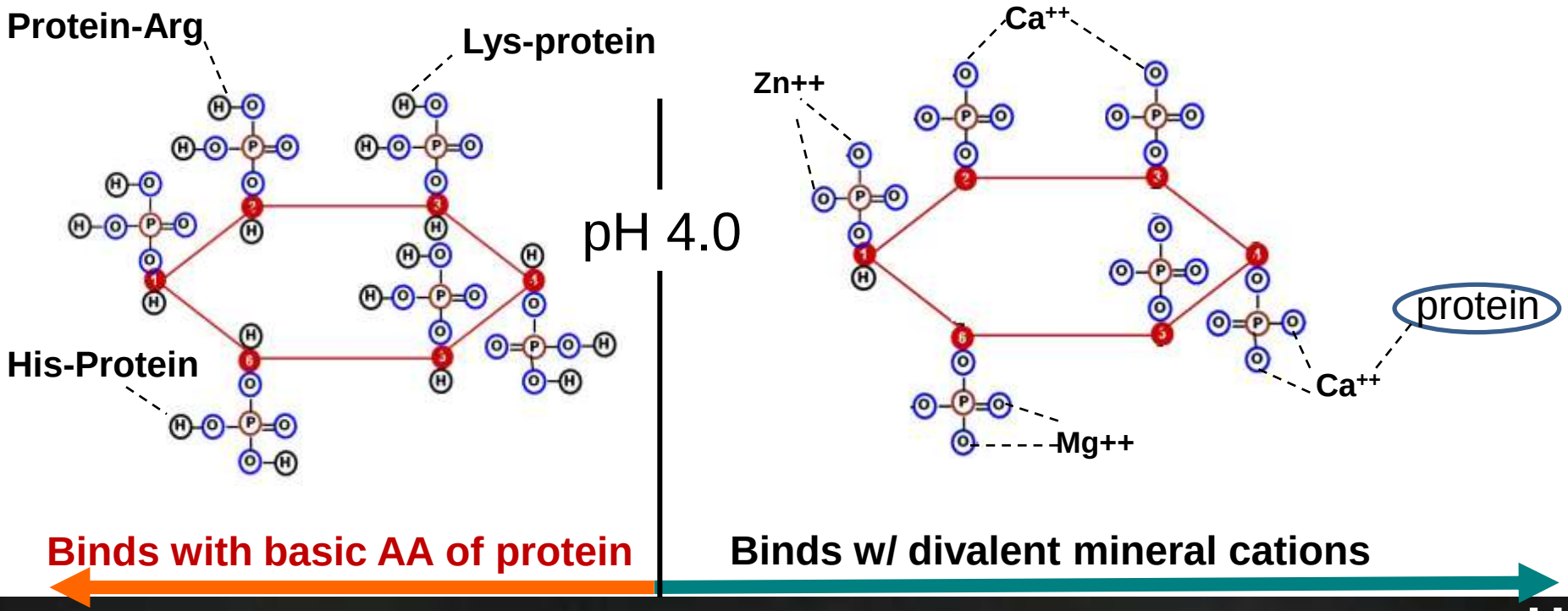
Interactions Of Phytic Acid With Dietary Nutrients Are pH Dependent

Mineral cations also chelate at low pHs if soluble (Tamin et al., 2003)

Proteins and phytate acid also interact at higher pHs >6 in presence of Ca^{2+} Briggs (1959, **Saio** et al. (1967,1968)

Gizzard / Proventriculus

Duodenum / Ileum / Jejenum



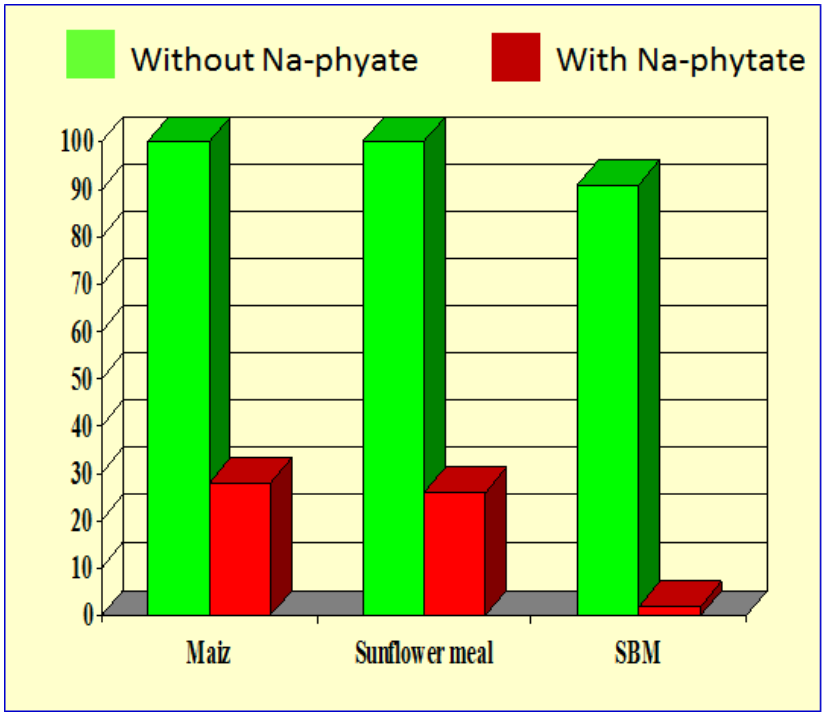
Binds with basic AA of protein

Binds w/ divalent mineral cations

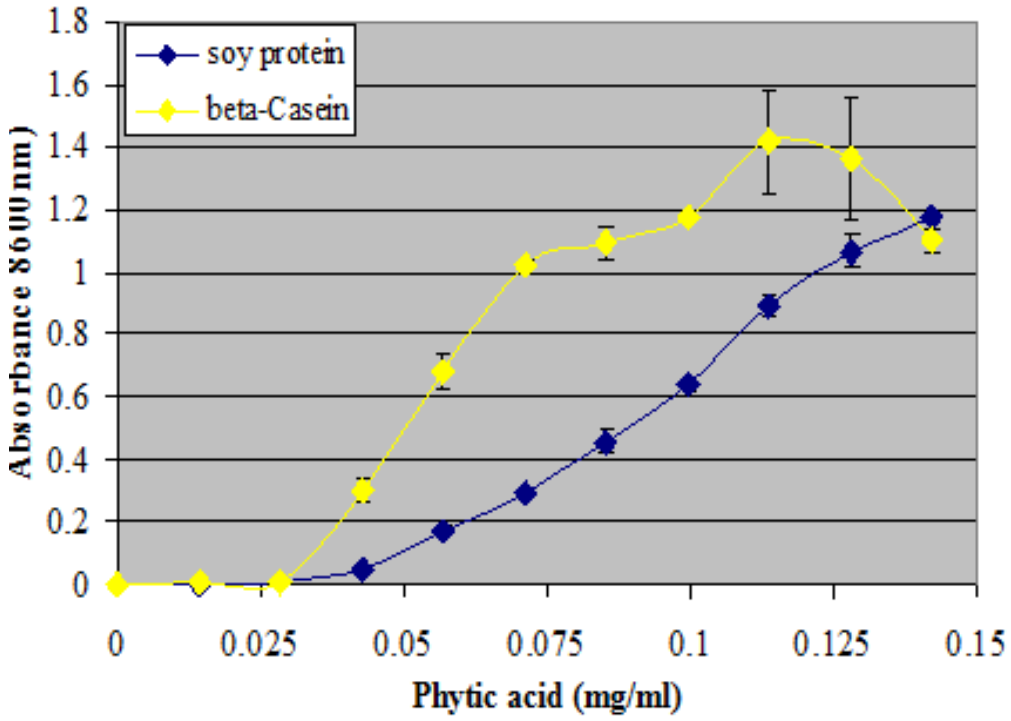
Nelson *et a*l., 1968; Maga, 1982; Angel *et al*., 2002, Selle *et al.,*2009,2012; Walk *et al.,*2012

Phytic Acid Interactions with Protein

- Protein-phytate complexes – form directly with phosphate group at low pH
- Tertiary bridges – via Ca and basic residues in the protein , at pHs>6
- Protein-phytate formation proportional to the ratio of phytate:protein



Kies *et al.*, 2006.

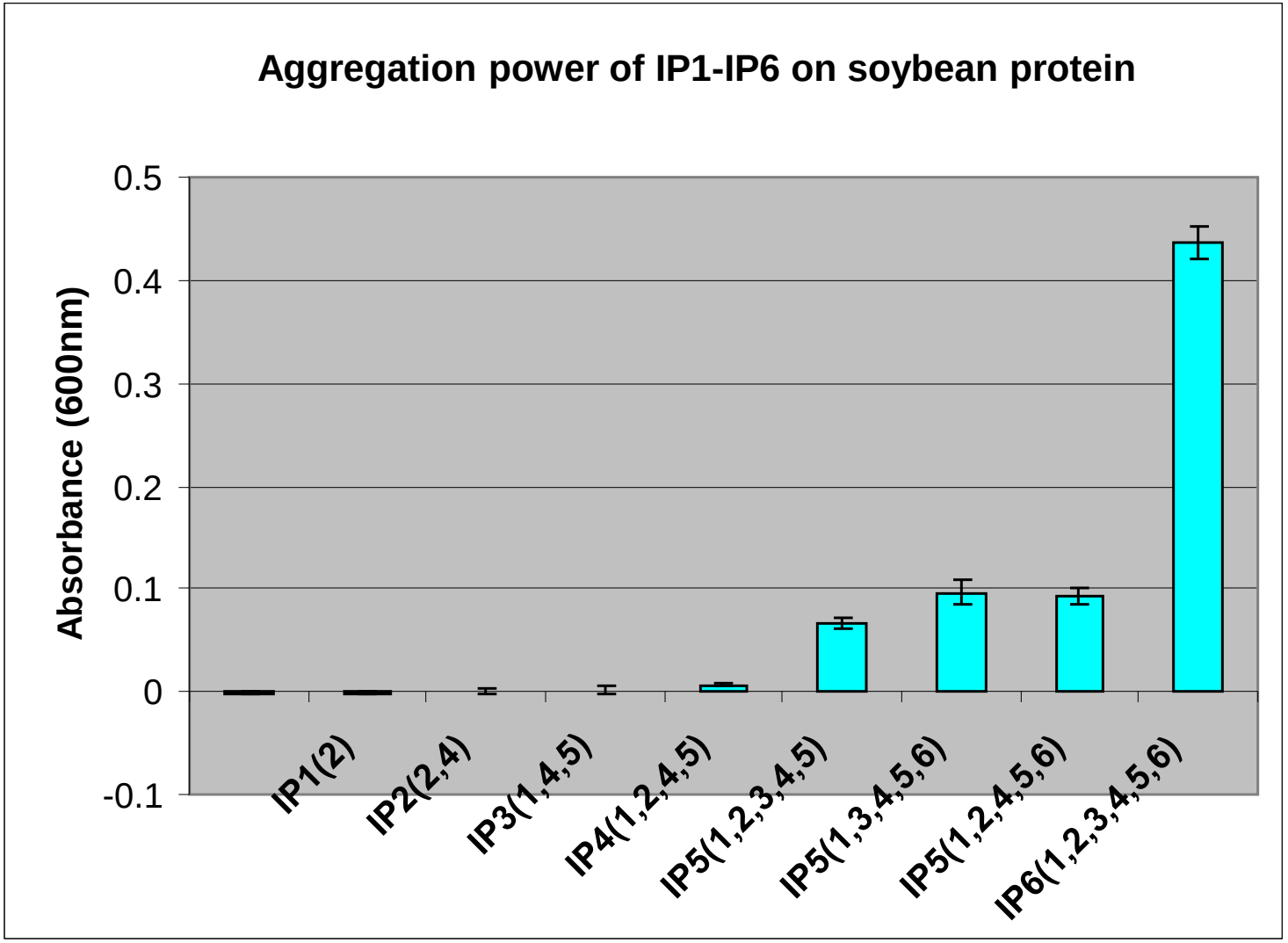


Yu et al.,2012 J. *Anim Sci.* 90:1824-32.

Protein-phytate complex formation is fundamental to phytate effects on protein/amino acid availability

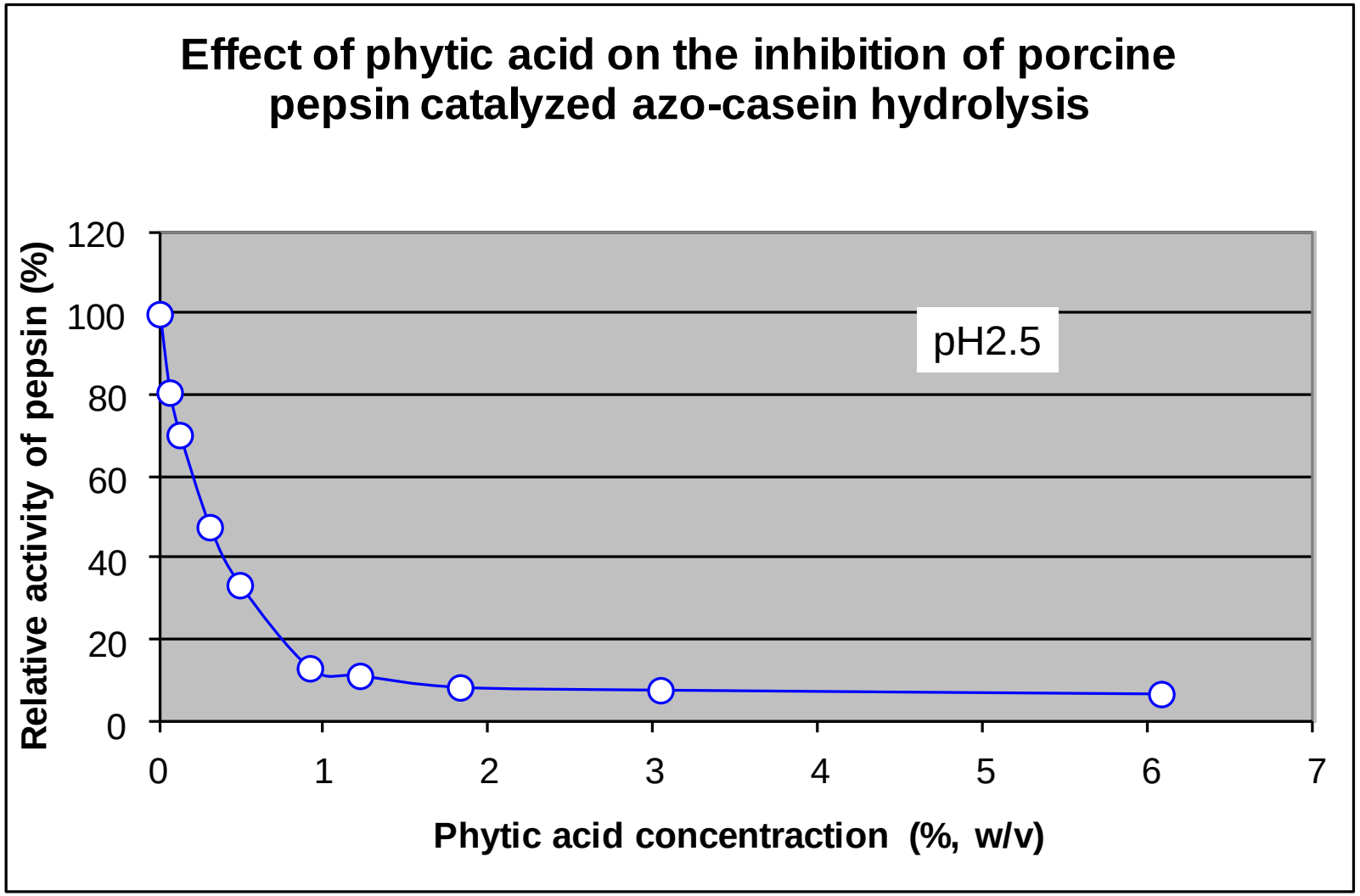
Selle et al., 2012, Adeola&Cowieson, 2014

Only IP6 And To A Lesser Extent IP5 Has The Ability To Bind Protein At Low pH



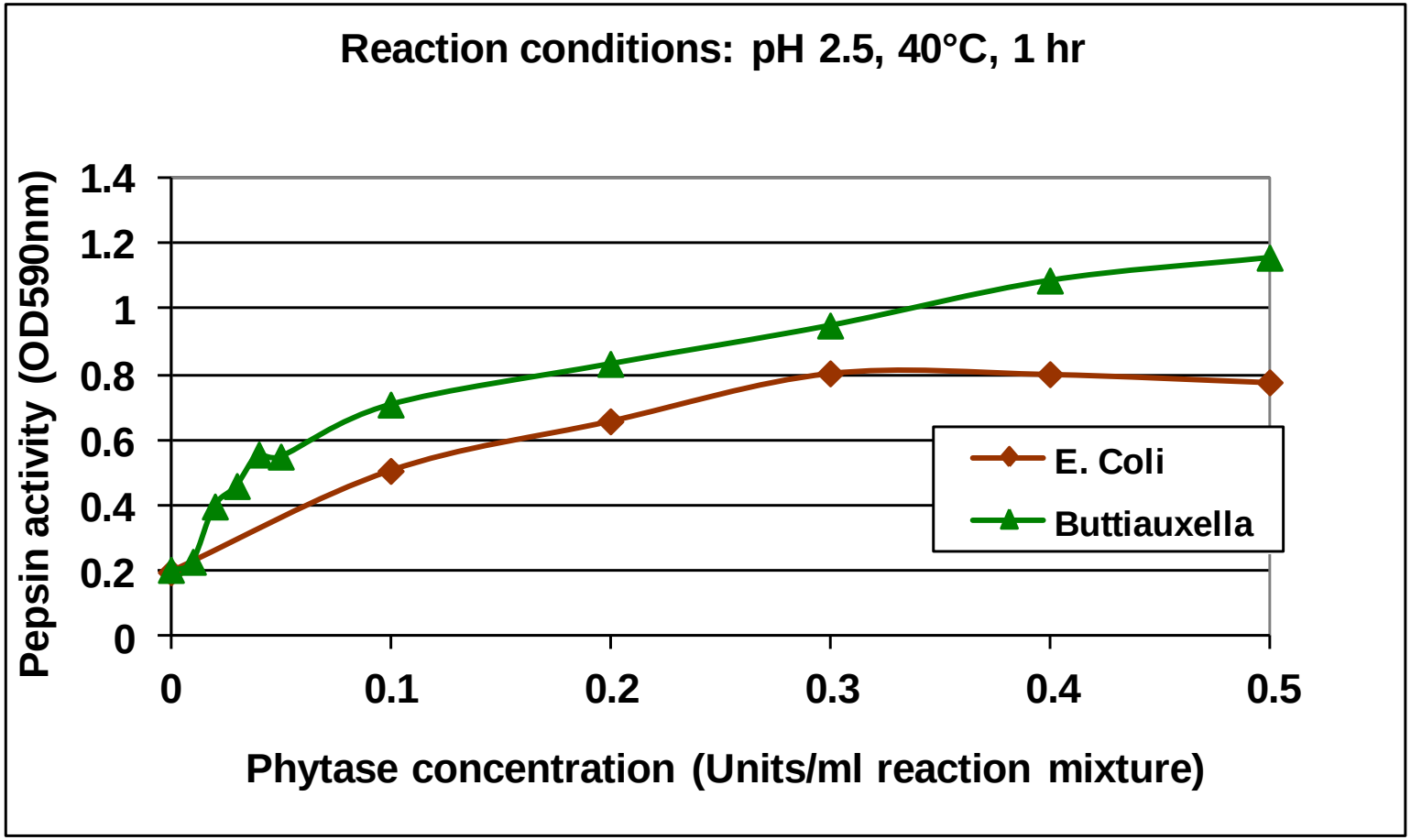
Yu *et al.*,2012 J. *Anim Sci.* 90:1824-32.

Phytate- Protein Complexes Are Not Broken Down By Pepsin



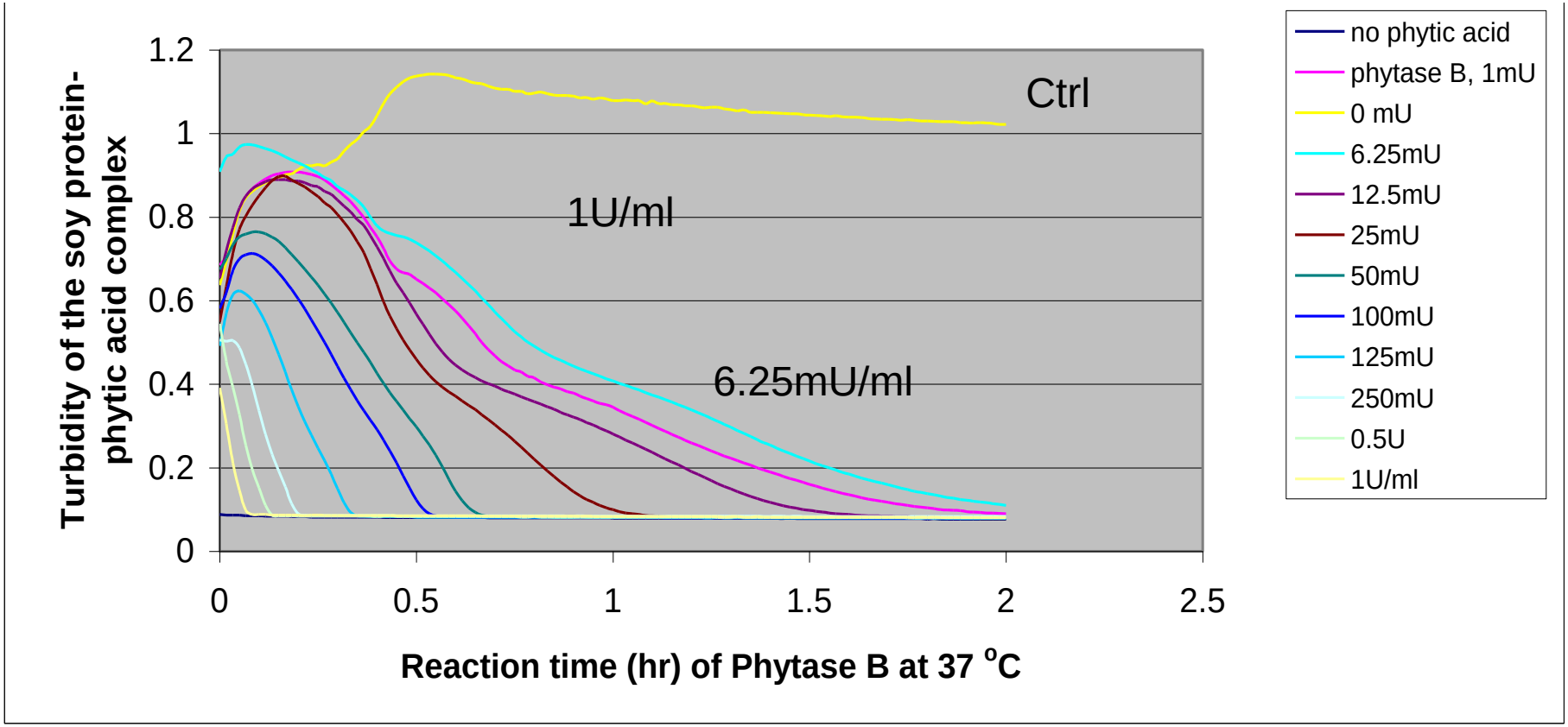
Yu *et a*l.,2012 J. *Anim Sci.* 90:1824-32.

Phytase Reverses Anti Nutritional Effects Of Phytate, Allowing Pepsin To Degrade Protein – Dose Dependent Benefits



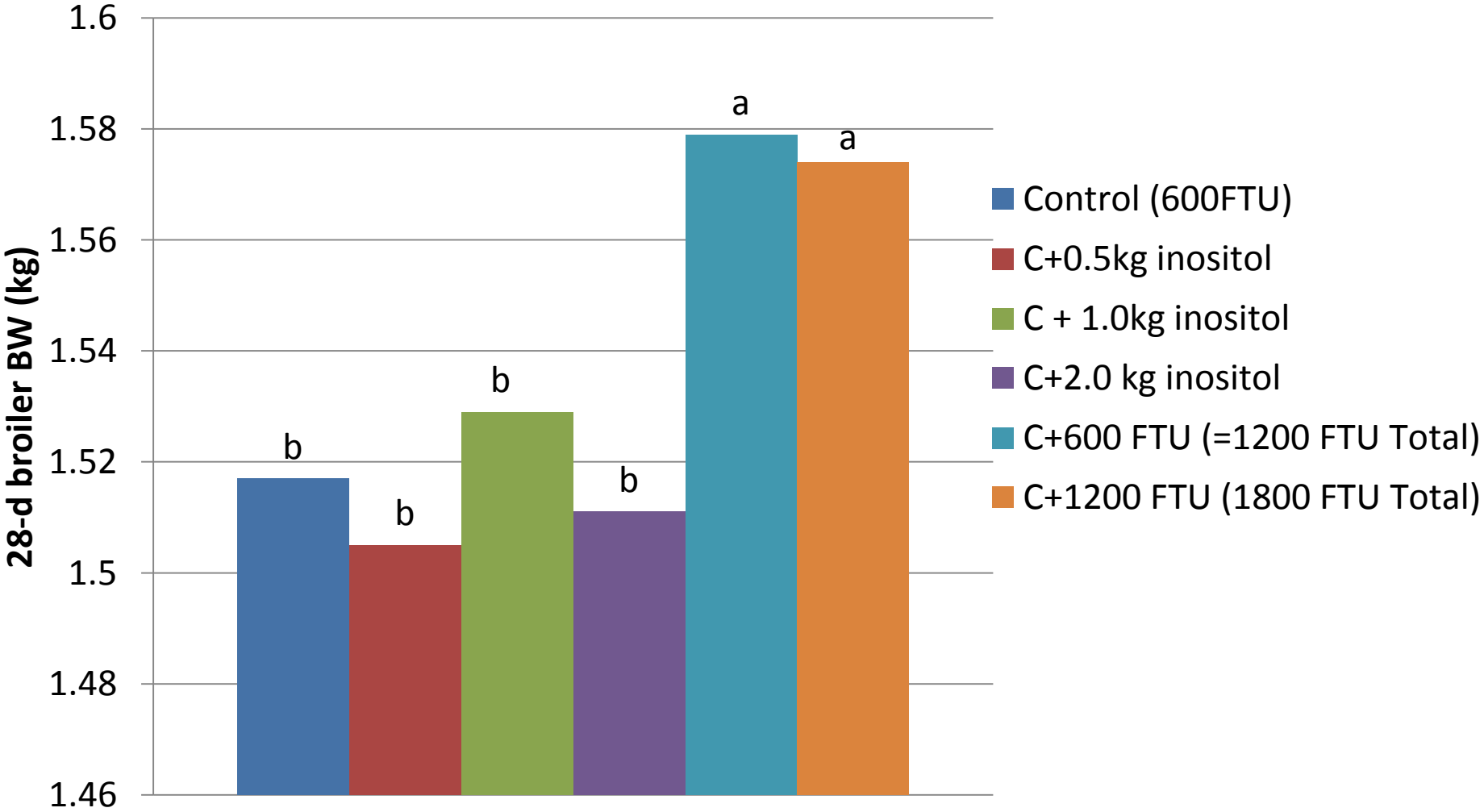
Yu, 2010 Unpublished

Degradation Of Protein-phytate Aggregates By Phytase – Rate Is Dose-dependent



Yu, 2010 Unpublished

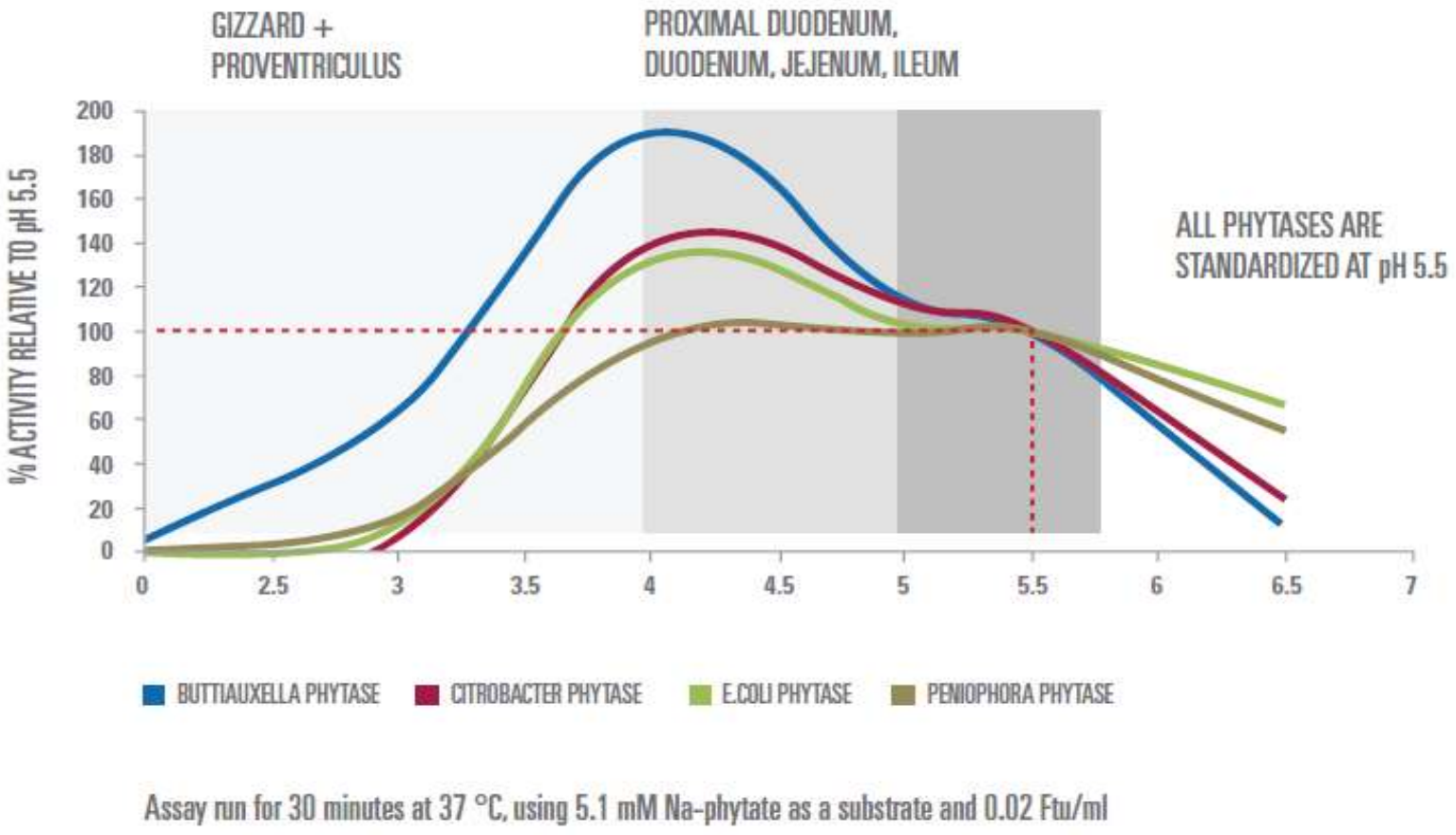
Does Inositol Play A Significant Role In "Superdosing" Effects Of Phytase ?



[a-b] indicates a significant difference at $p<0.05$

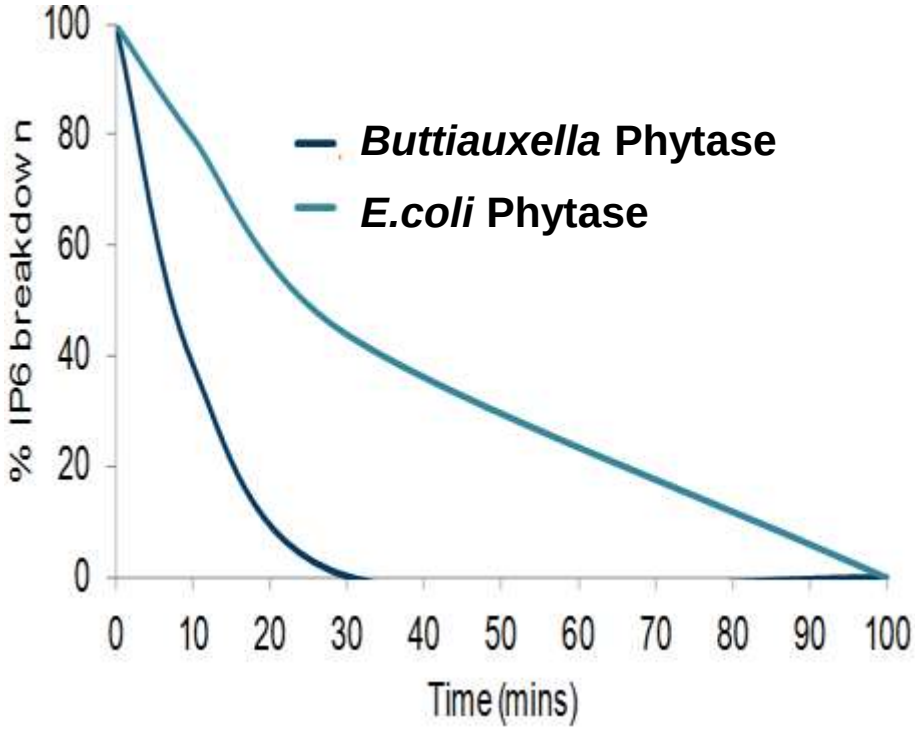
(Walters *et al*, 2015)

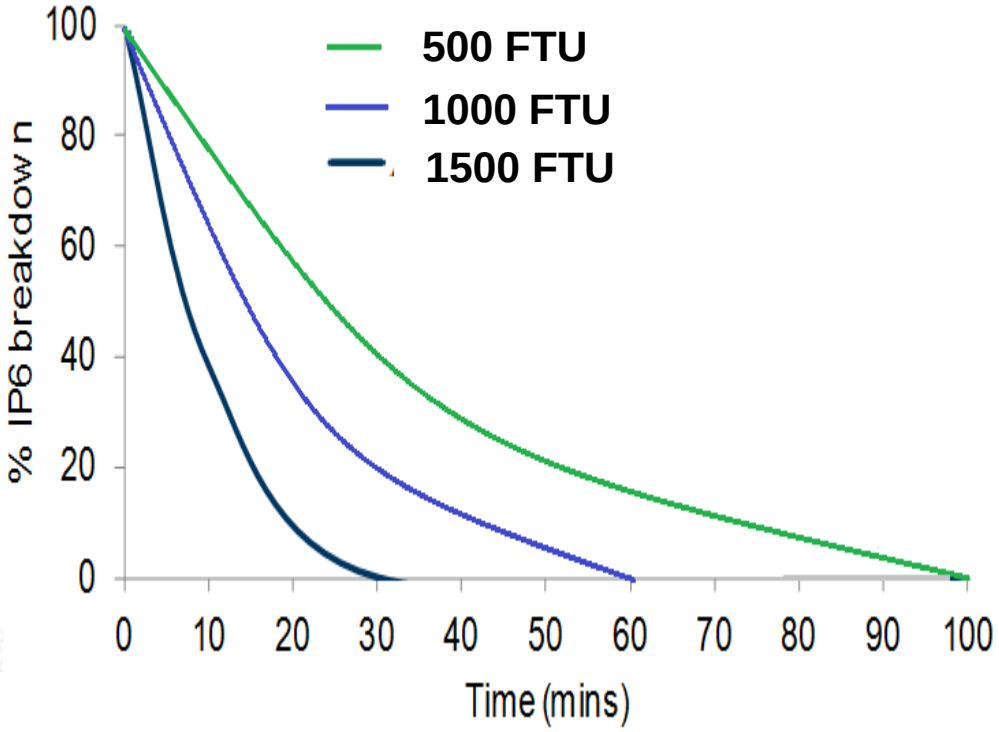
Different Phytases Have Different Ph Optima And Different RELATIVE Activity At Low pH Vs. Ph 5.5



DuPont Laboratory, 2012

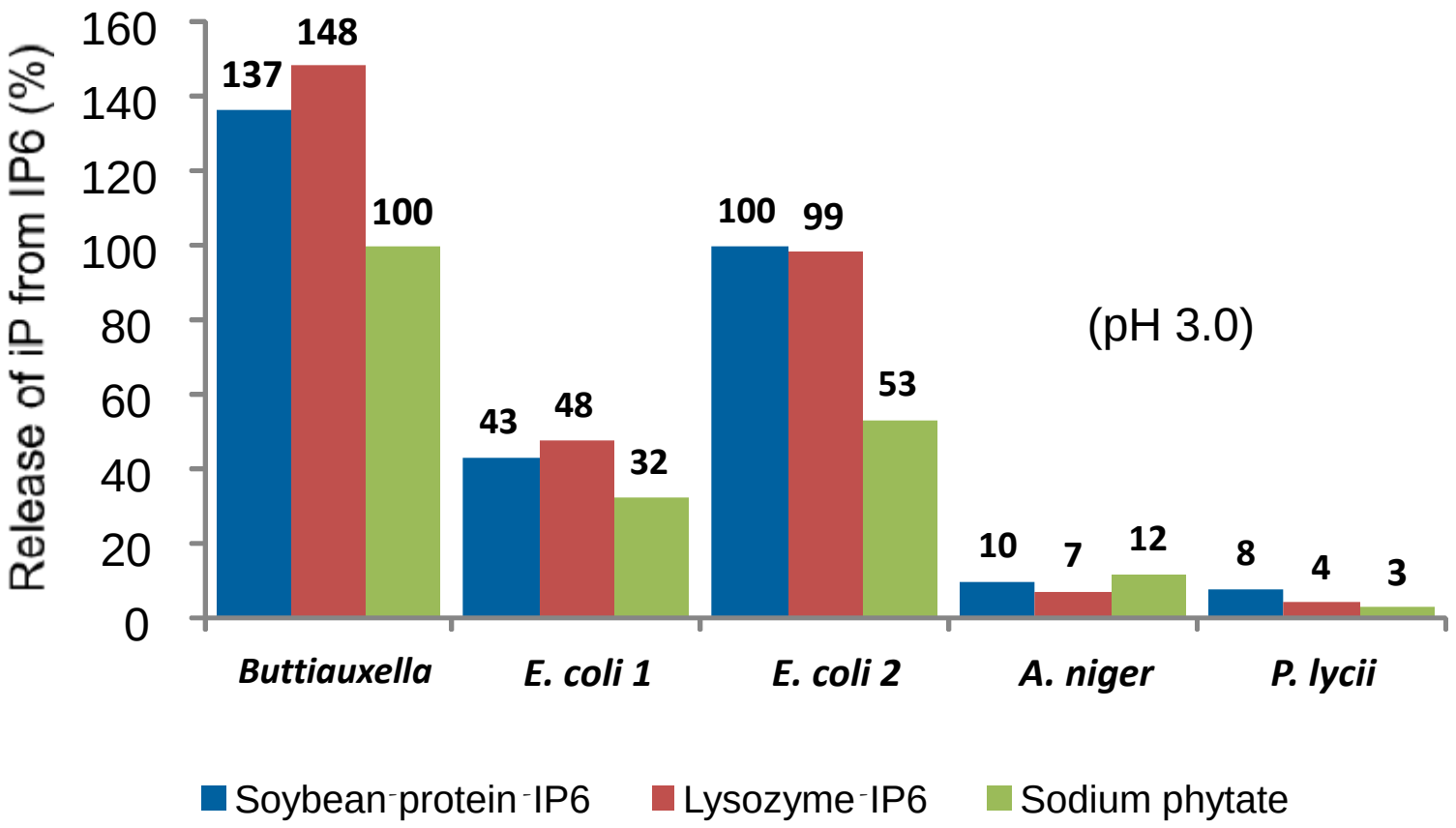
Effects Of Enzyme Kinetics Or Phytase Dose On Speed Of IP6 Hydrolysis





*using sodium phytate as a substrate

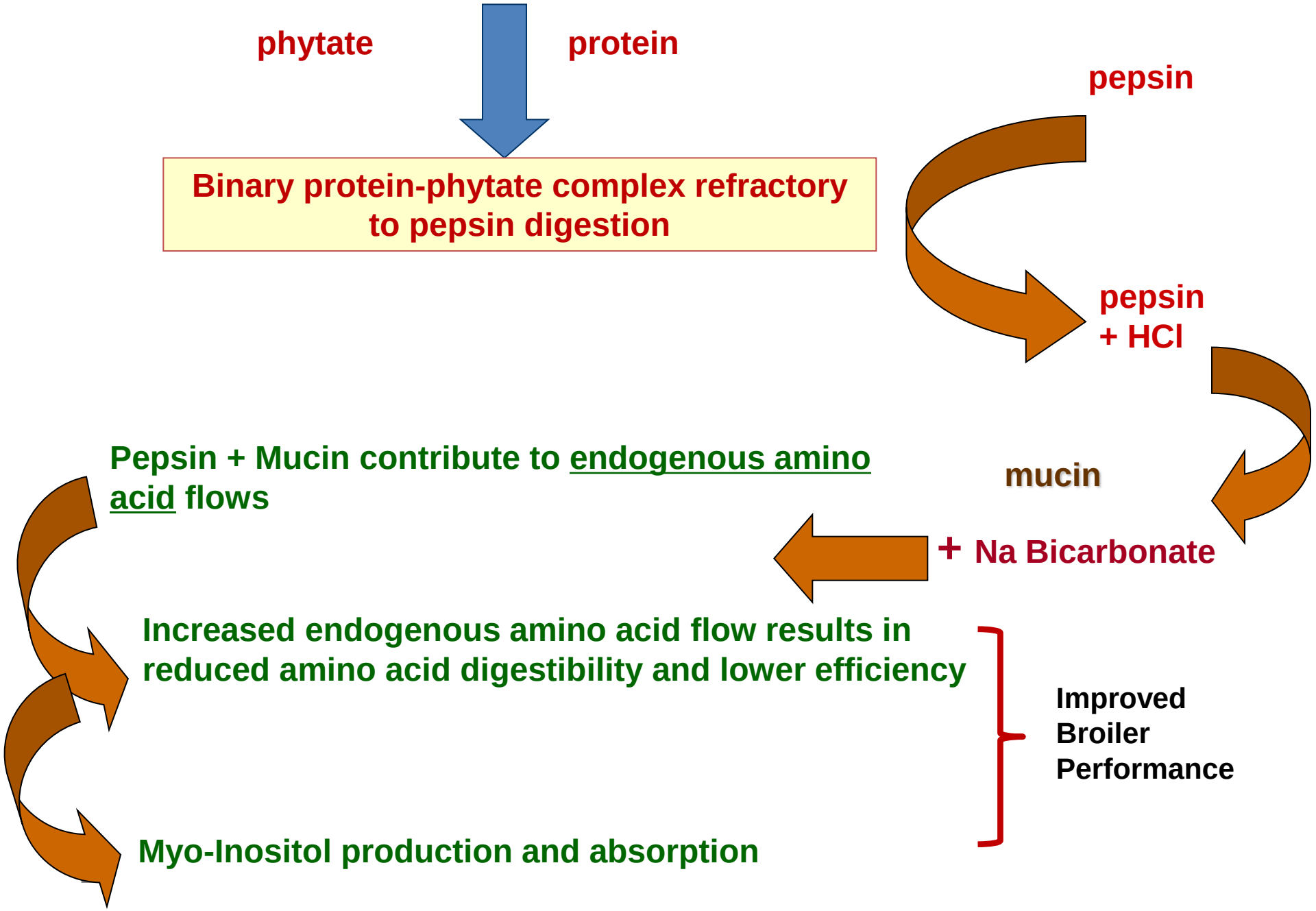
Large Differences Exist Between Phytase In Their Ability To Degrade Protein-phytate At Low pH



All values expressed relative to release of IP by *Buttiauxella* phytase on sodium phytate substrate as 100%

Yu & Dalsgaard, 2012

Mechanism Of Phytate Anti-nutrient Effects

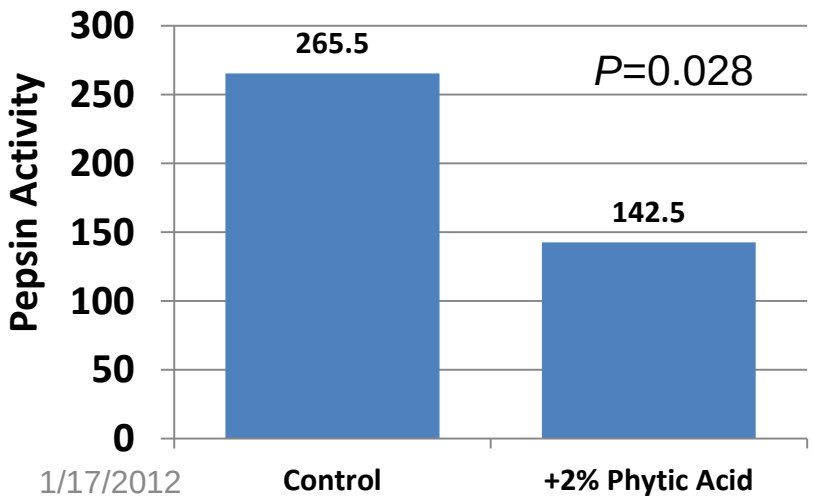


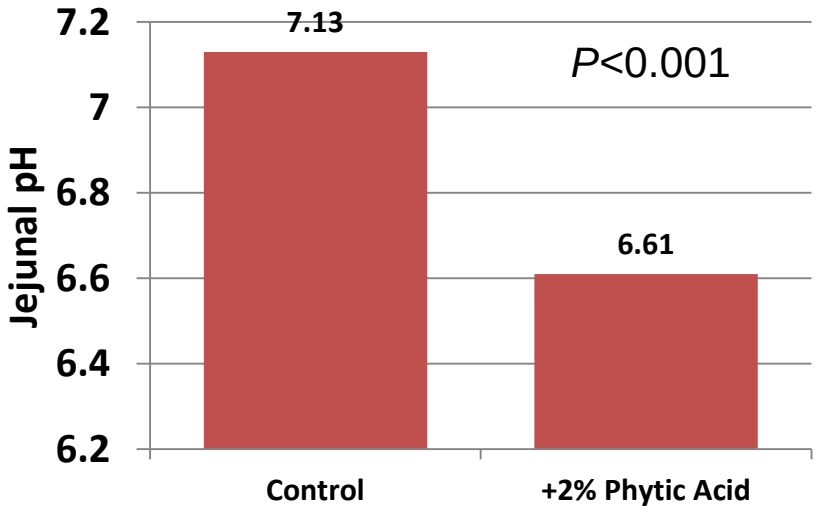
Negative Physiological Effects Of Phytate Have Also Been Shown *in vivo* In Weaner Pigs

Item	Diet[a]		SEM	Contrasts
	Control	PA		Control vs. PA
Pepsin activity[b], PU/ml	265.5	142.5	35.5	0.028
Stomach digesta pH	4.60	4.84	0.277	0.554
Jejunal digesta pH	7.13	6.61	0.122	0.0089
Jejunal mineral content, ppm				
K^+	653.4	691.2	75.8	0.737
Mg^{2+}	468.5	69.1	98.7	0.012
Na^+	2670.2	4191.9	163.9	<0.0001

[a] PA = control plus phytic acid
[b] Determined in stomach digesta.

Woyengo et al. / Livestock Science 134 (2010) 91–93





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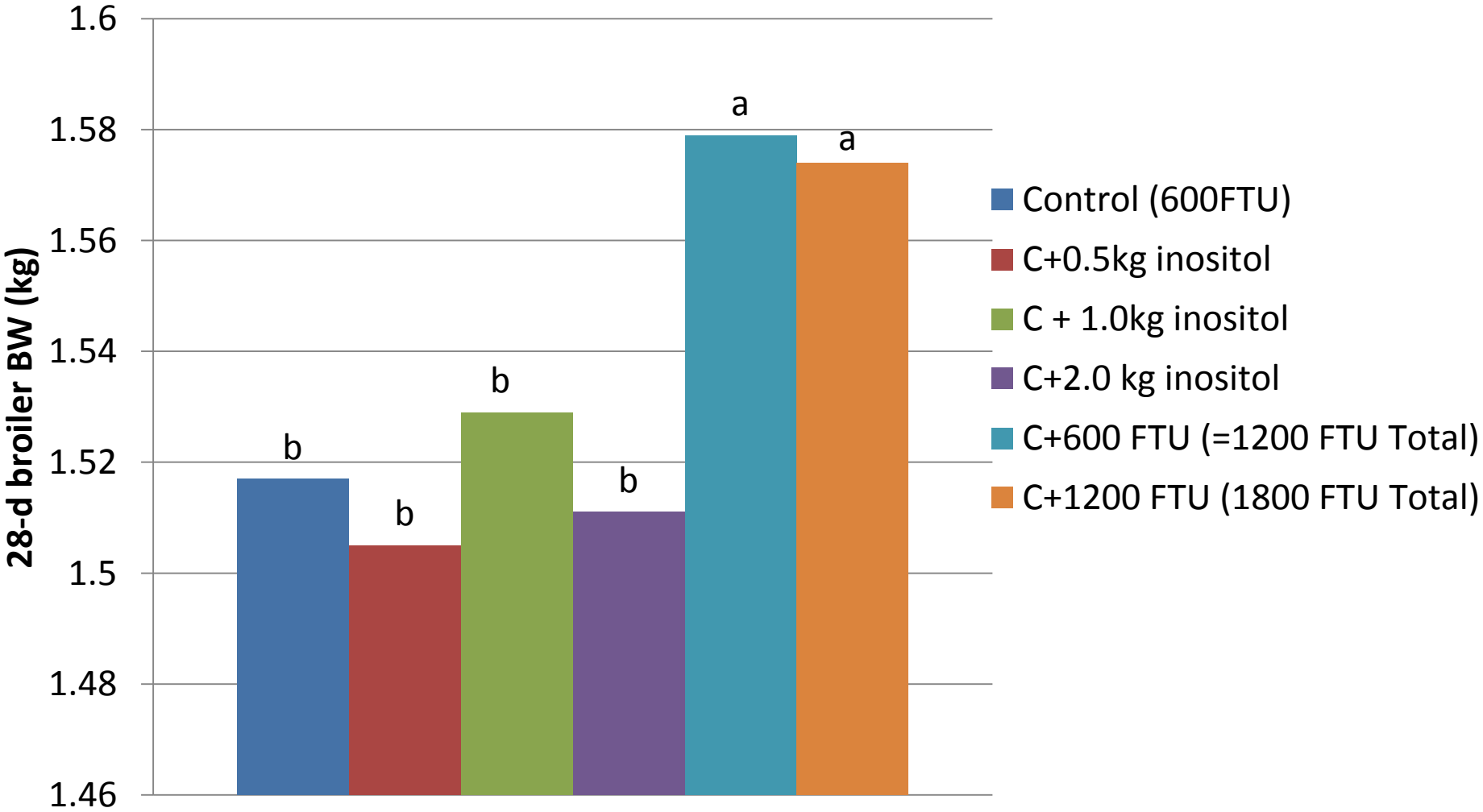
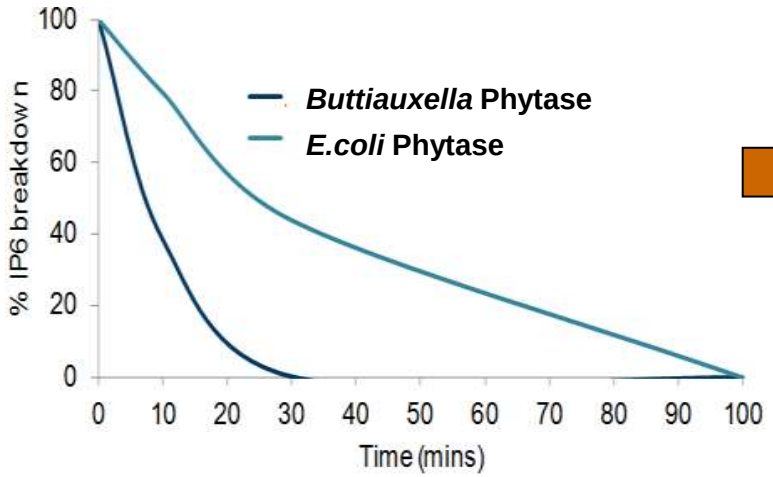
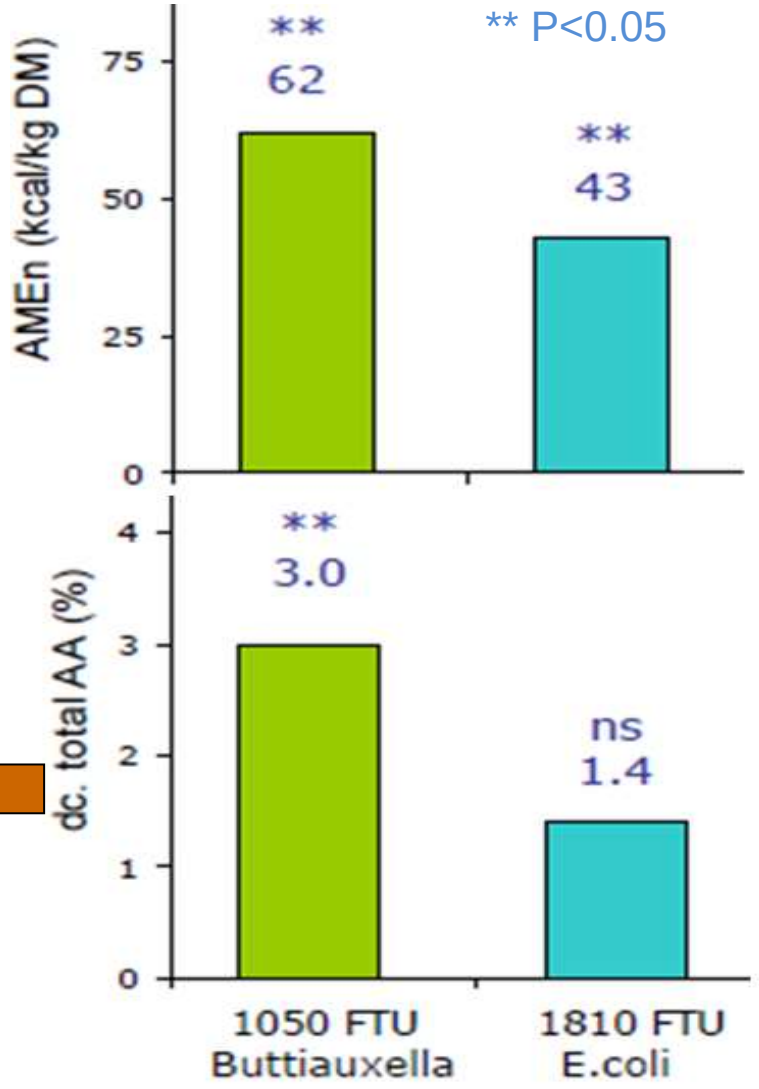


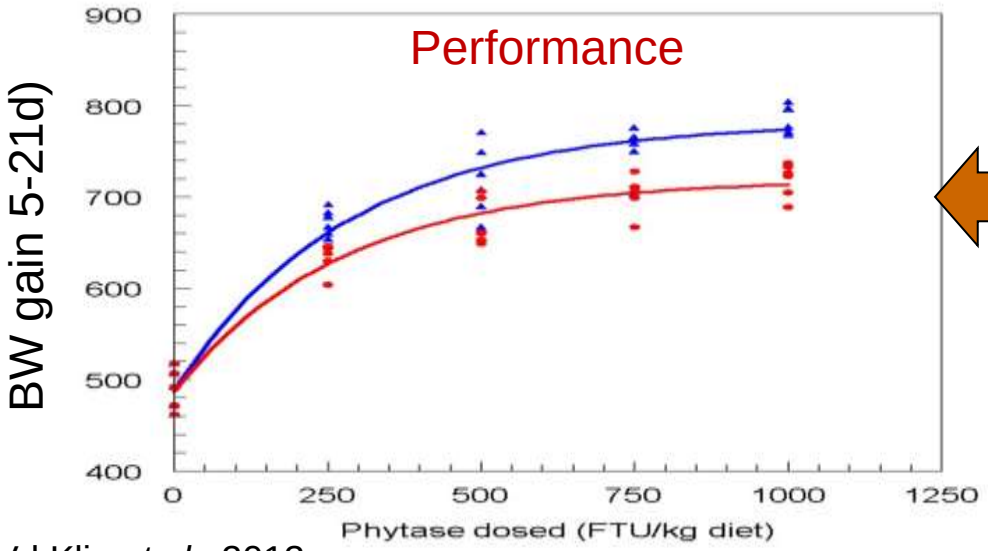
[a-b] indicates a significant difference at $p<0.05$

Walters *et al,* 2015

Differences In In-vitro Phytase Chemistry , IP6 Hydrolysis Rate & Protein-phytate Degradation Support Repeatable In-vivo Responses





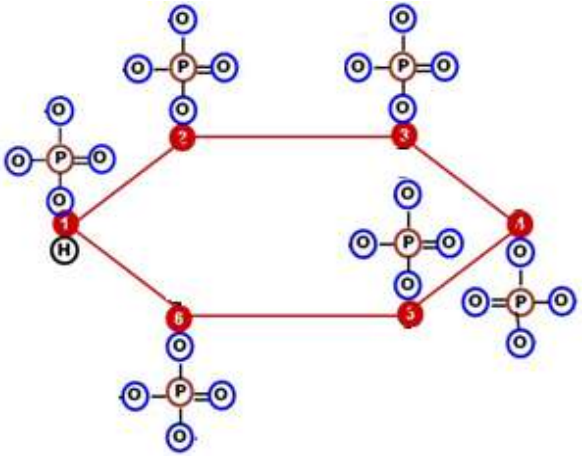


Vd Klis *et al.*, 2013

Tibia ash

Kwakernak *et al.*, 2013 ESPN

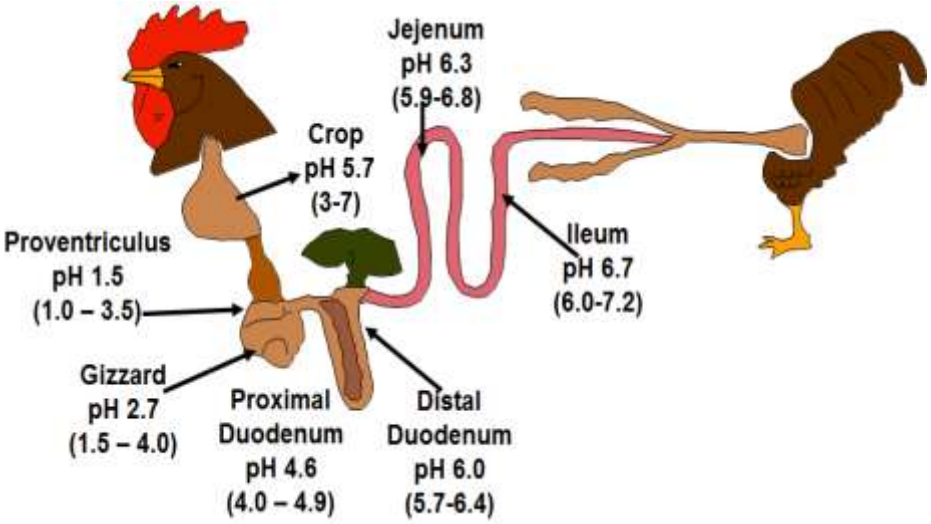
Phytase Decisions On *Source* And *Dose* Also Need Be Based On Phytate Interactions With Nutrients And Understanding Differences In Biochemistry Between Phytase Enzymes In The Context Of Digestive Physiology



Enzyme pH, kinetics

Interactions

Ca^{2+} Zn^{2+}
Protein, AA
Sodium



- Interactions of Phytate, Calcium and Phytase Enzymes **– impacts P contribution**
- Interactions of Phytate with Protein, Starch, and Na **– Anti-nutrient effects on live performance & drives ME & AA digestibility improvement from phytase**
- Differences in phytase enzyme pH optima and kinetics **- impact *in-vivo* results**

QUESTIONS?

University of Pretoria