MANIPULATION OF ANIMAL DIETS TO AFFECT MANURE PRODUCTION, COMPOSITION AND ODORS: STATE OF THE SCIENCE

Prepared by
A. Sutton, Purdue University
T. Applegate, Purdue University
S. Hankins, Purdue Univrsity
B. Hill, Purdue University
G. Allee , University of Missouri
W. Greene, Texas Agricultural Experiment Station
R. Kohn, University of Maryland
D. Meyer, University of California-Davis
W. Powers, Iowa State University
T. van Kempen, North Carolina State University

The amount and composition of freshly excreted manure can vary considerably and is primarily influenced by the original composition of the diet. In addition, feeding management practices can influence the efficiency of nutrient utilization in livestock and poultry operations. Odorous and gaseous compounds are emitted after excretion due to microbial metabolism in the digestive tract of the animal. Since the animal is the initial source of nutrient excretions and odors from animal operations, diet manipulation is a practical and potentially economical way to control excess nutrient excretions and odor emissions that will have a major impact to minimize pollution of water, soil and air. Research related to using diet manipulation to reduce nutrient excretions and minimize odors from livestock and poultry is summarized.

Optimizing nutrient availability and proportion in the diet to meet the animal's maintenance and production requirements is a recognized practice to decrease nutrient excretion. For instance, N utilization can be enhanced in cattle when they are fed degradable and undegradable protein in the correct balance. Similarly, in poultry and swine, the most optimal way to reduce N in excreta is to lower the amount of crude protein (CP) fed and to supplement diets with synthetic amino acids (AA). Reducing excess N from protein and balancing the essential profile required by the animal can substantially increase the efficacy of overall N retention in the animal. In swine, the impact of AA supplementation with low CP diets to reduce N excretion ranged from 28 to 62% depending upon the size of the pig, level of dietary CP reduction and initial CP level in the control diet. The average reduction in N excretion per unit of dietary CP reduction was 8.4%. Recent studies verified that practical swine diets with low CP and synthetic AA could reduce N excretion and ammonia emissions from 30 to 55%, hydrogen sulfide emissions by 30% and olfactometry odor measurements by 30%. However, on a practical basis, broiler chicken performance can be hindered by these lower CP diets due to a number of factors: reduced K levels, altered ionic balance, lack of nonessential AA, imbalances among and/or potential toxic concentrations of certain AA. There has been little research with turkeys, ducks and layers focusing on the reduction of CP and the addition of synthetic AA with the aim of reducing N excretion. With ever-changing genetics within individual animal species, requirements for individual genetic lines and yield-types are relatively uncertain, and research is needed to determine these requirements under commercial situations.

Recent research has reported that use of lower CP diets and phase feeding can reduce N excretion from 12 to 21% in feedlot cattle. This also reduced the runoff of N from the feedlots and reduced the amount of N volatilization losses from the feedlot surface by 15 to 33%. Other technologies that affect nutrient excretion from dairy cows are the use of somatotropin and three-time milking per day compared to two times per day. Improving nutrient utilization in dairy cattle through multiple feed management strategies could reduce N output from 15 to 30% without harming produc-

tion. Complex carbohydrates such as B-glucans, oligosaccharides and other non-starch polysaccharides (NSP) in animal diets can influence N excretion, resulting in increased bacterial protein production, and affect the electrolyte balance of the diet that will reduce the pH of manure and ammonia emission. This reduced emission of NH_3 is due to changing the ratio of N excretion in urine as urea and shifting the N excretion in feces in the form of bacterial protein. The removal of fiber and germ from corn in swine diets has recently been reported to result in a 56% reduction in dry matter excreted and 39% reduction in N excretion.

Supplementation of P to beef cattle fed in CAFOs is not necessary. Dietary P from typical energy, protein and fibrous feeds is adequate to meet cattle requirements for growth. For years, mineral P supplements have been added to dairy cow diets, typically containing 25 to 40% more P than recommended. The most obvious way to reduce the environmental threat from P in cattle manure is to eliminate excess P in the diet. Currently, it is very difficult to formulate low P diets for cattle by selecting low P containing ingredients. In addition, unfortunately, many by-product feeds used in the cattle industries are fed to reduce feed costs but are high in P. Recent beef cattle research has shown that P excretion can be reduced by 20 to 30% by not adding supplemental P to the diet in group-feeding studies and from 40 to 50% in nutrient balance studies. The reduction of supplemental P in dairy diets can potentially reduce P excretion from 25 to 50%.

The availability of P in the major feed ingredients (corn and soybean meal) for swine and poultry is very low because much of the P is bound to a phytate molecule. Poultry and swine do not have the natural-occurring enzyme phytase in their digestive systems to release the phytic P for productive uses. Therefore, it has been a common practice to add supplemental P sources to the diet, which means a significant amount of P is excreted in manure. New plant genotypes are being developed that contain lower levels of phytate P, such as the new high available P (HAP) corn and soybeans, that provide more available P in the diet for poultry and swine. Consequently, much less supplemental P is added to the diet and much less P is excreted (20-30%). Another management approach is to add the enzyme phytase to the diet to release the phytic P. Considerable recent research has shown that phytase addition will reduce P excretion from 25 to 35%. In addition, the efficacy of using phytase and HAP corn and soybeans together can reduce P excretion 50% and potentially more. Additional enzyme "cocktails," organic acids and vitamin D_3 metabolites can also affect the absorption and utilization of P that will reduce P excretion from 15 to 25%. Since there is considerable variability in the biological availability of P in various feed ingredients, research to determine availability is important for accurate feed formulation. These different availabilities vary due to soil mineral variation, growing conditions, cultivars and other factors. In general, dietary enzyme addition can improve the nutrient availability of feedstuffs and reduce excretion. Data for the P requirements of the broilers, turkeys, layers and ducks of current genetic strains are very limited. Using phase feeding programs to more nearly meet the needs of animals at different stages of the life cycle could significantly reduce P excretion.

Use of organic forms of Cu, Fe, Mn and Zn in swine diets resulted in lower levels of these minerals being added to the diet and excreted compared to conventional dietary mineral sources. Reduced dietary Cu, Zn, Mn and Fe concentrations fed throughout the life cycle of swine for three parities did not depress growth or alter feed efficiency and enzymatic activities indicative of health parameters. Salt and potassium (K) concentrations in the diet are critical in semi-arid and arid climates, where salinity problems can exist and sodium accumulation can adversely affect crop production. High salt levels will limit feed intake; however, this increases salt excretion. Potassium accumulation in forages receiving manure application with excessive K levels can potentially cause grass tetany conditions with cattle consuming forages with these high K levels. Minimal research has been conducted on the effects of diet on odor emissions from cattle manure, and this may become a major issue for cattle production in the future.

Research Needs

- ❑ Determine the effects and optimal concentrations of dietary CP levels, forms, ratios, AA levels, ratios and their interactions on animal performance, manure N composition and atmospheric N loss.
- ❑ Determine N requirements under varying production settings, production levels and stages of the animal life cycle. Quantify N excretions and forms at each stage of life cycle. Determine the available AA requirements of major genetic lines of animals under defined environmental and commercial conditions.
- ❑ Develop strategies to increase the retention of N for the production of milk, eggs and lean tissue. Develop metabolism modulators to increase retention of N and lean growth.
- ❑ Determine available P requirements of animals and excretion outputs of P on various diets.
- ❑ Develop nutritional strategies that improve the utilization of feed P and reduce P excretion, including phase feeding programs.
- ❑ Determine phytase interaction with vitamins, organic acids, Ca:P ratio, bioavailability of sources, probiotics, etc. on P utilization.
- ❑ Develop feeding strategies that reduce odors and ammonia emissions from manure.
- ❑ Determine the effect of nutrient availability in by-products, genetically enhanced crops and diet processing on nutrient excretion.
- ❑ Conduct mass balance studies to develop models for nutrient retention, excretion and characterization of manure.
- ❑ Evaluate methods to alter acid-base balance of diets for odor control and change in forms of nutrient excretion.
- ❑ Evaluate mineral sources and strategies on nutrient excretion
- ❑ Establish real-time nutrient evaluation of feed sources.
- ❑ Implement new technologies to reduce nutrient excretion on production operations.

In all species, there is a need for accurate manure volume and nutrient data under practical conditions at different ages and diets to assist in the development of storage facilities and comprehensive nutrient management plans (CNMP). Practical field studies to implement and fine-tune diet strategies and technologies are necessary, and in all of these studies, the economic feasibility, environmental benefits and costs of new diet modifications need to be determined. Economics is still a major issue determining if these technologies will be adopted.

The full text of the White Papers is available for $25 from Midwest Plan Service,

http://www.mwpshq.org/