

Amino acid composition and mineral bioavailability: Important feed quality traits in cereals

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Global cereal production: 2.000 mill tons

Protein content: 200 mill tons

Protein quantity

Protein quality



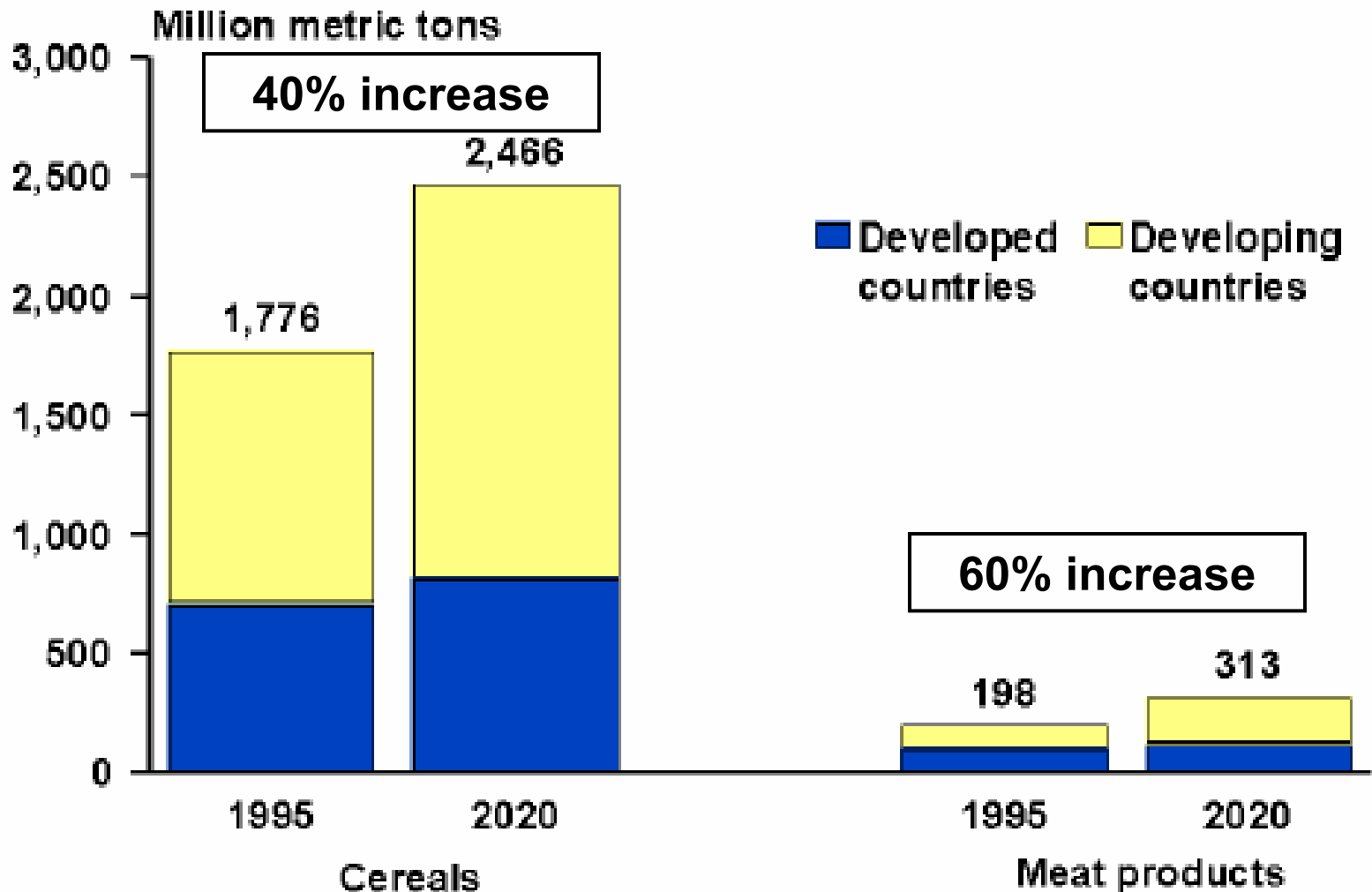
EU livestock and feed production (2005)



Beef:	8 mill t
Pork:	21 mill t
Poultry:	11 mill t
Milk:	142 mill t
Eggs:	6.5 mill t
Total value:	€ 129 bill.

Feed consumption: 450 mill t
EU feed production: 75%

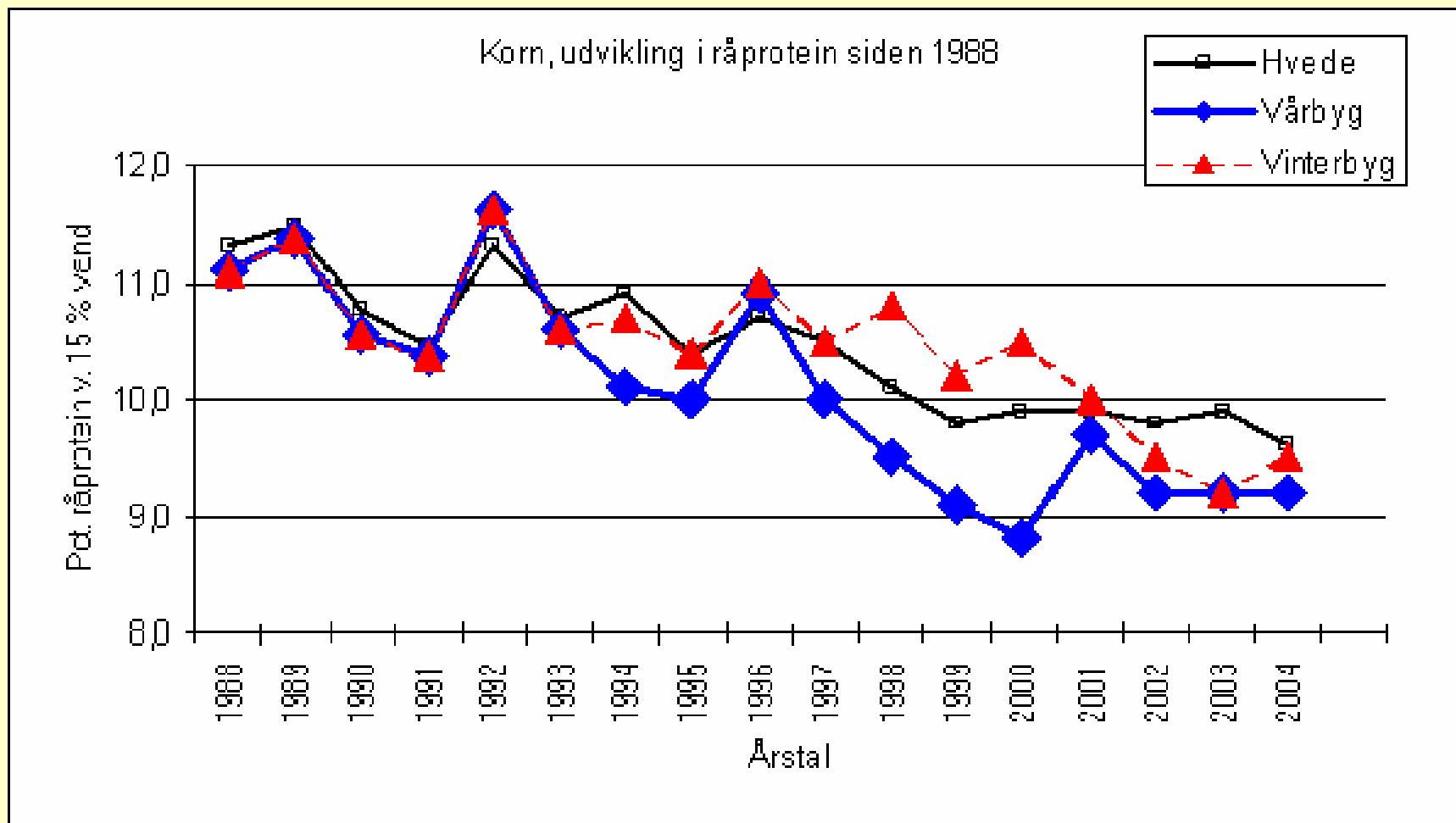
Total demand for cereals and meat products, 1995–2020



Source: P. Pinstруп-Andersen, R. Pandya-Lorch, and M.W. Rosegrant, *World Food Prospects: Critical Issues for the Early Twenty-First Century* (Washington, D.C.: IFPRI, 1999).



Reductions in the protein content of barley and wheat



The amino acid composition of the cereal grain

Problem

Barley and in particular wheat have a low content of essential amino acids, in particular lysine and threonine when used as feed for monogastric animals. To compensate soybean and oilseed rape cakes or amino acid produced by microorganisms or by chemical synthesis are added.

Barley and wheat grains have an excess of the amino acids proline and glutamine. These are degraded and excreted and give rise to a high nitrogen content in the urine



Amino acid composition of various feeds % of the ideal content for pig feed

	Ideal protein - for pigs	Soy cake	Barley	Wheat	Triticale
Raw protein, %		44,2	10,2	9,8	10,0
Lysine, %	7,1	6,1	3,6	3,0	3,4
Methionine, %	1,8	1,3	1,6	1,5	1,7
Threonine, %	4,6	3,8	3,3	2,9	3,0
Tryptophane, %	1,2	1,2	1,2	1,2	1,2
Isoleucine, %	4,1	5,0	3,7	3,6	3,6
Leucine, %	8,1	7,6	6,7	6,5	6,4
Valine, %	5,4	5,2	5,0	4,6	4,9

Amino acid supplementation

Lysine:
500.000 t

Threonine:
500.000 t

Methionine:
500.000 t

Tryptophan:
1.000 t



Markell Deloatch / Public Opinion



Storage proteins

Water: ALBUMINS

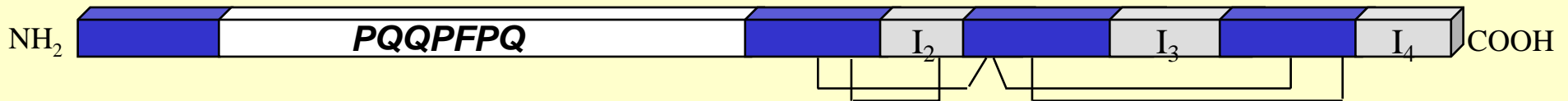
Saline: GLOBULINS

Water/alcohol: PROLAMINS

Acid or alkali: GLUTELINS

PROLAMINS:

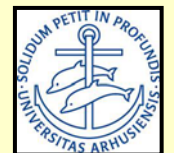
Sulfur rich (γ -gliadin)



Sulfur poor (C hordein)



HMW (subunit 1By9)



Amino acid composition of the different storage protein types in barley

Amino acid	B-hor	C-hor	D-hor	γ_3 -hor	Glutelins	Albumins	Globulins
Glx/Gln	35.4	41.2	29.6	32.4	11.8	9.6	11.4
Pro	20.6	30.6	11.6	16.5	6.5	5.6	4.4
Lys	0.5	0.2	1.1	1.6	5.3	5.3	5.2
Thr	2.1	1.0	8.1	3.1	5.5	4.5	3.9
Met	0.6	0.2	0.2	1.2	1.4	1.9	1.5
Cys	2.5	0	1.5	2.7	1.2	2.0	4.3
Phe	4.8	8.8	1.4	4.7	4.5	4.0	3.4



Protein quality and quantity are interrelated

- The prolamins act as a sink for excess nitrogen
- Excess nitrogen results in an even poorer amino acid composition

	0 nitrogen (g/kg DM)	180 kg N/ha (g/kg DM)
Lysine	3.6	4.7
Glutamic acid	19.2	35.9
Proline	8.8	16.6
Phenylalanine	3.9	7.6



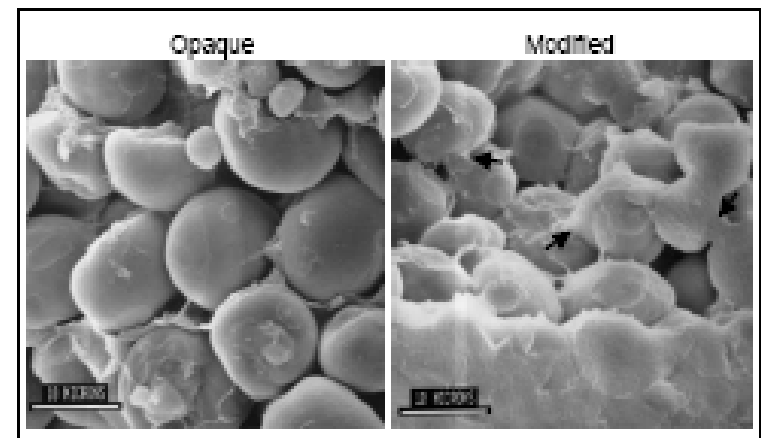
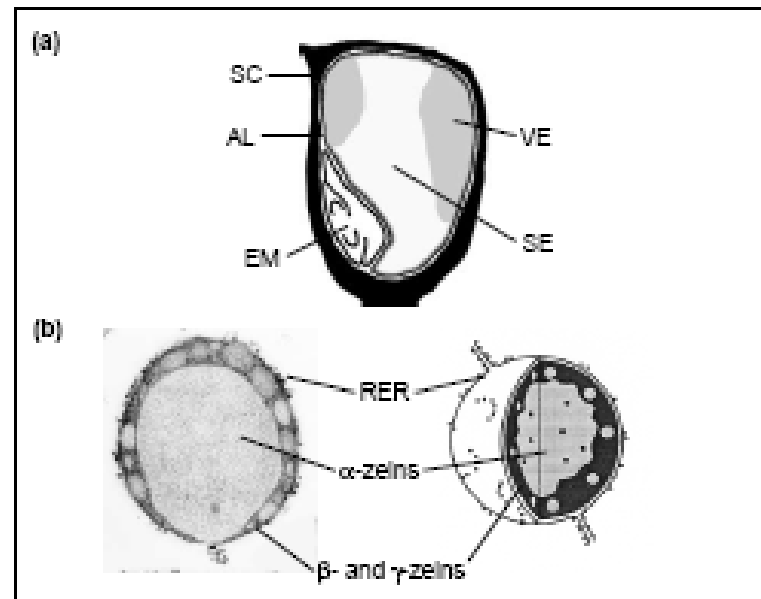
Reduktion of non-essential amino acids in wheat (e.g. 30 pct. reduction)

	Wheat
Protein, %	9,8
Non-essential amino acids, g/kg	49
Reduction, 30 pct.	15
Digestible fraction, g/kg wheat	14
g N/kg wheat	2,2
Reduced N-emission pr. pig, g	300
Normal emission pr. pig	3,3 kg N
Reduction in pct.	9

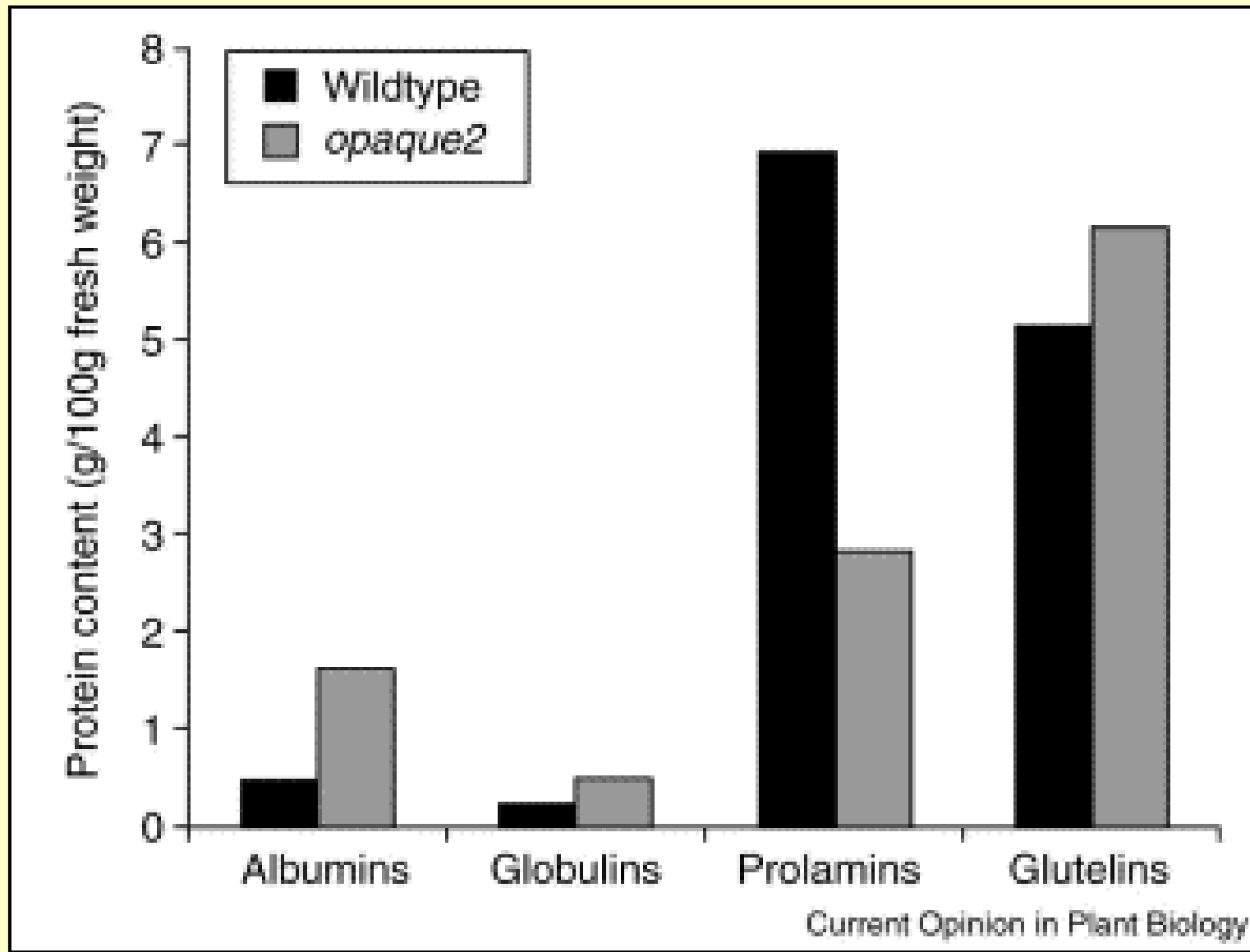
Source: Danske slagterier



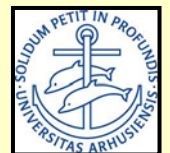
Quality Protein Maize



Quality Protein Maize



Current Opinion in Plant Biology



Nitrogen utilization in pigs

	High lysine barley	Average for 4 other barleys
N intake g pr day	30,6	29,7
N in faeces/ N intake %	30,3	25,3
N in urine/ N intake %	32,6	48,5
N assimilated g pr day	11,5	7,7
N assimilated/ N intake %	53,3	35,5

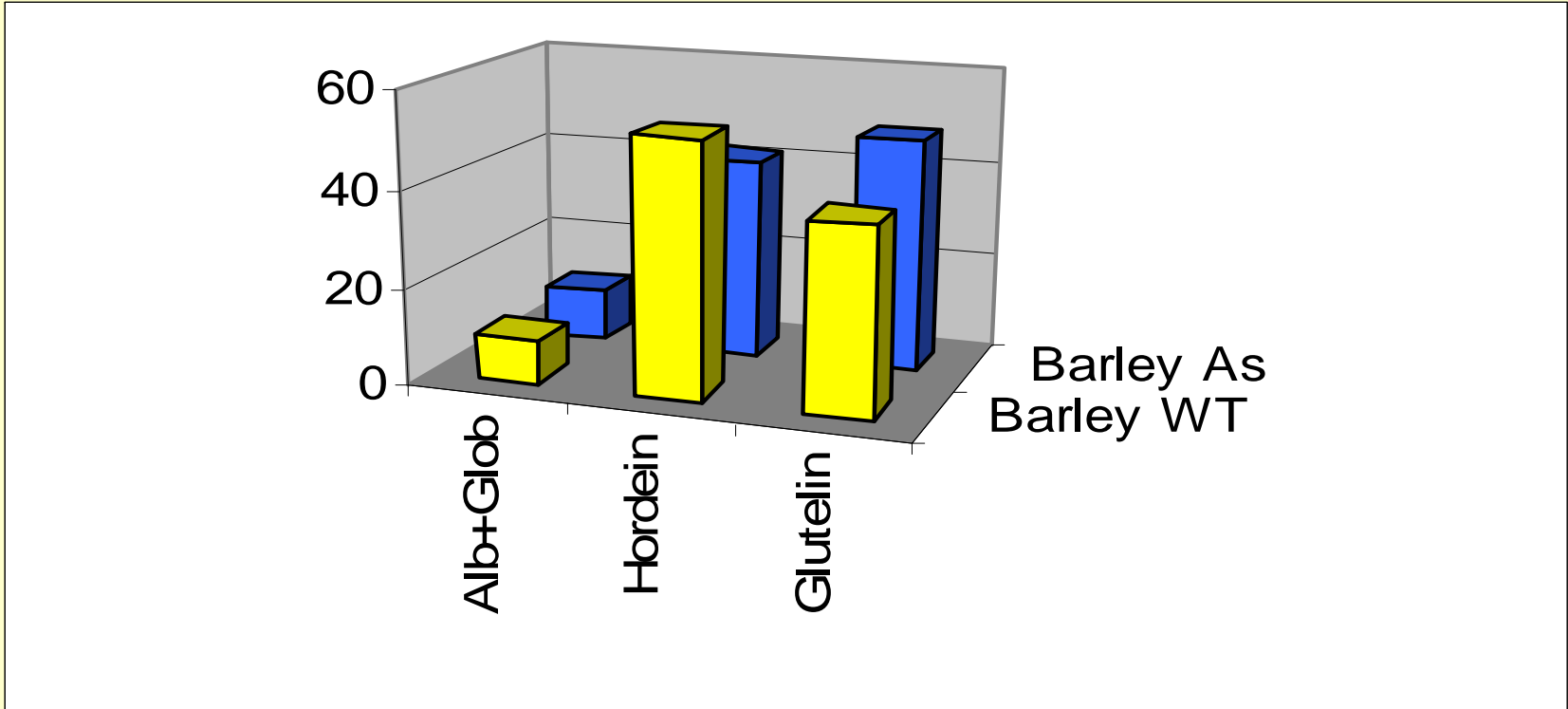
Transformation of *Brassica napus* with an antisense gene for cruciferin

Kohno-Murase et al. TAG 1995, 91, 627

Amino acid	CA#3	W e star	(%)
Cys	10,8	8,3	132
Lys	5,3	4,8	110
Met	1,3	1,2	108
His	2,9	2,7	107
Pro	7,8	7,4	105
Val	6	5,8	103
Glx	17,9	17,6	102
Thr	4,5	4,5	100
Ser	4,4	4,5	98
Ile	3,7	3,9	95
Gly	7,5	8	94
Ala	6,7	7,1	94
Leu	6,9	7,4	93
Phe	3,2	3,6	89
Arg	4,5	5,1	88



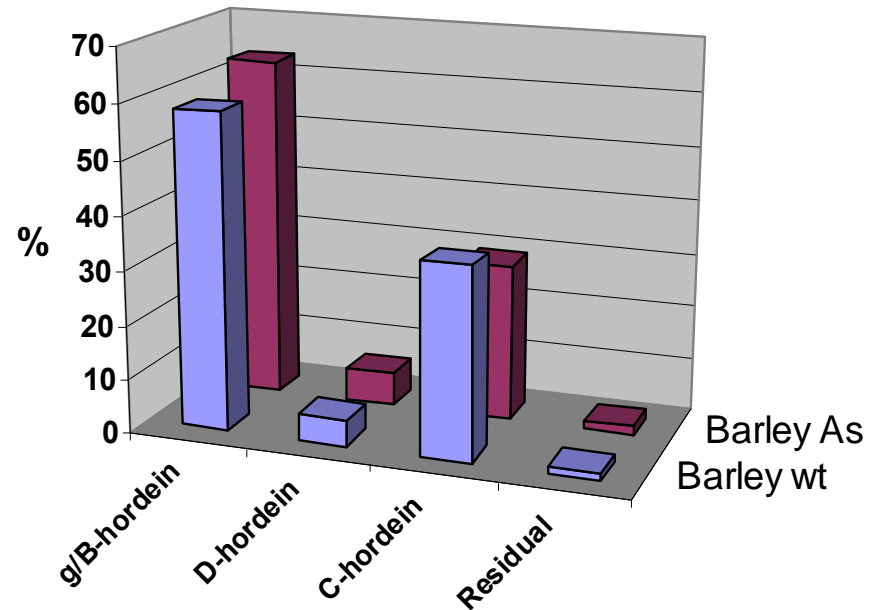
Relative proportions of albumin/globulin, hordein and glutelin in wt and As lines



	Alb/Glob %	Hordein %	Glutelin %
Wild type barley	9,2	52,3	38,5
Antisense barley	10,8	41,5	47,9

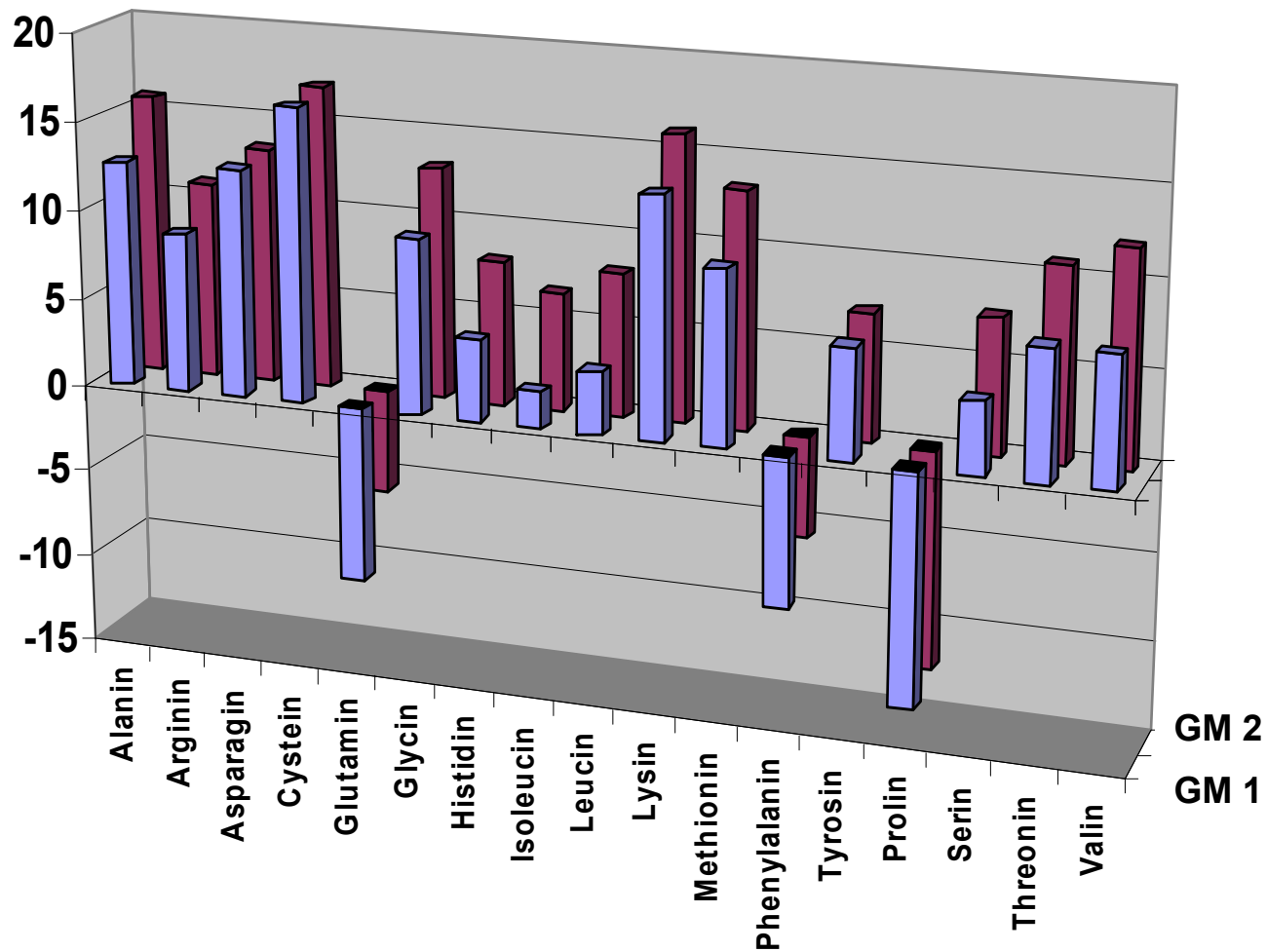


Relative proportions of γ /B-, C- and D-hordein in wt and As lines



	γ /B-hordein %	D-hordein %	C-hordein %	Residual %
Wild type barley	58.5	4,9	35,4	1.2
Antisense barley	63.4	6,0	29,1	1.5

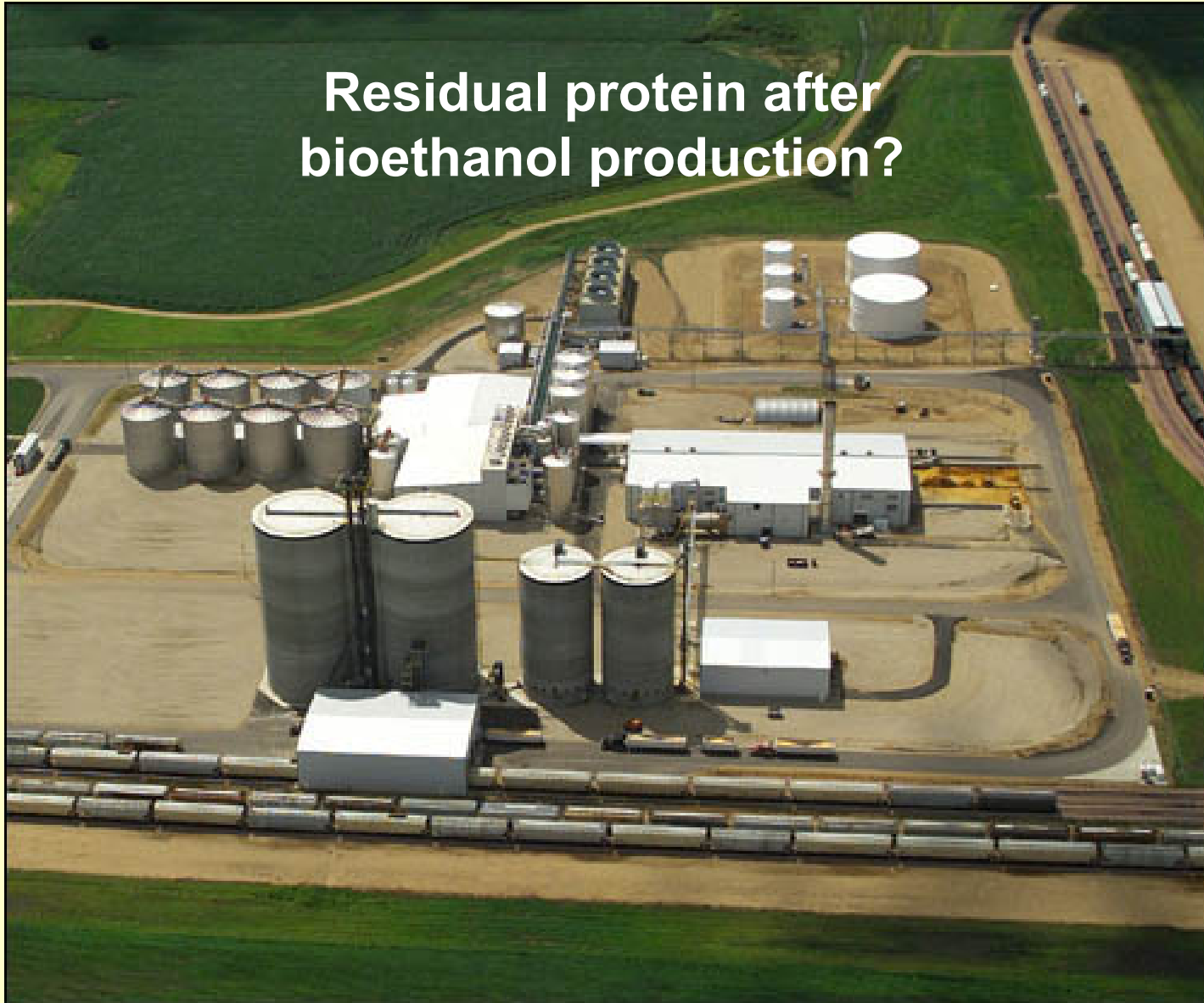
% changes in amino acid composition



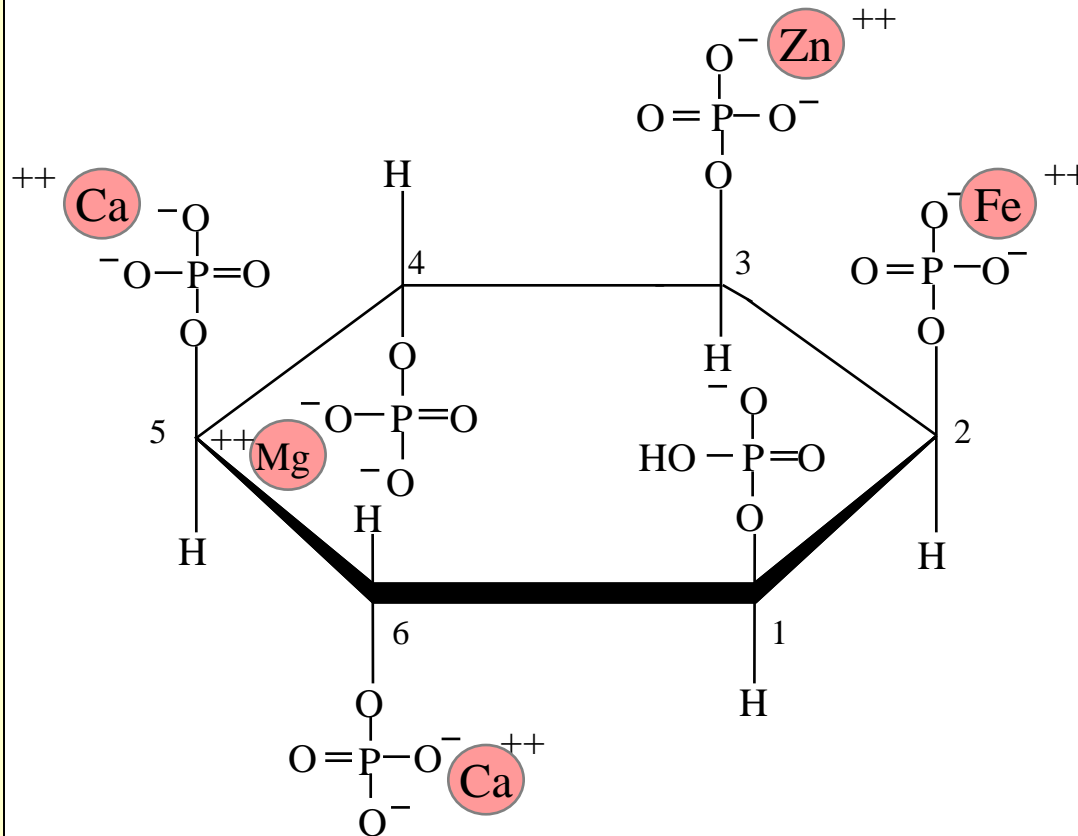
Lange et al. 2007 J. Agr. Food Chem. in press



**Residual protein after
bioethanol production?**



Phytic acid



- 70-80% of the phosphate reserves in seeds are bound as phytic acid.

- **Phytic acid:**

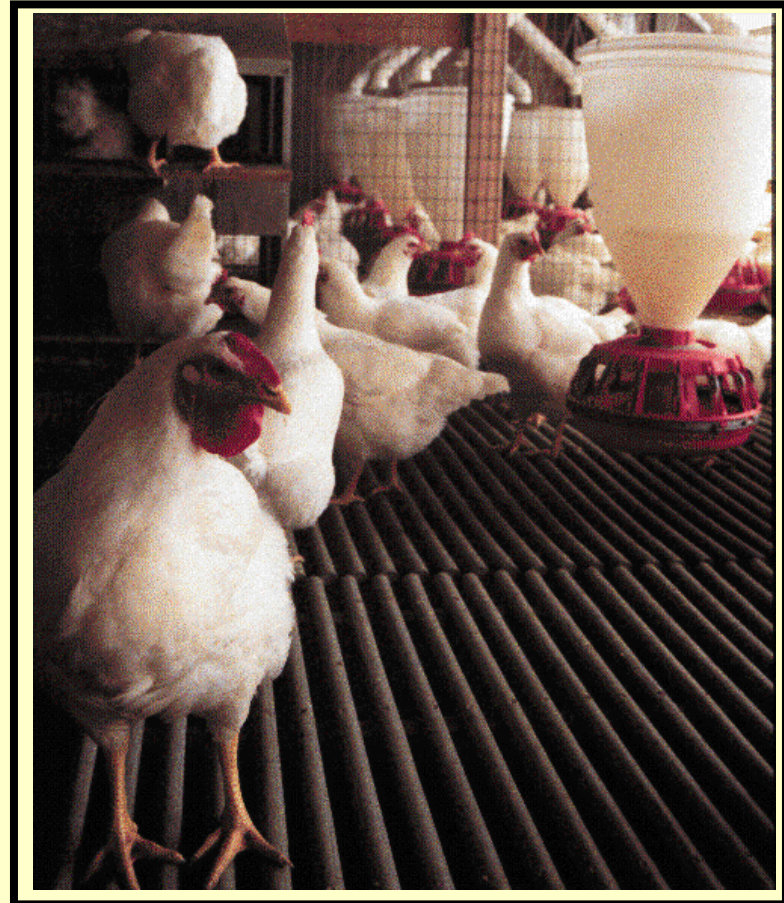
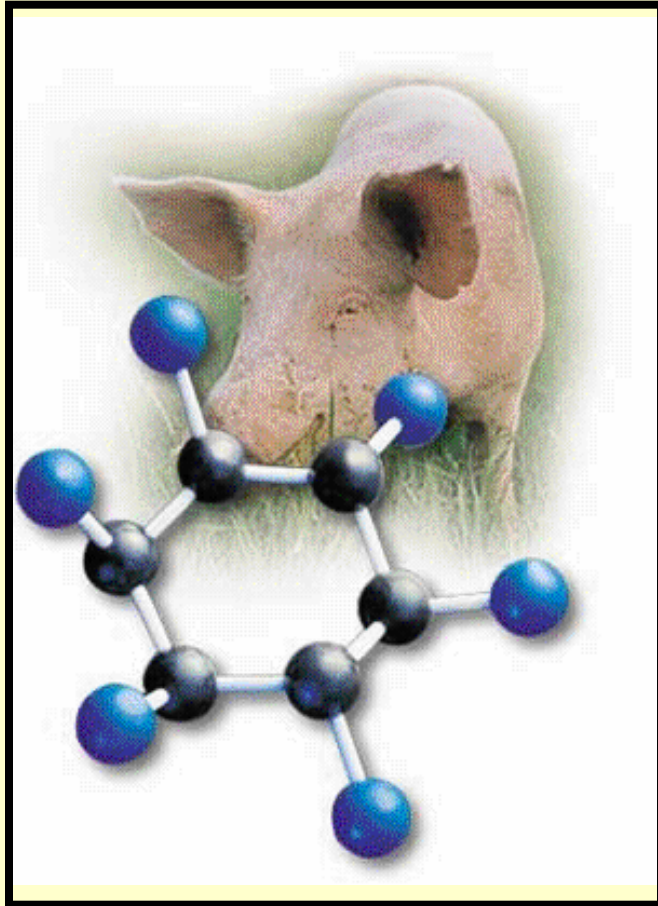
- is largely indigestible for monogastric animals

- inhibits the uptake of zinc, calcium and iron

- inhibits the uptake of amino acids/protein and starch

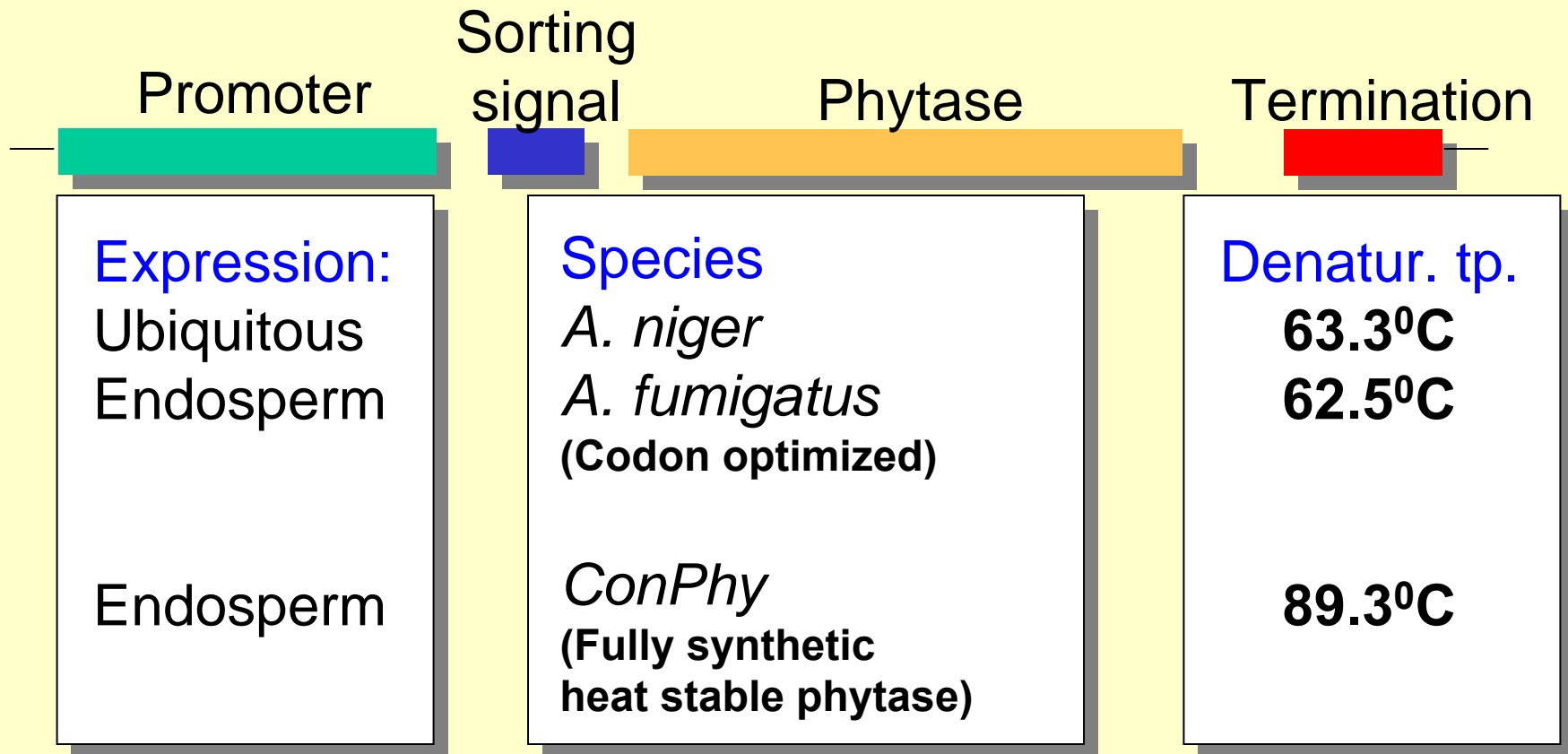
- may have anti-carcinogenic properties in the colon

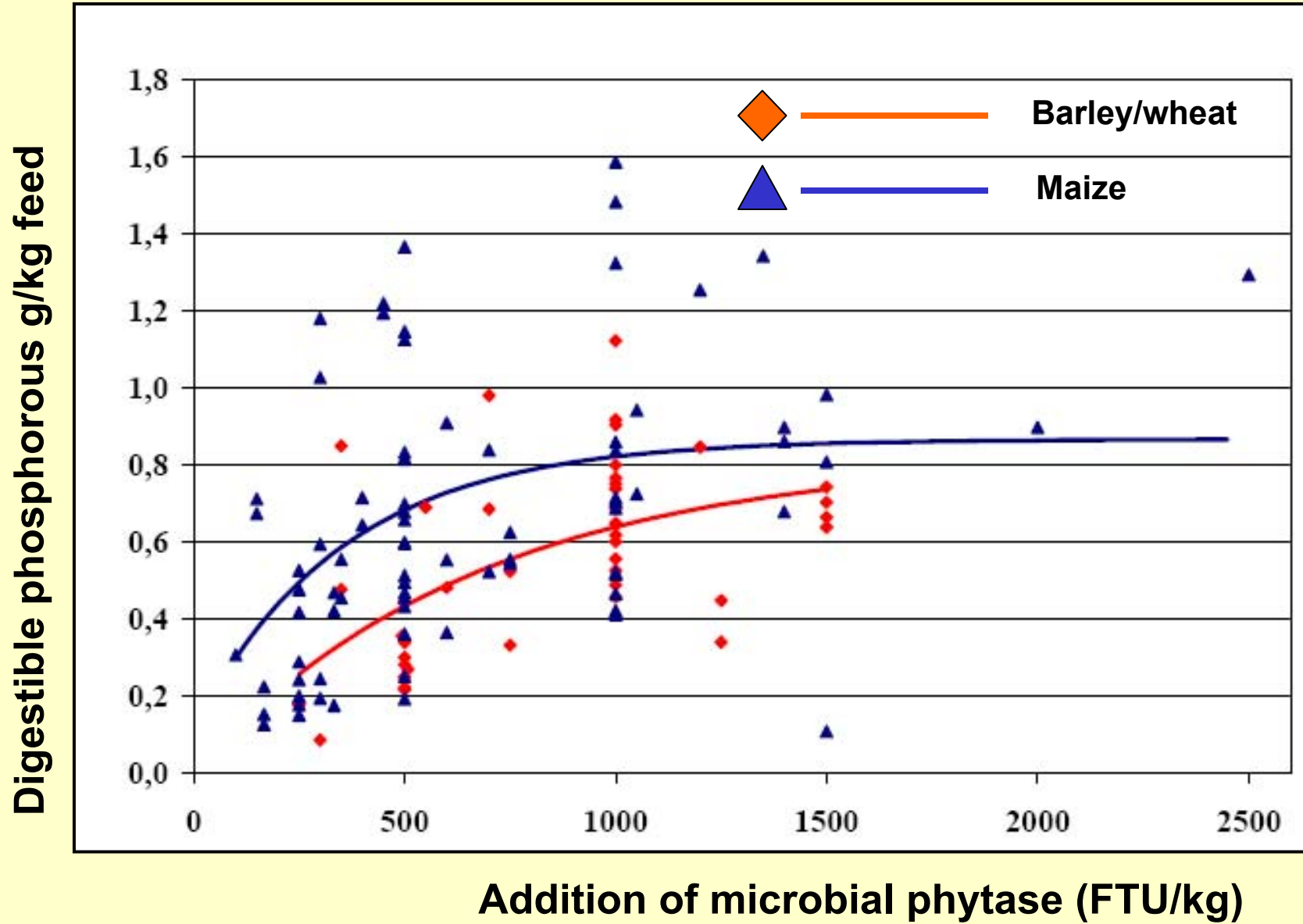
”Phytase, the wonder enzyme of the nineties”



The phytase market is currently the fastest growing among industrial enzymes with an annual value of €150 mill

Increasing the seed phytase activity in wheat and barley





Johansen og Poulsen 2003



**Thank you for
your attention**

