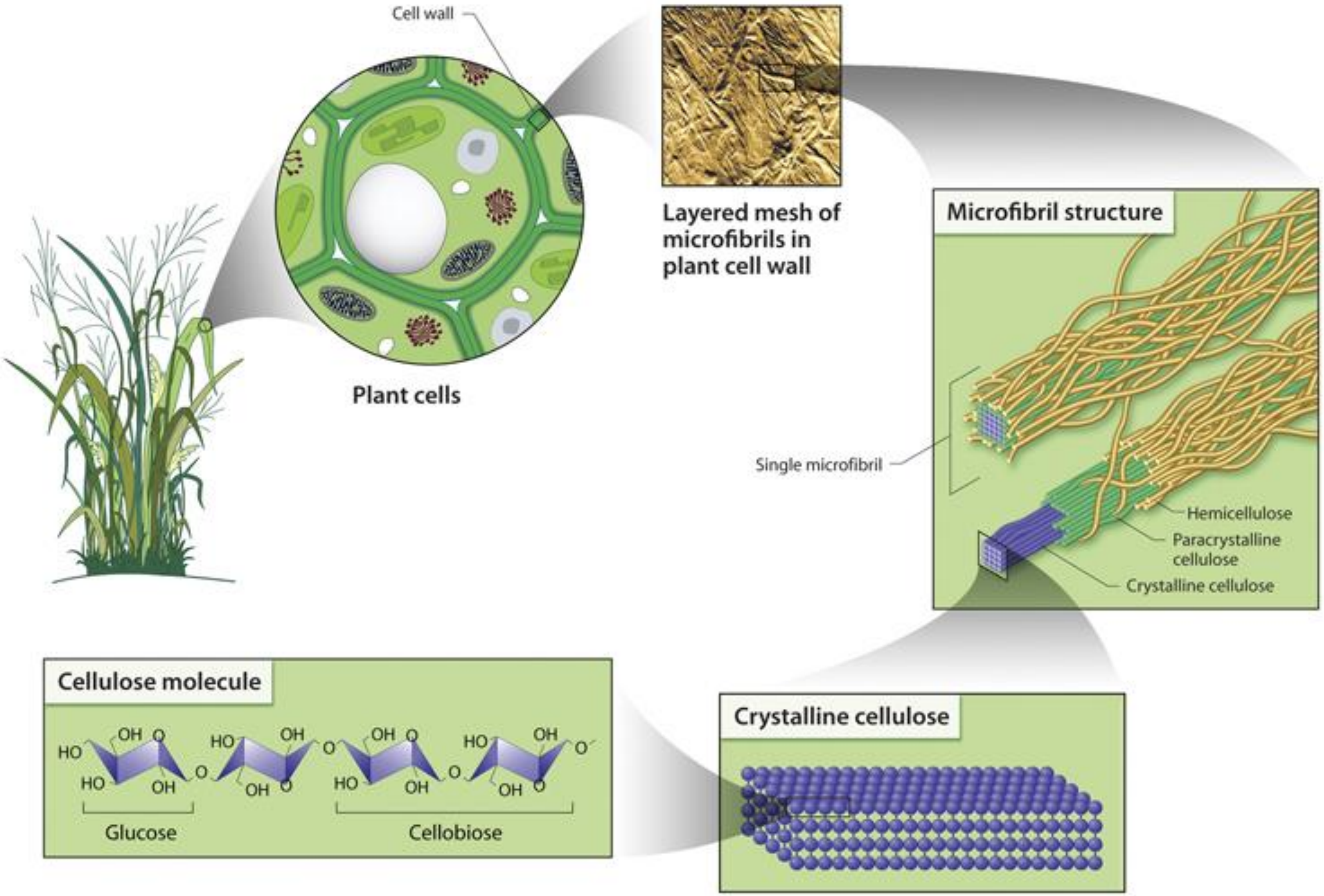
سازوکار انتخاب آنزیم ها

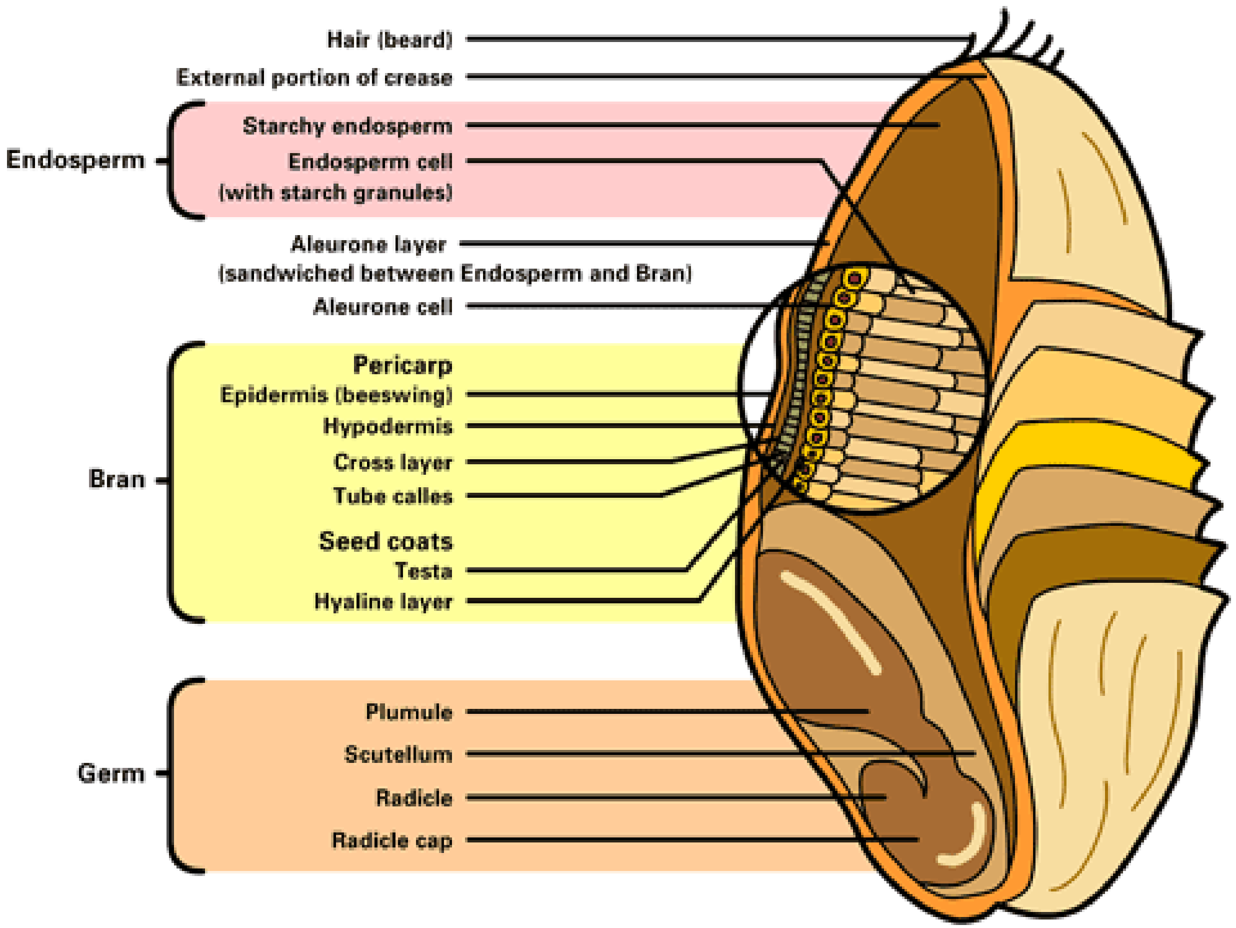
Speaker: M. Zaghari
Available at: minatoyoor.com

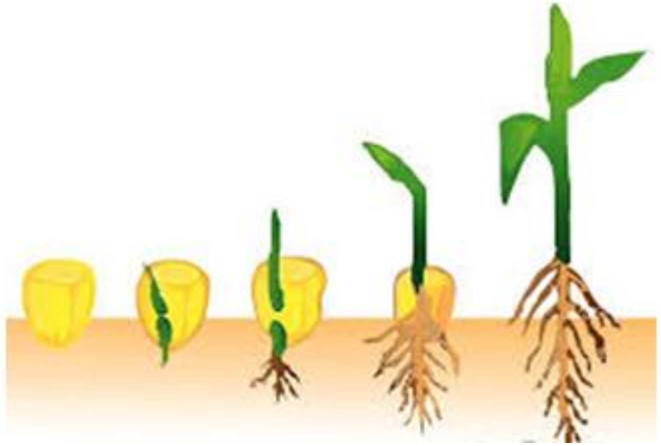


Genome size

2  = 


Cell wall
Plant cells
Layered mesh of microfibrils in plant cell wall
Microfibril structure
Single microfibril
Hemicellulose
Paracrystalline cellulose
Crystalline cellulose
Cellulose molecule
Glucose
Cellobiose
Crystalline cellulose


Hair (beard)
External portion of crease
Endosperm
Starchy endosperm
Endosperm cell
(with starch granules)
Aleurone layer
(sandwiched between Endosperm and Bran)
Aleurone cell
Bran
Pericarp
Epidermis (beeswing)
Hypodermis
Cross layer
Tube calles
Seed coats
Testa
Hyaline layer
Germ
Plumule
Scutellum
Radicle
Radicle cap



200 °C

9 kg/cm

6 kg/cm

Pulses/Legume	Botanical Name	Anti-Nutritional Factors
Broad/faba bean	*Vicia faba*	Protease inhibitors, Phytic acid, Phytohaemagglutinins, tannins
Chick pea/Bengal gram	*Cicer arietinum*	Protease inhibitors, Cyanogens, Phytic acid, saponins, Estrogens.
Cow pea	*Vigna unguiculata*	Protease inhibitors, Phytic acid, Phytohaemagglutinins.
Kidney bean	*Phaseolus vulgaris*	Protease inhibitors, Phytic acid, Phytohaemagglutinins, cyanogens, Saponins, Anti-vitamin E factors, Amylase inhibitor.
Hyacinth bean	*Dolichus lablab*	Protease inhibitors, Cyanogens, Phytohaemagglutinins.
Mung bean/ green gram	*Phaseolus aureus*	Protease inhibitors, Phytic acid, Saponins, Anti-thiamine factors.
Field pea	*Pisum sativum*	Protease inhibitors, cyanogens, Phytohaemagglutinins, Phytic acid, Saponins, Anti-vitamin E factors.
Pigeon pea/red gram	*Cajanus cajan*	Protease inhibitors, cyanogens, Phytohaemagglutinins, Phytic acid.
Black gram	*Phaseolus mungo*	Protease inhibitors (Trypsin, Chemotrypsin), phytic acid.

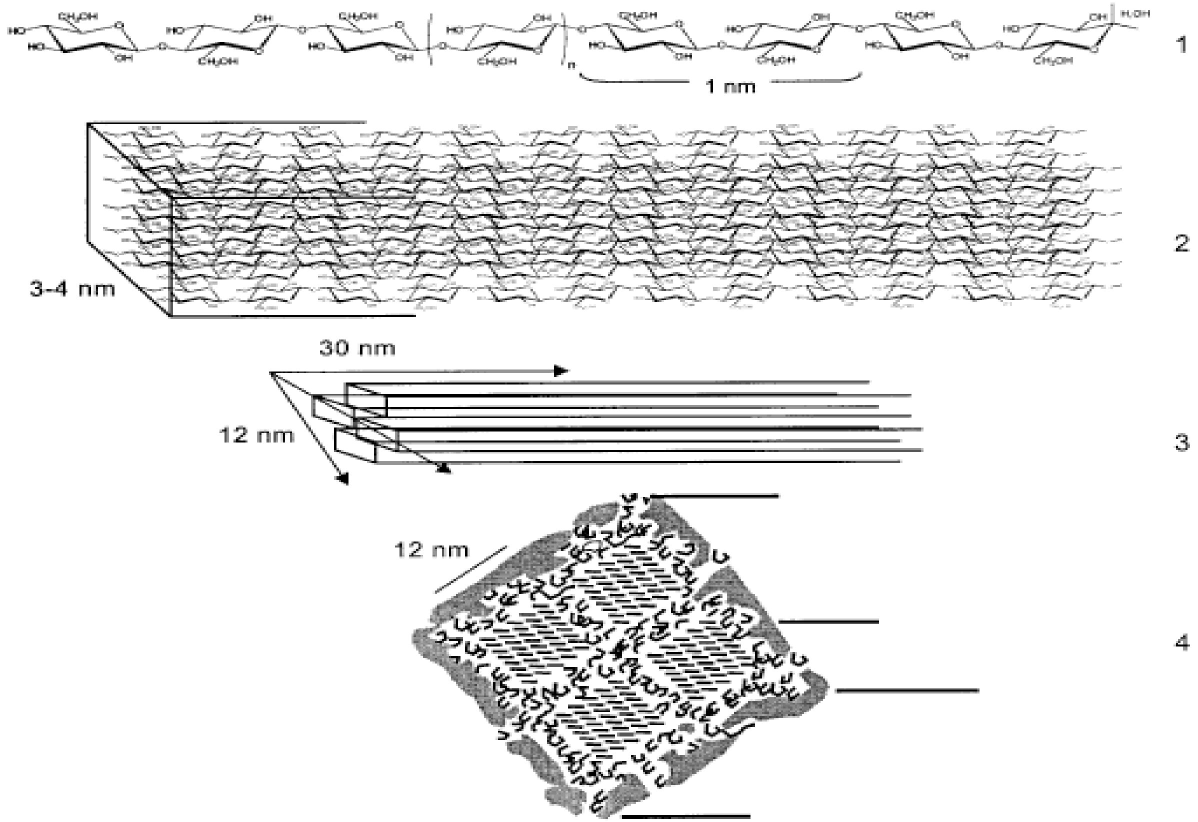
Oilseeds	Botanical Name	Anti-Nutritional Factors
Groundnut	*Arachis hypogaea*	Protease inhibitors, Phytic acid, Phytohaemagglutinins, Saponins, Estrogenic factors.
Rapeseed	*Brassica campestris napus*	Protease inhibitors, Glucosinolates, Phytic acid, tannins.
Indian mustard	*Brassica juncea*	Protease inhibitors, Glucosinolates, Anti-thiamine factor.
Cottonseed	*Gossypium spp.*	Phytic acid, estrogenic factors, Gossypol, Anti-vitamin E factor.
Linseed	*Linum usitatissimum*	Cyanogens, Phytic acid, Estrogenc factor, Anti-thiamine factor, Anti-pyridoxine factor.
Soybean	*Glycine max*	Protease inhibitors, Glucosinolates, Phytohaemagglutinins, Phytic acid, Saponins, Estrogenic factors, Anti-vitamin E factor, Anti-vitamin A factor, Anti-vitamin D factor, Anti-vitamin B_{12} factor, Allergens.
Sesame	*Sesamum indicum*	Phytic acid.

Source: Hill, 2003

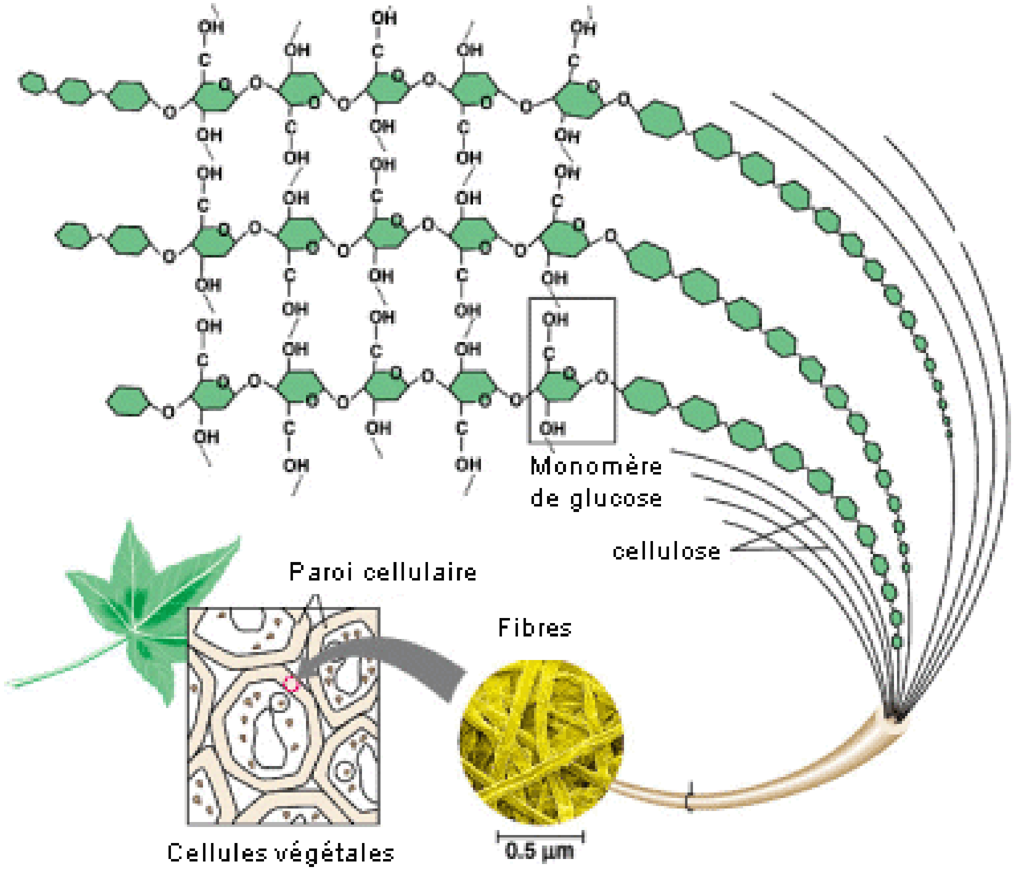
Feedstuffs	Antinutritional Factors
Soybean meal	Trypsin inhibitors (glycinin), lectins, oligosaccharides, phytic acid.
Peas	Lectins, tannins, oligosacharides.
Rapeseed meal	Glucosinolinates, tannins, phenolic acids.
Lupin	Alkaloids.
Sunflower meal	Tannins.
Wheat	Phytic acid, polyphenols, tannins, saponins.
Barley	β- glucans.
Some wild edible plants (bauhinia recemosa etc.)	Oxalate, phytate and tannins

Proteins	• Protease inhibitors >Trypsin inhibitors >Chemotrypsin • Hemagglutinins • Food allergens • Toxic amino acids
Glycosides	• Saponins • Cyanogens • Estrogens • Goitrogens
Phenols	• Gossypol • Tannins
Others	• Anti-minerals Phytic acid Oxalates • Anti-vitamins • Anti- enzymes

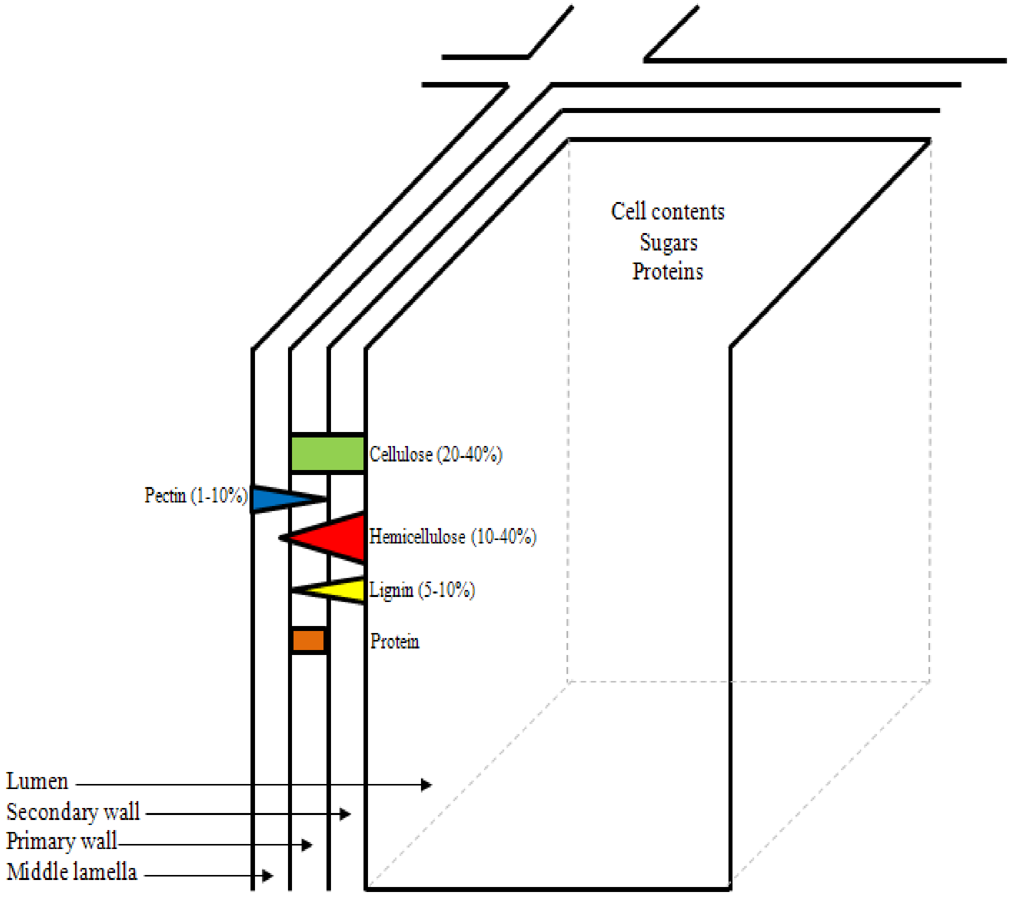
- Fiber
- Phytate
- Proteinaceous ANFs

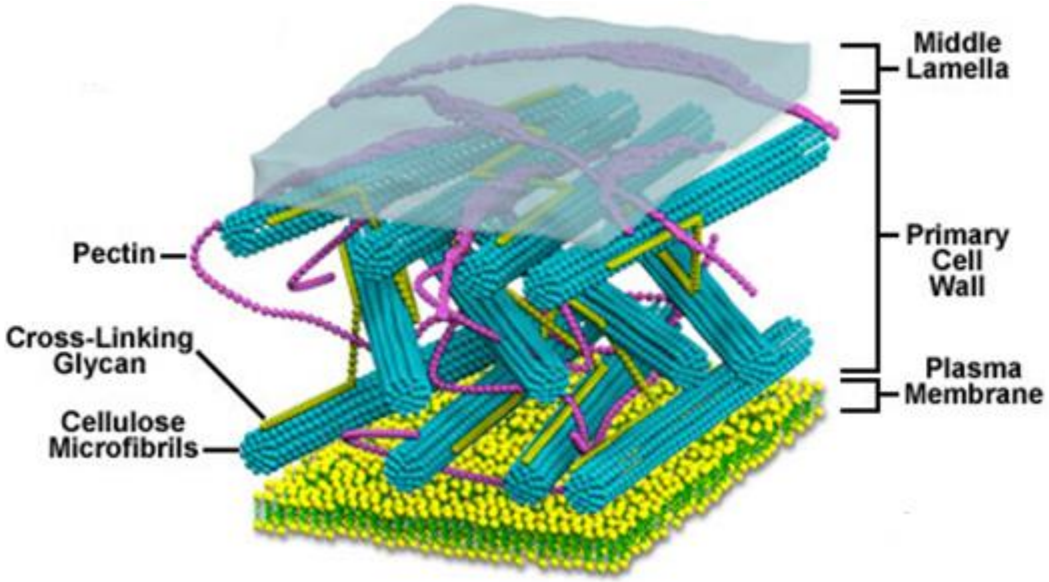


Chemical association in the plant cell wall: (1) the cellulose backbone, with an indication the length of its basic structural unit, cellobiose; (2) framework of cellulose chains in the elementary fibril; (3) cellulose crystallite; (4) microfibril cross section, showing strands of cellulose molecules embedded in a matrix of hemicellulose and protolignin


Monomère de glucose
cellulose
Paroi cellulaire
Fibres
Cellules végétales
0.5 µm

Plant cell wall structure

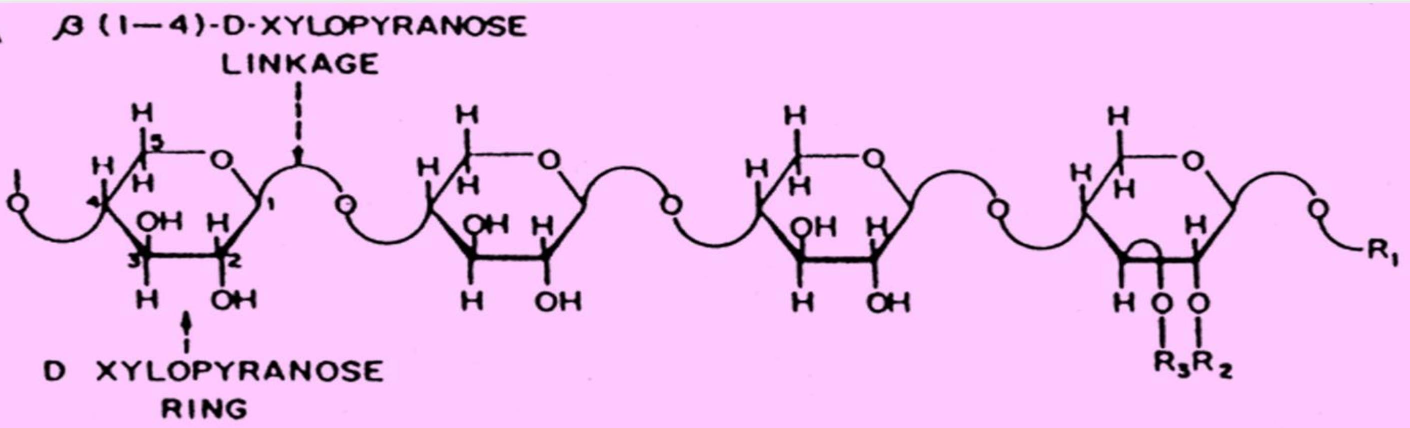




DEFINITION AND (

Polysacchari
defined and classifi
monosaccharides pre
furanose); (c) positio
(e) sequence of mono
substituents. Monosa
galactose, D-mannose
glucuronic acid and i

A



R_1:

p Coumaric acid
α-D-Glucuronic acid
α-D-Arabinofuranose

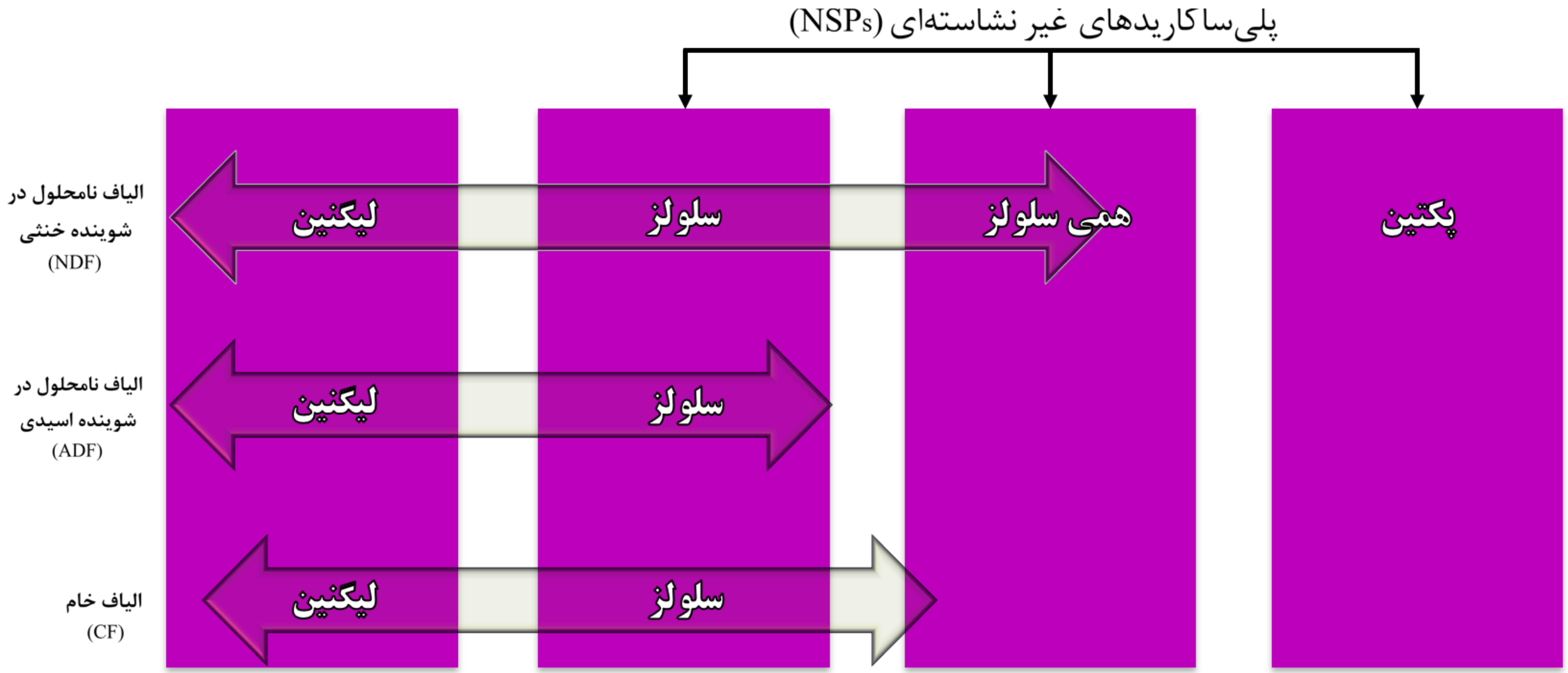
R_2:

Acetyl group
α-D-Glucuranopyranose [Cα Lignin]
4-O-Methyl-α-D-Glucuranopyranose [Cα Lignin]
α-L-Arabinfuranose [Cα and Cγ Lignin, Ferulic acid, Acetyl group, p Coumaric acid]
Cα Lignin

R_3:

Acetyl group
α-L-Arabinofuranose [Cα and Cγ Lignin, Ferulic acid, acetyl group, p Coumaric acid]
β-D-Galactopyranosyl (1—5) α-L-Arabinofuranose
β-D-Xylopyranosyl (1—2) α-L-Arabinofuranose
α-L-Arabinofuranosyl (1—2, 1—3, 1-2,3 Arabinofuranose)n
β-D-Galactopyranosyl (1—4) D-Xylopyranosyl (—2)-α-L-Arabinofuranose

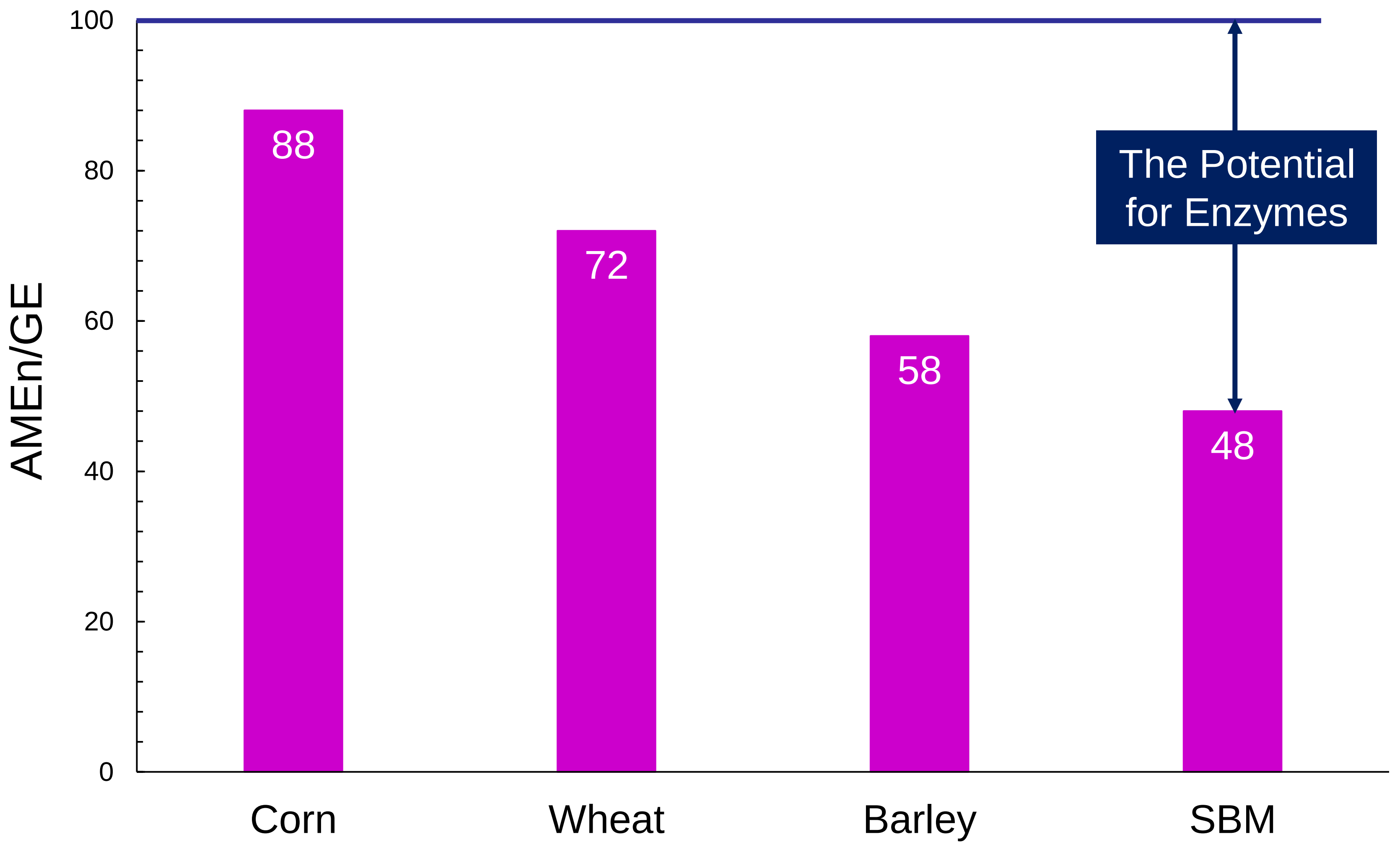
- Non-Starch Polysaccharides
  - Cellulose
  - Non-cellulosic polymers
    - Arabinoxylans
      mixed-linked β-glucans
      Mannans, galactans
      Xyloglucan
  - Pectic polysaccharides
    - polygalacturonic acids, which may be substituted with arabinan, galactan and arabinogalactan


پلی‌ساکاریدهای غیر نشاسته‌ای (NSPs)
الیاف نامحلول در شوینده خنثی (NDF)
الیاف نامحلول در شوینده اسیدی (ADF)
الیاف خام (CF)
لیگنین
سلولز
همی سلولز
پکتین
لیگنین
سلولز
لیگنین
سلولز

Soluble and insoluble fraction

- Insoluble
  - Binding nutrients
  - Acting as a diluents
  - Speeding up passage rate
  - Stimulating gizzard development
- Soluble
  - Increasing intestinal viscosity (higher molecular weight fractions only)
  - Excessive supply can stimulate bacterial overgrowth and dysbacteriosis
  - Providing fuel for beneficial bacteria (prebiotic effect)
  - Signaling bacteria to produce their own fiber degrading enzymes (stimbiotic effect)
  - Directly influencing the immune system
  - Indirectly influencing the immune system through changing bacterial populations community structure by all mechanisms noted above

Energy Gap



100
80
60
40
20
0
AMEn/GE
88
72
58
48
The Potential for Enzymes
Corn
Wheat
Barley
SBM

In the 1950s, pioneering scientists added amylases and proteases to the diets of various farm animals and observed benefits in productivity.

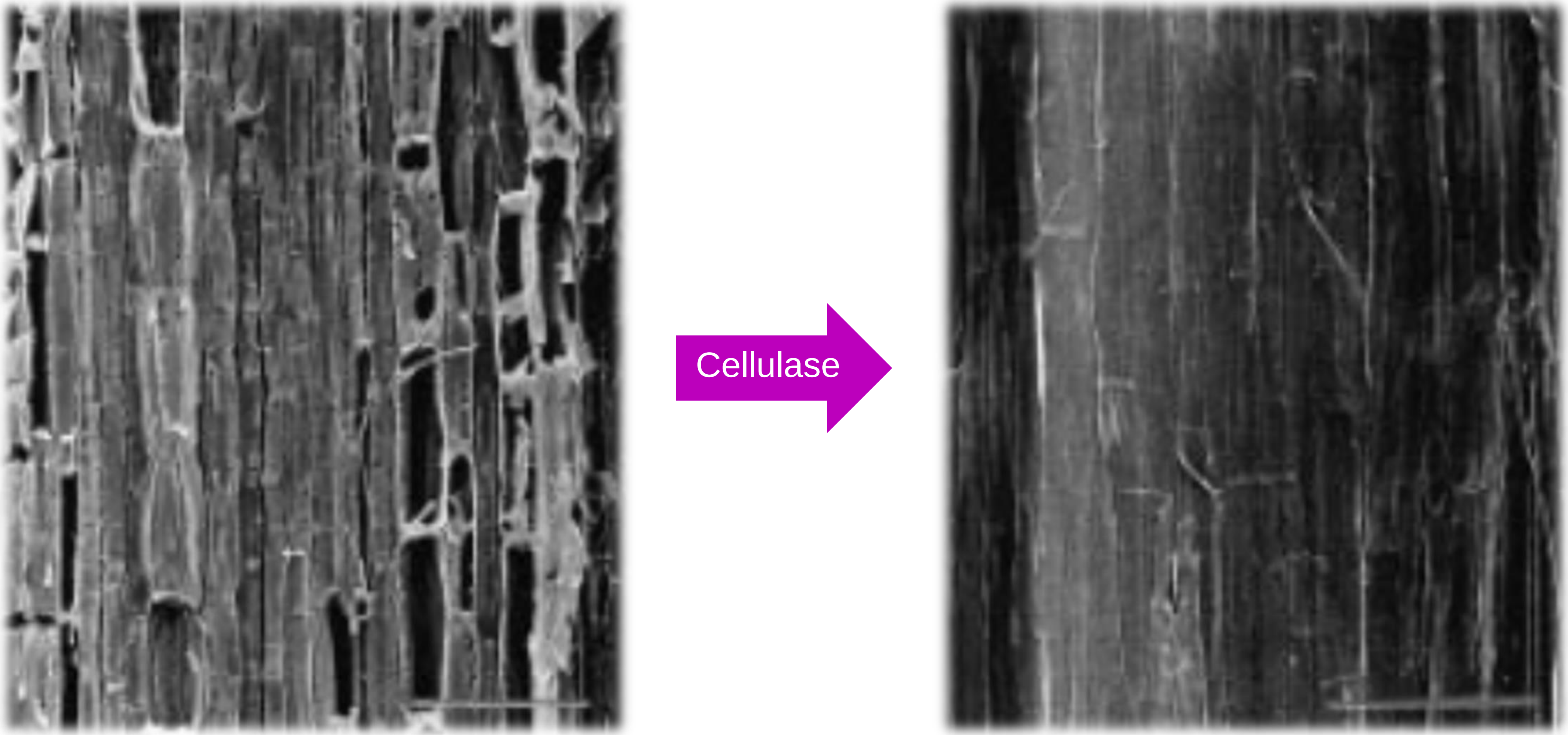
Possibly,Warden and Schaible (1962) were the first to show that exogenous phytase enhances phytate-P utilisation and bone mineralisation in broiler chicks.

Nevertheless, three decades elapsed before anAspergillus niger-derived phytase feed enzyme, with the capacity to lib-erate phytate-bound P and reduce P excretion, was commercially introduced in 1991.

Table 3. Effect of date pits and enzyme on chicken body weight and feed conversion ratio

	Body weight (g)			Feed conversion ratio		
Treatments	10 days	28 days	42 days	10 days	28 days	42 days
Control	161.8[a]	1078.0	2098.5	1.40	1.64	1.85
Main effect						
Enzyme						
Without enzyme	149.0[b]	1105.2	2070.7	1.26[b]	1.58[a]	1.94[a]
With enzyme	144.0[b]	1101.0	2090.4	1.32[a]	1.51[ab]	1.84[b]
SEM	2.13[b]	14.09	34.39	0.017	0.031[a]	0.031
Date pit						
10%	143.4[b]	1094.2	2133.1	1.34[a]	1.47	1.81[b]
20%	148.1[b]	1129.1	2058.1	1.36[a]	1.56	1.90[ab]
30%	149.0[b]	1086.0	2050.5	1.19[b]	1.61	1.96[a]
SEM	2.6	17.2	42.12	0.021	0.038	0.039
Probabilities						
Enzyme	0.09	0.83	0.68	0.01	0.12	0.03
Date pit	0.29	0.20	0.33	0.0001	0.04	0.03
Enzyme × date pit	0.65	0.58	0.47	0.24	0.21	0.75

DP, date pit; WE, without enzyme; E, enzyme supplementation.
[a,b] Means with different superscripts in each column are significantly different ($P < 0.05$). Differences between the control group and the remaining groups were assessed using Dunnett's test and significant differences ($P < 0.05$) are presented with different superscript in each column.


Cellulase

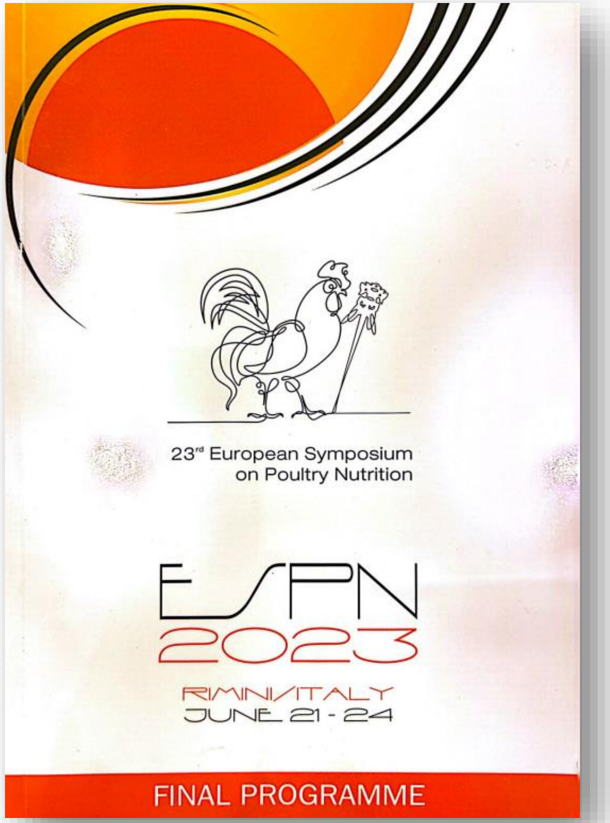
Parameter[2] (% of DM)	Wheat cultivar			
	Isengrain	Amiro	Guadalupe	Horzal
Starch	68.45	67.46	67.57	66.68
CP	9.01	9.94	10.94	13.71
Crude fiber	3.13	2.93	3.21	2.82
Ether extract	1.78	1.68	1.80	1.73
Ash	1.73	1.85	2.01	1.57
Neutral detergent fiber	15.26	17.06	17.30	16.85
Acid detergent fiber	3.72	3.80	4.41	3.52
Lignin	0.59	0.87	0.87	0.65
Total nonstarch polysaccharides	9.76	10.79	11.23	10.91
Total soluble nonstarch polysaccharides	1.33	2.40	2.04	2.41
Arabinose	0.35	0.66	0.65	0.76
Xylose	0.46	1.04	0.88	1.04
Total insoluble nonstarch polysaccharides	8.42	8.39	9.19	8.51
Arabinose	2.00	1.96	2.34	2.22
Xylose	2.95	3.30	3.34	3.20
Gross energy (kcal/kg)	4,368	4,438	4,407	4,469
Viscosity (cP)	4.98	5.89	6.47	4.53
Specific weight (kg/hL)	74.40	72.70	77.40	81.10
P (mm)	57.00	63.00	76.00	123.00
L (mm)	18.00	43.00	24.00	39.00
P/L	3.16	1.46	3.16	3.15
W (10^{-4} J)	49	102	84	222

Physical and chemical properties of water-soluble, nonstarch polysaccharides (WSNSPS) in cereals

Property	Wheat	Rye	Triticale	Barley	Oats
Yield of WSNSPS (%)[a]	0.6	1.7	0.7	1.2	1.0
Monosaccharide (mg/g)[b]					
Arabinose	238	254	281	66	81
Xylose	264	364	267	75	63
Glucose	43	55	34	481	443
Others	135	46	91	29	53
Total	680	719	673	651	640
M_w[c]	255 000	770 000	569 000	665 000	446000
M_n[d]	60 500	90 300	66 000	89 700	66 500
Polydispersity (M_w/M_n)	4.2	8.5	8.6	7.4	6.7
Viscosity, η (dL/g)[e]	1.7	5.9	4.0	4.5	3.1
Water-binding capacity (g water/g dry sample)	0.41	0.47	0.42	0.49	0.44
Relative growth depression[f]	+	+++	+(+)	++	++

جدول ۱۱-۲. ترکیب پلی ســاکاریدهای غیر نشاســته‌ای واریته‌های مختلف گندم‌های ایران (درصد در ماده خشک)

ارقام زراعی گندم	ماده خشک	زایلوز	آرابینوکسیلان	β-گلوکان	آمیلوز
آرتا	۹۱,۹	۲,۵	۴,۰	۱,۰	۲۲,۳۱
اترک	۹۱,۷	۲,۶	۴,۲	۱,۲	۱۹,۸۳
اکبری	۹۱,۴	۲,۶	۴,۲	۱,۲	۱۹,۳۱
الموت	۹۲,۴	۲,۹	۴,۷	۱,۱	۲۲,۳۸
الوند	۹۱,۳	۲,۹	۴,۷	۱,۰	۱۹,۵۷
بهار	۹۱,۲	۲,۵	۴,۰	۱,۲	۲۰,۳۲
بم	۹۰,۷	۲,۹	۴,۷	۱,۲	۱۹,۰۷
چمران	۹۱,۰	۲,۹	۴,۷	۱,۱	۲۳,۳۹
دریا	۹۱,۵	۲,۶	۴,۲	۰,۹	۲۱,۰۴
دز	۹۱,۹	۲,۷	۴,۳	۱,۲	۲۱,۳۲
کویر	۹۲,۰	۲,۶	۴,۲	۱,۲	۱۹,۵۳
موقان	۹۲,۰	۲,۹	۴,۷	۱,۰	۱۸,۵۶
نیک نژاد	۹۰,۹	۲,۶	۴,۲	۱,۲	۲۳,۴۵
پیشگام	۹۱,۹	۲,۴	۳,۸	۱,۱	۲۰,۸۷
پیشتاز	۹۱,۷	۳,۰	۴,۹	۱,۱	۲۰,۹۸
روشن	۹۱,۸	۲,۵	۴,۰	۰,۹	۱۹,۳۱
شیراز	۹۱,۲	۲,۴	۳,۹	۱,۱	۲۰,۴۲
شهریار	۹۲,۶	۲,۶	۴,۲	۰,۹	۲۰,۲۰
تجن	۹۱,۸	۲,۹	۴,۷	۱,۲	۲۱,۱۰
میانگین ± انحراف معیار	۹۱,۶۳±۰,۵	۲,۶۸±۰,۲	۴,۳۳±۰,۳۴	۱,۰۹±۰,۱۱	۲۰,۶۷±۱,۴۲



Enzymatic chemical gravimetric

Englyst & Uppsala procedures

Table 1. Non-starch polysaccharide and lignin content (g/kg dry matter) of selected feedstuffs

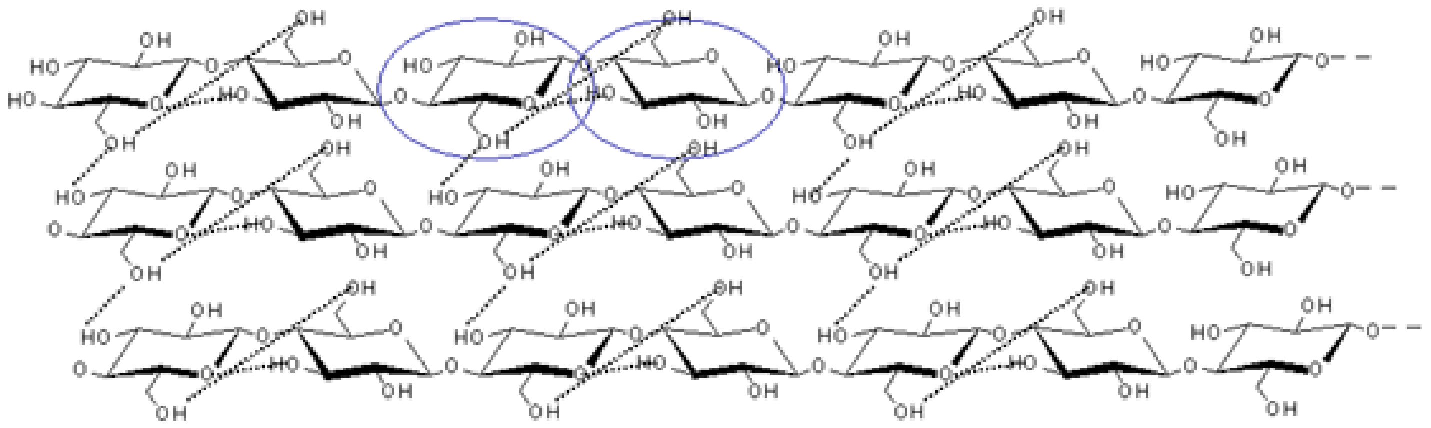
	Cell	Non-cellulosic polysaccharides						NCP	NSP	KL	Fibre
		Ara	Xyl	Man	Gal	Glc	UA				
Cereals											
Brown rice	1	5	4	1	1	8	2	21 (2)	22 (2)	13	35
Maize	22	22	30	3	5	10	7	75 (9)	97 (9)	11	108
Sorghum	15	17	13	1	3	10	4	51 (4)	66 (4)	16	83
Wheat	20	29	47	3	4	11	5	99 (25)	119 (25)	10	138
Rye	16	36	61	5	5	26	4	136 (42)	152 (42)	21	174
Barley	43	28	56	4	3	47	6	143 (56)	186 (56)	35	221
Oats	82	18	80	3	7	33	10	150 (40)	232 (40)	66	298
Cereal co-products											
Maize bran	83	72	116	4	20	16	44	271 (32)	354 (32)	25	379
Maize feed meal	33	33	48	2	9	10	20	123 (10)	156 (10)	18	174
Maize DDGS	58	52	71	19	13	21	16	192 (34)	250 (34)	39	289
Wheat bran	72	90	148	5	8	35	15	302 (29)	374 (29)	75	449
Wheat middling	19	48	67	8	7	33	10	171 (71)	190 (71)	11	201
Wheat DDGS	50	57	86	16	11	33	8	212 (67)	262 (67)	66	328
Rye bran	39	78	213	3	12	66	10	383 (63)	422 (63)	68	490
Barley hull meal	192	51	184	3	6	25	18	286 (20)	478 (20)	115	594
Oat hull meal	196	28	212	2	9	20	36	309 (13)	505 (13)	148	653
Protein rich feedstuffs											
Soybean meal	62	26	19	13	41	7	48	155 (63)	217 (63)	16	233
Rapeseed meal	52	43	17	6	19	21	61	168 (55)	220 (55)	134	354
Peas	53	26	13	2	7	36	32	127 (52)	180 (52)	12	192
Fava beans	81	24	12	2	6	32	33	109 (50)	190 (50)	20	210
Lupin	131	43	36	9	141	2	39	274 (134)	405 (134)	12	416
Palm cake	73	12	1	309	15	7	19	393 (32)	466 (32)	136	602
Sunflower cake	123	31	59	12	13	17	67	192 (57)	315 (57)	133	448

NCP, non-cellulosic polysaccharides; NSP, non-starch polysaccharides; Cell, cellulose; Ara, arabinose; Xyl, xylose; Man, mannose; Gal, galactose; Glc, glucose; UA, uronic acids; KL, Klason lignin; DDGS, distillers dry grains with soluble. Values in parentheses are soluble NCP/NSP.
Data from own database.

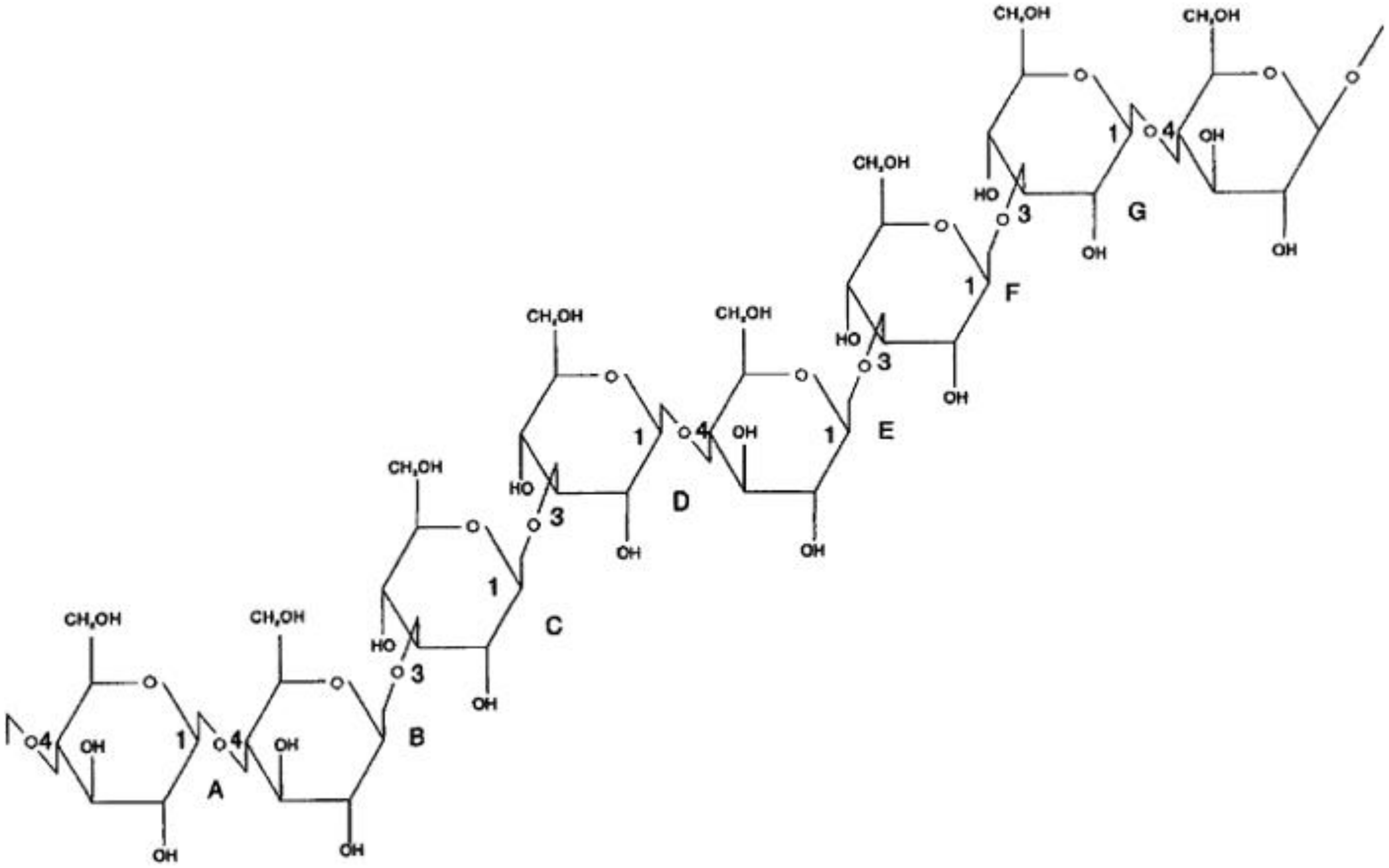
Nomenclature and action of β-glucan-degrading enzymes

Common name	Systematic name	Action
Cellulase	1,4-(1,3;1,4)-β-D-glucan 4-glucanohydrolase	Endohydrolysis of 1,4 linkages in cellulose and β-D-glucans containing 1,3 and 1,4 linkages
Laminarinase	1,4-(1,3;1,4)-β-D-glucan 3(4)-glucanohydrolase	Endohydrolysis of 1,3 or 1,4 linkages in β-D-glucans when the glucose residue whose reducing group is involved in the linkage to be hydrolyzed is itself substituted at C-3
β-glucosidase	β-D-glucoside glucohydrolase	Hydrolysis of terminal nonreducing β-D-glucosyl residues, with the release of β-D-glucose
Endo-1,3-β-glucanase	1,3-β-D-glucan glucanohydrolase	Endohydrolysis of 1,3 linkages in 1,3-β-D-glucans
Exo-1,3-β-glucanase	1,3-β-D-glucan glucohydrolase	Exohydrolysis of 1,3 linkages in 1,3-β-D-glucans, with the release of α-glucose
Endo-1,2-β-glucanase	1,2-β-D-glucan glucanohydrolase	Endohydrolysis of 1,2 linkages in 1,2-β-D-glucans
Lichenase	1,3–1,4-β-D-glucan 4-glucanohydrolase	Endohydrolysis of 1,4 linkages in β-D-glucans containing 1,3 and 1,4 linkages
Exo-1,4-β-glucanase	1,4-β-D-glucan glucohydrolase	Exohydrolysis of 1,4 linkages in 1,4-β-glucans
Endo-1,6-β-glucanase	1,6-β-D-glucan glucanohydrolase	Endohydrolysis of 1,6 linkages in 1,6-β-glucans

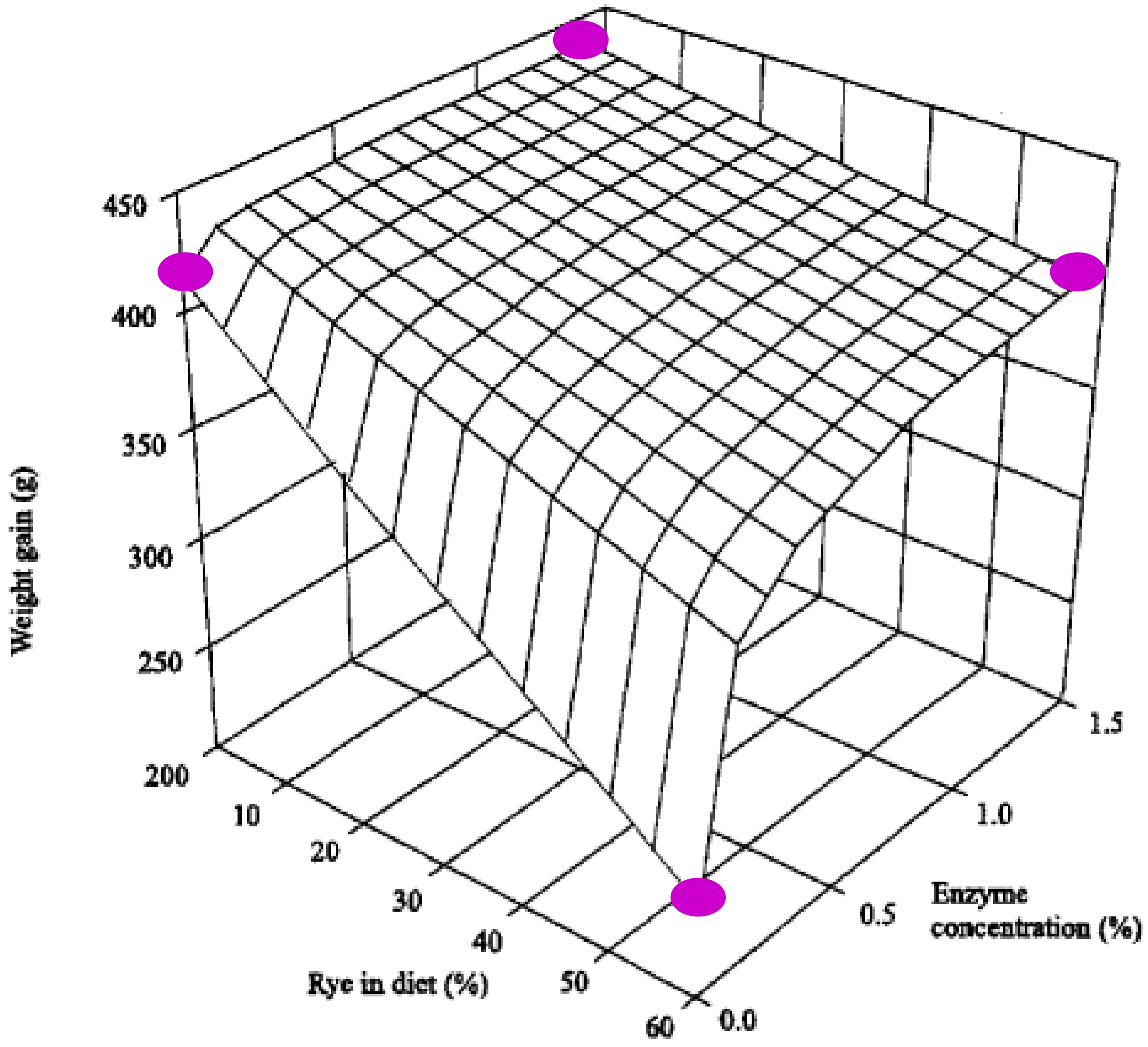
ß(1->4)-linked D-glucopyranose chain



Hydrogen bond

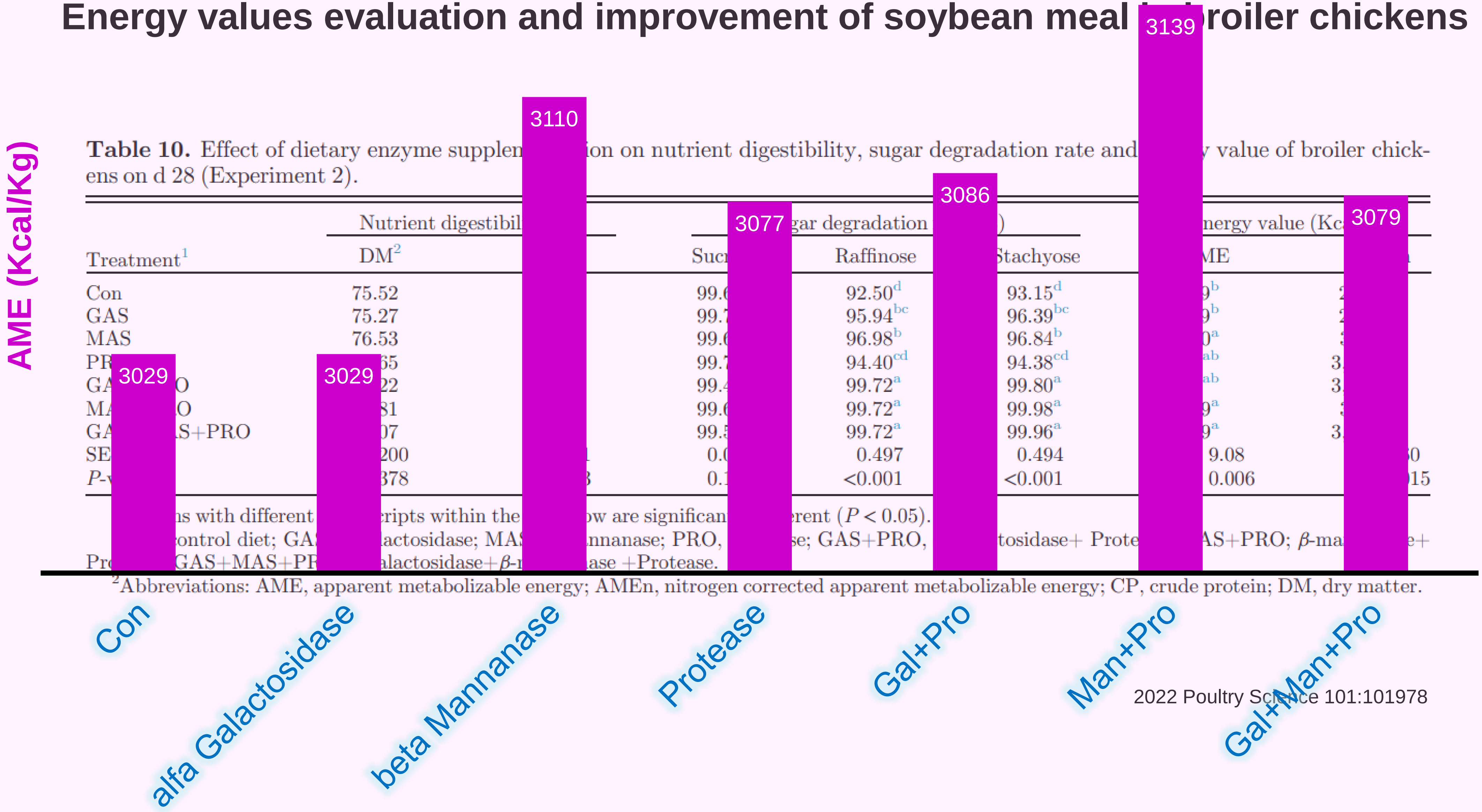


Action of laminarinase and endo-1,3-β-glucanase on a 1,3- or 1,4-β-D-glucan. Laminarinases cleave linkages C, D, F, and G, whereas endo-1,3-β-glucanases cleave linkages B, C, E, and F



Effect of enzyme concentration (X) and rye content of diet (Z) on chick weight gain (Y): $Y = 436.11 + 7.58 \log X - 0.63Z + 0.75Z \log X$.

Energy values evaluation and improvement of soybean meal broiler chickens



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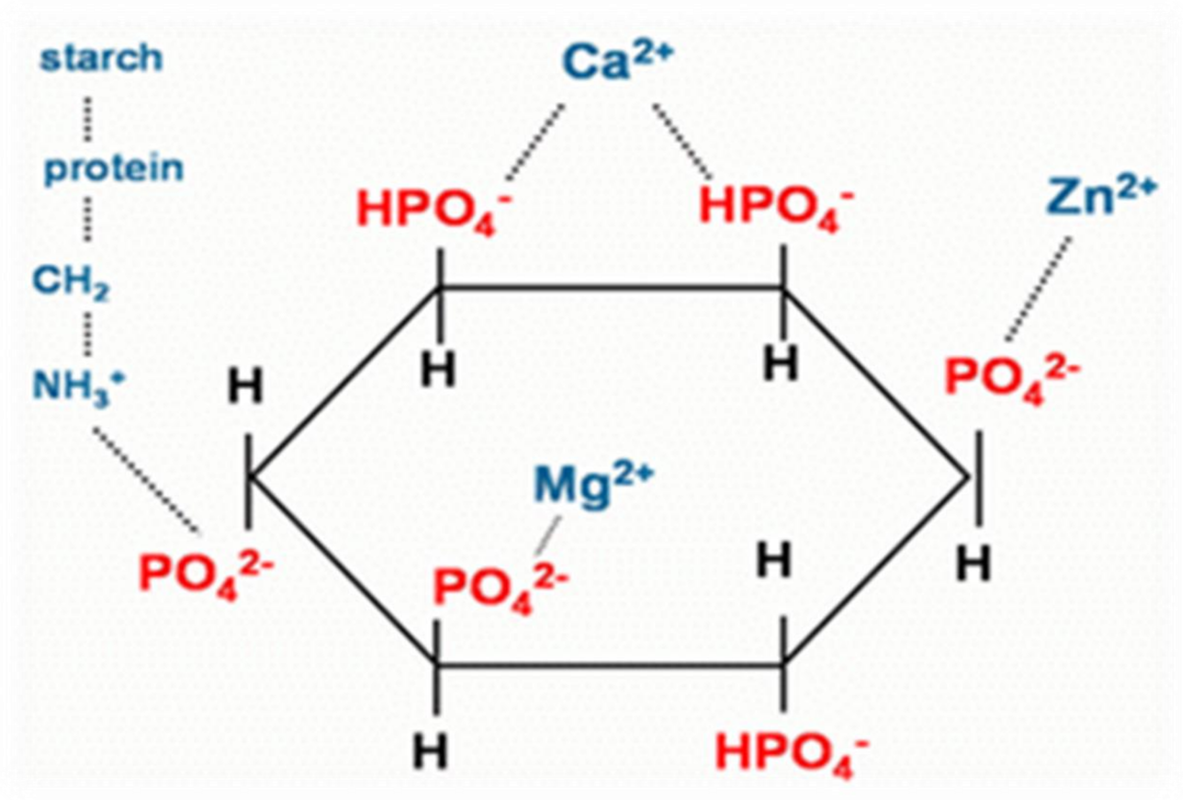
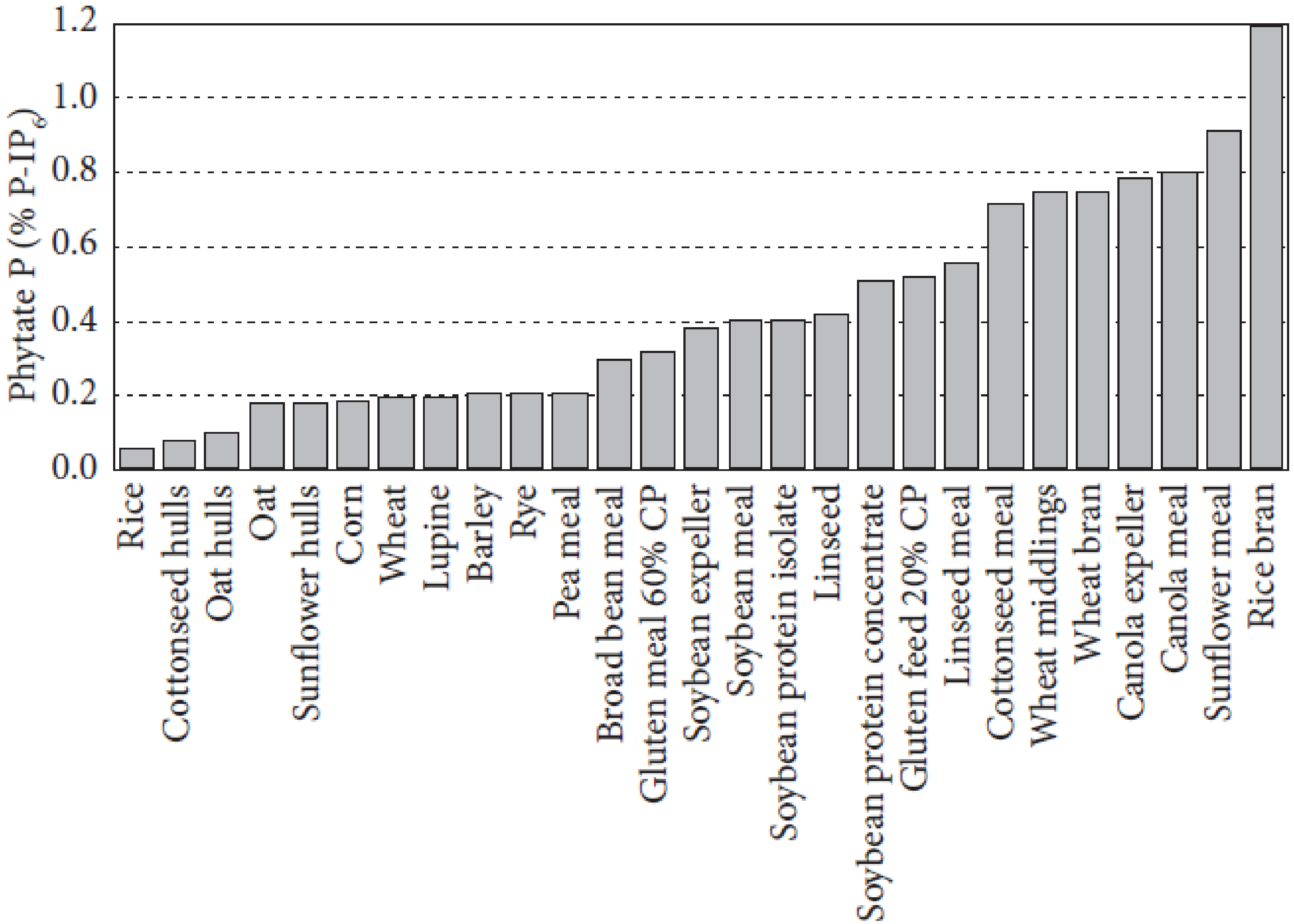
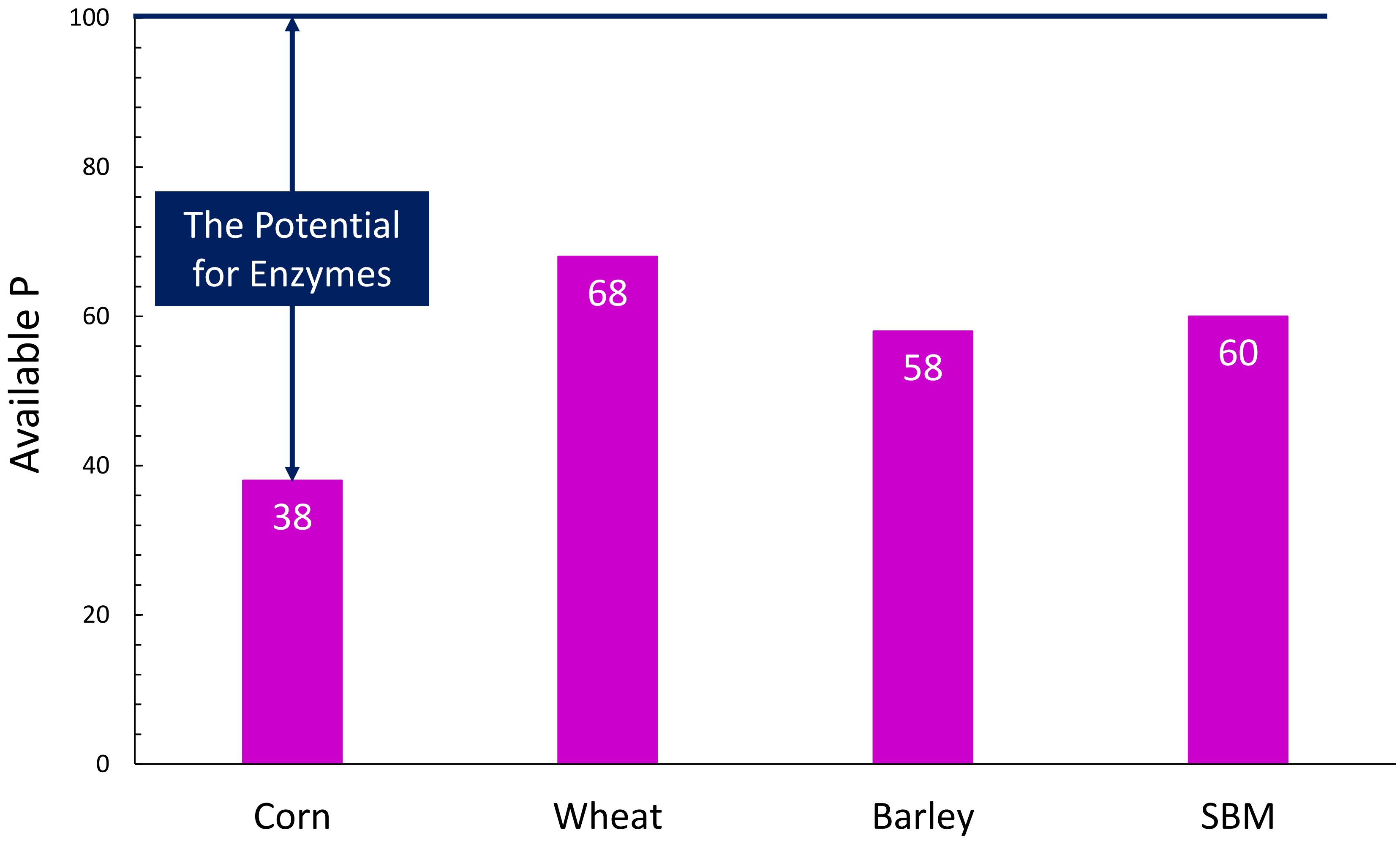
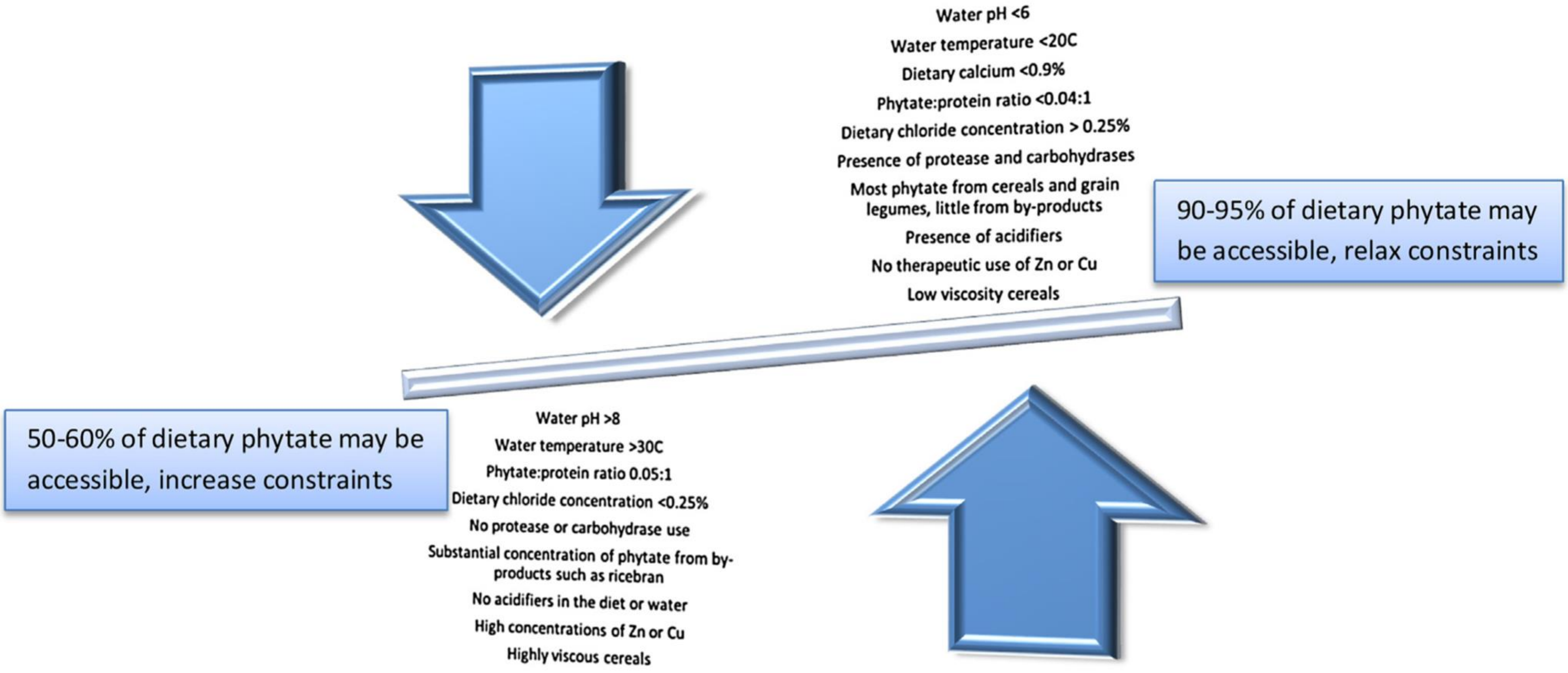

starch
protein
CH_2
NH_3^+
Ca^{2+}
HPO_4^-
HPO_4^-
Zn^{2+}
H
H
H
PO_4^{2-}
Mg^{2+}
PO_4^{2-}
PO_4^{2-}
H
H
H
HPO_4^-



Phytate P (% P-IP6)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Rice
Cottonseed hulls
Oat hulls
Oat
Sunflower hulls
Corn
Wheat
Lupine
Barley
Rye
Pea meal
Broad bean meal
Gluten meal 60% CP
Soybean expeller
Soybean meal
Soybean protein isolate
Linseed
Soybean protein concentrate
Gluten feed 20% CP
Linseed meal
Cottonseed meal
Wheat middlings
Wheat bran
Canola expeller
Canola meal
Sunflower meal
Rice bran

Phosphorus Gap



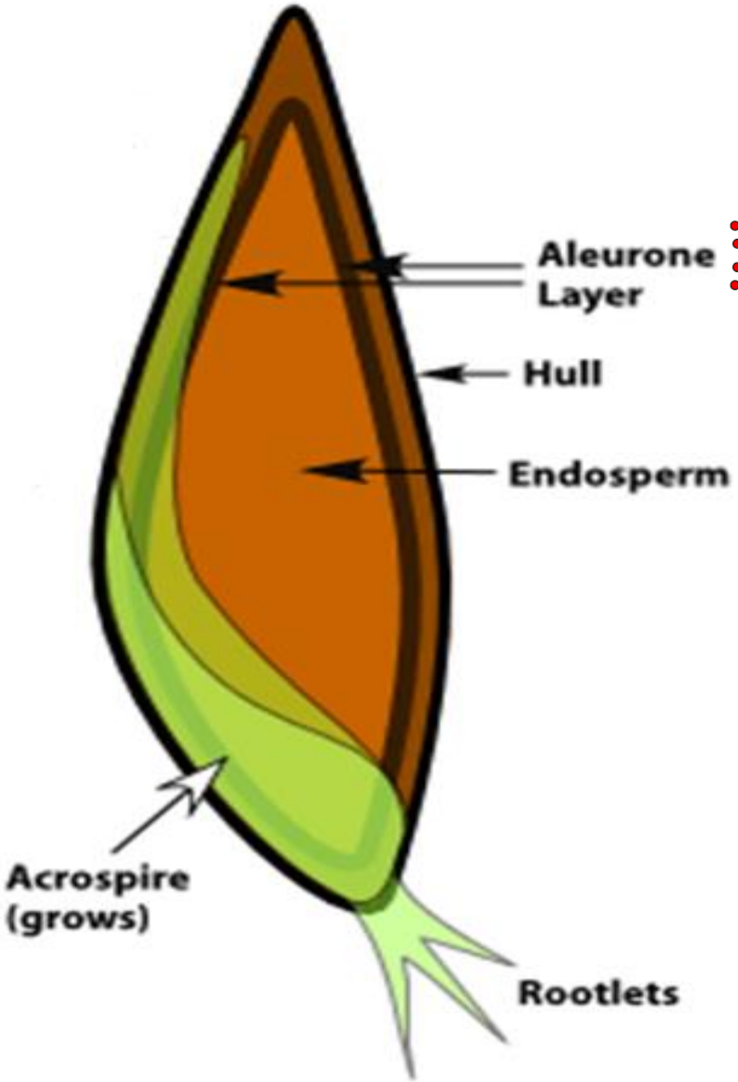

Water pH <6
Water temperature <20C
Dietary calcium <0.9%
Phytate:protein ratio <0.04:1
Dietary chloride concentration > 0.25%
Presence of protease and carbohydrases
Most phytate from cereals and grain legumes, little from by-products
Presence of acidifiers
No therapeutic use of Zn or Cu
Low viscosity cereals
90-95% of dietary phytate may be accessible, relax constraints
50-60% of dietary phytate may be accessible, increase constraints
Water pH >8
Water temperature >30C
Phytate:protein ratio 0.05:1
Dietary chloride concentration <0.25%
No protease or carbohydrase use
Substantial concentration of phytate from by-products such as ricebran
No acidifiers in the diet or water
High concentrations of Zn or Cu
Highly viscous cereals

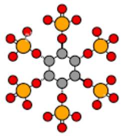
- More complete phytate destruction is dependent upon ingredient **location** (Bedford 2023).

- Phytate destruction reduce incidence of **Woody breast** and **Femoral head necrosis** (Greene *et al.,* 2020).

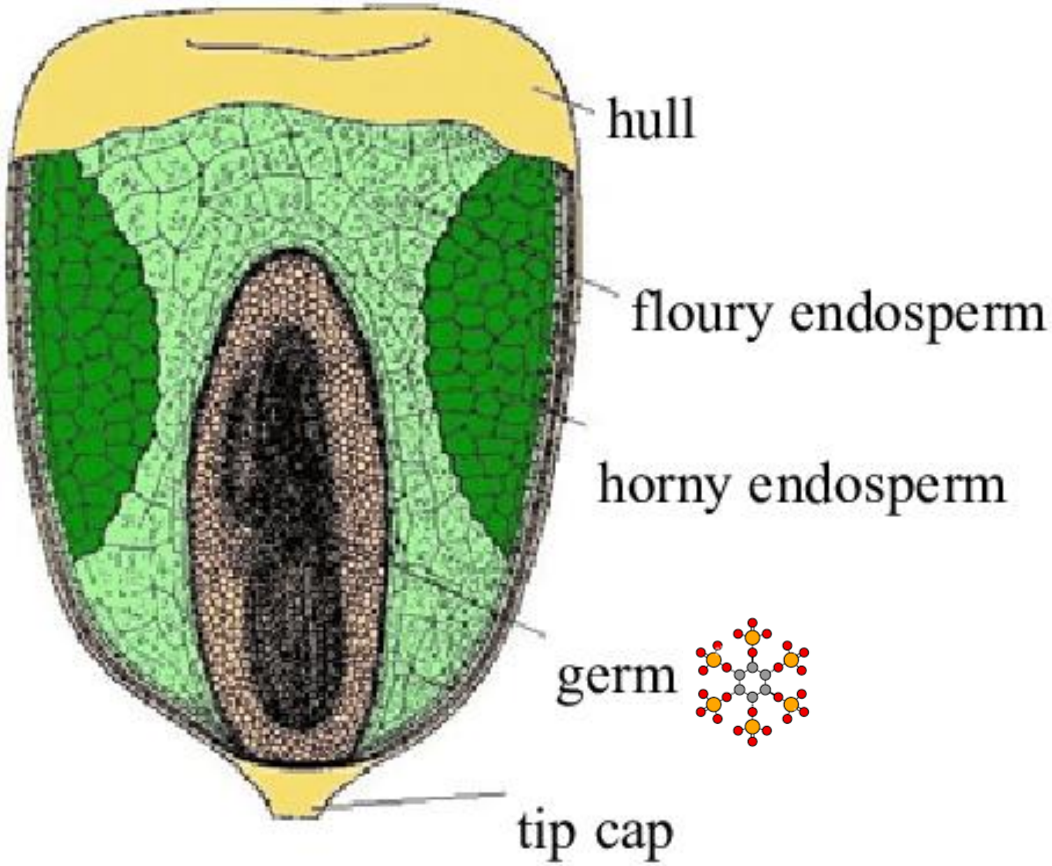
- Crop or Gizzard retention results in more phytate hydrolysis

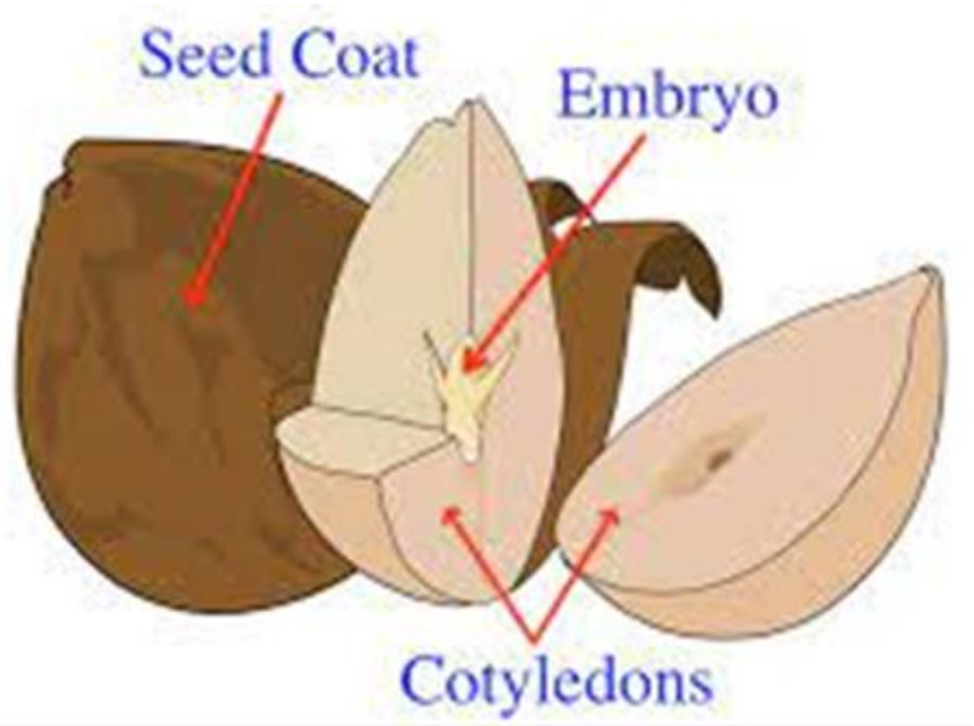
- Catalytic efficiency

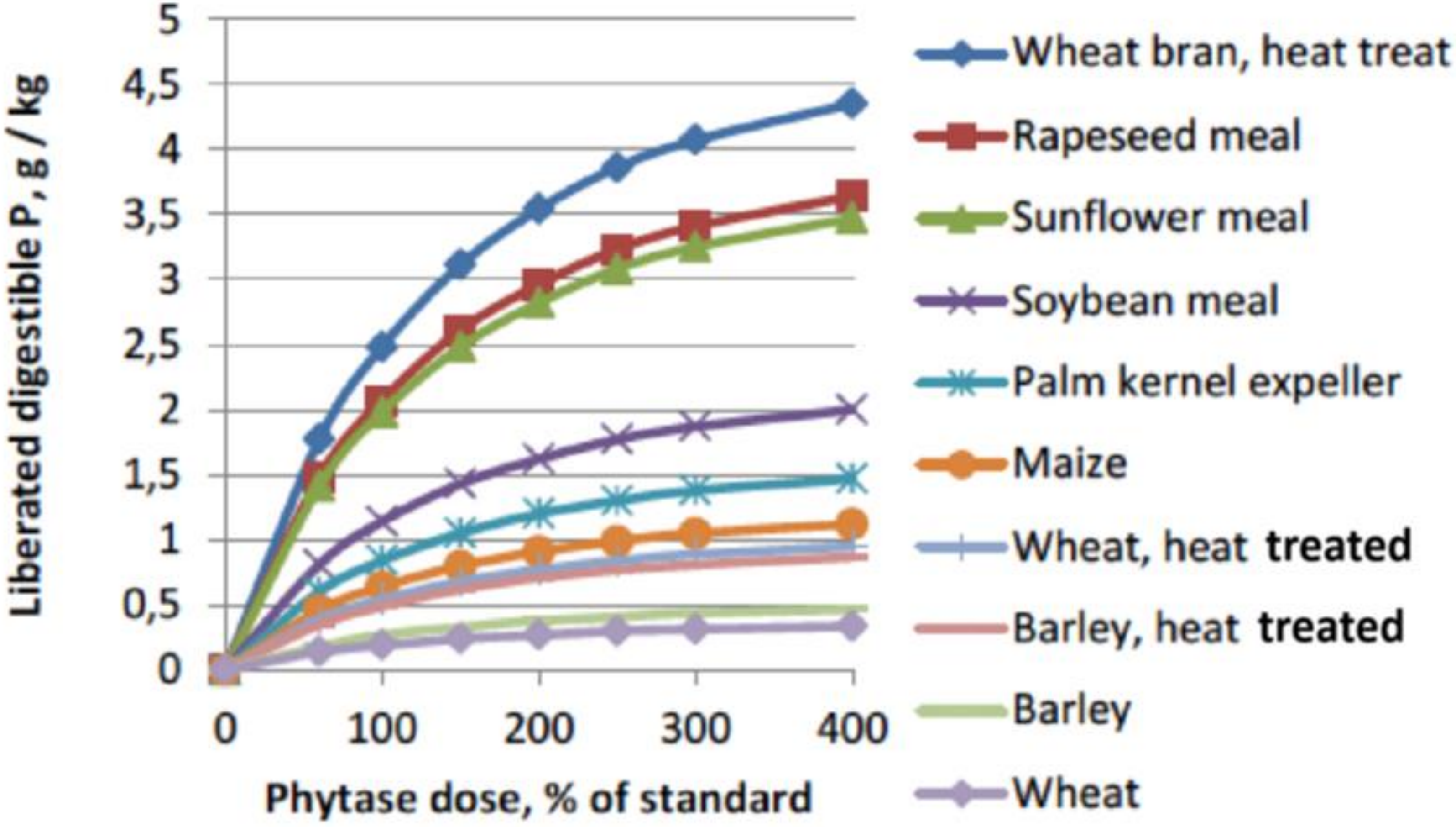




Xylanase increases the permeability of the aleurone layer of wheat, which is the site of phytic acid storage. Xylanase, by itself, will not target phytic acid, but a combination of xylanase and phytase may be mutually beneficial. By the same reasoning, the use of multiple carbohydrase activities may produce greater benefit than each of the enzymes acting individually.


hull
floury endosperm
horny endosperm
germ
tip cap


Seed Coat
Embryo
Cotyledons



Liberated digestible P, g / kg
5
4,5
4
3,5
3
2,5
2
1,5
1
0,5
0
0
100
200
300
400
Phytase dose, % of standard
Wheat bran, heat treat
Rapeseed meal
Sunflower meal
Soybean meal
Palm kernel expeller
Maize
Wheat, heat treated
Barley, heat treated
Barley
Wheat

Presently known distribution of representatives of the different catalytic classes of phytate degrading enzymes

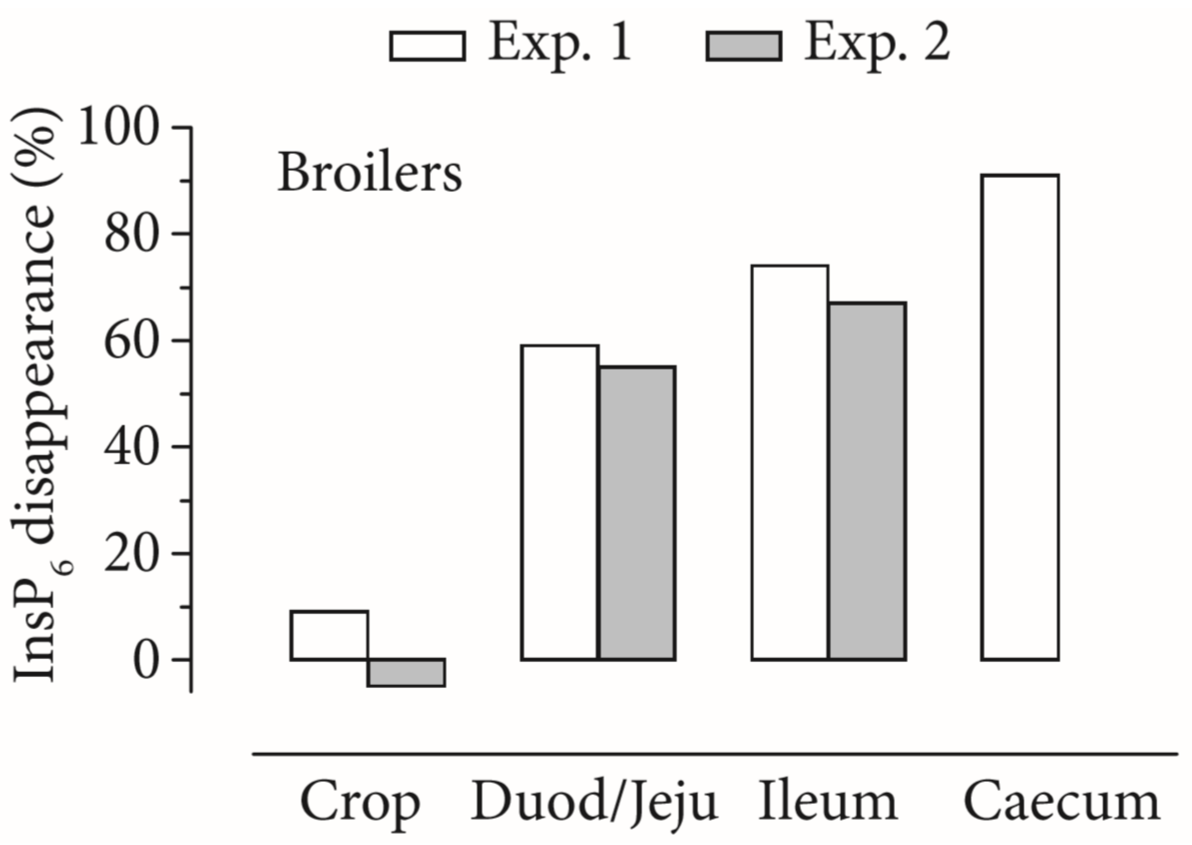
Type	Taxa			Exemplary protein	NCBI accession number	Amino acids[b]	MW kDa[b]	Isoelectric point[b,c]	pH optima	Temp. optimum (°C)	Specific activity (units/mg)	V_{max} (units/mg)	T_m (°C)	K_m (μM)	k_{cat} (s^{-1})
HAPhy	Bacteria	Gram-positive		*Selenomonas ruminantium* Agp	YP_005432715	413[d]	46	(7.9)	Predicted phytase						
		Gram-negative		*Escherichia coli* AppA	M58708	410	47	(6.1)	4.5	55	1,700	—	63.7	—	—
	Fungi	Ascomycetes	Filamentous	*Aspergillus niger* PhyA	CAA78904	448	49	4.8–5.2 (4.8)	2.0, 5–5.5	65	—	120	66.3	34	170
			Yeast	*Candida krusei* WZ-001	—	—	—	5.5	4.6	40	1,210	—	inactivated >50	30	—
		Basidiomycetes		*Peniophora lycii* PhyA (mushroom)	CAC48195	410	45	3.6 (4.4)	4–4.5	50–55	1,080	—	60	—	—
	Plants	Monocots		*Zea mays* Phy S11 (corn)	CAA11390	369[f]	80 (dimer)	(5.4)	4.8	55	2.3	—	—	117	—
		Dicots		*Arabidopsis thaliana*	AAB60740	449	51	(8.6)	Predicted phytase						
	Animals			Avian (*Gallus gallus*) MINPP (chicken)	NP_989975	430	48	(8.0)	5	—	—	0.7	—	140	—
BBPhy	Bacteria	Gram-positive		*Bacillus amyloliquefaciens* DS11	O66037	356[d]	39	(4.9)	7–8	70	—	—	inactivated >70	138	17
		Gram-negative		*Sphingomonas sp.* SKA58	EAT09404	336[d]	35	(4.7)	Predicted phytase						
		Cyanobacteria		*Nostoc sp.* PCC 7120	NP_488278	1,821	193	(4.2)	Predicted phytase						
PAPhy	Fungi	Ascomycetes	Filamentous	*Aspergillus niger* pH 6.0 optimum acid phosphatase (*APase*)	AAB31768	583	64	(5.1)	—	—	—	—	—	315	2.6
	Plants	Monocots		*Triticum aestivum* (wheat) phytase	AX298209	520[d]	58	7.4 (6.1)	6.0	45	137	—	—	—	—
		Dicots		*Glycine max* (soybean) GmPhy	AAK49438	519[d]	59	(5.1)	4.5–5	58	—	—	inactivated >60	61	—
PTPhy	Bacteria	Gram-positive		*Clostridium acetobutylicum* ATCC 824	NP_149178	319	36	(9.7)	Predicted phytase						
		Gram-negative		*Selenomonas ruminantium* PhyAsr	AAQ13669	319	37	(8.4)	4.5–5.5	50–55	—	—	inactivated >60	425	264
Unknown	Protozoa			*Paramecium tetraurelia* 51s	—	—	240 (hexamer)	—	7.0	—	10	—	—	250	—

Phytase activity (μmol phytic acid h^{-1}) in the digestive tract of laying hens fed wheat-corn-soybean meal-based diet without microbial phytase supplementation (Marounek et al., *2010).*[1]

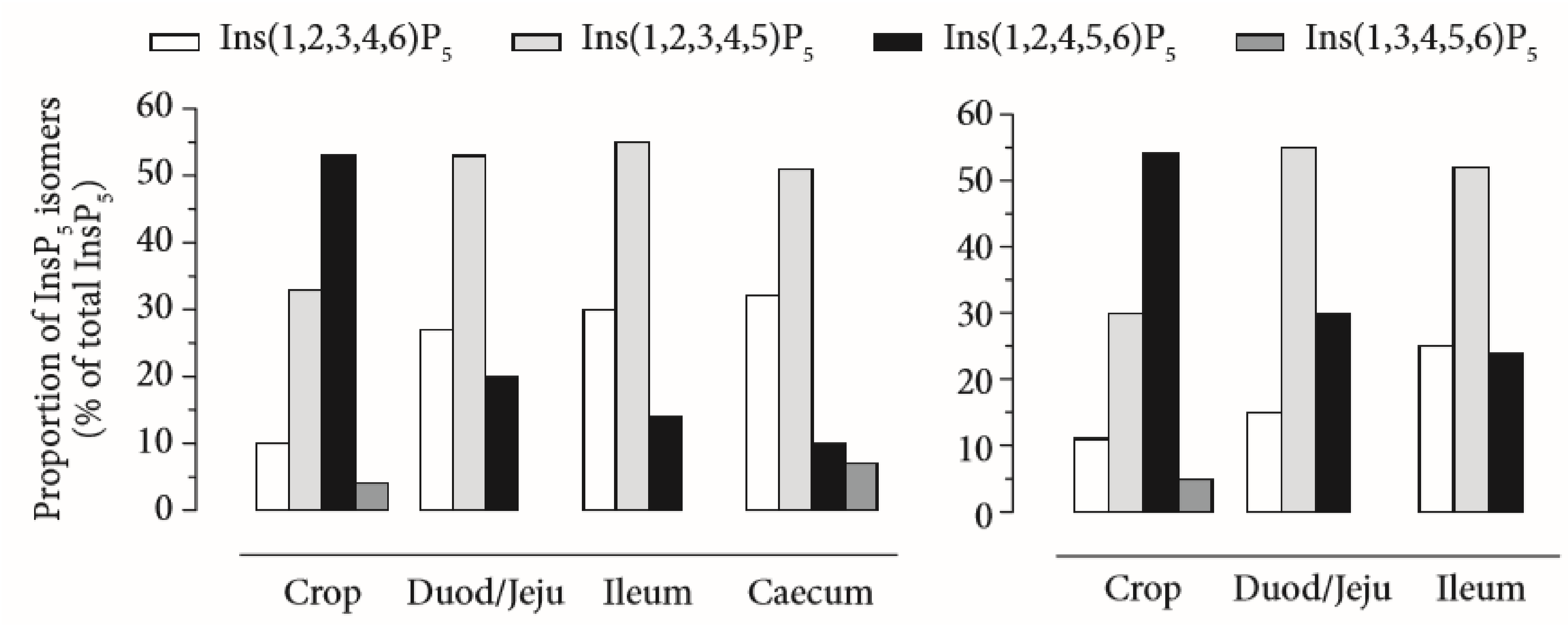
Segment	Specific (per g digesta)	Total (per segment)
Crop	10.2[a]	98[a]
Stomach	9.2[a]	97[a]
Small intestine	14.6[a]	359[b]
Small intestinal mucosa	11.5[a]	227[ab]
Sum pre-caecal		781
Caeca	135.4[b]	663[c]
Total		1,444

[1] Means within a column not sharing a common letter differ significantly ($P<0.05$).

Poultry GIT microbiota can utilize 10-25% of dietary phytate



InsP6 disappearance measured in sections of the digestive tract of broiler chickens fed maize-soybean meal-based diets without a phytase supplement; data from Rutherfurd et al. (2014) and Zeller et al. (2015, 2016).



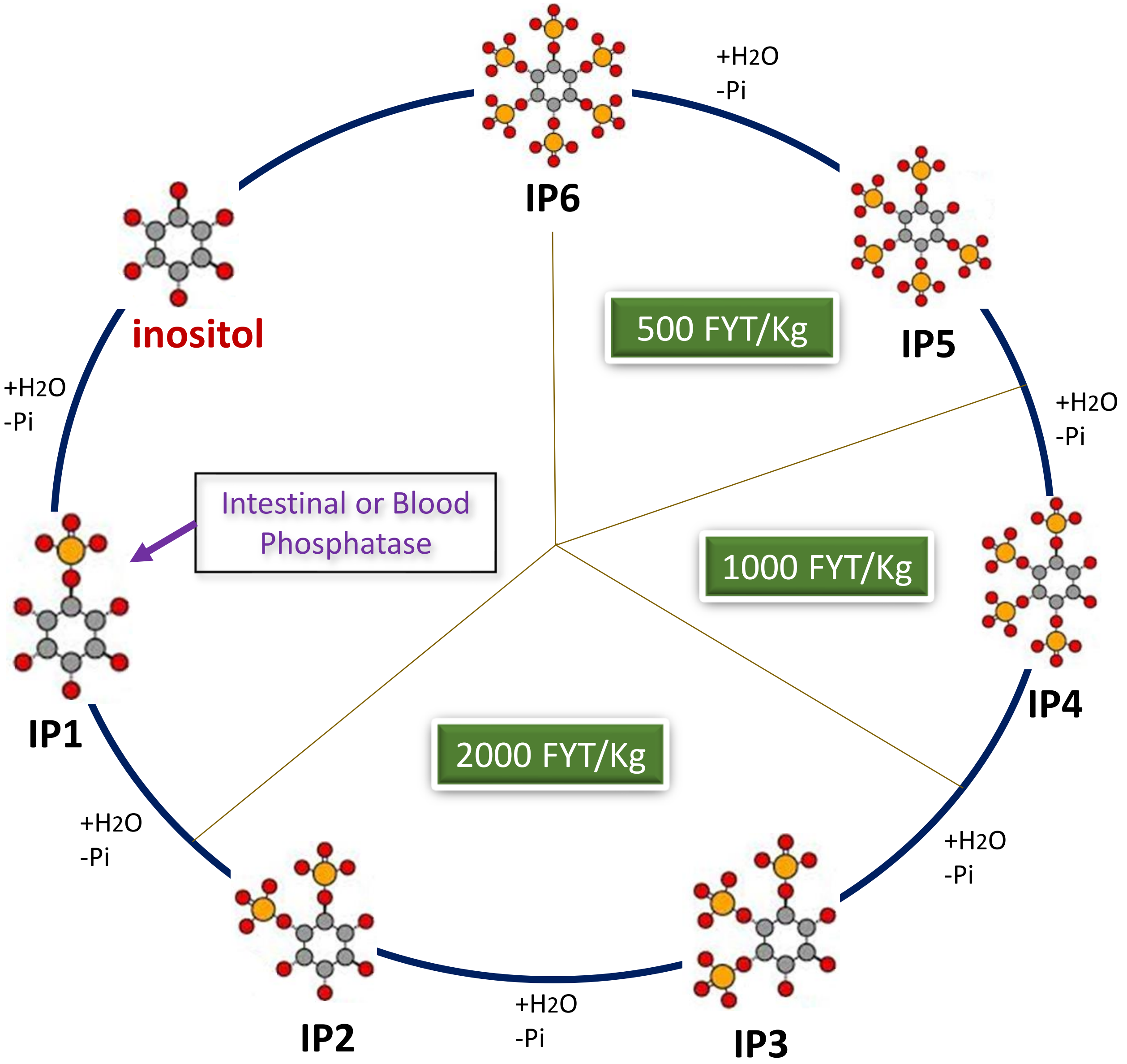
Pattern of InsP5 isomers detected in different sections of the gastrointestinal tract after feeding low-P maize-soybean meal diets without added phytase in two experiments with broiler chickens (Zeller et al., 2015, 2016).

Phytase activity in diet and digesta of broiler chickens fed diets with or without added microbial phytase from 8 to 22 days of age; activity measured at day 22 (Onyango et al.*, 2005).*[1]

	NC: low-P diet	NC +1000 FTU *Escherichia coli* phytase/kg	NC +1000 FTU *Peniophora lycii* phytase/kg
Feed (FTU/kg)	14	825	1,152
Digesta (FTU/kg DM intake)			
Crop	67[c]	649[a]	404[b]
Proventriculus and gizzard	28[b]	406[a]	63[b]
Jejunum	29[b]	554[a]	25[b]
Ileum	16[b]	91[a]	6[b]

[1] Means within a row not sharing a common letter differ significantly ($P<0.05$).

12. Phytase dosage



12. Phytase dosage

Cell Survival and Growth

myo-inositol is essential for growth and survival of cells

Central Nervous System

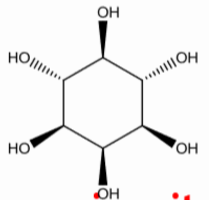
myo-inositol is essential for the development and function of peripheral nerves

Reproduction

myo-inositol restores normal ovulatory activity

Increases oocyte and egg quality

Increases fertilization rate, sperm motility and mitochondrial membrane potential in vitro



myo-inositol

Metabolism

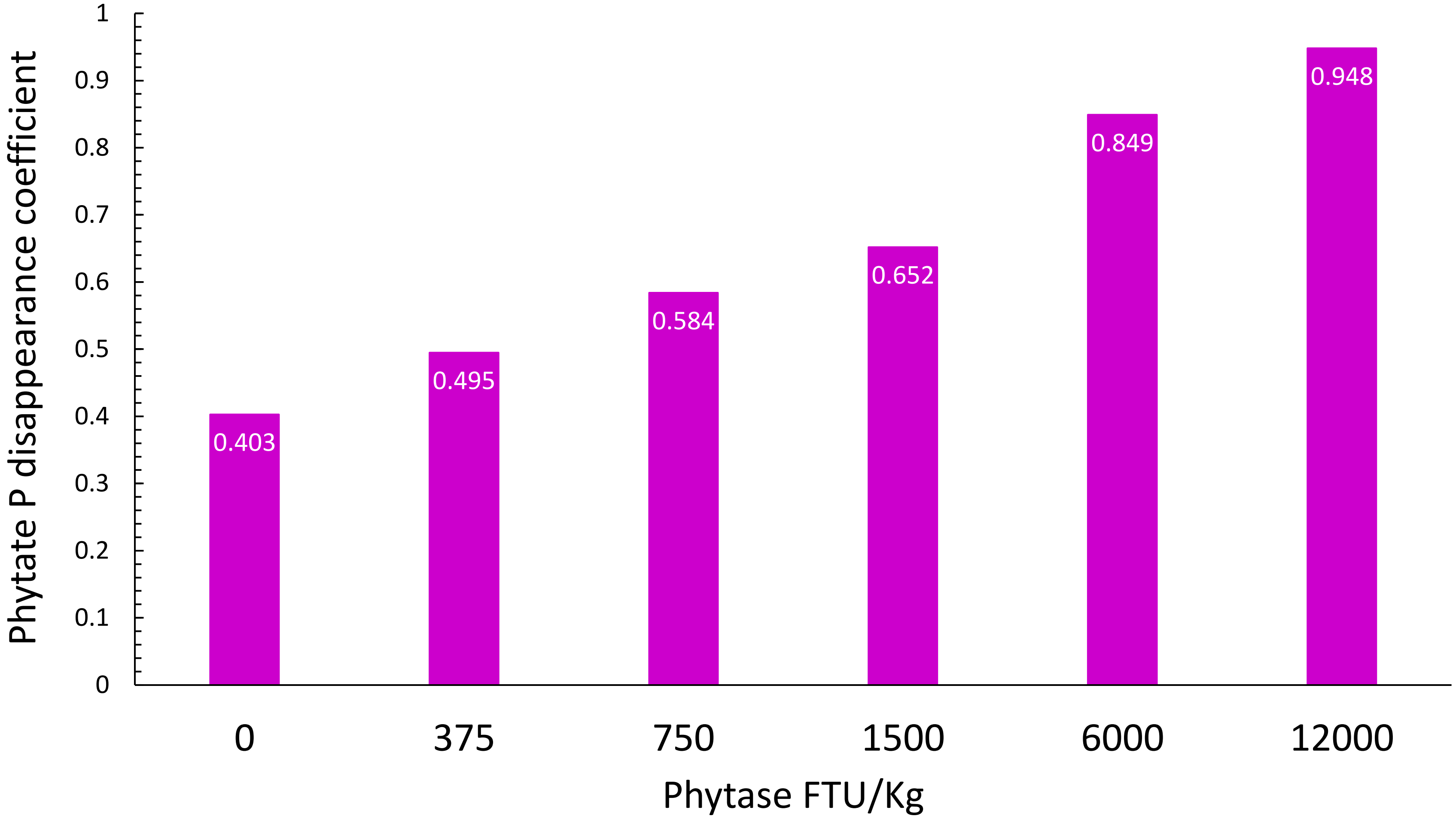
myo-inositol increases insulin sensitivity and decrease cholesterol, in the blood

myo-inositol decreases white adipose tissue deposition, increases muscle protein accretion and induces a growth promoting effect

Osteogenesis

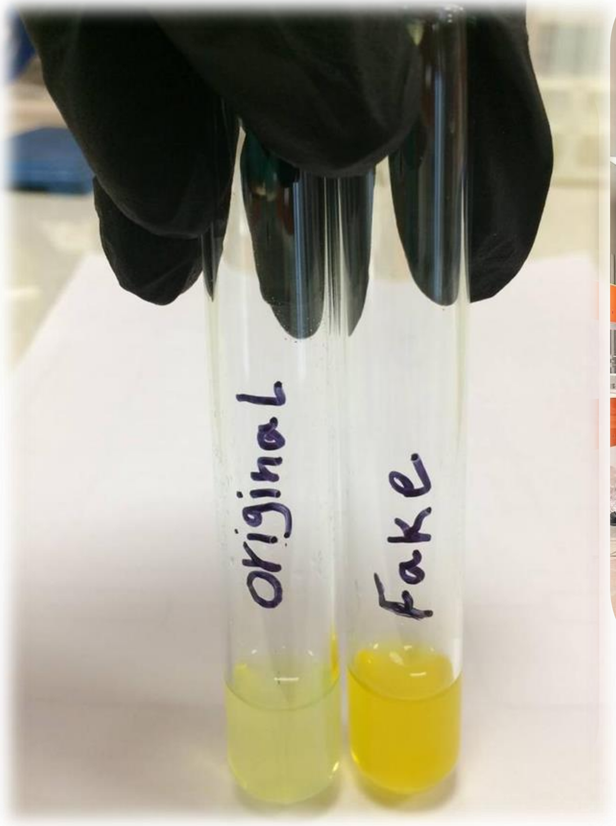
myo-inositol increases Ca in bones, Increases bone strength and is essential to bone formation, osteogenesis and bone mineral density

12. Phytase dosage



Shirley and Edwards, 2003

فعالیـت اسـتاندارد فیتـاز بـه عنـوان مقـدار آنزیمـی تعریـف می‌شـود کـه ۱ میکرومـول فسـفات معدنـی را از ۵ میلی‌مـولار سوبسـترای فیتـات سـدیم در دقیقـه در pH برابـر بـا ۵٫۵ و دمـای ۳۷ درجـه سـانتی‌گراد آزاد می‌کنـد و بـه صـورت FTU، FYT یـا OUT در هـر کیلوگـرم خـوراک بیـان می‌شـود (ویلانـس[1] و همـکاران، ۲۰۱۶). بـا ایـن حـال، از آنجـا کـه عوامـل زیـادی بـر عملکـرد فیتـاز در تغذیـه عملـی تأثیـر می‌گذارنـد، واحدهـای آنزیمـی ماننـد FYT ،FTU یـا OUT کـه در شـرایط برون‌تنـی[2] اندازه‌گیـری یـا بـرآورد می‌شـوند، پیش‌بینی‌کننـده مناسـبی بـرای کارایـی فیتـاز در داخـل بـدن حیـوان یـا درون‌تنـی[3] نیسـتند (بدفـورد و پارتریـج، ۲۰۱۱).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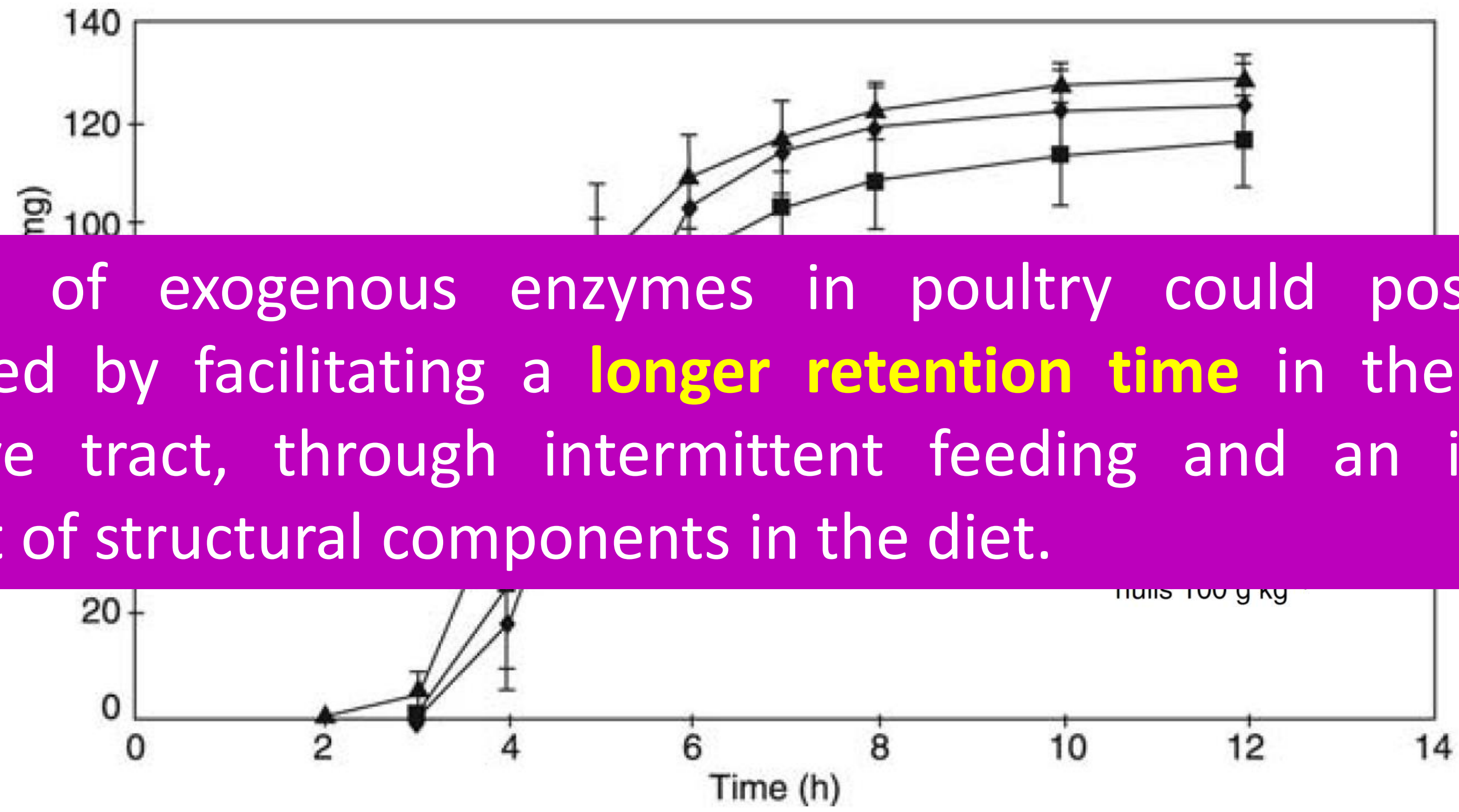


Efficacy of exogenous enzymes in poultry could possibly be increased by facilitating a **longer retention time** in the anterior digestive tract, through intermittent feeding and an increased content of structural components in the diet.

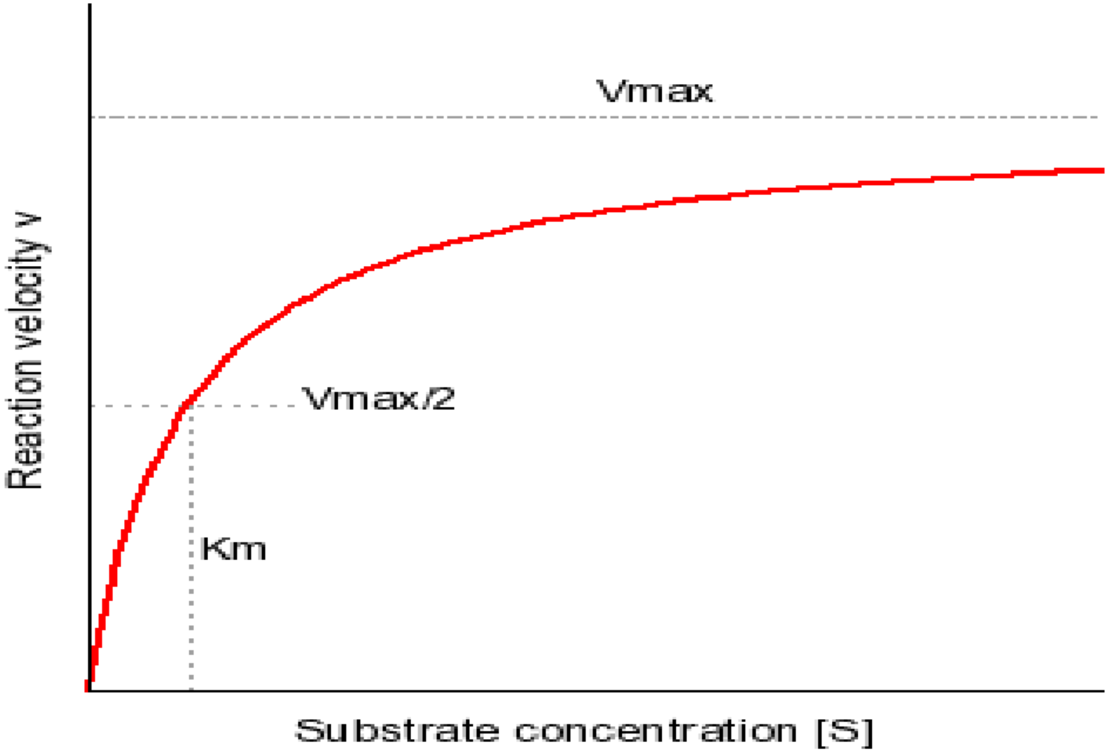
Cumulative excretion rates for broiler chickens fed wheat diets supplemented with oat hulls and without supplementation. Bars indicate standard deviation (*n* = 4). (From Hetland and Svihus, 2001.)

Leonor Michaelis

Maud Menten

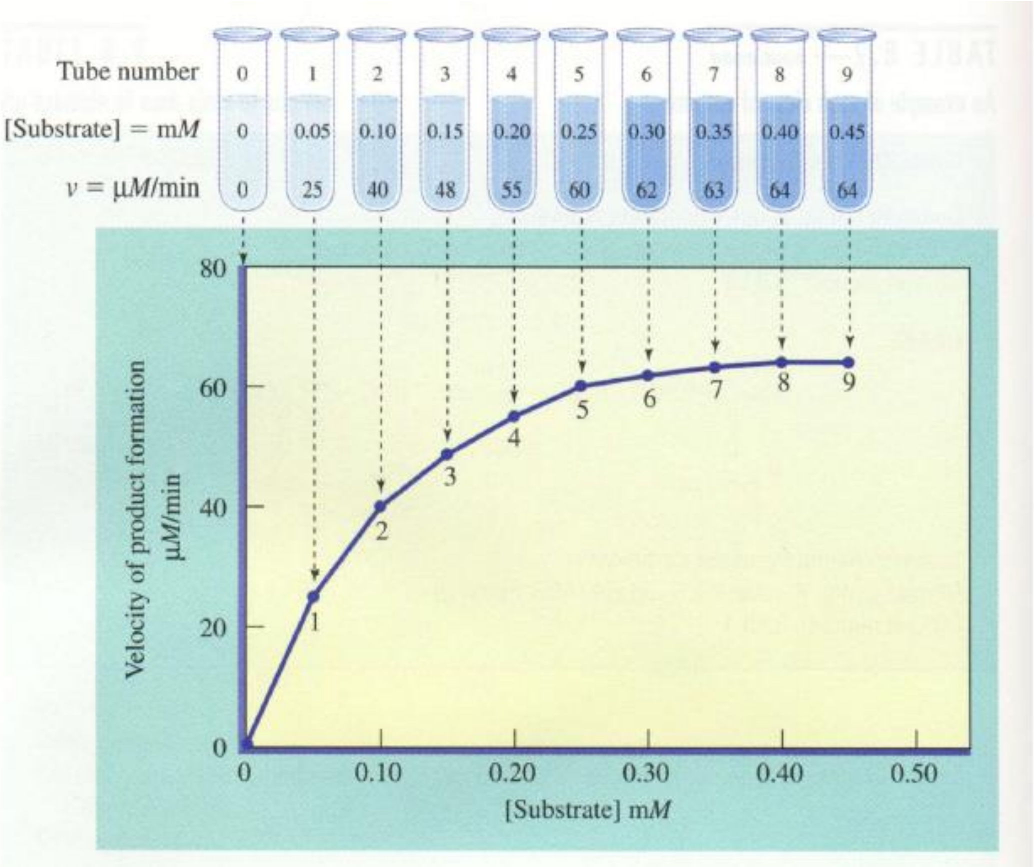
Michaelis Menten kinetics

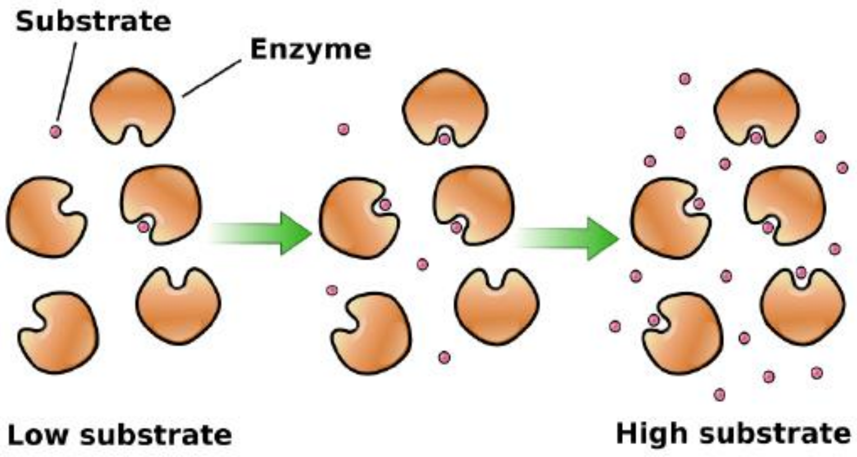
– Vmax represents the maximum speed rate achieved by the reaction, at maximum (saturating) substrate concentrations.



Phytate

4. Bio-catalytic reaction (Km, Vmax)





Catalytic Efficiency

$$Catalytic\ efficiency = \frac{K_{cat}}{K_m}$$

$$k_{cat} = \frac{V_{max}}{[ET]}$$

k_{cat} = turnover number

V_{max} = maximum reaction rate

$[E_T]$ = given enzyme concentration

turnover numbers k_{cat} for hydrolysis of sodium phytate by phytases reported so far range from <10 s^{-1} (soybean, barley P2, maize; Gibson and Ullah, 1988; Laboure *et al.*, 1993; Greiner *et al.*, 2000b) to 10,325 s^{-1} (*Yersinia intermedia*; Huang *et al.*, 2008). High affinity for sodium phytate is expressed by a low Michaelis–Menten constant K_M. K_M values of phytases studied range from <10 to 650 μM. Relatively low K_M values have been reported for phytases from *A. niger* (10–54 μM; Ullah, 1988; Wyss *et al.*, 1999a; Greiner *et al.*, 2009)