Animal Feed Science and Technology xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

Key principles concerning dietary amino acid responses in broilers

M.T. Kidd [a,*], P.B. Tillman [b]

[a] Center of Excellence for Poultry Science, Division of Agriculture, University of Arkansas System, Fayetteville, AR 72701, USA
[b] Poultry Technical Nutrition Services LLC, Buford, GA, USA

ARTICLE INFO

Article history:
Received 24 December 2015
Received in revised form 20 May 2016
Accepted 24 May 2016
Available online xxx

Keywords:
Amino acids
Experimental design
Ideal protein
Lysine
Glycine

ABSTRACT

Poultry meat and eggs are poised to play a greater role than present, in global food security in the coming years, as the preferred and primary protein source. Efficient production requires precision, of which dietary amino acids are central. As primary poultry breeders continue to provide broiler strains that have improved annual growth, health, and muscle accretion with lower feed intake, nutritionists should continue to assess digestible Lys needs and subsequent ratios of essential amino acids to digestible Lys. This review provides practical experimental design considerations for amino acid researchers and recent work for benchmarking nutrient matrices.

1. Introduction

The economic viability of poultry production is dependent upon sourcing high quality feed ingredients, having knowledge of their amino acid composition, and formulating a diet that supports the birds' maintenance and productive functions. The international standardization of amino acid analyses in feed ingredients (Fontaine, 2003), coupled with a better understanding of amino acid digestibility coefficients in feed ingredients, has led to more precise dietary formulations that closely meet the birds' needs. Selective breeding of primary parent stock, however, results in consistent-yearly productive improvements, and coupled with changes in poultry company economic targets, renders an annual evaluation of the flocks dietary amino acid needs for formulation adjustments over the life of the bird necessary. But most poultry companies, as well as universities, are limited in broiler or turkey floor pen research facilities, and are usually greatly limited in egg production research facilities. Moreover, poultry company floor pen research availability dictates evaluating numerous commercially available feed additives to assess novel efficiencies. It is important for university and contract research facilities to continue to assess amino acid needs of commercial poultry. The impact of amino acid minimums for precision feeding versus amino acid overages, which results in increased nitrogen excretion, should not be underestimated as the balance depends upon bird strain, environmental setting, and the companies production function optimization, which should include a consideration of economics.

The ideal protein concept is a good tool to calculate amino acids needs in modern broiler strains. As modern commercial broiler performance varies around the world due to variance in production environments, an understanding of dietary lysine

Abbreviations: TSAA, total sulfur amino acids.

* Corresponding author.
E-mail address: mkidd@uark.edu (M.T. Kidd).

http://dx.doi.org/10.1016/j.anifeedsci.2016.05.012
0377-8401/

needs, and an elucidation of dietary amino acid needs where data is lacking (e.g., Gly), is warranted. This review provides methodological considerations, in an applied nature, for floor pen broiler research and an overview of current amino acid needs relative to Lys for broilers, recent knowledge of Gly + Ser, and the economic impact of precision amino acid formulation.

2. Considerations in amino acid research

It is noted in the title of this manuscript that the term "response" is used to define amino acid need rather than the term "requirement". Indeed amino acid dose response studies can quantify requirements for a specific biological function (e.g., growth rate, feed conversion, or breast meat yield), but the commercial nutritionist can only input one number in least cost formulation; deeming "true requirements" as an economic input rather than physiological function. The most recent work assessing amino acid needs, with reference to the section herein, has focused more on an applied nature rather than of basic science. One issue encountered by nutritional scientists embarking on amino acid dose studies in the 1980s and 1990s was peer review criticism for lack of creativity in the experimental design (Baker, 1986). The importance of amino acid minimums in linear programing for rapidly growing "modern" broilers is well known, and as a current result, the more applied dose response has merit because it provides a set of response projections that commercial nutritionists can use to compare to their minimums. Currently, the most glaring issue with dose response work is consistency and repeatability, as numerous authors have published manuscripts whereby only one experiment, or a few minimally replicated experiments, are conducted. Indeed, the global number of university and contract research facilities for applied amino acid nutritional studies is limited. It is our hope that as universities in developing countries increase investment in poultry research and teaching, that the construction of integrated research facilities follows suit. Moreover, as poultry centers, institutes, clusters, and departments in the developing areas of the world are formed, their link to industry via applied research will be instrumental in their success. This section provides considerations for floor pen research studies with specific reference to industry applicability.

2.1. Genetic strain

Plavnik and Hurwitz (1982) assessed amino acid needs per therm in chickens varying in strain and gender. Amino acid needs per metabolizable energy as assessed from body weight gain and whole body composition were highest in the broiler-type males and lowest in the leghorn-type females (Plavnik and Hurwitz, 1982). As primary breeder companies continue to increase efficiency, growth rate, and health of commercial broilers, amino acid diet density must be adjusted to optimize body weight to age ratio. Moreover, modern broilers are not only more efficient, but have improved carcass quality as it has been demonstrated that broilers selected for low body fat have heightened weight gain concomitant with increased efficiency (Whitehead and Parks, 1988). Dietary amino acid needs must be assessed as the efficiency and increased growth rate, which is higher in proportion to whole body protein, in modern commercial broilers is improved. For example, a greater body weight gain and improved protein:fat ratio in fast versus slow growing broilers results in higher dietary lysine needs (Han and Baker, 1993).

Market weights of commercial broilers in the U.S. in 1960, 1970, and 1980 were 1.52, 1.64, and 1.78 kg, respectively (National Chicken Council, 2015). Although market weights of commercial broilers were increasing during the former time, the efficiency of feed utilization surpassed growth resulting in feed conversion ratios of 2.50, 2.25, and 2.05 in 1960, 1970, and 1980, respectively (National Chicken Council, 2015). With increased market weights in birds coupled with the improvement in feed conversion, researchers noted that dietary amino acid needs must be increased to adjust for the decrease in feed consumed. Thus, it was hypothesized that dietary amino acids needs may be higher in birds with improved whole body protein to whole body fat ratios.

Acar et al. (1991) evaluated lysine responses from six to eight weeks of age in Ross x Ross versus Peterson x Arbor Acres broilers. Strain x lysine interactions occurred demonstrating that Ross broilers responded to lysine for breast meat yield, but not Peterson x Arbor Acres broilers, and the lysine level that supported breast meat yield was higher than that of optimal growth responses in both strains (Acar et al., 1991). In the subsequent year, a comprehensive study in the same laboratory (Bilgili et al., 1992) utilized eight commercial broiler strains fed diets differing in lysine during the finishing period (42–53 days of age). This work showed that optimum lysine needs for breast meat yield are higher than growth performance, and this response, similar to the work of Acar et al. (1991), is dependent upon strain Bilgili et al., 1992. In an 8–22 day of age evaluation on broiler chick growth performance, Han and Baker (1993) noted that heavy broilers responded to higher lysine than light broilers for feed efficiency, but not for maximal growth. Moran (1994) evaluated methionine responses in commercially available broilers differing in lean and fat composition throughout the growing period and noted more negative effects in the lean broiler line due to methionine marginality, which was in agreement with previous work (Leclercq et al., 1993). Kidd et al. (2004) evaluated dietary threonine responses in three commercial strains differing in growth rate, but of similar genetic makeup and breeder hen age. Strain differences to dietary threonine only occurred for feed conversion with the high yield strain with low intake responding more poorly to low dietary threonine, but other threonine responses did not differ from 21 to 42 days of age resulting in a digestible threonine/lysine estimate of 0.68 across strains (Kidd et al., 2004). Although the broiler genetic makeup and market needs tend to dictate amino acid need differences, the former work strengthens the importance of the ideal protein concept for expressing essential amino acid needs relative to lysine. Therefore, it is vital lysine needs are assessed yearly as strains become more efficient.

Please cite this article in press as: Kidd, M.T., Tillman, P.B., Key principles concerning dietary amino acid responses in broilers. Anim. Feed Sci. Tech. (2016), http://dx.doi.org/10.1016/j.anifeedsci.2016.05.012