Introduction

A consequence of intensive animal agriculture is the production of large quantities of nitrogen rich waste products. Responsible farming practices require that changes be made to current production practices to minimize excess nitrogen excretion. Reeds (1990) states that "dietary allowances will always exceed needs by at least the degree to which inefficiencies are introduced by digestion, absorption and the metabolic transformations which accompany the ultimate utilization of dietary amino acids". Historically, the economics of farm animal growth were set by the maximization of meat (or egg) production and minimization of feed costs. The cost of safe waste disposal and/or recycling will be an added input cost in the future when assessing the use of a feedstuff. Therefore, current "cheap" feeds could become "expensive" feeds!

Annually, each North American will consume 30 kg pork, 28 kg chicken & turkey and 16 dozen eggs. Extrapolation of the feed required and the nutrients retained indicates that the monogastric animal industry is responsible for the production of large amount of waste (Table 1). Excess nitrogen can lead to pollution of water and may increase pest problems for commercial crops and give weeds a competitive advantage (Black, 1980; MacRae, 1990).

Discussion

This report addresses the question of "How can nutrition (both diet and feed management) be manipulated to reduce waste material". Nutrient retention describes all aspects of absorbability, digestibility, utilization and efficiency.

1. Feed Quality

"Factors which improve the quality of the nutrients in a diet rather than simply the quantity of the diet will improve nutrient retention" (Fuller et al., 1987). Considerable reductions in nitrogen pollution are possible by replacing part of the dietary protein by one or more of the limiting amino acids (Schutte, 1989; Kjeldsen, 1989; Abebe & Morris, 1990; Lucbert & Seroux, 1990; Aumuller, 1991; Gatel & Grosjean, 1991; and Warren & Farrell, 1991). Aumuller (1991) estimated that with phase feeding and accurate feed formulation (balancing with synthetic amino acids), nitrogen excretion by the monogastric animal industries may be reduced 30 to 50%.

Table 1. Per capita consumption of eggs, chicken, turkey and pork by North Americans relative to calculated animal feed and nitrogen intake and estimated nitrogen loss to produce each per capita unit

<table>
<thead>
<tr>
<th>Species</th>
<th>Per Capita Consumption</th>
<th>Feed Equivalent (kg)</th>
<th>Nitrogen Intake (kg)</th>
<th>Nitrogen Loss (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eggs</td>
<td>16 doz</td>
<td>35</td>
<td>1.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Chicken</td>
<td>23 kg</td>
<td>50</td>
<td>1.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Turkey</td>
<td>5 kg</td>
<td>15</td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>Pork</td>
<td>30 kg</td>
<td>120</td>
<td>2.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Total</td>
<td>220</td>
<td>5.1</td>
<td>5.1</td>
<td>2.6</td>
</tr>
</tbody>
</table>

USA: > 660,000 Tons Nitrogen/yr
Canada: > 60 Million kg Nitrogen/yr

\(^{1}\)Black (1989)
Balancing Dies with Amino Acids will Minimize Nitrogen Levels of Diet

<table>
<thead>
<tr>
<th>Egg Laying Hens:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Produce 276 eggs (23 doz)/hen yr</td>
</tr>
<tr>
<td>= 83 lbs feed/hen/yr</td>
</tr>
<tr>
<td>@ 18% CP feed (unbalanced diet)</td>
</tr>
<tr>
<td>= 15 lb CP/hen/yr</td>
</tr>
<tr>
<td>@ 15% CP feed (balanced diet)</td>
</tr>
<tr>
<td>= 12.5 lbs CP/hen/yr</td>
</tr>
<tr>
<td>= 2.5 lbs CP Excess/hen/yr</td>
</tr>
<tr>
<td>= 0.4 lb Nitrogen</td>
</tr>
</tbody>
</table>

For a flock of 80,000 hens:
100 Ton Excess Crude Protein/yr
33,000 lbs Nitrogen Excess!

In Pennsylvania (20 million hens):
26,000 Tons Excess Crude Protein/yr
8.3 million lbs Nitrogen Excess!!!

Cole (1991) reported significant differences in optimum level of lysine in a diet when feeding for maximum weight gain or maximum feed:gain. "Maximum voluntary feed intake generally occurs at the dose allowing maximal gain. As doses increase beyond the level needed for maximal gain, feed intake decreases, while gain remains constant. Roughly 12% more lysine is required for maximal feed efficiency than needed for maximal weight gain. This is perhaps not surprising in that the ratio of whole body protein to whole body fat continues to increase when additional lysine is supplemented beyond levels needed to maximize weight gain".

Blair (1992) used this concept of supplementing amino acids to reduce the dilution effect of crude protein on energy, in egg laying hens, as they attain peak egg production. "Quality control programs which use amino acid analysis to monitor feed ingredients as well as improved mixing efficiency can be used to lower safety margins of amino acids, allowing more room for energy in low-intake diets, thereby avoiding the post-peak production drop".

Diet processing, grinding, heat treatment, pelleting and crumbling all influence nutrient intake, availability and retention. Skoch et al (1983) reported that pigs fed steam-pelleted rations had a lower protein retention than those fed untreated mash diets. However, performance of pigs fed pelleted diets was superior to performance of pigs fed mash diets.

Feeds containing anti-nutritional factors must be altered to ensure no compromise in nutrient retention. Anti-nutritional factors include antitrypsic substances in soybean, glucosinolates in canola, tannins, gossypol, some carbohydrates, eg., beta-glucans and pectins (Liener, 1989; and Classen et al., 1991).

2. Fat, level and source

Crude protein (CP) retention by broiler chicken is influenced by fat sources (corn oil vs. tallow vs. a blend, Scott, 1992). There also is evidence of an interaction with age of the bird. At 7 days of age, no significant differences in CP retention related to dietary fat source were observed. However, by 21 days broilers fed the tallow versus corn oil or a blend retained more nitrogen. This may be due to changes in the rate of passage of digesta through an animal (Mateous, et al., 1982; Endres et al., 1988; Reid, 1988; and Wiseman, 1989). Delays in rate of food passage may improve nutrient retention by: 1) increasing the time nutrients are in contact with absorptive cells; and 2) altering the microbial population, thereby, affecting utilization of nutrients (Washburn, 1991).

3. Diet dilution

By diluting a diet with 20% undigestible nutrients, protein retention of broiler chicks increased in the period from 7 to 21 days and then remained constant (Scott, 1992). The theory is that dilution reduces actual intake of specific nutrients (eg., protein) and results in improved utilization of available protein in the feed and improved recycling of nutrients within its body. Other theories include those by Malmlof & Hakansson (1984) who suggest that undigestible dietary fiber provides a fermentable carbohydrate source for microorganism in the hind gut, which in turn are "empowered" to recycle urinary nitrogen and depress daily urinary nitrogen output.

Although there are positive effects of fiber inclusions on protein deposition and nitrogen retention, we must consider reduced energy intake, particularly in egg laying hens with small appetites. If diet dilution reduces the intake of energy required for absorption and metabolism, then retention of all nutrients will be compromised. The quantity of undigested nutrients in excreta may be reduced by fiber, but the actual volume of manure is greatly increased by feeding fiber!
4. **Feeding**
Feeding time or the chronology of appearance of absorbed nutrients at tissue level may be an important factor in determining retention (Henry, 1985). This concept was eluded to in explaining the performance of self-select fed animals. Ensuring specific nutrient consumption to match nutrient requirements, will reduce heat of digestion and metabolic requirement of “processing” excess nutrients. Scott and Balnave (1989) demonstrated that under hot temperatures, sexually maturing pullets were able to maintain high egg production, increase egg weight and gain body weight when allowed to self-select feeds with different protein and energy levels. There was also a substantial reduction in nitrogen excretion as the birds attained sexual maturity. The study also showed that nitrogen excretion was directly related to nitrogen intake at specific physiological “ages”.

5. **Age**
Scott (1992) reported that in broiler chicks 7 to 21 days of age, CP retention increased from 35 to 43% (P < 0.05). However, the same data demonstrated that actual CP excreted increased form 293 to 317 g/kg (P > 0.05). How does retention and excretion increase at the same time? One explanation may be increased gut microflora as the bird matures, another may relate to efficiency of nitrogen and other nutrient (eg., starch and fiber) utilization at different stages of development.

6. **Health status**
The health status of the animal will influence the animal's retention of nutrients. Stewart and Guerrero (1987) and Potkin (1988) demonstrated that gastrointestinal tract lesions in growing pigs have a negative impact on nutrient retention. Ruff (1985) lists the impact of reduced ability to ingest, digest and absorb nutrients with coccidiosis infections of avians.

7. **Phytic Acid**
Phytic acid, the main storage form of phosphorus in many seeds and cereals, may effectively "tie up" 80% of total plant phosphorus. In some cases the bioavailability of proteins may be compromised by phytic acid directly or by its inhibition of enzymes necessary for protein breakdown (trypsin, tyrosinase and pepsin, Nair et al., 1991).

**Conclusion**
There are many "adjustments" in the feeding and management of poultry that can reduce nitrogen excretion. New technologies, including synthetic amino acids and enzymes, should be considered as a means of reducing nitrogen excretion.

The concept of maximizing for meat (or egg) production and minimizing feed costs will require adding the cost of safe waste disposal and/or recycling in the future.

Formulating diets based on digestibility and the use of commercially available amino acids, will help minimize dietary amino acid excesses, and thereby reduce nitrogen excretion.

**Bibliography**


Gatel, F. & F. Grosjean, 1991. Effect of protein content of the diet on nitrogen excretion by pigs. 42nd Annual Meeting of the EAAP.


