Combined use of cereal extrusion and enzymes in chickens

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Background:

- Extrusion improves nutrient availability but it has not always been successful in improving feed efficiency in poultry.
- Extrusion increases the solubilisation of dietary fibre, and any beneficial effect in broilers may be counteracted by an increased digesta viscosity, which may impair nutrient digestibility and absorption.
- The negative effect of viscosity could be reversed with the use of exogenous carbohydrases.

Objective:

To evaluate the impact and interactions between cereal extrusion and addition of exogenous enzymes on growth, feed efficiency, nutrient utilisation, product quality and welfare in broiler chickens.

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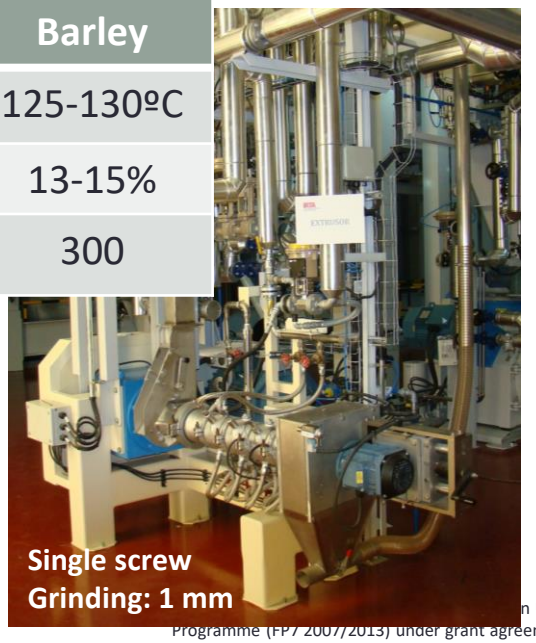
Material & Methods

Design: Randomized complete block design with a 2 x 2 factorial arrangement of treatments, with 6 replicates of 40 chickens per dietary TRT

	Cereal	Processing	Enzyme
Study-1	Wheat	Raw	No
Study-2	Barley	Extruded	Carbohydrases

	Wheat	Barley
Temperature	105-135ºC	125-130ºC
Water	14-15%	13-15%
Yield (kg/h)	200-250	300



Wheat: xylanase
1400 xylanase units/kg
388 β–glucanase units /kg

Barley: β-glucanase
2800 β–glucanase units/kg
199 xilanase units/kg

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Material & Methods:

- **Duration of the trial: 39 d**
- **1920 one-day male broiler chickens Cobb 500 FF (48 replicates of 40 chickens)**
- **4 + 4 dietary treatments**
- **Feeding program: three diets (starter 1-14 d; grower 15-29 d; finisher 30-39 d)**
- **Pelleted diets (grinding 3 mm): 1-14 d crumbles; 15-39 d pellets 3 mm**
- **Experimental unit: pen**
- **Statistical analysis within each cereal**
  ANOVA PROC GLM SAS: factorial 2 x 2 (Block, Extrusion, Enzyme, interaction)
  NPAR1WAY Procedure (Wilcoxon Scores)

Measurements:

- **Cereal characteristics**
- **BW, WG, FI and FE (g feed/g gain): 0-14 d, 15-29 d, 30-37 d**
- **Ileal digesta viscosity (D21)**
- **Apparent ileal energy, fat, nitrogen and amino acids digestibility (D21)**
- **Welfare assessment:**
  - **Litter quality and feather cleanness scores (D21, D28, D36)**
  - **Foot pad dermatitis (D36 at farm; D39 after slaughter)**
  - **Gait scores, activity and huddling behaviour (D11, D25, D39)**
- **Product quality (slaughter age D38)**

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Material & Methods : feed composition

	1-14 d		15-29 d		30-39 d	
Ingredients (%)	**Wheat**	**Barley**	**Wheat**	**Barley**	**Wheat**	**Barley**
Wheat (raw or extruded)	**62.5**	-	**63.8**	-	**69.0**	-
Barley (raw or extruded)	-	**55.2**	-	**57.6**	-	**62.3**
Soybean meal 48% CP	25.1	21.8	18.8	22.6	14.5	17.7
Full fat extruded SBM	5.0	15.0	10.0	10.0	10.0	11.0
Animal fat	3.4	4.4	3.3	6.0	3.3	6.1
Dicalcium phosphate	1.75	1.59	1.60	1.45	1.40	1.24
Calcium carbonate	0.70	0.77	0.66	0.73	0.61	0.69
Sodium chloride	0.37	0.34	0.36	0.35	0.34	0.33
L-lysine HCl	0.34	0.21	0.27	0.14	0.24	0.10
DL-methionine	0.31	0.32	0.25	0.26	0.22	0.23
L-threonine	0.12	0.07	0.08	0.04	0.07	0.03
Premix and others	0.40	0.38	0.32	0.32	0.32	0.32
Calculated nutrient content						
EMA (Kcal/kg)	**2950**		**3000**		**3050**	
Crude protein (%)	**21.2**		**19.9**		**18.3**	
Lysine (%)	1.32		1.19		1.05	
Methionine (%)	0.61		0.54		0.49	
Threonine (%)	0.86		0.78		0.71	
Calcium (g/kg)	9.0		8.4		7.6	
NPP (g/kg)	4.5		4.2		3.8	

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Results: effect of extrusion on cereal characteristics

	Wheat		Barley	
% DM	Raw	Extruded	Raw	Extruded
Dry matter	86.9	86.8	86.3	88.1
Crude protein	12.4	13.1	10.6	11.5
Starch	57.3	59.0	54.2	56.2
Fat	2.0	1.0	2.0	1.4
Ash	1.8	2.0	2.4	2.4
Crude fibre	2.6	2.4	4.3	3.7
Total NSP	10.8	11.4	17.1	17.1
β-glucans	0.48	0.50	3.82	3.95
WE viscosity, mPa.s	**1.40**	**1.62**	**2.81**	**4.63**
WSI	**0.07**	**0.16**	**0.08**	**0.15**
WAI	**2.01**	**5.31**	**2.33**	**4.97**

WSI= water solubility index
WAI= water absorption index

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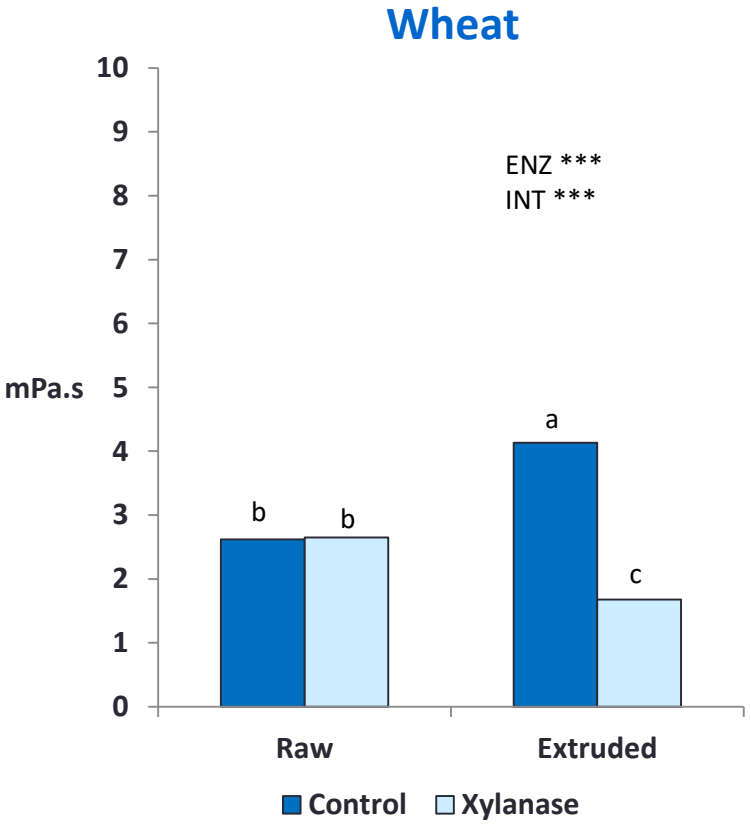
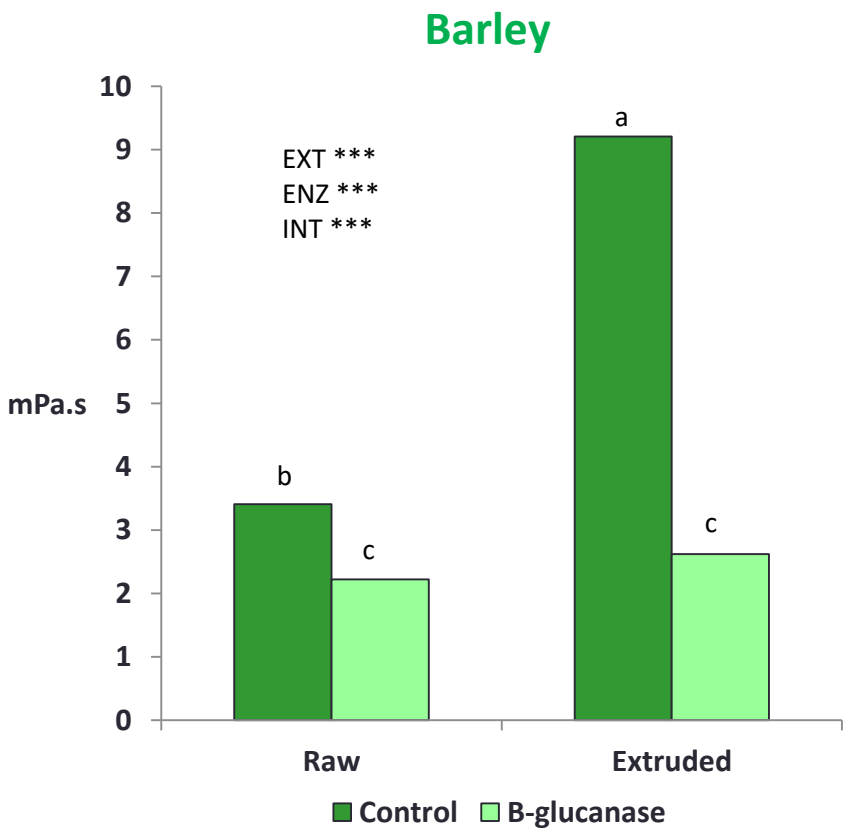
Results: ileal digesta viscosity D21





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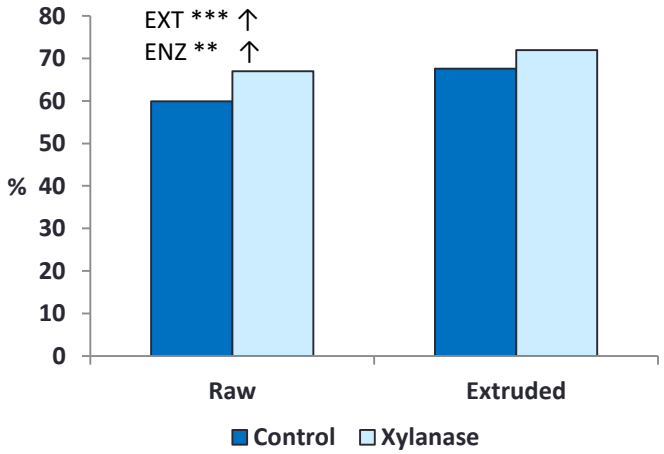
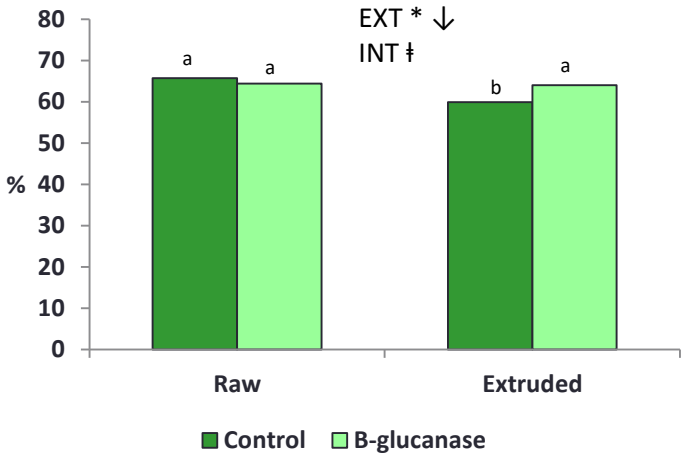
Results: apparent ileal digestibility D21

Wheat

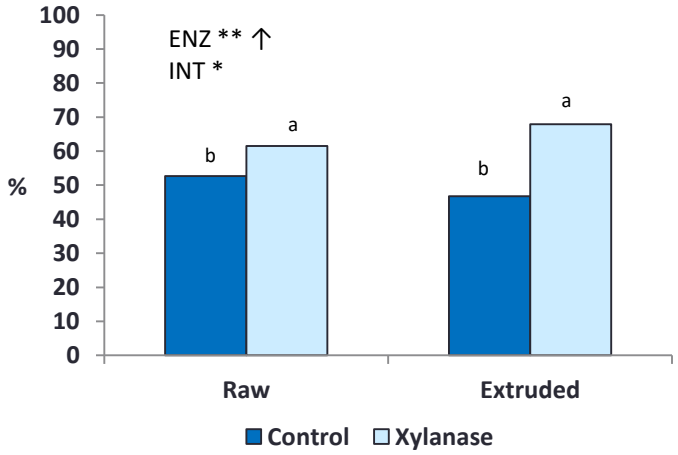
Barley

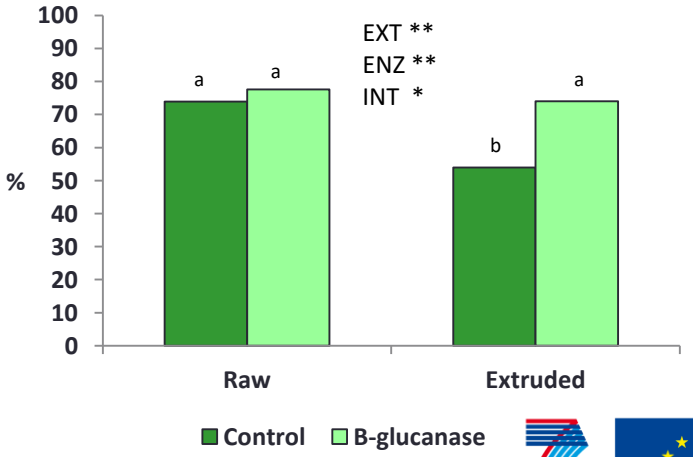
Energy





Fat





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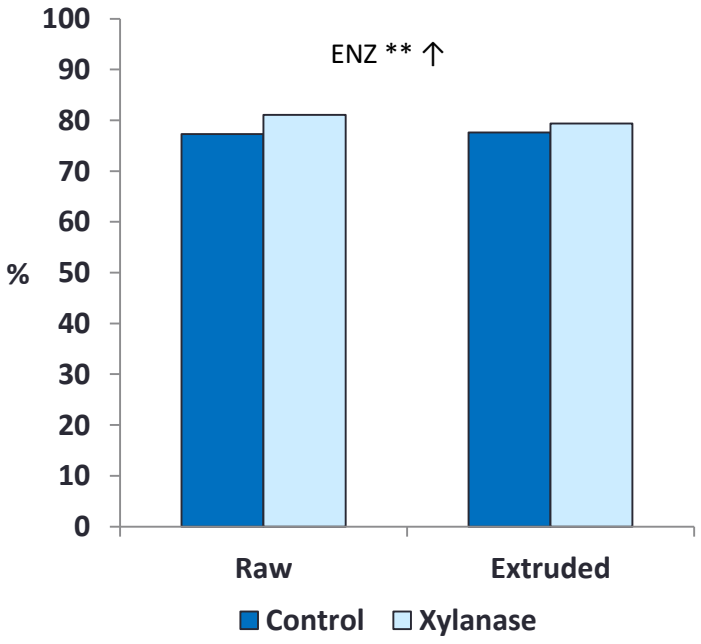
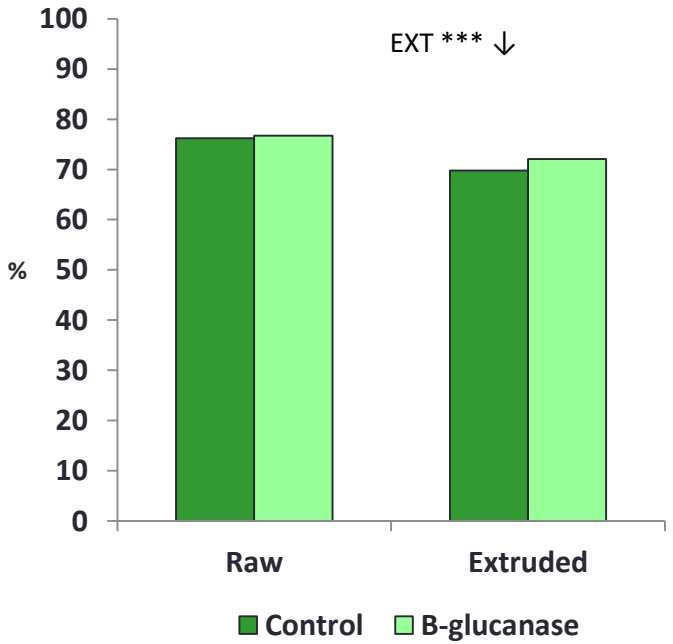
Results: apparent ileal digestibility

Nitrogen

Wheat



Barley



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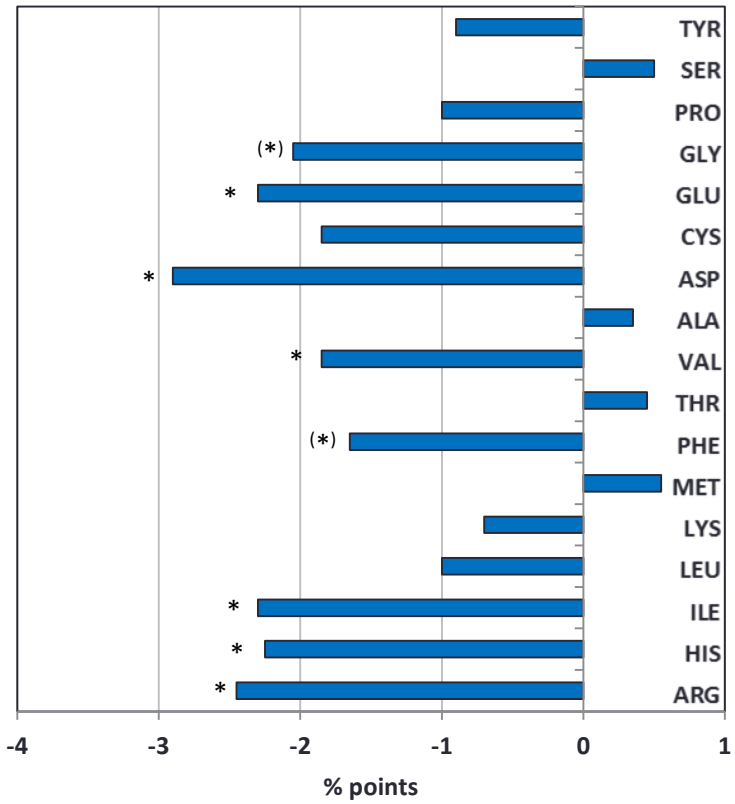
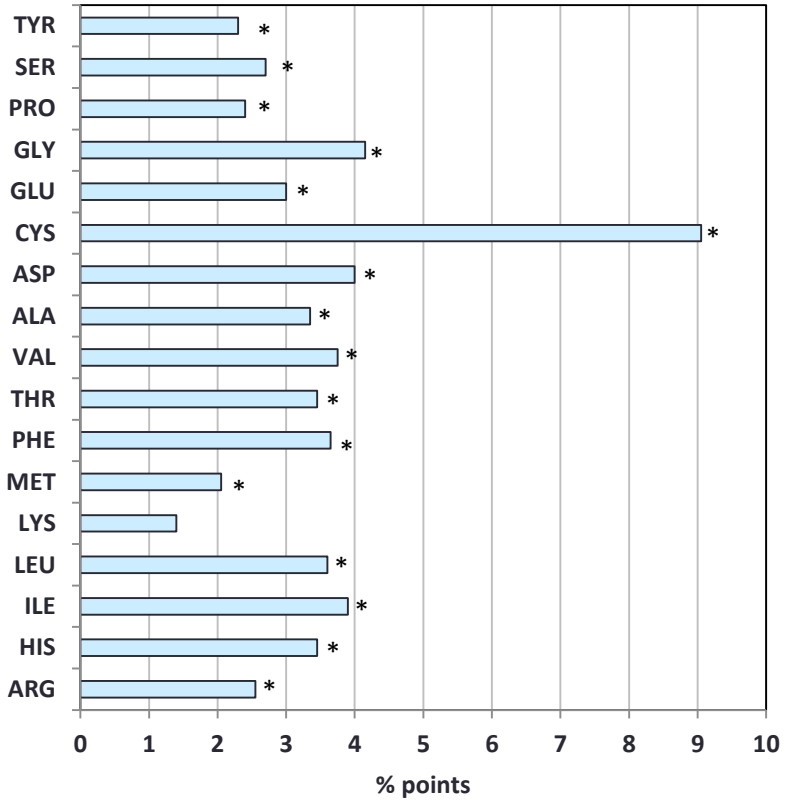
Results: apparent ileal amino acid digestibility

Wheat

Extrusion



Enzyme



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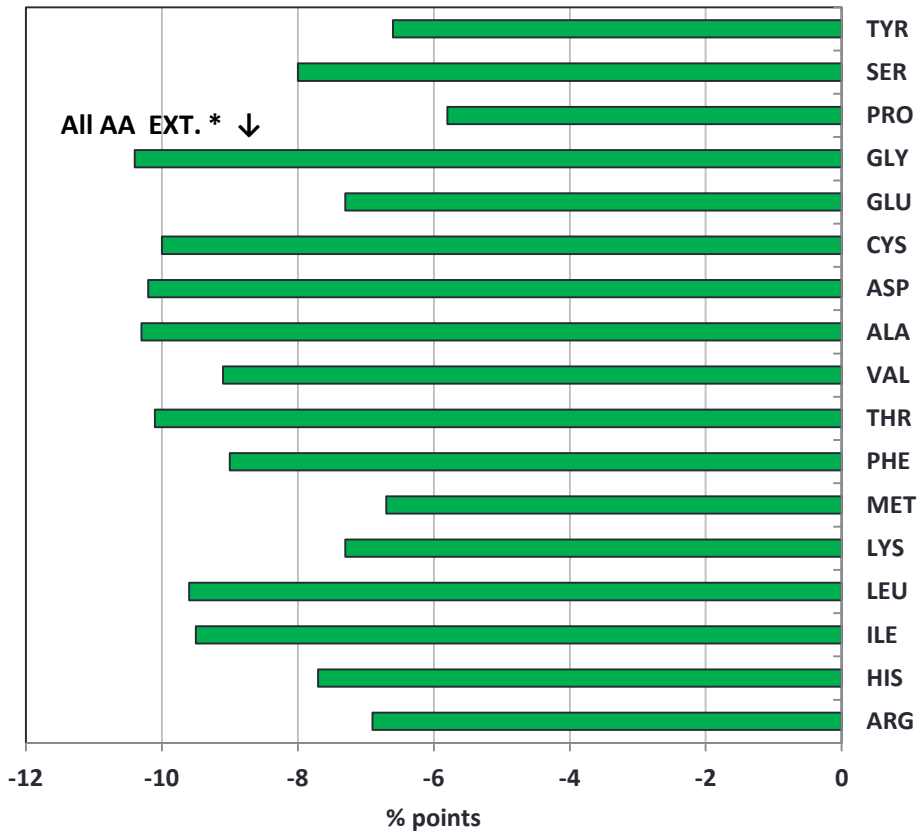
Results: apparent ileal amino acid digestibility

Barley: several extrusion x enzyme interactions (P<0.05)

Extruded vs. raw barley (without enzyme)



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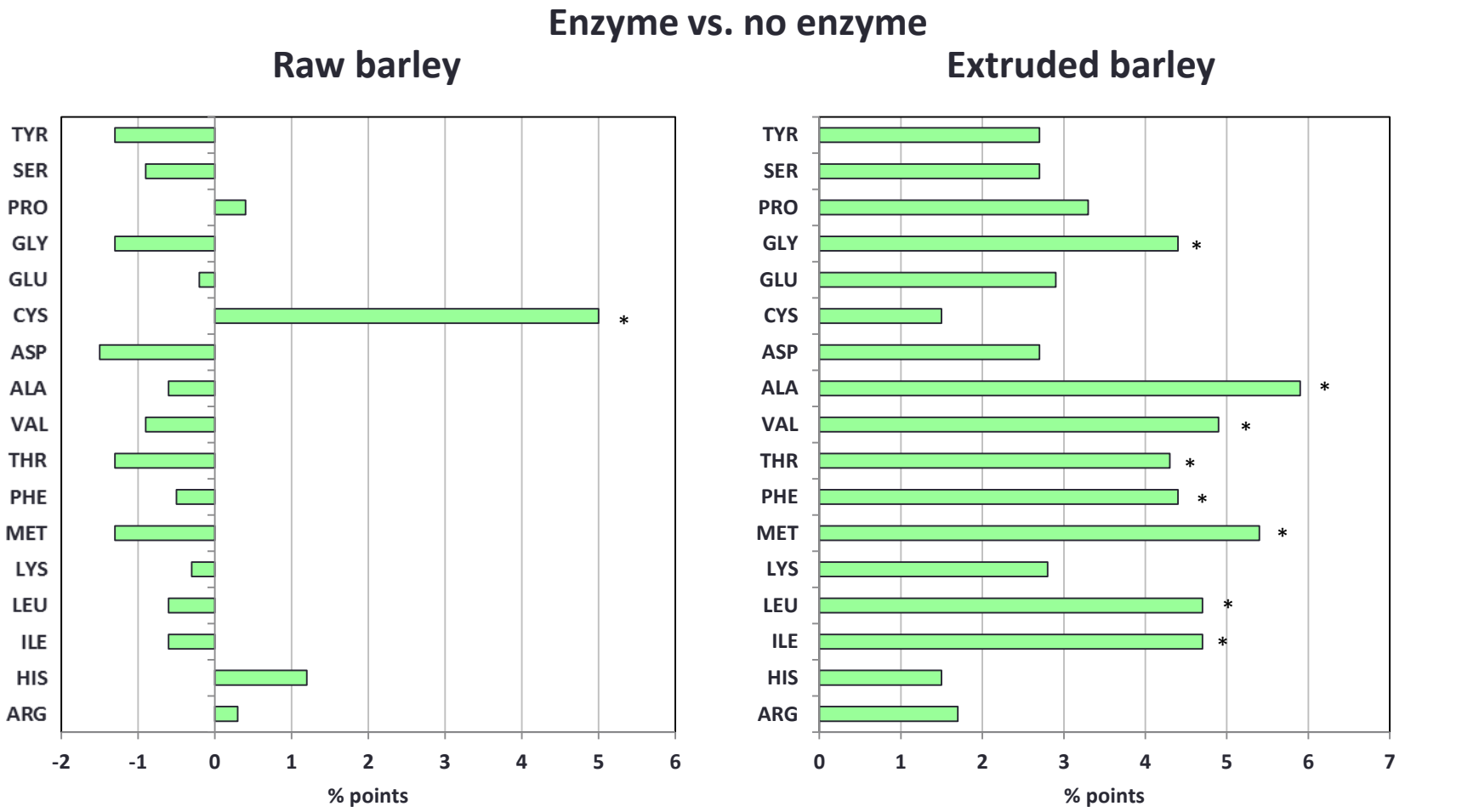
Results: apparent ileal amino acid digestibility



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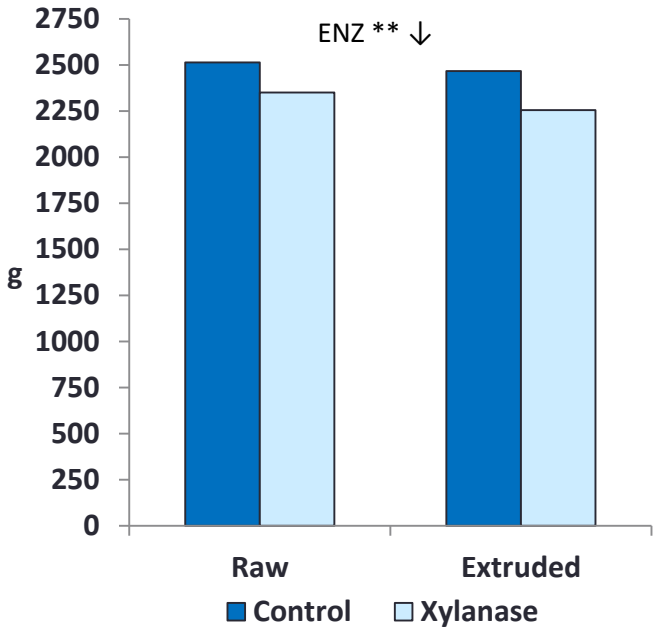
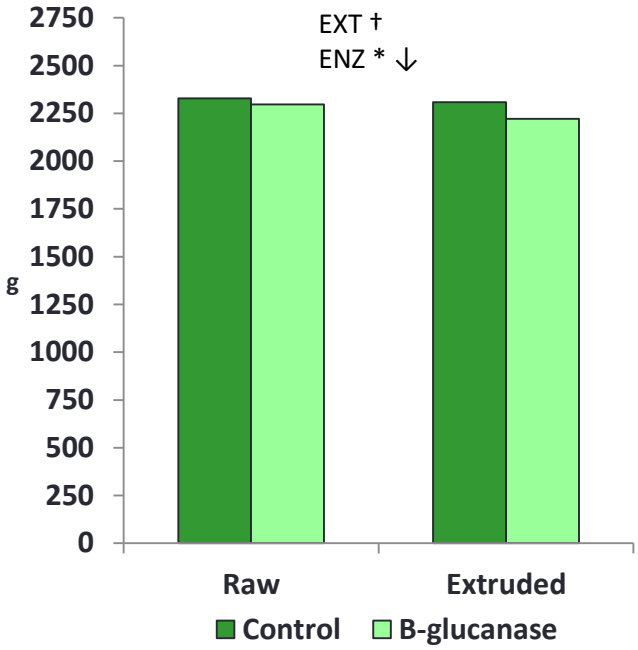
Results: performance

Final live weight D37

Wheat



Barley



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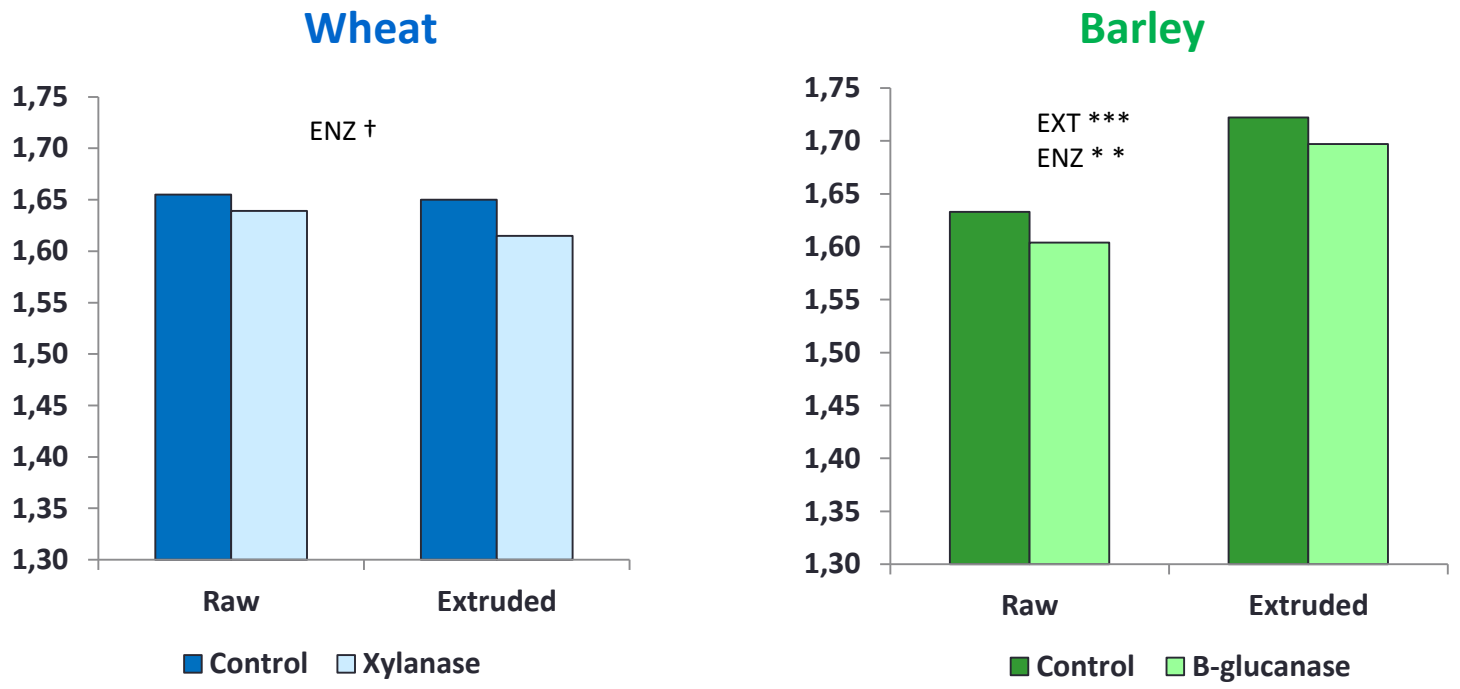
Results: performance

Feed to gain ratio (g feed/g gain) from 1-37 d



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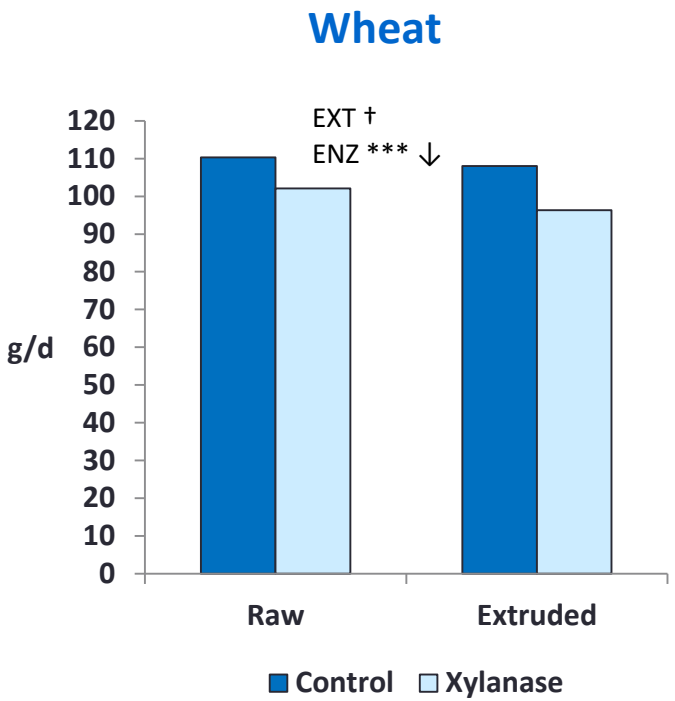
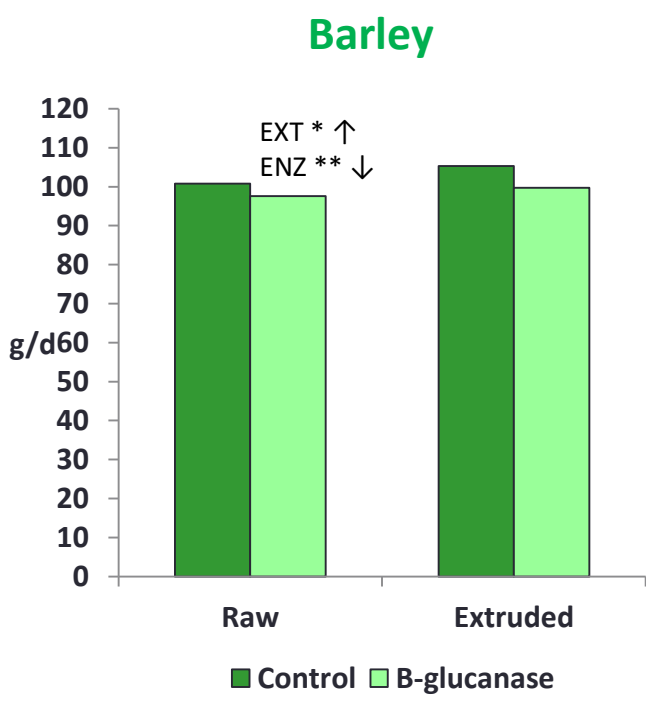
Results: performance

Daily feed intake from 1-37 d





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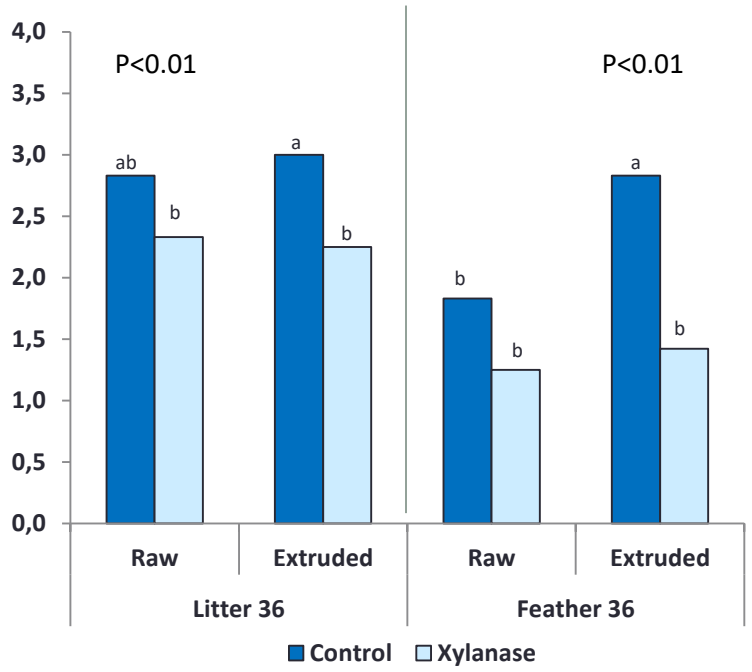
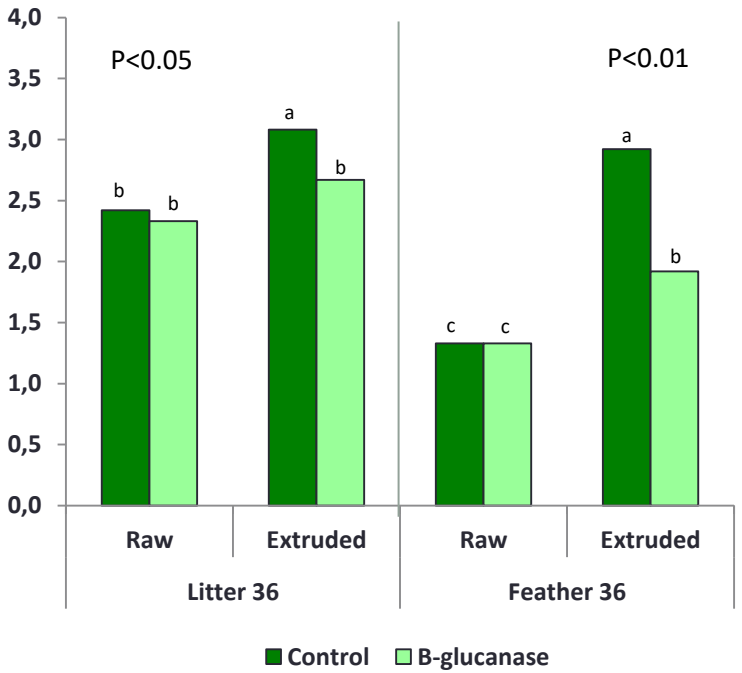
Results: welfare measurements

Litter quality and feather cleanness scores

Wheat



Barley



Litter: from 1= dry and friable to 5= wet, sticky and cake.
Feather: from 1=clean to 5=dirty

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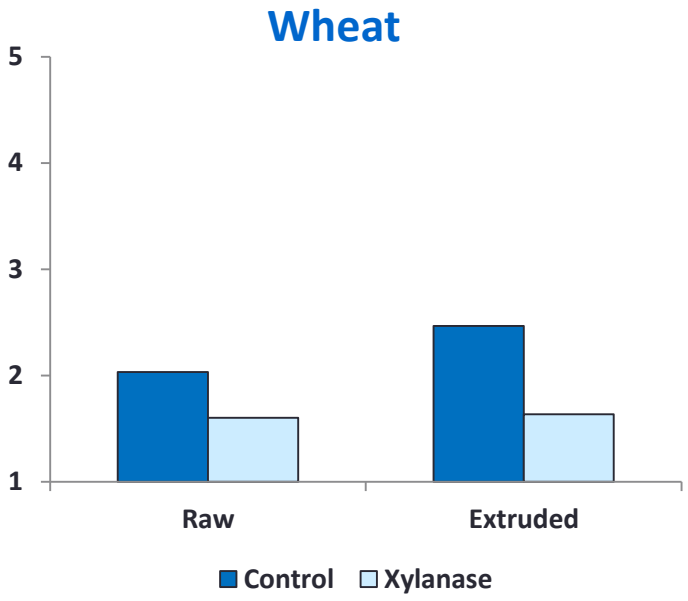
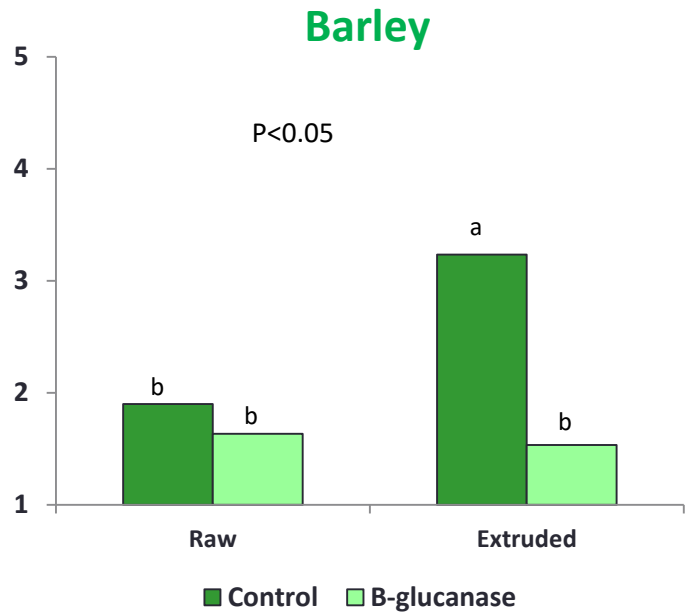
Results: welfare measurements

Foot pad dermatitis scores





Michel et al., 2012

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Results: product quality

Wheat diets Measurement	Raw	Raw+ xylanase	Extruded	Extruded+ xylanase	Extrusion	Enzyme	Interaction
Carcass yield (%)	77.2	77.6	77.6	78.5	*	†	NS
pH 15 min *pm*	6.32 ^{a}	6.17 ^{b}	6.17 ^{b}	6.23 ^{ab}	NS	NS	**
Colour muscle L*	58.3	58.0	56.5	57.4	*	NS	NS
Colour muscle a*	2.49 ^{b}	2.57 ^{b}	3.39 ^{a}	2.75 ^{b}	**	†	*
Colour muscle b*	0.61	0.88	-0.35	0.65	†	*	NS
Surface (g/mm)	15001	17129	15502	17113	NS	*	NS

Barley diets Measurement	Raw	Raw+ β-glucanase	Extruded	Extruded+ β-glucanase	Extrusion	Enzyme	Interaction
Carcass yield (%)	74.5	76.2	75.2	77.4	†	***	NS
pH 24 h pm	5.88	5.86	5.69	5.81	*	NS	NS
Intramuscular fat (%)	0.59	0.62	0.79	0.84	*	NS	NS
Colour skin a*	3.02	3.17	4.70	3.47	*	NS	NS
Colour skin b*	2.09 ^{c}	3.68 ^{bc}	5.39 ^{a}	4.09 ^{ab}	**	NS	*
Colour muscle L*	57.5	57.0	59.2	57.9	*	NS	NS
Shear force (kg)	1.89	1.62	1.62	2.01	NS	NS	***
Surface (g/mm)	17379 ^{ab}	15295 ^{bc}	14419 ^{c}	18400 ^{a}	NS	NS	**
Slope (kg.mm)	341^{a}	283 ^{b}	289 ^{b}	348 ^{a}	NS	NS	***

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Summary:

- Wheat extrusion:
  - ↑ digesta viscosity and ↓ AID for some amino acids.
  - ↑ AID for energy but had no major effects on chicken performance.

- Barley extrusion:
  - Impaired FCR, ↑ feed intake and digesta viscosity, ↓ AID for energy, fat, protein and amino acids.
  - Impaired litter quality, feather cleanness and foot pad dermatitis.

- Xylanase ↑ AID for energy, fat, nitrogen and amino acids for raw and extruded wheat, and ↓ digesta viscosity and improved litter and feather cleanness for extruded, but these improvements did not correlate with performance.

- For extruded barley, β-glucanase improved FCR, largely ↓ digesta viscosity and ↑ AID for energy, fat and most AA, and improved litter, feather cleanness and foot pad dermatitis, but these improvements did not result in improved performance.

Conclusions:

- Wheat or barley extrusion was not successful in improving productivity of broiler chickens.
- Carbohydrase supplementation increased nutrient digestibility, reduced intestinal viscosity and improved welfare of chickens, but did not improve productivity.

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