United States Department of Agriculture

Natural Resources Conservation Service

Ecological Sciences Divison

October 2003

Effects of Diet and Feeding Management on Nutrient Content of Manure

Introduction

Accumulation of excess nutrients on the farm results in a whole-farm nutrient imbalance that can contribute to water and air pollution. A major portion of nutrients brought onto livestock and poultry farms comes from purchased feeds. Reducing nutrients or selecting more efficient feed nutrient sources and/or feeding techniques can significantly reduce the nutrient content of excreted manure (helping to achieve a whole farm nutrient balance), and help to reduce odors and other gaseous emissions from manure.

The U.S. Department of Agriculture (USDA) and the Environmental Protection Agency (EPA) released *Unified National Strategy for Animal Feeding Operations* in March 1999. Importantly, the Strategy articulated a national performance expectation that all animal feeding operations should develop and implement technically sound, economically feasible, and site-specific comprehensive nutrient management plans (CNMPs) to minimize potential adverse impacts on water quality and public health. Feed management is one component of a CNMP.

Proper management of animal diets is a valuable tool to help balance nutrient flows, to achieve a whole-farm nutrient balance, and to reduce the potential negative impacts some nutrients have on the environment.

This technical note describes a series of basic nutrition and feeding management principles and potential adjustments that can be made on livestock and poultry operations to reduce nutrient excretions. This technical note was prepared from material published by the Federation of Animal Science Societies (FASS), Savoy, Illinois (fass@assochg.org). Additional technical notes provide specific feeding management and nutrient excretion information for beef, dairy, poultry, and swine. These technical notes are not intended to be all-inclusive. Farmers or operators should consult with Extension personnel or qualified animal nutritionists for detailed information and thorough evaluations of the animal diets and feeding management programs for livestock or poultry operations.

This is the first in a series of nutrient management technical notes on feeding management.

Series was prepared by **Dr. Alan Sutton,** professor of Animal Science at Purdue University, West Lafayette, Indiana, and **Charles H. Lander,** national agronomist, NRCS, Washington, DC. This series was developed from material published by the Federation of Animal Science Societies (FASS), Savoy, Illinois.

Digestive processes

The digestive process begins with the intake of feed ingredients provided to meet animal maintenance, production, and reproduction requirements. The requirements for production are affected by stage of growth and the type of product (e.g., meat, milk, eggs) involved. How well the animal can retain nutrients for productive purposes depends upon the bioavailability of the nutrients in the diet, absorption, and metabolism. The quantity of nutrients excreted by animals is affected by three main factors:

- the amount of dietary nutrients consumed,
- the efficiency with which they are utilized by the animal for growth and other functions, and
- the amount of normal metabolic losses (endogenous). In other words, the amount of excreted nutrients can be expressed as:

Nutrients excreted = Nutrient intake – Nutrients utilized + Nutrients from endogenous sources

The primary way to reduce the amount of nutrients excreted by animals is to decrease the amount that is consumed and increase the efficiency of utilization of the dietary nutrients for formation of the product.

The goal of efficient and productive feeding of animals, within economic and environmental constraints, is to provide essential available nutrients for maintenance and production with minimal excess amounts.

Nutrients in feeds can vary considerably, and not all nutrients in feeds are available to the animal. Therefore, any means of increasing the digestibility or availability of nutrients will increase the potential for animal use and retention and reduce the amount of nutrients excreted. There is increasing interest today in using enzymes, genetically modified feed ingredients, and feed-processing technologies to enhance the availability of nutrients so as to meet the specific animal needs and reduce excretion of nutrients. In addition, a routine feed analysis program is imperative so that diets can be formulated and periodically adjusted to meet, but not exceed, the nutrient requirements of the animal.

Ruminants and nonruminants have different digestive systems. The ruminant (cattle and sheep) is capable of digesting and utilizing nutrients and energy from forages as well as from the easily digestible grains (concentrates). The nonruminant (poultry and swine) cannot effectively use a large amount of forages (fiber). Also, poultry and swine cannot digest some of the nutrients, particularly phytate phosphorus (P) contained in grains. Usually, 50 percent of the P in the grains and oilseeds is in the form of phytate, which is not available to swine and poultry. Therefore, to meet their P requirements, their diets must include additional P, generally supplied by mineral supplements. The combination of the P in feed grains and the additional mineral P added to the diet increases the total P consumed by the animal. A considerable portion of the nonavailable P and/or extra P not needed by the animal is excreted. If the diet contains an enzyme called phytase, which will release the phytate form of phosphorus from the grains, then supplemental phosphorus in the diets can be reduced.

Following are some factors that should be considered for making adjustments in the diet or feeding program to reduce anticipated excretion of nutrients and manure volume. In all cases, nutrients should be managed to meet the animal needs and, of equal importance, to minimize nutrient excesses.

Feed management factors

Recommended feed management practices for a particular operation may include implementation of grouping strategies, including grouping by gender and increasing the number of production groups; appropriately adjusting diets based on climatic factors; minimizing feed wastage; and employing processing options to improve feed use efficiency. Further information is provided in the species-specific technical notes.

Grouping—(1) Place animals of similar ages, weights, and/or production levels together. (2) Place animals of the same gender together. Split-sex feeding divides the animals by gender so that diets can be formulated to meet the special nutrient needs of each sex.

Climate—Adjust diet to meet specific climate conditions (e.g, temperature, wind, precipitation), or adjust the building climate to optimize nutrient utilization.

Phase feeding—Use multi-phase feeding versus minimal-phase feeding. Phase feeding provides a series of diets that are formulated to more closely meet the nutrient needs of the animal at a particular stage of growth or production. Dividing the growth period into several periods with a smaller spread in body weight allows producers to provide diets that more closely meet the animal's nutrient requirements.

Wastage—Minimize feed and water spillage.

Processing—Pelleting, extrusion, steaming, micronization, ensiling, and reducing particle size increase the digestibility of diets for swine and poultry. Processing feeds (e.g., grinding, pelleting, and fermenting) releases nutrients in the diet so the animal can absorb and retain more nutrients and excrete less nutrients and manure volume. Processing is not as critical for ruminants; however, coarse grinding, ensiling, and steaming have been effective for ruminants.

Diet manipulation factors

Diet considerations that are described in more detail in the technical notes on individual species include formulation based on feed available nutrients, the use of growth promotants to improve feed use efficiency, consideration of genetic factors that influence nutrient needs, use of specialty feeds, and consideration of nutrient intake from water supplies.

Available nutrients—Know the availability of nutrients in feed ingredients and formulate diets based upon available nutrients in the feed ingredients. Nutritionists should use the respective National Research Council (NRC) nutrient requirements for each farm animal as a guide to formulating diets unless data are available on the farm showing nutrient requirements of a specific genetic line of animals.

Nutrient levels—Some nutrient levels in commercial animal diets may be excessive. Chemical analyses of ingredients and reformulation are critical to minimizing excesses.

Genetics—Know the genetic capability of the animal, including feed intakes and responses to environmental conditions (e.g., climate, disease pressure, housing system).

Growth promoters—Antibiotics and other growth promoters increase feed efficiency. Growth promoters reduce nutrient excretion by increasing nutrient utilization.

Specialty feeds—Providing specific feed ingredients (e.g., high-oil corn, nutrient-dense corn, low-phytate corn, and soybeans) helps achieve a proper balance or increased availability of nutrients. Some of these are not commercially available today, but may be so in the near future.

Water supplies—Water supply sources can contribute significantly to mineral intakes.

Supplemental phosphorus—Reduce supplemental P and add phytase to swine and poultry diets to reduce P excretion. Remove all supplemental P in beef cattle diets and most of the supplemental P in dairy cattle diets to reduce P excretion.

Crude protein—Reduce dietary protein content and add synthetic amino acids to swine and poultry diets; reduce protein and select nitrogen (N) sources that cattle can absorb more effectively.

Benefits of reducing nutrients

Reducing the nutrient content of farm animal manure has the following benefits:

- A smaller land base per animal unit is required for manure application. This may provide a means to balance nutrients on a whole-farm basis.
- Greater volumes of manure can be applied per acre of land to meet agronomic rates for crop production. This may result in less labor and fuel costs for land application and reduce the potential need to supplement crop nutrient budgets with commercial fertilizer. Applying greater amounts of organic matter from manure per acre could result in more carbon sequestration and reduced emissions of gases responsible for global warming.
- Reduced N and sulfur excretion have the potential to reduce odors.

Reduced volumes of manure production will reduce the requirement for manure storage capacity and increase the flexibility for timing of manure application to cropland.

Dietary adjustments

The table on page 4 provides potential reductions in the excretion of nutrients with the dietary and/or feeding management adjustments mentioned above for livestock and poultry on operations that have not yet adopted diet and/or feeding management strategies to reduce manure nutrient content. It should be noted, however, that these potential effects are not additive. For more specific information, see the FASS fact sheets and the NRCS technical notes in this series for the specific animal species.

Potential reductions in the excretion of nutrients

Strategy	Nitrogen reduction (%)	Phosphorus reduction (%)
Formulate diet closer to requirement	10–15 (nonruminants) 10–25 (ruminants)	10–15 (nonruminants) 10–30 (ruminants)
Reduced protein/AA supplementation (nonruminants)	10–25 (poultry) 20–40 (swine)	n/a [1]
Protein manipulation (ruminants)	15–25	n/a [1]
Use of highly digestible feeds	5	5
Use of phytase/low P (nonruminants)	2–5	20–30
Selected enzymes	5	5
Growth promotants	5	5
Phase feeding	5–10	5–10
Split-sex feeding	5–8	n/a [1]

1 Not applicable.

Table data adapted from Federation of Animal Science Societies (FASS) publication, *Dietary Adjustments to Minimize Nutrient Excretion from Livestock and Poultry*, January 2001.

• • • • • •

Glossary terms used in the series of nutrient management technical notes

Available nutrient basis. Formulating a diet based on the bioavailability of the nutrients from the feed ingredients in the diet for the intended production purposes.

Bacterial protein (BCP). The crude protein in rumen bacteria made up of amino acids and nucleic acids.

Barrow. Male castrate of swine.

Bioavailability of nutrients. The amount of nutrient in the diet that is released in the digestion process and that can be absorbed in a form that can be used in the body for normal metabolic functions of the nutrient.

Bovine growth hormone. A natural nonsteroidal protein hormone produced in the pituitary glands of cattle that helps cows produce milk. The growth hormone produced in cattle will only be effective in cattle. This protein has been produced synthetically in bacteria.

Broiler. Chicken produced for meat.

By-products. Feed ingredients from sources that are normally waste products from other industries.

Concentrates. Plant materials (feeds) that contain relatively high starch content.

Crude protein. A measure of dietary protein that is based on the assumption that the average amino acid in a protein contains 16 percent nitrogen. Thus, total chemically determined nitrogen × 6.25 (100 ÷ 16) = crude protein.

Crystalline amino acid. Amino acid produced in its pure chemical form.

Cystine. A sulfur-containing amino acid that can replace up to one-half of the methionine requirement.

Degradable intake protein (DIP). Crude protein that is degraded in the rumen by micro-organisms.

Denitrification. The process by which nitrogen is converted to nitrogen gas (N_2) and nitrous oxide (N_2O) and returned to the atmosphere.

Diet formulation. The process of combining an assortment of feed ingredients into a diet that will meet the nutrient and energy requirements of the animal for the intended purpose for which the animal is produced.

Digestibility. The relative amount of nutrients released from the digestion process.

Digestion. The process of breaking down nutrients through chewing and the action of enzymes to release nutrients that can be absorbed in animals.

Dry-matter intake. The amount of completely dry feed consumed by animals.

Dry precipitation. Chemicals combining in the atmosphere and falling to Earth.

Endogenous. Nutrients within the animal that may be produced or synthesized. Excretion of endogenous nutrients may occur from the recycling of nutrients and normal cellular metabolic processes.

Endogenous phytase. The enzyme naturally derived within the animal or from microbial sources within the animal that degrades phytate and releases phosphorus.

Feed use efficiency. The amount of live weight gain, milk production, or egg production per unit of feed consumed.

Fermentation by-products. By-products that have been processed by anaerobic fermentation.

Fermented feeds. Feeds that have been processed and preserved by anaerobic fermentation. A typical example is the acid fermentation of whole corn plant silage.

Forage. Plant material that contains relatively high fiber content.

Gilt. A term used to describe young female swine before sexual maturity.

Grass tetany. A nutritional disease caused by inadequate magnesium in the blood. It most commonly occurs among lactating animals grazing on rapidly growing, lush spring pastures containing less than 0.2 percent magnesium and more than 3 percent potassium and 4 percent nitrogen.

Ideal protein basis. Formulating a diet based on the concept that the protein content of the diet has a balance of amino acids that exactly meets the animal's amino acid requirements.

Layer. A chicken raised to produce eggs.

Leaching. The process by which plant nutrients move down through the soil profile, potentially reaching ground water.

Lysine. A basic amino acid required for growth.

Metabolizable protein (MP). Protein (amino acids) absorbed from the small intestine of ruminants. Contains bacterial protein and undegraded intake protein.

Methionine. A sulfur-containing amino acid required for growth.

Microbial protein synthesis. The process by which protein is synthesized in the rumen as micro-organisms grow and multiply.

Near infrared spectroscopy. Feed analysis performed using near infrared light wave reflectance.

Nonruminant (monogastric). An animal that has a simple stomach (one compartment) and must utilize concentrate diets.

Phase feeding—Changing the nutrient concentrations in a series of diets formulated to meet an animal's nutrient requirements more precisely at a particular stage of growth or production.

Phytase. An enzyme that degrades phytate, making phosphorus available to nonruminants.

Phytate phosphorus. A complex, organic form of phosphorus that is bound to the phytate molecule and is not readily digested by nonruminant animals.

Precision nutrition. Providing the animal with the correct ratio and quantity of nutrients in a diet at the ideal ratio to most efficiently produce the end product for which the animal is raised.

Ruminant. An animal capable of digesting forages (roughages) because it has a large stomach with four compartments that have micro-organisms present.

Somatotropin. The hormone that regulates growth, affects the metabolism of all classes of nutrients, stimulates milk production, and improves productive efficiency.

Sparing effect. The process whereby one chemical or metabolite reduces the need or requirements for another nutrient.

Split sex feeding. A feeding and housing program that divides animals by gender and formulates diets to meet the specific nutrient requirements of each sex more precisely.

Total digestible nutrients (TDN). Total of all the nutrients in the diet that are available to the animal.

Undegraded intake protein (UIP). Feed protein that is not degraded in the rumen by micro-organisms.

Volatilization. The process by which chemicals evaporate at ordinary temperatures.

Wet-chemistry procedures. Analysis of nutrients using standard, approved laboratory procedures.

Wet-dry feeding systems. Feeding systems designed to introduce water with dry feeds, either at prescribed times or at any time on demand by the animal. By introducing water at the time of feeding, the potential for water spillage and dust from feed sources is reduced.

• • • • • •