Altering feed composition as alternatives to zinc oxide and to reduce post-weaning diarrhoea.

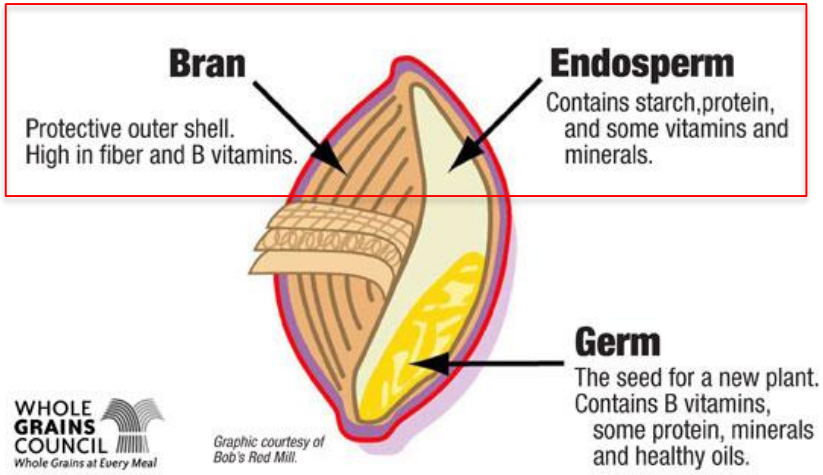
The effects of wheat bran inclusion on piglet performance in the nursery and removal of pharmaceutical zinc.

primary diets

What is wheat bran?

Nutrient		Average[1]
Ash	%	4.52
Calcium	%	0.08
Crude Fibre	%	9.29
Crude Protein	%	15.74
Moisture	%	12.46
NDF	%	38.91
Oil A	%	4.50
Oil B	%	3.28
Phosphorus	%	0.88
Sodium	%	0.02
Starch	%	21.33
Particle Size	microns	>1000[2]

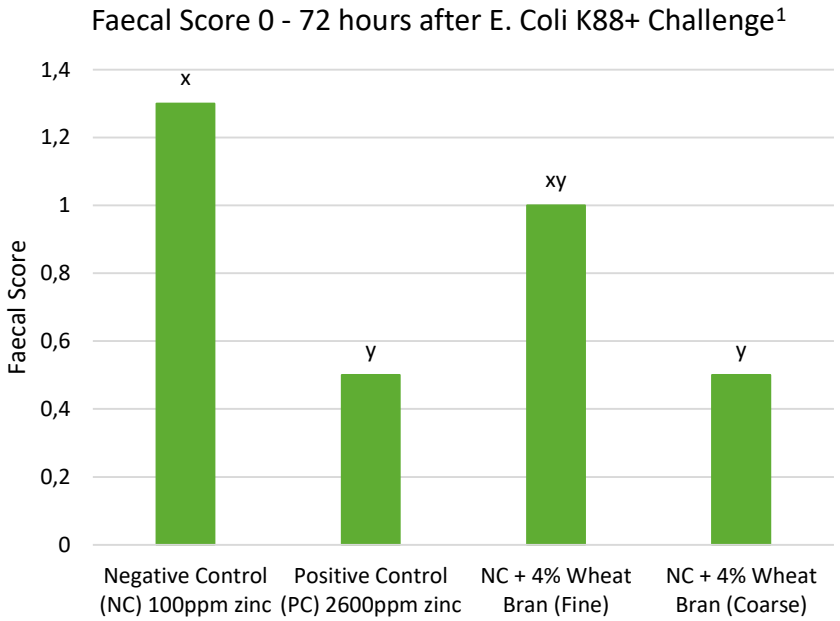
[1]Average of routine QC analysis from Aug 17 to May 19
[2]75% retained by 1000micron sieve as opposed to 2000microns or 500microns.



Why are we interested in wheat bran?

Additional prescribed zinc oxide is added to piglet diets to prevent post-weaning diarrhoea.

Coarse ground wheat bran (1088µm) at an inclusion of 4% has been shown to reduce post-weaning diarrhoea in piglets in the absence of zinc oxide.



[1]Adapted from Molist, F., Gómez de Segura, A., Pérez, J. F., Bhandari, S. K., Krause, D. O. and Nyachoti, C. M. (2010) Effect of wheat bran on the health and performance of weaned pigs challenged with *Eschericia coli* K88+. *Livestock Science* (133) 214 – 217

How?

1) By binding ETEC K88 and reduce adhesion to intestinal mucus, reducing numbers of E Coli in the gut:
   - Demonstrated in vitro as binding of *E. coli* K88 to wheat bran and a reduced adhesion of *E. coli* K88 to porcine intestinal mucus in the presence of wheat bran[2].

2) By influencing microbiota profile in the hind gut[1,3,4].
   - Reduced E. Coli population in ileal muscosa and digesta 7 days post *E. coli* K88 challenge in the absence of zinc oxide[1].
   - Reduced E. coli and Coliforms in faeces 12 days post *E. coli* K88 challenge in the absence of zinc oxide[3].
   - Increased Firmicutes and reduced Bacteroidetes 7 days post *E. coli* K88 challenge in colon digesta in the absence of zinc oxide[4].

3) By influencing SCFA expression in the hind gut[3,4].
   - Increased total SCFA, Propionic Acid and Butyric Acid in faeces 12 days post-weaning in the absence of zinc oxide[3].
   - Increased total SCFA and Acetic Acid in colon digesta 7 days post *E. coli* K88 challenge in the absence of zinc oxide[4].

[2]González-Ortiz, G., Pérez, J. F., Hermes, R. G., Molist, F., Jiménez-Díaz, R. and Martín-Orúe, S. M. (2014) Screening the ability of natural feed ingredients to interfere with the adherence of enterotoxigenic *Eschericia coli* (ETEC) K88 to the porcine intestinal mucus. *British Journal of Nutrition* 111 (4) 633 - 642
[3]Molist, F., Hermes, R. G., de Segura, A. G., Martín-Orúe, S. M., Gasa, J., Manzanilla, E. G. and Pérez, J. F. (2011) Effect and interaction between wheat bran and zinc oxide on productive performance and intestinal health in post-weaning piglets. *British Journal of Nutrition* 105, 1592 - 1600
[4]Molist, F., Manzanilla, E. G., Pérez, J. F. and Nyachoti, C. M. (2012) Coarse, but not finely ground, dietary fibre increases intestinal *Firmicutes:Bacteroidetes* ratio and reduces diarrhoea induced by experimental infection in piglets. *British Journal of Nutrition* 108 (1) 9 - 15

Question: What are the potential piglet growth performance benefits of the inclusion of 4% coarse ground wheat bran to commercial UK diets?

Hypothesis: the addition of 4% course ground wheat bran to commercial UK starter diets improves performance (average daily gain and feed conversion ratio) of pigs in the absence of additional zinc oxide.

Hypothesis: the addition of 4% course ground wheat bran to commercial UK starter diets improves performance (ADG, FCR) of pigs in the absence of added zinc oxide.

- 2 x 2 Factorial:
  - 100mg/kg zinc vs 2600mg/kg zinc
  - 0% wheat bran vs 4% wheat bran
- 100 mixed sex piglets (JSR 9T x GC 900)
- Weaned at 26.5 days of age and 8kg live-weight.
- 4-5 pigs per pen, 6 pens per treatment.
- Bodyweight measurement taken at day 12 and 20 post-weaning. Feed intake, mortality, health and faecal score also recorded.

Disease	Status					
	Pos	Pres	Abs	Neg	No. & type pigs affected	Action/treatment/control methods*
EP	√				Growers	Vaccination
PRRS	√				Growers	Vaccination
PMWS/PDNS	√				Growers	Vaccination
Strep. meningitis	√				Weaners	Individual treatments
APP			√			
Ileitis/*Lawsonia*			√			
Sarcoptic mange			√			
Atrophic rhinitis			√			
Swine dysentery			√			
Worms	√					Med
Coccidiosis	√					Med
Clostridia			√			

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Diet Information

- Commercial wheat and barley diets.
- Protein sources:
  - Soya (predominantly HiPro)
  - Fishmeal
  - Milks
  - Potato Protein
- Good lactose levels and use of cooked cereals.
- All diets contain:
  - Phytase (No matrix applied)
  - Xylanase (No matrix applied)
  - Benzoic Acid
  - Live Yeast Probiotic
- Wheat bran replaced wheat and some wheatfeed.
- Isonutritious:
  - Net Energy Piglet
  - SID Amino Acids
  - Digestible Phosphorus

Diet 1 (Day 0 – 12)	**Zinc**	**Y**	**Y**	**N**	**N**
	WBran	**N**	**Y**	**N**	**Y**
Oil	%	7.12	7.10	7.81	7.79
Protein	%	20.92	20.86	21.01	20.94
Fibre	%	2.39	2.38	2.58	2.57
Ash	%	5.53	5.51	5.68	5.66
Calcium	%	0.70	0.70	0.70	0.70
Phosphorus	%	0.70	0.70	0.70	0.70
Sodium	%	0.23	0.23	0.23	0.23
Vitamin A	iu/kg	12500	12500	12500	12500
Vitamin D	iu/kg	2000	2000	2000	2000
Vitamin E	iu/kg	300	300	300	300
Zinc	mg/kg	2600	2600	100	100
Wheat Bran	%	0	4	0	4
Diet 2 (Day 13 – 20)	**Zinc**	**Y**	**Y**	**N**	**N**
	WBran	**N**	**Y**	**N**	**Y**
Oil	%	6.27	6.25	7.22	7.20
Protein	%	21.03	20.96	20.85	20.79
Fibre	%	2.55	2.54	2.88	2.87
Ash	%	5.44	5.42	5.62	5.60
Calcium	%	0.72	0.72	0.72	0.72
Phosphorus	%	0.66	0.66	0.68	0.68
Sodium	%	0.20	0.20	0.20	0.20
Vitamin A	iu/kg	12500	12500	12500	12500
Vitamin D	iu/kg	2000	2000	2000	2000
Vitamin E	iu/kg	200	200	200	200
Zinc	mg/kg	2600	2600	100	100
Wheat Bran	%	0	4	0	4

Results

	Added Zinc Level mg/kg		Wheat Bran Level %			P-Values		
	100	2650	0.0	4.0	SED	Zinc	WB	Zinc x WB
Day 1-12 (Diet 1)								
ADFI (g/pig/d)	231	248	236	243	8.945	0.2118	0.6059	**0.0417**
ADG (g/pig/d)	**168^{b}**	**227^{a}**	189	206	12.379	**0.0040**	0.3469	**0.0277**
FCR (g/g)	**1.43^{a}**	**1.11^{b}**	**1.34^{a}**	**1.20^{b}**	0.043	**<.0001**	**0.0427**	**0.0234**
Day 13-20 (Diet 2)								
ADFI (g/pig/d)	562	613	569	606	18.806	*0.0761*	0.1826	0.1882
ADG (g/pig/d)	407	451	409	450	21.183	0.1633	0.1921	0.8977
FCR (g/g)	1.41	1.37	1.41	1.37	0.051	0.5820	0.6147	0.3848
Overall (day 1-20)								
ADFI (g/pig/d)	364	394	369	388	11.662	*0.0865*	0.2653	*0.0761*
ADG (g/pig/d)	**264^{b}**	**317^{a}**	277	303	13.033	**0.0114**	0.1723	0.1624
FCR (g/g)	**1.39^{a}**	**1.25^{b}**	1.36	1.29	0.032	**0.0072**	0.1545	0.4944
Day 12 weight (kg)	**10.03^{b}**	**10.73^{a}**	10.24	10.52	0.154	**0.0058**	0.2138	**0.0329**
Day 20 weight (kg)	**13.29^{b}**	**14.34^{a}**	13.51	14.12	0.259	**0.0119**	0.1164	0.1610

[1]ANOVA performed by JMP 14 with zinc inclusion and wheat bran inclusion as the factors and replicate as the covariates; Superscripts represent differences between treatments (P<0.05)

No differences in mortality, health or faecal score between treatments.

The Impact of Zinc Oxide Removal

Added Zinc Level mg/kg	Day 20 Weight (kg) 100	2650	P-Value	Benefit of Added Zinc
PLTR 241	12.78[b]	14.11[a]	**0.0490**	**+ 1.33kg**
PLTR 251	13.46[b]	15.33[a]	**0.0001**	**+ 1.87kg**
PLTR 256	13.60[b]	15.31[a]	**<.0001**	**+ 1.71kg**
PLTR 258	13.29[b]	14.34[a]	**0.0119**	**+ 1.05kg**
PLTR 259	14.20[b]	15.88[a]	**0.0004**	**+ 1.68kg**
PLTR 263	14.93	14.74	NS	-

All trials carried out at the University of Leeds with indoor bred piglets. JSR 9T x GC 900

Results

	Added Zinc Level mg/kg		Wheat Bran Level %			P-Values		
	100	2650	0.0	4.0	SED	Zinc	WB	Zinc x WB
Day 1-12 (Diet 1)								
ADFI (g/pig/d)	231	248	236	243	8.945	0.2118	0.6059	**0.0417**
ADG (g/pig/d)	**168^{b}**	**227^{a}**	189	206	12.379	**0.0040**	0.3469	**0.0277**
FCR (g/g)	**1.43^{a}**	**1.11^{b}**	**1.34^{a}**	**1.20^{b}**	0.043	**<.0001**	**0.0427**	**0.0234**
Day 13-20 (Diet 2)								
ADFI (g/pig/d)	562	613	569	606	18.806	*0.0761*	0.1826	0.1882
ADG (g/pig/d)	407	451	409	450	21.183	0.1633	0.1921	0.8977
FCR (g/g)	1.41	1.37	1.41	1.37	0.051	0.5820	0.6147	0.3848
Overall (day 1-20)								
ADFI (g/pig/d)	364	394	369	388	11.662	*0.0865*	0.2653	*0.0761*
ADG (g/pig/d)	**264^{b}**	**317^{a}**	277	303	13.033	**0.0114**	0.1723	0.1624
FCR (g/g)	**1.39^{a}**	**1.25^{b}**	1.36	1.29	0.032	**0.0072**	0.1545	0.4944
Day 12 weight (kg)	**10.03^{b}**	**10.73^{a}**	10.24	10.52	0.154	**0.0058**	0.2138	**0.0329**
Day 20 weight (kg)	**13.29^{b}**	**14.34^{a}**	13.51	14.12	0.259	**0.0119**	0.1164	0.1610

[1]ANOVA performed by JMP 14 with zinc inclusion or fibre source as the factor and replicate as the covariates; Superscripts represent differences between treatments (P<0.05)

No differences in mortality, health or faecal score between treatments.

Results

Added Zinc Level mg/kg Wheat Bran Level %	150 0.0		150 4.0	2650 0.0		2650 4.0	SED	P Value
Day 1 – 12 (Diet 1)								
ADFI (g/pig/d)	**214^{b}**	>	**247^{ab}**	**259^{a}**	=	**237^{ab}**	12.650	**0.0417**
ADG (g/pig/d)	**138^{b}**	>=	**197^{ab}**	**240^{a}**	=	**214^{a}**	17.507	**0.0277**
FCR (g/g)	**1.58^{a}**	<	**1.29^{b}**	**1.10^{b}**	=	**1.12^{b}**	0.060	**0.0234**
Day 13 – 20 (Diet 2)								
ADFI (g/pig/d)	526		599	613		613	26.595	0.1882
ADG (g/pig/d)	385		430	433		470	29.957	0.8977
FCR (g/g)	1.39		1.42	1.42		1.32	0.072	0.3848
Overall (day 1 – 20)								
ADFI (g/pig/d)	338		389	400		388	16.492	*0.0761*
ADG (g/pig/d)	237		290	317		316	18.432	0.1624
FCR (g/g)	1.44		1.34	1.27		1.23	0.046	0.4944
Day 12 weight (kg)	**9.64^{b}**	>=	**10.43^{ab}**	**10.85^{a}**	=	**10.62^{a}**	0.217	**0.0329**
Day 20 weight (kg)	12.72		13.87	14.31		14.38	0.367	0.1610

[1]Tukey HSD performed by JMP 14 with treatment as the factor and replicate and weaning weight as the covariate; Superscripts represent differences between treatments ($P<0.05$).

Conclusions from this Trial:

Hypothesis: the addition of 4% course ground wheat bran to commercial UK starter diets improves performance (ADG, FCR) of pigs in the absence of zinc oxide.

1) There was an interaction between ZnO inclusion and Wheatbran inclusion for ADFI, ADG and FCR during the first 12 days of trial.
    a. Wheatbran inclusion in diets that do not contain ZnO is beneficial for piglet performance.
    b. Wheatbran inclusion in diets which do contain ZnO is neutral for piglet performance.

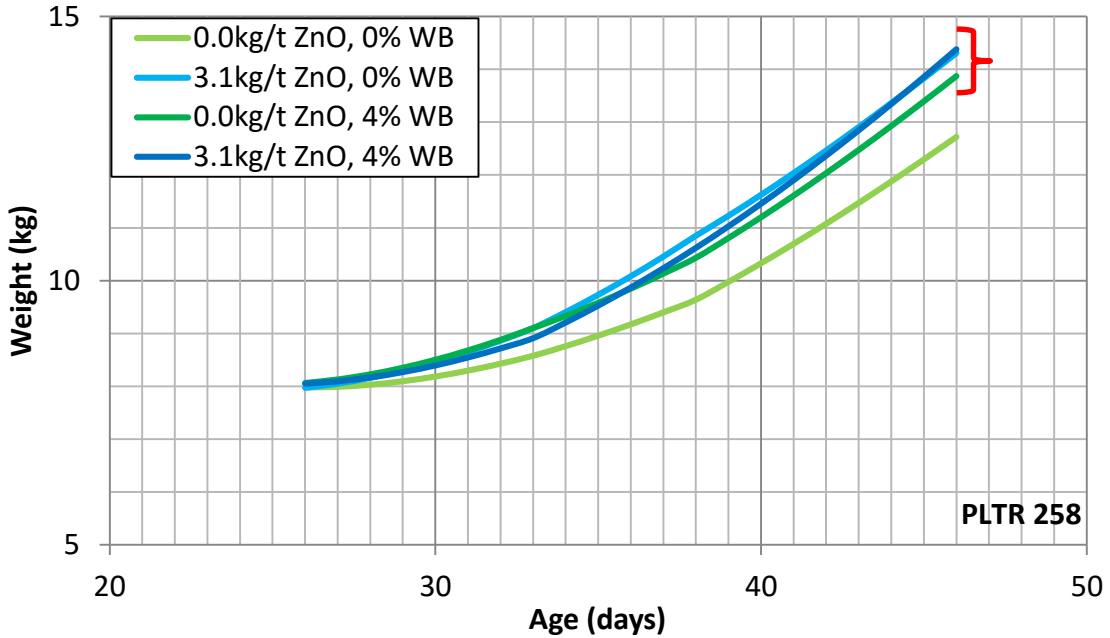
2) There were no differences in Faecal Score, Cleanliness, Health or Mortality between any treatments in this trial.

3) Removal of 3.1kg/t ZnO from starter diets in this trial resulted in a significant reduction in ADG and a significant increase in FCR over the 20 day trial period.

Conclusions from this Trial:

Hypothesis: the addition of 4% course ground wheat bran to commercial UK starter diets improves performance (ADG, FCR) of pigs in the absence of zinc oxide.

4) Performance of pigs receiving no zinc oxide but receiving diets which contained 4% wheat bran performed more similarly to the zinc oxide treatments than to the negative control, but do not entirely recover performance loss from zinc oxide removal.



Summary

- Addition of 4% wheat bran to diets increased feed intake, daily gain and improved feed conversion ratio during the first 12 days post-weaning when zinc was not fed.

- The growth performance of this diet was intermediate to diets containing zinc oxide and the negative control.

Implications

- Incorporation of 4% wheat bran to diets designed to be fed in the absence of zinc oxide could contribute towards a nutritional strategy to recover performance loss as a result of zinc oxide removal.

- However, there is still some growth performance gap which requires alternative management and/or nutritional intervention to bridge.

Thank you