Iowa State University Extension and Outreach

Evaluating Production Metrics in Relation to Sustainability in a Wean-to-Finish Barn

Improving the sustainability of the United States' (US) pork supply chain requires a better understanding of the relationship between the environment and production practices. Pork producers play a crucial role in environmental stewardship, however, the impact of production efficiency on greenhouse gas (GHG) emission has not been well-established. Interpreting the influence of specific production metrics on GHG emission is essential for benchmarking and improving the environmental sustainability of the pork industry.

During their growth period, pigs generate three major greenhouse gases: carbon dioxide, methane, and nitrous oxide. Carbon dioxide is produced as a byproduct of maintenance and growth and is emitted through exhalation during respiration. Methane and nitrous oxide are generated primarily by manure and are dependent on the type of manure management system implemented in the barn.

The wean-to-finish sustainability calculator was designed to provide farmers with a tool to estimate the impacts of various levels of production efficiencies (feed efficiency and mortality), allowing them to determine how specific improvements in finishing can influence the environmental footprint. The calculator provides insight into GHG emissions at the individual barn level to enable continuous improvements in the pork industry.

Sources of Greenhouse Gas Production

From the Pig

An equation for carbon dioxide production from respiration was previously published by Philippe and Nicks. The boundaries of this equation were expanded using the slope to satisfy the weight range of finishing pigs.

The Intergovernmental Panel on Climate Change (IPCC) established guidelines and equations for methane and nitrous oxide production for specific swine manure management systems. Two manure management systems for swine production were taken into consideration: deep pit and anaerobic lagoon. Two timepoint selections were used only for deep pit: deep pit storage greater than one month and deep pit storage less than one month .

Methane and nitrous oxide were converted to their carbon dioxide equivalents using their global warming potential: methane (25) and nitrous oxide (298).

From the Diet

The GHG contributions from the diet were estimated using wean to finish diet formulations reported by Thoma' et al. Ingredients included corn, soybean, and dried distillers grain.

Corn and soybean GHG emissions are estimated by the amount of carbon dioxide equivalents produced for a bushel of product, and do not include feed processing.

Ingredient percentage was multiplied according to dry matter intake.

The quantity of the ingredient was multiplied by the carbon footprint for the production system.

Dried distillers grain was modeled using the EcoInvent unit processer specific for US conditions reported by Thoma' et al. The carbon footprint accounts for fermentation, drying, and other processes that are standard of US corn ethanol plants.

Wean-to-Finish Production Metrics

Data was collected for baseline closeout weight and days in the barn until market. Baseline average daily gain, dry matter intake, and feed efficiency curves were obtained.

A mortality equation was designed to assume production of GHG from respiration, feed, and manure management system; this was calculated only for the period of time the animal is alive.

Total GHG emissions are sourced from the amount of gas emitted by live and dead pigs. Estimates for GHG production by live pigs follows the assumption that the pig reached market weight (281 pounds). Estimates for GHG production by pigs that died follows the assumption that the pig reached the halfway point (140.5 pounds). Barn size and mortality rate is set by the user.

$$\text{Mortality} = \frac{\text{Total GHG emissions from pigs}}{281 \text{ lb.} \times \text{Barn size} \times (1 - \text{Mortality} \times 0.01)}$$

Summary

From these assumptions, GHG emissions can be calculated based on mortality, manure management systems, feed efficiency, and feed type; all of which can be applied within specific production parameters set by the user. The calculator can be manipulated to compare current production practices and target closeouts for the barn. A percent change is generated to demonstrate the potential improvement or decline of the different production metrics' influence on emissions; the calculator is free to download from the Iowa Pork Industry Center website (ipic.iastate.edu/information/WFPorkSustainabilityCalculator.xlsx). To evaluate the assumptions used within this calculator, sensitivity analyses were conducted for mortality (Table 1), feed efficiency (Table 2), and feed type (Table 3).

Table 1. Sensitivity analyses of carbon dioxide equivalents per pound market hog by mortality.

Mortality, percentage			4	6	8	10	12
Manure Management Systems	Anaerobic lagoon	With distillers grain	6.12	6.19	6.26	6.33	6.41
		Without distillers grain	5.75	5.82	5.88	5.95	6.02
	Deep pit >1 month storage	With distillers grain	3.54	3.57	3.61	3.66	3.70
		Without distillers grain	3.16	3.20	3.23	3.27	3.31
	Deep pit <1 month storage	With distillers grain	2.80	2.83	2.87	2.90	2.93
		Without distillers grain	2.43	2.46	2.49	2.52	2.55

Mortality was analyzed at 4%, 6%, 8%, 10%, and 12%. Output is represented as pounds of carbon dioxide equivalents per pound market hog. As mortality increased there was not a discernible increase in GHG emissions from this analysis. When pigs are considered dead, all GHG produced and included within the calculator are set at the halfway point to market weight. Feed efficiency was set to 2.57 pounds to represent industry average.

Table 2. Sensitivity analyses of carbon dioxide equivalents per pound market hog by feed efficiency.

Feed Efficiency, pounds			2.50	2.55	2.60	2.65	2.70
Manure Management Systems	Anaerobic lagoon	With distillers grain	6.02	6.14	6.26	6.38	6.50
		Without distillers grain	5.66	5.77	5.88	6.00	6.11
	Deep pit >1 month storage	With distillers grain	3.48	3.55	3.62	3.69	3.75
		Without distillers grain	3.11	3.17	3.24	3.30	3.36
	Deep pit <1 month storage	With distillers grain	2.76	2.81	2.87	2.92	2.98
		Without distillers grain	2.39	2.44	2.49	2.54	2.58

Feed efficiency was analyzed at 2.50, 2.55, 2.60, 2.65, and 2.70 pounds. Output is represented as pounds of carbon dioxide equivalents per pound of market hog. When pounds of feed efficiency increases, emissions increase by ~0.10 pounds of carbon dioxide equivalents per pound of market hog regardless of manure management systems and feed type. Mortality was set at 6% to represent industry average.

Table 3. Sensitivity analyses of carbon dioxide equivalents per pound market hog by feed type.

Feed type		With distillers grain	Without distillers grain
Manure Management Systems	Anaerobic Lagoon	6.19	5.82
	Deep pit > 1 month storage	3.57	3.20
	Deep pit < 1 month storage	2.83	2.46

Feed type was analyzed for diets with or without distillers' grain. Output is represented as pounds of carbon dioxide equivalents per pound of market hog. Diets including distillers grain emit ~0.4 pounds of carbon dioxide equivalents per pound of market hog compared to diets without distillers' grain across all manure management systems. Mortality was set to 6% and feed efficiency 2.57 pounds to represent industry average.

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References

Dong, H., J. Mangino, T. A. McAllister, J. L. Hatfield, D. E. Johnson, D. Bartram, D. Gibb, and J. H. Martin. 2020. 2006 IPCC Guidelines for National Greenhouse Gas inventories - Chapter 10: Emissions from livestock and manure management.

MetaFarms Production Index: Nursery, Finishing, Wean-to-Finish Closeout Performance, and Market Hog Sales. 2019.

PIC 2019 Wean to Finish Guidelines. 2019. Hendersonville.

Philippe, F. X., and B. Nicks. 2014. Review on greenhouse gas emissions from pig houses: Production of carbon dioxide, methane and nitrous oxide by animals and manure. dx.doi.org/10.1016/j.agee.2014.08.015 Agriculture, Ecosystems and Environment 199:10–25. doi:10.1016/j.agee.2014.08.015.

Thoma, G., D. Nutter, R. Ulrich, M. Charles, J. Frank, and C. East. 2011. National Life Cycle Carbon Footprint Study for Production of US Swine. 1-75.

Thomson, A., E. Coronel, and K. Young. 2021. Field to Market: The Alliance for Sustainable Agriculture. Environmental Outcomes from On-Farm Agricultural Production in the United States. 4th edition.

Understanding Global Warming Potentials. 2021. United States Environ. Prot. Agency. Available from: epa.gov/ghgemissions/understanding-global-warming-potentials.