Opportunities to Optimize Nutrient Intake by Feeding Management

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Importance

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). 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). Presentation of feed and matching the pig's nutrient requirements allows for the optimization of feed to conversion to protein and thereby reduce the environmental impact of pork production.

Phase Feeding

As pigs grow, their nutrient requirements decrease relative to their body weight, but feed intake increases. Feeding a single diet across the grow-finish period can result in over- or under-supplying nutrients at different stages. Phase feeding involves providing multiple diets across weight ranges or time periods to better match pig requirements (NRC, 2012).

Research shows that increasing the number of feeding phases reduces nutrient excretion without reducing performance. Lee et al. (2000) demonstrated that 3- and 4-phase feeding compared to single-diet feeding reduced nitrogen (N) and phosphorus (P) excretion by 12% and 3%, respectively. While growth performance remained similar, closer alignment of diet to requirements improves nutrient efficiency and reduces waste (Menegat et al., 2020).

sows, precision feeding reduced N and P excretion by 11-14% (Gaillard et al., 2020). In lactating sows, diet blending reduced N excretion by up to 61% without affecting litter growth (Spinler et al., 2023). While not always improving feed efficiency, precision feeding improves nutrient utilization and reduces waste.

Split-Sex Feeding

Barrows and gilts have different growth patterns: barrows eat more and deposit more fat, while gilts are leaner and more feed-efficient. Feeding both sexes the same diet can lead to oversupply of nutrients in gilts and undersupply in barrows. Split-sex feeding addresses these differences by formulating diets specific to each sex (Lewis and Southern, 2000). While specific reductions in nutrient excretion are not yet well quantified, gilts benefit from higher nutrient density diets while barrows benefit from less nutrient oversupply. Immunocastration, which alters nutrient utilization patterns compared to physical castration, also reduces N and P excretion by 14–24% per kilogram of lean meat gain (Van den Broeke et al., 2022).

Phase feeding observations in grow-finish (54-104 kg) study (Lee et al., 2000)

Feeding Strategy	Growth Performance	Feed Efficiency	N Excretion	P Excretion
Single diet	Baseline	No difference	Baseline	Baseline
2-, 3-, or 4-phase diets	No difference vs. single diet	No difference	↓ 12%	↓ 3%

Phase feeding observations in grow-finish (27-127 kg) study (Menegat et al., 2020)

Number of diet phases	Effect on nutrient needs	Effect on N excretion	Effect on P & trace mineral excretion
1-2 Phases	Nutrients oversupplied	Higher	Higher
3-4 Phases	Closer match to pig's requirements	Lower	Lower

Limit Feeding

Most pigs are fed ad libitum, but restricted feed intake (limit feeding) can improve nutrient utilization by reducing fat deposition and feed wastage. This strategy is common in breeding herds but less often applied in grow-finish pigs due to possible effects on growth rate (Haydon et al., 1989; Patience et al., 2015). Feeding pigs at 85% of ad libitum intake improved feed efficiency by ~5% in early studies due to reduced fat deposition (Haydon et al., 1989). However, more severe restriction (70%) reduced efficiency. With modern genetics that deposit less fat, benefits of limit feeding are less clear, and reduced ADG can extend days to market (Patience et al., 2015). Still, limit feeding can reduce feed wastage and improve efficiency in specific contexts.

Meal Size

Meal size and feeding frequency influence digestive efficiency, gut health, and nutrient absorption in pigs. While pigs are typically fed ad libitum, adjusting the pattern of nutrient delivery can enhance utilization and reduce waste.

Meal size has a direct impact on nutrient digestibility due to gastrointestinal transit. When pigs consume large meals, the intestine becomes distended, which accelerates contractions and moves digesta more quickly through the gastrointestinal tract. This reduces retention time and lowers nutrient digestibility because of less contact with digestive enzymes, absorption sites, and fermentative microbiota (Chassé et al., 2021). In contrast, smaller meals help maintain a steady flow of digesta, supporting more efficient nutrient breakdown and absorption.

Feeding Frequency

Increasing feeding frequency enhances nutrient utilization and feed efficiency by improving digestive enzyme secretion and stabilizing metabolic processes. Growing pigs fed 3–5 times daily had a 4.8–6.7% improvement in feed efficiency and an 18% increase in crude protein digestibility compared to pigs fed a single large meal (Jia et al., 2021). Frequent meals also stabilized blood glucose concentrations and improved digestibility of dry matter, gross energy, and crude protein (Chassé et al., 2023). Likewise, pigs fed 6 meals per day had ~10% greater feed efficiency than those fed 2 meals, with improvements attributed to better digestibility rather than reduced feed wastage (Schneider et al., 2011).

Summary

- Large meals speed gastrointestinal transit and reduce nutrient digestibility
- Smaller meals improve nutrient breakdown and absorption through continuous digesta flow
- Feeding 3-5 meals/day improved feed efficiency (up to 6.7%) and protein digestibility (+18%)
- Frequent feeding stabilizes glucose and increased DM, energy, and protein digestibility
- Six meals per day increased feed efficiency by ~10% compared to two meals per day

Sow Herd Management

Providing more feed than required can lead to unnecessary nutrient use and increased environmental impact. For gilt development, overfeeding can be avoided by breeding gilts at the correct body weight and age. In gestating sows, excess feed increases backfat thickness and lowers milk production, while

increasing feed allowance before farrowing shows little benefit for piglet birth weight and should generally be avoided unless sows are in poor body condition (Goncalves et al., 2016; Almeida et al., 2017; Gianluppi et al., 2020).

For lactating sows, ad libitum intake is recommended, though intake thresholds may be necessary when sows consume more than required, such as during extended lactation or with small litters. During the wean-to-service interval, ad libitum feeding of lactation diets is unnecessary; sows require no more than 2.7 kg of gestation feed daily (Graham et al., 2015; Gianluppi et al., 2020). Adjusting feed allowance and diet during this short period reduces feed wastage and nitrogen excretion, though the precise savings need further study.

Minimizing Feed Wastage

Reducing feed wastage is a key strategy to improve feed efficiency and reduce nutrient excretion in manure. Poor feeder design and feed presentation can result in 5-6% of feed intake being wasted (Han et al., 2001). Skerman and Willis (2016) demonstrated that increasing feed wastage from 0 to 15.2% increased ammonium N and total N in manure, with the greatest increase occurring between 0 and 4.2%. This highlights how even small amounts of feed wastage significantly contribute to nutrient losses.

Feed Pan Coverage & Feeder Design

Diet presentation and feeder design strongly influence feed wastage. Mash feed can adhere to pigs' faces, contributing 1.5 g of waste per feeder visit (Gonyou et al., 1998), and rooting behavior can lead to ~3.4% wastage in poorly designed feeders (Van Kempen and Van Heugten, 2000). Across 11 nursery feeder types, wastage ranged from 1.7% to 11% (Taylor and Curtis, 1989). Although wet-dry feeders increase ADFI and ADG, they do not improve feed efficiency compared to dry feeders (Gonyou and Lou, 2000; Bergstrom et al., 2012; Nitikanchana et al., 2012). Proper feed pan coverage is critical, with recommendations of 40-50% coverage for most pigs, ~60% coverage for pigs 40-70 kg, and ~30% for pigs over 70 kg to minimize waste (Tokach et al., 2012; Myers et al., 2012). Adjusting feeder openings in wet-dry systems as pigs grow also improves efficiency (Bergstrom et al., 2012).

Water Wastage

Water wastage adds to manure volume and disposal costs. Cup drinkers reduce water use by 25% and manure volume by 22% compared to swing nipple drinkers (Brumm et al., 2000). Similarly, nursery pigs with cup drinkers used 17% less water than those with nipple drinkers without affecting growth (Vande Pol et al., 2022). Wet-dry feeders also cut water disappearance by 25% relative to dry feeders (Brumm et al., 2000). Reducing both feed and water wastage therefore lowers costs and nutrient loads in manure while maintaining pig performance.

Summary

- Small feed losses (< 4.2%) increase manure nitrogen excretion
- Proper feeder design (i.e., wet/dry feeders) reduces water losses up to 25% and manure volume by 22%
- Optimal feed pan coverage: 40-50% overall; ~60% for 40-70 kg pigs, ~30% for > 70 kg pigs

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