

Historical perspectives in poultry nutrition and feeding management

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As a graduate student in the early 1970's I was always intrigued and in awe of senior researchers and their various reviews of discoveries in animal nutrition. In awe, because I suspected that my generation would never have the opportunity to discover any new nutrients or investigate truly new roles for various diet components. I still recall a professor telling us that there would be no new frontiers in animal nutrition and that perhaps we should consider other avenues of science. It is true that no new nutrients have been discovered by my generation of nutritional scientists, yet the dramatic development and expansion of the poultry industries have provided us with a plethora of continually evolving challenges, both academic and applied over the last 40 years. Today, the chicken is arguably the most comprehensively researched animal in society and so we have very detailed knowledge of its nutrient needs under a range of growing conditions and market needs. To some extent this has simplified nutrition, since together with limited genetic variance in all poultry species, feeding poultry has become globally standardized, and there are few "secrets" in formulation. Fine-tuning of feeding programs today relate to degree of real-time knowledge of ingredient composition, the impact of "environment" on the ability of birds to eat, and the ever evolving changes in consumer demands for specific food products.

Improved transportation and rural electrical supply for incubation were the underpinnings of the fledgling poultry industries in the late 1940's early 1950's. At that time, diets were quite complex being composed of a long list of ingredients that invariably included dried milk products, fish meals and often liver meal or meat scraps. Birds fed milk products always outperformed, a situation most likely related to the supply of riboflavin and perhaps some other B-vitamins. Breeding stock and table egg production was seasonal, mainly due to the late discovery of the importance of vitamin D. While the significance of manipulating the light cycle was known for prolonging the laying cycle, early confinement systems, even with windowed houses, provided inadequate levels of vitamin D for sustained calcium metabolism. Cod liver oil and then synthetic vitamin D were critical components in diets that allowed for year round poultry production. Less dramatic, but as important was the discovery of the importance of selenium in animal nutrition. For the young bird, the metabolism and significance of selenium was intimately tied to that of vitamin E, and Leo Jensen (1999) eloquently describes the discovery of the role of selenium in poultry nutrition, which was arguably the last "unique" discovery in our discipline. The last 50 years has therefore seen no true discoveries, yet

continual developments in poultry nutrition have allowed or supported the incredible changes that have occurred in efficiency of production of both meat and eggs.

Genetic potential of broilers and turkeys, and egg production on modern layer strains has been supported by judicious supply of energy from cereals and amino acids from both plant and animal source ingredients. While a diet balanced in all nutrients is essential for productivity it is argued that an adequate supply of energy has been the single most important component in poultry diets. Unfortunately, diet energy is the most fickle of nutrients to assay since it is the result of utilization of all energy yielding components and is greatly influenced by biological processes. After 50 years of researching usable energy, we still have no system in place that enables guarantee of the energy in feeds or ingredients during commercial transaction- a rather questionable practice in a multi-billion dollar industry. Certainly we have tried to resolve this issue over the years. The 1920's and 1930's was the golden era of researching energy systems and with the prevalence of ruminant research at the time, Net Energy and Productive Energy systems were fashionable, albeit the most difficult to assay, and the most variable in relation to biology of the animal. Net Energy spilled over into early poultry nutrition, and the classical work of Fraps (1946) described Productive Energy for maintenance and gain from consideration of body accumulation of protein and fat following consumption of known quantities of feed. The subsequent integration of the gross energy value of these nutrients allowed for calculation of Net Energy. This energy evaluation system was plagued with variable results across and within labs (likely due to variable maintenance needs) and so diet energy was a difficult concept to include in practical formulation. Interestingly, Titus in the 4th edition of his classical book "The Scientific Feeding of Chickens", published in 1961, devotes just one page to energy metabolism. Unfortunately this same text contains a full chapter on "Hormones and nutrition" a topic that still haunts the industry after 50 years of redundancy.

Poultry nutrition became more rational and logical with the acceptance of the concept of Metabolizable Energy. Now nutritionists had a basis for energy evaluation that was quickly embraced for relative ease of measurement, and accuracy and precision for both mixed feeds and ingredients. For the most part ME values were additive. Hill and Anderson, Potter, Sibbald and Slinger and others worked out various refinement to the assay, but by and large the ME system appeared equitably for diets and ingredients and was little impacted by bird age or productive status. Because birds eat quite precisely to their energy requirements, development of consistent and standardized ME values provided us with the critically needed basis for relative quantitation of all other nutrients. Over the last 40 years there have been suggestions for refinement of ME, such as TME, yet the underlying system has proven its usefulness in commercial formulation and description/economic evaluation of ingredients. Interestingly, NE

systems are again being researched, mainly in Europe, where mathematical adjustment factors are applied to simple chemical analyses, which is reminiscent of the cumbersome and unpredictable system described by Fraps (1946)

Having a basis for energy evaluation, and hence prediction of feed intake, has allowed for refinement of the incorporation of all other nutrients in diets. Initially this situation involved crude protein, methionine and lysine together with macro and micro minerals. Protein: energy and nutrient: energy ratios were the basis for formulation in the 1970's. These formulation systems parallel the overwhelming dominance of the use of predominantly corn and soybean meal in poultry diets. Using these two major ingredients of very consistent composition meant that crude protein was a reasonable barometer of amino acid levels beyond the first one or two limiting ones. With the advent of accessible and reasonably priced computer hardware and software, much more complex formulation possibilities arose and least-cost formulation allowed for consideration of an array of alternate ingredients. In the late 1970's we reverted to more complex lists of ingredients within most diets. Reliance on crude protein as a metric for amino acid availability was suddenly untenable. So called by-product ingredients were of variable composition and nutrient availability while the processing conditions applied to these and animal based ingredients required a better understanding of nutrient availability. The TME energy system was refined to assay available amino acids and today diets are invariably formulated in terms of digestible or available amino acids. Concurrently, synthetic amino acids became economically attractive, and over time variable quantities of methionine, lysine and threonine have reduced the emphasis on protein-rich ingredients. These amino acids are generally regarded as equivalent to that provided via intact proteins and the in the future we may also have access to valine and isoleucine. The protracted saga concerning the efficacy of various methionine sources has taxed the patience of most poultry nutritionists. In this regard, the broiler chicken is probably more capable than the statistician in evaluating any such nutrient source.

Least-cost formulation led to the necessity for better quality control programs at the feed mill, for diets and especially for incoming ingredients. By-product ingredients are less consistent in composition than are corn and soybean meal. Although the latter is definitely a by-product of oil production, the scale of operation and the standardization of processing world-wide have resulted in a product of very consistent composition. Other vegetable ingredient by-products and cereal by-products are invariably produced in smaller quantities at many more locations, and so local knowledge became paramount for successful incorporation in diets. Unfortunately we have not progressed too far in indentifying nutrient levels in raw ingredients prior to feed manufacture or even before birds are fed or birds or eggs marketed. Few manufacturing industries would accept this level of uncertainty in a production system. Proximate analysis has its obvious limitations, yet still there are millions of dollars spent each year on such crude

chemical analyses. In this regard I am always amazed when presented with analyses of gross energy of ingredients or diets, with the defense that it's included in the analyses "package". Over the last 30 years we have had various forays into real time nutrient analyses, with the most promising still being Near Infra Red Analysis. There is no doubt that light absorbance correlates with chemical components and so there is a sound basis for the technology. Unfortunately NIRA performs best when assaying "normal" samples and is less reliable for quantifying outliers. At a feed mill, it is information about ingredients that differ from the norm that is the most important. Unfortunately library information that includes such outliers is limited and so like a normal distribution, predictions are most accurate for the "average" sample.

Having suggested the perhaps insurmountable task of developing accurate and precise real-time estimates of available nutrients in ingredients, the job is less daunting than first appears since we have a very limited supply of different raw ingredients to handle and assay world-wide. Over the last two years I have been asked numerous times to speak on the subject of "alternate ingredients" in poultry nutrition. I have declined simply because there are no new alternate ingredients world-wide. The exception is limited quantities of glycerol available locally adjacent to biodiesel plants. An ingredient may be an alternate to an individual feed mill, but rest assured that it is main-stream elsewhere. Overtime we have settled on about 18 ingredients used world-wide, and that are being competitively sought by all poultry (and swine) nutritionists. In the EU, with their restrictive legislation, there are just 12 ingredients to choose from, and world-wide there are less than 8 that are traded by the boat-load. There are, and never will be true alternate ingredients, and information about the 18 or so available is already out there in the literature.

Over time there has been some interesting detective work used to establish the feeding value of certain ingredients and periodically plant geneticists have accommodated our request to improve composition. Rapeseed meal or Canola meal as it's now called is the classic example. Rapeseed was promoted for its high oil content to be used in human foods, although during the war years it was used almost exclusively as marine engine oil and as a for-runner of biodiesel. The residual meal was marketed as an alternate to soybean meal. Unfortunately the meal contained residual glucosinolates, which are cyanide-containing compounds and so had predictable deleterious effects on bird growth, with the most common sign being enlarged thyroid. All attempts at heat treatment and mechanical or chemical extraction failed to remove the toxins. Concurrently issues were raised about one fatty acid in rapeseed oil, namely erucic acid, as causing unusual fatty acid infiltration in heart tissue of rats. Plant scientists, in what some regard as a prelude to genetic engineering, selected seeds that were low in both glucosinolates and erucic acid. The resultant rapeseed was called "double-zero" and later the name changed to Canola (Canadian oil seed) as a means of branding and marketing. Yet

another interesting phenomena resulting from the use of rapeseed or canola is the fact that some brown-egg birds produce fishy-flavored eggs when fed much more than 5% of the diet. Certain brown-egg birds lack the enzyme necessary to clear trimethylamine from the body, a product that arises from intestinal bacterial breakdown of sinapine in the seeds or meal. The development of Canola is unfortunately an isolated example of plant geneticist developing “ingredients” specifically with animal nutrition as the main criteria. Today, virtually all plants are selected and developed for agronomic reasons and we are left to work with the resultant seed or by-product, as exemplified by the ever decreasing protein in newer varieties of corn. We should not lose focus of the main attribute of cereals, namely their energy contribution. To potentially engineer corn, for example, to contain more lysine is doomed to failure because of the logistics of separation/identity preservation through transport and storage and the fact that the amount of lysine to be contributed to a diet will still be minimal in relation to bird needs. Over the last 20 years we have been relatively free of problematic issues related to specific ingredients. Certainly the concern about mycotoxins in many ingredients has fueled significant discussion and expanded research budgets. Apart from the adverse effects noted with aflatoxin, the role of mycotoxins has perhaps been overemphasized, in part due to their ubiquitous nature and the current ease of assaying, and so defining positive results in terms of ppb or even ppt. As a frequent target for blame in situations of unaccountable poor performance, they have spurred the introduction of a new class of feed additive.

Over the last 10 years we have lost focus on feeding the bird per se, since our activities have been redirected at placating consumer concerns, fears and paranoia about their food supply. One can discuss the topic of perception vs. reality of the science surrounding food supply, yet while food remains cheap and consumers are concerned only about their self-centered western life style, then it seems inevitable that we will have to redirect research and feeding practices of all segments of the industry. In the short term we seem intent on losing our focus on feeding the world. The current situation in Europe exemplifies the dilemma of trying to feed birds with minimal feed additives and maximal use of water medication. Likewise our QC programs at the feed mill have lost focus as it relates to nutrient supply of the bird, being replaced with emphasis on traceability and accountability related to human “health”. No doubt there will continue to be a plethora of studies aimed at finding the next alternate to subclinical antibiotics in animal feed. We are still quite ignorant about the microbial population in the gut and even the exact nature and process of “digestion”. As a challenge, try to find information on the exact level of all digestive enzymes produced by broilers in the first 14d of life. Our attempts at adding exogenous enzymes to feeds are often based not on the science and physiology of digestion, but on feed- and weigh- mentality. Our future progress and direction in poultry nutrition relates to more comprehensive studies of enzymology and gut microbiology. Having

resolved these issues our limits to productivity will be a better understanding of calcium metabolism in ever-younger market weight broilers and in layers approaching the magical threshold of producing 365 eggs per year.

References

Fraps G.S. (1946) Composition and productive energy of poultry feeds and rations. Texas Agr. Exp. Sta. Bulletin 678

Jensen,L (1999) History and importance of selenium for poultry. A.L.Moxon Honorary Lecture, Ohio State Special Circular #167-99.

Titus H.W. (1961) The scientific feeding of chickens 4th Ed The Interstate Publ, Danville, Illinois.