



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

Ron Aldwin S. Navales, Mike D. Tokach, Joel M. DeRouchey, Katelyn N. Gaffield, Jason C. Woodworth, Robert D. Goodband, Jordan T. Gebhardt, Russell M. Euken, Jack C. M. Dekkers, and Caitlyn M. Phillips

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). Trace minerals such as copper (Cu), zinc (Zn), manganese (Mn), and iron (Fe) are essential for pig health, growth, and reproduction. However, they are often over supplied at levels far above the NRC (2012) requirements, either as a safety margin or for growth promotion. This over-supplementation leads to substantial excretion of minerals, primarily in feces, which can accumulate in soils and contribute to environmental contamination (Faccin et al., 2023).

Microminerals

Surveys of U.S. swine diets indicate that vitamin and trace mineral premixes are often formulated at 2–10 times requirement estimates (Faccin et al., 2023). Feeding above requirement is common in nursery pigs, where pharmacological levels of Zn (2,000–3,000 mg/kg) and high Cu (up to 250 mg/kg) are used to improve gut health and performance (Hill et al., 2000; Shelton et al., 2011). However, these levels lead to excessive fecal mineral excretion.

Improved strategies for mineral nutrition, including precision supplementation and replacement with organic forms, can reduce environmental loading of trace minerals while maintaining performance. Replacing inorganic minerals with organic or chelated forms improves bioavailability and reduces excretion. For example, Xiong et al. (2023) demonstrated that lowering Cu, Zn, and Mn supplementation by using organic sources reduced fecal mineral output by 17–53%. Hansen et al. (2023) showed that feeding Zn at requirement levels, instead of pharmacological concentrations, decreased total Zn excretion by up to 49% without impairing pig growth.

	100% Inorganic Trace Minerals	30% Organic Trace Minerals	45% Organic Trace Minerals	60% Organic Trace Minerals
Cu, mg/kg	159.0	92.7	101.7	114.5
Zn, mg/kg	846.7	395.3	418.0	521.0
Mn, mg/kg	762.7	609.2	635.5	671.3

Adapted from Xiong et al., 2023

Summary

- Trace minerals are often supplemented 2-10x NRC (2012) requirements, leading to unnecessary excretion
- Pharmacological Zn (2,000-3,000 mg/kg) and high Cu (> 250 mg/kg) are common in nursery diets, but result in heavy fecal mineral losses

- Organic minerals have higher bioavailability and allow for lower inclusion levels with similar performance outcomes
- Replacing organic Cu, Zn, and Mn with organic forms reduced fecal excretion by 17-53%
- Feeding Zn at requirement level, rather than pharmacological doses, lowered excretion up to 49%

Literature Cited

- Andretta, I., F. M. W. Hickmann, A. Remus, C. H. Franceschi, A. B. Mariani, C. Orso, M. Kipper, M. P. Létourneau-Montminy, and C. Pomar. 2021. Environmental impacts of pig and poultry production: insights from a systematic review. *Front. Vet. Sci.* 8:750733. doi:10.3389/fvets.2021.750733
- Faccin, J. E. G., M. D. Tokach, R. D. Goodband, J. M. DeRouchey, J. C. Woodworth, and J. T. Gebhardt. 2023. Industry survey of added vitamins and trace minerals in U.S. swine diets. *Transl. Anim. Sci.* 7:txad035. doi:10.1093/tas/txad035
- Hansen, S. V., J. V. Nørgaard, T. Woyengo, and T. S. Nielsen. 2023. The relationship between zinc intake, dietary content, and fecal excretion in pigs. *Livest. Sci.* 271:105228. doi:10.1016/j.livsci.2023.105228
- Hill, G. M., G. L. Cromwell, T. D. Crenshaw, C. R. Dove, R. C. Ewan, D. A. Knabe, A. J. Lewis, G. W. Libal, D. C. Mahan, G. C. Shurson, et al. 2000. Growth promotion effects and plasma changes from feeding high dietary concentrations of zinc and copper to weanling pigs (regional study). *J. Anim. Sci.* 78:1010–1016. doi:10.2527/2000.7841010x
- National Research Council. 2012. *Nutrient Requirements of Swine: 11th Revised Edition*. Washington, DC: The National Academies Press. <http://www.nap.edu/catalog/13298>
- Shelton, N. W., M. D. Tokach, J. L. Nelssen, R. D. Goodband, S. S. Dritz, J. M. DeRouchey, and G. M. Hill. 2011. Effects of copper sulfate, tri-basic copper chloride, and zinc oxide on weanling pig performance. *J. Anim. Sci.* 89:2440–2451. doi:10.2527/jas.2010-3432
- Xiong, Y., B. Cui, Z. He, S. Liu, Q. Wu, H. Yi, F. Zhao, Z. Jiang, S. Hu, and L. Wang. 2023. Dietary replacement of inorganic trace minerals with lower levels of organic trace minerals leads to enhanced antioxidant capacity, nutrient digestibility, and reduced fecal mineral excretion in growing-finishing pigs. *Front. Vet. Sci.* 10:1142054. doi:10.3389/fvets.2023.1142054

This work was supported by the National Pork Board grant #22-092.