Optimizing nutrition of commercial livestock for minimal negative impact on the environment through precision feed formulation[1]

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ABSTRACT: Manure (excretory products, including feces and urine) produced by animals throughout the world represents an enormous amount of organic matter and inorganic minerals added to the environment each day. Environmental stress is suffered by confined livestock as a result of dust and toxic gases produced during manure decomposition or other animal waste problems. The primary way to reduce the amount of nutrients excreted by animals is to decrease the amount consumed and increase the efficiency of utilization of the dietary nutrients. "Precision Nutrition" is a concept currently being introduced as a new approach to evaluate, adjust, properly utilize and possibly reduce the excretion of potentially damaging nutrients within livestock and poultry operations. Precision diets are formulated to precisely meet the animal's specific minimum requirements for essential nutrients throughout the production period to minimize excretory loss to the environment. Proper management of the diets of farm animals can be a valuable tool for reducing nutrient excretion, thereby significantly reducing potentially negative impacts of animal production on the environment.

Key words: commercial livestock, precision feed formulation, environment

INTRODUCTION

The poultry industry has historically played a leading role among agricultural industries throughout the world (Daghir, 1995; Sainsbury, 2000). This leading role has led to the development of a highly specialized industry made up of a larger, automated production and marketing units than any other livestock industry.

Conventional poultry feed composition and rationing systems, leads to substantial waste of nutrients and contamination of the environment from unabsorbed N, P and minerals (Dunn, 1999). Five major problems in commercial poultry production are: (1) pollution of environment with mineral in poultry feces; (2) feeding excess nutrients; (3) over utilization of expensive feeds and low utilization of less expensive but more poorly digested feedstuffs; (4) increased feed intake with consequent nutrient wastage by poultry in alternative systems; and (5) increased nutrient requirements of imported new strains of poultry (Henuk, 2001; Henuk and Dingle, 2002a,b). Dunn (1999) and FASS (2001a) have identified that the feeding of excess nutrients needs to be addressed by all animal nutritionists and have recommended that there be a reduction of 5–10% of most nutrients in livestock rations. This paper will review the optimizing nutrition of commercial livestock for minimal negative impact on the environment through precision feed formulation.

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MANURE PRODUCTION OF COMMERCIAL LIVESTOCK

Manure (excretory products, including feces and urine) produced by animals throughout the world represents an enormous amount of organic matter and inorganic minerals added to the environment each day (Pond and Pond, 2000). The volume of waste produced is a function of a number of variables including type, age and body weight of livestock, how they are housed and fed, the amount and type of bedding material and whether the waste is diluted with water (Table 1). Broadly speaking, the potential pollution factors in animal manure are summarized in Table 2.

Table 1. Livestock waste production (Grundey, 1980).

Type of livestock	Approx. body weight, kg	Waste production, l/d		Approx. DM, %
		Range	Typical	
Cattle:				
- Calf (< 2 months)				
(liquid concentrate feed)	73	4.0–6.1	5.0	13
- Calf (< 6 months)	140	6.3–7.8	7.5	13
- Heifer (< 12 months)	270	-	15.0	13
- Heifer (12-18 months)	380	-	20.0	13
- Beef (< 12 months)	400	10–34	27.0	13
- Dairy cow	500	32–54	41.0	13
Pigs:				
- Piglet	5	-	1.0	10
- Weaner	12	1.5–2.5	2.0	10
- Fattener (fed dry meal)	50	2.0–5.5	4.0	10
- Fattener (fed water : meal 2.5 : 1)	50	2.0–5.0	4.0	10
- Fattener (fed water : meal 4 : 1)	50	4.0–9.0	7.0	6
- Fattener (fed swill)	50	-	15.0	4
- Fattener (fed whey)	50	14–17	14.0	2
- Dry sow	-	-	4.5	10
- Sow + litter to 3 weeks	-	-	15.0	10
Poultry:				
- Broiler (including litter)	2	-	0.04	60
- Duck	2	-	0.03	12
- Goose	3.5	-	0.55	25
- Laying hen	2	0.10–0.14	0.114	25
- Turkey	7	-	0.17	23

Table 2. Pollution factors in animal manure (Mordenti and Piva, 1992).

Factor	Incl.
Nitrogen	ammonia, volatile N compounds
	nitrites, nitrates
	soluble organic compounds
Carbon	methane, carbon dioxide
Phosphorus	soluble inorganic compounds
Metals	Cu, Zn, soluble salts
Drugs	residues

GASEOUS POLLUTANTS FROM FARM ANIMALS TO ENVIRONMENT

Environmental stress from confined animal production results from both dust and toxic gases produced during manure and urine decomposition of animal waste. In addition to normal atmospheric components, air in confined animal quarters can contain exotic or natural suspended components in excess. These may include gases, liquid droplets, solid particles either organic or inorganic, viable or nonviable; noxious, pathogenic, or inert (Curtis, 1972). ThE main noxious gases are ammonia, hydrogen sulfide, CO_2, methane, and a host of strongly odoriferous organic gases in minute quantities (Pusillo, 1990).

Although most of the gases resulting from animal production are not directly a hazard to animal and human health, their smell is repulsive, which still makes them undesirable. Offensive odours produced by large confinement facilities or intensive feeding operations have resulted in serious and seemingly irresolvable situations. Odours emanate from confinement houses and manure storage areas, and are created during cleaning, transportation, and spreading of accumulated manure (Pusillo, 1990).

Three groups of gaseous pollutants originating from farm animals can be distinguished: first, fermentation and respiration gases, second, ammonia and nitrogen oxides and third, noxious odours. Their origin differs in that the first group is produced directly by farm animals, whereas the second and third groups result from microbial conversions during storage (Tamminga, 1992). Total production of gasses from different classes of farm animals are summarized in Table 3.

Table 3. Loss of gaseous pollutants (kg/animal/year) from farm animals (after Tamminga, 1992).

Farm animal	Body weight, kg	CH_4	NH_3	VFA
Lactating cow	650	100	8.8	-
Beef cattle	450	50	5.7	-
Lactating sow	200	-	8	-
Growing pig	75	0.3	3.0	0.14
Laying hen	2	-	0.2	-
Broiler	0.5	-	0.1	-

REDUCING THE QUANTITY OF OUTPUT OF ANIMAL MANURE THROUGH PRECISION FEED FORMULATION

Reducing N and P pollution from animal production is critical to the long term health of the environment we all must live in (Cole, 1993; Dunn, 1999; Grandhi, 2001). Commercial poultry are fed diets with higher protein content than most farm animals, so that poultry manure can be a potential source of the N pollution (Meluzzi et al., 2001). Growing pigs, in general, excrete 70% of the N present in their feed, beef cattle 80–90% and broilers 55%. Other estimates are that pigs and poultry excrete some 65% of their N intake and 70% of their P intake (Dunn, 1999). Indeed, a large proportion of P in the diets of pigs and poultry is excreted in faeces, creating environmental problems (Kies et al., 2001).

"Precision Nutrition" is a fairly new concept being introduced as a new approach to evaluate, adjust, properly utilize and reduce the excretion of potentially damaging nutrients within livestock and poultry operations to the environment. Proper management of the diets of farm animals through precision feed formulation can be a valuable tool for reducing nutrient excretion, thereby significantly reducing potentially negative impacts on the environment (FASS, 2001a). In Western Europe, for example, changes in feeding management have led to reduced environmental pollution. Particularly in the Netherlands, but also in Germany, France, Denmark and Britain, multiphase feeding and the addition of phytase in feeds in some regions greatly reduced emissions (Dunn, 1999). It has been demonstrated that nutrient levels of poultry can be amended to reduce nutrient excretion and this also has the potential to decrease feed costs (FASS, 2001b). It has also been reported that formulation of diets for commercial poultry without a vitamin and mineral premix decreased feed costs (Dingle and Henuk, 1999; Henuk, 2001; Henuk and Dingle, 2002b). However, this is only feasible during the final phase of production just prior to processing.

The primary way to reduce the amount of nutrients excreted by animals is to increase the efficiency of utilization of the dietary nutrients (FASS, 2001a) and not feed any nutrients in excess.

One of the most positive developments in feed and feeding for intensive livestock enterprises has been the German "RAM" system, which entails the formulation of very precise rations for pigs, according to the region, the herd genetics, the management and the feed components available. Developed by the Chamber of Agriculture for the Weser-Ems district in Lower Saxony, the RAM systems has proved to decrease N emission in faeces and urine by 20% and that of P by 29% (Dunn, 1999). Possible feeding management adjustments for livestock and poultry to decrease N and P output in excreta without affecting nutrient availability for production are summarised in Table 4. Animal nutritionists therefore have a potentially large role to play in precisely reformulating diets to decrease waste to the environment (FASS, 2001b).

Table 4. The potential reductions in nutrients with dietary and/or feeding management adjustment related to specific food-animal species (after Dunn, 1999; FASS, 2001b).

Strategy	N reduction, %	P reduction, %
Formulation closer to requirement	10–15	10–15
Reduced protein/AA supplementation (non-ruminants)	10–25 (poultry)	-
	20–40 (swine)	-
Reduced protein (ruminants)	25–30	-
Reduced P (ruminants)	-	20–30
Use of highly digestible feeds	5	5
Phytase/low P (non-ruminants)	2–5	20–30
Phytase/low P/HAP corn (non-ruminants)	2–5	40–50
Cellulases	5	5
Growth promotion (e.g. somatropine and clenbuterol)	5	5
Phase feeding	5–10	5–10
Split-sex feeding	5–8	5–10
Other feeding management practice effects:		
Fineness of grind/pelleting (non-ruminants)	20–24 reduced manure excretion and reduces N excretion 5	
Chelated or organic: Zn, Cu, Se, Mn form of minerals (non-ruminants)	15–50 reduced mineral excretion	

CONCLUSIONS

Proper management of the diets of farm animals can be a valuable tool for reducing nutrient excretion, thereby significantly reducing potentially negative impacts on the environment and animal nutritionists therefore have a potentially large role to play in precisely reformulating diets to decrease waste to the environment.

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