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Increasing production efficiency through improved feed management

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Animal Nutrition and Health Solutions Manager,
DSM Animal Nutrition & Health Indonesia

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Increasing production efficiency through improved feed management

Agenda

- Metabolizable energy?
- Energy gaps in raw material
- NSPs and NSP Enzymes
- Undigested Amino Acids and Need of Protease
- What is Phytate Phosphorus?
- Why Phytase is needed?
- Why do we need feed enzymes ?
- Feed Enzyme Benefits
- Feed cost reduction
- Alternative RMs & maximizing utilization by layers
- Environmental impact

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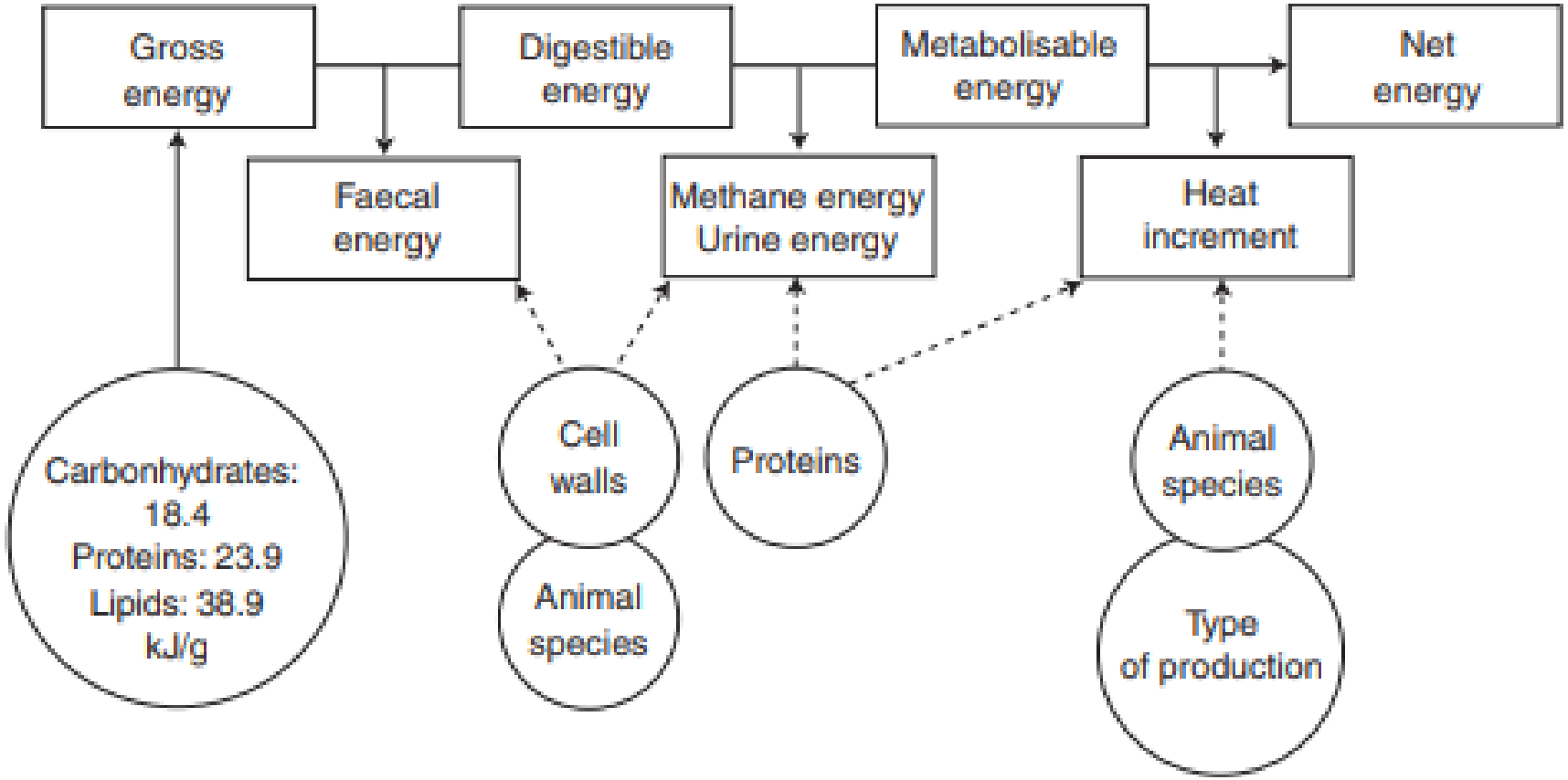
Optimizing Metabolizable energy



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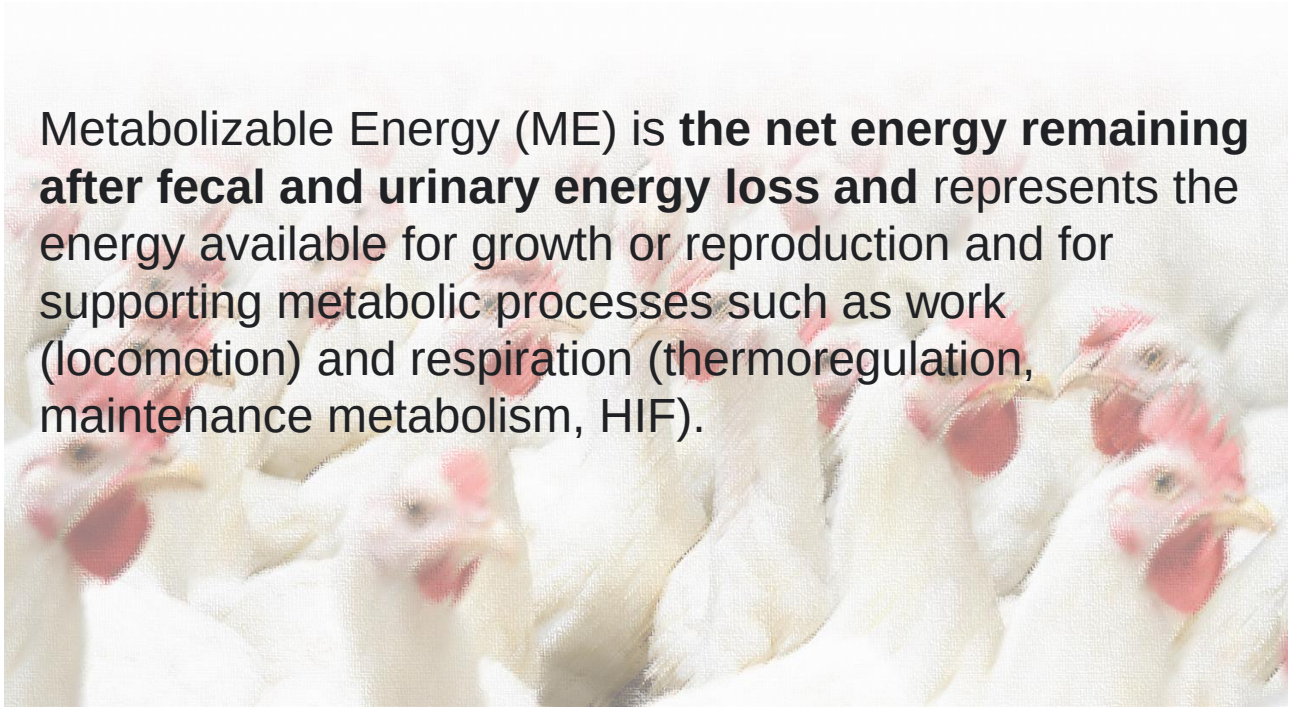
What is Energy and its Classification?

Energy is not a nutrient but a property of energy-yielding nutrients when they are oxidized during metabolism

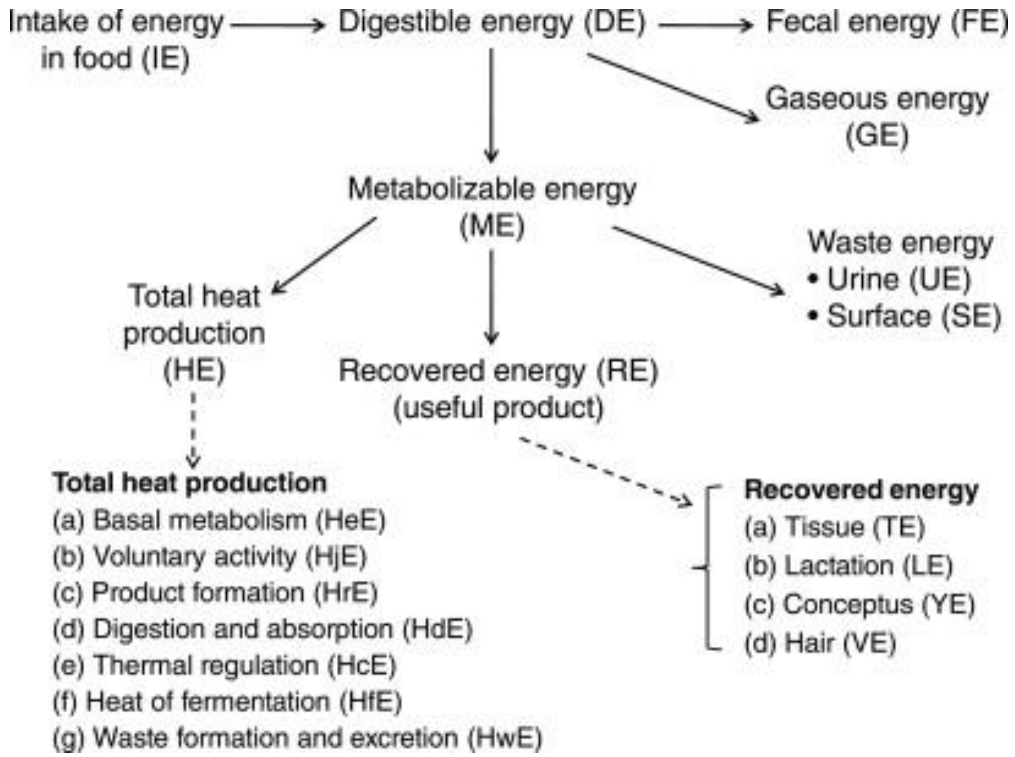


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What is Metabolizable Energy ?



Metabolizable Energy (ME) is **the net energy remaining after fecal and urinary energy loss and** represents the energy available for growth or reproduction and for supporting metabolic processes such as work (locomotion) and respiration (thermoregulation, maintenance metabolism, HIF).



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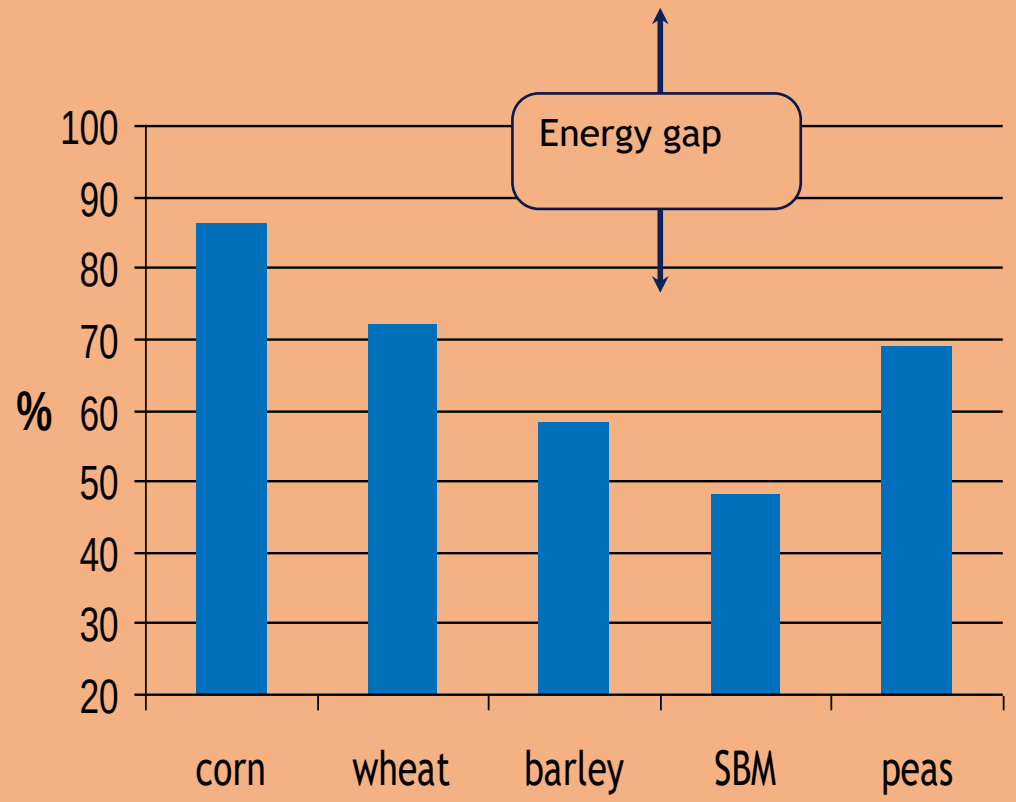
Feed Raw Materials based on Energy content

Raw Material	Class	Energy content
Corn	Cereals	Higher energy source
Wheat	Cereals	Higher energy source
Rice	Cereals	Higher energy source
Soybean meal	Meals	Medium energy source
Canola meal	Meals	Medium energy source
Wheat Bran	By Products	Lower energy source
Rice Bran	By products	Lower energy source
DDGS	By Products	Lower energy source

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Energy Gap in Ingredients



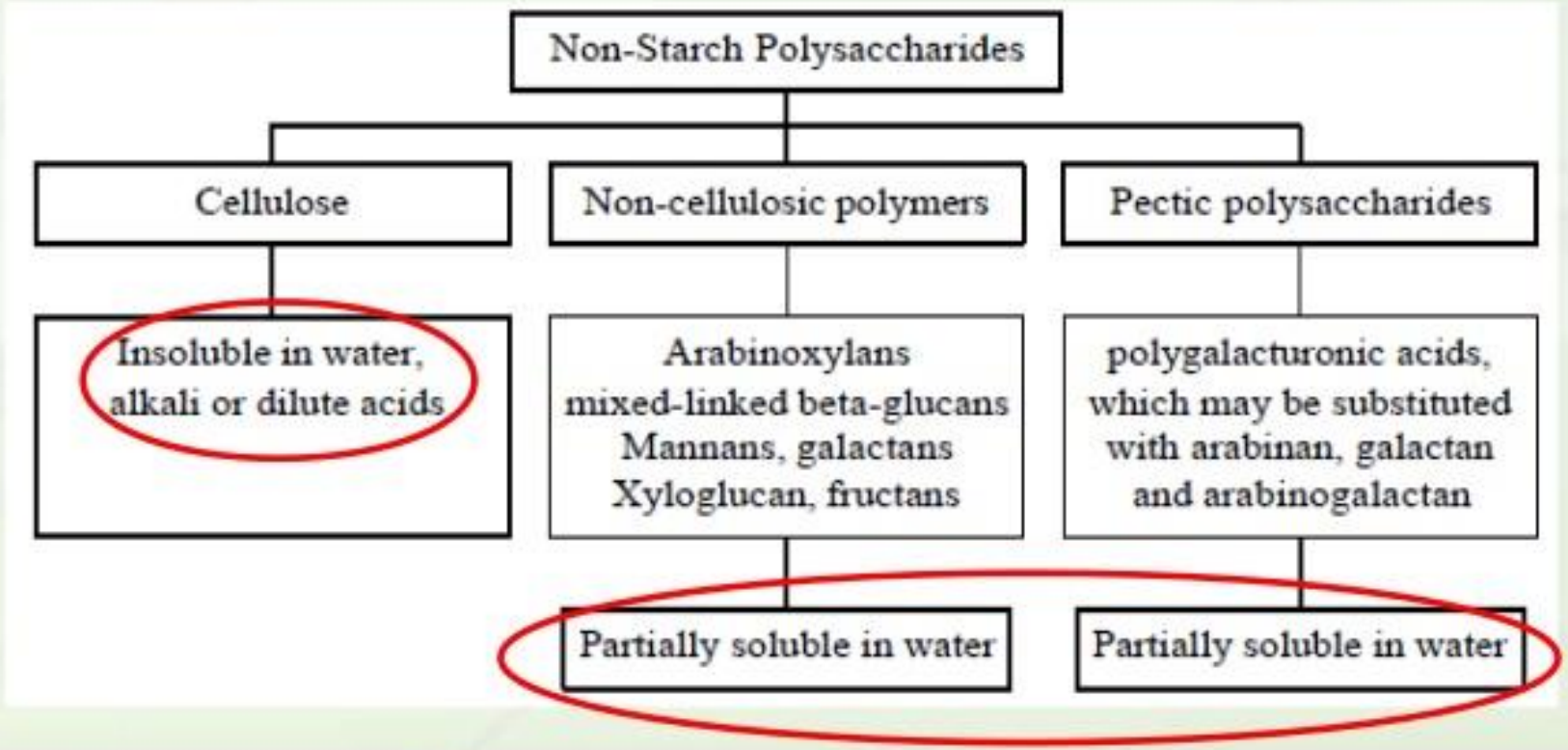
Difference between Gross Energy and Metabolizable Energy indicates potential for increasing energy release using tailor made enzymes

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NSPs

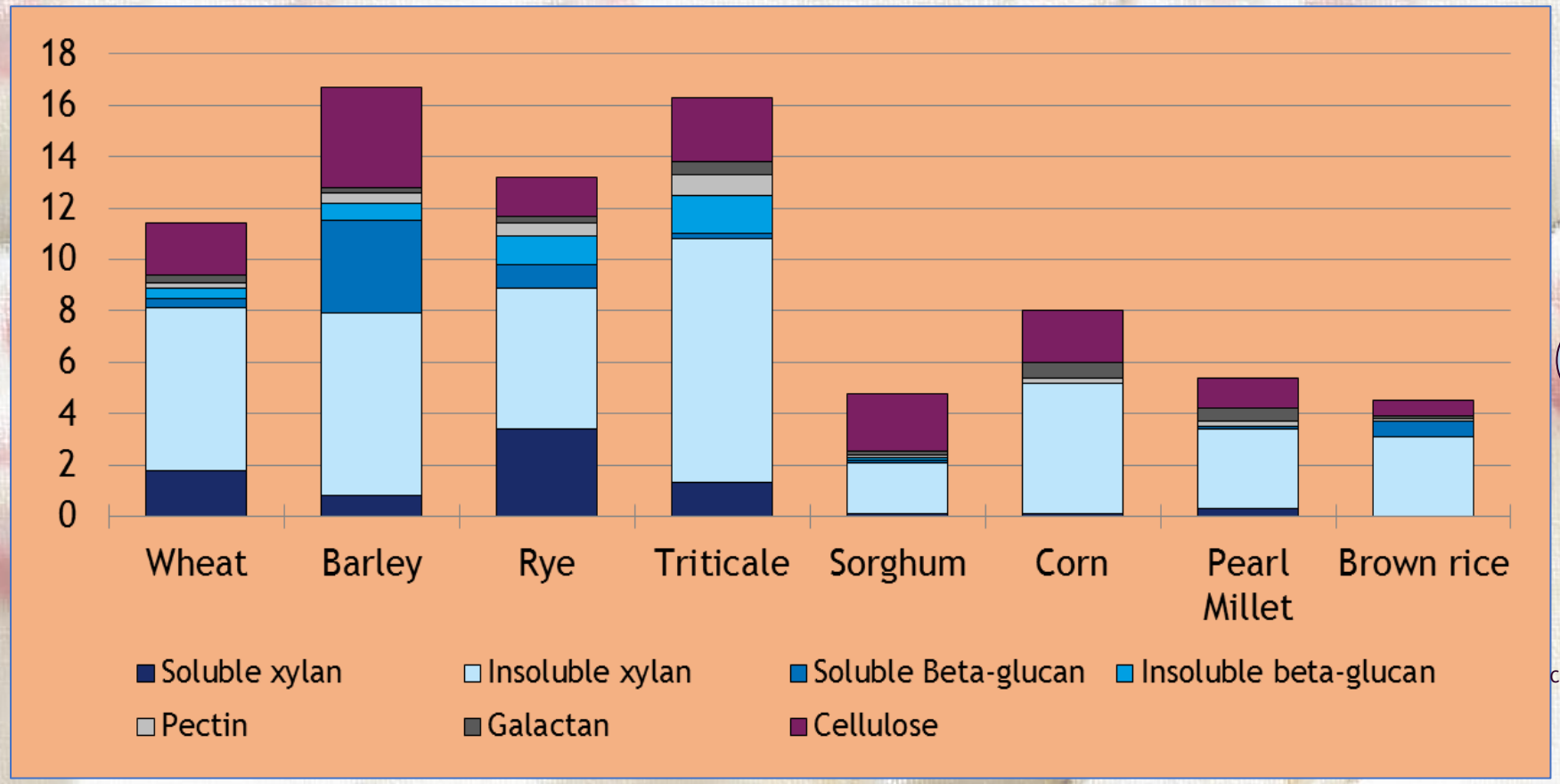
Classification of NSPs

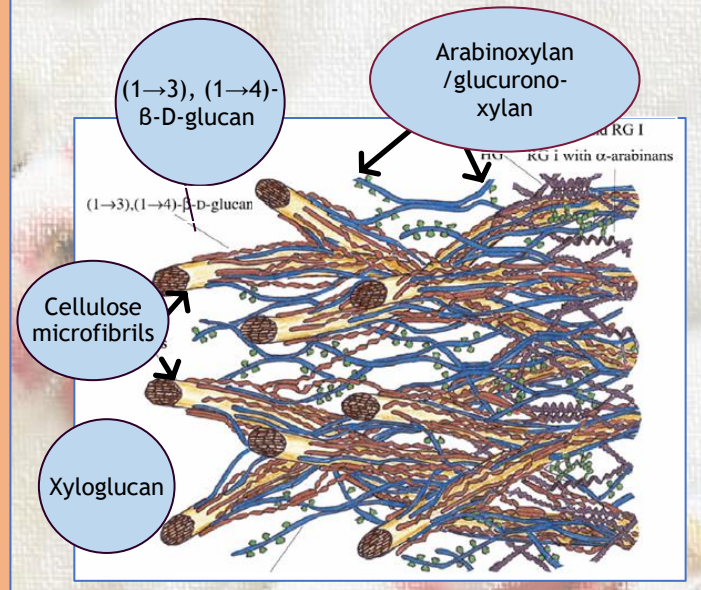


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Differences in the Composition of the Cereal Cell Wall

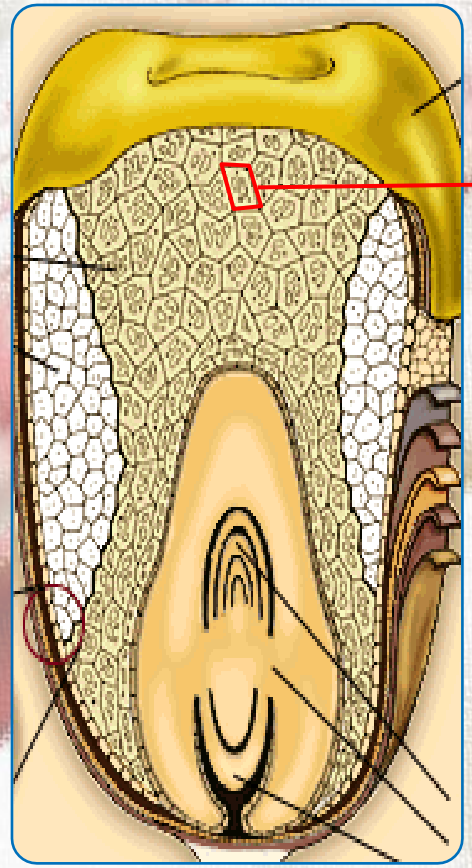




Carpita, N.C. and Gibeaut, D. M (1993). The Plant Journal 3(1):1-30.

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Composition of the Corn/Maize Cell Wall





Nutrients (starch and protein) entrapped by the arabionoxylan network

The main chemical components in cereal cell walls in the endosperm are cellulose and arabinoxylans. The structure of cellulose are alike in cereals but the structure of the arabinoxylans in the different cereals varies.



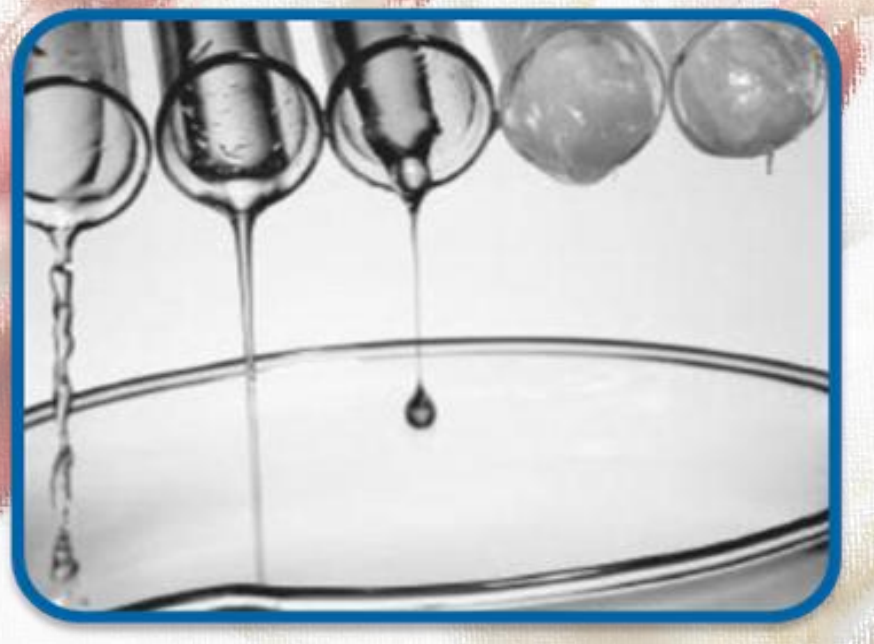
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NSP as ANFs (Anti-nutritional Factors)

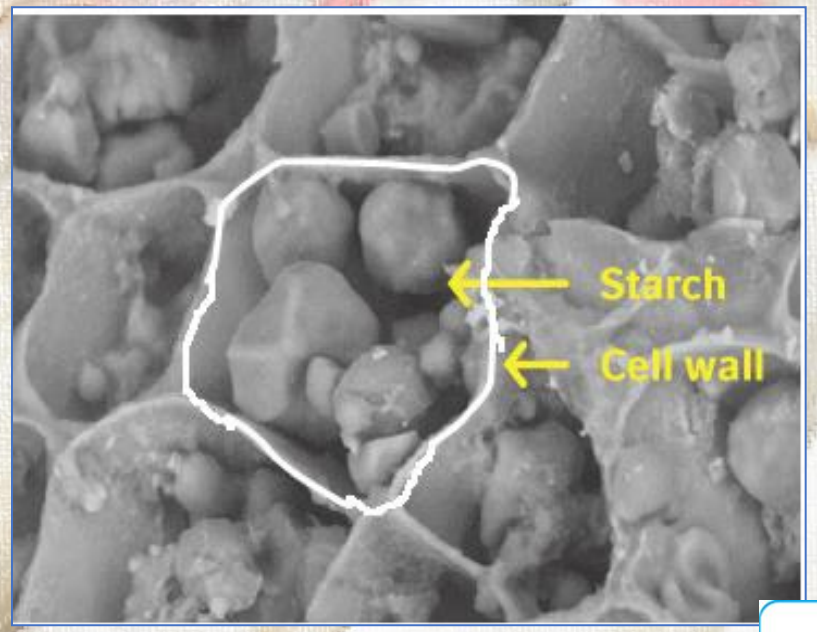
Viscosity effect

- Decreased feed passage time
- Increase water binding capacity
- Increase unwanted bacterial population
- Wet or sticky litter
- Dirty Eggs, Hock burns and Breast blisters



Cage effect

- Capture nutrients
- Increase dietary problems
- Limits nutrient to gut wall
- Reduces action of endogenous enzymes



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Cereals & by-products (from mono-cotyledonous plants)

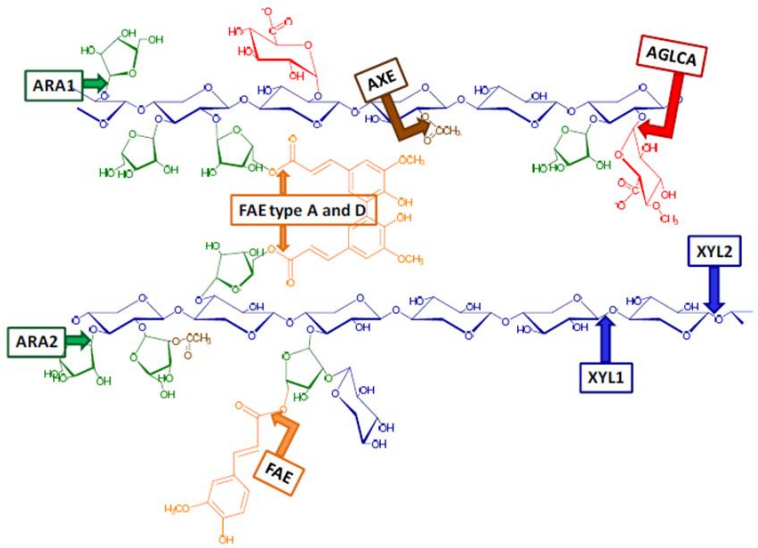


Non-Starch Polysaccharides in cereals and their by-products:

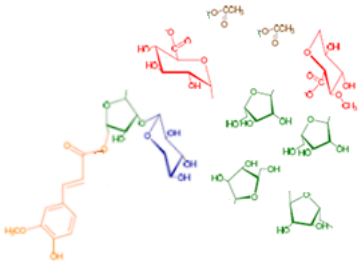
- Cellulose
- Hemicelluloses
  - β-glucans
  - Xylans (Arabinoxylans)
  - Xyloglucans

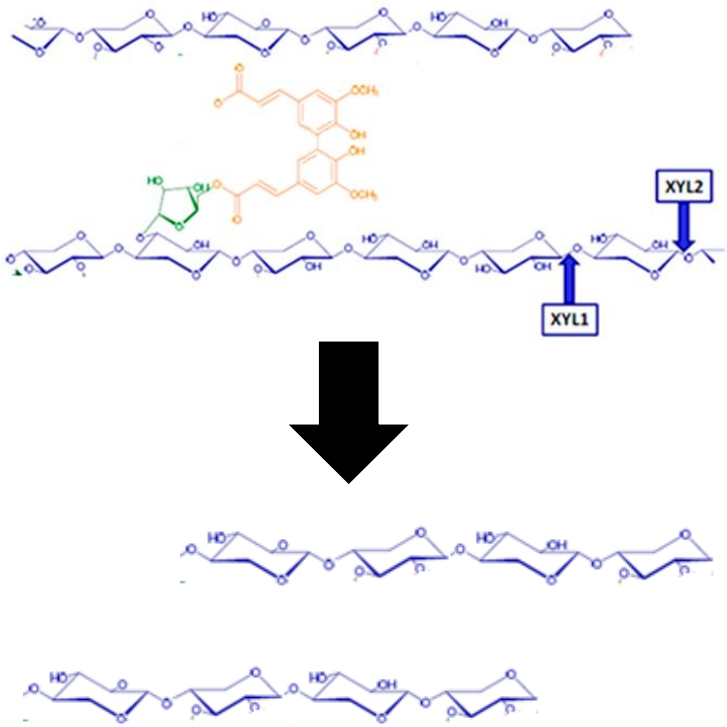
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Corn needs debranching enzymes and xylanases for solubilisation



Tentative structure of corn Arabinoxylan (insoluble) with enzymes to attack branch points





Xylan oligomers (known to be prebiotic)

MultiGrain Enzyme Activities	
Beta - glucanase	
Xylanase	✓
Cellulase	
Xyloglucanase	
Arabinoxylan de-branching activities	✓

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Wheat

- Each endosperm cell is surrounded by a cell-wall unique for wheat, consisting of 70% arabinoxylans
- Wheat contains both soluble and insoluble arabinoxylan in the endosperm cells
- Starch is stored as granules in starchy endosperm cells
- If both entrapped nutrients are released and gut viscosity is reduced, this will maximize the energy value of wheat-based diets



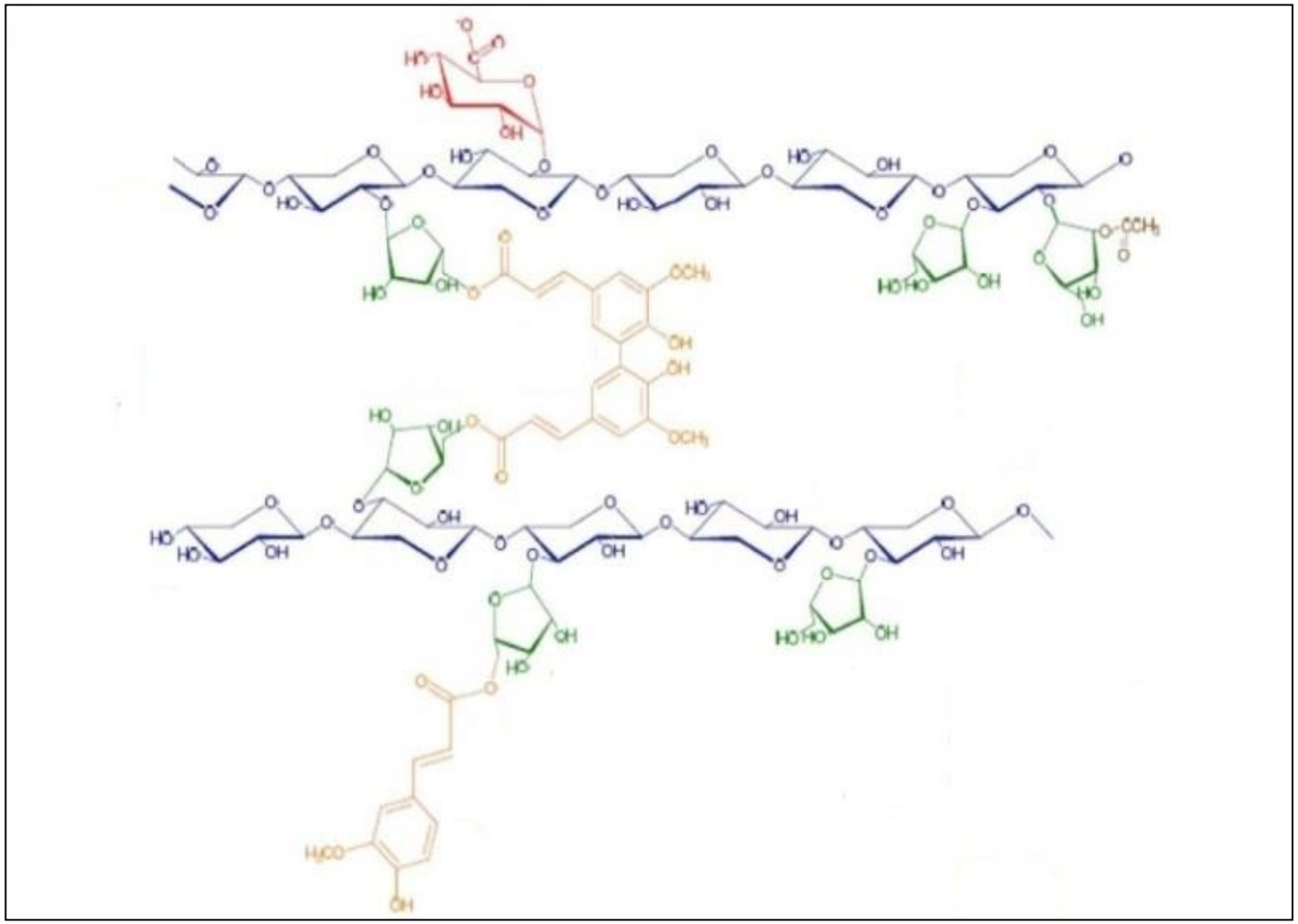


ATTENTION TO CAROTENOID SUPLEMENTATION

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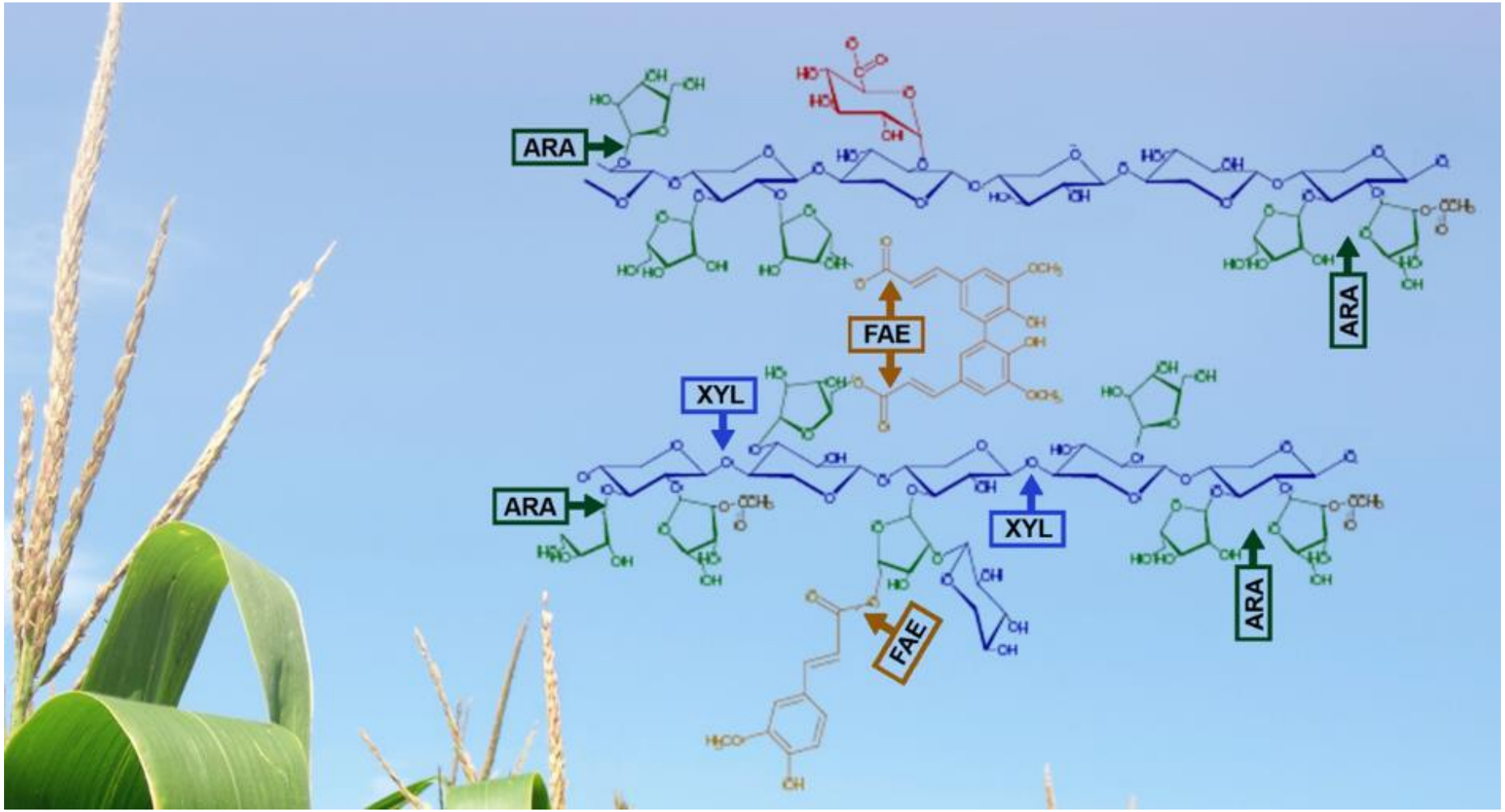
Wheat arabinoxylan: less substituted arabinoxylan



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Corn DDGS

Arabinoxylan needs de-branching enzymes & xylanases for solubilization





- Arabinoxylan de-branching activities (arabinofuranosidase) are needed.
- If only a xylanase is available, it is difficult to work on a such highly substituted arabinoxylan structure.

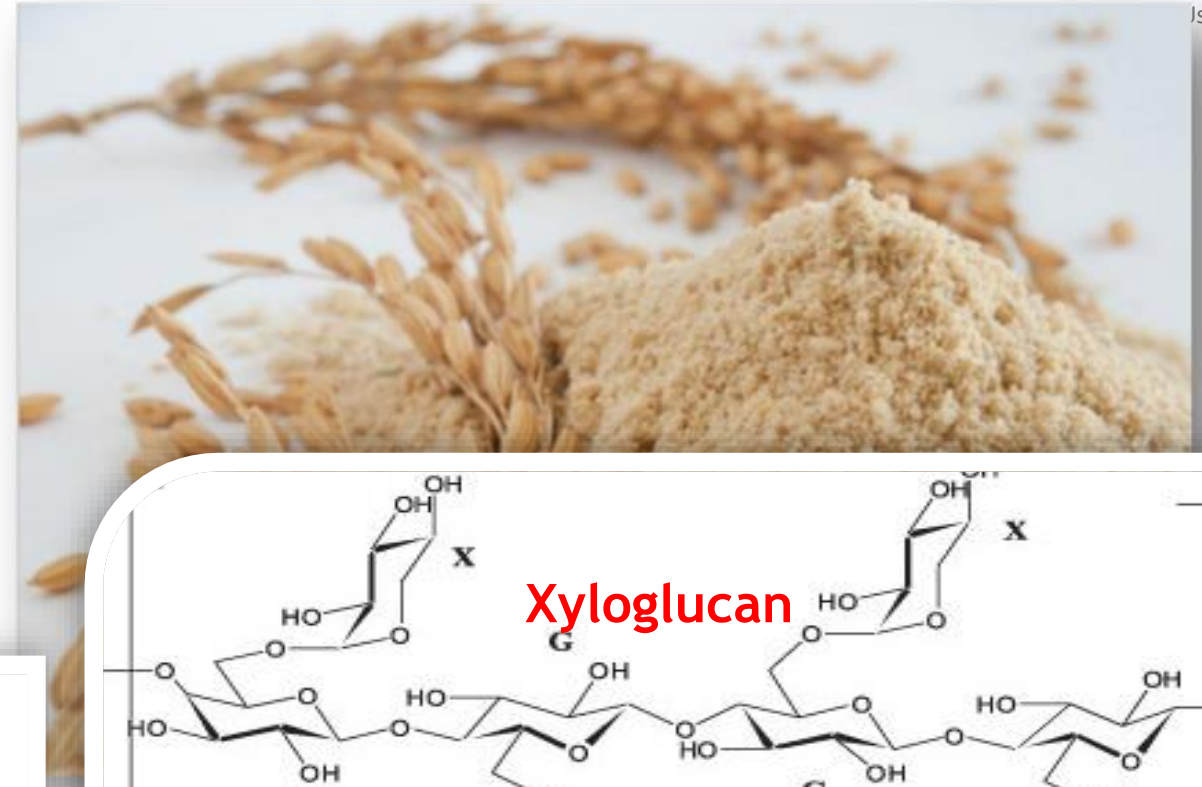
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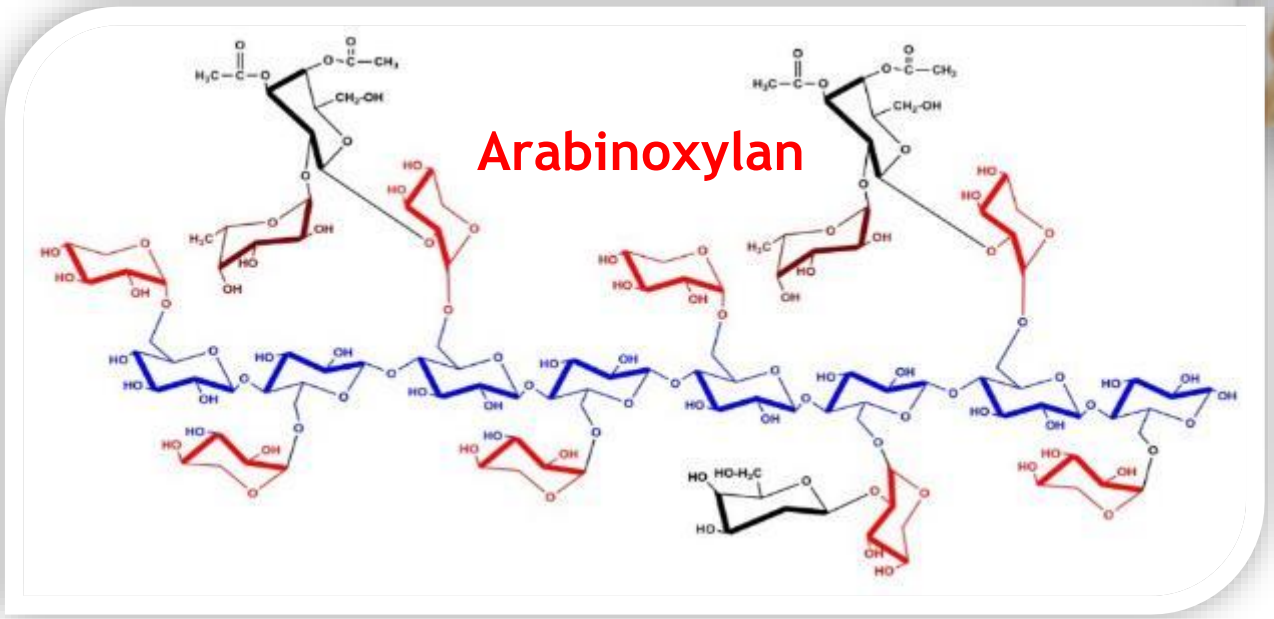
Use Only

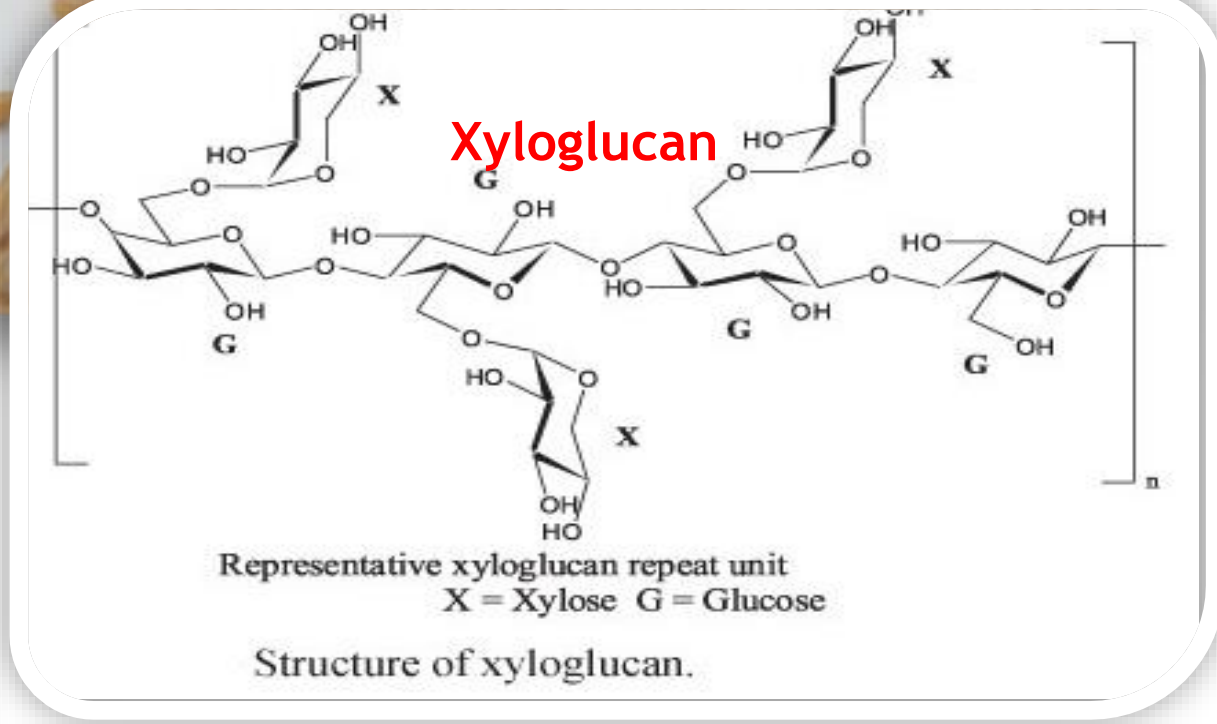
Rice Bran (& rice polish)

A great and low-cost source of :

- Protein
- Energy (full-fat rice-bran)
- Phosphorus







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Oil Seeds & Tubers
(from di-cotyledonous plants)



Non-Starch Polysaccharides in oil seeds, tubers and their by-products:

- Cellulose
- Hemicelluloses
  - Xyloglucans
- Pectins
  - Mannans (Galactomannans
  - Galactans (Arabinogalactans)
  - Arabinans
  - Homogalacturonan
  - Rhamnogalacturonans
  - Xylogalacturonan

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Palm Kernel Meal

Only for ruminants ?

- Good quantities are available in South-East Asia (Malaysia – Indonesia).
- A low-cost alternative protein source.
- High in lignin (10-18%), which is reducing feed intake.
- Sometimes is causing wet droppings, if the right enzymes are not used.
- It could be used up to 10% in layer diets.
- It contains 62-66% NSP:
  - 50% mannans
  - 11% cellulose
  - 3% arabinoxylan

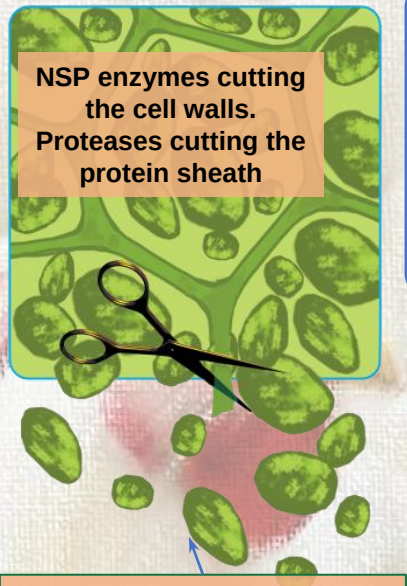


PKM %	Protein	Fiber	Fat
Expelled-extracted	15	18	8.5
Solvent	17	18.5	2.5

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NSP Enzymes

- Nutrients in cereals and vegetable protein sources are stored inside the plant cells
- Degradation of the plant cell wall will allow greater utilization of energy
- Different approaches need to be used for different plant species to maximize the benefit
- The reward is better overall energy utilization and improved producer returns



Releasing the nutrients captured inside intact cells is called the cage effect

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Enzyme activities in RONOZYME® MultiGrain

MultiGrain Enzyme Activities	
Beta - glucanase	
Xylanase	
Cellulase	
Xyloglucanase	
Arabinoxylan de-branching activities	

The combination of these enzyme activities is a perfect match for optimizing diets with cereals

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Raw Materials	DIF Energy
Corn	3%
Wheat	5%
Barley	8%
Sorghum	3%
Triticale	5%
Oat	8%
Millet	3%
Rice Broken	3%
Rice Brown	3%
Cassava	3%
Wheat Bran	7%
De-Oiled Rice Bran	6%
Full-Fat Rice Bran	4%
Rice Polishing	4%
Corn DDGS	4%
Corn Gluten Feed	4%
Corn Germ Meal	5%

RONOZYME® MultiGrain

DIF Values Recommendations For Poultry and Piglets

Species	Recommended dose (g/MT)
Broilers	100 - 120
Layers, Breeders	80 - 120
Turkeys	100 - 150
Ducks, Quails	100 - 150
Piglets (<35 Kg)	100 - 150

DIF
Digestibility Improvement Factor

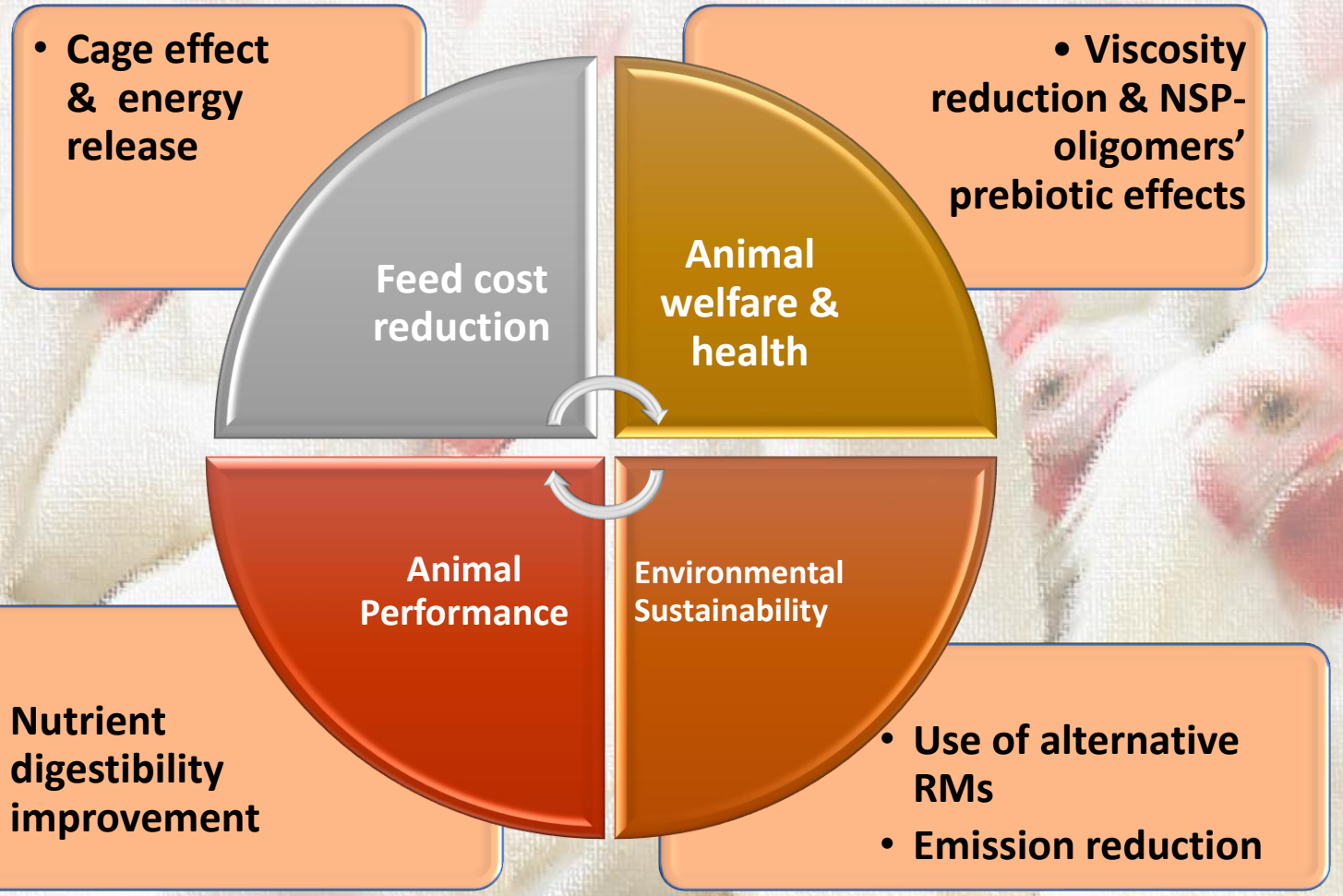
Dose should be adjusted to the level and quality of relevant substrate in the diet

If ***RONOZYME Multigrain*** is used in combination with other ***RONOZYMES***, please contact the local DSM technical staff for advice.

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RONOZYME® MultiGrain Benefits



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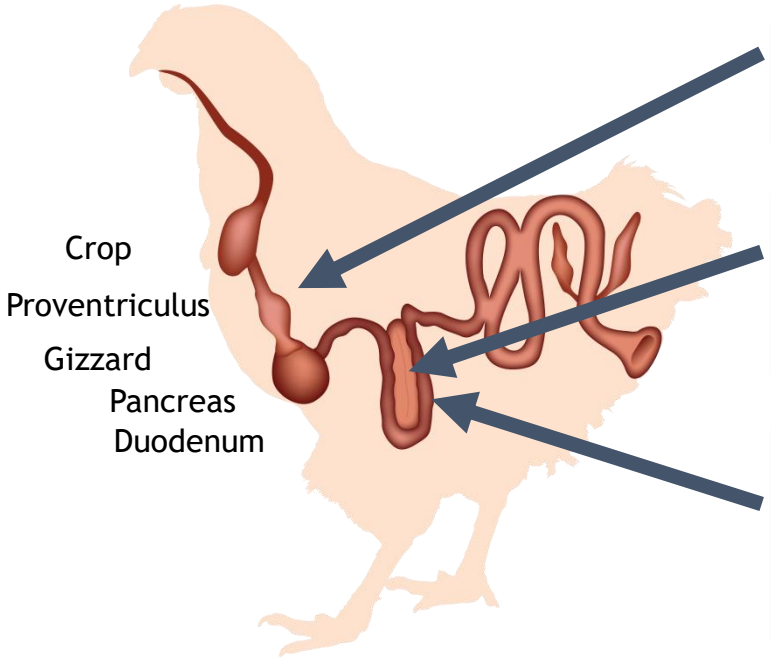
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Optimizing Your Protein Source



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Protein digestion in poultry already well developed



Pepsin (+HCl) → Dietary Proteins

Trypsin
Chymotrypsin
Elastase → Polypeptides

Aminopeptidases
Carboxypeptidases
Dipeptidases → Oligopeptides + free AAs

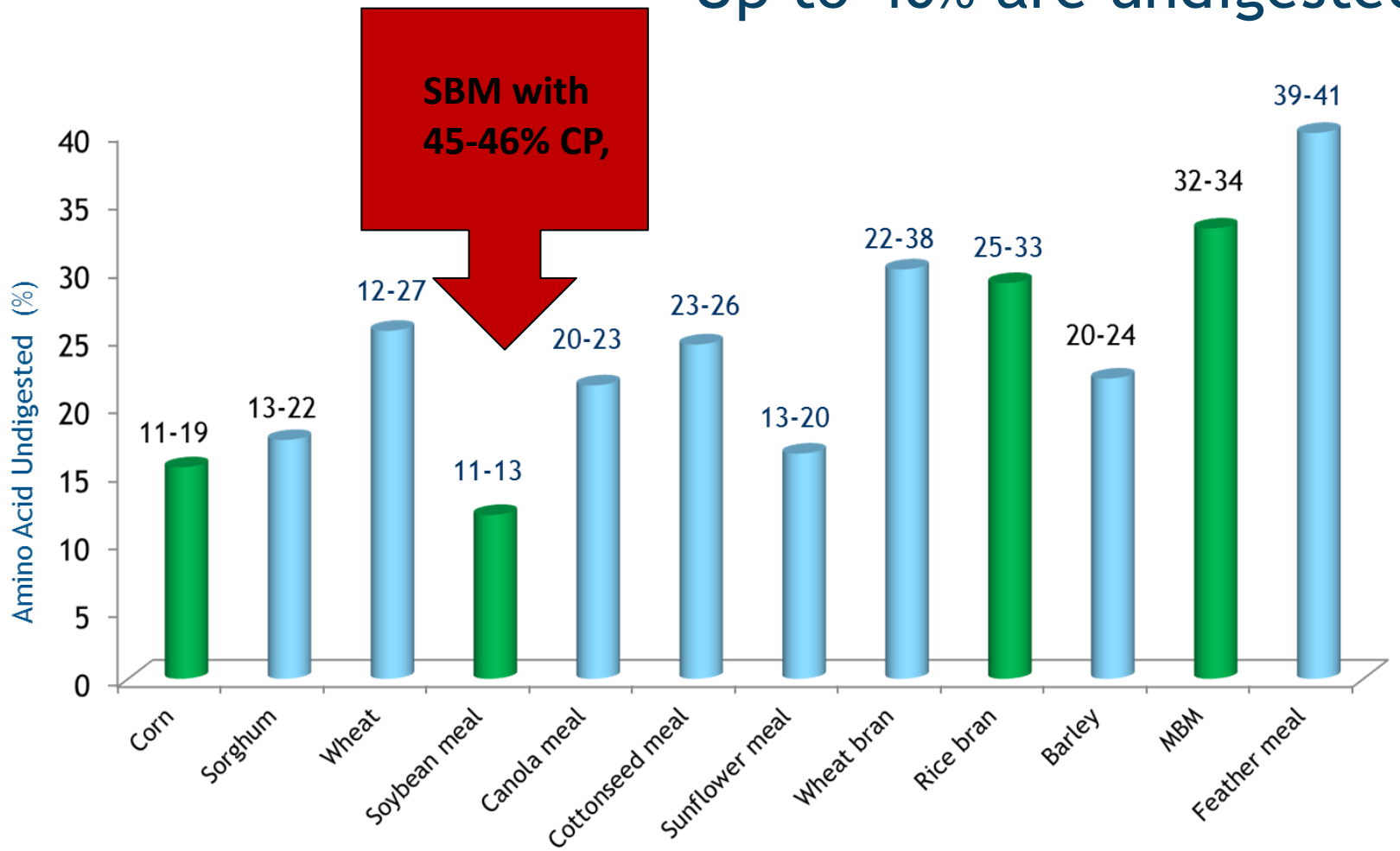
Free AAs

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Mean amino acid undigested fraction (%), valuable substrate for improvement

Up to 40% are undigested



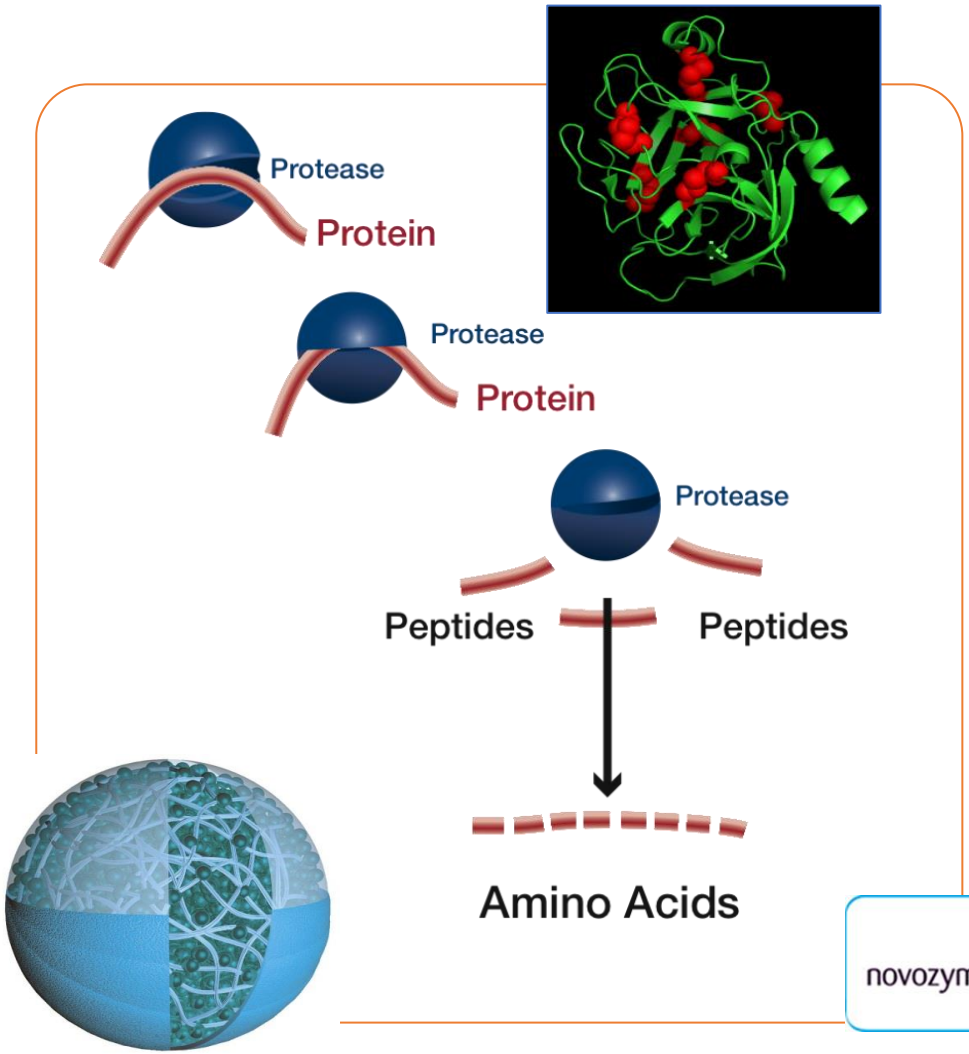
Source: Several authors

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Novel unique Mono-Component Protease from *Nocardiopsis prasina* produced in *Bacillus licheniformis*

- >95% pure protease activity
- Broad specificity
- Stable at low pH/with pepsin
- Stable during feed processing
- Safe to humans and environment
- Fully compatible with other feed enzymes
- Complements endogenous enzymes like pepsin and pancreatic proteases



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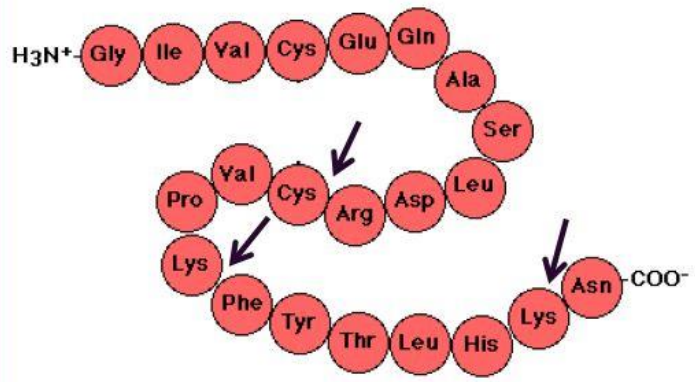
Novel unique Mono-Component Protease from *Nocardiopsis prasina* produced in *Bacillus licheniformis*

PROTEASE SPECIFICITY

Different proteases results in different hydrolysis products

Specific protease

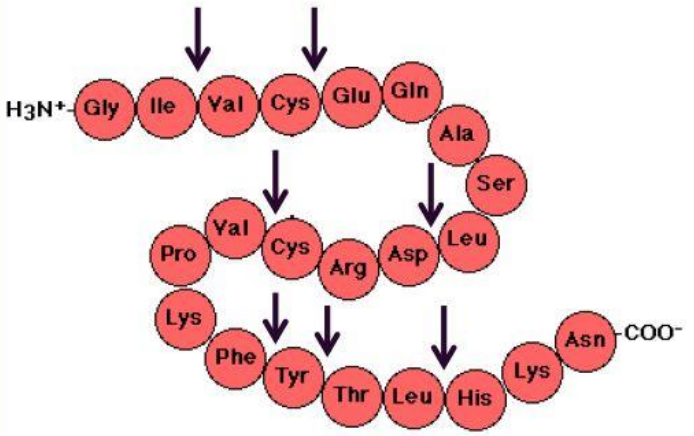
Trypsin
specific for Arginine and Lysine



Hydrolysis is limited
(few cuts)

Unspecific protease

RONOZYME® ProAct
preference for hydrophobic amino acids



Hydrolysis is aggresive
(many cuts)

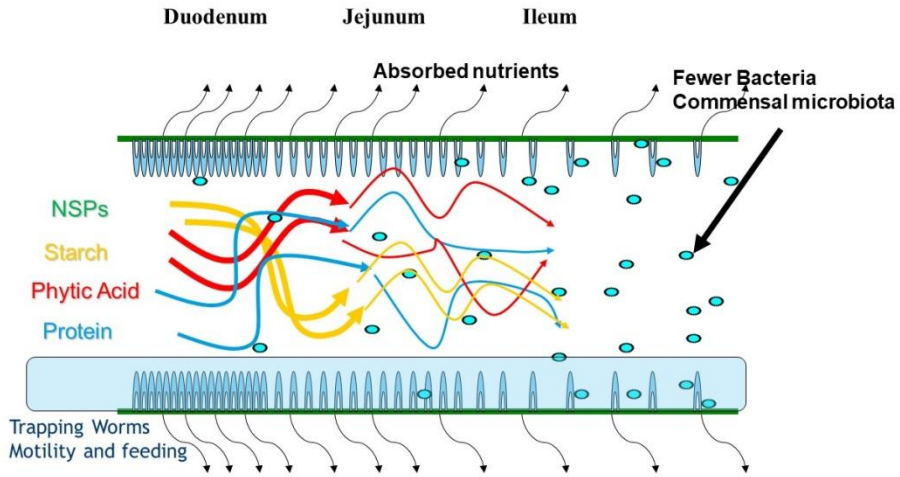
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RONOZYME ProAct positive effects on Gastro-Intestinal Functionality

- **Maintenance and enhancement of intestinal integrity is essential** for bird performance when antimicrobials are not included in feed, as commercial poultry face **numerous enteric pathogen challenges**
- Diets with a low energy to protein ratio lead to higher feed consumption, resulting in an excessive protein intake and increased nitrogen levels in the digesta
- ***ProAct*** **improves tight junction integrity, reduces inflammation, reduces mucin secretion, increases villi height & villus to crypt ratios.**
- **Bacteria like *Clostridium perfringens*,** lack the ability to produce 13 out of the 20 essential amino acids, **their growth is stimulated in an environment rich with proteins**. ***ProAct*** helps reducing such risk.

Reducing the risk of development of enteric pathogens

Improved protein digestibility helps reducing risk of development of pathogenic bacteria



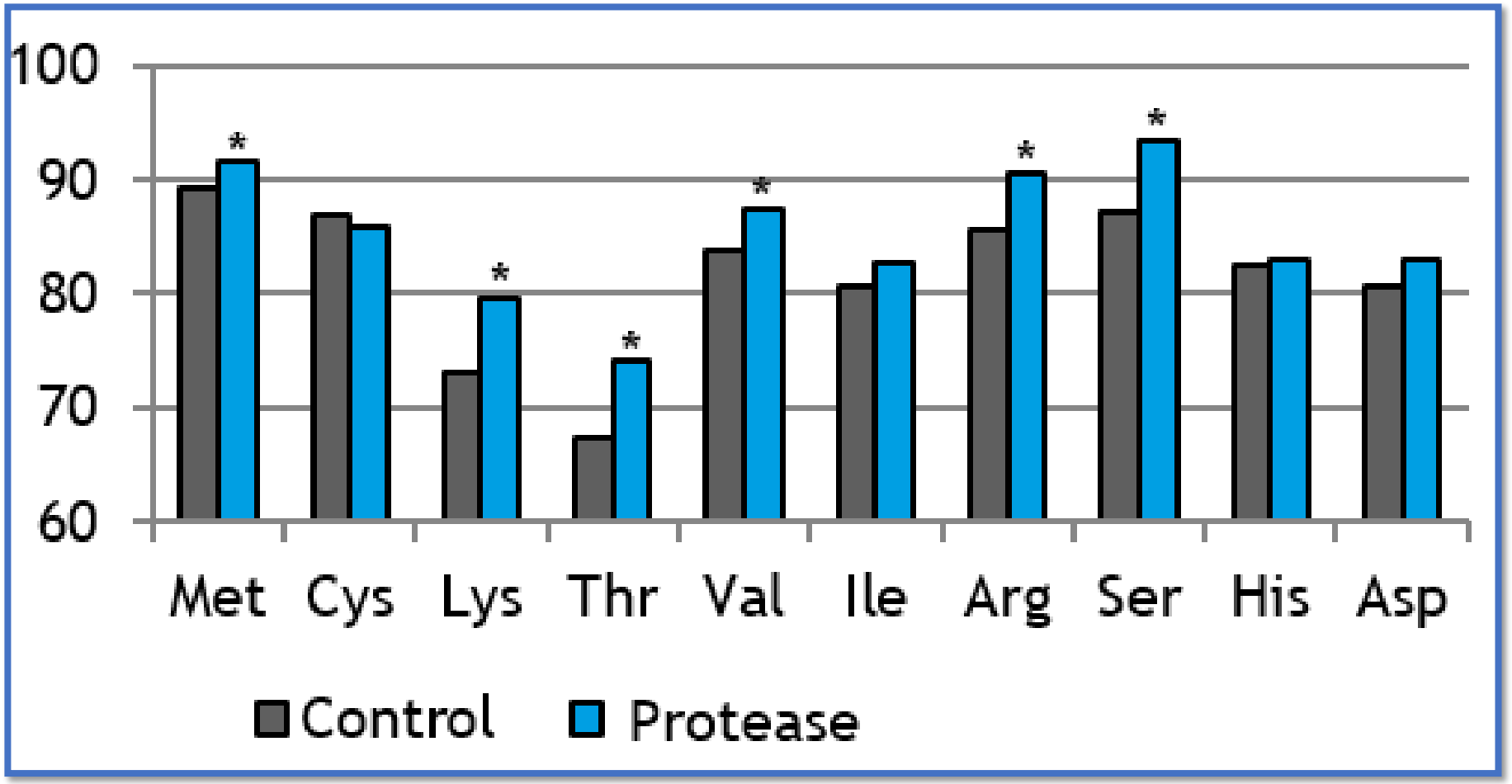
This reinforces the beneficial effects of ProAct beyond direct nutritional benefits

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Corn DDGS - Protease effect





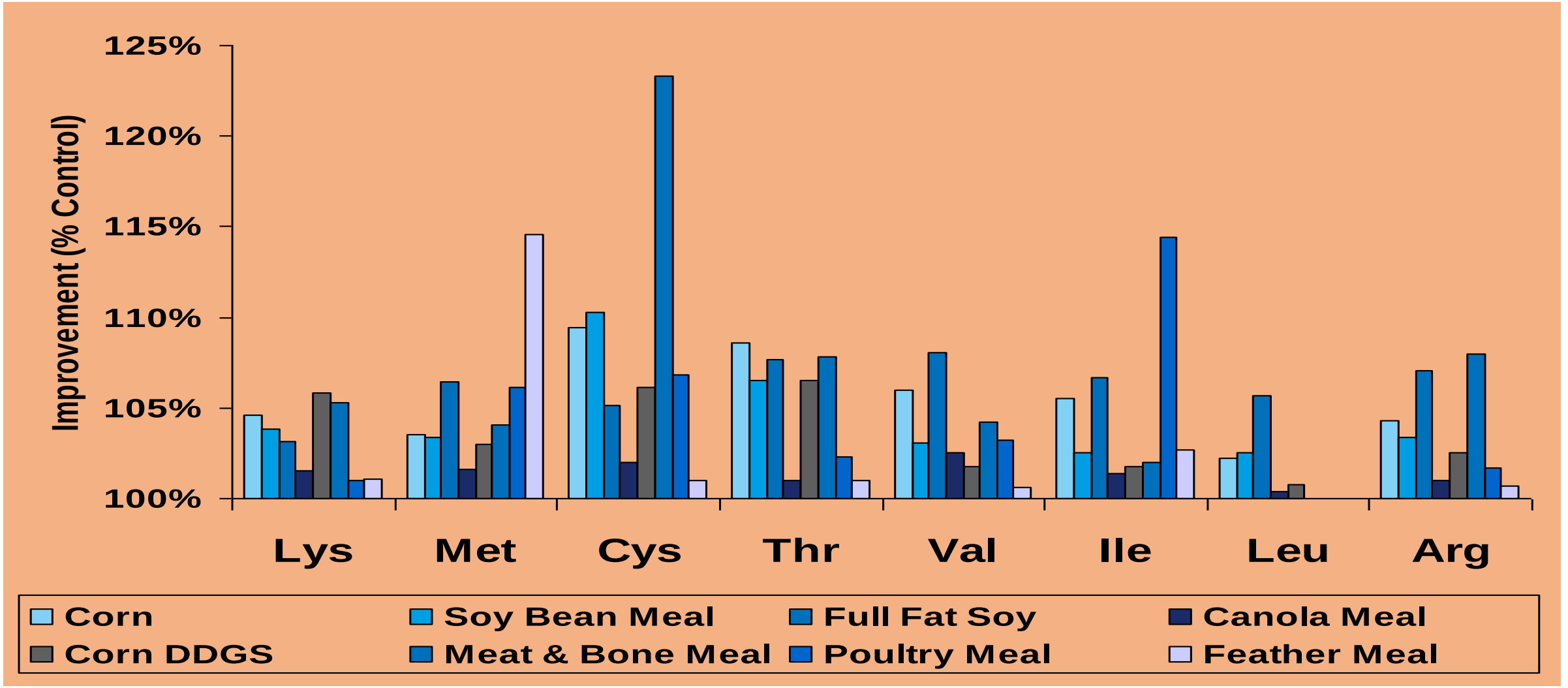
- USA trial
- HyLine W36 white layers,
- 56 wks of age

Source: *Angel, R. et al.* "Effects of a mono-component protease on true ileal amino acid digestibility of selected ingredients for commercial laying hens." Abstract 508 – Poster - PSA 2011

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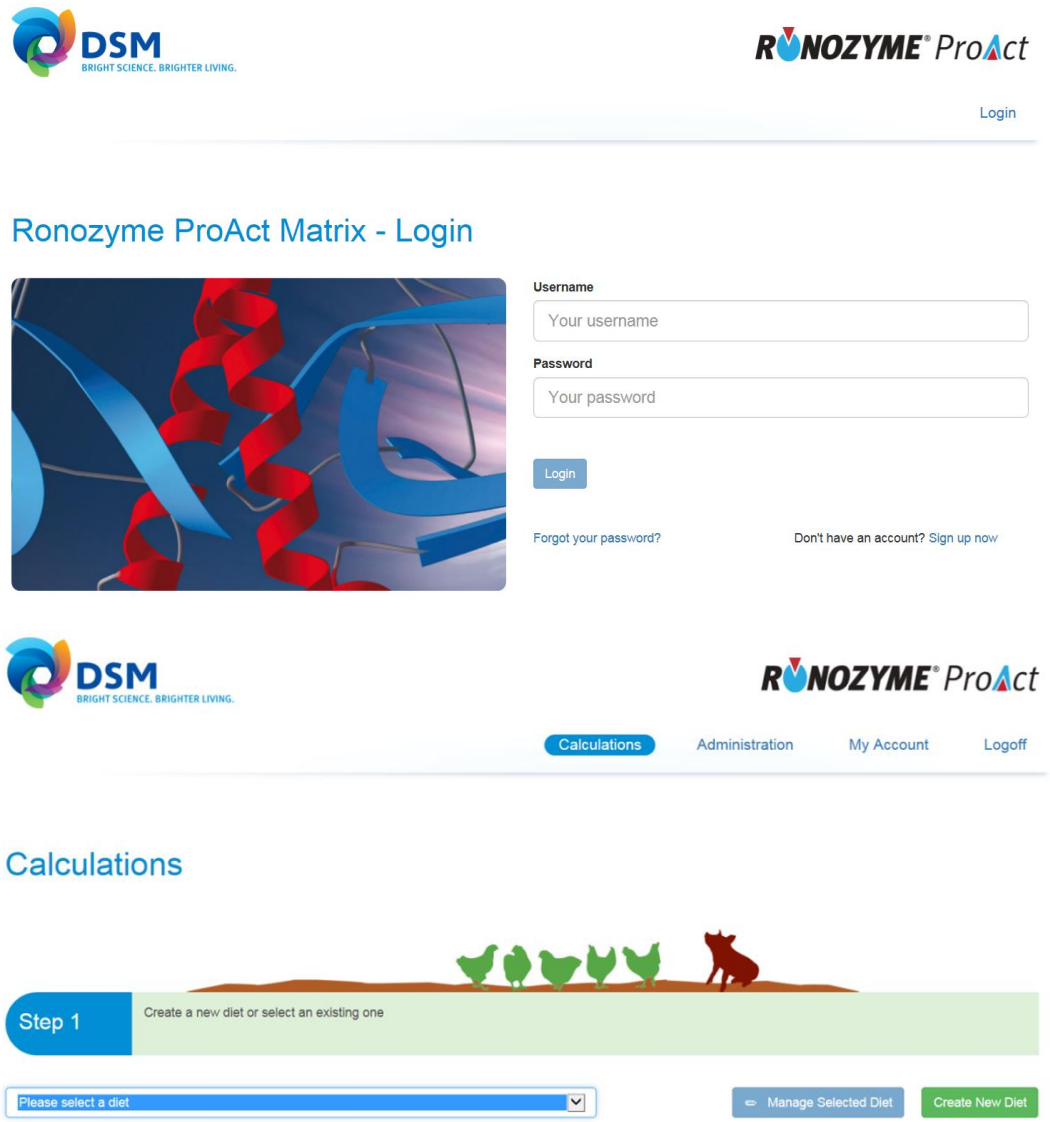
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Improved amino acid digestibility



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Friendly Tool to Optimized Your Diet



- Corn
- Wheat
- Soy Bean Meal
- Full Fat Soy
- Canola Meal / Rapeseed Meal
- DDGS Corn
- Meat Bone Meal
- Poultry by Product
- Feather Meal
- Barley
- Sunflower Meal
- Sorghum
- Fishmeal
- Wheat Middlings
- Pura
- DDGS Wheat
- Peas
- Beans
- Guar Meal
- Palm Kernal Meal
- Rice Broken
- Rice polishings

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BRIGHT SCIENCE. BRIGHTER LIVING.

RONOZYME® ProAct

Phase 1 Feed - Results

Nutrient	RONOZYME ProAct Contribution (%)	Contribution of RONOZYME ProAct in Feed (%)	RONOZYME ProAct Matrix Value (%)
CP	2.570	0.378	1'888.8
d. Met	2.210	0.006	30.9
d. M+C	3.574	0.019	94.7
d. Lys	2.961	0.017	87.4
d. Thr	5.163	0.026	129.1
d. Trp	1.193	0.002	7.8
d. Arg	2.358	0.019	95.5
d. Val	2.983	0.019	96.9
d. Ile	2.651	0.015	72.9
d. Leu	1.156	0.014	71.1
E (Kcal/Kg)		11 - 62	

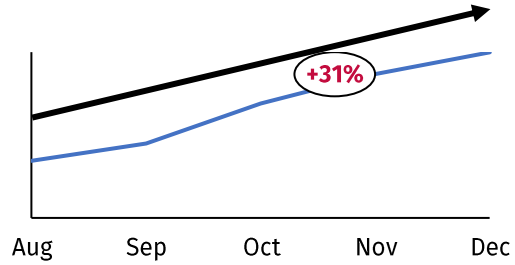
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Improving feed efficiency and reducing Diet cost with proact

Feed millers seeing record input prices

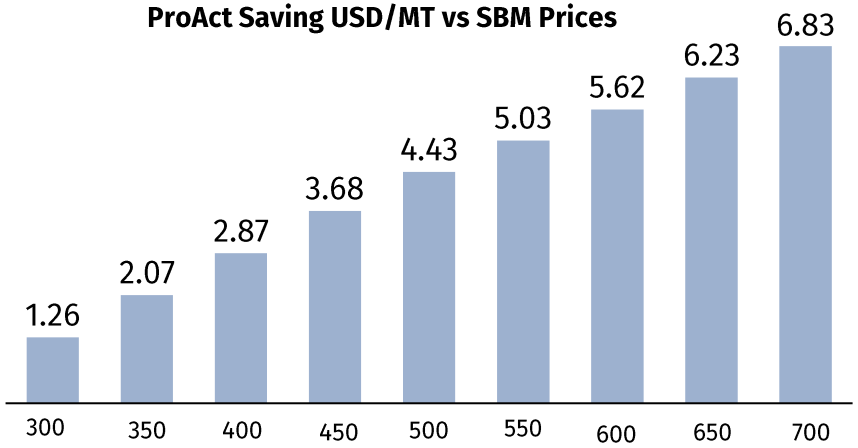
The increased demand for soybean meal and the unfavorable weather condition in some major producing areas had drove up the prices of SBM by 31% in the past 4 months. With margins being squeezed starting from feed millers, the increased cost may pass downstream leading to higher prices of chicken, eggs, pork and beef.



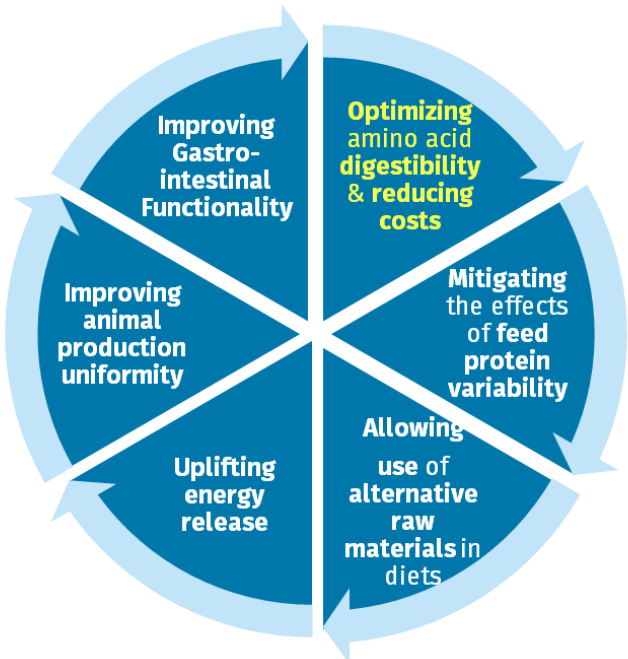


https://www.barchart.com/futures/quotes/ZM*0

With the effective use of ProAct, up to USD 6.8/MT savings can be delivered



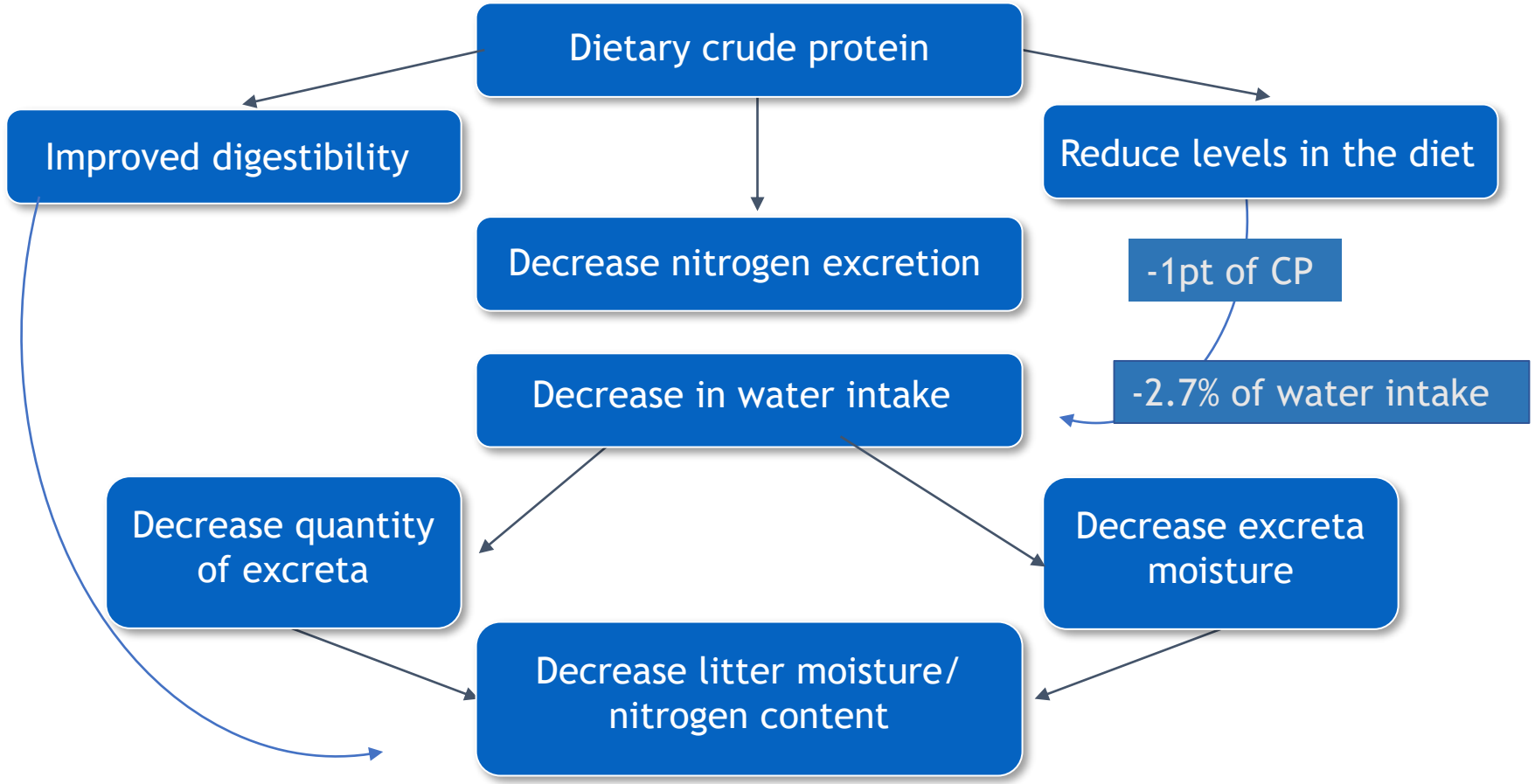
Not forgetting other benefits of ProAct…..



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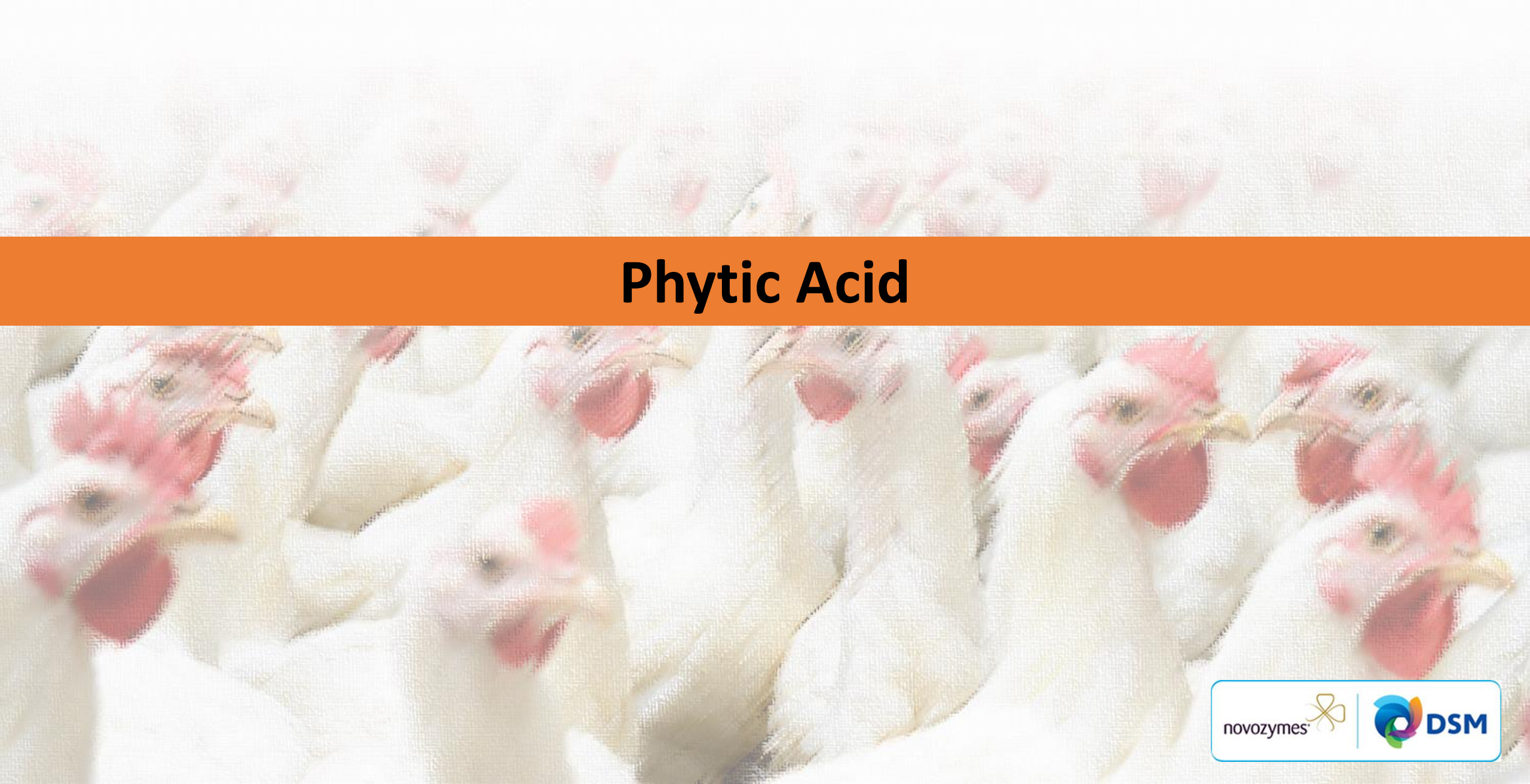
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Dietary Protein Influences Water Intake and Litter Quality



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Phytic Acid



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Phytase - definitions, uses and benefits

PHYTIC ACID

- Phosphorous storage in plants
- Indigestible by mono-gastrics

PHYTASE

- Catalyzes the hydrolysis of phytic acid
- Used in animal feed to release phosphate
- Reduces need for addition of inorganic phosphate

BENEFITS

- Reduced feed costs
- Reduced levels of phosphorus released to the environment

SYNONYMS :

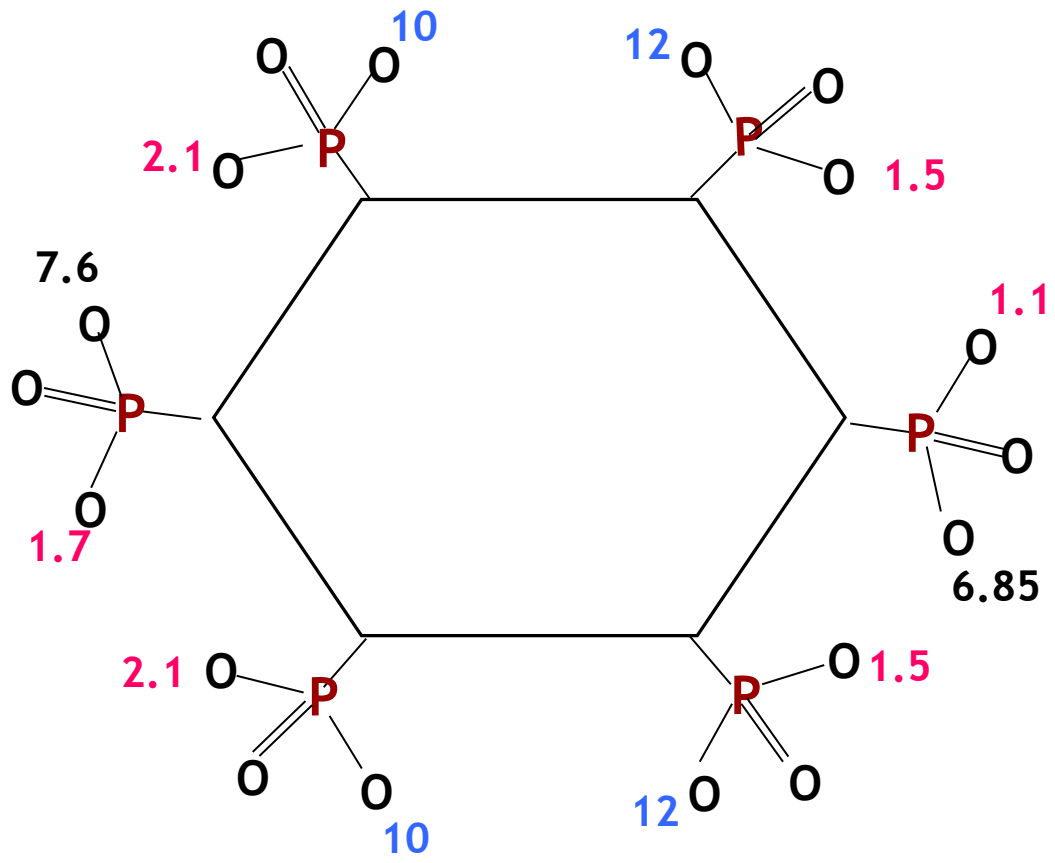
- **INOSITOL-HEXAKIS-PHOSPHATE**
- **INOSITOL PHOSPHATE (IP)**

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Phytic Acid Charge

- These oxygens are negatively charged for pH 1.1-2.1
- These oxygens are negatively charged for pH 6-8
- These oxygens are negatively charged for pH 10-12

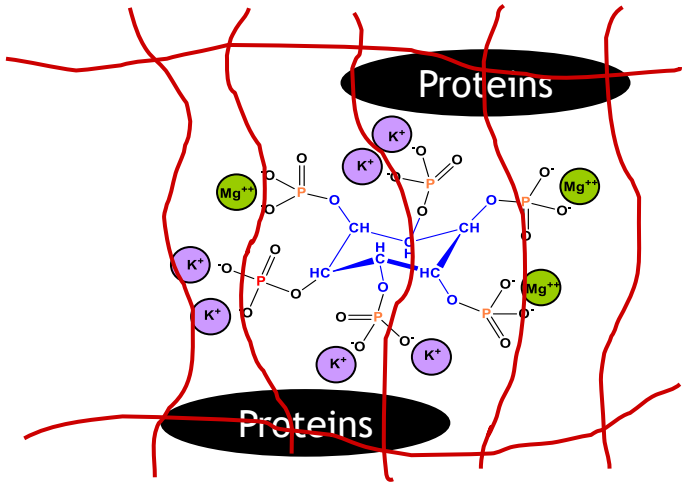


Phytic acid is negatively charged above pH 1.1 and becomes increasingly negatively charged as pH rises through the small intestine.
This drives all of the antinutritional effects of phytic acid in animal nutrition.

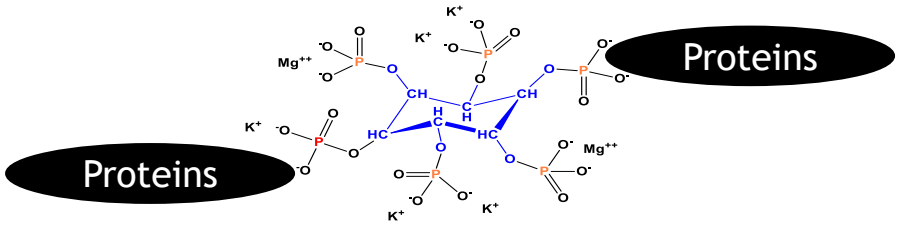
A. J. R. Costello, T. Glonek, and T. C. Myers (1976). 31P nuclear magnetic resonance-pH titrations of myo-inositol hexaphosphate. *Carbohydrate*, **46**:159-171.

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Phytic acid - Phytate life cycle

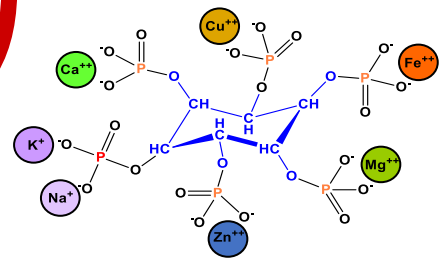


Phytate in plant cell wall



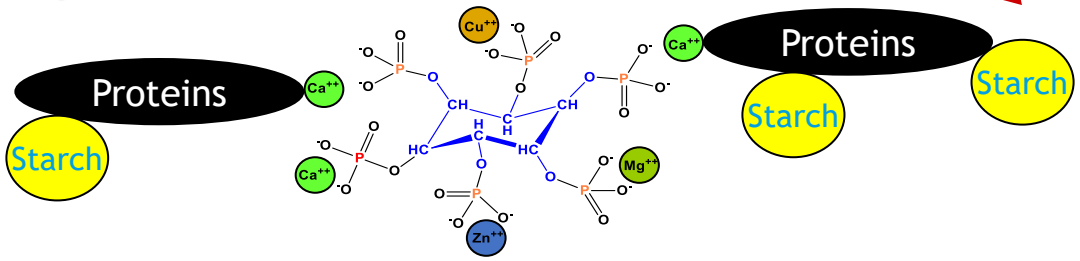
Binary protein-phytate complexes

Phytic acid has 12 negative charges which can bind various positive charged molecules

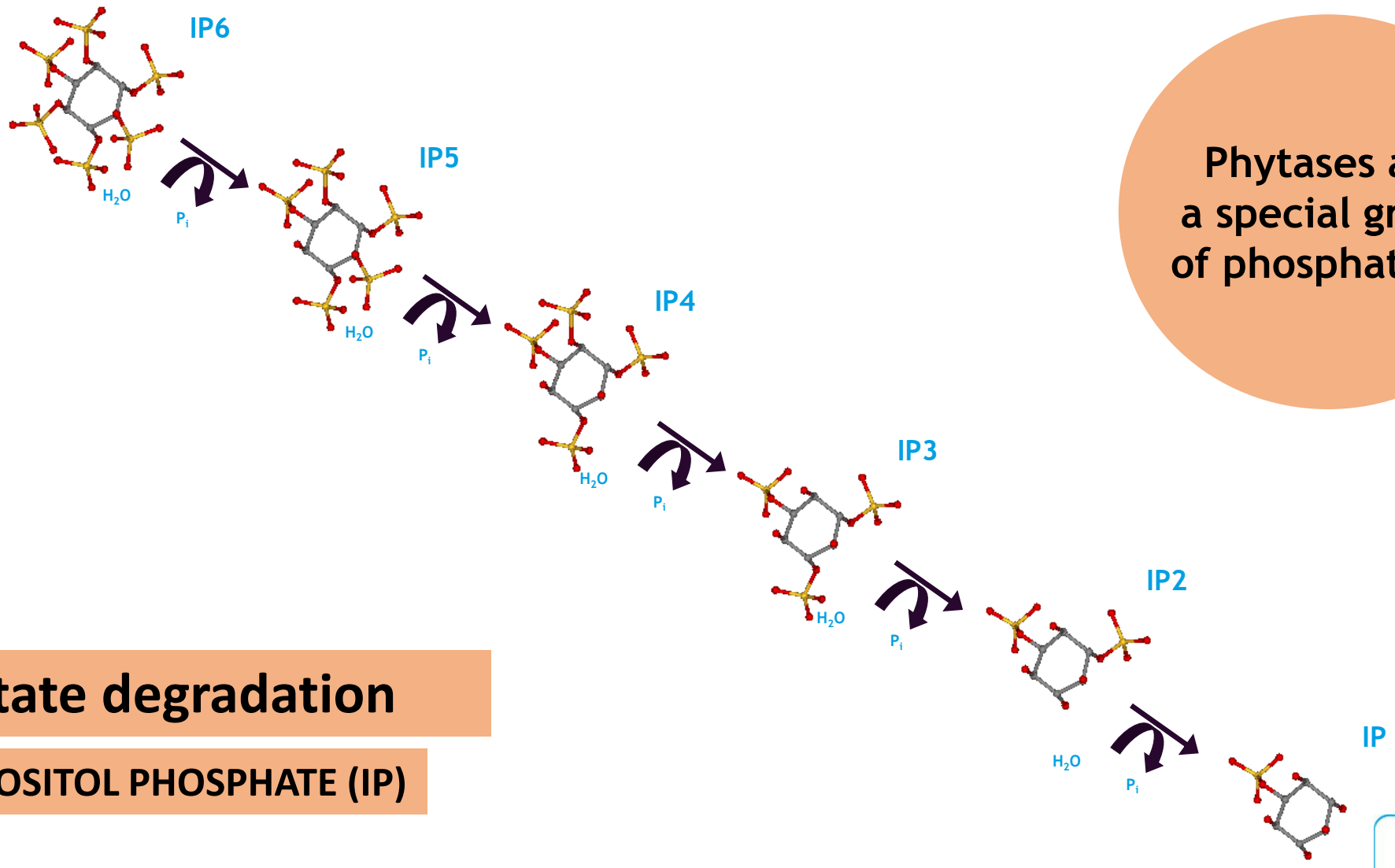


Mineral-phytate complexes

Tertiary protein-mineral-phytate complexes with Ca



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Phytases are a special group of phosphatases

Phytate degradation

(INOSITOL PHOSPHATE (IP)

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Phytate – Phytase *in vivo* interaction

Absorption Pi (IP1, IP2,IP3)

Feed	Stomach *pH 1.5 - 3*	Duodénum *pH 3 - 6*	Final Phase

Phytate Insoluble (Ca, K, Mg)

Phytase

Phytate Soluble

Phytase

IP1
IP2
IP3
IP4
IP6

Complexes Phytate+Protein Insoluble

Pi

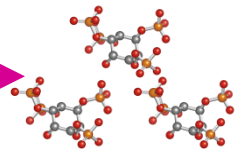
Phytate Soluble

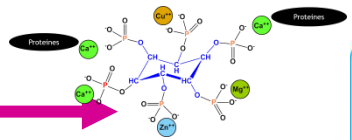
IP1
IP2
IP3

Phosphatase endogenous

Excretion in feaces

IP4
IP5
IP6

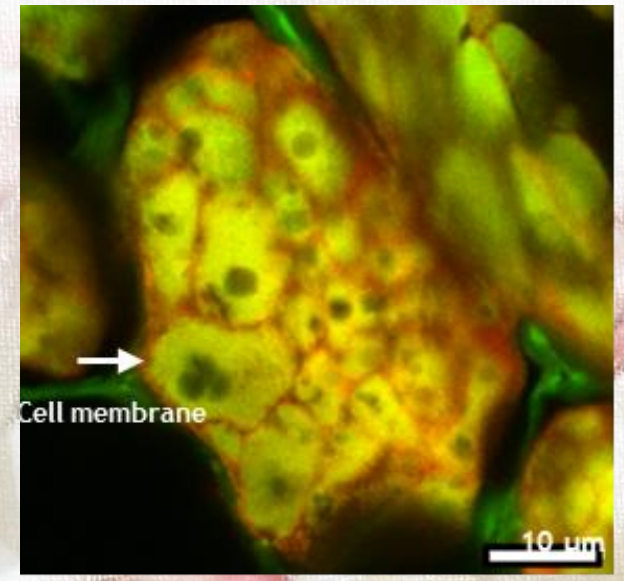




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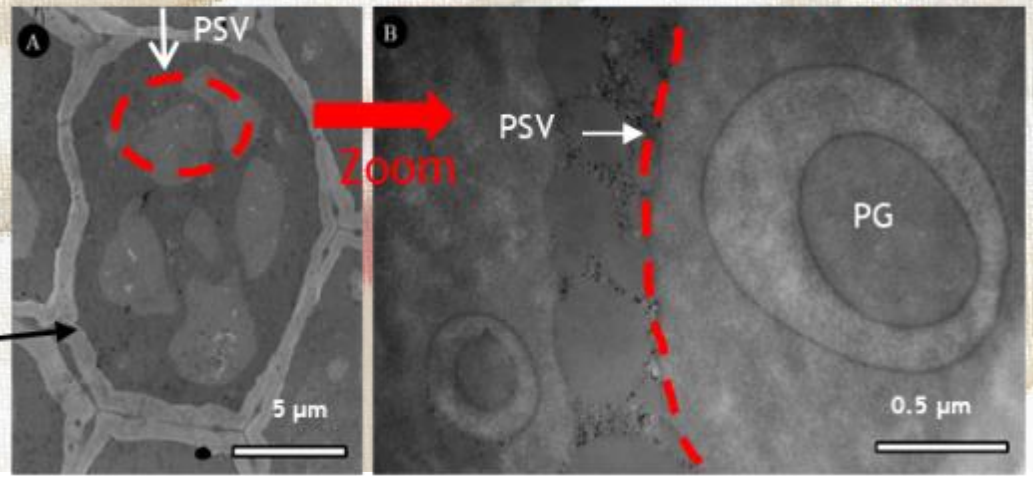
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Why do we need feed enzymes ? - The substrate

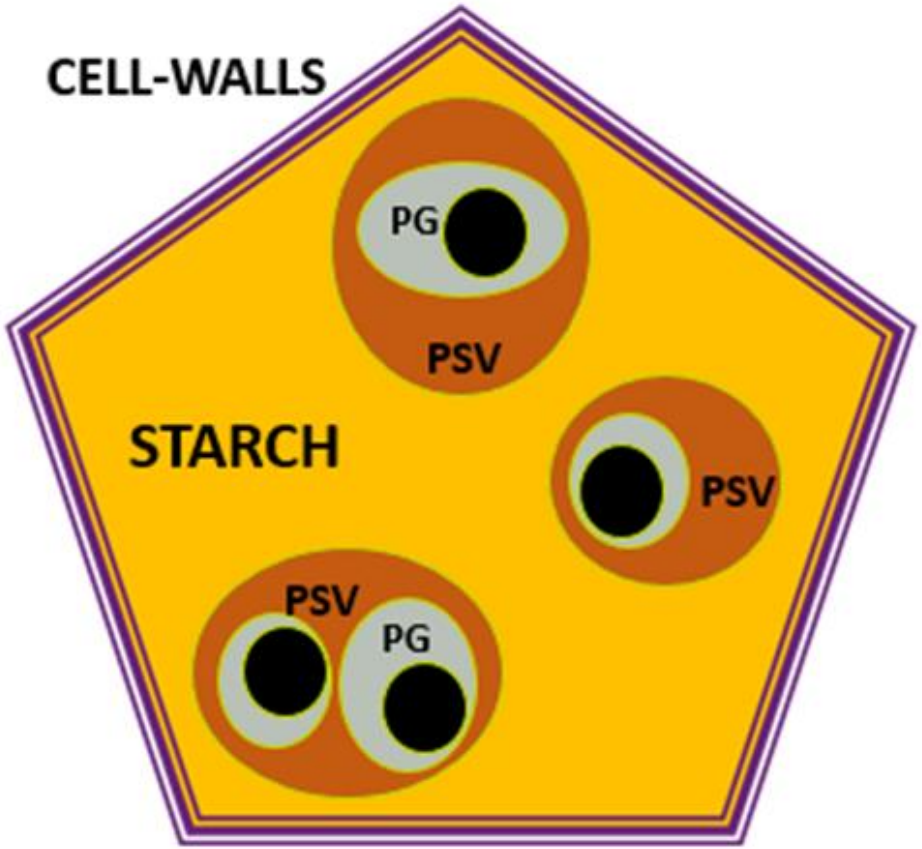


Layers do not have Phytases and NSP-enzymes to hydrolyze Phytate and NSPs respectively.

Transmission electron microscopy



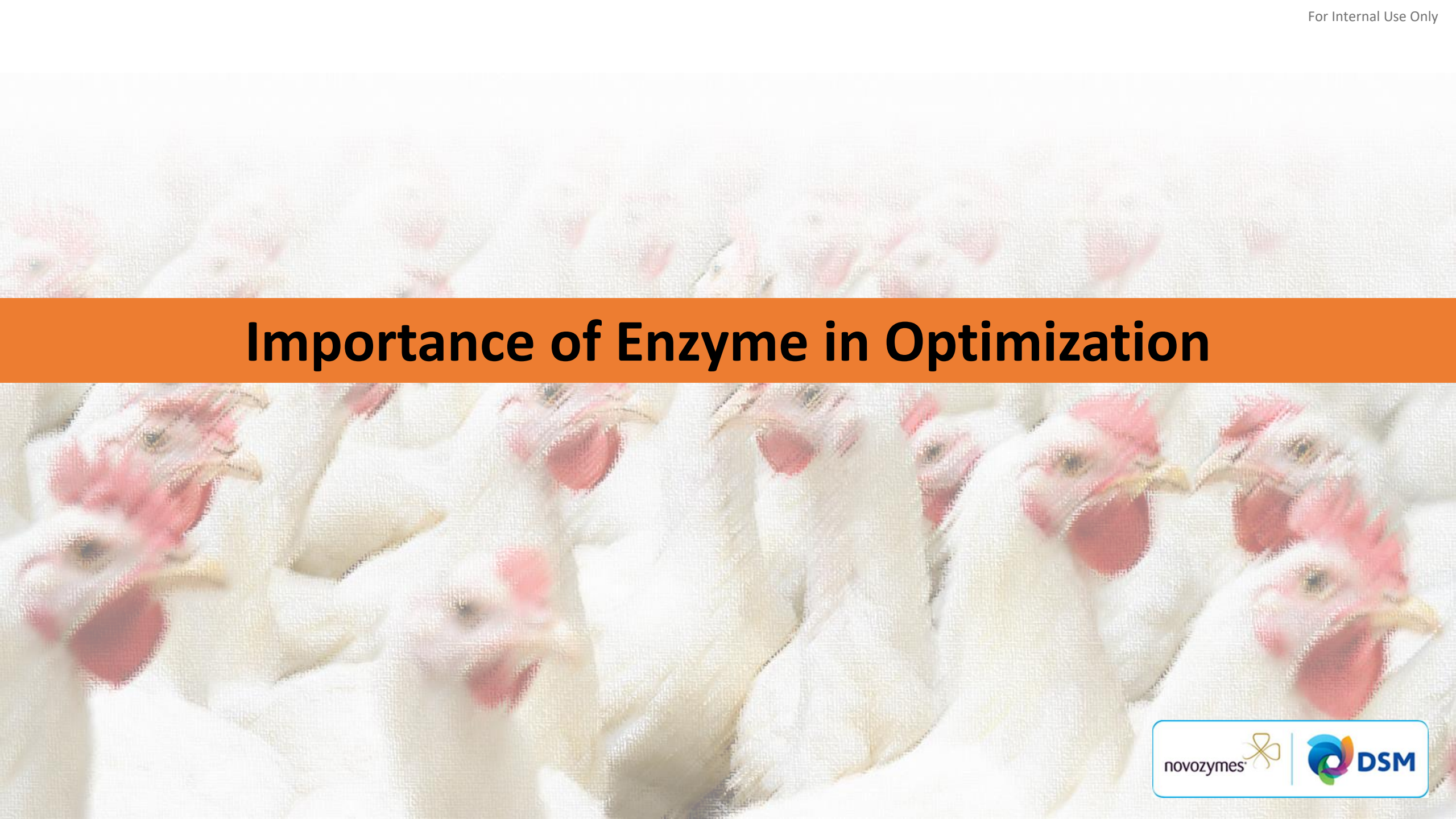
Cell-Wall



PSV – Protein Storage Vacuole
PG – Phytate Globoid

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Importance of Enzyme in Optimization



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Feed Waste Reduction (or better feed utilisation)

FEED	DIGESTION	NUTRIENT ABSORPTION	WASTE	PROFITABILITY
Without enzymes	Average	Average	Average	Average
With feed enzymes	**Better**	**Better**	**Minimum**	**Better**

Some factors affecting Feed Utilization:

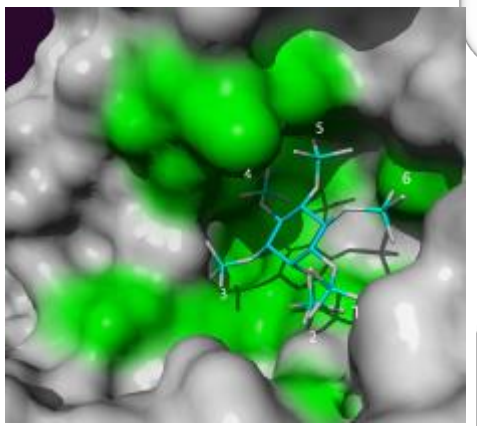
- Feed quality
- Gizzard function
- Gut Health & Integrity

Feed Enzymes could affect these factors via :

- Feed digestibility improvement
- Coarsely ground feed is welcome
- Better protein utilization, viscosity reduction, prebiotic NSP-oligomers

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Feed Enzyme Benefits



- Phosphorus release (phytases)
- Cage effect & energy release (Carbohydrases)
- Amino Acid Digestibility improvement (proteases)

- Viscosity reduction
- Prebiotic effects of NSP-oligomers
- Less nutrients for pathogenic bacteria
- Less endogenous heat production for starch digestion (Heat Stress)

Feed cost reduction

Layer welfare & health

Less Dirty Eggs
Strong Egg-Shell

Animal Performance

Environmental Sustainability



- Nutrient digestibility improvement
- *MYO*-inositol release
- Anti-antinutritional effects (phytate-NSPs-Trypsin Inhibitors)

Use of alternative RMs

- Nitrogen & Phosphorus emission reduction
- Green House Gas emission reduction (CO_2e)

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Feed cost reduction
with feed enzymes

- A layer Diet formulated with Hy-Line W-80 nutrient specs for Phase-2 with 100g FI.
- It contains ~12% “alternative” & local RMs.
- MBM is also considered as “alternative” RM, for which its quality needs attention.
- “Other Additives” are Vitamins, Minerals, Tryptophan, Salt, Toxin Binder, Choline, Soda.
- Multi NSP enzyme contains xylanase, de-branching activities, xyloglucanase, cellulase, B-glucanase.

Raw Material	Rs/Kg	No Enzymes
Broken Rice	13	200.00
Maize	17	433.90
Soyabean Meal	70	119.44
Rice Bran De-oiled	12	2.68
Rice DDGS	45	15.00
Rapeseed Meal	29	30.00
Groundnut Meal	50	30.00
Sunflower Meal	30	25.00
Meat & Bone Meal-LP	65	20.00
Shell Grit	2	100.67
DCP	36	11.28
DL-Methionine	270	1.84
Lysine-HCl	200	1.65
Threonine	209	0.45
Other Additives	78	8.08
Phytase (standard dose)	*620*	
Protease	*1,650*	
Multi NSP enzyme	*1,150*	
Total		1,000

Nutrient	Unit	
C Protein	%	16.0
C Fiber	%	3.3
C Fat	%	2.5
ME	Kcal/Kg	2,700
Calcium	%	4.30
Av Phosphorus	%	0.38
Sodium	%	0.17
Chloride	%	0.23
Dig Lysine	%	0.72
Dig Methionine	%	0.42
Dig M + C	%	0.64
Dig Arginine	%	1.00
Dig Tryptophan	%	0.16
Dig Threonine	%	0.50
Dig Valine	%	0.65
Dig Leucine	%	1.13
Dig IsoLeucine	%	0.53

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Feed cost reduction

with phytase

- The first diet was optimized with Av.P, Ca & Na contribution from a standard phytase dose.
- The second diet was optimized with Av.P, Ca, Na matrix, together with 50% of the recommended matrix for CP, AA & Energy (standard phytase dose).

- Alternative RMs = ~ 17%
- Desktop enzyme ROI = from 1:13 to 1:26

- Conditions for achieving these substantial diet cost savings:
  - Good phytase (at least 3G – stability)
  - Sufficient substrate (phytate-P)

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Raw Material	Rs/Kg	No Enzymes	Phytase with Av.P/Ca/Na	Phytase with full matrix
Broken Rice	13	200.00	200.00	200.00
Maize	17	433.90	428.27	406.18
Soyabean Meal	70	119.44	115.00	110.00
Rice Bran De-oiled	12	2.68	20.71	48.46
Rice DDGS	45	15.00	15.00	15.00
Rapeseed Meal	29	30.00	30.00	30.00
Groundnut Meal	50	30.00	30.00	30.00
Sunflower Meal	30	25.00	25.00	25.00
Meat & Bone Meal-LP	65	20.00	20.00	20.00
Shell Grit	2	100.67	101.30	101.45
DCP		11.28	2.77	2.47
DL-Methionine	270	1.84	1.83	1.69
Lysine-HCl	200	1.65	1.68	1.52
Threonine	209	0.45	0.45	0.27
Other Additives	78	8.08	7.93	7.90
Phytase (standard dose)	*620*		*0.06*	*0.06*
Protease	*1,650*			
Multi NSP enzyme	*1,150*			
Total		1,000	1,000	1,000
	Rs/MT	**25,624**	**25,156**	**24,644**
SUBSTANTIAL DIET COST SAVINGS			**(468)**	**(981)**
	$/MT		**(6.2)**	**(13.1)**

For a 10,000 layer flock, 358,000 Rs per annum

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Feed cost reduction
with phytase & protease

- Protease diet was optimized with a specific AA/ME matrix.
- Phytase effect on AA was already discounted by 50%.

- Alternative RMs = ~ 19%
- Desktop enzyme ROI = 1:7.

- **Additional protease benefits:**
  - Gut health – more clean eggs
  - Trypsin Inhibitors' degradation
  - Flexibility on diet optimization
  - Feed protein variability reduction
  - Less Nitrogen emissions

Raw Material	Rs/Kg	No Enzymes	Phytase with Av.P/Ca/Na	Phytase with full matrix	Phytase & Protease
Broken Rice	13	200.00	200.00	200.00	200.00
Maize	17	433.90	428.27	406.18	396.75
Soyabean Meal	70	119.44	115.00	110.00	100.00
Rice Bran De-oiled	12	2.68	20.71	48.46	68.35
Rice DDGS	45	15.00	15.00	15.00	15.00
Rapeseed Meal	29	30.00	30.00	30.00	30.00
Groundnut Meal	50	30.00	30.00	30.00	30.00
Sunflower Meal	30	25.00	25.00	25.00	25.00
Meat & Bone Meal-LP	65	20.00	20.00	20.00	20.00
Shell Grit	2	100.67	101.30	101.45	101.59
DCP	36	11.28	2.77	2.47	2.31
DL-Methionine	270	1.84	1.83	1.69	1.40
Lysine-HCl	200	1.65	1.68	1.52	1.42
Threonine	209	0.45	0.45	0.27	0.09
Other Additives	78	8.08	7.93	7.90	7.89
Phytase (standard dose)	*620*		*0.06*	*0.06*	*0.06*
Protease	*1,650*				*0.15*
Multi NSP enzyme	*1,150*				
Total		1,000	1,000	1,000	1,000
SUBSTANTIAL DIET COST SAVINGS	**Rs/MT**	**25,624**	**25,156**	**24,644**	**24,127**
			(468)	**(981)**	**(1,497)**
	$/MT		**(6.2)**	**(13.1)**	**(20.0)**

For a 10,000 layer flock, 546,000 Rs per annum

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Feed cost reduction
with phytase & NSP multi-enzyme

- The Multi-NSP-enzyme diet was optimized with a calculated ME contribution of 60 kcal/Kg.
- Together with the Phytase ME effect, the enzymes were contributed a total of **102 kcal/Kg.** Enzyme energy contribution was managed with the addition of Rice Bran.
- Alternative RMs = ~ 20%
- Desktop enzyme ROI = 1:9.
- **Additional benefits:**

  - Lower Starch diets are less thermogenic, which is good for birds under Heat Stress.
  - Gut health from viscosity reduction & prebiotic effects of NSP-oligomers.
  - Feed energy variability reduction.
  - Flexibility on diet optimization.

For a 10,000 layer flock, 410,000 Rs per annum

Raw Material	Rs/Kg	No Enzymes	Phytase with Av.P/Ca/Na	Phytase with full matrix	Phytase & NSP-enzyme
Broken Rice	13	200.00	200.00	200.00	200.00
Maize	17	433.90	428.27	406.18	371.97
Soyabean Meal	70	119.44	115.00	110.00	110.00
Rice Bran De-oiled	12	2.68	20.71	48.46	83.14
Rice DDGS	45	15.00	15.00	15.00	15.00
Rapeseed Meal	29	30.00	30.00	30.00	30.00
Groundnut Meal	50	30.00	30.00	30.00	30.00
Sunflower Meal	30	25.00	25.00	25.00	25.00
Meat & Bone Meal-LP	65	20.00	20.00	20.00	20.00
Shell Grit	2	100.67	101.30	101.45	101.63
DCP	36	11.28	2.77	2.47	2.04
DL-Methionine	270	1.84	1.83	1.69	1.65
Lysine-HCl	200	1.65	1.68	1.52	1.37
Threonine	209	0.45	0.45	0.27	0.21
Other Additives	78	8.08	7.93	7.90	7.86
Phytase (standard dose)	*620*		*0.06*	*0.06*	*0.06*
Protease	*1,650*				
Multi NSP enzyme	*1,150*				*0.08*
Total		1,000	1,000	1,000	1,000
	Rs/MT	**25,624**	**25,156**	**24,644**	**24,500**
			(468)	**(981)**	**(1,125)**
	$/MT		**(6.2)**	**(13.1)**	**(15.0)**

SUBSTANTIAL DIET COST SAVINGS

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Feed cost reduction

with phytase, protease & NSP multi-enzyme

- All three enzyme categories were contributed a total of 125 kcal/Kg ME.
- Enzyme energy contribution was managed with the addition of Rice Bran.
- Alternative RMs = ~ 22%
- Desktop enzyme ROI = 1:4.

For a 10,000 layer flock, 596,000 Rs per annum

- **Additional benefits:**
  - Lower Starch diets are less thermogenic.
  - More digestible diets, less waste.
  - More clean eggs from the combined benefit of both NSP-enzymes and protease.
  - Feed energy & protein variability reduction.
  - Flexibility on diet optimization.

Raw Material	Rs/Kg	No Enzymes	Phytase with Av.P/Ca/Na	Phytase with full matrix	Phytase & NSP-enzyme & Protease
Broken Rice	13	200.00	200.00	200.00	200.00
Maize	17	433.90	428.27	406.18	362.53
Soyabean Meal	70	119.44	115.00	110.00	100.00
Rice Bran De-oiled	12	2.68	20.71	48.46	103.03
Rice DDGS	45	15.00	15.00	15.00	15.00
Rapeseed Meal	29	30.00	30.00	30.00	30.00
Groundnut Meal	50	30.00	30.00	30.00	30.00
Sunflower Meal	30	25.00	25.00	25.00	25.00
Meat & Bone Meal-LP	65	20.00	20.00	20.00	20.00
Shell Grit	2	100.67	101.30	101.45	101.76
DCP	36	11.28	2.77	2.47	1.88
DL-Methionine	270	1.84	1.83	1.69	1.37
Lysine-HCl	200	1.65	1.68	1.52	1.27
Threonine	209	0.45	0.45	0.27	0.06
Other Additives	78	8.08	7.93	7.90	7.86
Phytase (standard dose)	*620*		*0.06*	*0.06*	*0.06*
Protease	*1,650*				*0.15*
Multi NSP enzyme	*1,150*				*0.08*
Total		1,000	1,000	1,000	1,000
	Rs/MT	**25,624**	**25,156**	**24,644**	**23,992**
			(468)	**(981)**	**(1,633)**
	$/MT		**(6.2)**	**(13.1)**	**(21.8)**

SUBSTANTIAL DIET COST SAVINGS

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Conclusion

- Feed enzymes could contribute to more profitable and sustainable layer farming
- They are improving nutrient utilization, reducing nutrients which are escaping digestion (wasted)
- Right selection of enzyme activities could “unlock” the potential of many alternative local raw materials
- Enzymes are also offering some strong side benefits related to layer performance, health & welfare.