



Improving Feed and Nutrient Utilization by Optimizing Diet Energy and Nutrient Levels: Protein

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Introduction

Global meat production is expected to rise by 12% from 2023 to 2032, with pork production growing from 117 to 129 million metric tons per year (OECD and FAO). Most of the environmental impact in pig farming comes from the feed system, which includes crop cultivation, feed manufacturing, and transportation. Improving pig health, management, and feed efficiency, as well as better handling of swine waste, can help meet the growing demand for pork while reducing its environmental impact (Andretta et al., 2021). Protein, the nutrient responsible for lean accretion and when unbalanced, can have a significant environmental impact. While pigs require amino acids (AAs) for growth, reproduction, and maintenance, feeding excess crude protein (CP) leads to higher nitrogen (N) excretion and greater environmental losses.

Protein

When swine diets are formulated using intact protein sources, such as soybean meal, excess nitrogen (N) is often excreted due to metabolic inefficiencies and imbalances in amino acid (AA) supply (Van Kempen et al., 2003; NRC, 2012). Reducing dietary crude protein (CP) content while supplementing crystalline AA lowers N excretion without compromising performance. Kerr (2003) reported that total N excretion in growing pigs decreased by 8% for every 1% reduction in CP when diets were balanced for essential AA. Similarly, Wang et al. (2018) summarized that N excretion decreased linearly with reduced dietary CP, with validation by Zhao et al. (2019) and Pomar et al. (2021).

For gestating sows, lowering CP (from 13.3% to 10.1%) reduced fecal and urinary N excretion without affecting reproductive

performance or N efficiency (Yang et al., 2022). In lactating sows, decreasing CP from 16.0% to 13.2% reduced N excretion by 26–30% during early and peak lactation (Huber et

Table 1. Nitrogen excretion reduction with lower dietary CP

Stage of production	CP reduction (%)	Reduction in N excretion (%) or g/d
Growing pigs	1% ↓ CP	~8% ↓ N excretion
Kerr (2003); Wang et al. (2018); Zhao et al. (2019); Pomar et al. (2021)		
Gestating sows	13.3 → 10.1% CP	23.6 → 18.4 g/d (↓ 5.2 g/d)
Yang et al. (2022)		
Gestating sows	13.5 → 12.0% CP	No effect on performance; ↓ BUN
Fang et al. (2019)		
Lactating sows	16.0 → 13.2% CP	↓ N excretion 26% (early), 30% (peak)
Huber et al. (2015)		
Lactating sows	1% ↓ CP	↓ N excretion 9.3% (early), 10.7% (peak)
Huber et al. (2015)		
Lactating sows	Low CP + AA supplementation	↓ urinary N, maintained performance
Pedersen et al. (2019)		

al., 2015), equating to 9.3–10.7% less N excretion per 1% CP reduction. Similar results were reported when crystalline AA were included in low-CP lactation diets, improving N efficiency without reducing litter performance (Pedersen et al., 2019).

The lysine-to-protein (Lys:CP) ratio is a critical benchmark to ensure sufficient N supply for non-essential AA synthesis. NRC (2012) estimates suggest maximum SID Lys:CP ratios of ~6.5 for nursery pigs, 6.2 for 20–75 kg pigs, 6.0 for 75–100 kg pigs, and 5.8

for 100–135 kg pigs, ensuring adequate protein supply while reducing excess N.

Overall, optimizing protein nutrition through reduced CP diets supplemented with crystalline AA lowers N excretion, decreases blood urea nitrogen (BUN), and improves environmental sustainability while maintaining pig performance (Lu et al., 2017).

Table 2. Recommended standardized ileal digestible (SID) Lys:CP ratios

Body Weight Stage	Max SID Lys:CP ratio	Source
Nursery pigs (4-9 weeks)	6.35-6.5	Millet et al (2018); NRC (2012)
20-75 kg	~ 6.2	NRC (2012)
75-100 kg	~ 6.0	NRC (2012)
100-135 kg	~ 5.8	NRC (2012)

Summary

- Reducing CP through crystalline AA decreases N excretion by ~8% for every 1% reduction in CP
- Lys:CP is critical to ensure sufficient non-essential N supply and prevent performance losses
- Gestating and lactating sows fed reduced CP diets with AA supplementation show 20-30% lower urinary and fecal N losses without harming sow body condition or reproductive outcomes

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