RESEARCH PRIORITIES IN BROILER BREEDER NUTRITION

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Summary

Today's commercial broiler is the fastest growing and most efficient bird ever produced. It represents the combined efforts of genetics and management. However, with this tremendous improvement in broiler performance comes a greater challenge in the ability to manage broiler breeders properly. Much like the broiler, the broiler breeder is also changing rapidly and, although geneticists are also selecting for increased egg production, the customers demand that the emphasis be placed on broiler traits. This does not create broiler breeders which are any more difficult to manage than in the past but, as the bird changes, innovative nutritional and management approaches must also be developed to match these needs.

I. INTRODUCTION

Consumer demand for lean poultry products necessitates that product leanness and uniformity be improved. As a result, technologies resulting in greater protein production, not overall bird mass, will be emphasized. The shift of focus to the profit center of lean tissue mass necessitates that nutritional advances occur which enable muscle growth at optimal rates while minimizing fat accretion. Though this direction may slow bird growth rate research directed at reducing the growth-depressing consequences of stress may help offset this dilemma. Nonetheless, technological developments must occur within the bounds of increasing environmental restrictions, which are becoming more intense. Knowledge related to bird energetics, stress management and waste production are evolving and new management approaches are being employed. A more thorough understanding of energy metabolism is fundamental to improving profitability of production enterprises.

Future poultry expertise will undoubtedly be similar to today's highly technical industry practices on numerous fronts including nutrition, ventilation, hatchery, health and management. Research related to broiler breeder energy and amino acid requirements throughout their life cycle will become a priority. For example, research has shown that the way pullets are grown may have a dramatic effect on subsequent hen performance. Recommendations for pullet rearing programs are and will continue to focus not only on body weight but also on body composition. Breeder nutrient requirement research will be conducted to optimize pullet body composition and change the growing curve to improve egg production and, more importantly, chick production.

There are large differences between various countries in relation to chick production. Broiler breeder hen performance statistics show that countries such as the United States lag significantly behind performance figures for the same breed in other areas of the world. These differences are especially evident with the heavier, fast growing, high yielding broiler breeds. Many companies focus only on pullet costs and often neglect what impact changes in pullet rearing may have on subsequent hen performance. Controlling costs are essential for a company to survive but there must be a balance between cost reduction and performance. There are many opinions as to why certain countries have better flock performance. Clearly, feed formulations, feed management, body weights and body compositions differ. However, what these differences mean for bird health and productivity remains uncertain.

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There is a great wealth of information available on nutrition and management of broiler breeders but the industry often lacks basic knowledge of pullet and breeder hen metabolism and the nutrient requirements for optimal productivity. Though many companies offer feed and weight guidelines for rearing pullets it seems that much of the industry practices and rearing management guidelines are based more on circumstantial opinions and trial-by-error than on scientific evidence and documented solutions. Therefore, the intent of this paper is to describe some of the trends that may take place in broiler breeder research and to add fundamental knowledge describing relationships between nutrition, growing curves, bird body composition, hen performance and mortality.

II. ENERGY REQUIREMENT SCHEMES

Broiler breeder research directed at optimizing body composition of pullets and hens will be essential in understanding what the flock requires for good chick performance. The degree of carcass fatness is well documented to be impacted by both non-nutritional and nutritional factors. The effects of age (Edwards, 1971; Kubena et al., 1972), sex (Summers et al., 1965) and ambient temperature (Swain and Farrell, 1975) are known among the non-nutritional factors. Fraps (1943) described the nutritional effects of varying dietary ingredients on carcass fat. Since then many studies have established that as the dietary energy:crude protein ratio is widened carcass lipids increase (Donaldson et al., 1956; Summers et al., 1965; Kubena et al., 1972). The effect appears to be independent of energy source because dietary fat substitution for carbohydrate at a constant dietary energy:crude protein ratio has little effect on carcass fat (Barton, 1979; Lauren et al., 1985). Without exception such studies have utilized the metabolizable energy (ME) system as a basis for varying ingredient concentrations and ratios.

An understanding of energy and protein metabolism for all poultry classes is fundamental to diet formulation and profitable production. The nitrogen corrected metabolisable energy (\(\text{ME}_n\)) system currently is accepted as the standard for ration formulation. However, by definition \(\text{ME}_n\) does not quantitatively predict energy deposition by birds. Any difference in heat increment alters energy retention and, thereby, may affect cellular energy:nutrient ratios. Other factors affecting \(\text{ME}_n\) utilization include stress factors such as disease agents (bacteria, viruses and protozoa), social stress created by other animals and man, malnutrition, toxicities and the thermal environment. Diets based on \(\text{ME}_n\) do not necessarily correlate with bird energy retention and may have energy:nutrient ratios varying independently of \(\text{ME}_n\).

Efficiency of \(\text{ME}_n\) use for tissue gain depends on numerous variables. Efficiency varies with substrate source, for lipogenesis being approximately 75, 84, and 61% for carbohydrates, fats and proteins, respectively (De Groote, 1969; Chudy and Schiemann, 1971; Hoffmann and Schiemann, 1971). The high availability of fat ME\(_n\) for tissue gain, however, requires that fat is used for lipogenesis (Bossard and Combs, 1961). Utilization of protein for tissue energy gain depends upon the biological value of the protein source and should not be constant (De Groote, 1973). Indeed, one could summarize that the bird's energetic efficiency for use of protein or any substrate is the net result of partitioning consumed substrate energy into maintenance needs versus accretion of protein and fat.

Dietary protein recommendations for optimum rates of lean tissue accretion range from high (Kubena et al., 1972) to low levels complemented with specific amino acids (Waldroup et al., 1976). Whether the carcass leanness associated with feeding high protein diets is attributable to substrate limitations (amino acids), or due to greater heat production per unit of ME\(_n\) for dietary amino acids, carbohydrates and fat is subject to debate. Research conducted at Oklahoma State University by Mittelstaedt (1990) examined the true
metabolizable energy (TME) utilization of carbohydrate, protein and fat sources for energy, protein and fat gain. Despite similar TME consumption among the energy-supplemented groups carcass energy was impacted significantly. Total carcass energy gain was 17, 27, and 30% greater for gelatin-, starch- and corn-oil supplemented groups, than for birds fed the basal diet. Estimated energy gain from the basal ration was similar among the energy supplemented groups due to nearly identical feed consumptions. However, total energy gained differed (P<0.05) across experimental groups with the highest value of 1.82 MJ/bird observed for the birds fed corn oil verses only 0.70 MJ/bird for birds fed gelatin. As a result, energetic efficiency varied among the energy supplemented groups. Efficiency of ingredient TME usage for carcass energy deposition averaged 50.0, 39.1, and 19.9%, for supplemental corn oil, starch and gelatin, respectively.

An additional consequence of low protein MEₙ utilization efficiency is that the birds heat load is increased. Elevated heat load has little consequence when birds are housed at or below thermoneutral temperatures. However, if the bird’s heat load is elevated by high ambient temperature stress, without a concomitant increase in heat dissipation, elevated heat load can be devastating (Wiernusz and Teeter, 1993). Belay and Teeter (1992) fed birds various protein levels and energy:protein ratios. Increasing dietary energy and/or narrowing energy:protein ratios by relaxing restrictions on amino acid balance (which necessitated increased dietary protein) significantly impacted bird carcass composition. Improving amino acid balance and lowering dietary crude protein concentration increased survival both in the thermoneutral environment (4.4%) and in the heat stressed environment (10.8%). Lowering crude protein (at adequate amino acid balance) for birds subjected to heat stress can prove beneficial. Research is needed to identify which amino acid excesses cause the greatest risk.

Diets formulated on the MEₙ system do not necessarily correlate with bird energy retention since the energy:nutrient ratios of depot tissue can vary independent of MEₙ. In order for the broiler breeder to achieve optimum carcass composition with maximum energetic efficiency an energy-requirement scheme must account for the variation in substrate-mediated heat production.

III. AMINO ACID REQUIREMENT SCHEMES

Rearing broiler breeders for optimum chick output is a complex and multifaceted undertaking. Pullet nutrition and feeding, as one portion of that undertaking, is constantly in flux as genetic packages and management styles change. Nutrient modulation during the replacement phase can and does influence a number of important factors involved in the laying period. Unfortunately, follow-up can be difficult as final egg/chick numbers are so far removed in time from nutritional changes that may be made during the early rearing period. A number of research programs have looked at pullet nutrition and correlated changes in diet with subsequent reproductive performance.

Protein and amino acid inclusion levels of the pullet starter, developer, pre-breeder and breeder feeds have been investigated in a number of laboratories. Results become difficult to interpret because feed intake varies and this results in differing protein intakes even when similar dietary crude protein levels are fed. Reproductive performance enhancements have been noted when increased protein levels were fed throughout the rearing period in quail (Lilburn et al., 1992) or during the prelay period in broiler breeders (Brake et al., 1985, Cave, 1984, Lilburn and Myers-Miller, 1990). Trials by Walsh and Brake (1997) indicated that breeder female fertility was increased if protein intakes to 20 weeks of age were increased.
Recent broiler breeder research at Auburn University has explored the influence of early protein nutrition on body composition and reproductive performance. Pullets were fed isoenergetic starter diets with 120, 160 and 200 g crude protein/kg to six weeks of age. Amino acid densities were scaled to the protein levels. Protein intakes to six weeks were 177 g, 231 g and 278 g for the 120, 160 and 200 g crude protein/kg treatments, respectively. Breast meat growth was enhanced by dietary crude protein intake while carcass fat was reduced. This relationship was supported by internal research conducted at Oklahoma State University which indicated higher early crude protein intake increases lean tissue accretion, skeletal mass and flock uniformity. Egg production increased with increases in starter protein levels such that cumulative and settable egg production to 31 weeks was greatest in the 200 g crude protein/kg group. Promoting optimal growth during the first few weeks of a chick’s life appeared to positively influence hen performance. This may relate to the concept of nutritional programming discussed recently by a number of groups (Knight and Dibner, 1998; Giesen, 1998).

In a second study conducted at Auburn University, early crude protein intake benefits were assessed by measuring egg production through 65 weeks of age. Similar body composition trends were noted as in the first experiment. The study is still ongoing but pullets fed higher crude protein levels early came into production slightly earlier and maintained a higher level of egg production through 45 weeks. Although final results have not been analyzed it appears that hens fed 180 g of crude protein to four weeks of age were substantially ahead of those fed 140 g during the same period. A relatively small increase in total protein intake appears to have a positive influence on egg production through peak lay and beyond.

IV. CARCASS COMPOSITION

Future research will also be directed not only towards early protein intake but also to establishing relationships between optimal body composition, body weight programs and subsequent breeder performance. University studies have been conducted and corroborated by field data which indicate that there are critical periods during pullet rearing where growth rate needs to be enhanced for better hen performance. In effect these observations indicated that the shape of the pullet body weight curve has an effect on hen performance. Rearing recommendations will be modified in the future once a greater understanding of the bird’s needs are reached.

A broiler breeder study conducted at Oklahoma State University was designed to examine feeding curve (linear, sigmoid), starter composition (protein level) and overall program effects on hen live weight, live weight variability, change in body composition (lean, fat, bone mass), and egg production. Further, the relationships between body composition, egg production, egg weight and bird mortality were also extensively modeled. Chicks consuming higher amounts of crude protein had increased muscle and skeletal tissue accretion and better flock uniformity. In this study a number of correlations were also evident. Bird lean gain from 12 to 16 weeks of age was positively correlated with egg production to 32 week of age. The correlation of lean gain from 28 to 32 weeks of age was negatively correlated with egg production at 32 weeks of age. After week 20 it appears that hen performance is negatively affected when birds are both gaining weight and producing eggs. This supports recommendations that once light stimulation is initiated the flock must be at the correct body weight and have the ideal body composition.
V. CONCLUSION

Rearing broiler breeders for optimum chick production and quality can be a complex enterprise. As broiler breeder nutrition and feeding guidelines are established they must be constantly updated as the genetic packages and management styles change. Nutrient intake during the replacement phase can and does influence a number of important factors involved in lay. However, final chick numbers are so far removed from the rearing program that correlations between them are difficult. Research must be conducted in such a way that bird requirements are elucidated and modeled. Proper body composition will require more thought and understanding of the bird's development (fleshing) from feeding programs and nutrient consumption. Nutrient consumption will likely be fundamental to addressing the issue of proper pullet growth and optimum carcass composition.

REFERENCES