

### Reference 10

Wang, HL; Long, WT; Chadwick, D; Velthof, GL; Oenema, O; Ma, WQ; Wang, JJ; Qin, W; Hou, Y; Zhang, FS 2020 Can dietary manipulations improve the productivity of pigs with lower environmental and economic cost? A global meta-analysis AGRICULTURE ECOSYSTEMS AND ENVIRONMENT, 289, 106748. 10.1016/j.agee.2019.106748

### Background and objective

Inappropriate management of pig manure contributes considerably to pollution of waterbodies by nitrogen (N) and phosphorus (P), and to air pollution by ammonia (NH<sub>3</sub>) and hydrogen sulfide (H<sub>2</sub>S) emissions. Dietary manipulation is recognized as a possible pollution mitigation measure, but it may affect pig growth and thereby production costs. The objectives of this study are therefore to i) determine the effects of four specific dietary manipulation strategies on N and P excretion, emissions of NH<sub>3</sub> and H<sub>2</sub>S and the growth performance of pigs, using a meta-analysis of published data, and ii) to evaluate the cost-effectiveness of these dietary manipulation strategies through marginal abatement cost curves analysis.

### Search strategy and selection criteria

Studies related to the effects of pig dietary manipulations on growth performance, nutrient excretion and emissions were searched using the bibliographical databases: Web of Science and China National Knowledge Infrastructure. The peer-review studies published in the period between January of 1990 and July of 2018 in both English and Chinese were searched. 1) Only data from studies with control treatments were included in our database, so as to allow side-by-side comparisons.; 2) Studies to be included had to include at least one of the following indicators: (i) growth performance; (ii) N and/or P digestibility; (iii) total N and/or P excretion; (iv) NH<sub>3</sub> and/or H<sub>2</sub>S emission from manure; 3) When an experiment in a study had more than one treatment (e.g. various levels of crude protein reduction, various doses of adding enzymes, various fermented feed ingredients and additives), each treatment had a control for comparison. In addition, data quality was further checked by considering the following criteria on treatment design: 4) the effects of dietary manipulations have to be tested as the main objectives of the treatments; 5) the experiments must be conducted in randomized and controlled trials; 6) feed additives have to be administered through the feed; 7) animals must be free of diseases.

### Data and analysis

A mixed-effects model was used to calculate the mean effect size and the 95% confidence intervals (CIs) of each group and performed in the nlme (linear and nonlinear mixed effects models) package of R statistical software Version 3.1. Experimental sites were considered as a random effect factor, to allow accounting for variances among studies. The lnR of individual pairwise comparison was the dependent variable. The significance of the effects on emissions was statistically assessed at 0.05 level.

| Number of papers | Population | Intervention   | Comparator  | Outcome   | Quality score |
|------------------|------------|--|---|---|---------------|
| 245              | Swine      | 1) Low crude protein (CP) diet; 2) Enzymes supplementation; 3) Fermented feed; 4) Other diet additives supplementation | 1) No reduction of dietary CP; 2-4) No feed additives | Metric: 1) Average daily gain; 2) Ratio gain to feed intake; Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control | 68.75         |

### Results

- Diets supplemented with exogenous enzymes, fermented feed ingredients and other additives improved the growth performance of pigs in terms of average daily gain and ratio of gain to feed intake.
- The average daily gain and ratio of gain to feed intake increased by 5.5% and 3.0% through supplementation of exogenous enzymes, respectively.
- The average daily gain and the ratio of gain to feed intake of pigs increased by 6.8% and 5.2% with the use of fermented feed ingredients ( $P < 0.01$ ), respectively, and by 5.5% and 3.2% with the use of other additives in diets. Significant increases in average daily feed intake were found for supplementation of enzymes in diets.
- Overall, mean average daily gain and gain to feed ration (G:F) significantly decreased by 3.8% and 4.3%, respectively, when dietary CP content was lowered by 0.2–12.0%.
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### Factors influencing effect sizes

- Enzyme type : Among the four types of enzymes, the impacts of phytase and carbohydrase were statistically significant.
- Dietary crude protein (CP) reduction : The effect of lowering crude protein content on average daily gain and ratio of gain to feed intake (G:F) became non-significant if the CP reduction was less than 4%.

### Conclusion

All dietary manipulation strategies investigated here significantly enhanced the growth performance of pigs in terms of average daily gain and ratio of gain to feed intake, except for lowering crude protein content at a high level (i.e. > 4% crude protein reduction).