INDUSTRIAL BIOSCIENCES

The role of science and technology to support profitable future of poultry industry

San Juan Del Rio, March 10th, 2015

Milan Hruby

Outline

- Food Security Index
- How enzymes and/or direct fed microbials
  - » Can help the industry to produce more protein
  - » Increase food safety and shelf life of meat
  - » Can enable new alternative raw materials
- Future technologies
  - » Which might change the industry
- Summary

Crop production → Animal production → Processing and distribution → Consumer

DuPont 2014 Segment Sales

$11.3B
Agriculture

$3.5B
Nutrition & Health

$6.1B
Performance Materials

$2.4B
Electronics & Communications

$35B*

$3.9B
Safety & Protection

$6.5B
Performance Chemicals

$1.3B
Industrial Biosciences

* Segment sales includes transfers.

The DuPont Global Food Security Goals

By the end of 2020, DuPont will help the world meet the challenge of achieving global food security

Innovating to Feed the World

We will commit $10 billion to R&D and 4,000 new products will be introduced.

Engaging and Educating Youth

We will facilitate two million engagements of young people around the world in educational opportunities.

Improving Rural Communities

We will work to improve the livelihoods of at least three million farmers and their rural communities through targeted collaborations and investments.

The Global Food Security Index

DuPont commissioned the Economist Intelligence Unit in 2012 to develop the Global Food Security Index

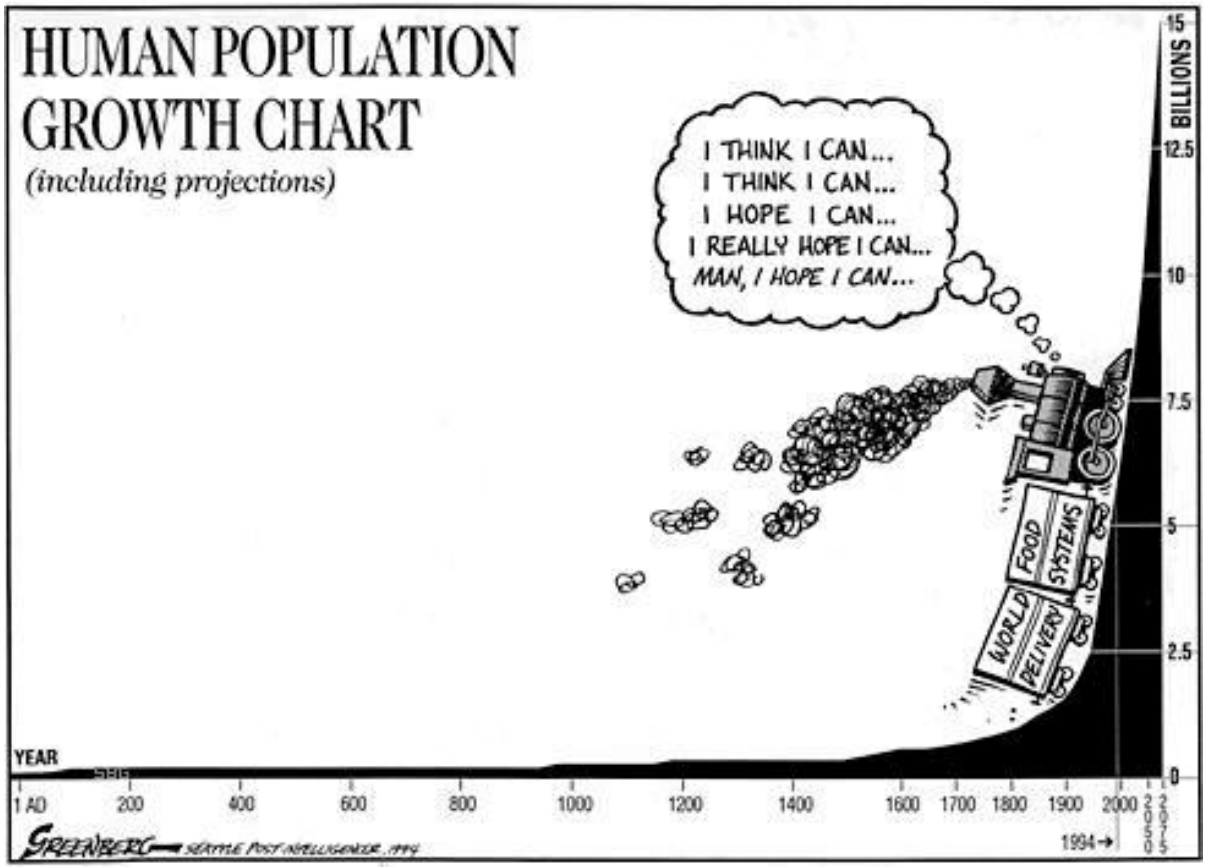
- Ranks **109 countries** according to their relative levels of food security using 29 indicators divided into three categories: **Affordability, Availability, Quality and Safety.**
- Provides a rigorous, structured framework for **understanding the drivers of food security.**

Visit foodsecurityindex.eiu.com

Protein Needs Are Increasing

FAO* expects world demand for (animal-derived) protein to double by 2050

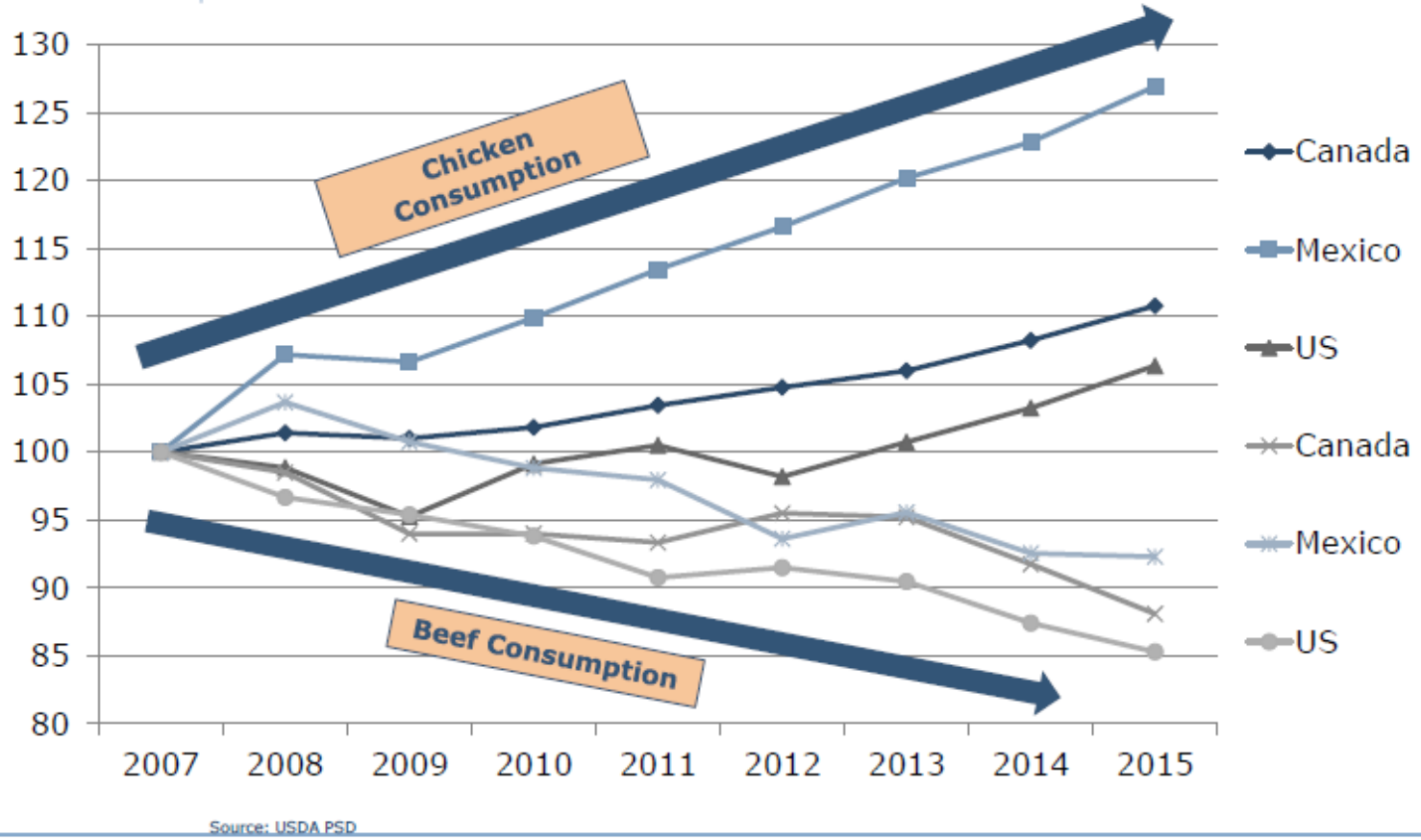
- Increasing population (9 billion by 2050)
- Emerging economies
- Increasing urbanization
- Recognition of protein's role in a healthy diet
- Increased need for protein in the elderly population



*FAO: Food and Agriculture Organization of the United Nations

More cluck, less chuck!

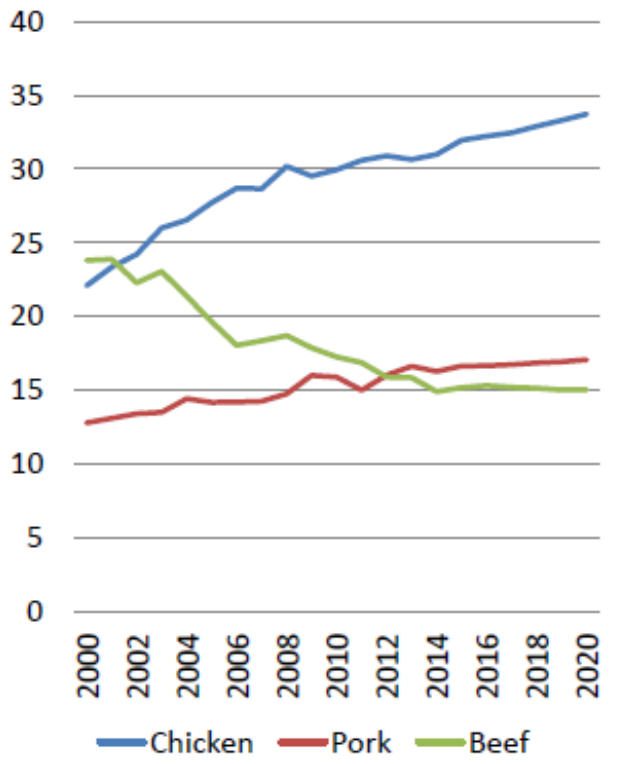
Indexed Domestic Consumption of North America



Source: USDA PSD

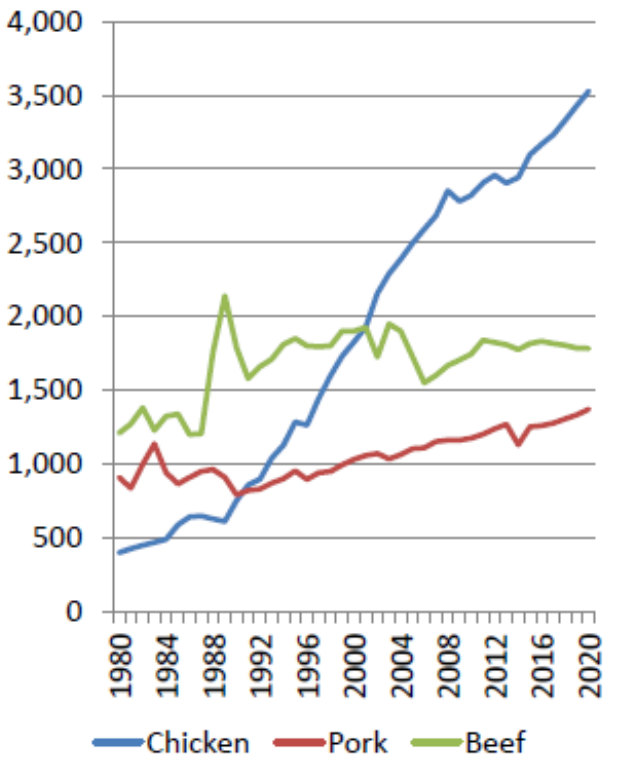
Chicken to Satisfy Rising Mexican Meat Consumption

Consumption per capita (kilos)



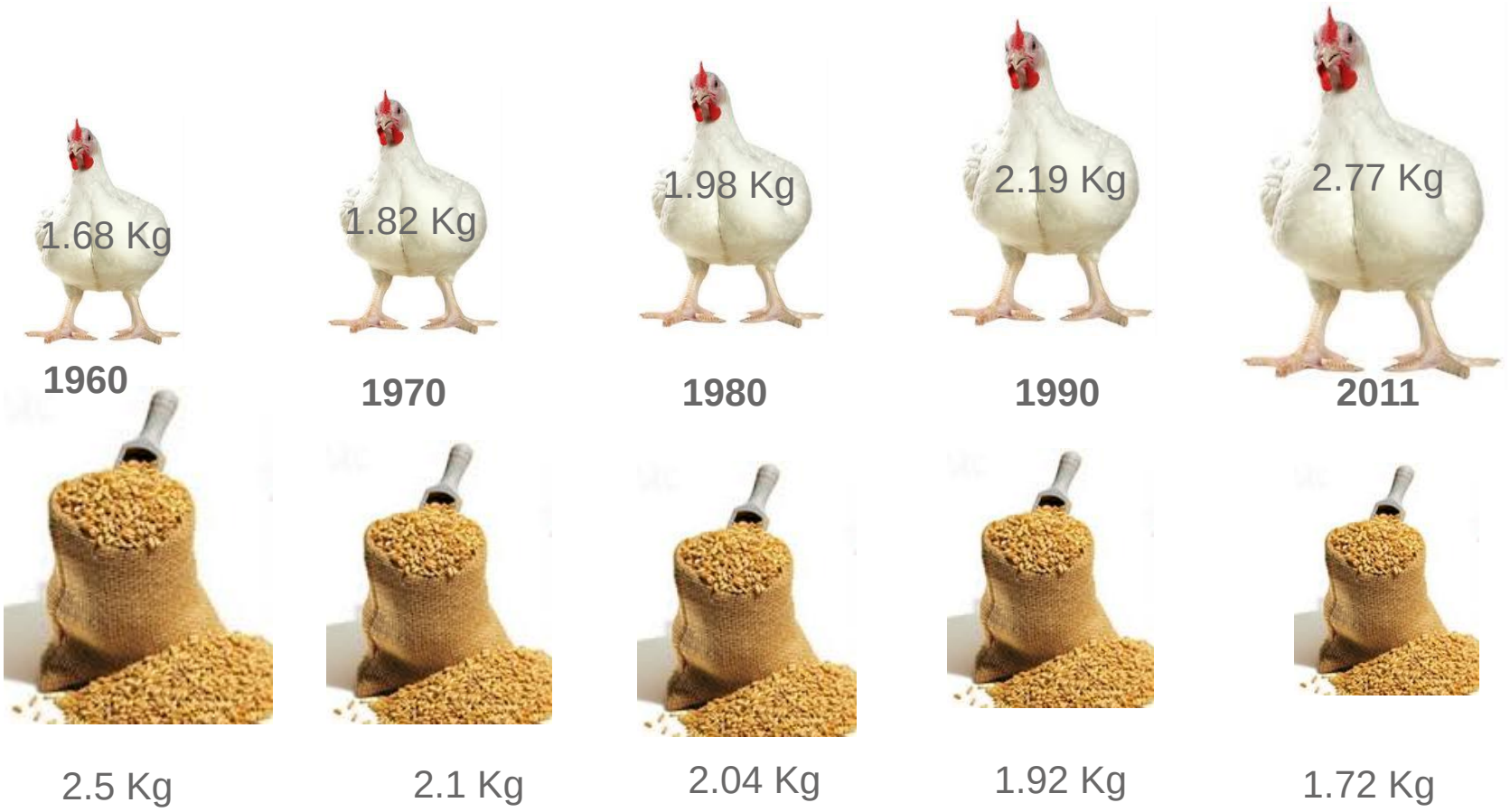
Source: INEGI, Rabobank

Production (000 tons)



Source: INEGI, Rabobank

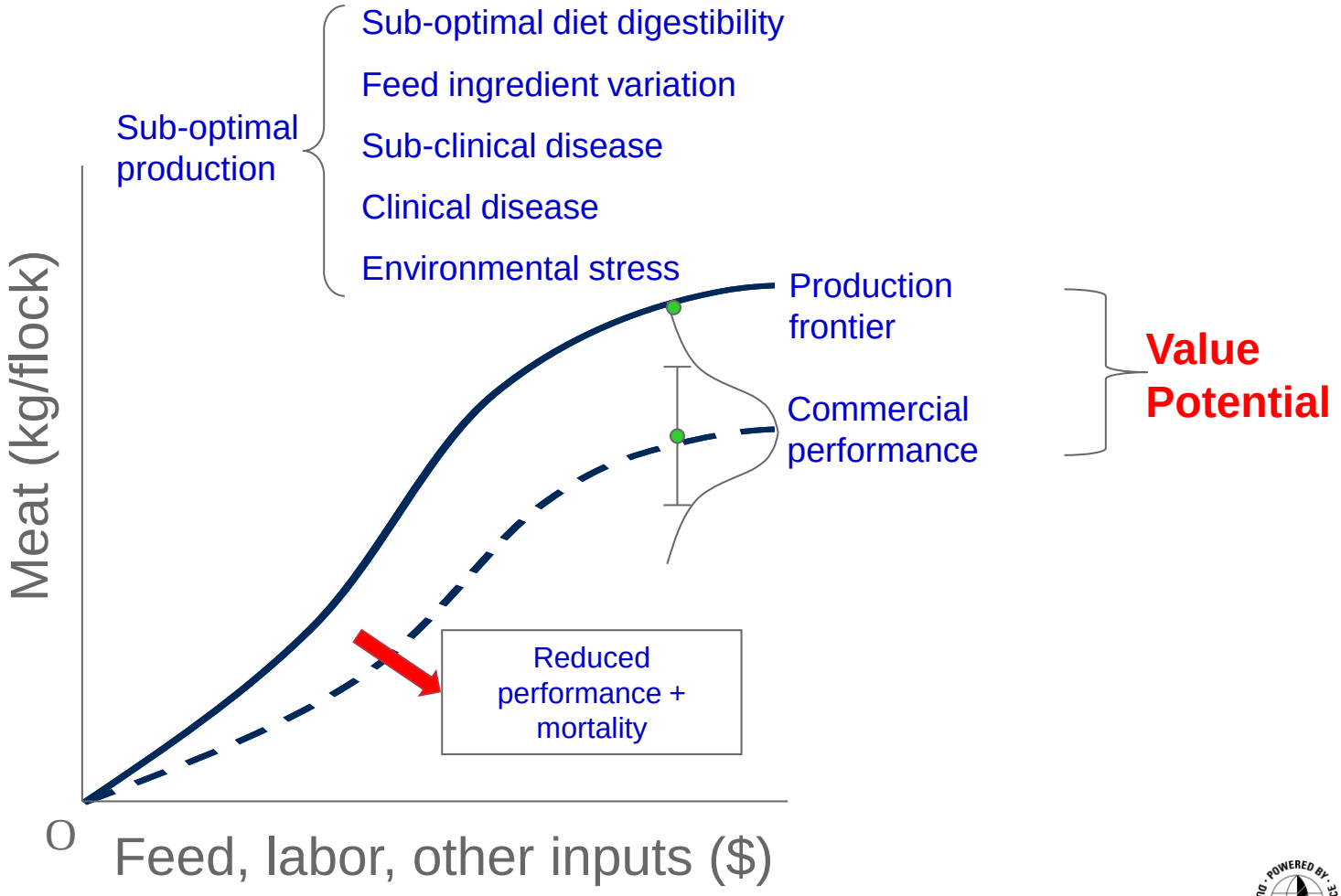
Improvement in Slaughter Weight Versus Feed Conversion Ratios*



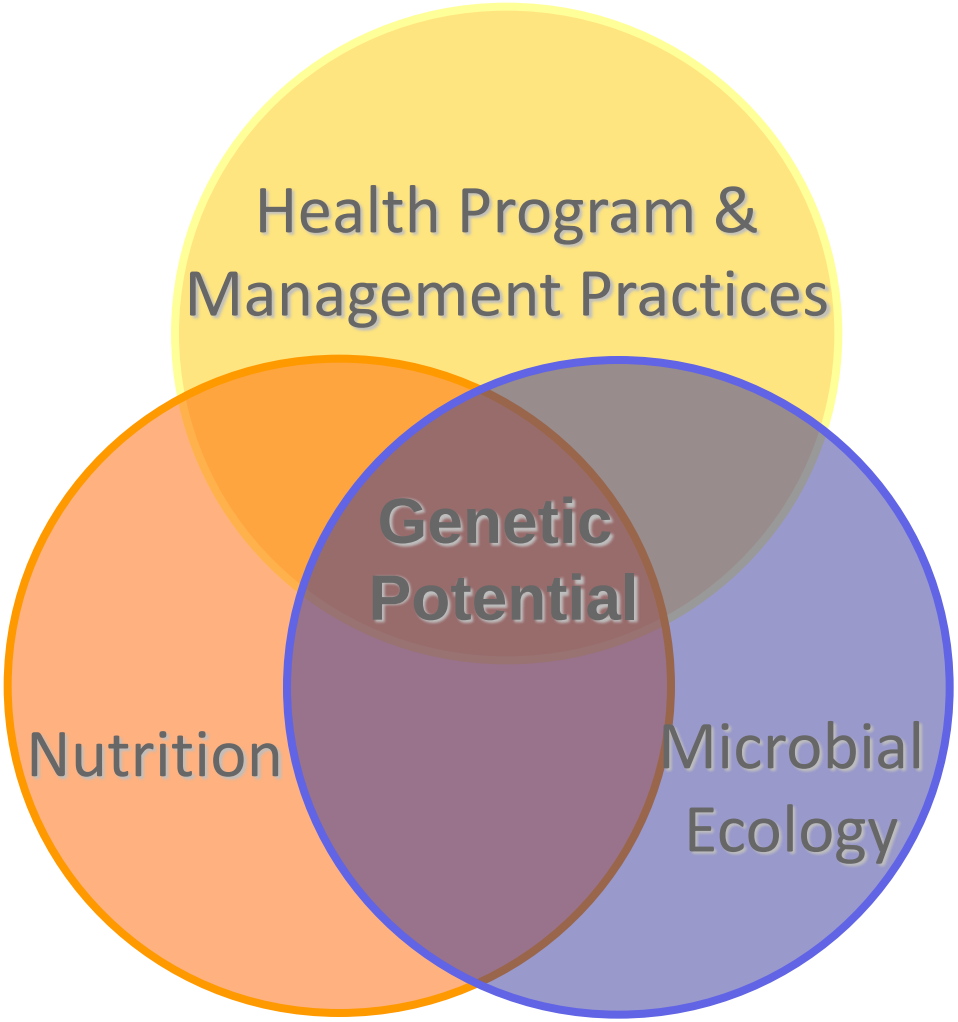
*Amount of feed required for 1Kg weight gain

Based on Rauw et al., 1998 and Ross info

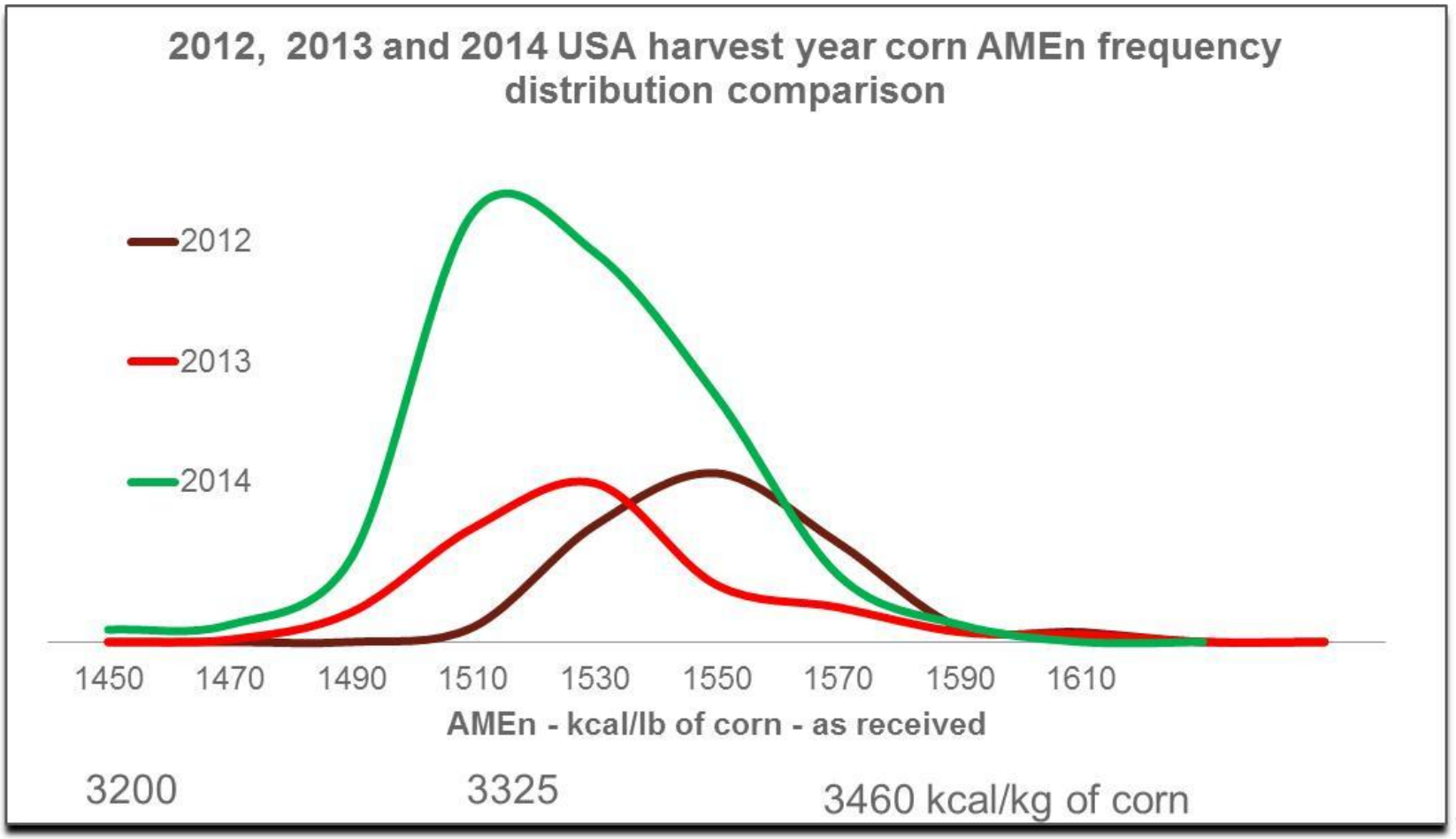
Still Genetic Potential to be Captured



Optimizing Genetic Potential:
How do we fit into this complex puzzle?



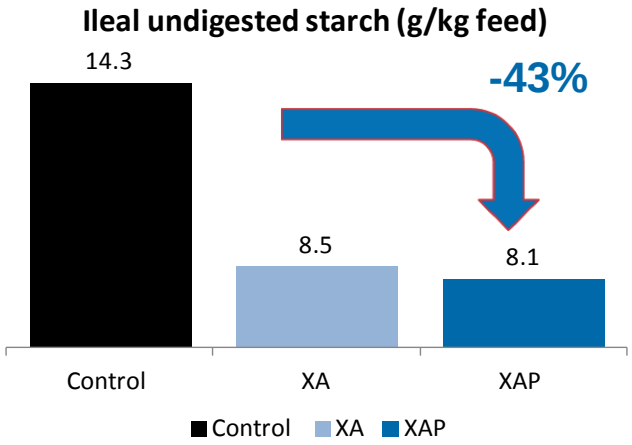
Corn quality (AMEn) varies – performance variability

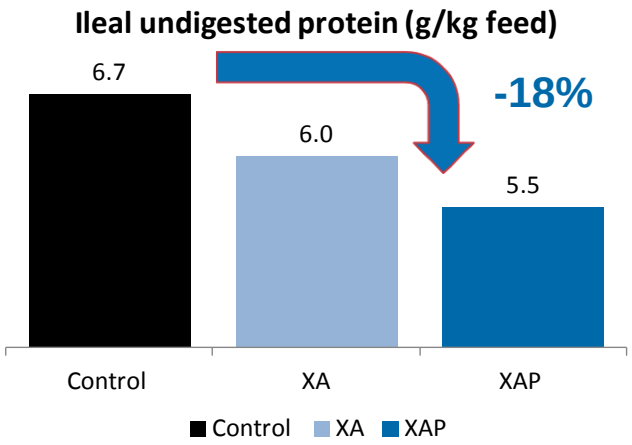


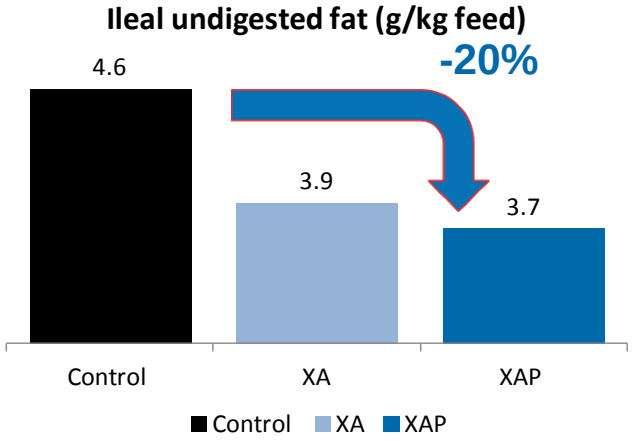
Enzymes Work by Targeting Specific Substrates

Substrate	Effect of substrate	Enzyme
Soluble viscous NSPs (e.g arabinoxylans)	↑ viscosity and digesta retention time ↓ nutrient absorption ↑ proliferation of intestinal microflora	Xylanase
Insoluble, non-viscous NSPs	↓ accessibility of nutrients by physical entrapment	Xylanase
Starch	Metabolisable energy ↑ substrate for gut microflora	Amylase
Protein	Metabolisable energy and AA ↑ substrate for gut microflora (neg)	Protease
Lipid	↑emulsification, digestibility of lipids	Lipase
Raffinose and stachyose	Undigestible by animal enzymes	α-galactosidase
Beta glucan	↑ viscosity and digesta retention time	β-glucanase
Phytate	Binds minerals, protein and starch	Phytase

Enzymes Reduce the Amount of Undigested Substrate Reaching the Lower Gut







Adapted from Romero et al., 2012

X: Xylanase; A: Amylase; P: Protease

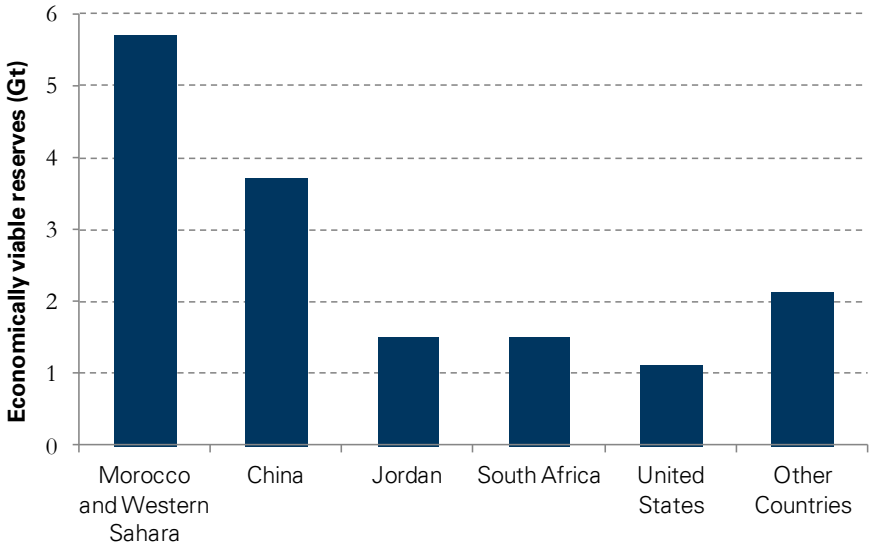
Inorganic Phosphorus: A Non-Substitutable and Finite Resource

http://nicholsoncartoons.com.au/phosphate-mines-in-vogue-226.html

Inorganic Phosphorus: A Non-Substitutable and Finite Resource

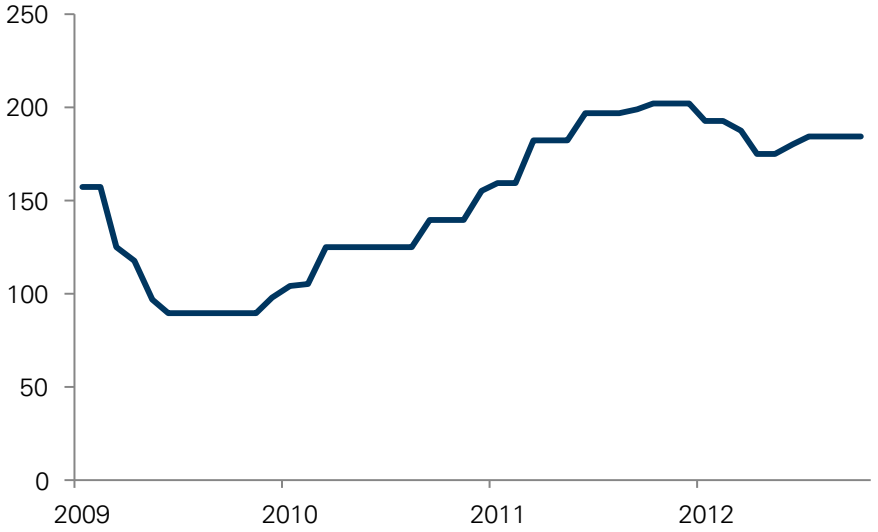
- There are no substitutes for phosphorus in agriculture
- As world phosphate demand grow, both for animal feed and fertilisers, increasing price pressures will continue

Global Inorganic Phosphate Reserves



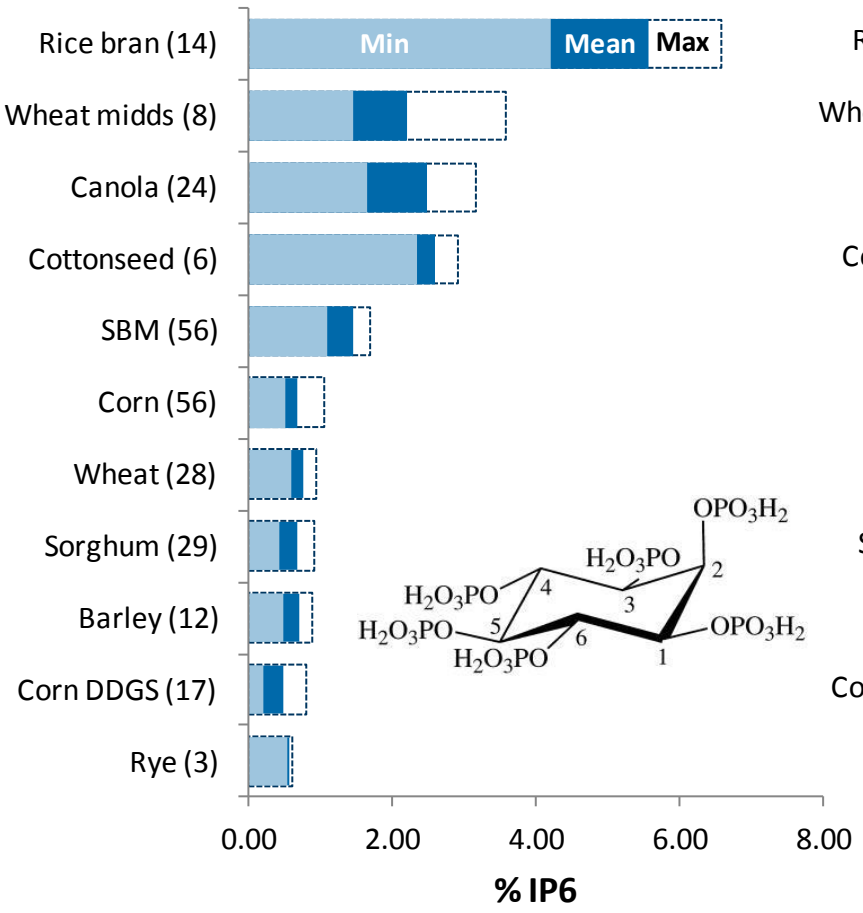
(U.S. Geological survey, 2010)

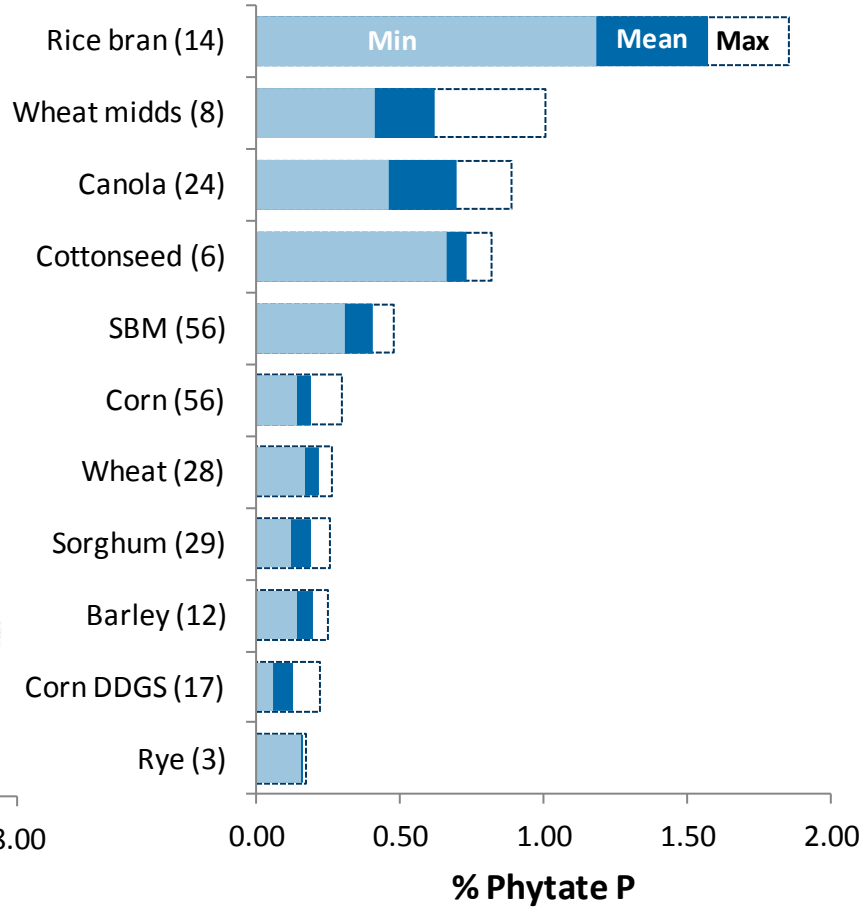
Monthly rock phosphate prices ($/MT)



(World Bank, 2012)

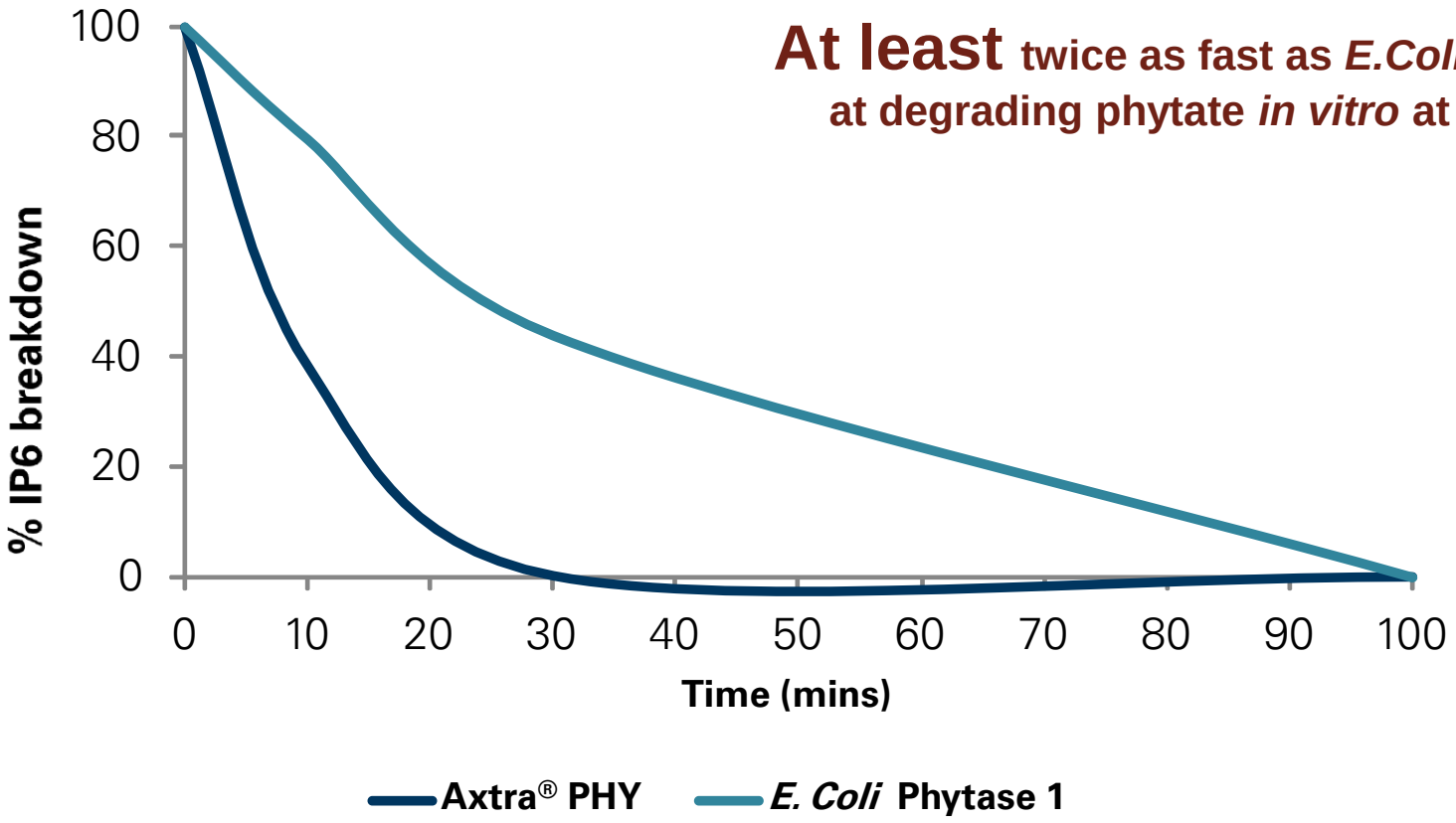
Phytate also Known as IP6 is the Natural Store of Phosphorus in Plants but the Content is Variable





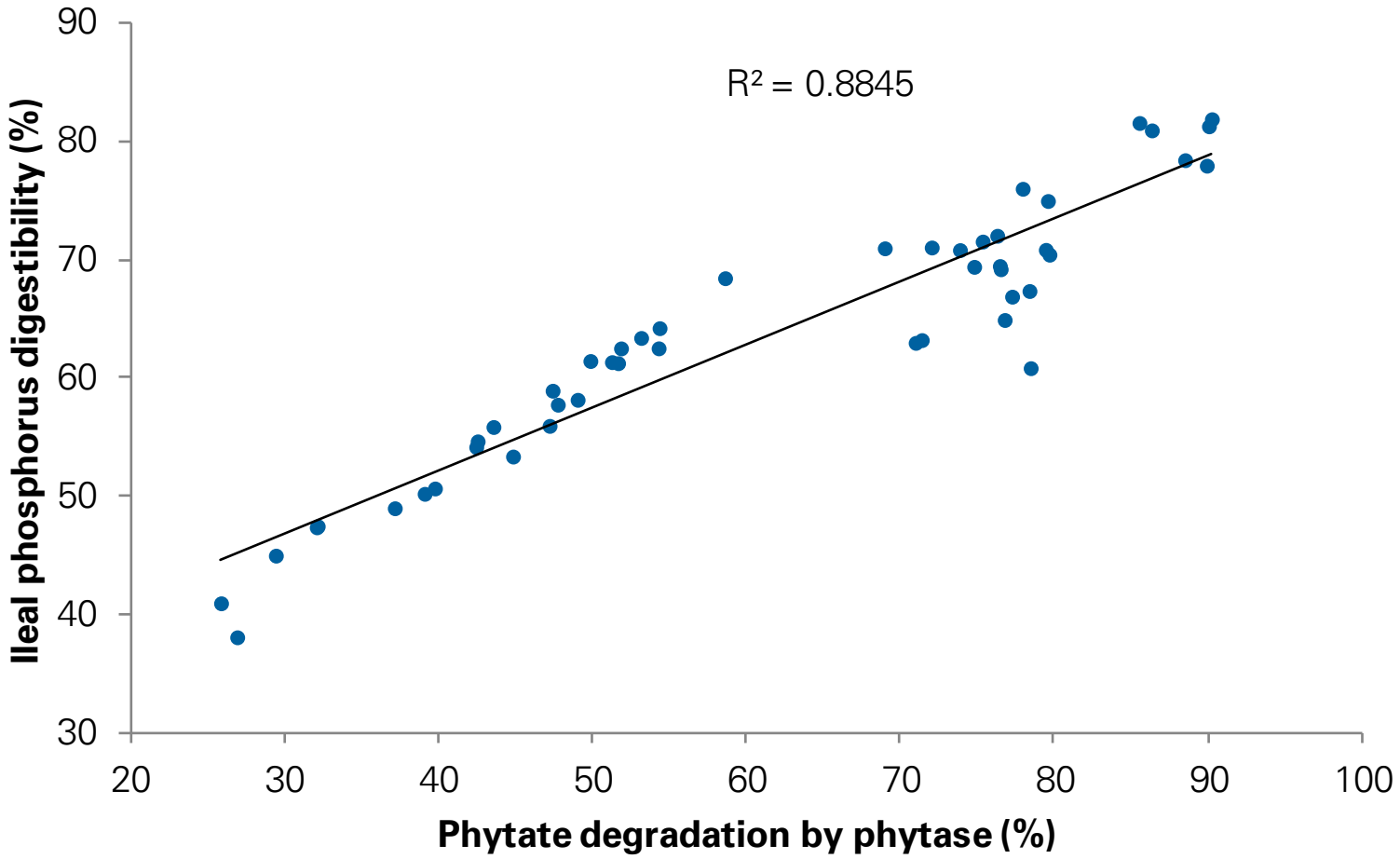
Axtra® PHY offers faster degradation of IP6 verses an *E. Coli* phytase (pH 2.5)

At least twice as fast as *E.Coli* phytase at degrading phytate *in vitro* at low pH



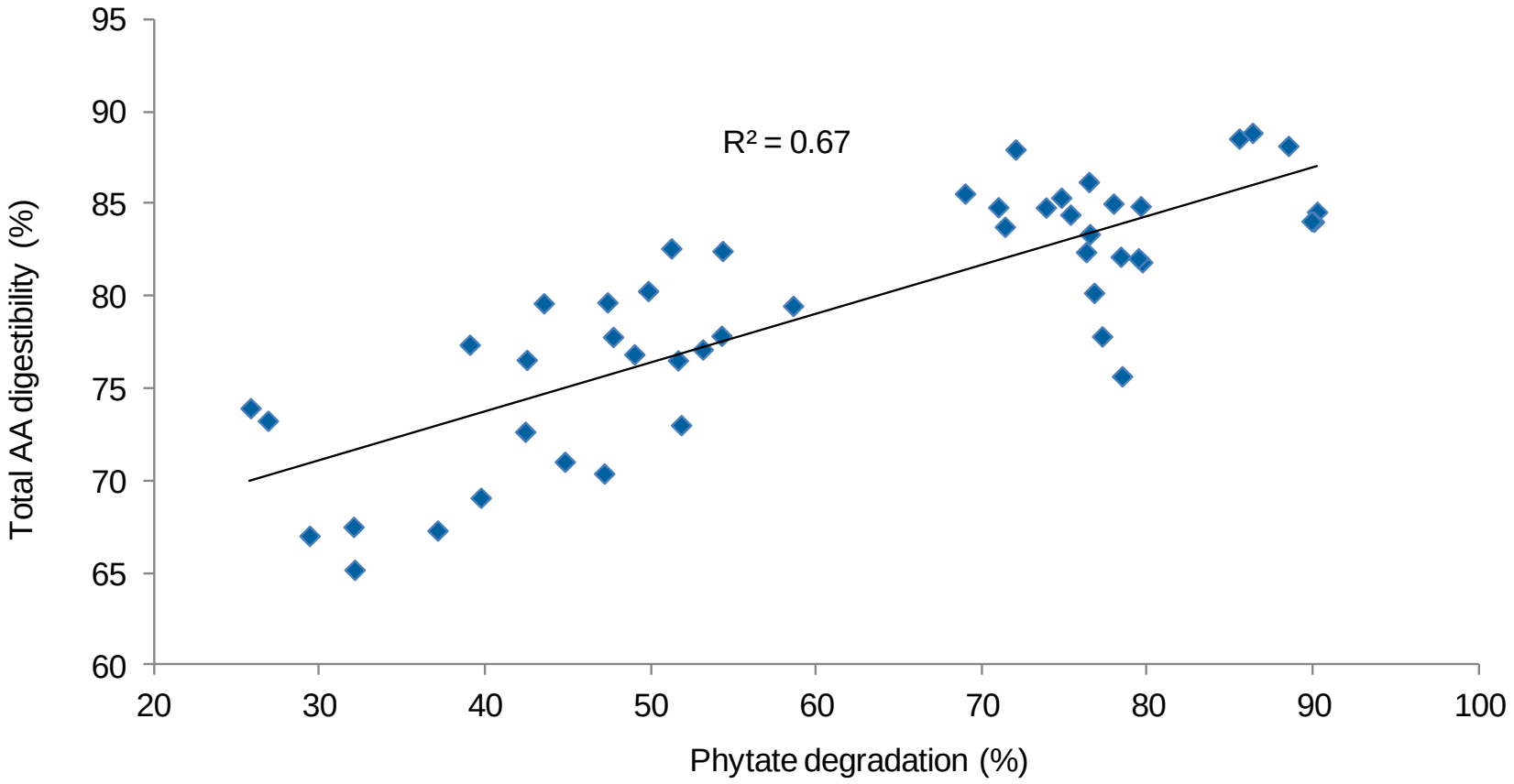
*using sodium phytate as a substrate

A nutritionists' view is driven by this strong correlation *in vivo*



Amerah *et al.* 2012

Phytate Degradation by Phytase Increases Protein Digestibility



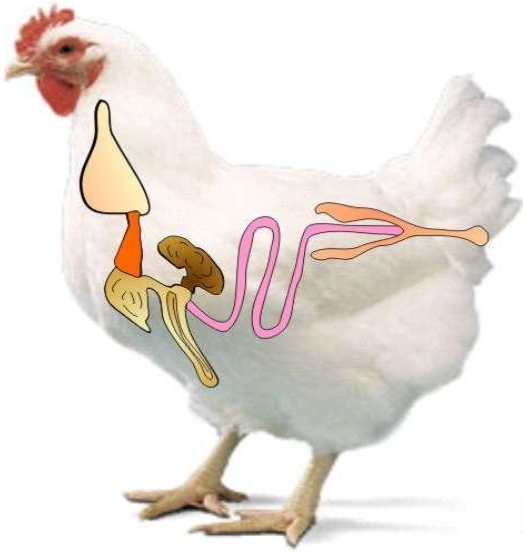
There is a strong correlation between phytate breakdown and protein digestibility in vivo

Amerah *et al.*, 2012

Direct Fed Microbials (DFMs) – What Are the Beneficial Effects for the Avian?

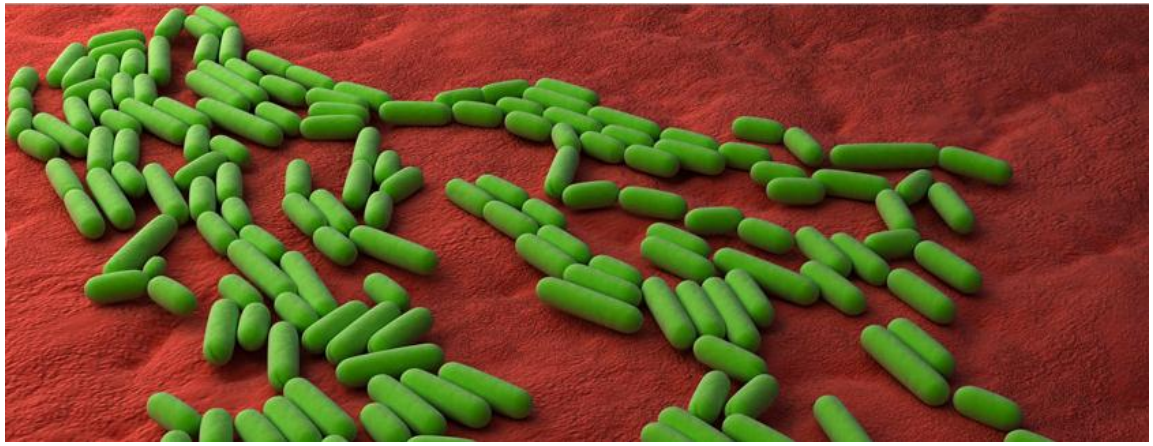
Health

↓ Lower mortality
↑ Stimulates serum antibody
↑ Stimulates gut Ab (sec IgA)
↓ Systemic, asymptomatic inflammation
↓ Enteric pathogen levels
↓ Foodborne pathogen levels



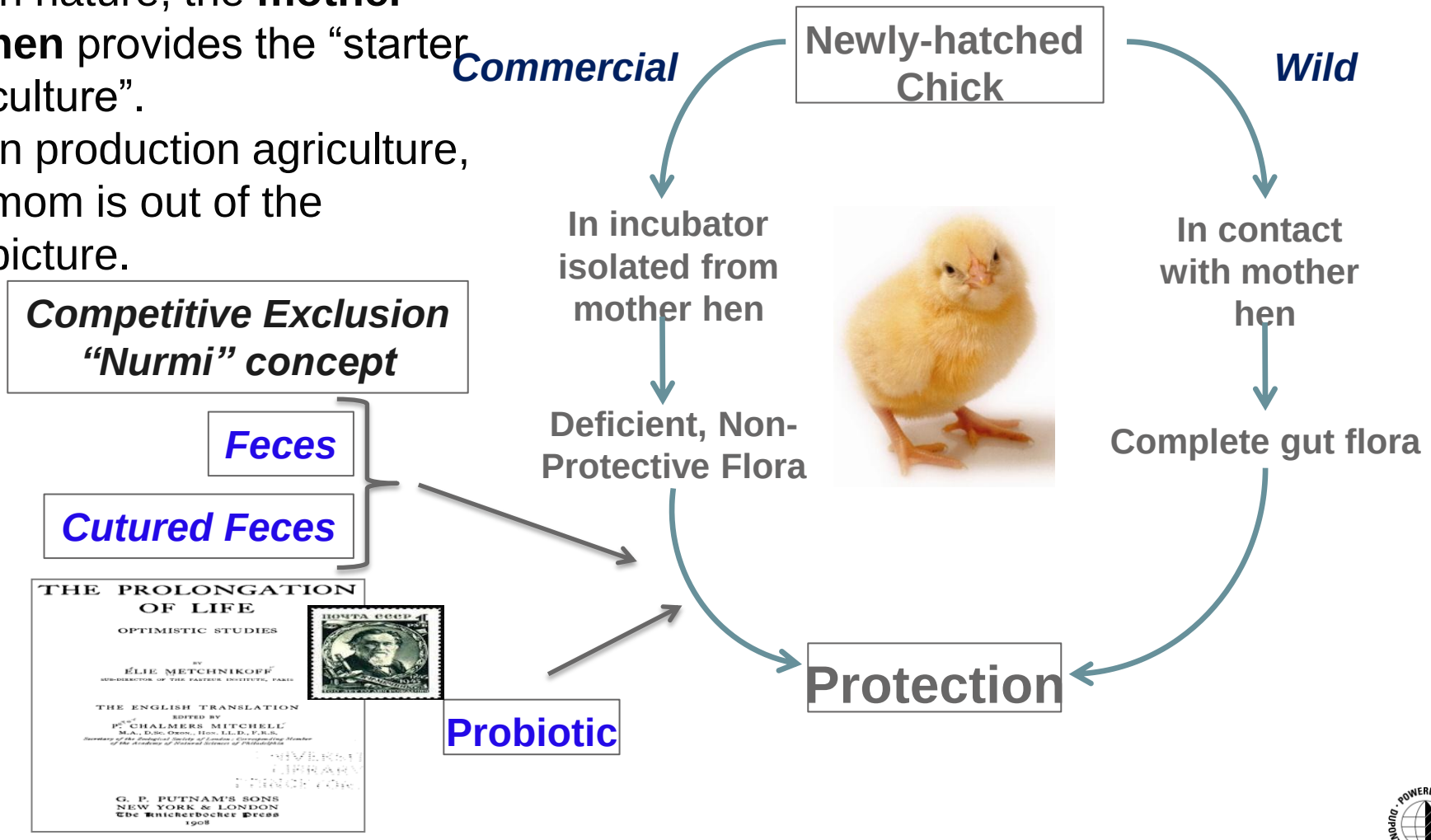
Performance

↑ Final body weight
↓ Feed Conversion Ratio
↑ Egg production



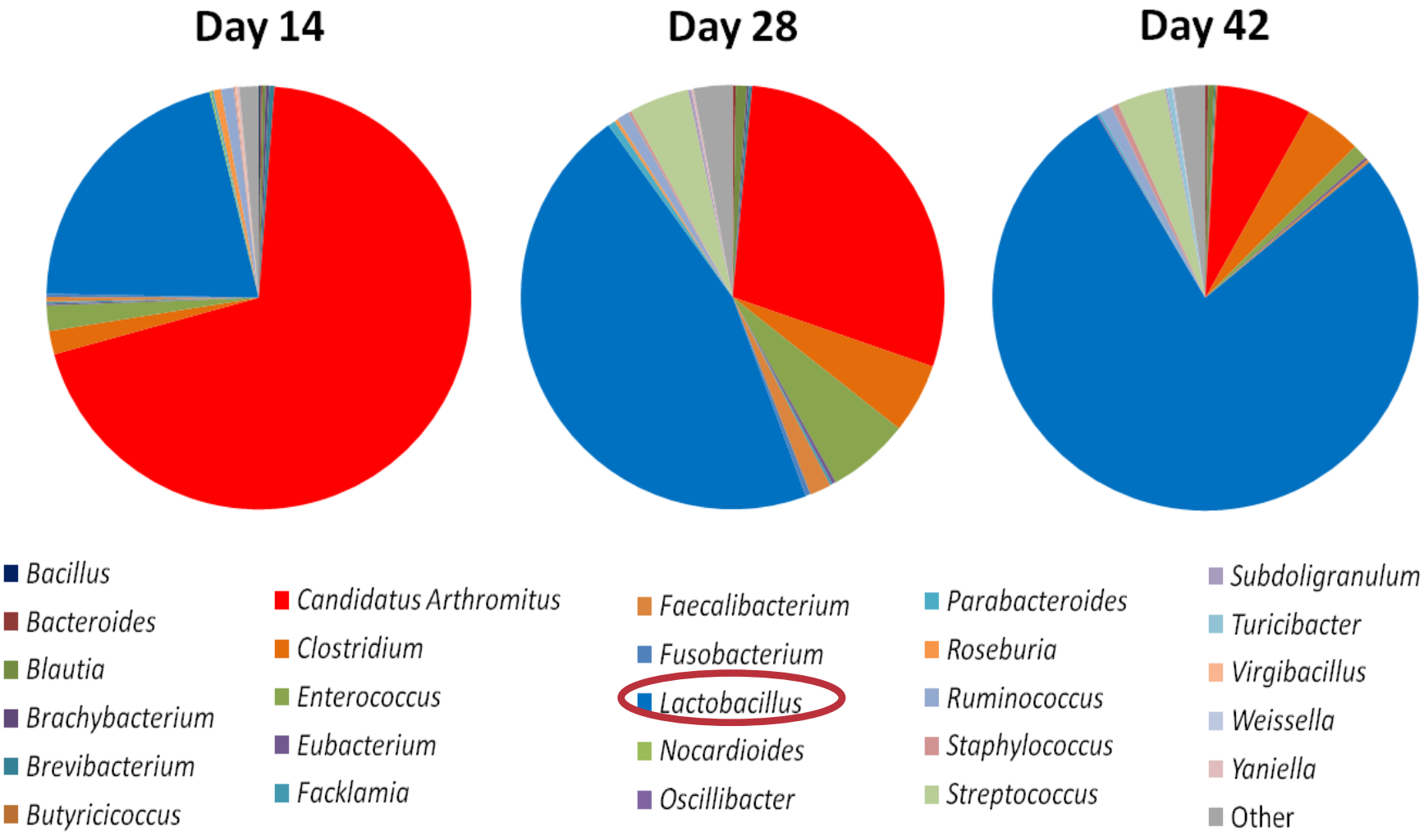
Probiotic & competitive exclusion concept for poultry

In nature, the **mother hen** provides the "starter culture".
In production agriculture, mom is out of the picture.



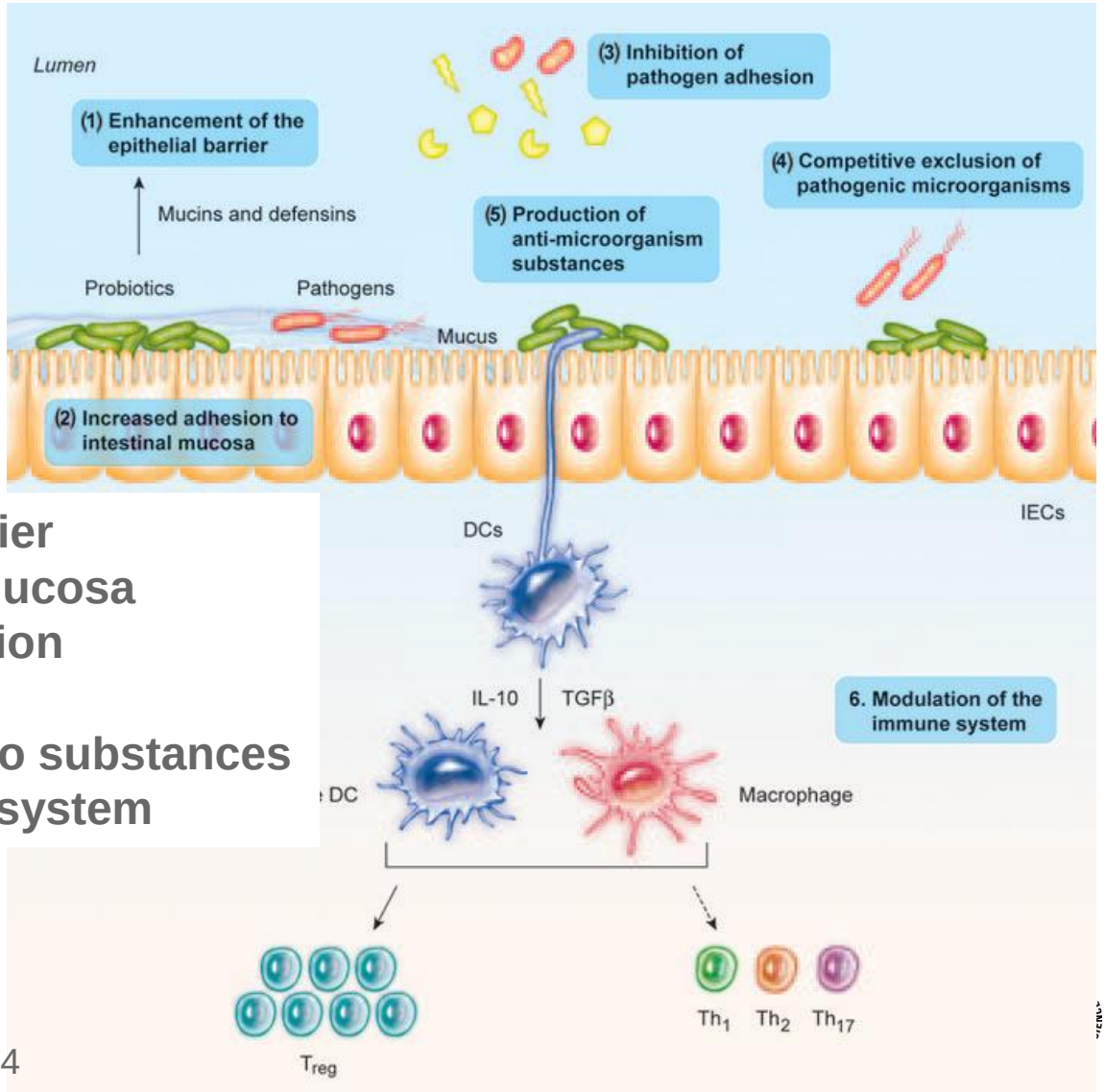
Adapted from Fuller, *J. Poult Sci*.2001

Changes in the relative proportions of bacterial populations with age



Neumann *et al*

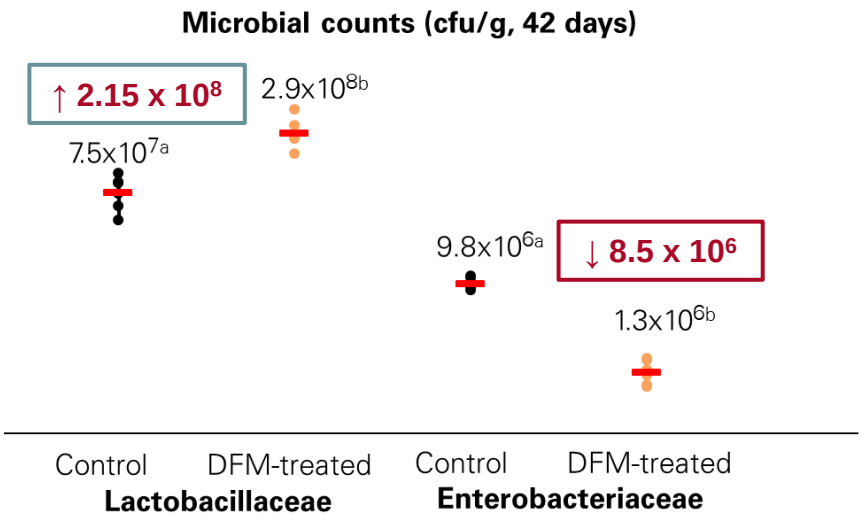
DFMs – How Do They Do Their Work?

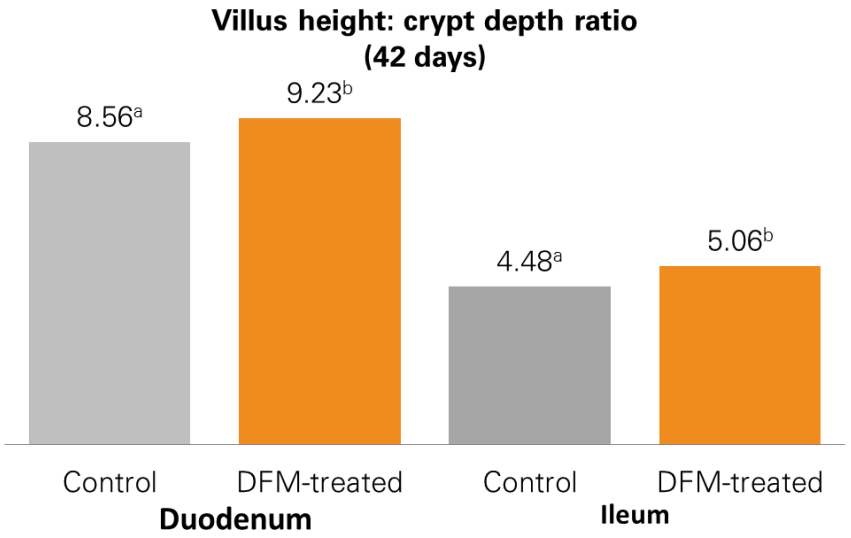


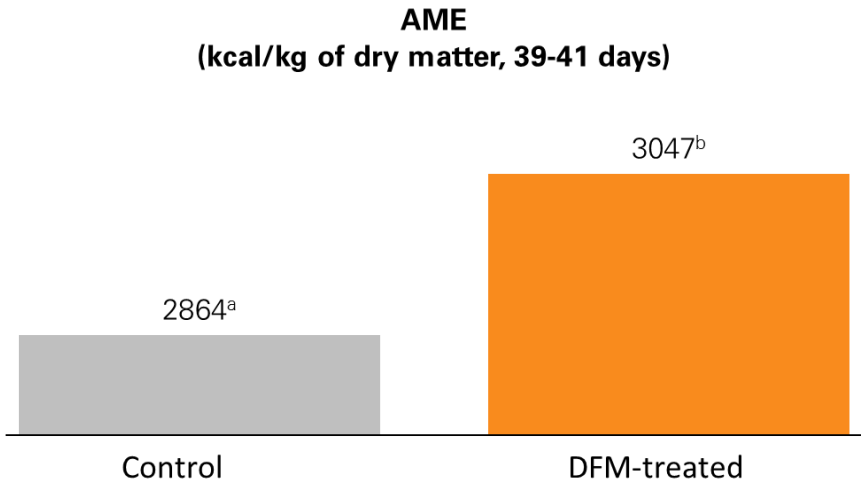
1) Enhance epithelial barrier
2) Increase adhesion to mucosa
3) Inhibit pathogen adhesion
4) Competitive exclusion
5) Production of anti-micro substances
6) Modulation of immune system

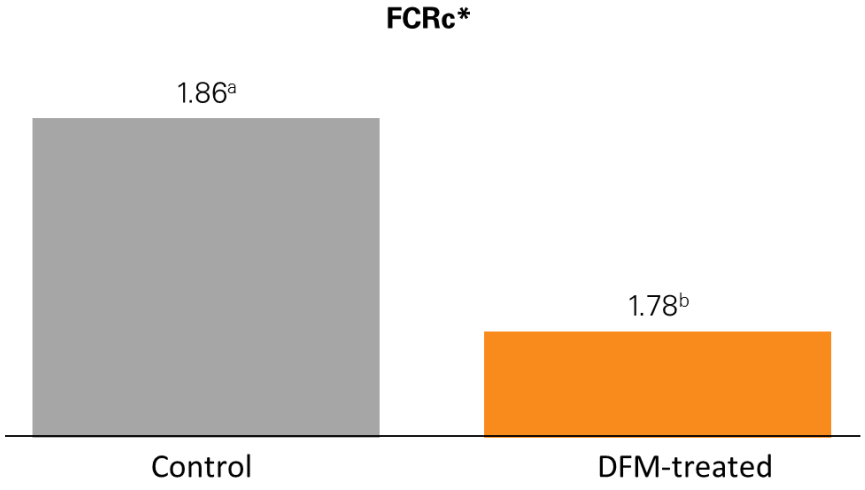
Bermudez-Brito, et al.
Ann Nutr Metab 2012;61:160–174

Mode of action of *Bacillus* based DFM





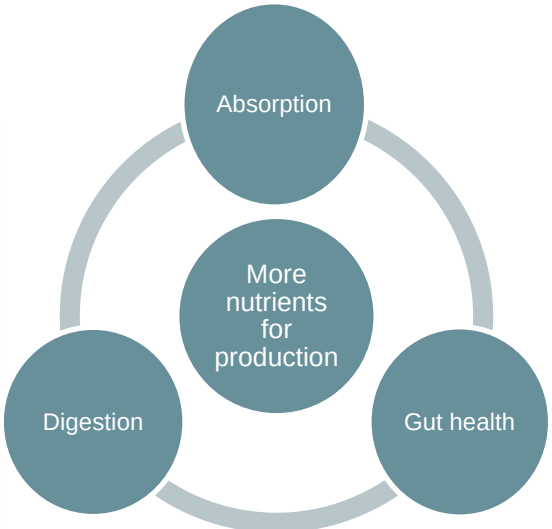




[ab] indicates a significant difference at P<0.05

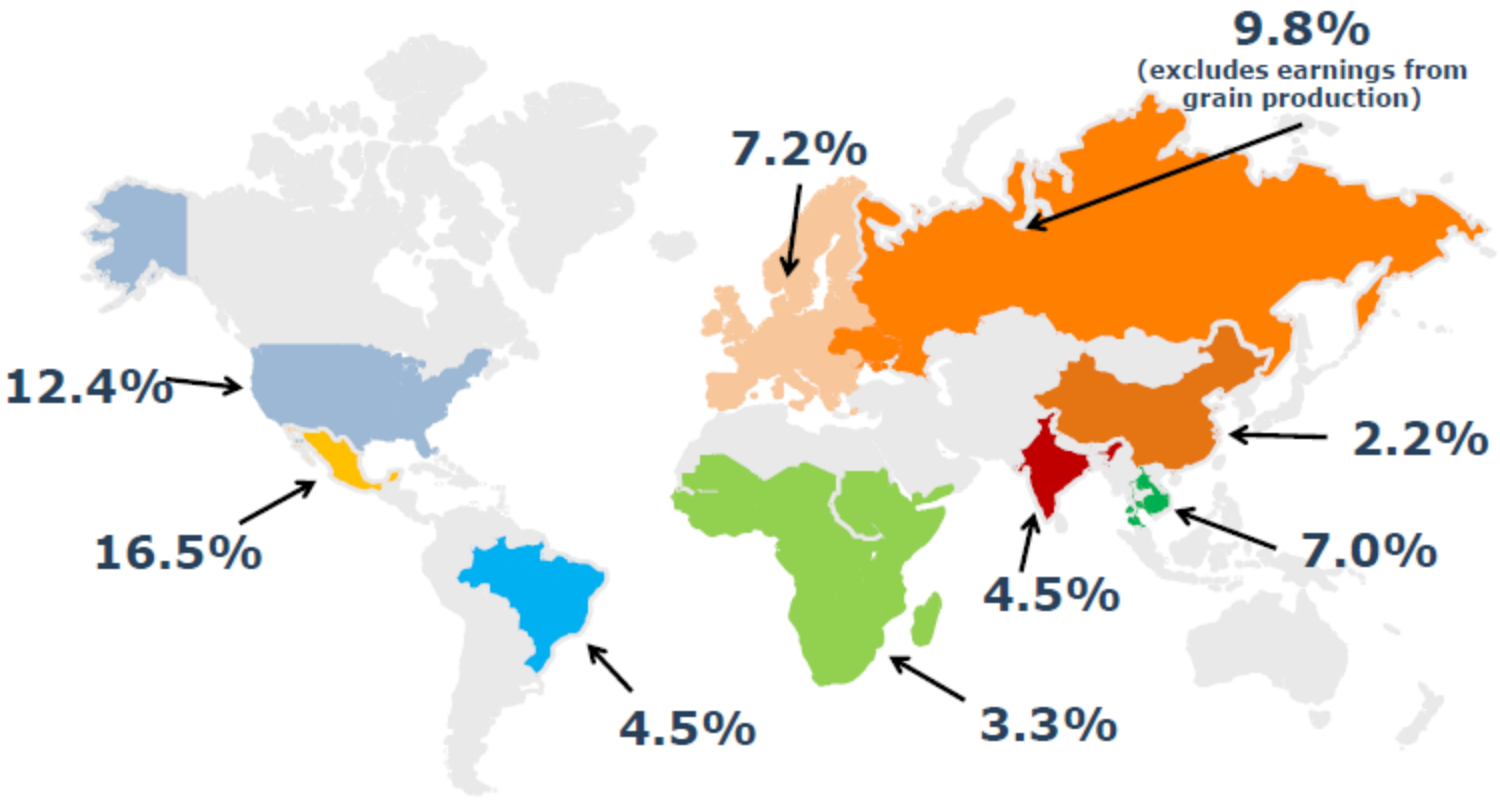
Enzymes and DFMs in Poultry Nutrition

The advantage of enzymes	The advantage of DFMs
Hydrolyze substrate • Specific • Fast • pH dependent Functionality can be designed Catalysts	Live organisms • Metabolism *in-situ* • Reproduce • Adapt to substrates in the gut Modulate microbial populations Modulate immunity



North America Favorable Chicken Production Margins

EBIT Margins of Publicly Traded Chicken Producers

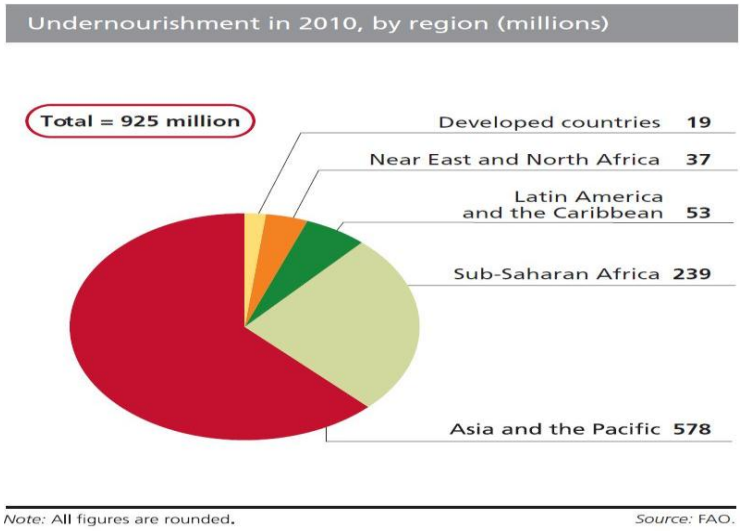


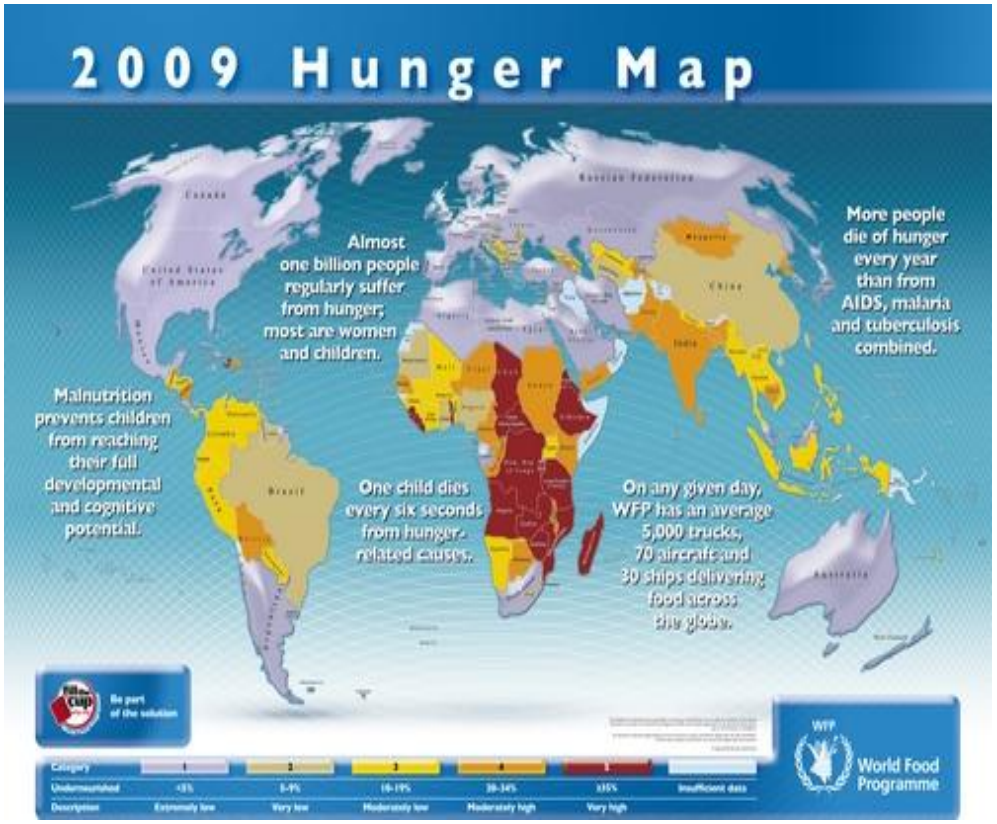
Source: Company Filings

Other areas of food security focus

Annually, Roughly 1/3 of all Food Produced…… is Wasted.*

- High social impact
- High risk problem
- Highly multidisciplinary





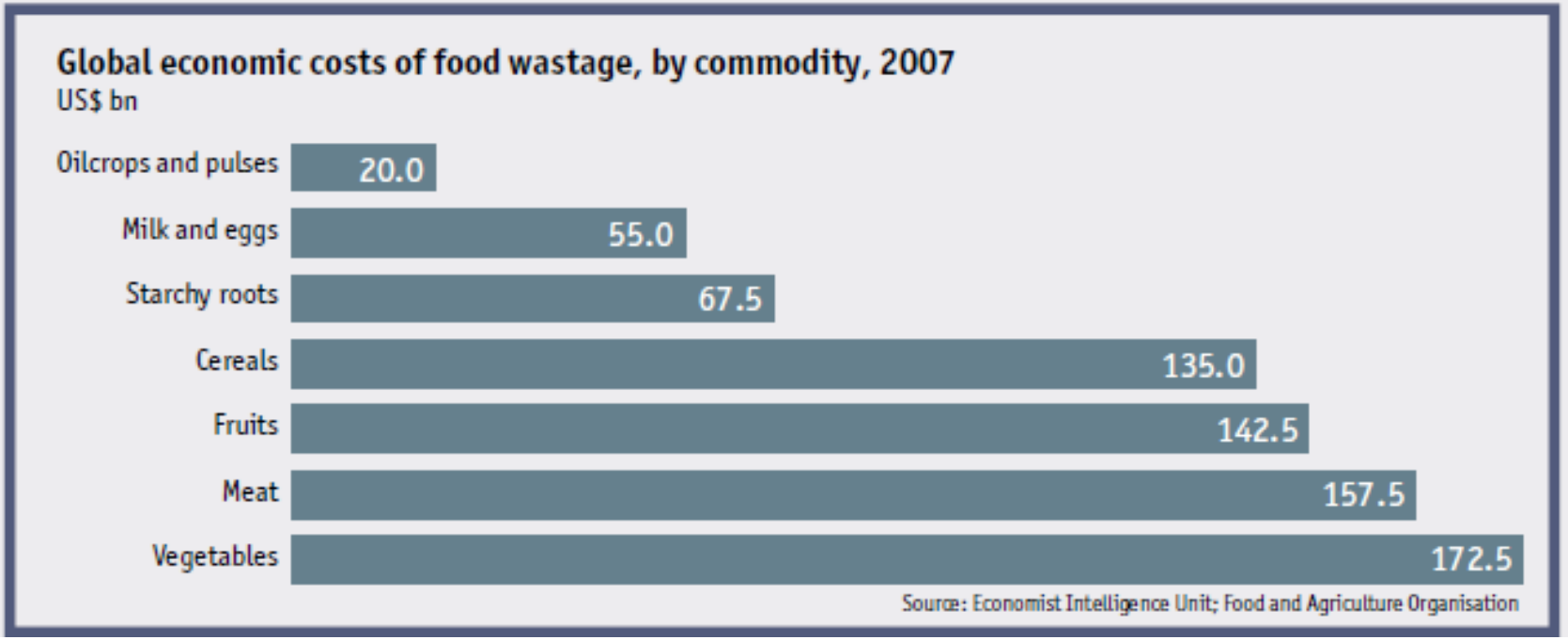





* FAO Stats 2011, http://faostat.fao.org

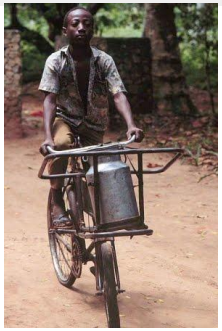
Cost of Food Wastage in $bn per year

Global food security index 2014: An annual measure of the state of global food security
SPECIAL REPORT: Food loss and its intersection with food security



Raw Milk Preservation - an Example



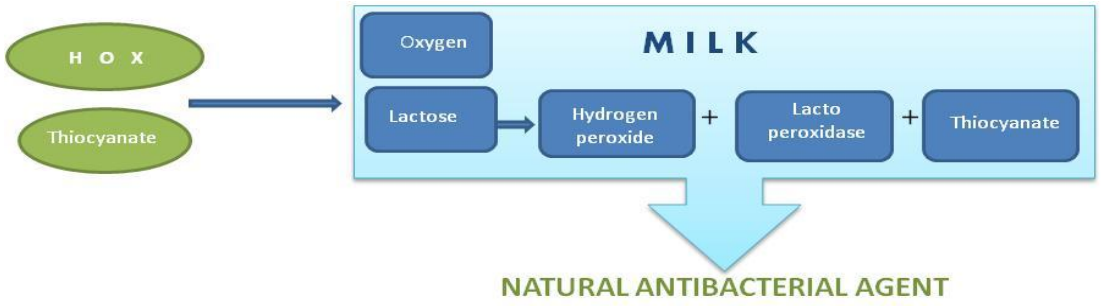



The Problem

Extending the **shelf life of raw milk**, where no refrigeration is available, for a period of approximately 15-18 hours.

A Solution

An enzyme from DuPont, HOX or Hexose Oxidase, to stimulate the milk's natural defenses against spoilage bacteria.



DuPont™ Danisco®

Food protection ingredients

Our food protection solutions help you deliver taste, freshness, food safety and food waste reduction.

Fermented Fresh Dairy
Cheese
Cured Meats
Yeast & Mold Inhibition
Pathogen Inhibition

Gram-Positive Control
Gram-Negative Control
Yeast & Mold Control

Single Plant Extracts
Proprietary Blends
of Natural Extracts

DANISCO.

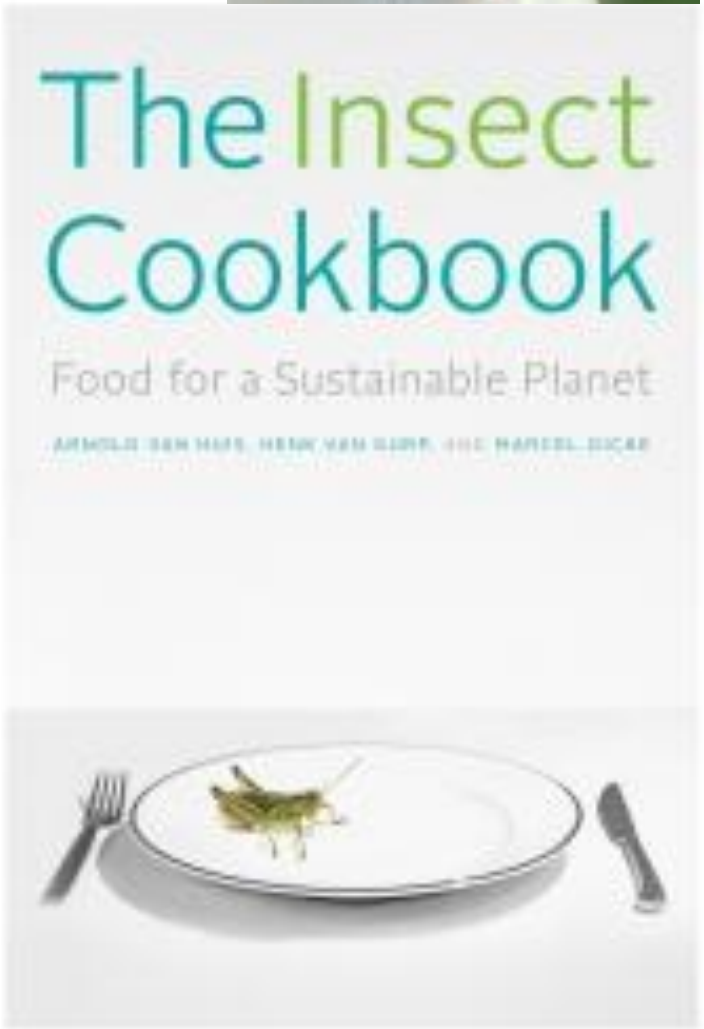
A Look at the Future

Future Feed Stocks – New Challenges

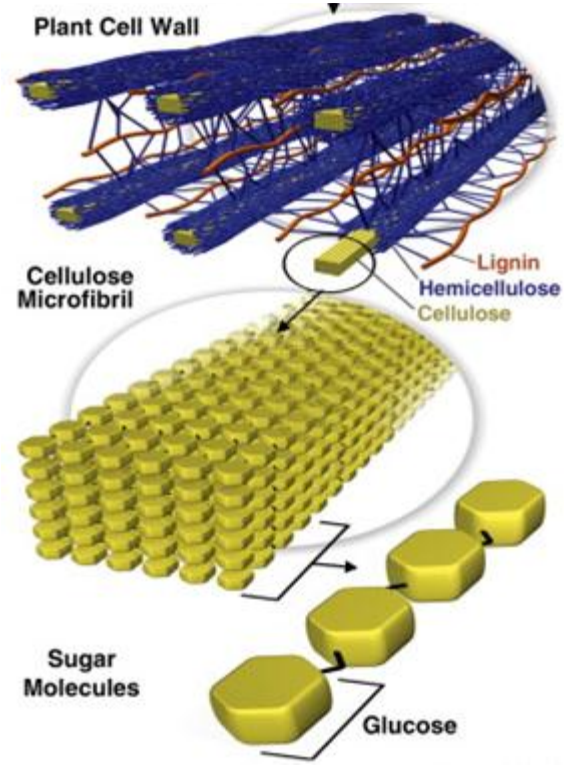
Protein for poultry from grass

Algae from ethanol plant shows promise as poultry feed
http://ethanolproducer.com/articles/8220/algae-from-ethanol-plant-shows-promise-as-poultry-feed

A4 FEED
ALGAE FOR FEED



Biomass Challenge



Sannigrahi et al., 2010

- 1. Hemicellulose: broken down with exogenous enzymes eg. Xylanase
- 2. Cellulose: Crystalline structure, difficult for enzymes to access
- 3. Lignin: non-fermentable, no energetic value for animals

Summary

- Dupont is committed to Food Security
- Enzymes and DFMs
  - » Increased animal production efficiency
  - » More sustainable production
  - » Healthier better perfoming animals
  - » Profitable industry
- Reduced food waste
- New alternative non-food feedstocks
- New technologies
  - » Understanding of physiology at gene level
  - » Alternative meat production methods

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