IOWA STATE UNIVERSITY
Department of Animal Science

Low or high crude protein diets – what are the pros and cons of each

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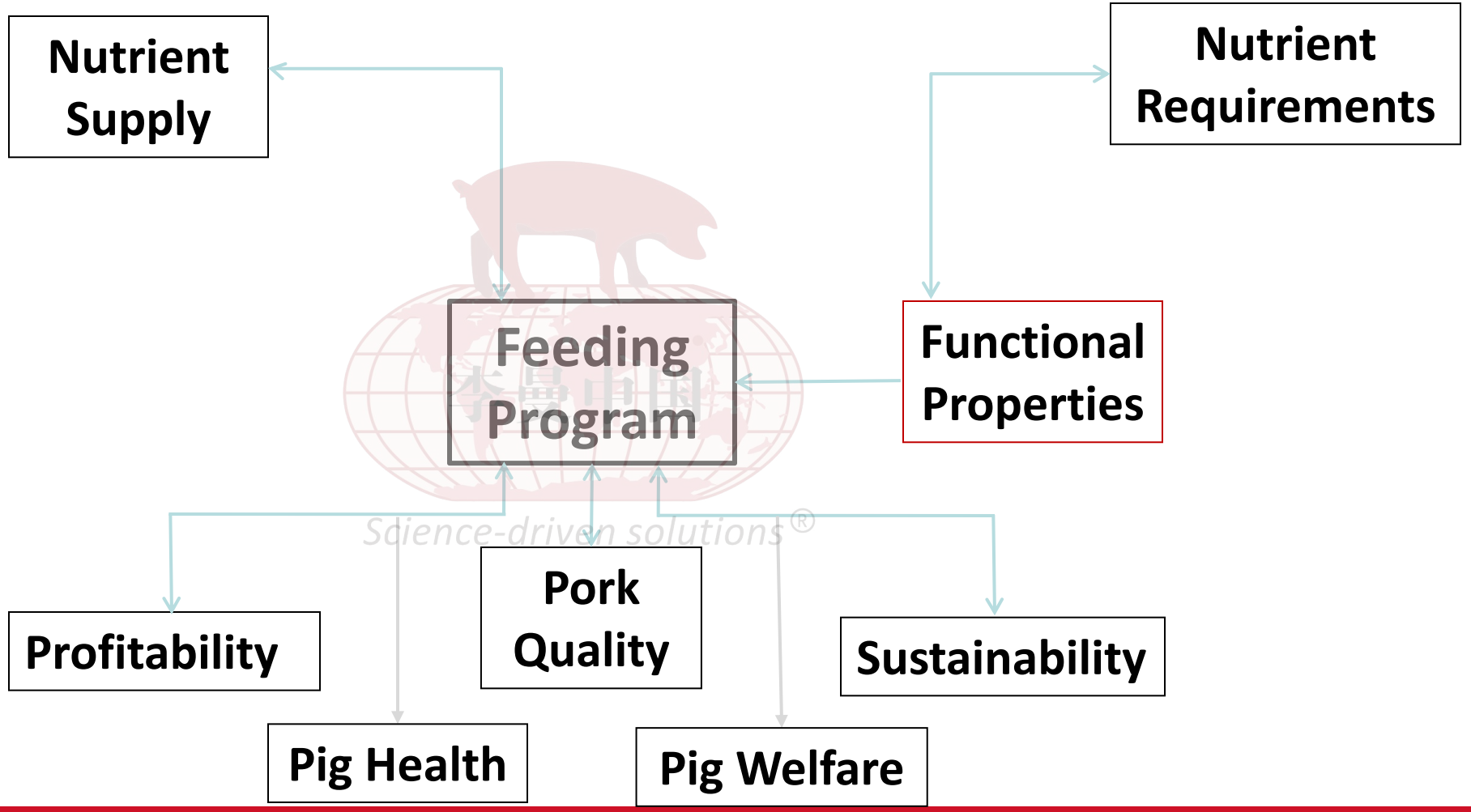
Objectives of a feeding program



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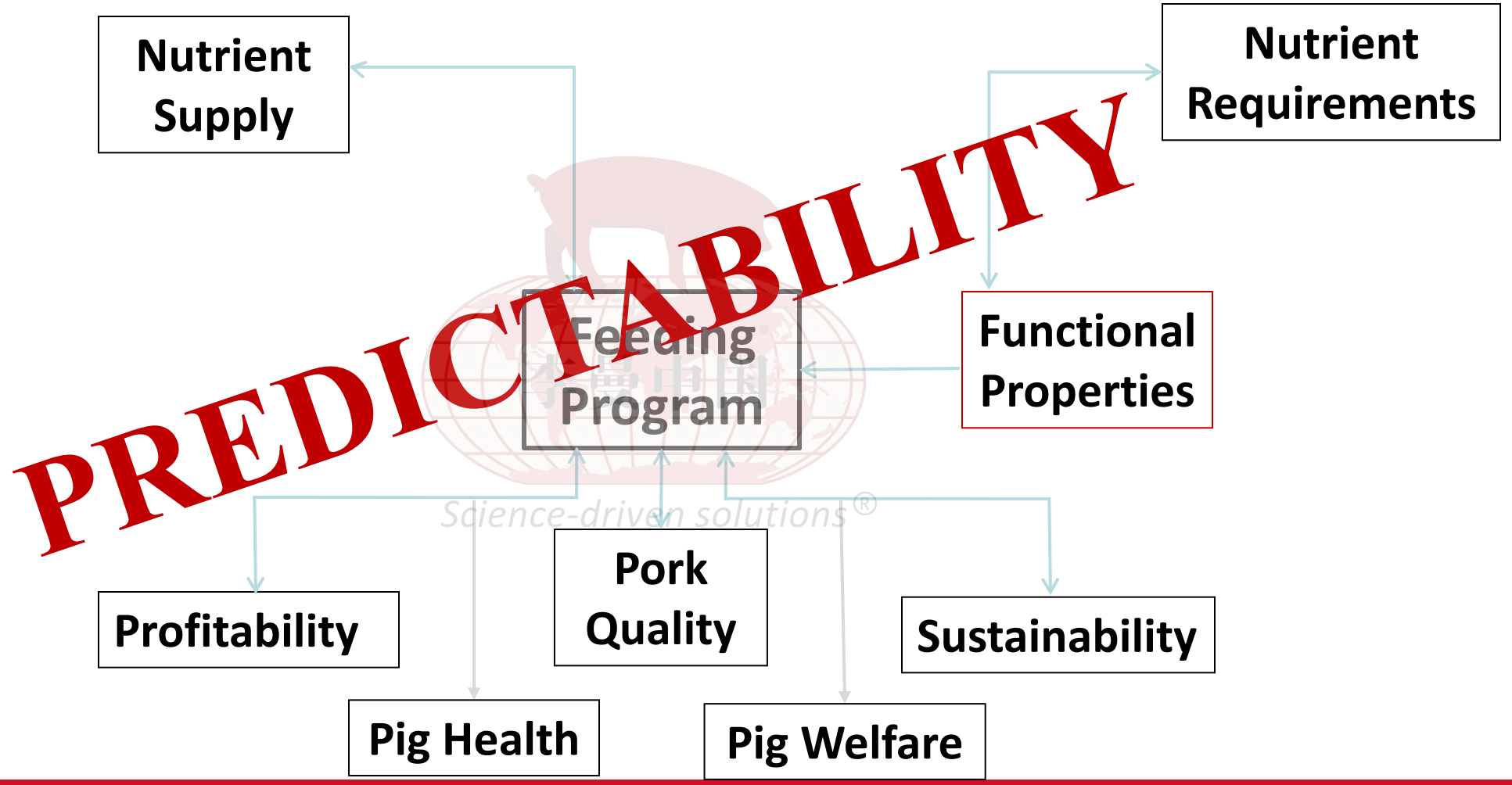


Equal performance with diverse diets

Item	30% DDGS	60% DDGS	P-Value
Bodyweight, kg			
Day 0	30.3	29.3	0.005
Market	122.4	121.9	0.41
CV, %			
Day 5	18.0	17.6	0.72
Day 95	10.9	10.5	0.59
Gain, kg/d	0.91	0.92	0.59
Feed intake, kg/d	2.07	2.03	0.21
Gain:feed (Whole Body)	0.44	0.45	0.11
Gain:feed (Carcass)	0.34	0.34	0.91

Source: Weber et al., 2015

Reasons for feeding low crude protein diets

1. Reduce dependence on imported soybean meal
   - China imports 95 to 98 MMT of soybeans and soybean meal per year
     - More than 80% goes to feed livestock

     - S&P Global, 2023

   - Ministry of Agriculture and Rural Affairs (MARA) encourages reduced levels of soybean meal in diets
     - Last April, goal was set to reduce soybean meal inclusion rates by half a percentage point per year for the next 5 years

Reasons for feeding low crude protein diets

2. Reduce land area required to sustainably utilize swine manure on crop land
   - Each percentage point reduction in diet protein level lowers nitrogen excretion in urine plus faeces by:
     - 7%: Swanstrom et al., 2023
     - 8%: Wang et al., 2018
     - 11%: Monteiro et al., 2017
     - 11%: Osada et al., 2011
   - The amount of reduction will depend on the nature of the diet

Reasons for feeding low crude protein diets

3. Reduce emissions of ammonia and other gaseous products from swine barns

Reasons for feeding low crude protein diets

4. Reduce land area required to grow soybeans to meet the needs of livestock
   - Synthetic amino acids reduce the land area required to feed the U.S. pig herd by ~14-15%

- Tokach, 2010

Reasons for feeding low crude protein diets

5. Lower concerns with antinutritional factors which could be present in inadequately processed soybean meal
   - Trypsin inhibitor
     - Acceptable below <3 TIU/mg
   - Oligosaccharides (stachyose, raffinose)
   - Antigens (glycinins, ß-conglycinin)
   - etc

Reasons for feeding low crude protein diets

6. Less undigested protein reaching the lower gut to be fermented, thus reducing production of amines, indoles and other products that cause GI upset
   - Fermented sulfur amino acids produce H_2S
   - Fermented AAA produce indoles, phenols, skatole
   - Fermented amino acids in general produce ammonia

Reasons for feeding low crude protein diets

7. Caecal and colonic microbial populations highly sensitive to quantity and composition of digesta protein and amino acids

Reasons for feeding low crude protein diets

8. Reduced water usage
   - Excess protein in the diet increases daily water intake, ratio of water:feed and daily urine output
     - Shaw et al., 2006

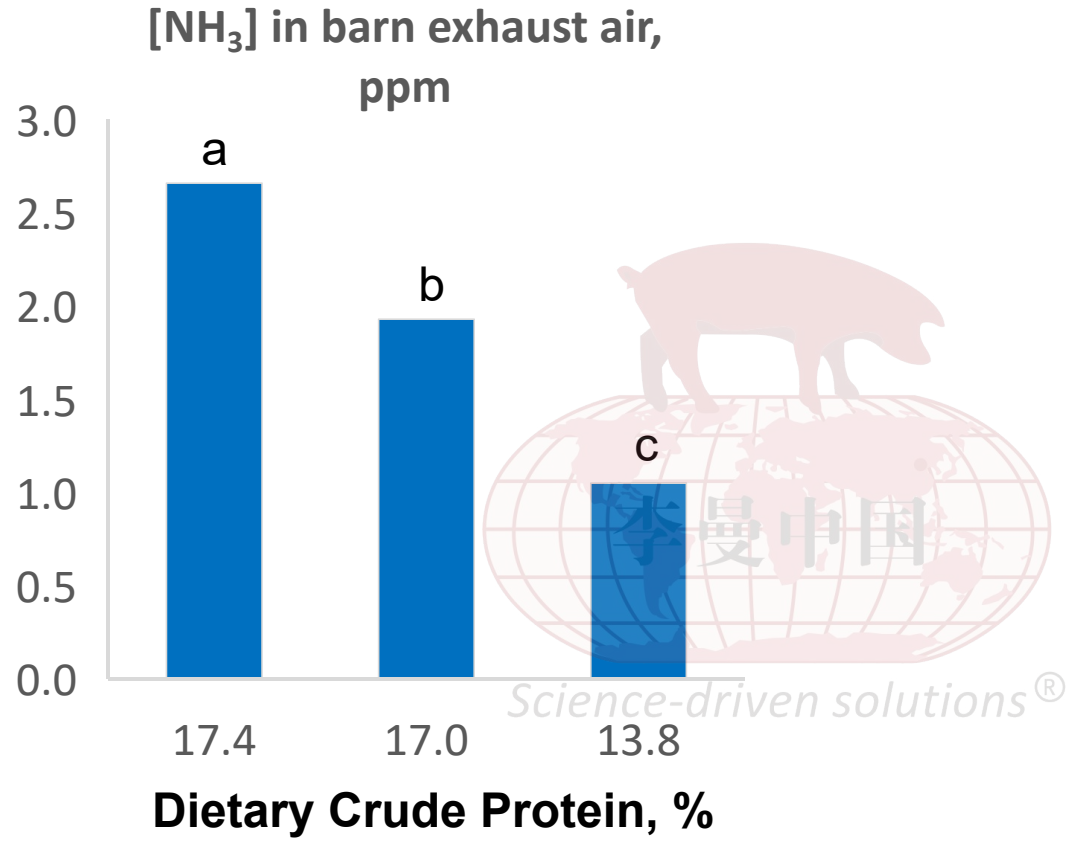
Challenges in feeding low crude protein diets

1. Maintaining growth performance
   - Especially feed conversion but also growth rate
2. Maintaining carcass leanness
3. Low protein diets may increase feed cost
   - Depends on feed ingredient markets

Why are low protein diets a challenge?

1. Puts greater pressure on our understanding of amino acid requirements
   - Valine, histidine, leucine, isoleucine, arginine
2. Ensuring that Non-Essential Amino Acid nitrogen is present in sufficient quantities
3. Formulation of dietary energy is much more complex
   - NE greatly preferred over ME or DE

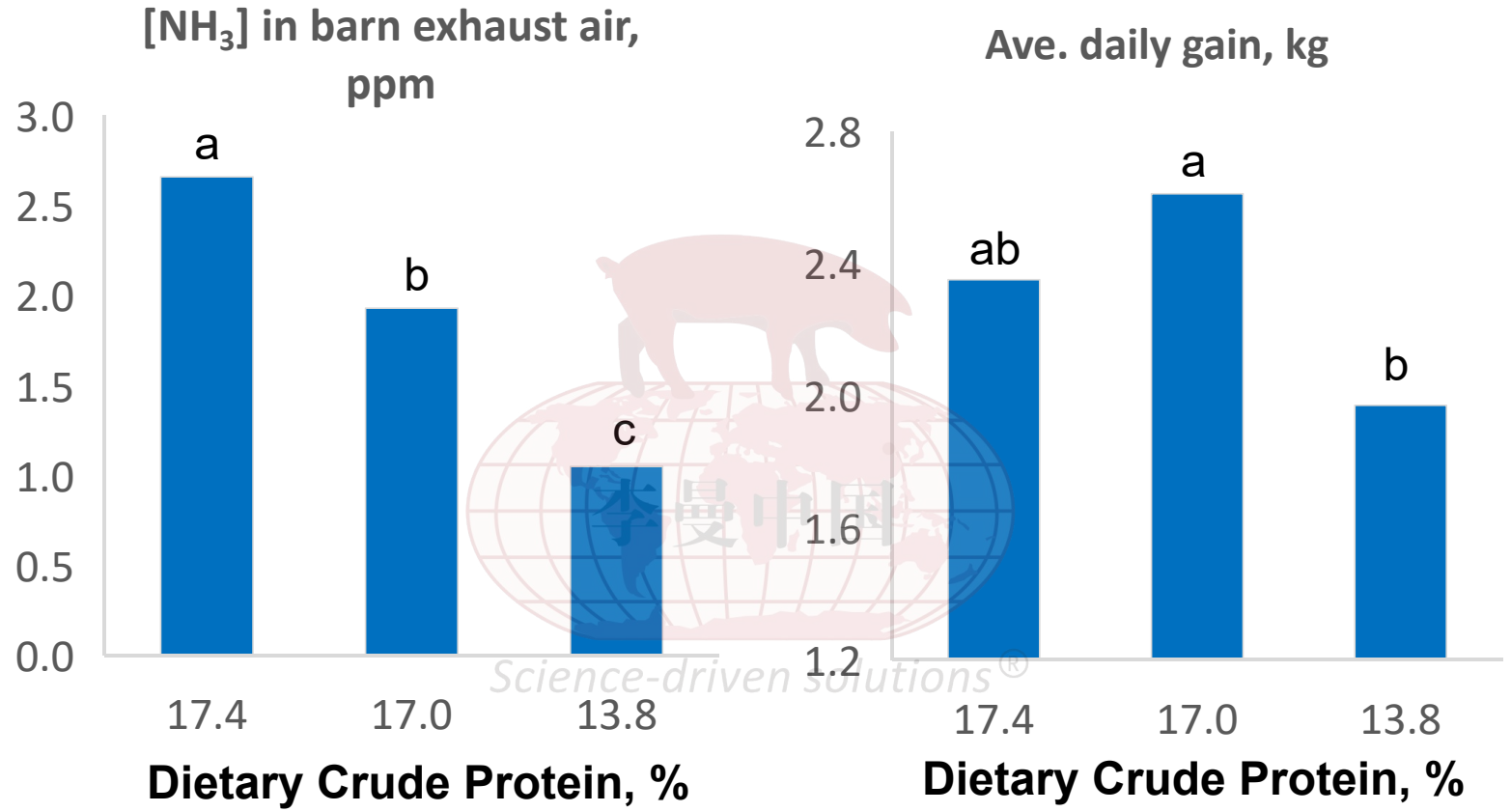
Reduced dietary crude protein reduces nitrogen emissions but also growth rate



Average pig initial wt. = 47 kg housed in environmental chambers; corn-SBM diet vs corn-SBM with synthetic Lys vs reduced Crude Protein (CP) with synthetic Lys, Met, Thr, Trp; SID lysine equal in all diets. Differing letters differ, P<0.05

Source: Panetta et al., 2006

Reduced dietary crude protein reduces nitrogen emissions but also growth rate



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Source: Panetta et al., 2006

Low protein diets require a source of non-essential amino acid nitrogen to maximize nitrogen retention

	16% CP	12% CP + DAAN+ IDAA	12% CP+LYS+ TRP+THR +DAAN	12% CP + LYS+TRP+ THR	12% CP
Initial BW, kg	21.87[a]	21.73[a]	21.80[a]	21.88[a]	21.20[b]
Daily gain, kg	0.576[a]	0.500[b]	0.512[b]	0.515[b]	0.442[c]
N retention, g/d	13.99[a]	13.81[a]	13.37[a]	11.79[b]	8.51[c]

Source: Kerr and Easter., 1995

Low protein diets (15.8% vs 13.7%) can achieve similar performance with very careful formulation

Item	15.9% CP	13.7% CP	P-value
Init. Wt. kg	24.7	24.4	0.330
Final Wt., kg	128.5	126.3	0.231
Grower			
Daily gain, kg	0.881	0.877	0.819
Gain:feed	0.417	0.415	0.783
Finisher			
Daily gain, kg	1.010	0.972	0.153
Gain:feed	0.329	0.338	0.187
Backfat, mm	21.6	21.7	0.937

Source: Monteiro et al., 2017

Reasonable expectations when feeding reduced protein diets

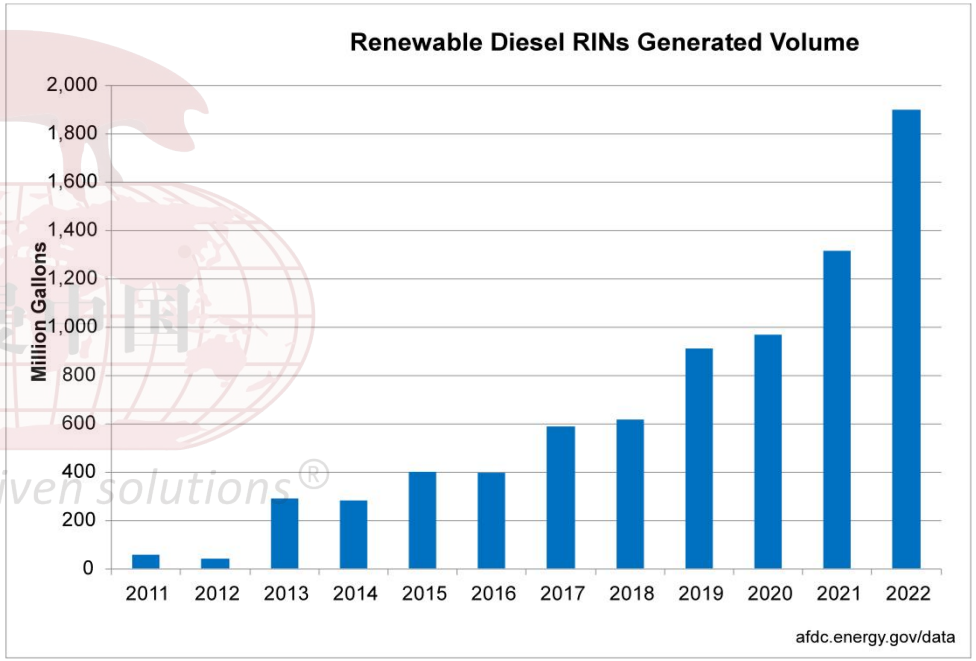
Reduction in diet crude protein level, %	Impact
2	Maintain growth performance and carcass quality
3	Maintain growth rate; feed conversion and backfat become more challenging
4	Great precision in formulation/manufacturing required
5	Extremely difficult to avoid loss in performance and increased backfat
6	Would not recommend, unless reduced performance is acceptable

Reasons for feeding high protein (soybean meal) diets

Renewable Diesel

Anticipated growth in renewable diesel production

- Produced from fats and oils, such as soybean oil and canola oil
- Chemically the same as petroleum diesel
  - ✓ Can be used to blend with conventional diesel or replace it altogether
- If demand for renewable diesel continues, there could be a huge surplus of soybean meal leading to lower cost

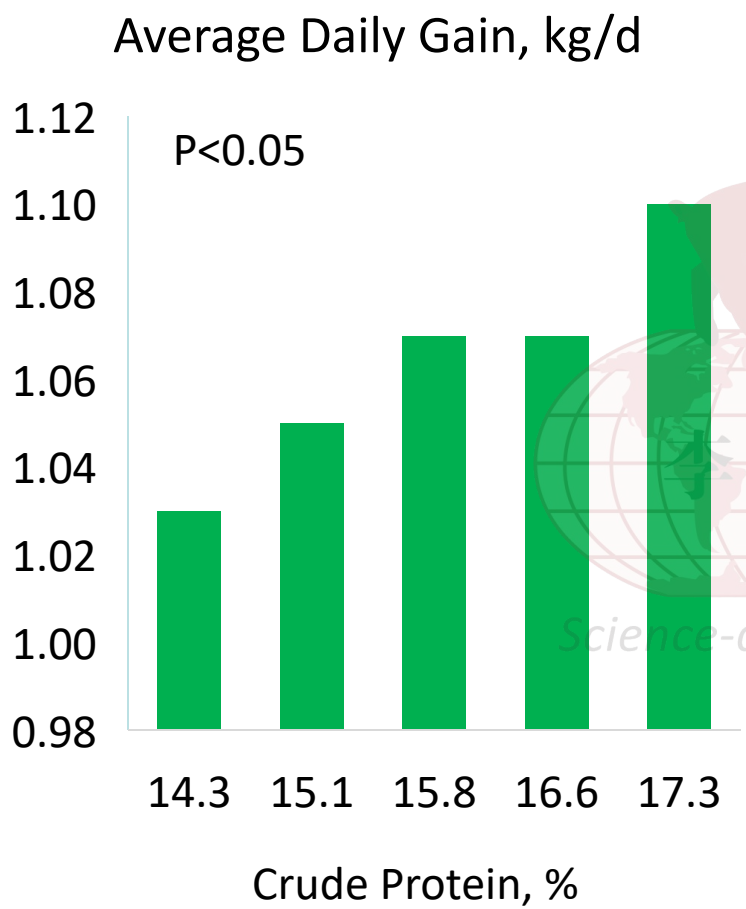


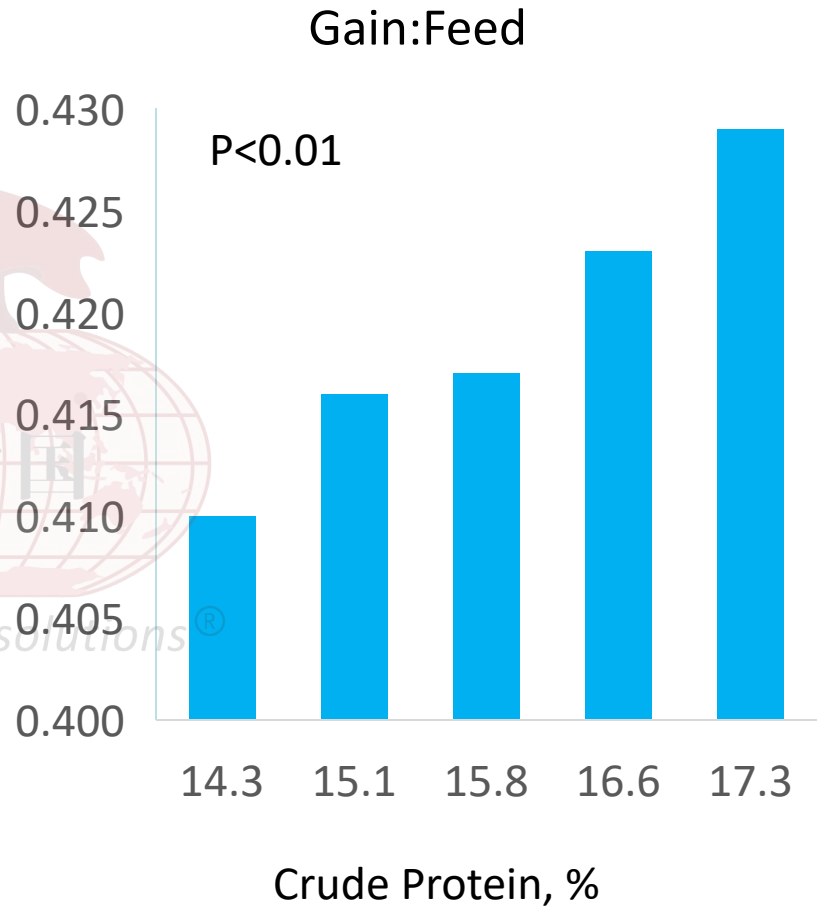
Impact of increasing crude protein/soybean meal on performance and financial returns: Expt 1

- NE, SID lysine, SID TSAA, SID threonine, SID Tryptophan constant
- Weight range: 45 to 85 kg;
- 1,035 pigs: 9 reps of 23 pigs/pen/treatment
- Crude protein range: 14.3 to 17.3%
- Soybean range: 17.8 to 26.7% (example phase)
- Included crystalline lysine, methionine, threonine, tryptophan, valine and isoleucine as needed
- L-lysine HCl from 0.60% to 0.23%

Source: Xue et al. (Cargill), 2023

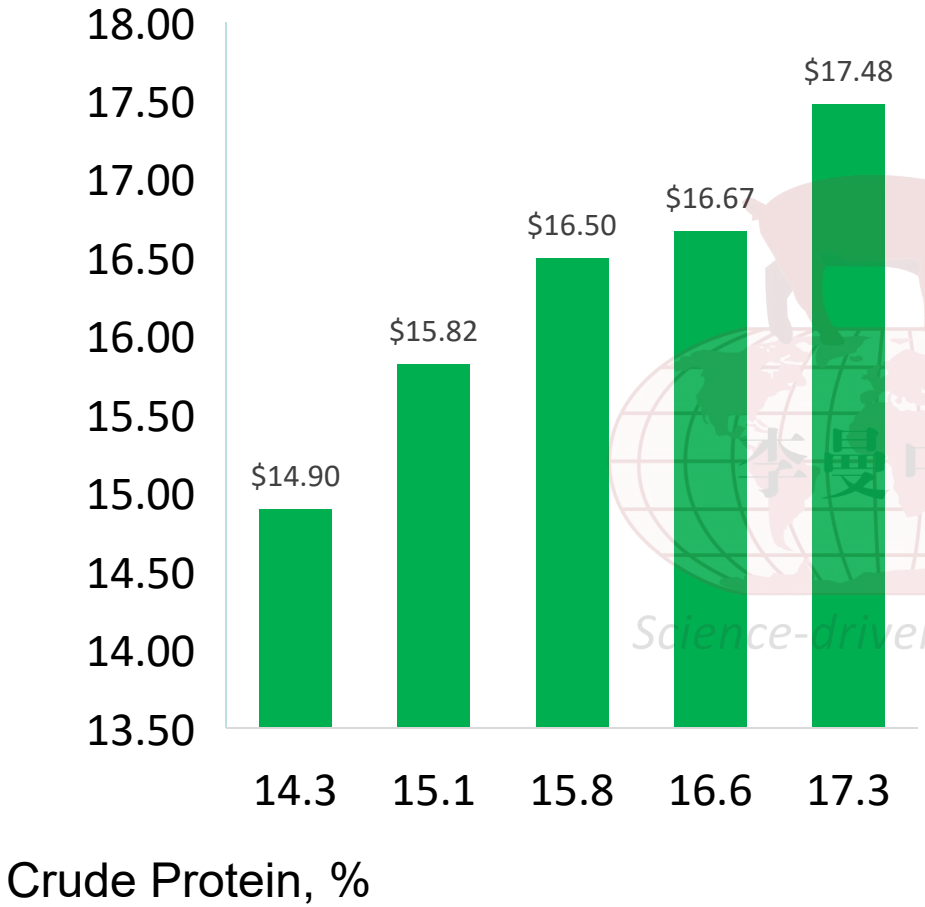
Impact of increasing crude protein/soybean meal on ADG and Gain:Feed





Source: Xue et al. (Cargill), 2023

Impact of increasing crude protein/soybean meal on return over feed cost, $/pig



- Market price: $1.75/kg
- Corn price: $7.40/bu
- SBM price: $440/ton
- Fat price: $1,040/ton

Source: Xue et al. (Cargill), 2023

Impact of increasing crude protein/soybean meal on performance and carcass composition: Expt 2

- ME constant
- Weight range: 23 to 126 kg
- 240 pigs: 20 reps of 4 pigs/pen/treatment
- Crude protein range: 15.2 to 22.3%
- Soybean range: 26 to 48% (phase 1)
- Included crystalline lysine, methionine, threonine, tryptophan, and valine as needed
- L-lysine HCl from 0.35% to 0%

Source: Swanstrom et al. (ISU), 2023

Phase 1 ingredient composition

	Dietary treatment		
Ingredient, %	**L-SBM**	**M-SBM**	**H-SBM**
Corn	70.527	60.237	49.202
Soybean meal	**26.000**	**37.232**	**48.000**
Calcium carbonate	1.056	0.751	0.766
Monocalcium phosphate	0.879	0.667	0.611
Salt	0.500	0.500	0.500
VTM premix	0.300	0.300	0.300
L-lysine HCl	0.345	-	-
L-threonine	0.169	0.017	-
DL-methionine	0.150	0.055	-
L-valine	0.052	-	-
L-tryptophan	0.013	-	-
Phytase	0.009	0.009	0.009
Soybean oil	-	0.233	0.612

Phase 1 energy and nutrient composition

Item	Dietary treatment		
	L-SBM	M-SBM	H-SBM
ME, Mcal/ kg	3.20	3.20	3.20
Crude protein, %	**17.91**	**21.83**	**25.98**
Calcium, %	0.78	0.67	0.71
Available P, %	0.37	0.34	0.34
Ca: Av. P	2.10	1.98	2.09
SID lysine, %	**1.06**	**1.06**	**1.32**
SID Ile:Lys	0.57	0.74	0.73
SID Leu:Lys	1.20	1.45	1.36
SID Met + Cys:Lys	0.58	0.58	0.49
SID Thr:Lys	0.65	0.65	1.62
SID Trp:Lys	0.18	0.22	0.22
SID Val:Lys	0.67	0.79	0.76
g SID Lys:ME	**3.32**	**3.32**	**4.13**

Impact of crude protein/soybean meal level on growth performance

	Dietary treatment			*P* - value	
Item	L-SBM	M-SBM	H-SBM	Trt	Trt × Sex
ADG, kg	1.00	0.98	1.00	0.366	0.644
ADFI, kg	2.48	2.43	2.46	0.656	0.693
G:F	0.43	0.42	0.43	0.202	0.968

Source: Swanstrom et al. (ISU), 2023

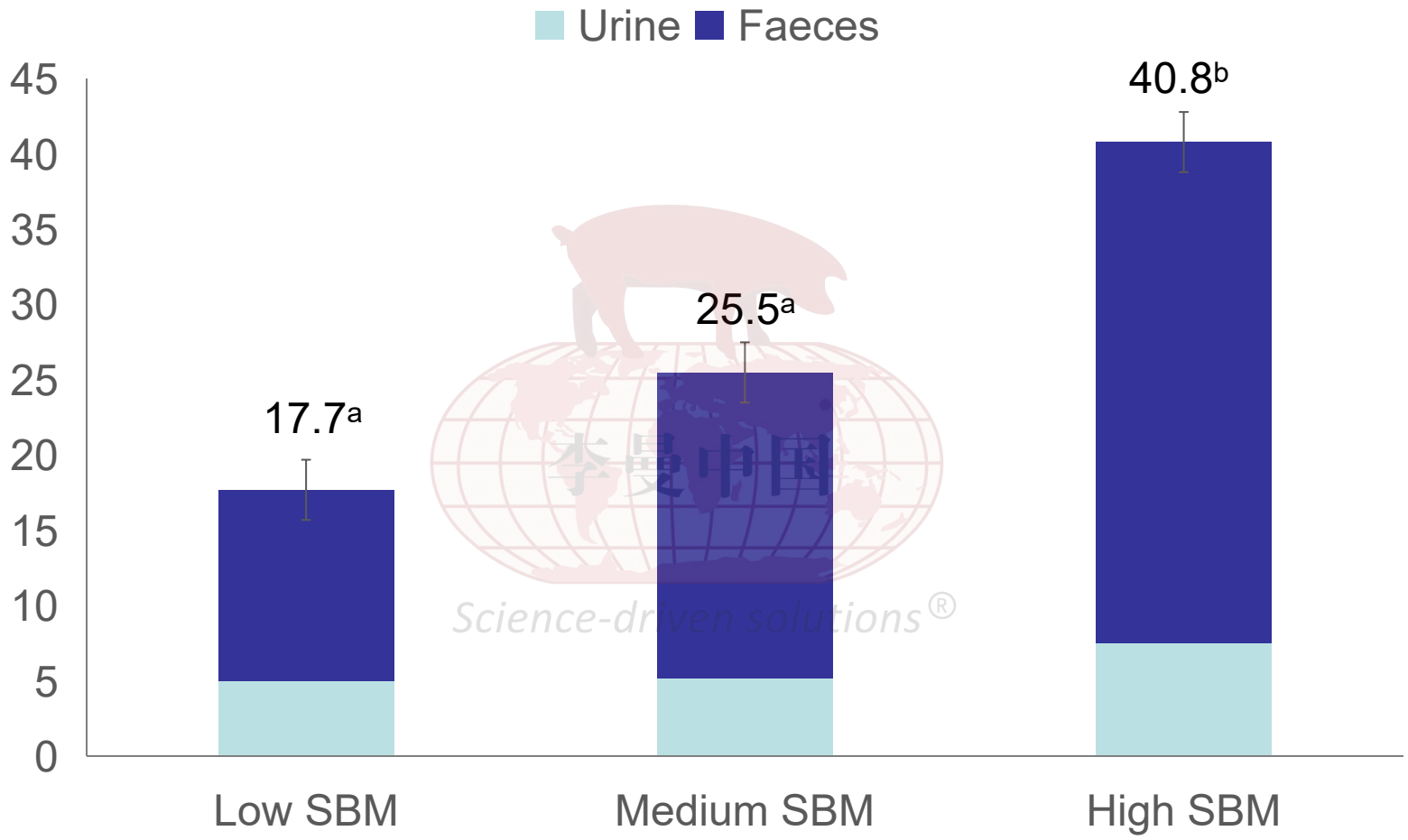
Impact of crude protein/soybean meal level on carcass composition

	Dietary treatment			*P* - value	
Item	**L-SBM**	**M-SBM**	**H-SBM**	**Trt**	**Trt × Sex**
Carcass weight, kg	101	100	99	0.254	0.704
Backfat, cm	1.26[b]	1.17[ab]	1.09[a]	0.021	0.387
Loin depth, cm	7.73	7.61	7.68	0.564	0.795

[a,b] Means with different superscripts differ, $P < 0.001$

Source: Swanstrom et al. (ISU), 2023

Impact of crude protein/soybean meal level on nitrogen excretion, g/d



[a,b] Means with different superscripts differ, $P < 0.001$

Source: Swanstrom et al. (ISU), 2023

Take home messages

- There are many benefits to feeding reduced crude protein diets
- Reducing crude protein more than 2% is challenging and 4% or more is quite difficult
  - Will require greater precision in diet formulation and in feed manufacturing
  - Some technical questions still need to be answered
- High protein (soybean meal) diets are showing benefits in terms of pig performance, but the explanations remain unclear