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Lowering the dietary protein levels by the use of synthetic amino acids and the use of a mono component protease

S.L. Vieira*, C. Stefanello, H.S. Cemin

Departamento de Zootecnia, Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves, 7712, Porto Alegre, RS, 91540-000, Brazil

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ABSTRACT

Responses of broilers to dietary amino acids (AA) have been extensively studied especially after their synthetic and crystalline forms became available. Synthetic (DL-Met and Met analogue) as well as crystalline (L-Lys and L-Thr) AA are now widely used in commercial production diets to reduce crude protein (CP) levels to allow competitive bird performance. In parallel, birds diets formulated without excess CP have reduced nitrogen excretion as well as lower costs. Diet composition affects the order of limiting AA after Thr and this has led to some debate on the feasibility of including the next limiting AA, which would be the fourth, in most of the scenarios. Using maize-soy type diets, the literature suggests that Val is the fourth AA limiting. As the commercial cost of L-Val is progressively reduced, concerns have been raised on the effectiveness of its supplementation to produce broiler responses that are similar compared with feed that does not contain this AA. Antagonisms between branched-chain amino acids (BCAA) have been reported in the past; however, their use in the current maize-soy diet commercial setting is unlikely. Formulation of diets with crystalline L-Val can potentially modify the ratio between BCAA as it is supplemented in diets that are further reduced in CP. Increased availability of AA can also be achieved when diets are supplemented with exogenous proteases; however, the resulting impact in the total profile of AA is different because a wider group of AA becomes simultaneously available when compared to diets receiving addition of synthetic/crystalline AA one by one. A scenario of CP reduction in diets seems clear with the increasing use of supplemental AA along with protease in broiler diets. The knowledge of CP reduction strategies, such as protease and synthetic AA supplementation, can be a valuable asset due to the competitive nature of broiler meat production business.

1. Introduction

Protein is a costly nutrient in poultry feeds. Broiler diets are usually formulated using linear least cost software frequently setting a minimum concentration of crude protein (CP) in a strategy to have minimum levels of indispensable and dispensable AA intakes so that performance is not limited. The increasing cost of feed ingredients and the competition with the biofuel industry indicates a scenario of increased costs for plant-based ingredients in the future. Additionally, the composition of AA in the diets is variable according to ingredient inclusion; different protein sources (plant or animal), and inclusion of

Abbreviations: BCAA, branched-chain amino acids; CP, crude protein; Cys, cysteine; d, days; dig., digestible; PROT, protease unit.

* Corresponding author.
E-mail address: slvieira@ufrgs.br (S.L. Vieira).

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synthetic and crystalline AA. The main commercially available supplemental AA sources used in poultry diets are L-Lysine (L-Lys), DL-Methionine (DL-Met) or Methionine analogues (Met-ana), and L-Threonine (L-Thr). These are usually included in diets as digestible (dig.) AA maintaining ratios to dig. lysine (Lys) to satisfy the ideal protein concept (Baker and Han, 1994).

2. Provision of protein sources

Formulating diets with a reduced CP level is possible with the use of supplemental AA if commercially available at competitive prices. Using the ideal protein concept also allows for a greater precision in formulation and ensures that a balanced AA profile is formulated to optimise growth performance and breast meat yields. This formulating approach has been increasing among nutritionists and targets the reduction in imbalances between the limiting AA and other dietary AA (Vieira and Angel, 2012). Nutritionists also have to consider the opportunities for commercial use of crystalline valine (L-Val) and isoleucine (L-Ile), which can further reduce minimum dietary CP, as these are fourth- and fifth-limiting AA added to maize-soy diets (Corzo et al., 2007; Berres et al., 2010). Higher inclusion of maize protein will translate to increase in dietary leucine content of the diet. Depending on the restrictions used to formulate the diets, this may lead to a change in the ratio between the 3 branched-chain amino acids (BCAA). Some formulation strategies have been used to reduce feed costs, however they may not maintain performance within expected parameters when further reductions in CP are applied.

Feeds formulated with reduced CP are less expensive; however, it may limit broiler protein accretion, negatively influencing profitability, especially regarding the broiler breast meat market (Vieira et al., 2004; Dozier et al., 2008). Constant increases in feed ingredient costs, especially protein meals (e.g. soybean meal), that are not accompanied by increases in the market price of meat is a primary driver of feed formulations.

The ideal protein concept has gained importance as a method to supply balanced protein in feeds for broilers. This approach attempts to reduce the amount of absorbed AA that are in relative excess to Lys, thus avoiding excess oxidation, decreasing metabolic costs, and improving AA balance (Lemme, 2003; Vieira and Angel, 2012). Diets formulated using this principle have been proposed to optimise animal utilisation of dietary protein (Emmert and Baker, 1997; Baker et al., 2002; Coneglian et al., 2010; Corzo et al., 2010).

The three first limiting AA in maize-soy diets, methionine (Met), Lys and threonine (Thr), are well established. Some recent studies have focused on determining the fourth- and fifth-limiting AA for broilers; however this can be variable according to the ingredients used in commercial feed formulation (Corzo et al., 2007; Berres et al., 2010; Miranda et al., 2015). Concentrations of AA, ratios among indispensable AA to Lys as well as expression of AA on a total or digestible basis are also important sources of variation that hinder comparisons among studies that evaluate feeding programs varying in AA density. Many researchers and nutritionists consider feed formulations using digestible AA to be the best way to measure the AA value of ingredients. Reductions in CP with adoption of the dig. AA concept should greatly reduce feed cost and N excretion. Further benefits of formulating on a dig. AA basis include decreasing safety margins; increasing performance prediction accuracy as well as increasing broiler carcass and commercial cuts size uniformity (Vieira and Angel, 2012).

Major differences exist among the formulation approaches that nutritionists take to formulate dietary protein in feeds (Vieira and Angel, 2012). Some of these differences are related to whether AA requirements are expressed as total or dig., which becomes more important as the diet complexity increases in terms of ingredient composition. All-vegetable diets with maize and soybean meal or diets with poultry by-products have different AA composition as a result of the ingredient source and the respective inclusion and profile. As AA follow in the limiting order of deficiency, the fourth-limiting AA becomes more sensitive to the overall allowances of AA in macro ingredients. However, actual deficiencies of the fourth-limiting AA in broiler diets are not frequently seen in practical production, even when frequent modifications in feed formulation change the dietary AA profile. This is due to CP safety margins adopted during linear least-cost feed formulation, which limits the occurrence of AA deficiencies after Thr.

Profile of AA and order of limitation are directly related to CP levels, ingredients, and their respective inclusion in feed formulation programs, as shown in Table 1. Formulating diets with commercially-available sources of Lys, Met, and Thr allows for significant CP reduction. The extent to which CP levels can be reduced is determined by the requirement of the next limiting AA, which in turn varies according to available ingredients. In high CP diets, there is an evident surplus of AA; as CP is reduced, AA-to-Lys ratios are improved and thereby excretion costs for those not involved in protein synthesis and feed costs are reduced. Valine is clearly the limiting AA after Thr in all-vegetable diets, whereas Ile becomes the fourth co-limiting AA with Val when formulating with animal by-products. Miranda et al. (2015) demonstrated that supplementing diets with commercially-available L-Val and L-Ile resulted in growth performance and meat yield of broilers similar to those obtained with diets having comparable dig. Val and Ile levels derived from non-synthetic AA sources, which allowed for a reduction in the inclusion of soybean meal and other protein feedstuffs in the diets. Data on the use of these two AA sources have increased recently; however, practical implementation is difficult because feed formulation for broilers differs widely around the world.

Antagonism between BCAA in broilers has long been known (Burnham et al., 1992). The first two steps in the catabolism of these AA involve the same enzymes: BCAA aminotransferase and branched-chain α-keto acid dehydrogenase. The latter is highly regulated in a dose-response manner by Leu α-keto acid; moreover, Val and Ile have little or no effect on the regulation of BCAA catabolism (Wiltafsky et al., 2010). Disproportionate dietary Leu creates a decline in feed intake, which may be accountable for most of the growth-depressing effects of BCAA antagonism. Thus, it is suggested that feed formulations use

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