Effects of genetics of wheat and broilers on digestive efficiency

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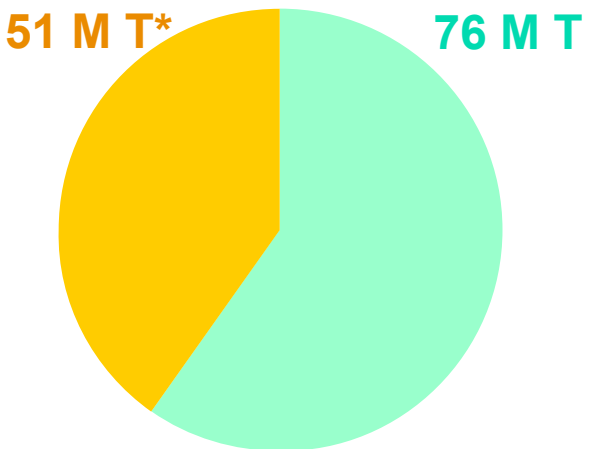
2012

Cereal productions and utilizations in EU

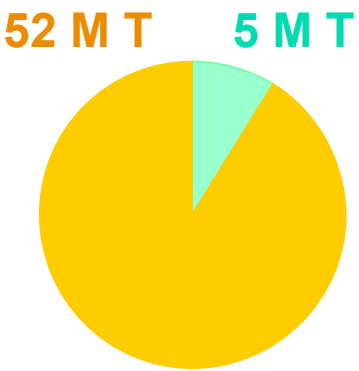
Animal consumption

Other utilizations

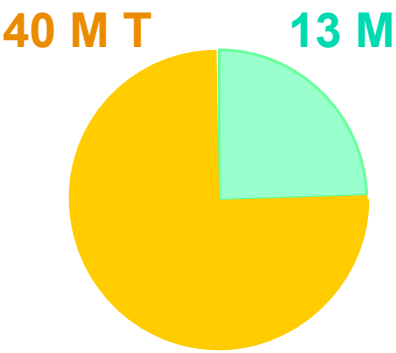
Wheat



Maize



Barley



*Millions tons per year, 2010/2011

Source : AGPB, France

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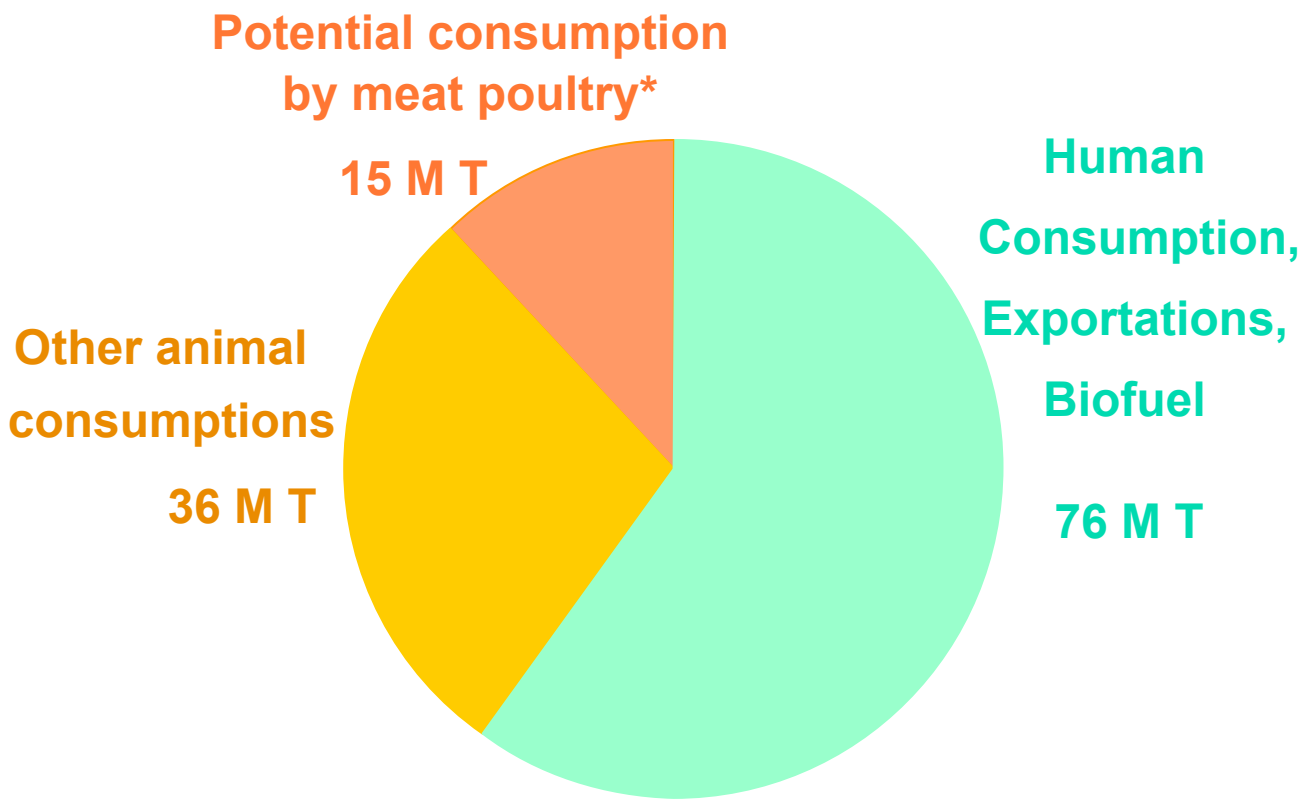
Distribution of the utilization of wheat produced in Europe



*Deduced from the european production of meat poultry : 15 M Tons (source : ITAVI, France)

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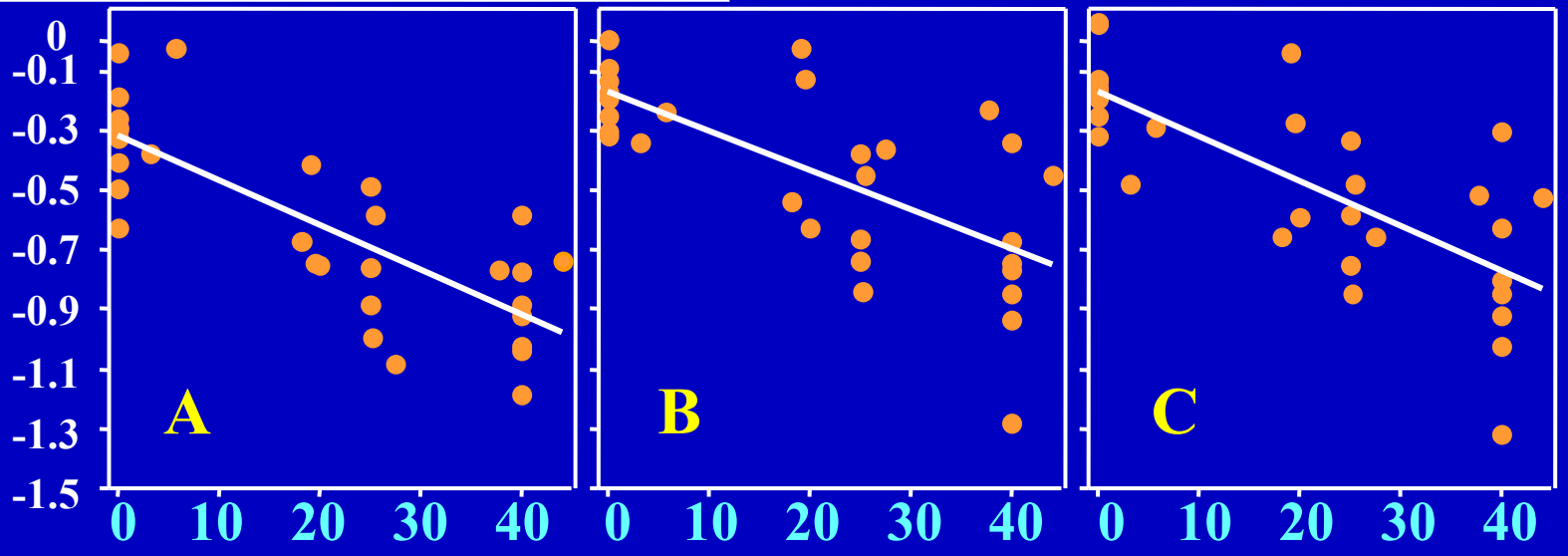
Wheat is often
a major ingredient
of broiler diets
in Europe

Differences between mean measured and calculated AMEn values of 30 diets in 4w broilers

Measured AMEn – calculated AMEn (MJ / kg DM)



Wheat introduction in diets (%)

Calculated AMEn (MJ/kg DM)

A 0.155 Nx6.25 + 0.343 Lip. + 0.167 Sta. + 0.130 Sug.

B 0.9362 GE - 0.0644 Nx6.25 - 0.105 $WICW^{1.2}$

C 16.68 + 0.197 Lip. - 0.222 Ash - 0.187 WICW

After Carré et al., 2002. ENC, Guelph. 139-149.

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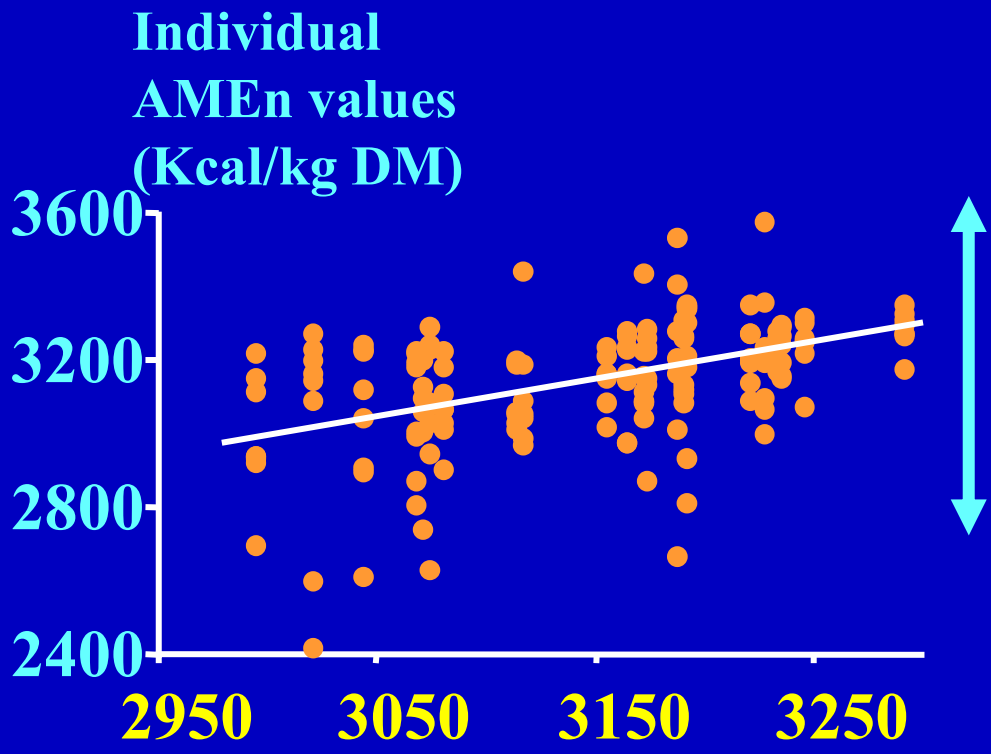
Unexpected low energy values
can be observed
with wheat introduced
in broiler diets

Variations of AMEn values of 22 wheat diets differing only by the wheat cultivar, in 3w broilers.



Variability from individual birds

900 Kcal/kg DM

300 Kcal/kg DM

Variability from wheat cultivars

After Carré et al. 2002

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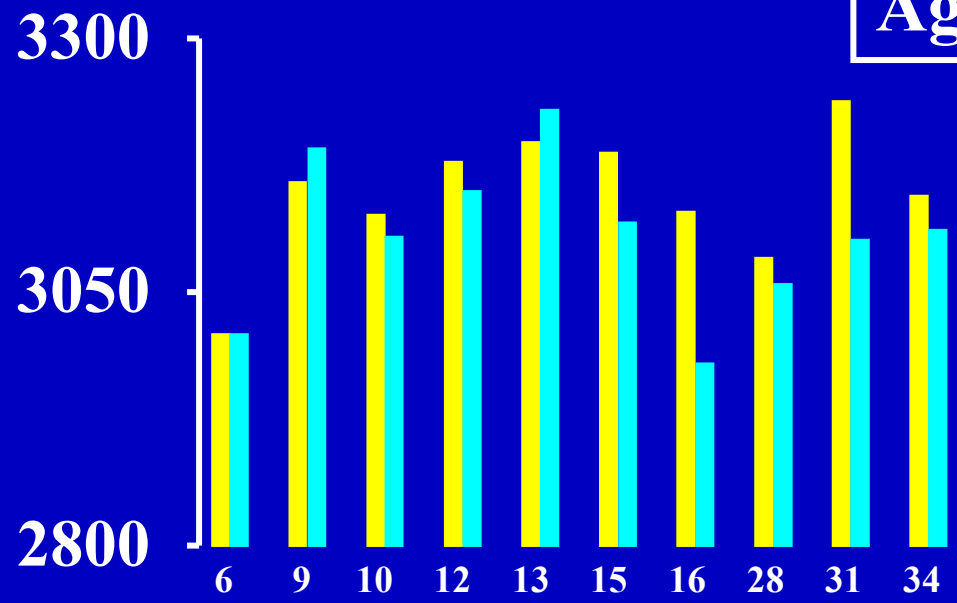
Wheat in broiler diets
induce a great variation
in AMEn value of diets,
coming both from

wheat cultivar

and

individual birds (900 Kcal/kg)

AMEn value of wheat in 3w broilers (Kcal/kg DM)



Effects	*P*
Cultivar	0.0001
Agronomy	0.0354

Carré *et al.*, FSOV, 2011

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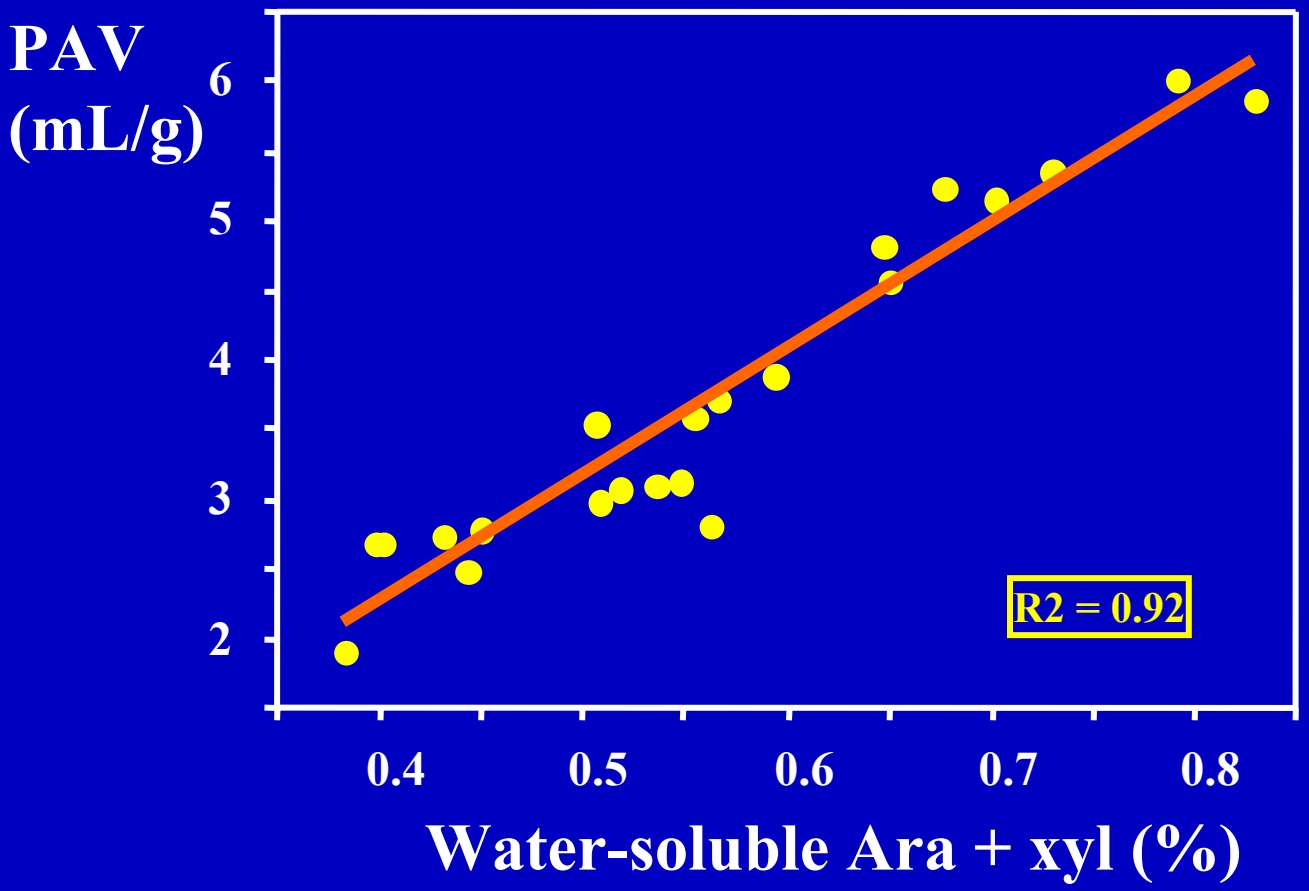
Relationship between viscosity of wheat water-extract [potential applied viscosity (PAV)] and water-soluble arabinoxylan content of wheat among 22 wheat cultivars



Carré et al., 2002

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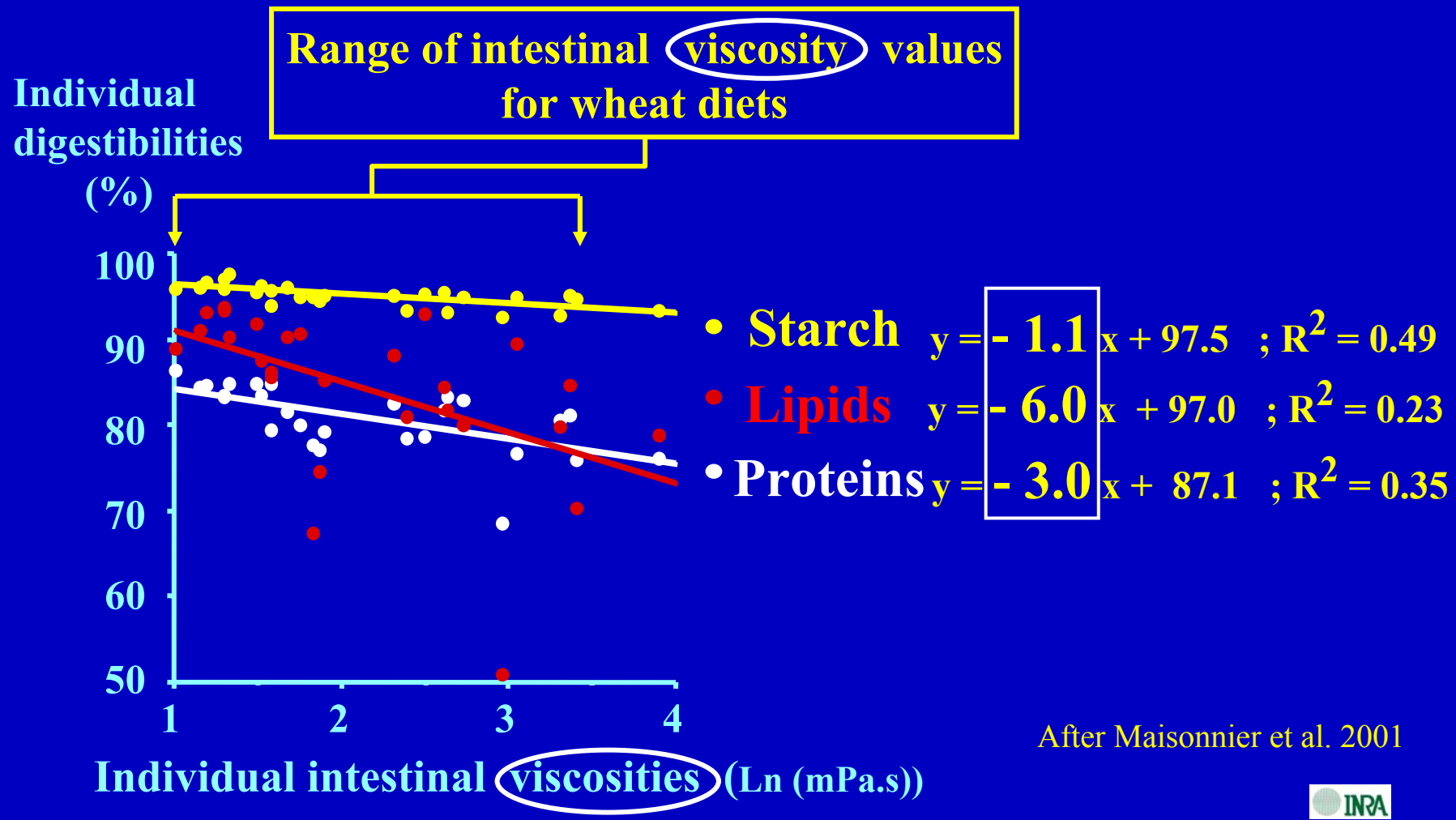
Digestibility variations due to intestinal viscosity, in broilers fed with maize diets added with graded levels of guar gum (0, 0.1 and 0.3 %)



After Maisonnier et al. 2001

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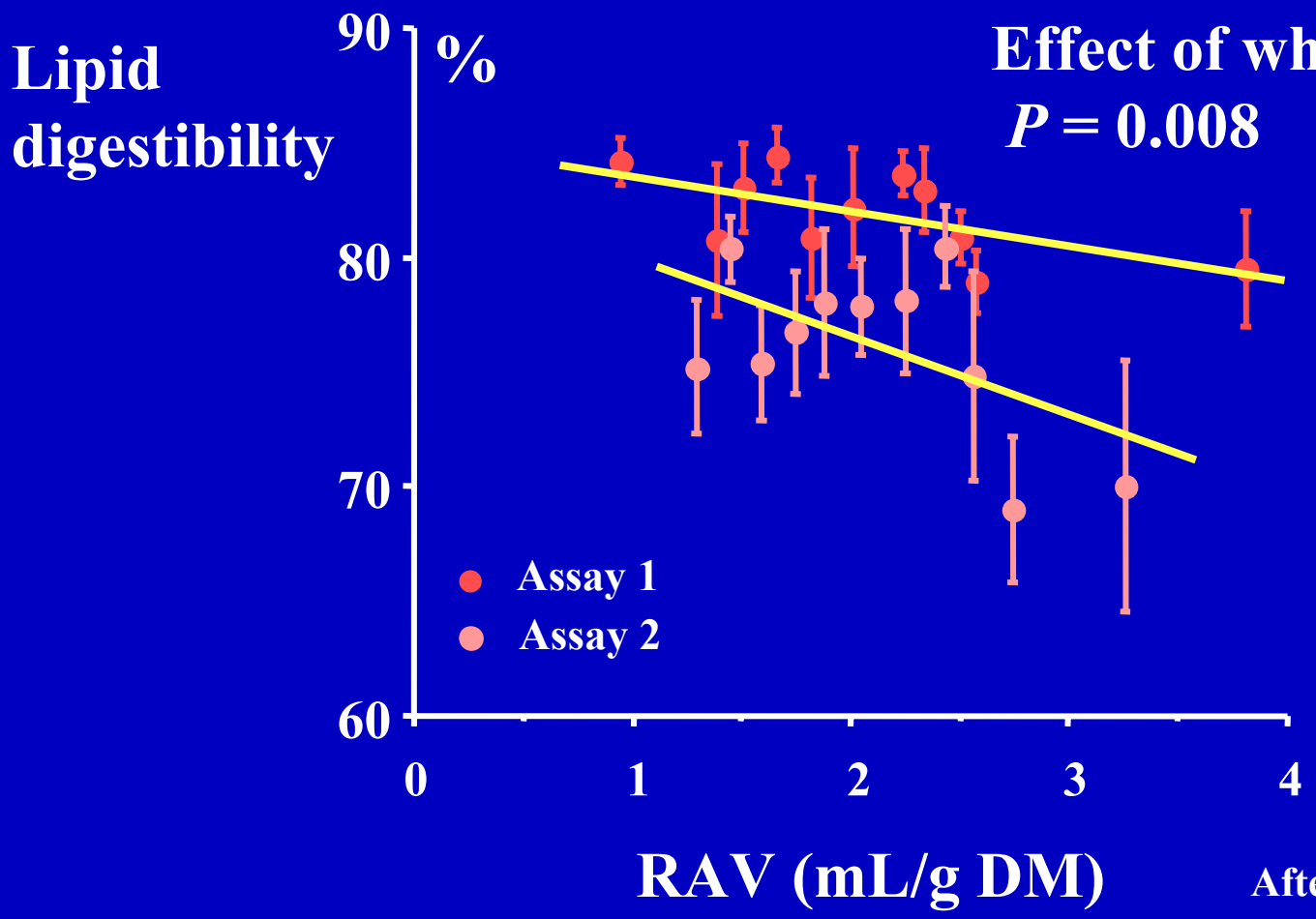
Effect of viscosity (RAV) of wheats (55% in diets) on lipid digestibility in 3 w. broiler chickens.



After Carré et al. 2002

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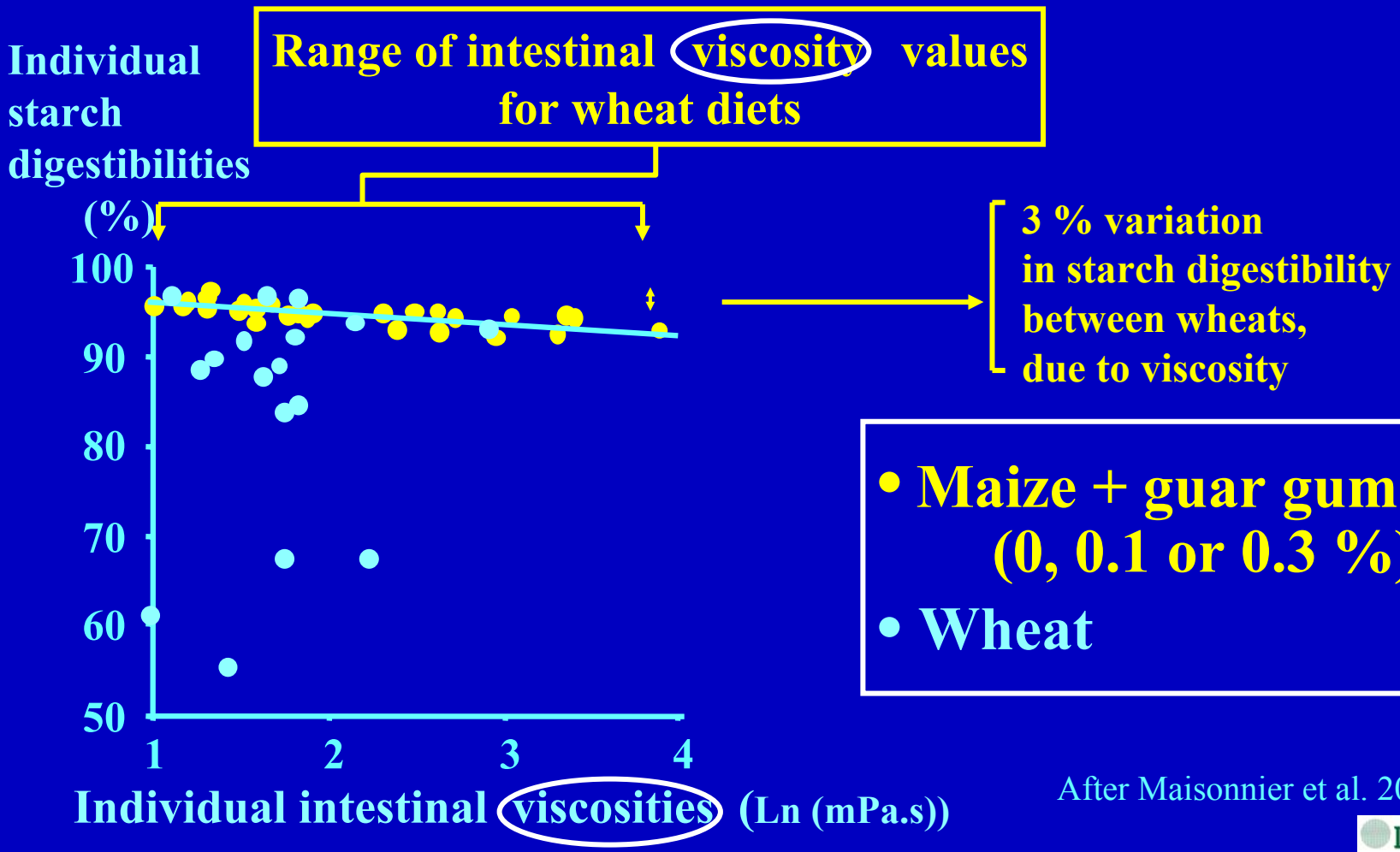
Starch digestibility variations due to intestinal viscosity , in broilers fed with guar gum (0, 0.1 and 0.3 %) maize diets or with wheat diets



After Maisonnier et al. 2001

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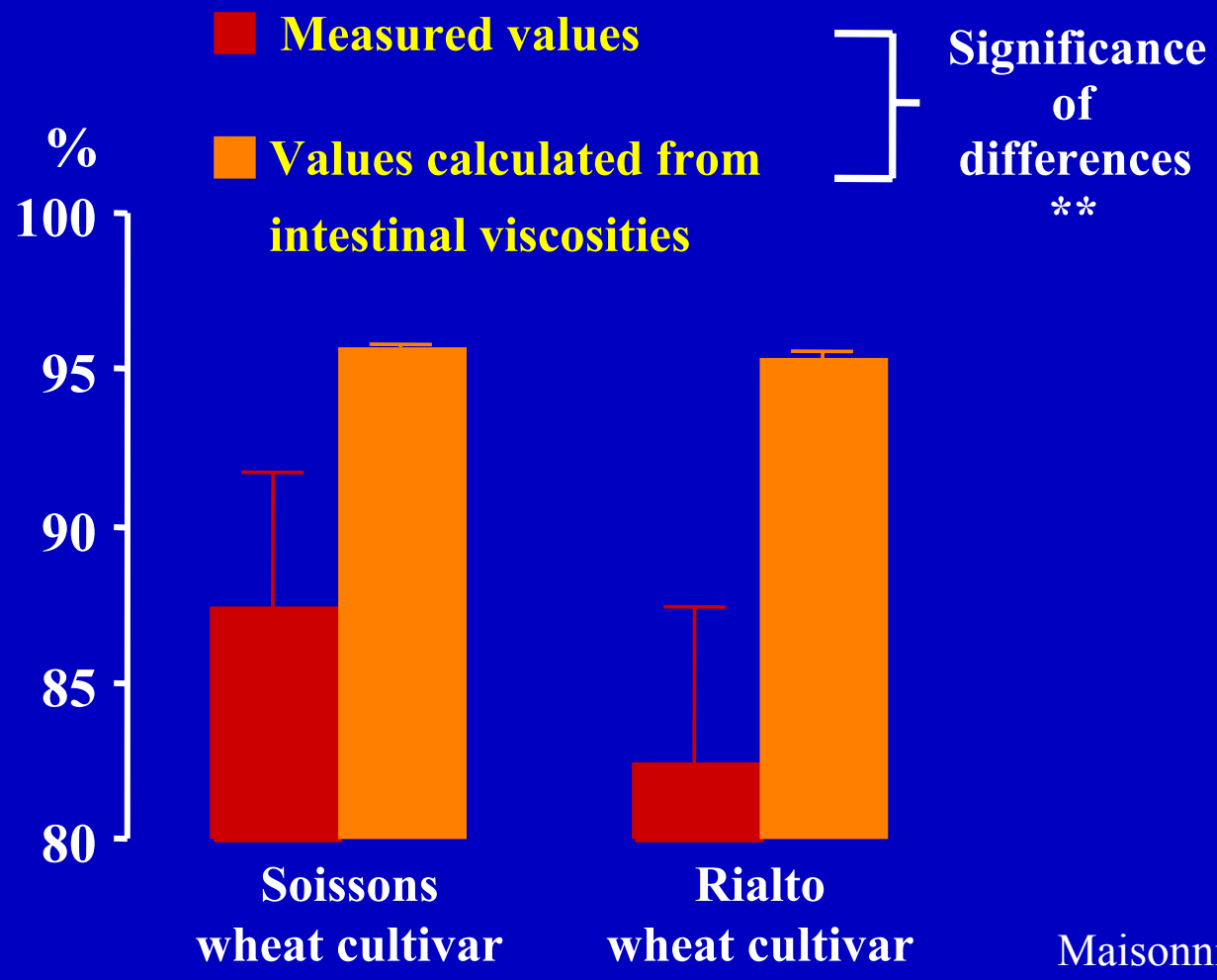
Digestibility of starch in 3 w. broiler chickens fed on pelleted wheat diets



Maisonnier et al. ,2001

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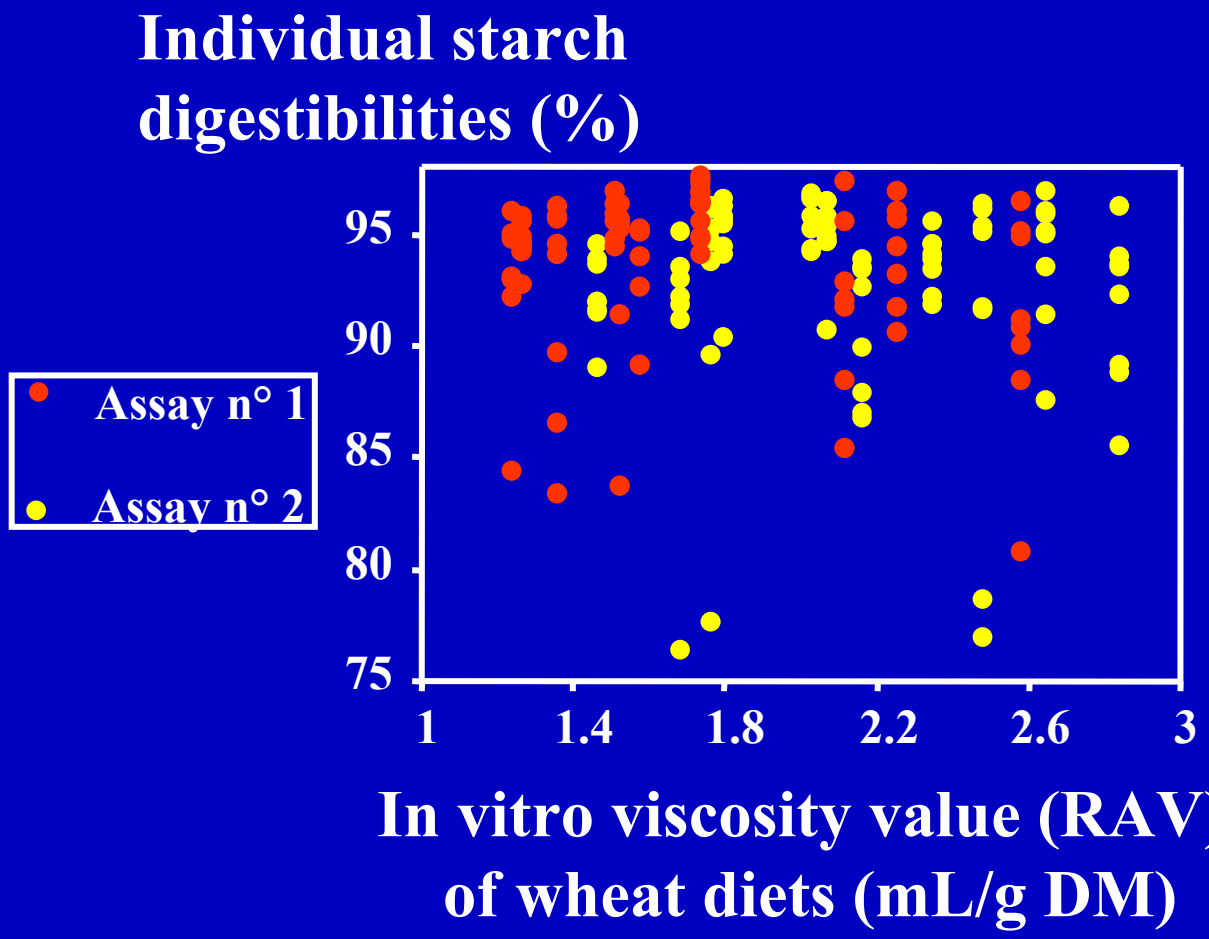
Starch digestibility in broiler chickens fed with pelleted diets containing 55% wheat



No significant effect of *in vitro* viscosity

After Carré et al. 2002

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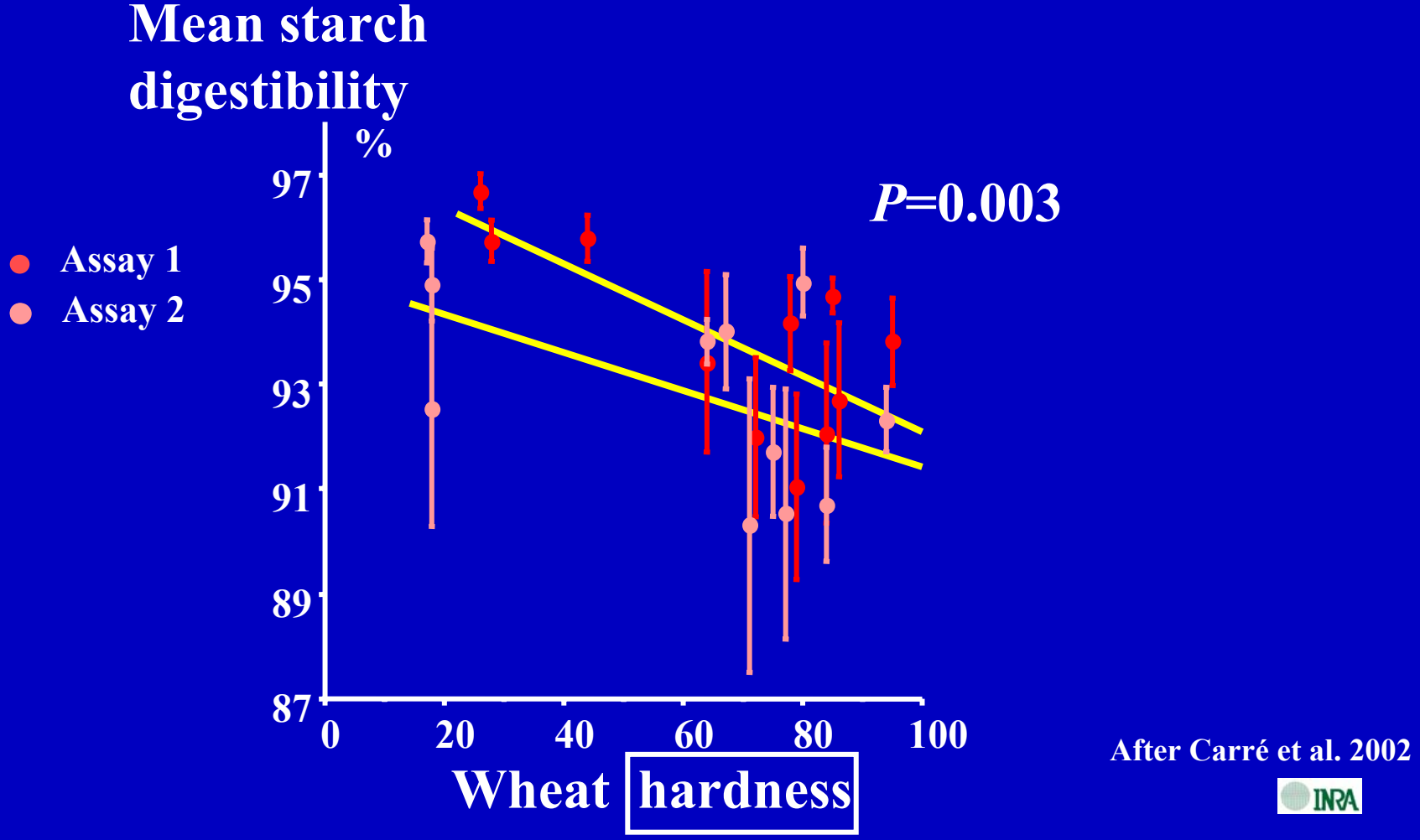
Relationship between starch digestibility and hardness of wheat, in 3 w. broiler chickens fed on pelleted wheat diets



After Carré et al. 2002

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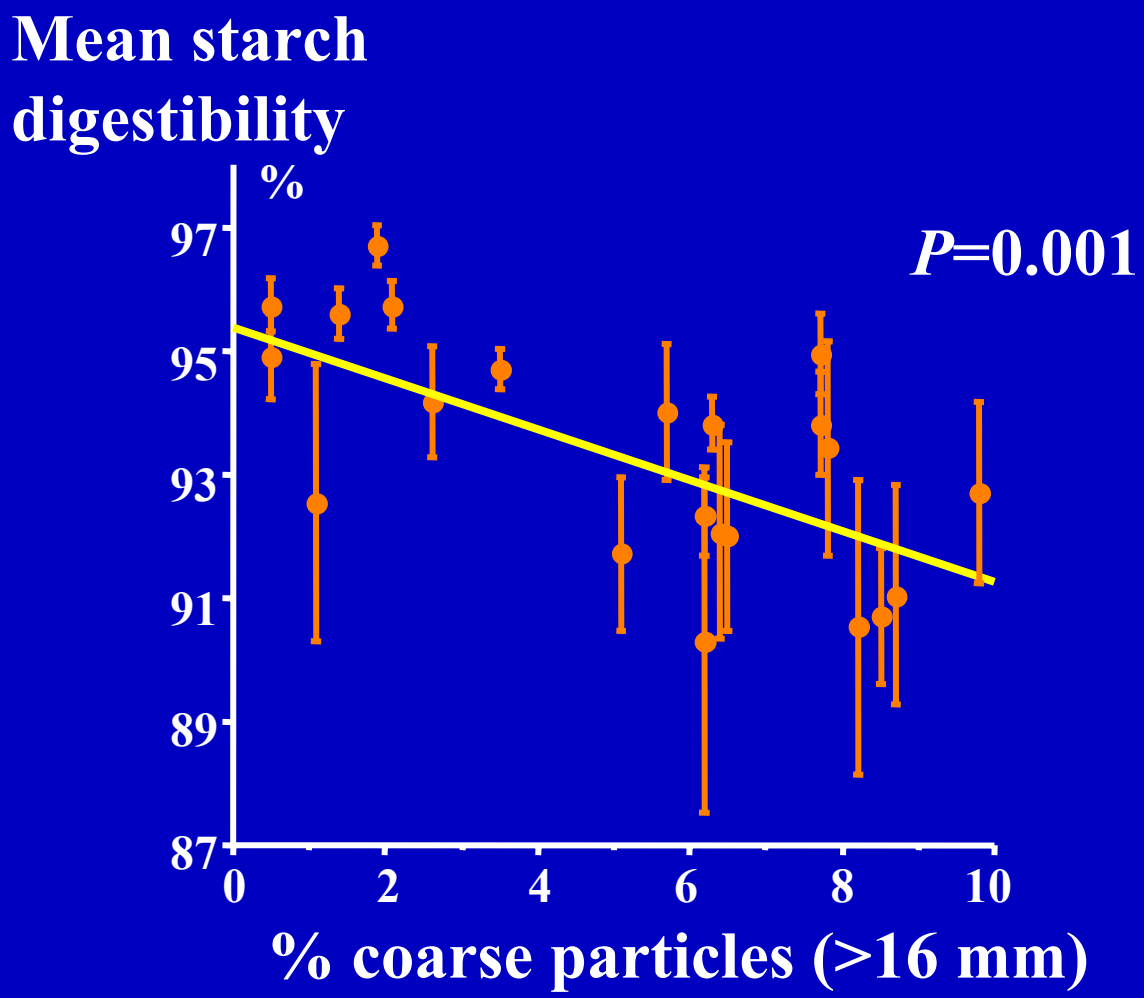
Relationship between starch digestibility and particle size of wheat flours before pelleting, in 3 w. broiler chickens fed on pelleted wheat diets



After Carré et al. 2002

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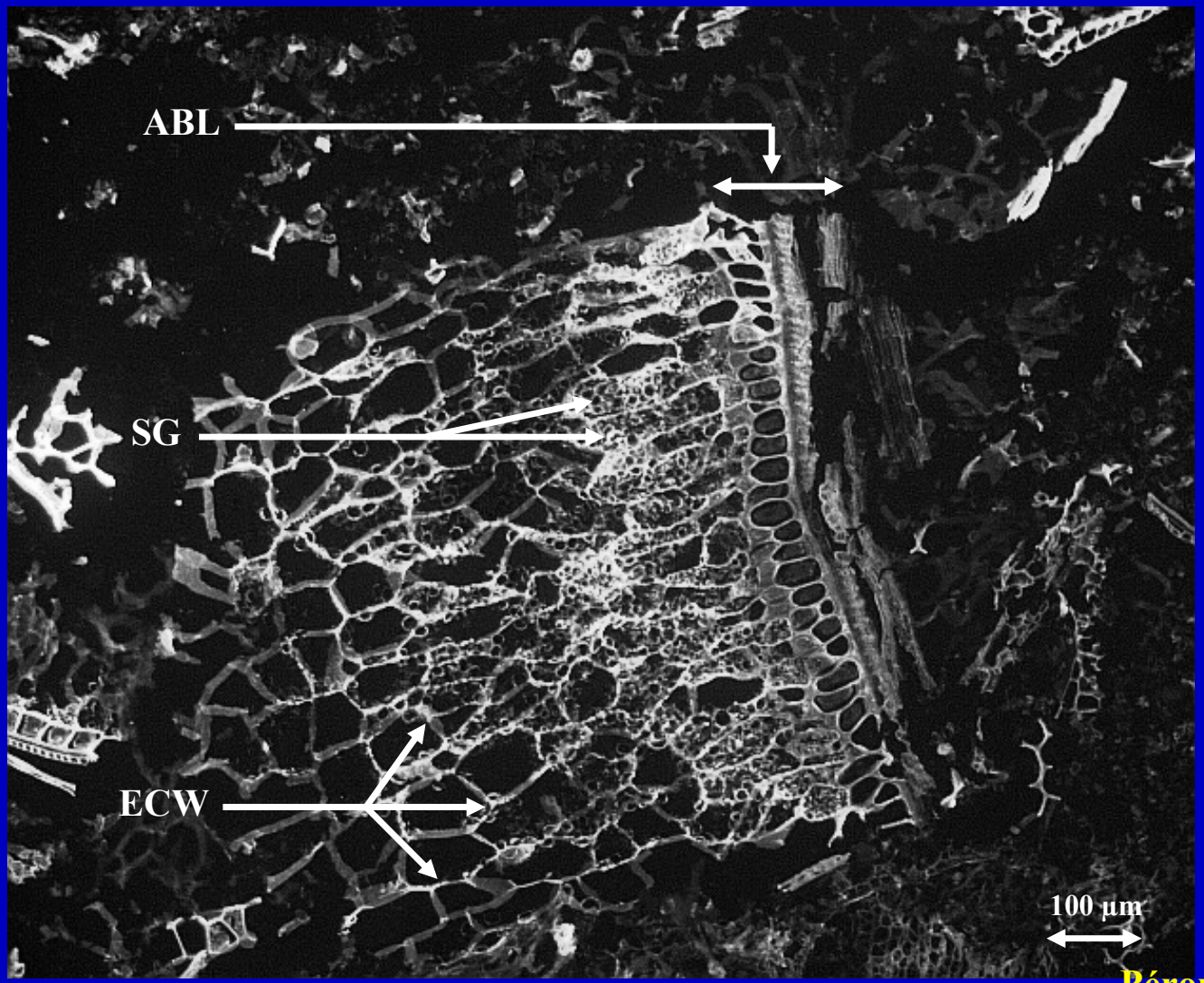
Photomicrograph of a wheat particle in chicken ileum content : undigested starch granules (SG), endosperm cell walls (ECW), aleurone+bran layer (ABL).

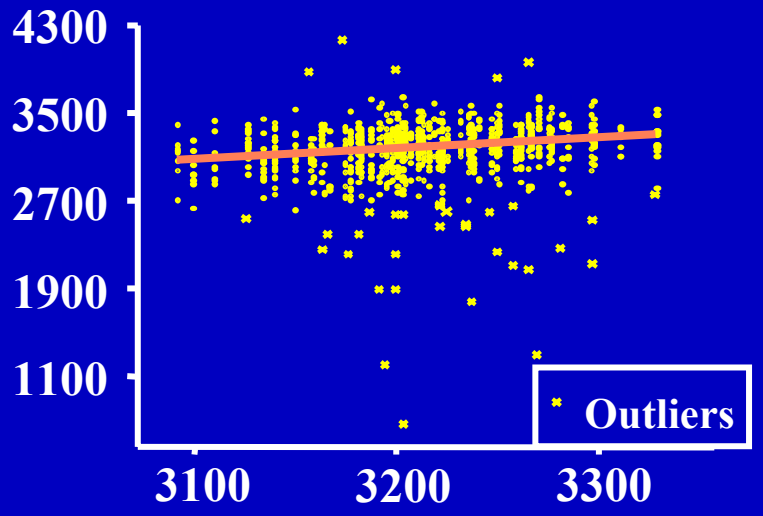


Péron et al., 2007

Regression using 9 assays (Carré *et al.* (2002, 2005, 2010), combining 77 different wheat samples and 893 3w broilers

Wheat AMEn* in 3w broilers (Kcal/kg DM)

*Values are corrected for assay effect



R^2 = 0.072
RSD = 172
P = 0.0001
n = 858 broilers

8% variation in wheat AMEn

AMEn = 3708 – 34.5 WICW – 1.12 H – 33.4 RAV

WICW : Water-insoluble cell-wall (% DM)
H : Hardness (from de 1 à 100)
RAV: Real Applied Viscosity (ml /g DM)

Carré *et al.*, 2010.
13th EPC, Tours

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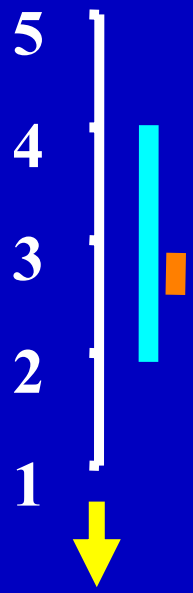
Wheat variations from cultivars and environments

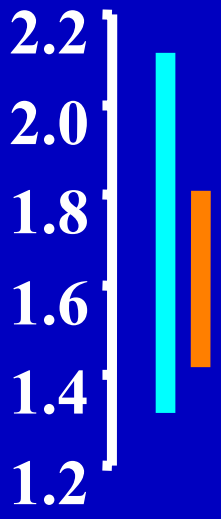
Maxi
Mini : | Cultivars (12) | Environments (6)

Water extract viscosity

PAV

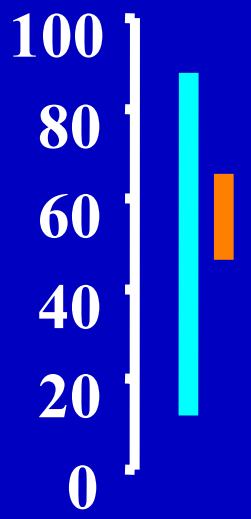


RAV

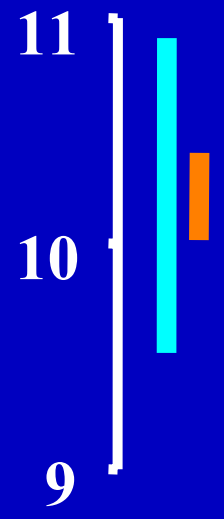


Insoluble fibre

Hardness



WICW



After Oury et al. 1998

Candidate genes on wheat chromosome 1B (Quraishi *et al.*, 2011)

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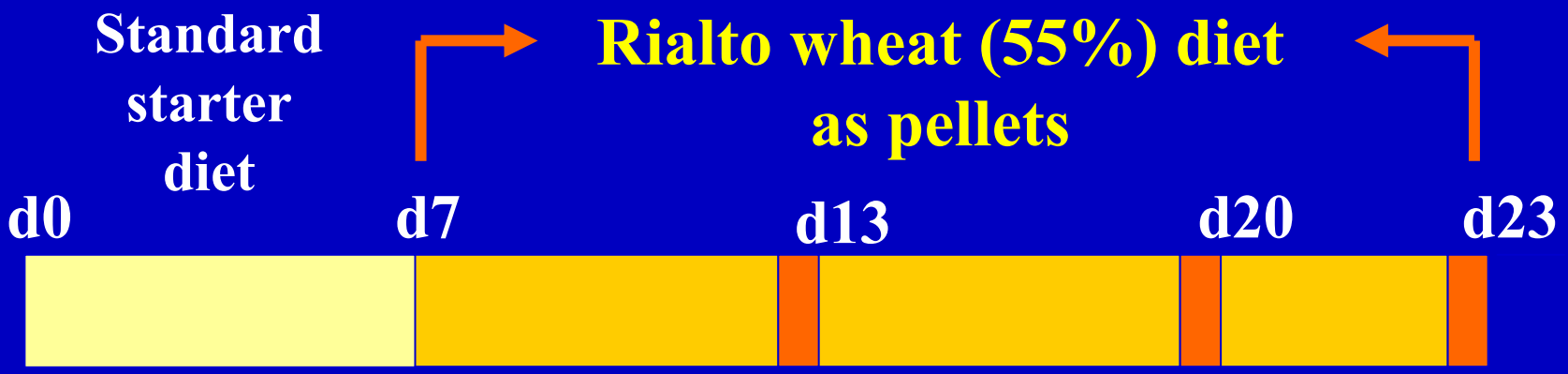
The energy value of wheat for broilers can be improved using cultivars with

low hardness,

low viscosity

low insoluble fibre

Determination of metabolisable energy (AMEn) for the selection of divergent Digestion lines



Ad libitum feeding

Feed deprivation

Feed efficiency

AMEn and digestibilities

Excreta analyses by NIR

Mignon-Grasteau *et al.*, 2004
Poultry Sci. 83: 860.

Heritabilities and genetic correlations in Digestion lines (G0 + G1) (n=864)

	Dig. of Lipids	Dig. of Starch	Dig. of Prot.	Feed conv. d13-d20	AMEn d21
DL	*0.47±0.04*	0.54	0.70	-0.89	0.91
DS		*0.37±0.03*	0.74	-0.51	0.83
DP			*0.33±0.03*	-0.55	0.86
FC				*0.30 ±0.03*	**-0.82**
AMEn					*0.37±0.03*

Diet : 55% wheat from the Rialto cultivar

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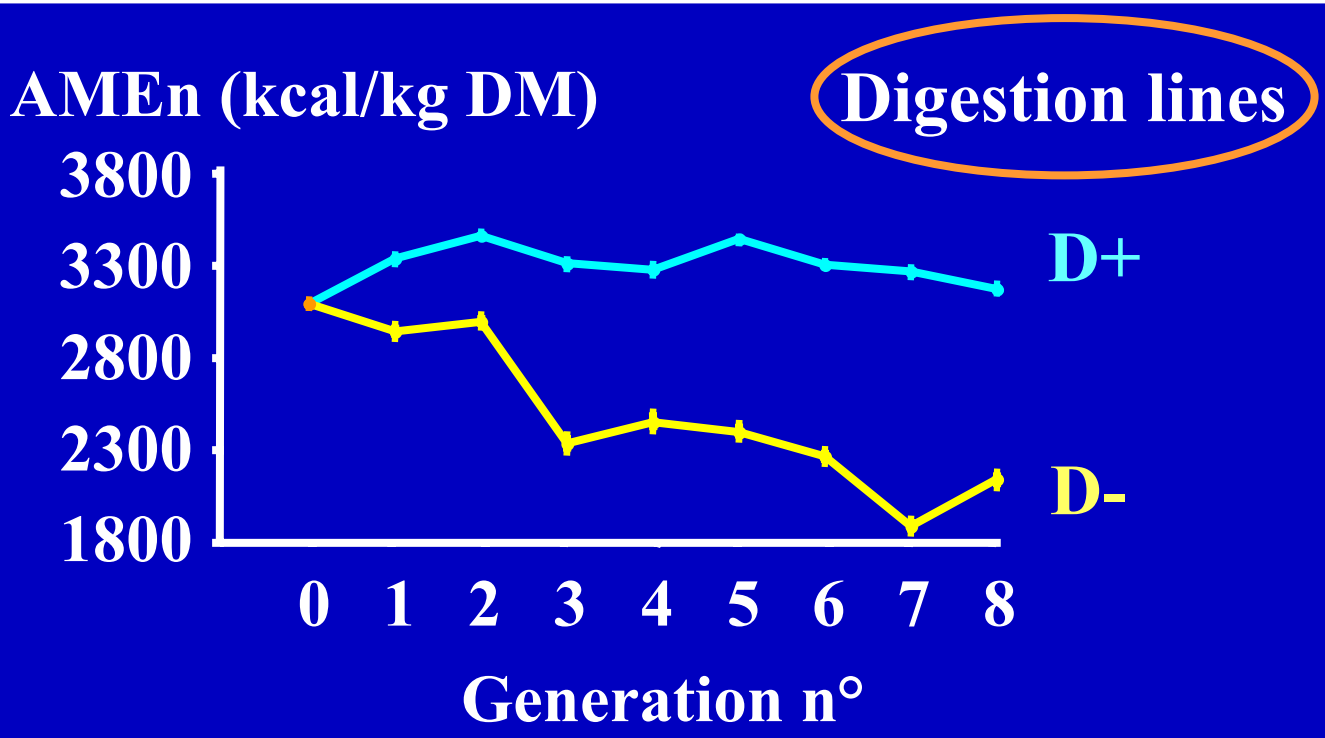
Mignon-Grasteau *et al.*, 2004 Poultry Sci. 83: 860.

A genetic divergent selection on AMEn measured at 3 weeks using a Rialto wheat diet* (Mean and SE, n= 210)



Origine : commercial pure sire broiler line

Selection :12♂, 36♀ per line

*Mignon-Grasteau *et al.*, 2004. Poultry Sci., 83: 860.

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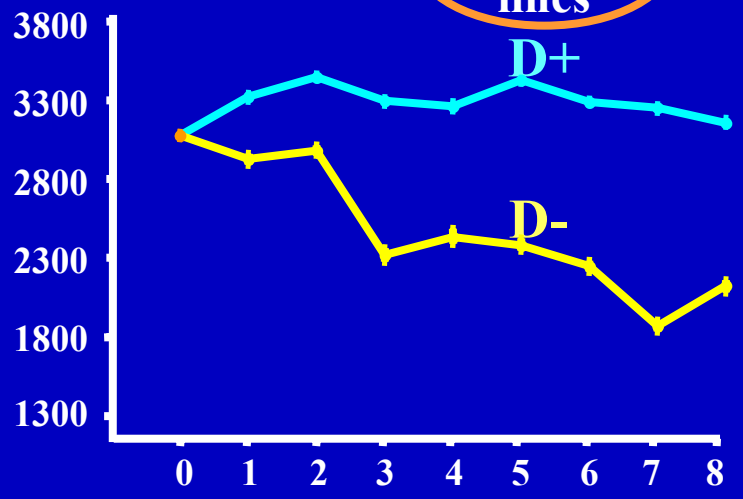
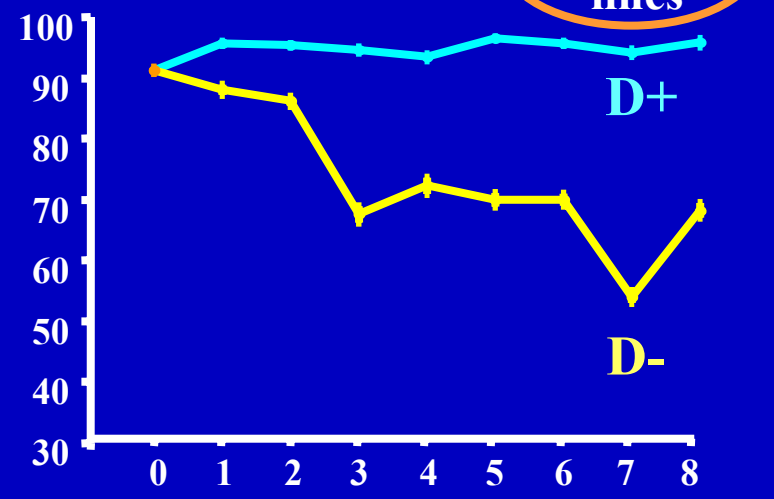
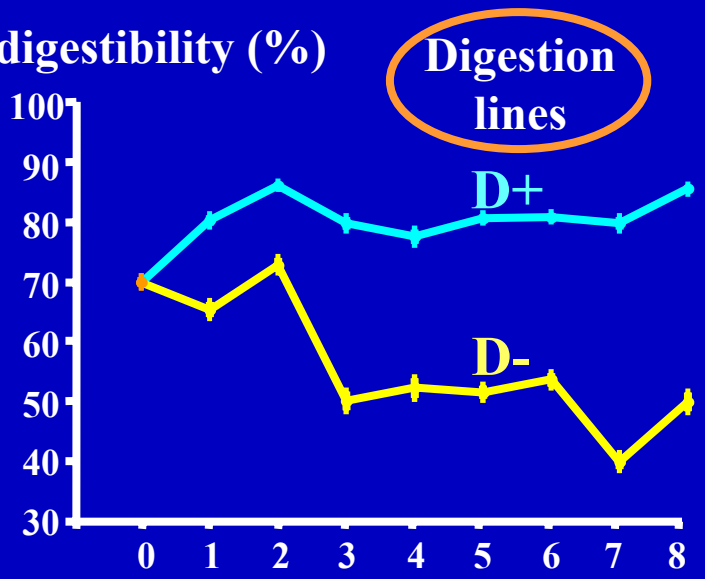
AMEn (kcal/kg DM)



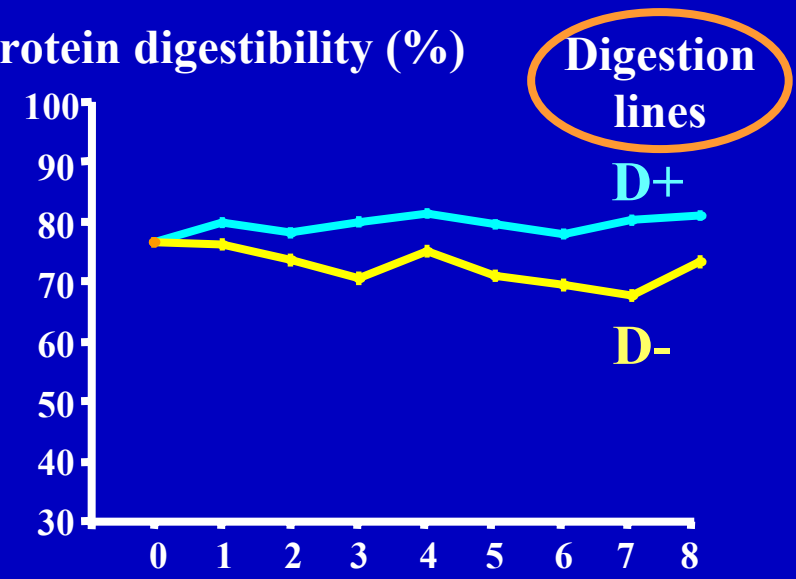
Starch digestibility (%)



Lipid digestibility (%)



Protein digestibility (%)



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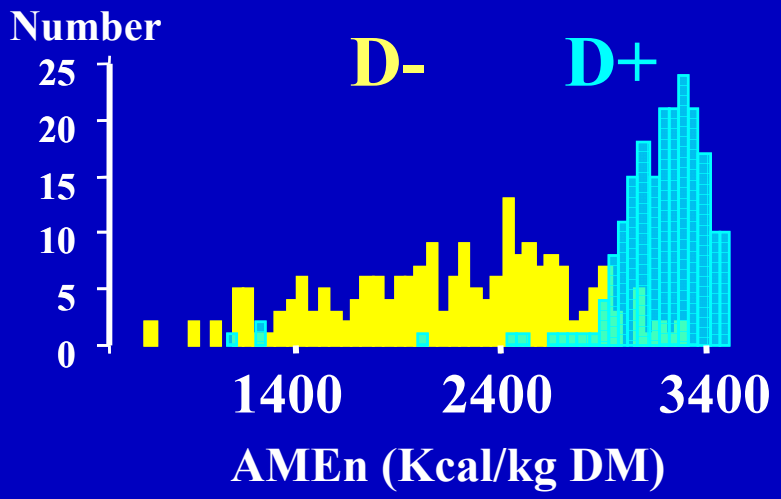
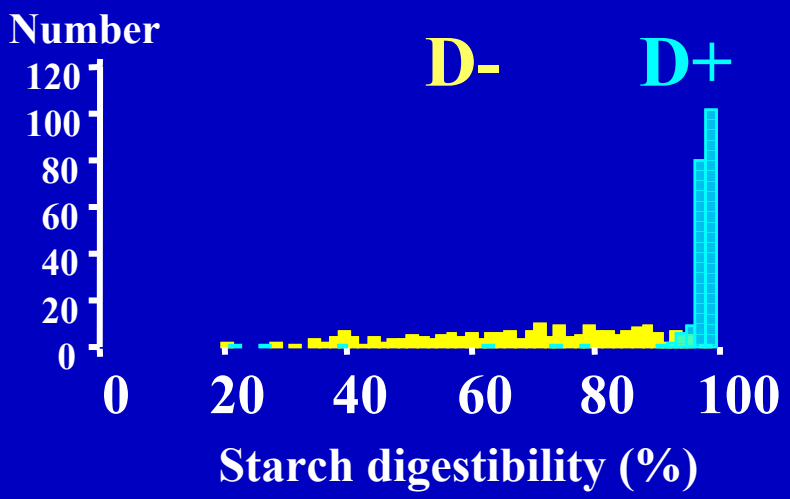
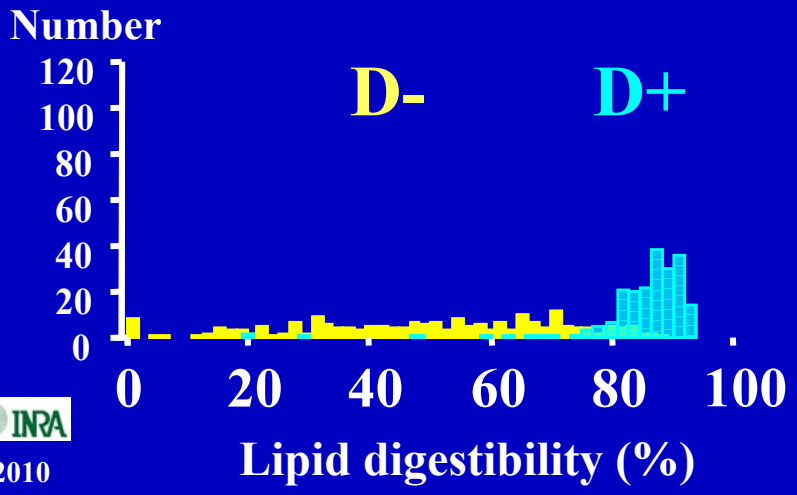
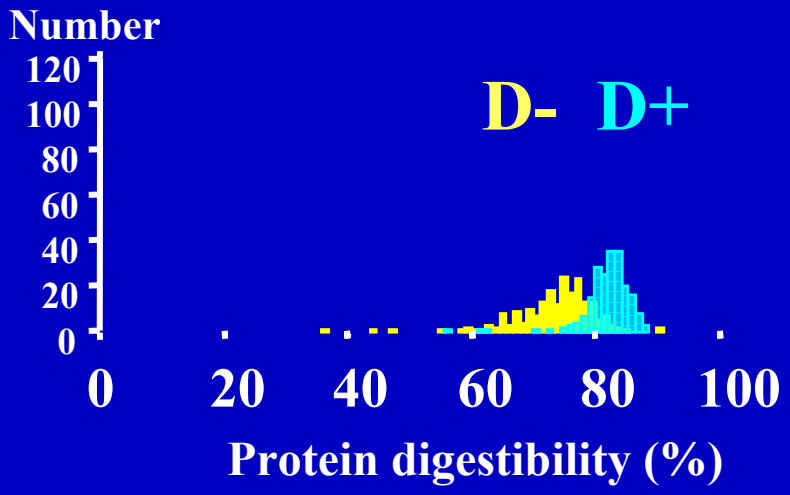
Distribution of AMEn and digestibility values in Digestion lines (G8) on a Rialto wheat diet









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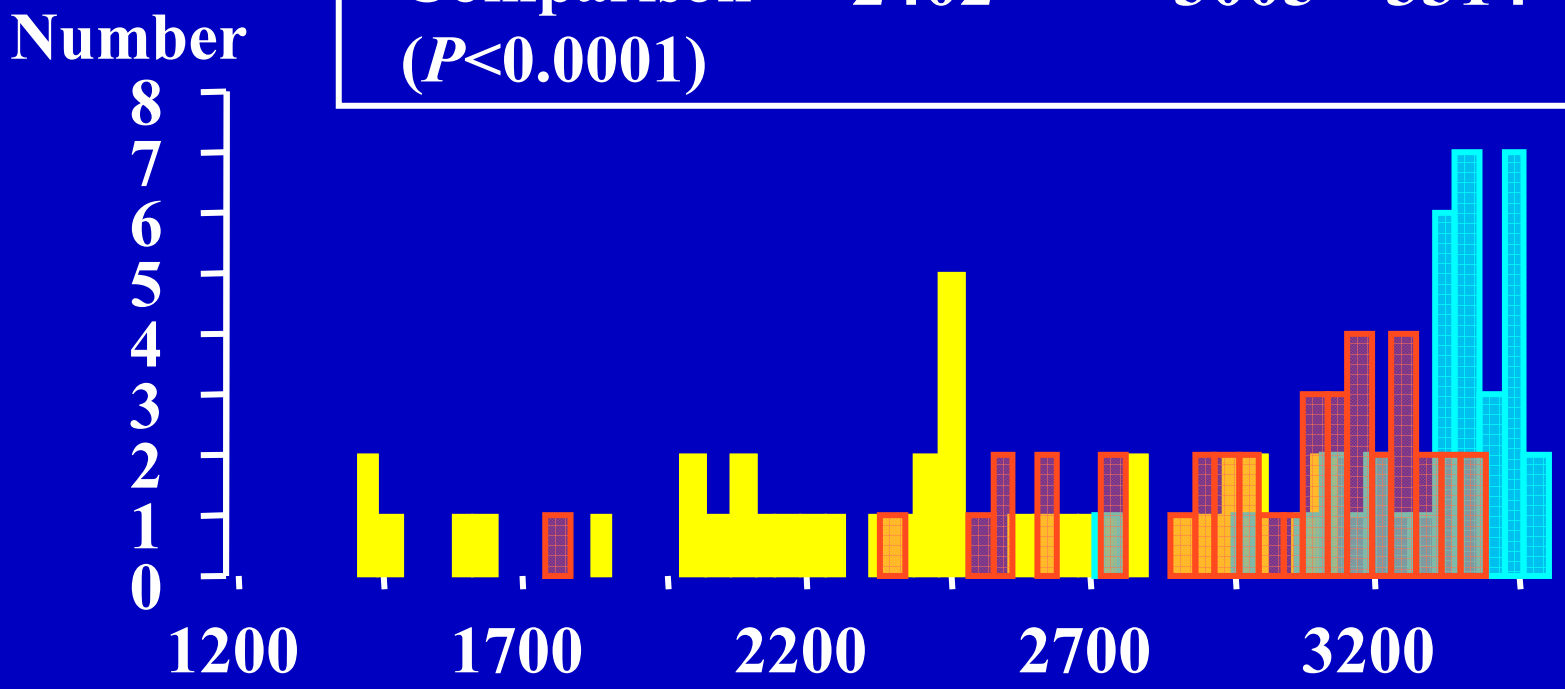
Distribution of AMEn values (Kcal/kg DM) of a Rialto wheat diet measured at 3w in chickens from Digestion lines (G7) and Ross (PM3) strain

	D-	Ross	D+
Comparison ($P<0.0001$)	2402 A	3005 B	3314 C



COSADD

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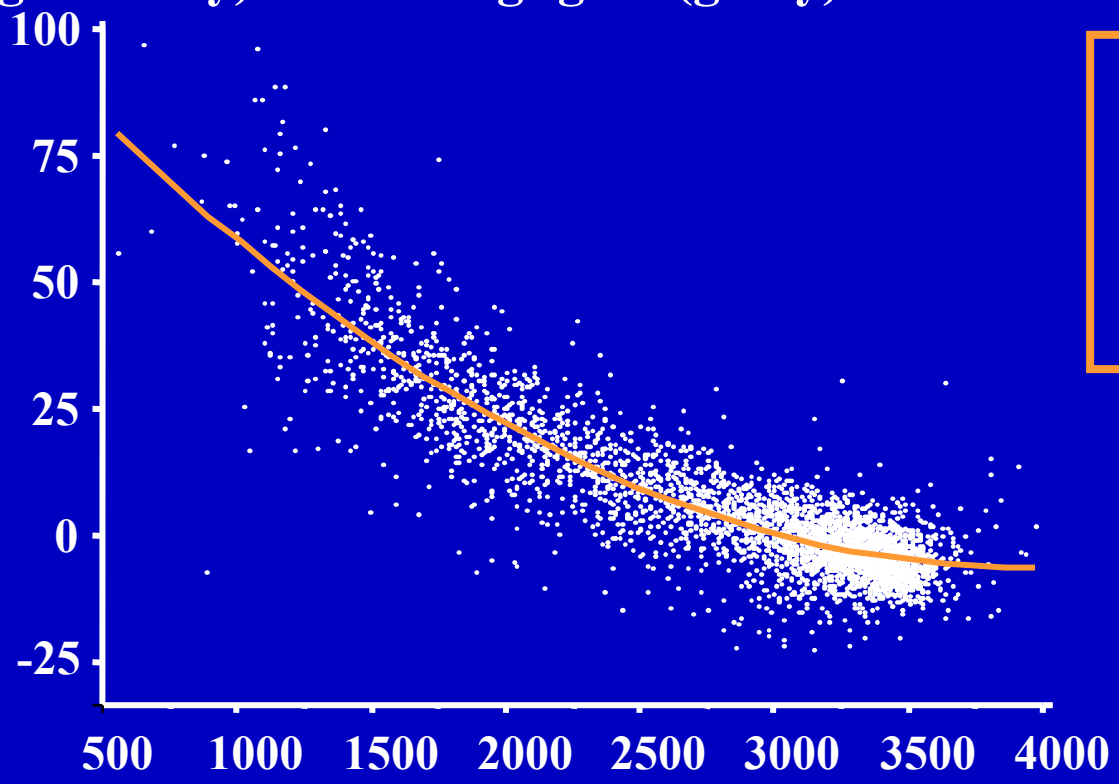
2007

Digestion lines (G0 – G8) from 20d to 23d (n=3780)

Residual feed intake (equation from G0) :

Feed int.(g DM/day) - 0.768 Wgt gain (g/day) – 28.5

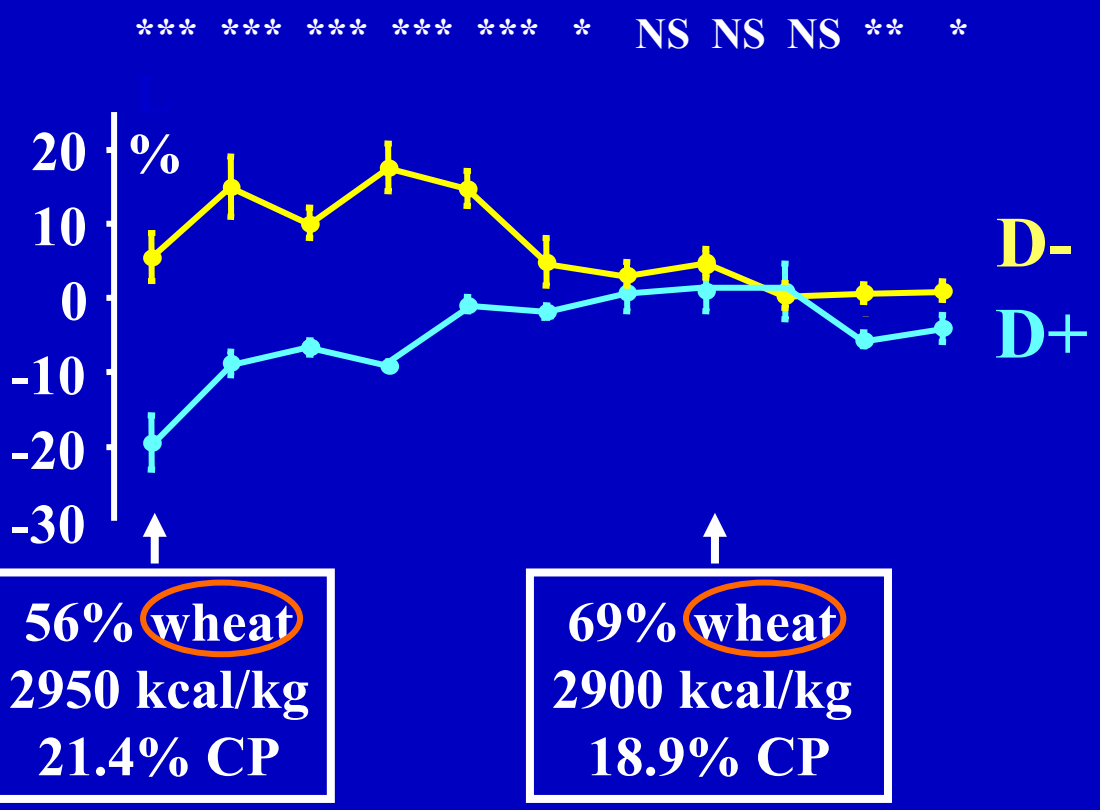


Rialto wheat diet

INRA 2010

Residual feed intake from the multiple regression line giving *feed intake as a function of metabolic weight and growth.*

Data are expressed as per cent of the mean feed intake



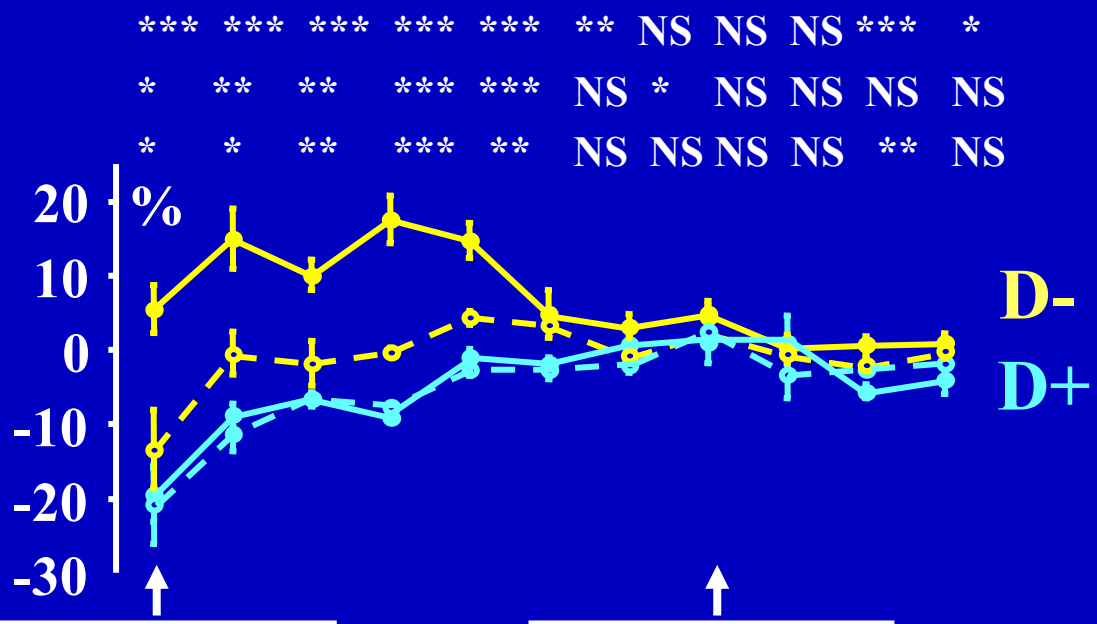
4th generation.
Rialto wheat diets.
Means and SE.
n= 8 floor pens.
10 birds / pen.

Carré *et al.*, 2005. 15th ESPN: 42-44.

INRA

Residual feed intake from the multiple regression line giving *feed intake as a function of metabolic weight and growth.*

Data are expressed as per cent of the mean feed intake



Line (L) effect
Cereal (C) effect
L x C interaction

D- Wheat
D- Corn
D+ Wheat
D+ Corn

56% cereal
2950 kcal/kg
21.4% CP

69% cereal
2900 kcal/kg
18.9% CP

2nd 4th 6th 8th 10th 12th Week of age

Carré *et al.*, 2005. 15th ESPN: 42-44.

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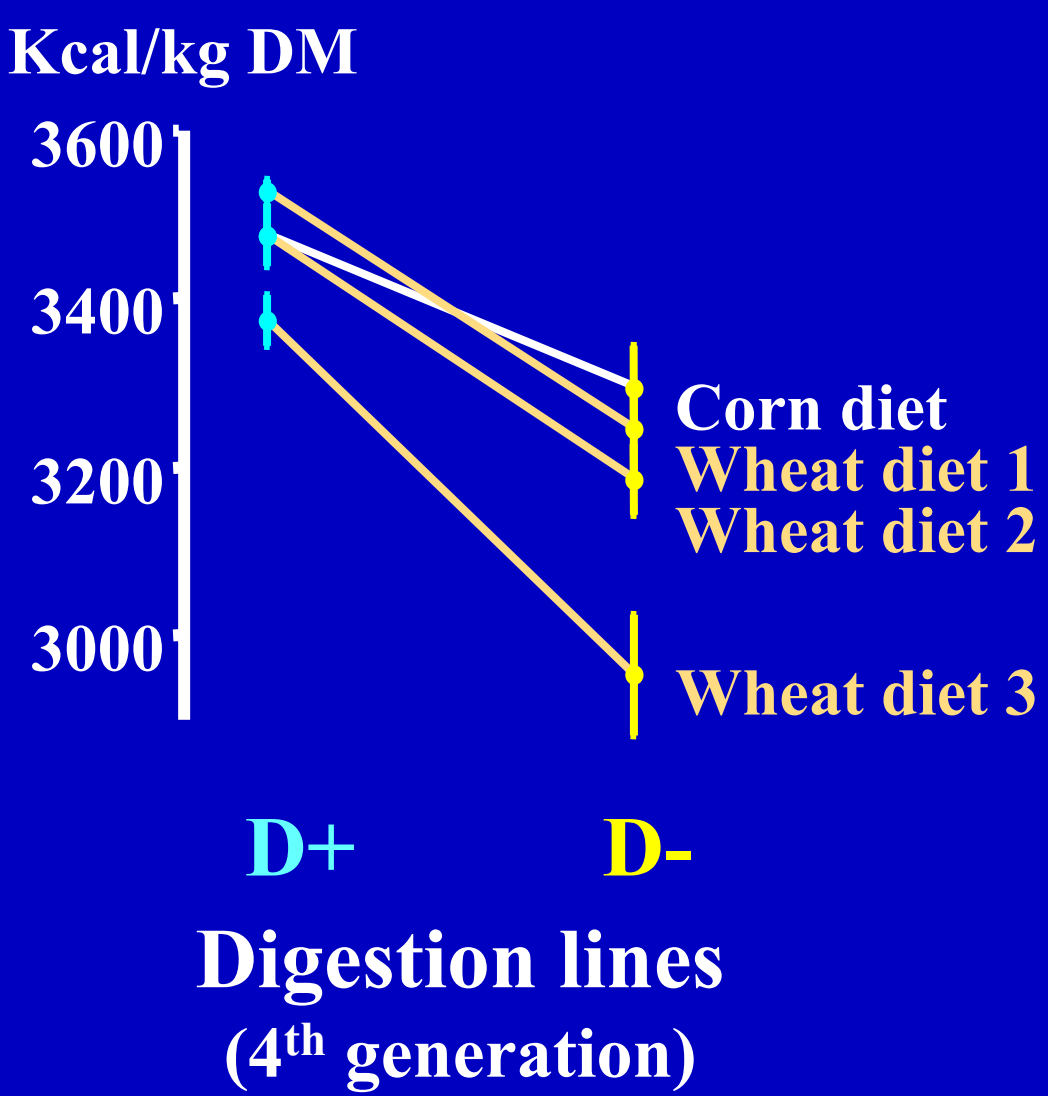
AMEn (3 weeks) (Means and SE)



Effects

Line	***
Cereal	*
Line x cereal	*

Carré *et al.*, 2007.
W. Poultry Sci. J. 63: 585

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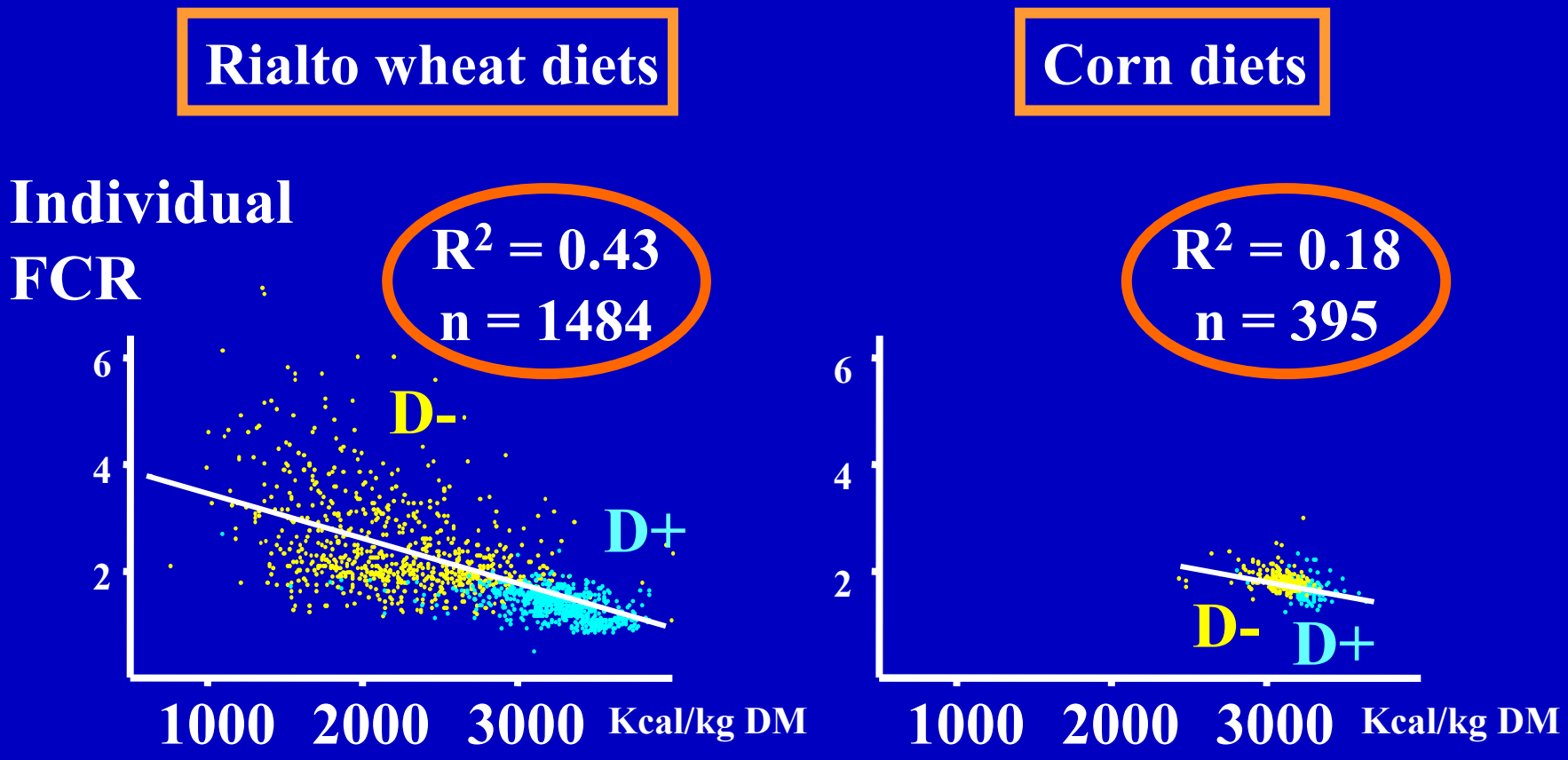
Relationships between FCR (3rd week of life) and AMEn. D+ and D- chickens are from 4, 6, 7 and 8th generation. Data are corrected for assay effect.



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Heritabilities and genetic correlations in Digestion lines (G0 – G8)

		AMEn		Dig. of starch		Dig. of lipids		Dig. of proteins	
		Wheat	Corn	Wheat	Corn	Wheat	Corn	Wheat	Corn
AMEn	Wheat	*0.32*	0.73	0.84	0.35	0.82	0.92	0.80	0.66
	Corn		*0.15*	0.84	0.77	0.31	0.61	0.81	0.58
DS	Wheat			*0.28*	0.63	0.57	0.59	0.66	0.54
	Corn				*0.26*	0.04	0.20	0.47	0.48
DL	Wheat					*0.25*	0.84	0.65	0.76
	Corn						*0.04*	0.86	0.75
DP	Wheat							*0.29*	0.88
	Corn								*0.09*

Mignon-Grasteau *et al.*, 2010.
9th W.Congr. Gen. Livestock Prod.;
Leipzig. CD : 4 pages.

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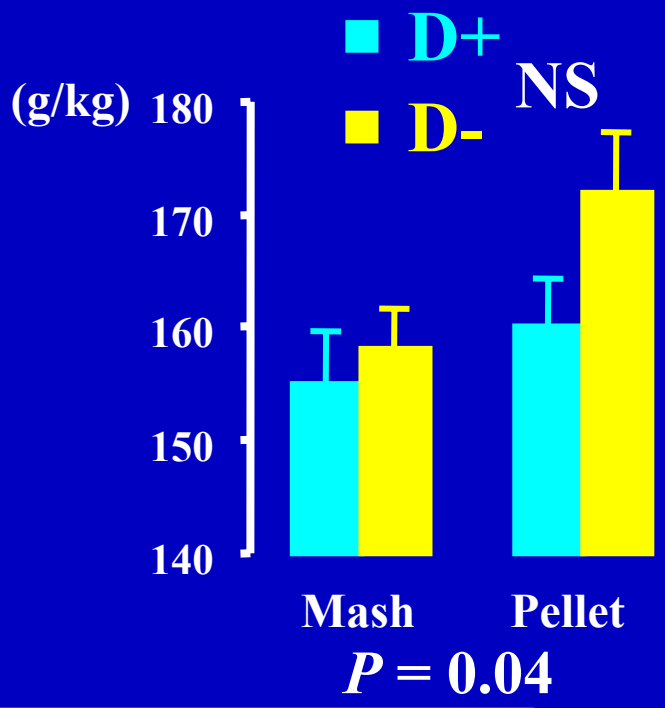
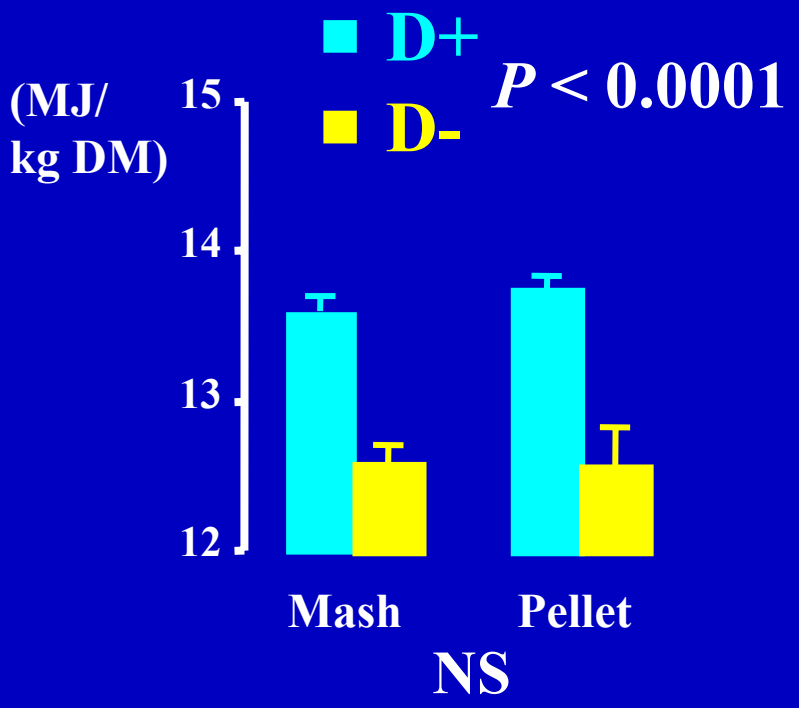
AMEn values and relative daily feed intakes at 3 w in Digestion lines (G3) fed a wheat (Rialto cultivar) diet given as mash or pellet

Daily feed intake / body weight



AMEn

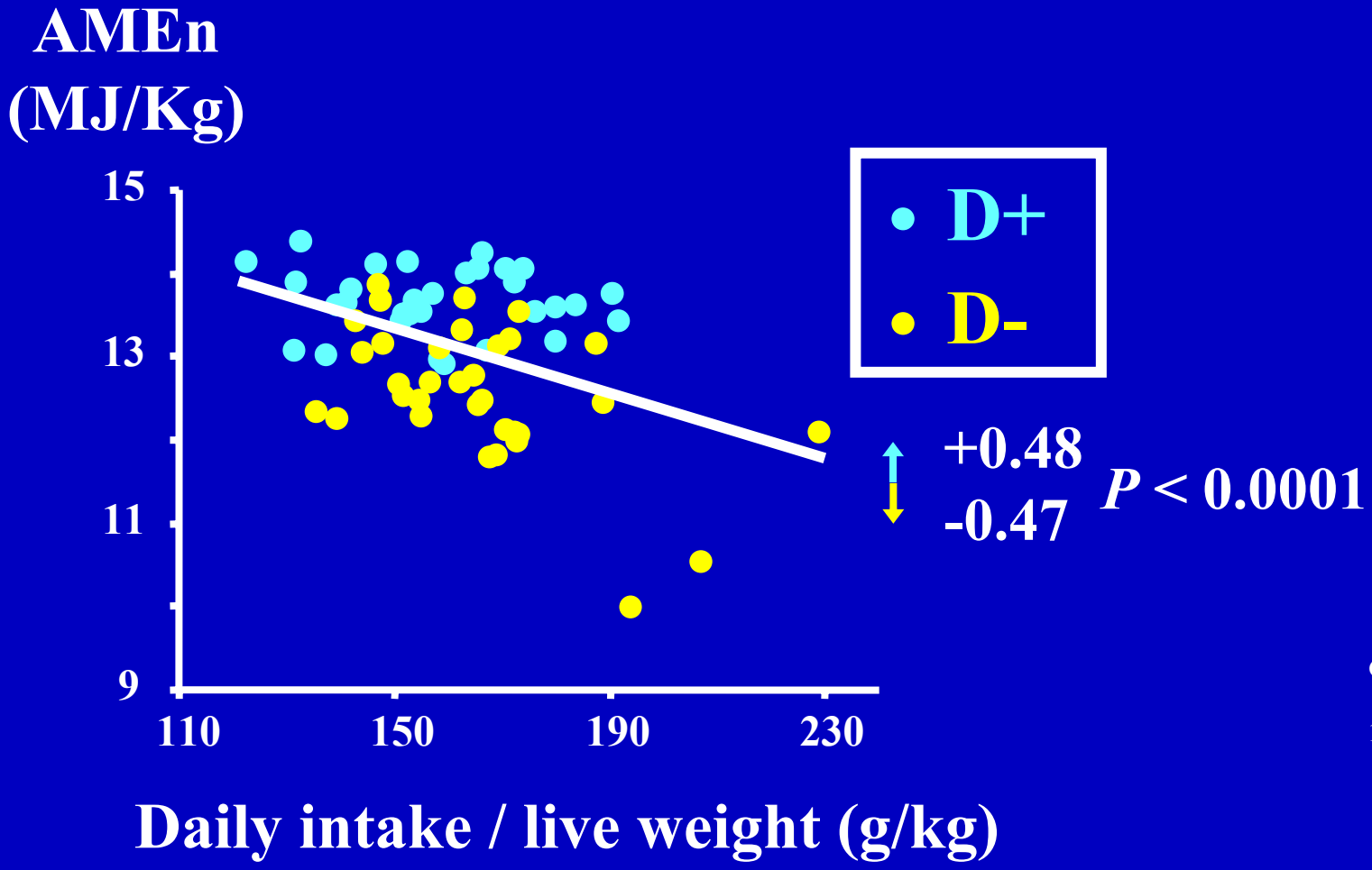


(M ± SE; n=17 individuals)

Carré *et al.*, 2005. 15th ESPN: 42-44.

INRA

AMEn values and relative daily feed intakes at 3 w in Digestion lines (G3) fed a wheat (Rialto cultivar) diet given as mash or pellet



Carré *et al.*, 2005. 15th ESPN: 42-44.

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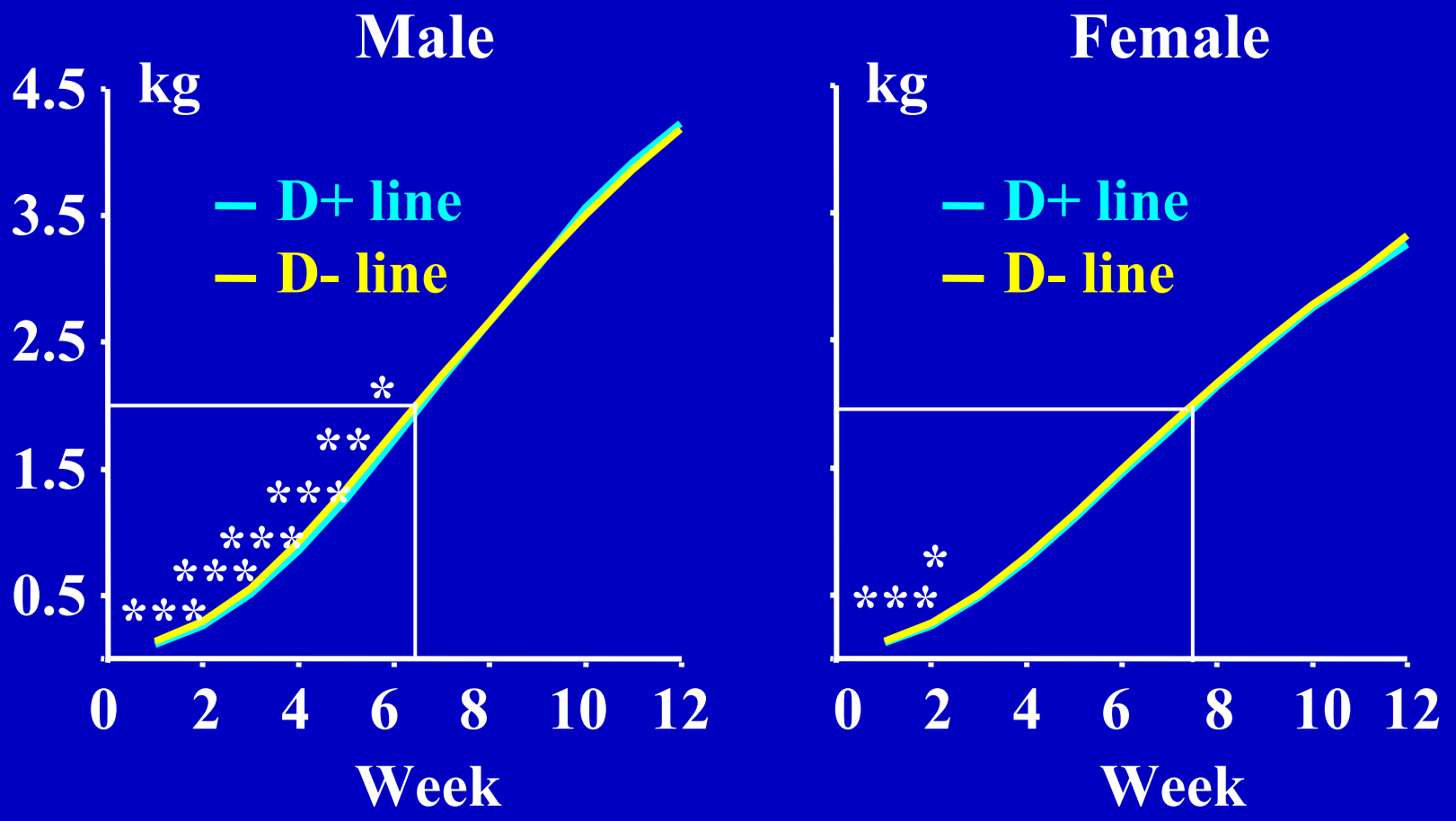
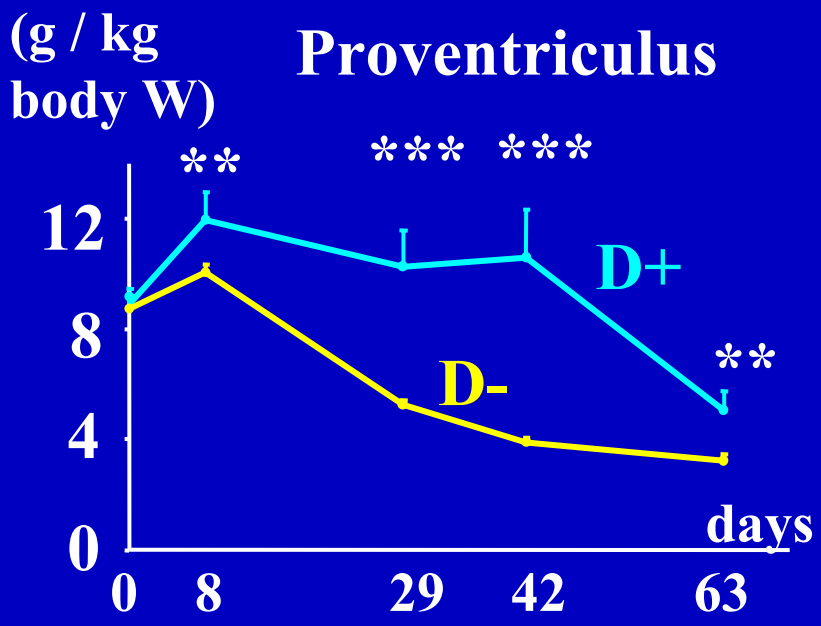
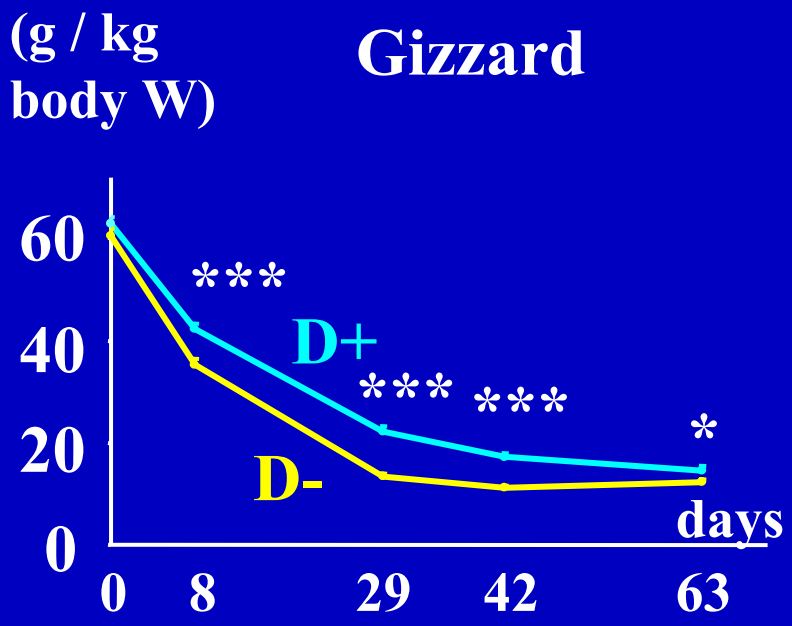
Growth curves of Digestion lines (4th generation) fed a corn diet.

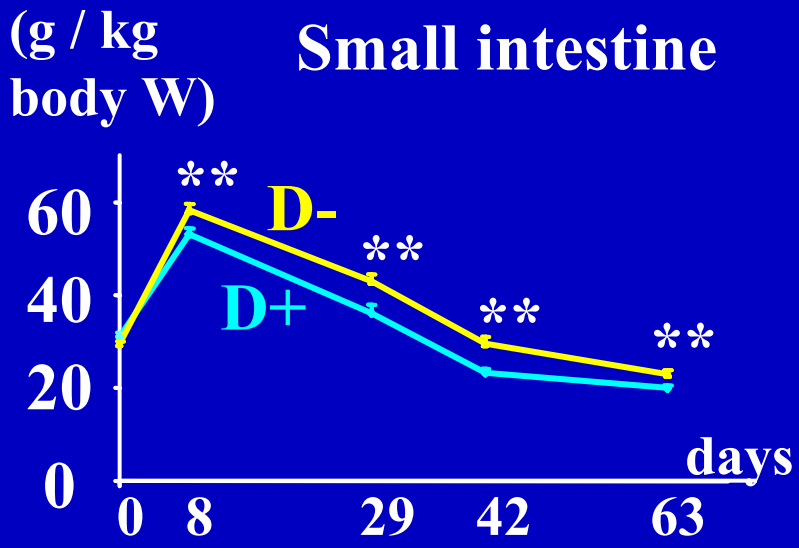


Carré *et al.*, 2008.
23rd WPC: CD: 8pages.





G8 Standard pelleted corn diet



Rougière and Carré, 2010. Animal, 4: 1861.

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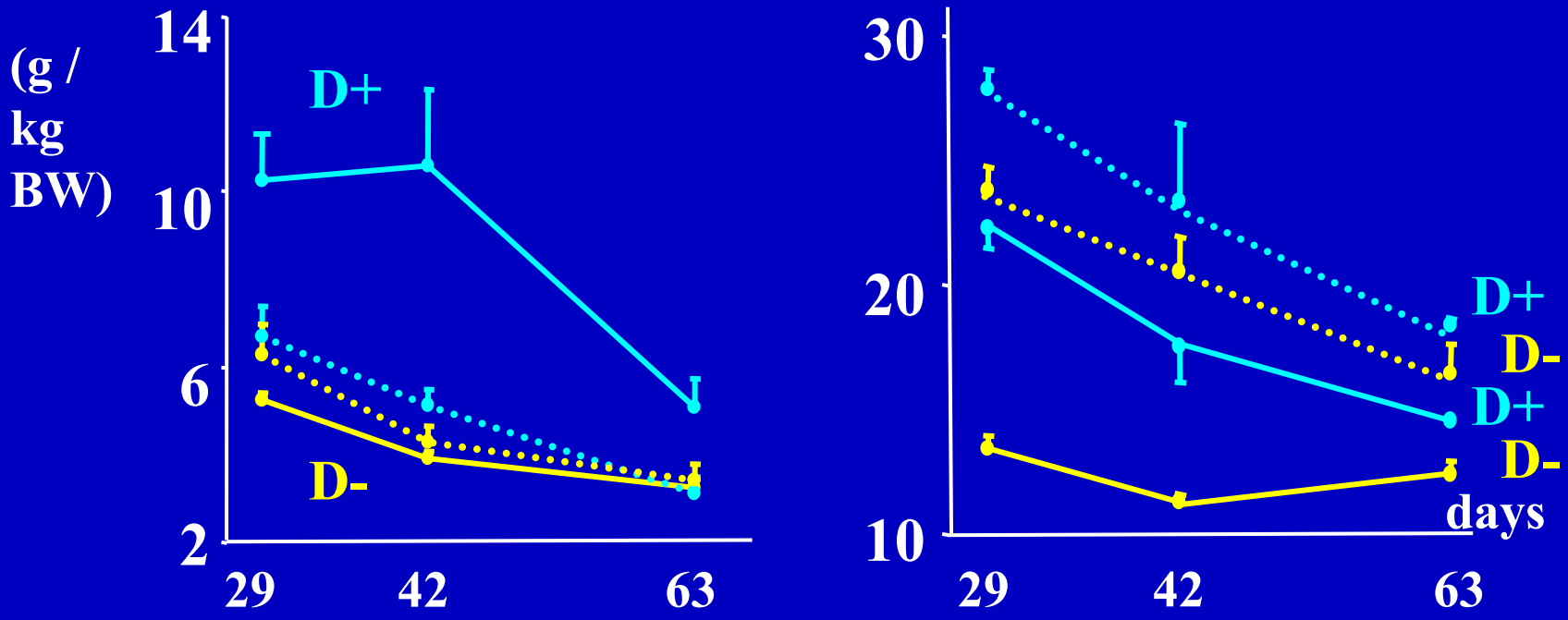
Effects	Proventriculus			Gizzard		
Line	***	***	*	***	***	**
Diet	0.07	**	**	***	***	***
Line x Diet	**	**	**	*	*	



Standard corn diet, pelleted

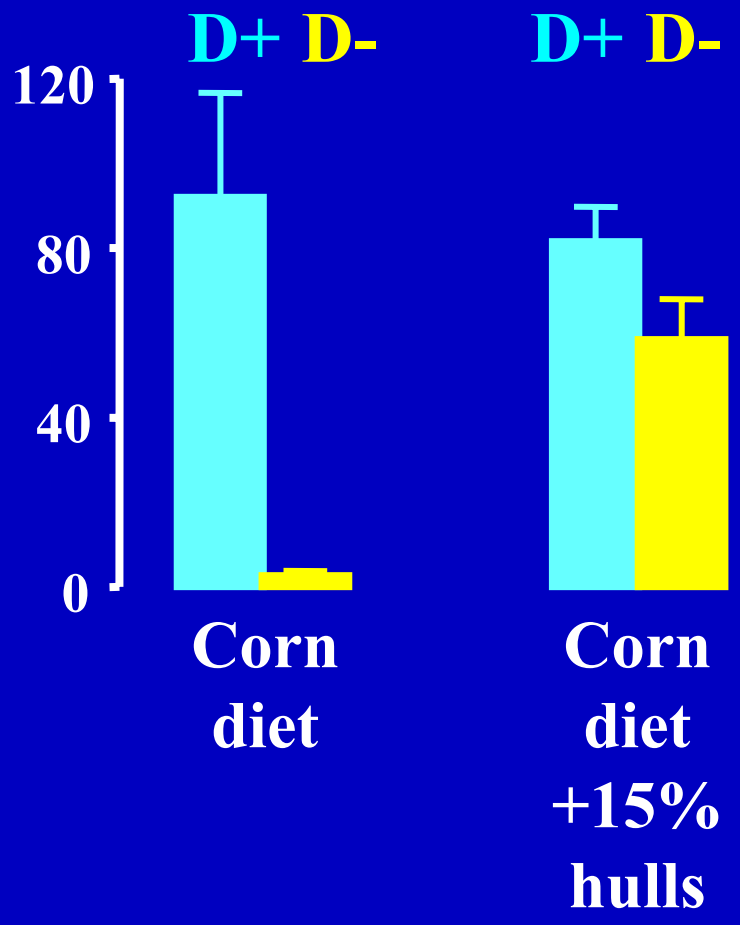
Standard corn diet diluted with 15% sunflower hull, pelleted

G8

Rougière and Carré, 2010. Animal, 4: 1861.

INRA

Mean retention times (min) of fine particles in gizzard + proventriculus of 4 w old chickens from D+ and D- lines (G8).



effects		*P*
Line	:	0.0003
Diet	:	NS
Line x Diet	:	0.02

Rougière and Carré, 2010. Animal, 4: 1861.

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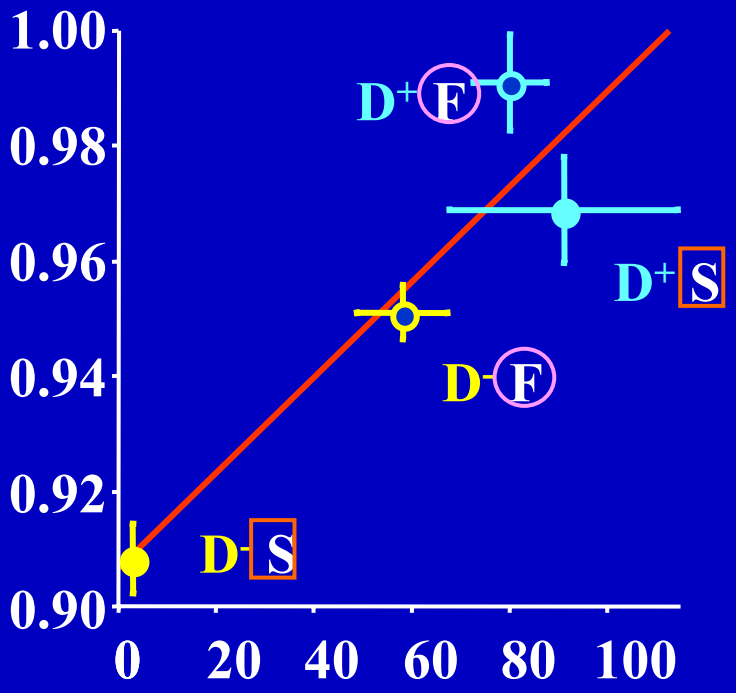
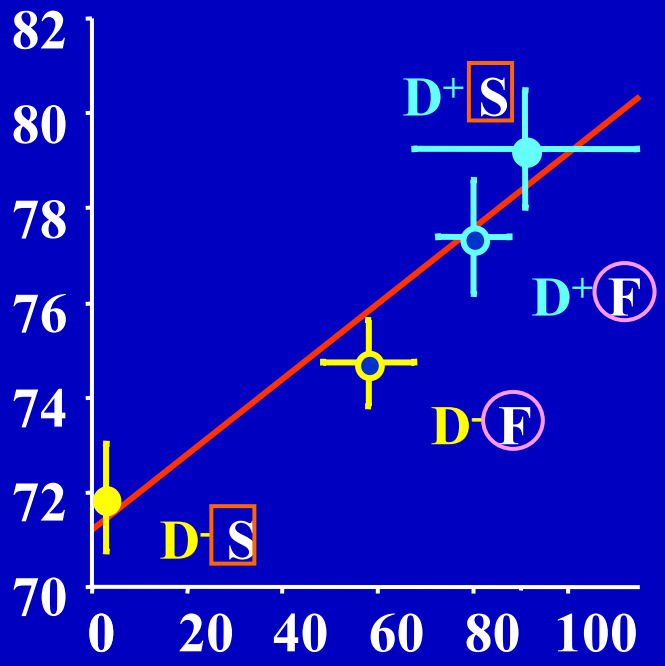
4 w old chickens from D+ and D- lines (G8)

■ D+ line ■ D - line

Measured AMEn / calculated AMEn



Protein digestibility (%)



Mean retention time (min) of fine particles in gizzard-proventriculus system

Rougière and Carré, 2010. Animal, 4: 1861.

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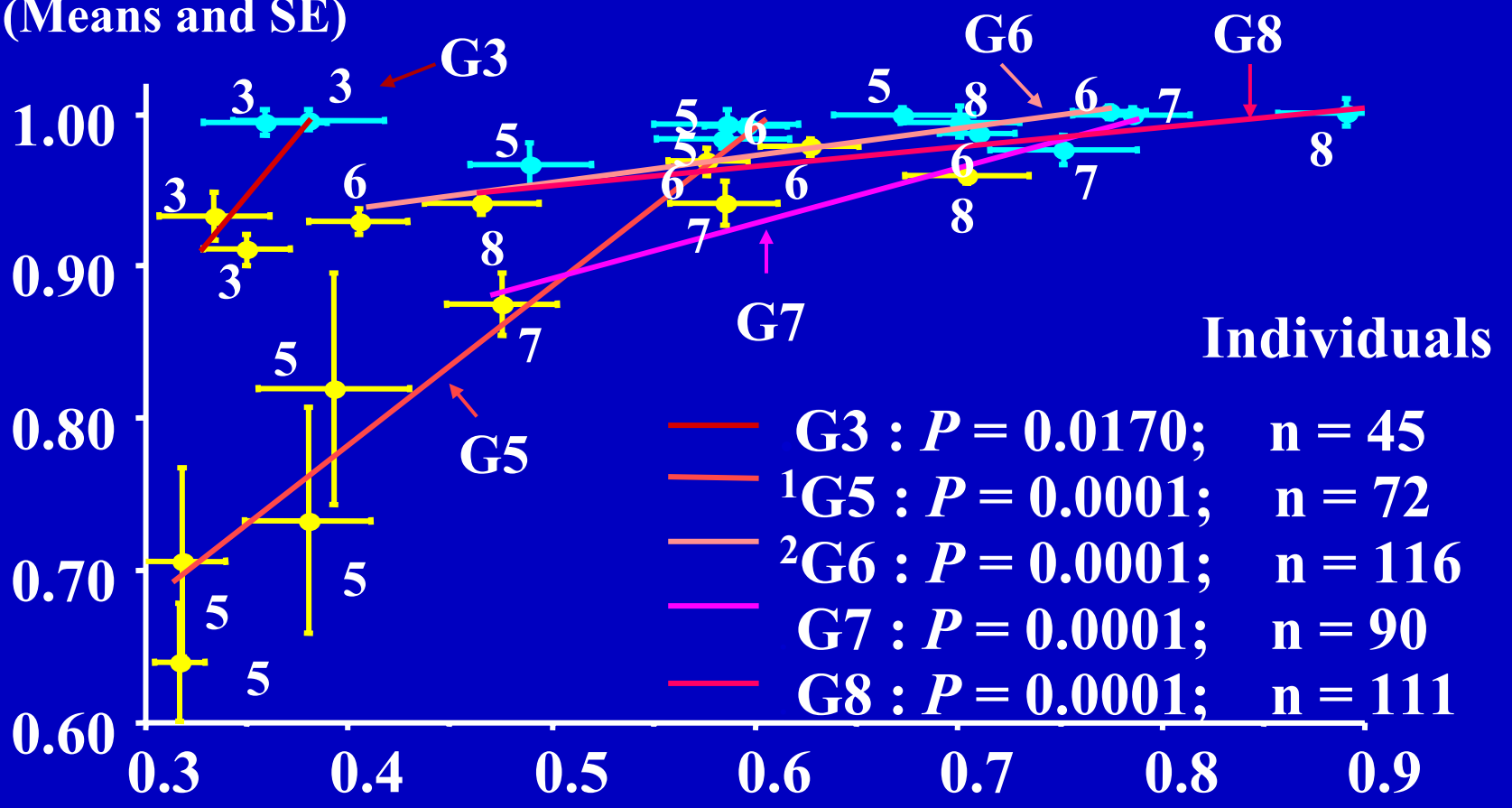
Measured AMEn (3 weeks) / Calculated AMEn

(Means and SE)

• D+ line • D - line



Gizzard / small intestine weight ratio (Means and SE)

[1]García *et al.*, 2007. Animal, 1: 1435.

[2]Rougière et al., 2009. Poultry Science, , 88: 1206.

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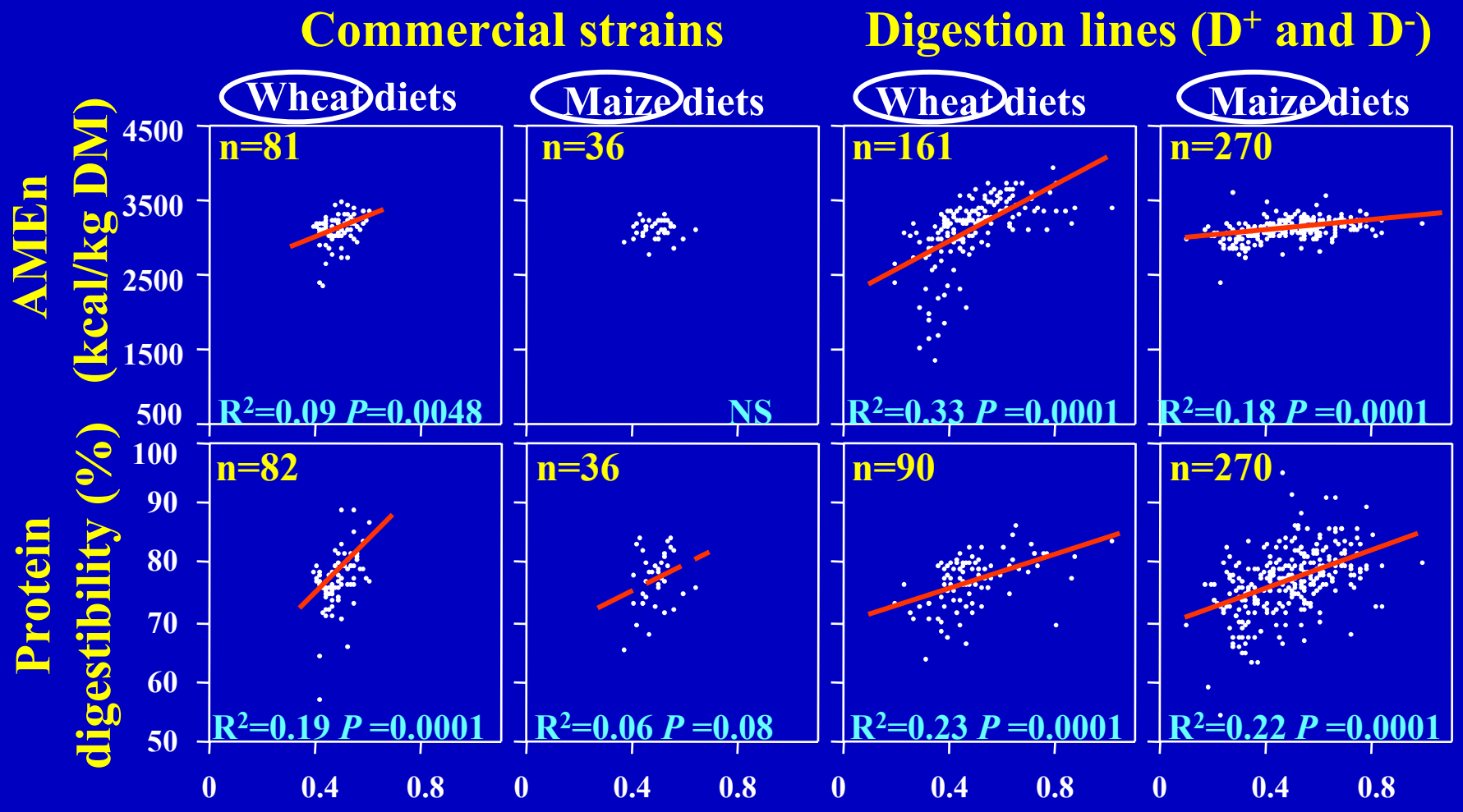
2009

RELATIONSHIPS BETWEEN INDIVIDUAL DIGESTION EFFICIENCIES AND INDIVIDUAL DIGESTIVE ANATOMY IN 3 WK BROILERS.

Database from 8 studies, corrected for diet and age effects.



Carré *et al.*, 2010.
13th EPC, Tours

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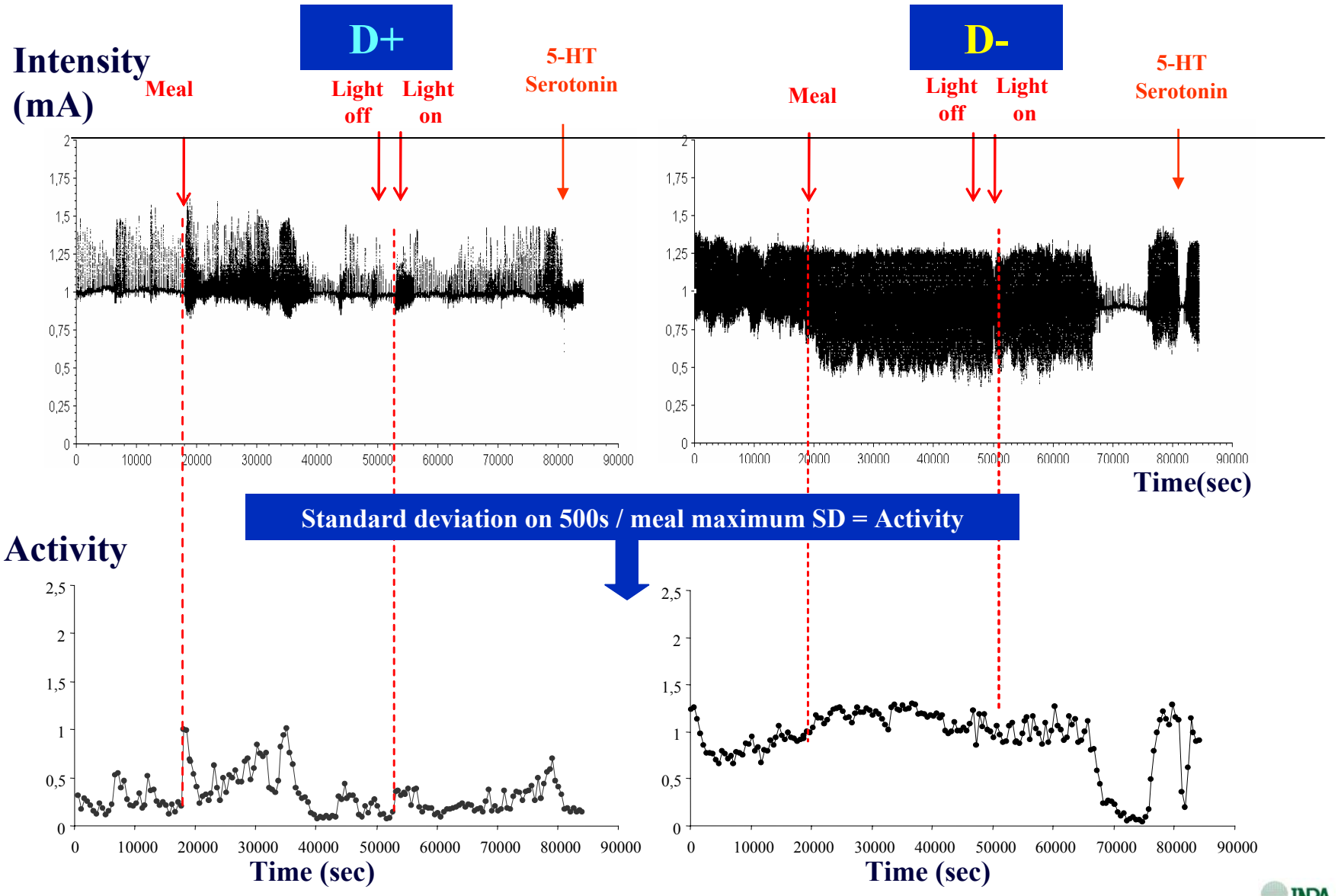
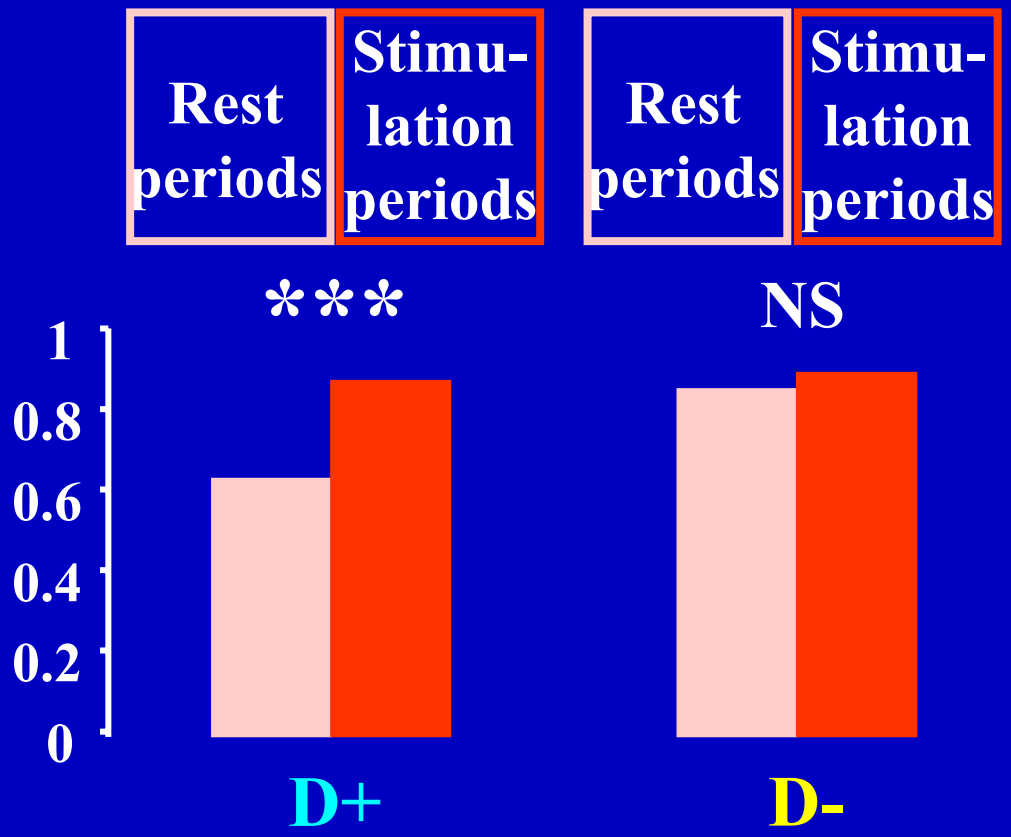
Motility responses of strain gauge transducers implanted on the outer surface of gizzard



Rougière *et al.*, 2012. Poultry Sci., 91 :460.

Effects of D+ and D− lines on gizzard activities observed for 500 s over various periods during a continuous 24-h recording (6 birds per line) (df = 1984).



Effects (*P*)		
Line	Period	L x P
0.0001	0.0001	0.0018

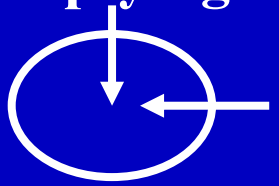
Rougière *et al.*, 2012. Poultry Sci., 91 :460.

Hypotheses for explaining differences between D+ and D- lines

Development of upper tract functions during early stage of growth

Upper tract functions

Gizzard emptying



Pancreatic secretions

Mixture by duodenum motility

Efficiencies and coordination of upper tract functions → D+ : +++ ; D- : - - -

Coarse particles required for upper tract functions → D+ : + ; D- : +++

Intestine growth

Adaptation to low efficiency of upper tract functions → +++

INRA 2010

Digestive efficiency of broilers can be improved
by a genetic selection on FCR
during growth (2-5 weeks)
with birds being fed on a wheat diet

A great part of differences in digestive efficiency between D+ and D- lines were due to differences in functions of upper digestive tract

Recent QTL analyses at INRA revealed
at least 4 candidate genes
associated with
broiler digestive efficiency variations

INRA

15 publications on D+ and D- lines (2004-2012)

Mignon-Grasteau, S.; Muley, N.; Bastianelli, D.; Gomez, J.; Péron, A.; Sellier, N.; Millet, N.; Besnard, J.; Hallouis, J.M.; Carré, B. 2004. Poultry Science, 83:860-867, 1249.

Péron, A.; Gomez, J.; Mignon-Grasteau, S.; Sellier, N.; Besnard, J.;Derouet, M.; Juin, H.; Carré, B. 2006. Poultry Science, 85: 462-469.

Péron, A.; Svihus, B. ; Gabriel, I. ; Bérot, S. ; Tanguy, D. ; Bouchet, B. ; Gomez, J.; Carré, B. 2007. British Poultry Science, 48: 370-380.

García, V.; Gomez, J.; Mignon-Grasteau, S.; Sellier, N.; Carré B. 2007. Animal 1: 1435-1442.

Carré, B.; Mignon-Grasteau, S.; Péron, A.; Juin, H.; Bastianelli, D. 2007. World's Poultry Science Journal, 63 : 585-596.

Carré, B.; Mignon-Grasteau, S.; Juin, H. 2008. World's Poultry Science Journal, 64: 377-390.

Rougière, N.; Gomez, J.; Mignon-Grasteau, S. ; Carré, B. 2009. Poultry Science, 88: 1206–1215.

Bastianelli, D. ; Bonnal, L. ; Juin, H. ; Mignon-Grasteau, S. ; Davrieux, F. ; Carré, B. 2010. Journal of Near Infrared Spectroscopy, 18 : 69-77.

de Verdal , H.; Mignon-Grasteau , S.; Jeulin , C.; Le Bihan-Duval , E.; Leconte , M.; Mallet , S.; Martin C.; Narcy A. 2010. Poultry Science, 89 : 1955–1961.

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Mignon-Grasteau, S. ; Bourblanc, M. ; Carré, B. ; Dourmad, J.Y. ; Gilbert, H. ; Juin, H. ; Noblet, J. ; Phocas, F. 2010. Productions Animales 23: 415-426.

de Verdal, H. ; Narcy, A. ; Bastianelli, D.; Chapuis, H. ; Nathalie Même, N. ; Urvoix, S. ; Le Bihan-Duval, E. ; Mignon-Grasteau, S. 2011. BMC Genetics 12:59

de Verdal, H. ; Narcy, A. ; Bastianelli, D.; Chapuis, H. ; Même, N. ; Urvoix, S. ; Le Bihan-Duval, E. ; Mignon-Grasteau, S. 2011. BMC Genetics 12:71.

Rougière N.; Malbert C.-H.; Rideau N.; Cognié J.; Carré B. 2012. Poultry Science, 91: 460–467.

Pelhaitre A.; Mignon-Grasteau S.; Bertin A. 2012. Applied Animal Behaviour Science, 139 :114-122.

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