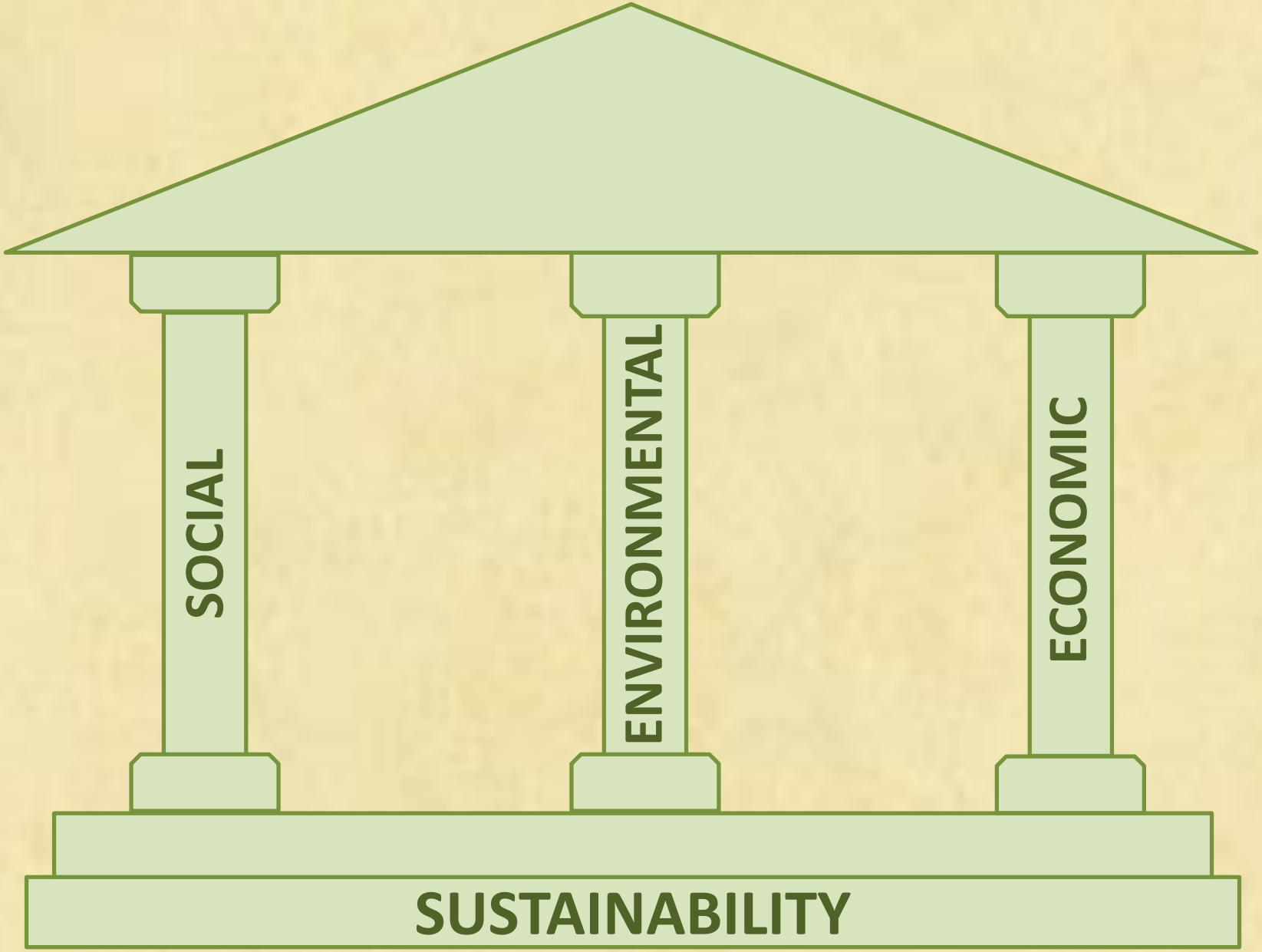
SUSTAINABLE PORK PRODUCTION IN THE U.S.: Does nutrition have a role beyond economic efficiency?

IOWA STATE UNIVERSITY
APPLIED SWINE NUTRITION

Presented at NANP Summit, Washington, DC. April 10, 2019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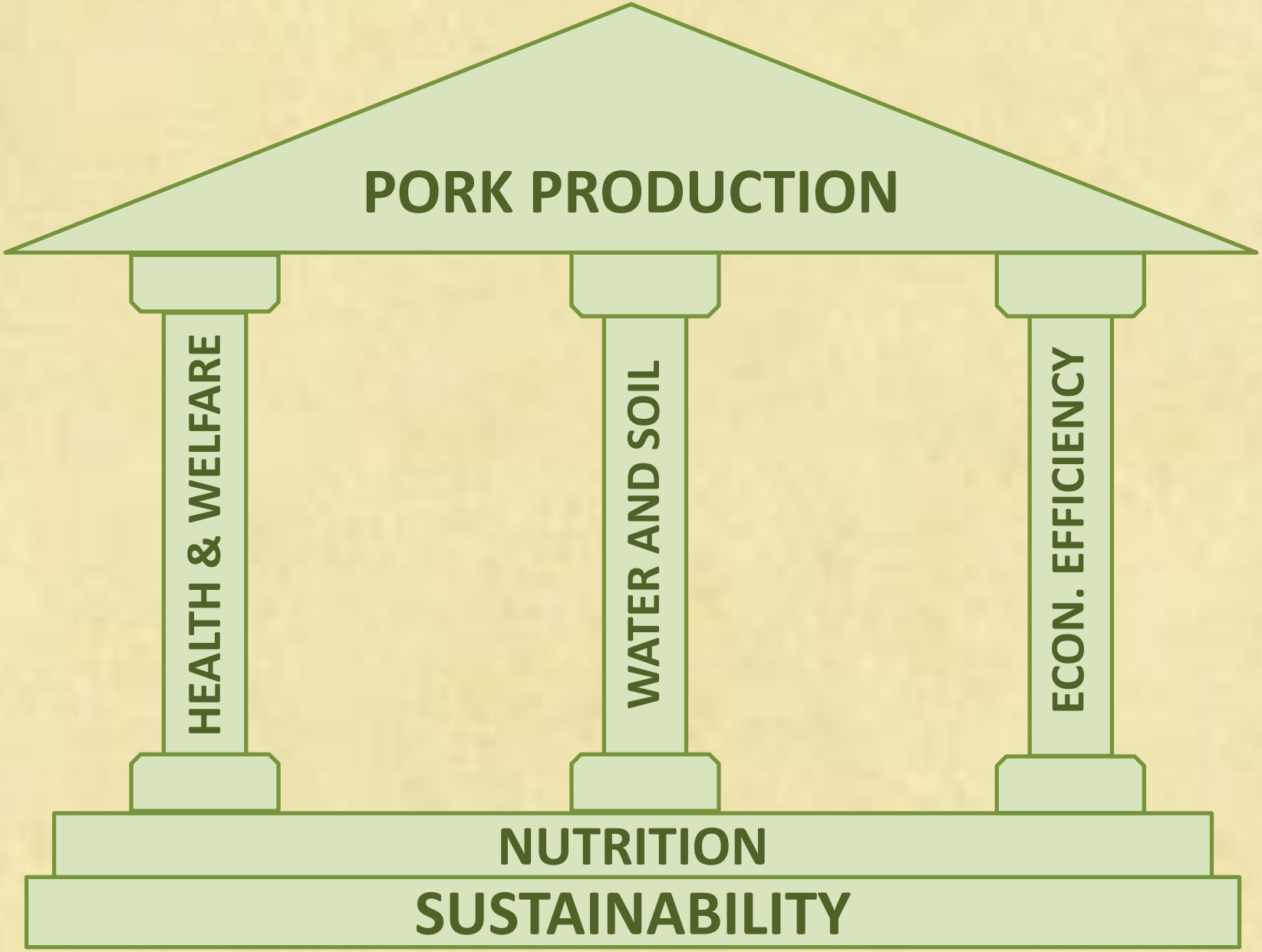
PORK PRODUCTION
HEALTH & WELFARE
WATER AND SOIL
ECON. EFFICIENCY
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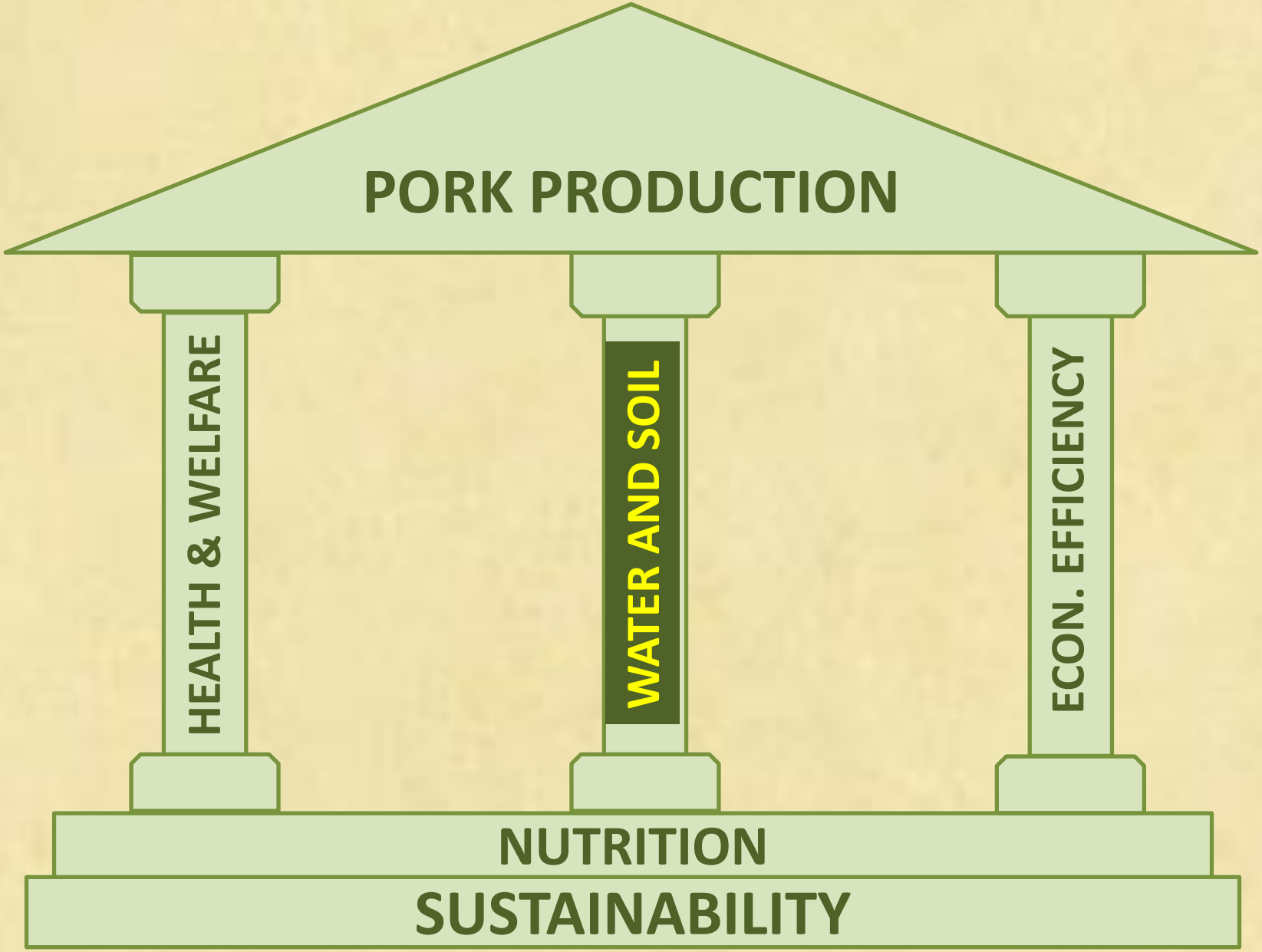
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Typical water balance: growing pig

INTAKE	mL	LOSSES	mL
Drinking water	4,500	Urine	2,760
Metabolic water	900	Respiration, etc.	1,950
Water in feed	250	Faeces	450
		Sub-total	5,160
		Retained	490
Total	5,650	Total	5,650

45 kg pig gaining 785 g/d, feed conversion of 2.54, eating 2,000 g/d of a diet containing 17% crude protein and 4% total fat.

Patience et al., 2001

Impact of diet on water intake and excretory patterns in growing pigs, g/d

	CTL	Hi P	Exc P	Exc M	P-value
Diet Protein, %	17.8	21.4	25.4	20.4	
Diet P, %	0.47	0.51	0.54	0.76	
Intake	63.0^{a}	69.1^{b}	81.0^{c}	67.5^{b}	<0.05
Fecal output	15.3^{a}	17.2^{b}	20.3^{c}	19.0^{b,c}	<0.05
Urinary output	23.9^{a}	25.9^{b}	35.7^{c}	23.6^{a}	<0.05
Excretion	39.2^{a}	43.1^{b}	56.0^{c}	42.6^{b}	<0.05
Resp. + Ret.	23.8	26.0	25.0	24.9	0.57
PDR	149	162	156	156	0.57

Shaw et al., 2006

Influence of drinker flow rate on water ~~intake~~ disappearance and performance of weaned pigs from 3-6 wks of age

	Water delivery rate (mL/min)			
	175	350	450	700
Water disappearance (L/d)	0.78	1.04	1.32	1.63
Feed intake (g/d)	303	323	341	347
Water:feed ratio	2.57	3.22	3.87	4.70
Daily gain (g)	210	235	250	247
Feed conversion (F:G)	1.48	1.39	1.37	1.42
Apparent time drinking (min/d)	4.46	2.97	2.93	2.32

Brooks and Carpenter 1990

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Wasted water, L/d	0	0.22	0.45	0.75

Brooks and Carpenter 1990

Comparison of different drinker devices

Wet/dry vs. Dry Feeder

4.49 vs 6.06 L/pig/d

(-25%)

Swinging vs. Wall-mounted Nipple Drinker

4.90 vs. 5.50 L/pig/d

(-11%)

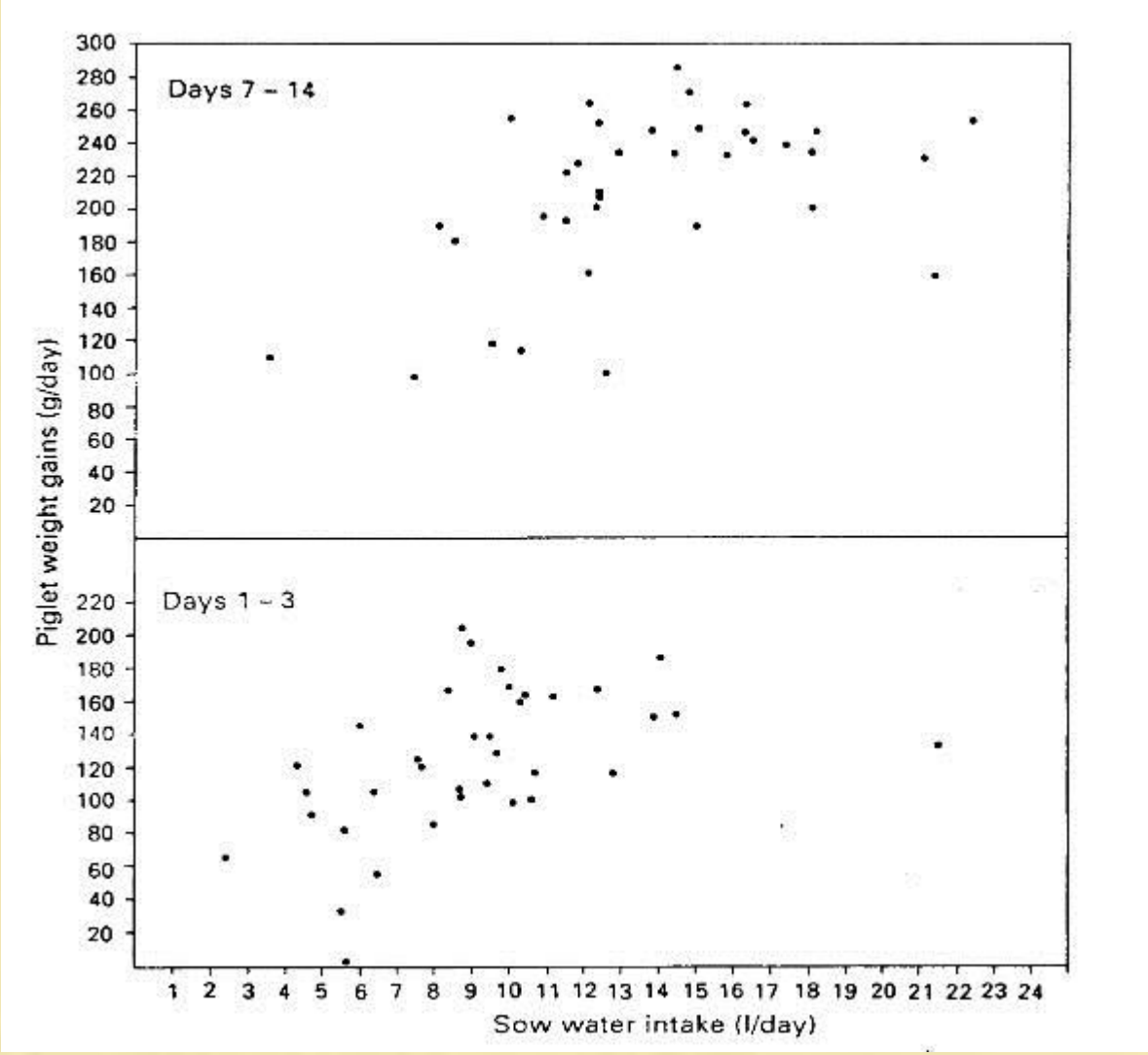
Bowl vs. Swinging Nipple Drinker

3.78 vs. 5.01 L/pig/d

(-25%)

Brumm et al., 2000

Mean daily weight gains of 37 litters in relation to daily water intake of the sow



Fraser et al. 1993

Precision feeding benefits the environment: Reduced nitrogen output

Use of synthetic amino acids in the diet allows us to lower crude protein by as much as 4 percentage points

Each percentage point reduction in diet protein lowers the nitrogen content of manure by 4 to 5%

- Vonderohe et al., 2016

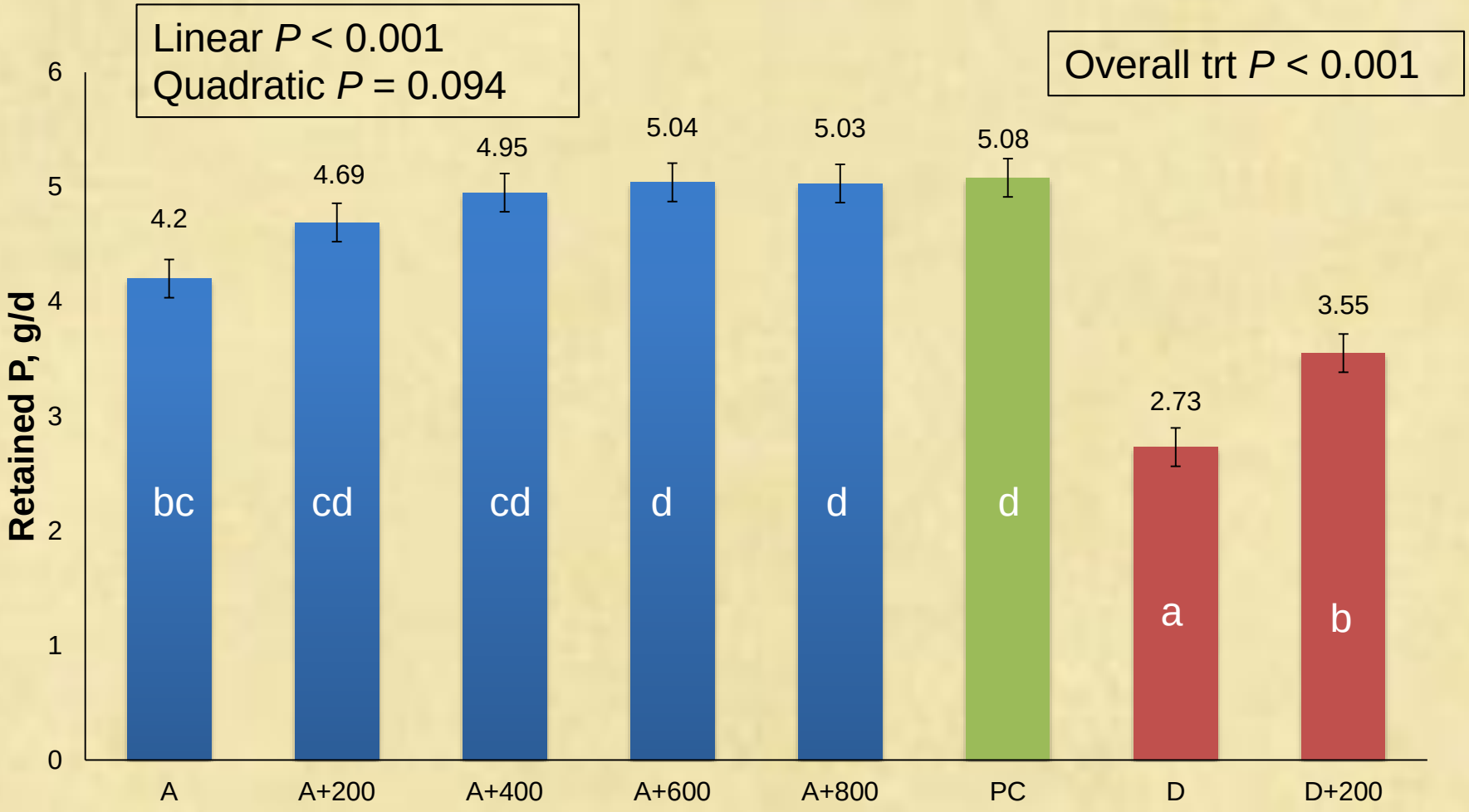
Precision feeding benefits the environment: Land use

Use of synthetic amino acids reduces the quantity of soybean meal in the diet

Reduces land required to feed the U.S. pig herd by ~14-15%

- Tokach, 2010

Effects of phytase on retained phosphorus



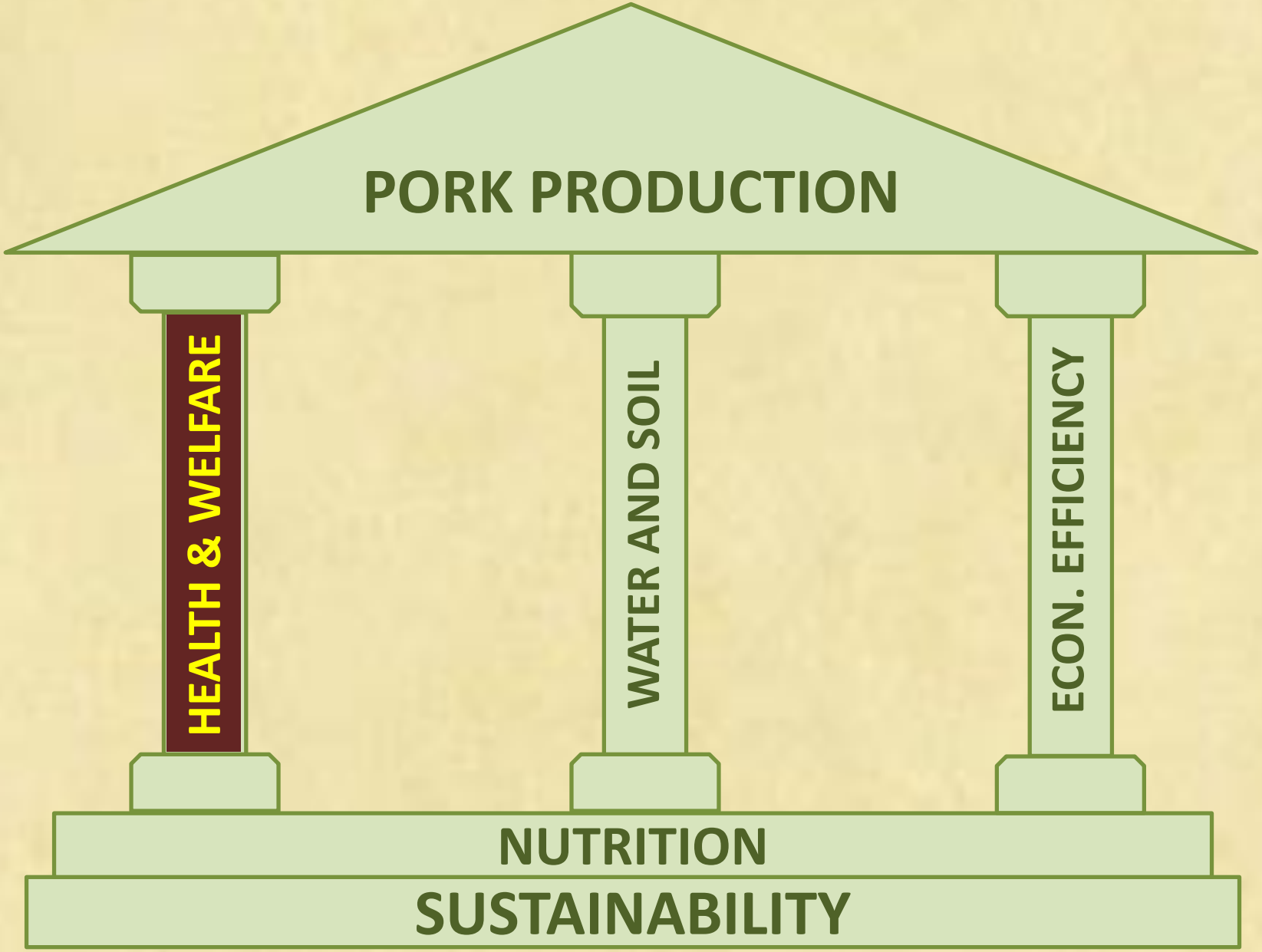
*Orthogonal contrasts were performed in the P-adequate diets

Olsen et al., 2018

Impact of phytase on phosphorus balance in weanling pigs

Phytase, FTU/kg	0	250	500	1000	2000	Sign.
Intake, g/d	5.03	5.02	4.91	5.17	5.27	L
Fecal, g/d	3.01	2.68	2.36	2.09	2.33	L,Q
Urine, g/d	0.01	0.01	0.01	0.02	0.02	L
Balance, g/d	2.01	2.33	2.28	3.06	2.92	L,Q
Soluble organic, % of intake	48	42	40	31	34	L,Q

Beaulieu et al., 2007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Growth performance

	Health Challenge[2]			Sex[3]			Pooled	P-value[1]	
Item	LCh	MCh	HCh	Barrows	Mixed	Gilts	SEM	HC	Sex
Start BW, kg	13.3^{b}	13.7^{a}	12.4^{c}	13.0	13.1	13.2	0.2	< 0.001	0.186
Final BW[4], kg	129.1	130.6	130.6	133.6^{z}	130.5^{y}	126.1^{x}	1.4	0.354	< 0.001
Start BW CV, %	21.0^{a}	-	26.2^{b}	23.7	23.6	23.6	1.0	< 0.001	0.984
End BW CV, %	12.2^{a}	-	15.5^{b}	14.3	14.0	13.3	0.8	< 0.001	0.328
ADG[4], kg	0.86^{a}	0.79^{b}	0.74^{c}	0.82^{z}	0.80^{zy}	0.77^{y}	0.01	< 0.001	< 0.001
ADFI[4], kg	2.05^{a}	2.00^{a}	1.83^{b}	2.06^{z}	1.95^{y}	1.85^{x}	0.03	< 0.001	< 0.001
G:F[4]	0.42^{a}	0.40^{b}	0.40^{b}	0.40^{x}	0.41^{y}	0.42^{z}	0.004	< 0.001	< 0.001
Carcass basis									
ADG[4], kg	0.61^{a}	0.55^{b}	0.50^{c}	0.56^{z}	0.56^{z}	0.54^{y}	0.01	< 0.001	0.004
G:F[4]	0.30^{a}	0.28^{b}	0.28^{b}	0.27^{y}	0.29^{z}	0.29^{z}	0.004	< 0.001	< 0.001

$^{a\text{-}c}$ or $^{z\text{-}x}$ within a row, least square means lacking a common superscript differ, $P < 0.05$

[1]Probability values for main effects of HC or sex

[2]LS means of HC

[3]LS means of sex

[4]Average start body weight used as a covariate

Cornelison et al., 2017

Fixed-time economic model

Parameter	LCh	MCh	HCh
Production impact			
Days on feed	138	142	149
Days to market	133	133	133
Carcass weight produced, kg	202,558	175,623	150,858
Economic impact			
Total revenue, $	307,173	272,059	228,898
Total costs, $	273,558	266,082	245,103
Net profit, $	33,615	5,977	(16,205)
Profit/pig marketed, $	15.70	3.09	(9.56)
Profit/pig placed, $	14.01	2.49	(6.75)
Opportunity lost, $	-	27,638	49,820
Loss/pig marketed, $	-	12.61	25.27
Loss/pig placed, $	-	11.52	20.76

Cornelison et al., 2017

Effect of immune system stimulation (LPS) on energy balance

Item	CON	ENZ	ISS	SEM	*P*-value
DMI, kg	0.51	0.51	0.46	0.03	0.348
Energy balance, kcal/kg $BW^{-.60}$/kg DMI/d					
ME intake	771.3	755.9	751.1	37.7	0.924
Heat production					
HP_{total}	278.8^{b}	274.9^{b}	333.0^{a}	14.9	**0.040**
FHP*	207.8	206.6	243.3	12.9	0.135
Retained energy	488.9	476.5	418.7	32.0	0.318
ME_m‡	239.0^{b}	239.5^{b}	295.5^{a}	15.3	**0.045**

Measured days 16 - 17 (final challenge)

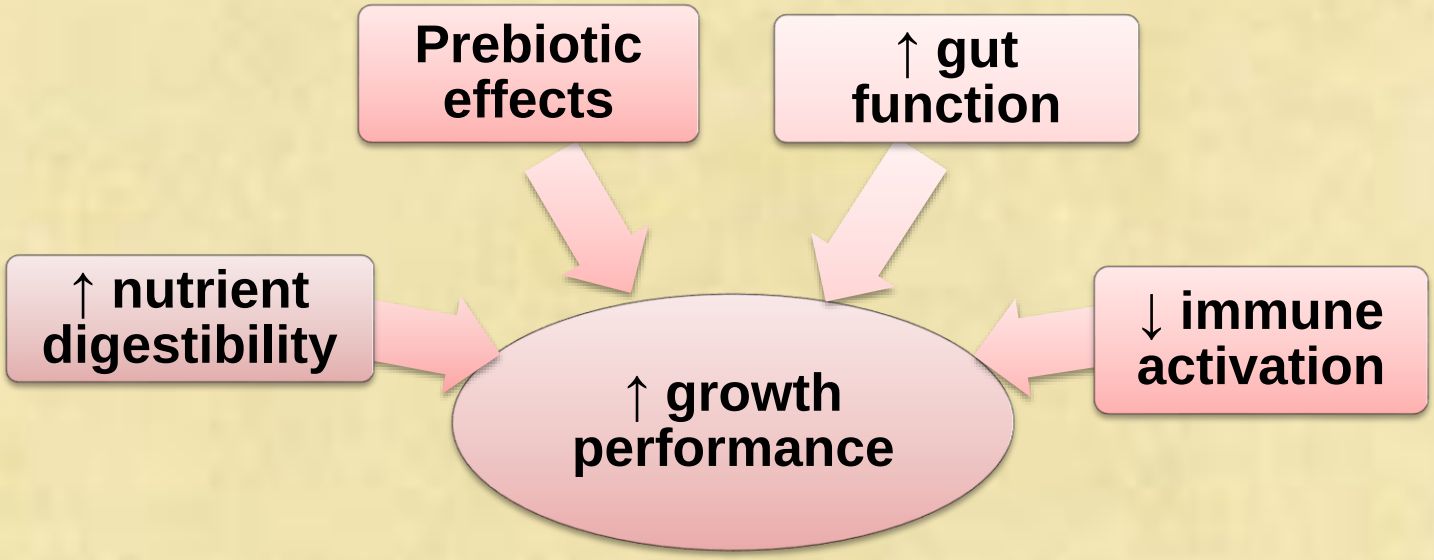
*Fasting heat production (FHP)

‡ME used for maintenance (ME_m)

Huntley et al., 2018

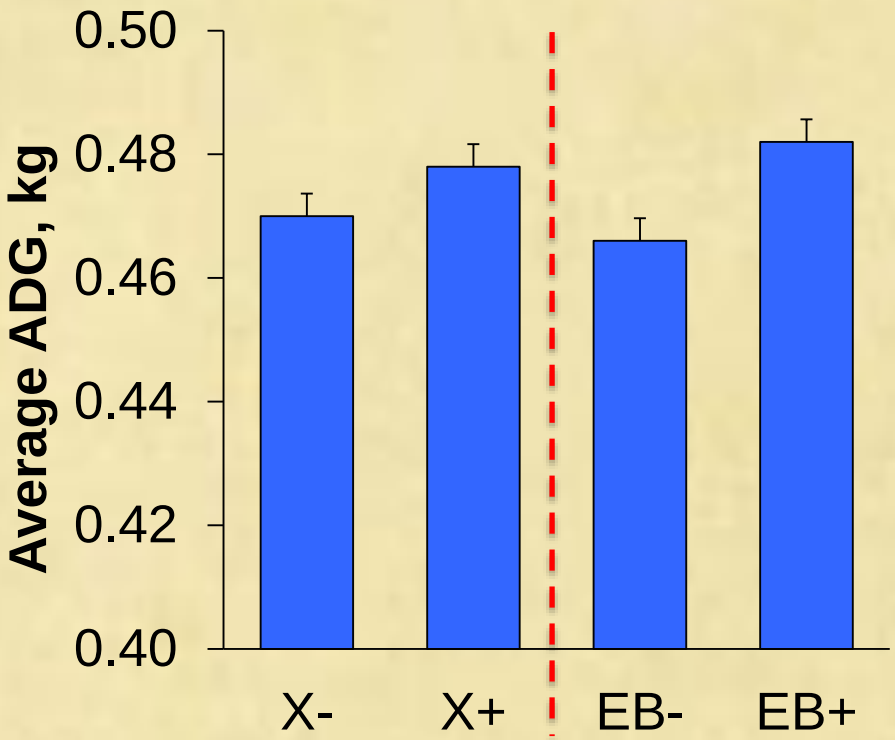
Carbohydrase use in swine diets

- Improve fiber and nutrient digestibility
- However, improvement in growth performance inconsistent
- Need to better understand the mechanisms

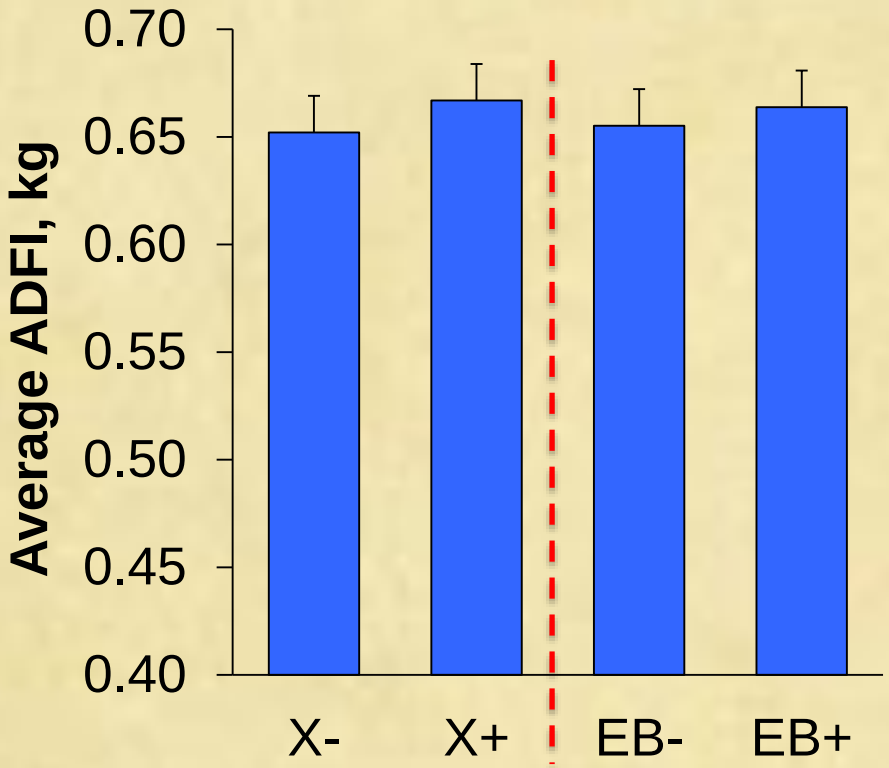


Impact of xylanase (X) and an enzyme blend (EB) on growth performance

Trt	X	EB	X*EB
P-value	0.251	**0.024**	0.910



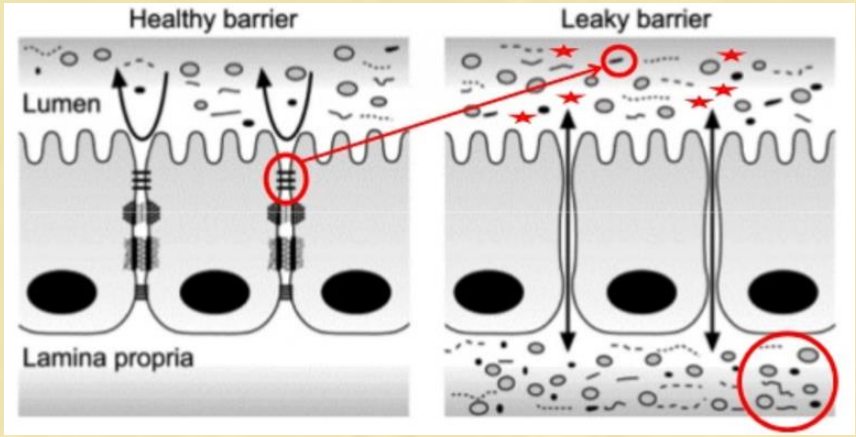
Trt	X	EB	X*EB
P-value	0.491	0.639	0.738

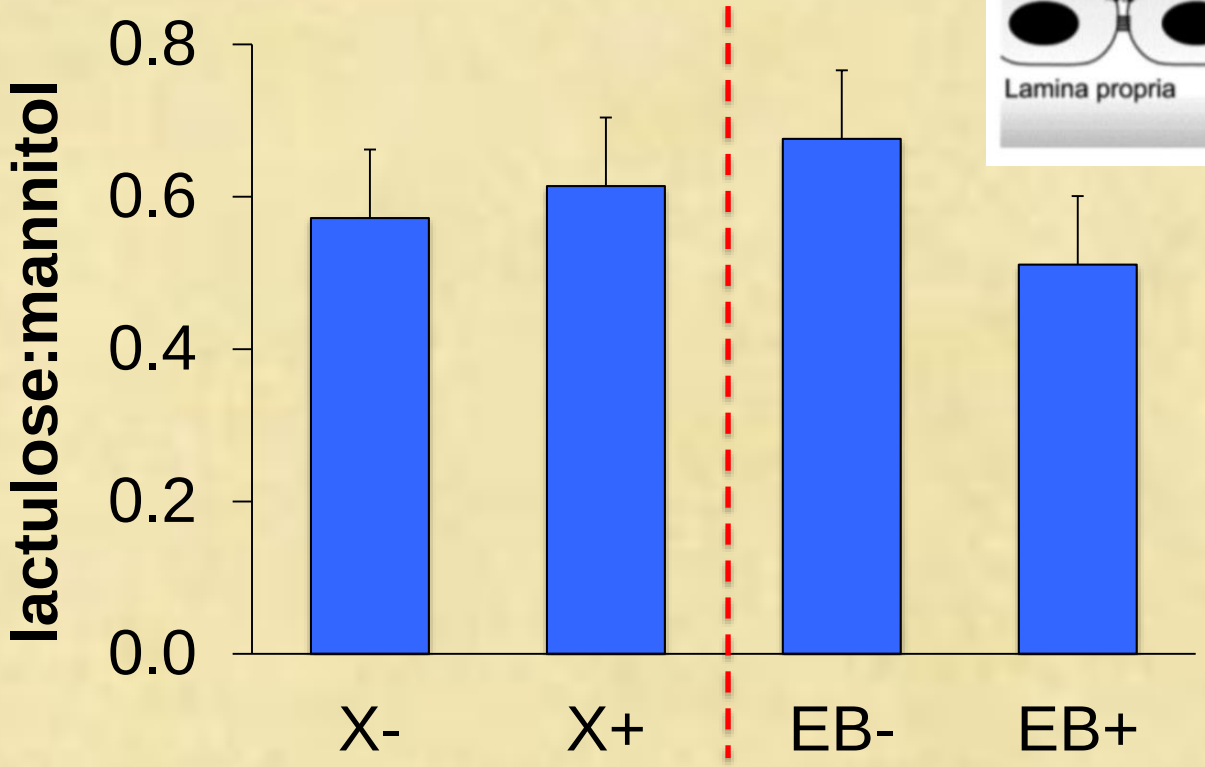


Li et al., 2018

Impact of xylanase (X) and an enzyme blend (EB) on small intestinal barrier integrity

Trt	X	EB	X*EB
P-value	0.490	**0.012**	0.055



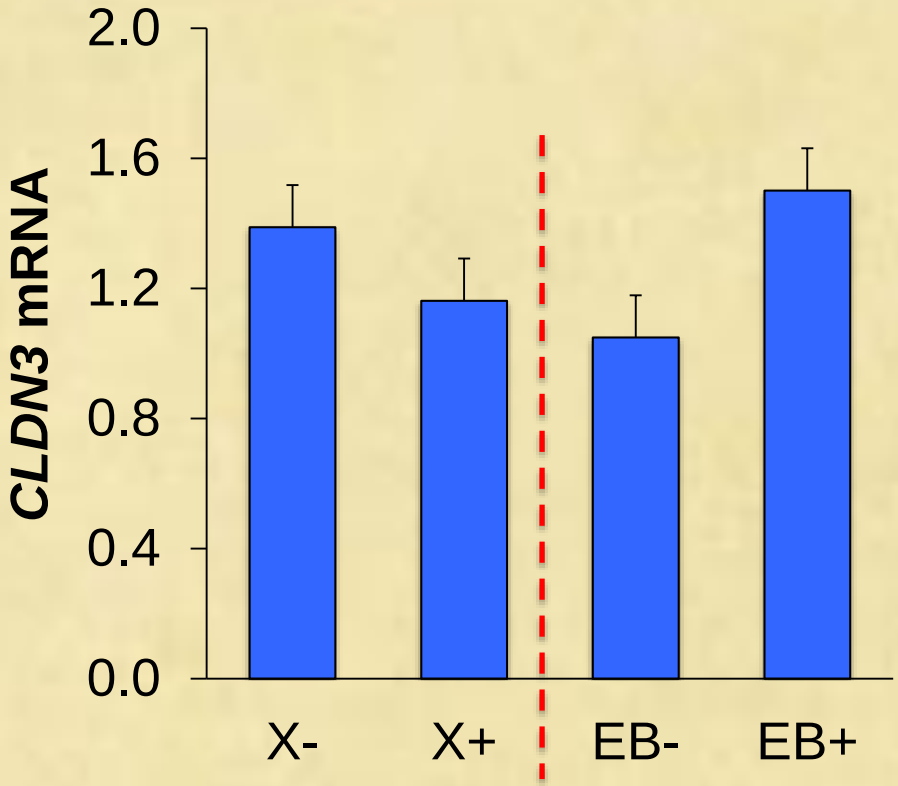


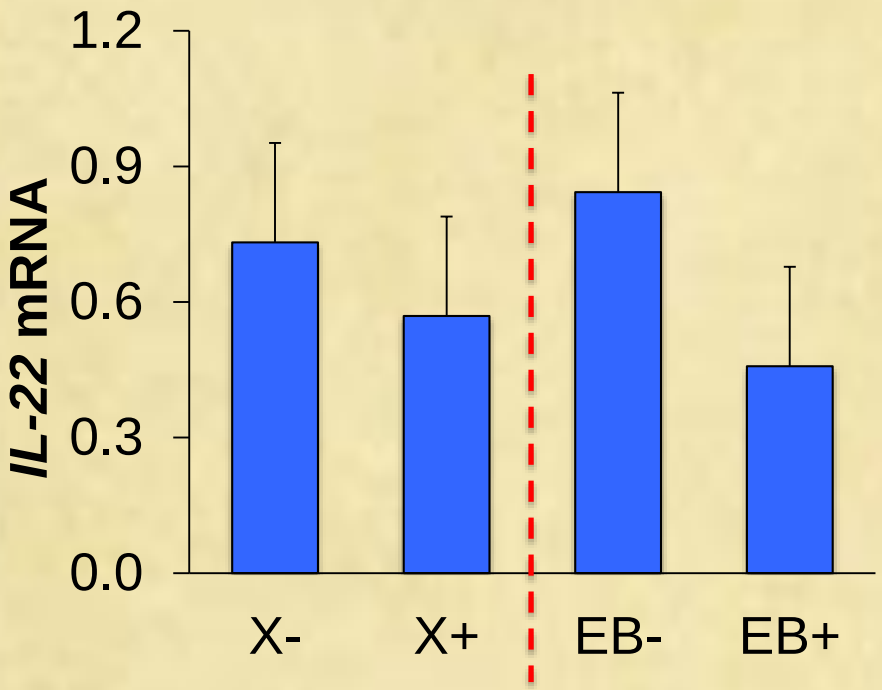
Li et al., 2018

Impact of xylanase (X) and an enzyme blend (EB) on gene mRNA levels in the ileum

Trt	X	EB	X*EB
P-value	0.573	**0.007**	0.260

Trt	X	EB	X*EB
P-value	0.363	**0.037**	0.742



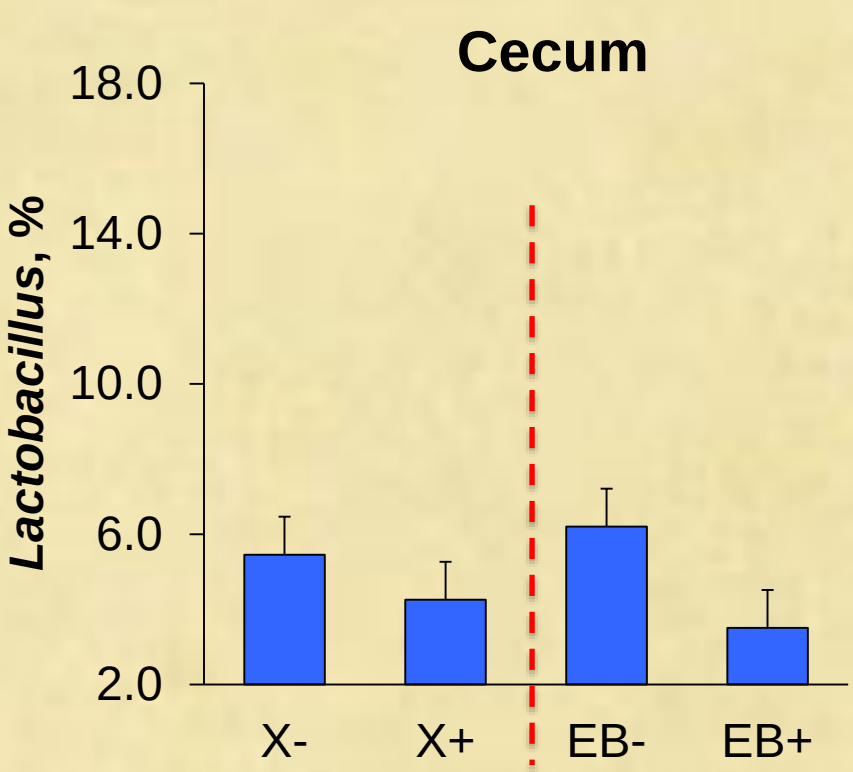


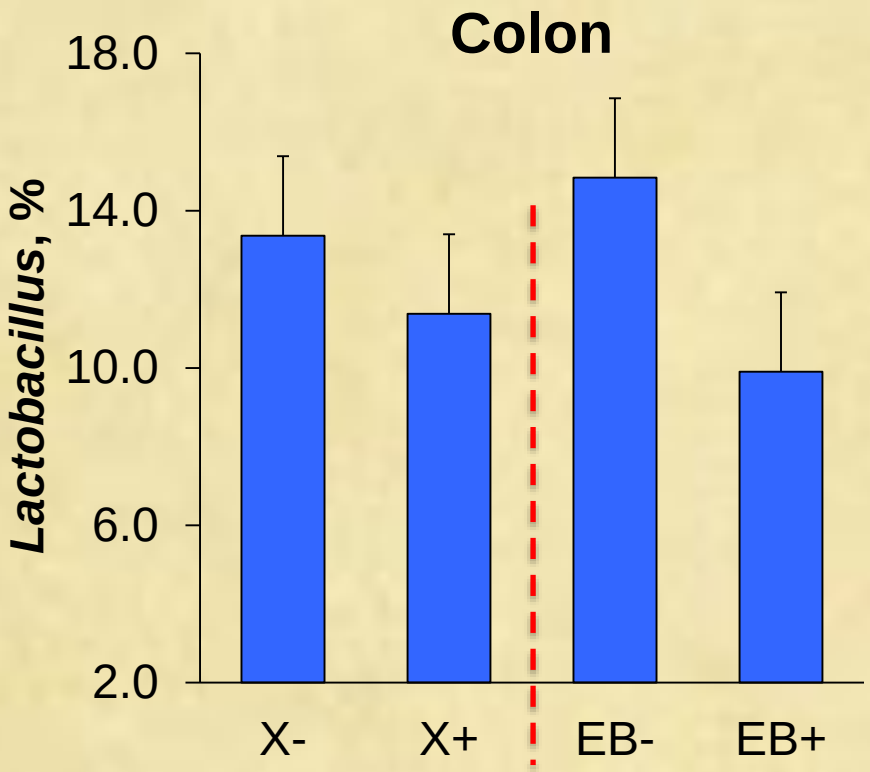
Li et al., 2018

Impact of xylanase (X) and an enzyme blend (EB) on relative abundance of intestinal bacteria

Trt	X	EB	X*EB
P-value	**0.046**	**0.001**	0.076

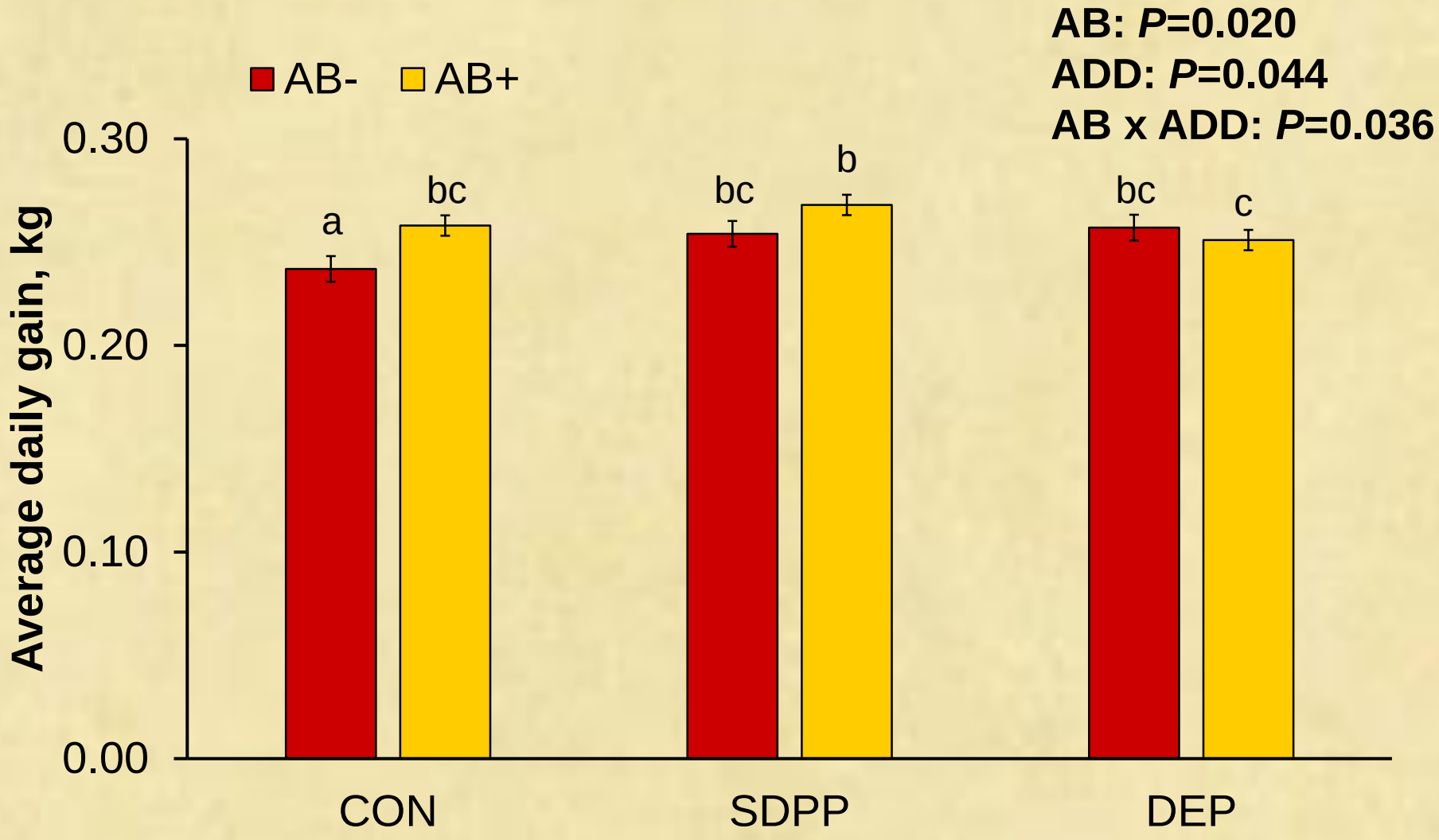
Trt	X	EB	X*EB
P-value	0.246	**0.032**	0.446





Li et al., 2018

Effects of antibiotics and additives on overall ADG



Ruckman and Patience, 2019

Effect of fiber in the diet of gestating sows on hunger behaviors

Higher fiber diet:

- Did not reduce feeding motivation
- Reduced explorative behavior
- Reduced drinking behavior
- Lower levels of circulating grehlin

Straw bedding:

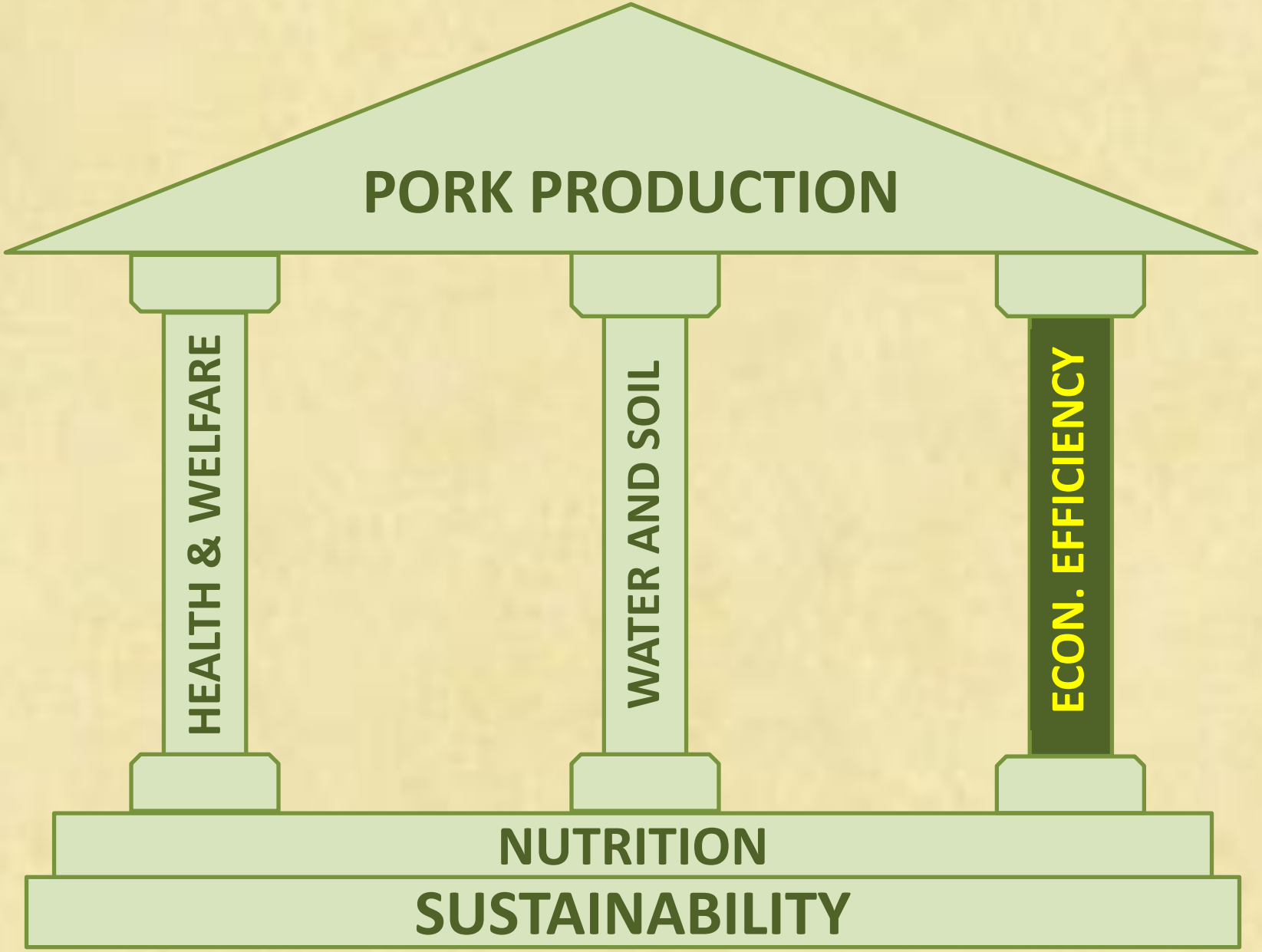
- Did not alter any of the above parameters
- Increased time spent laying

Jensen et al., 2015

Impact of supplemental dietary fiber on litter outcomes

	Control	Treatment	SEM	P-value
No. sows	310	334		
Total piglets born/litter	18.4	18.1	0.29	0.38
Piglets born alive/litter	16.8	16.9	0.25	0.78
Stillborn piglets, % of total born	**8.8**	**6.6**	**0.47**	**<0.001**
Piglets weaned/litter	14.2	14.4	0.23	0.66
Preweaning mortality, %	14.6	13.7	0.68	0.21
Overall mortality, %	**22.3**	**19.9**	**0.71**	**0.004**
Causes of mortality				
- Crushing, %	4.7	5.0		0.41
- Poor viability at birth, %	**2.8**	**1.5**		**<0.001**
- Diarrhea, %	**0.7**	**0.3**		**0.004**

Feyera et al., 2017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One of the most difficult challenges facing the nutritionist is selecting the optimal dietary energy concentration

DIET DE, Mcal/kg	3.05	3.19	3.33	3.47	3.61
Initial wt., kg	31.2	31.1	31.5	31.2	31.1
Final wt., kg	115.1	115.5	115.3	115.0	115.6
Daily gain, kg	1.00	1.02	1.04	1.02	1.03
Daily feed, kg[1]	2.66	2.62	2.62	2.52	2.44
Feed conversion[1]	2.56	2.50	2.44	2.38	2.27

[1] Effect of diet DE content significant, $P < 0.05$.
Low DE diet contained 16.4% NDF; high DE diet contained 9.6% NDF

Source: Beaulieu et al., 2009

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DE intake, Mcal/d	**8.22**	**8.49**	**8.76**	**8.61**	**8.71**

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DE intake, Mcal/d	8.22	8.49	8.76	8.61	8.71
Fat depth, mm	**16.8**	**17.8**	**18.3**	**18.6**	**19.4**
Loin depth, mm	**61.7**	**60.5**	**62.7**	**60.3**	**61.0**

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Economics of lower energy diets

	Corn/SBM	-50 kcal NE/kg	-100 Kcal NE/kg	-150 kcal NE/kg
Parameter/pig	**0%**	**3.75%**	**7.50%**	**15%**
Feed cost in trial	$63.89	$62.64	$63.80	$61.16
Carcass gain needed, kg	-	1.8	1.4	4.0
Days needed	-	2.8	2.1	6.3
Cost of space	-	$0.39	$.30	$.88
Cost of additional feed	-	$2.40	$1.91	$5.28
Total cost	**$63.89**	**$65.43**	**$66.00**	**$67.32**
Difference from control	-	$1.54	$2.11	$3.43

Source: Frederick and Cline, 2015

Examples of how nutrition can contribute to sustainability of the pork industry

Environmental

- Conservation of water
- Reduced N and P content of manure
- Reduced land required to feed pigs

Social

- Improve animal health
- Improve animal welfare
- Develop alternatives to antibiotics important in human medicine

Economic

- Optimize diet to improve farm financial success

THANK YOU