Improving Nutrient Utilization Through Diet Formulation

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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). Pork is a major source of protein worldwide, but it also contributes to the environmental footprint of meat production. 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). The selection of ingredients, diet composition and dry matter of the diet can have significant influence on feed efficiency and the environmental impact of swine production.

Ingredient Selection

The choice of feed ingredients plays a central role in nutrient utilization and environmental outcomes. Ingredient nutrient digestibility, fiber type, and byproduct inclusion all influence energy efficiency, nitrogen (N) and phosphorus (P) excretion, and greenhouse gas emissions. Selecting ingredients that maximize nutrient retention while minimizing waste is essential for sustainable pork production (Patience, 2012; Shurson et al., 2022).

Cereal grains provide most dietary energy, but nutrient variability across sources can affect efficiency (Patience, 2012). For example, corn DDGS inclusion increases dietary fiber, which shifts N excretion from urine to feces but can also reduce energy efficiency (Velayudhan et al., 2015). Alternative ingredients like canola meal or wheat byproducts provide protein and energy but may increase fiber and reduce digestibility. Life cycle assessment (LCA) studies show that ingredient sourcing influences the carbon footprint of diets, with soybean meal and synthetic amino acids carrying unique trade-offs (Menegat et al., 2020; Shurson et al., 2022). Balancing ingredient choices requires accounting for cost, nutrient efficiency, and environmental impact simultaneously.

Feed Additives

Feed additives provide targeted tools to enhance nutrient utilization and reduce environmental emissions. Common additives include enzymes (i.e., phytase, carbohydrases, and proteases), acidifiers, and direct-fed microbials. These additives increase nutrient digestibility, improve gut health, and reduce excretion of nitrogen and phosphorus.

Feed additives play a key role in improving feed efficiency and reducing nutrient excretion in swine production. Enzymes are among the most tested additives, with carbohydrases, β-glucanase, and xylanase improving nutrient utilization in barley- and wheat-based diets (Omogbenigun et al., 2004; Newbold and Hillman, 2011; NRC, 2012). However, their impact in corn–soybean meal diets remains variable, with responses ranging from negative to highly positive (Rao et al., 2023).

Proteases also enhance amino acid digestibility and feed efficiency (Han et al., 2001; Gaillard et al., 2020a). Phytase reduces phosphorus (P) excretion by releasing phytate-bound P, replacing inorganic P, and improving mineral and amino acid utilization, with curvilinear responses at higher doses (Lewis and Southern, 2000; Dersjant-Li et al., 2015; Symeou et al., 2014; Czech et al., 2022; Zouaoui et al., 2018). These enzyme-driven improvements directly target nutrient digestibility, lowering nutrient losses in manure.

Other additives act indirectly by enhancing performance or gut health, reducing nutrient waste. Acidifiers improve protein and mineral digestibility and reduce ammonia emissions (Eriksen et al., 2010). Probiotics and yeast extracts support gut balance, immunity, and gastrointestinal health (Baek et al., 2024), while betaine, CLA, and L-carnitine affect energy and lipid metabolism (Rao et al., 2023). Ractopamine substantially improves growth (12%) and feed efficiency (10-13%), lowering total nutrient excretion despite higher nutrient-dense diets (Apple et al., 2007; Coble, 2010). Ionophores, such as narasin, improve energy efficiency through shifts in volatile fatty acid production (Becker et al., 2023). Historically, in-feed antibiotics improved performance (Cromwell, 2002), but modern swine systems have minimized these benefits, with limited effects in finishing pigs (Dritz et al., 2002). Overall, feed additives reduce nutrient excretion either by improving digestibility or enhancing growth performance and efficiency.

Liquid Feeding

Liquid feeding delivers diets in a slurry form, blending feed with water. This system improves feed intake, reduces dust, and can increase digestibility of nutrients in certain contexts. Liquid feeding uses either food industry by-products mixed with dry feed or dry ingredients blended with water, resulting in diets with 20–30% dry matter (Brooks et al., 2001). In growing pigs, this method has been shown to improve growth rate by 3–8% and feed efficiency by up to 10%, though results vary with diet and experiment (De Lange and Zhu, 2012).

Beyond performance, liquid feeding benefits the environment by recycling co-products from the human food industry. It can also activate natural phytase during fermentation or through added enzymes, which helps pigs use nutrients more efficiently and lowers nitrogen (N) and phosphorus (P) excretion (Brooks et al., 2001).

Summary

- Major ingredients (cereals, protein sources and by-products) used in diets will have the largest impact on environmental outcomes; thus, thus balancing these goals with feed cost must be considered.
- Certain feed additives have been shown to improve nutrient utilization, thus are a tool when economical to utilize.
- Liquid feeding is a practice that can improve feed efficiency and envirnemtal o outcomes, but barriers for wide-scale adoption in the US are present.

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