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Review Article

Threonine - Lysine ratio and its effect on broiler Performance

Talha E. Abbas*

Department of Animal Production, Faculty of Agricultural Technology and Fish Science,
University of ALneelain, Khartoum, Sudan. P.O. Box: 12702.
*Corresponding author: *talhabbs@yahoo.com*

Abstract

Researchers keep striving so as to reach cheapest and optimum ration formulation that lead to better broilers performance and carcass characteristics. Feed represents about 70-80% of the cost of broiler meat production. Protein is considered as the most expensive ingredient in the formulated feed for broilers. Recently the concept of the use of high quality protein in feed formulated for broilers has been adopted. High quality protein, mainly, means protein with an adequate amount and an appropriate balance of essential amino acids. The most important essential amino acids in poultry diets are methionine, lysine and threonine. They also are known as first, second and third or fourth limiting amino acid, respectively. Till now some nutritionist formulating broilers feed on basis of crude protein, and that might make broilers diet to contain level of amino acids higher than required, and hence increase the cost of feed. Recently synthetic amino acids become available and that help in reducing the level of crude protein in broilers diet. As it is commonly known, deficiency or excess of essential amino acids in broilers diet will affect the performance, growth, collagen, elastin and mucin formation, bones, gut function and immunity. Threonine also, entered in important metabolic processes like uric acid formation, protein synthesis and pancreatic enzyme resynthesis. Researchers also reported that, imbalance of essential amino acids will also affect broilers performance because some of these amino acids interact with each other.

Keywords: Limiting amino acids, amino acid imbalance, interaction, performance, immunity.

Introduction

The concern of reducing crude protein in the broilers diet emerges so as to achieve two goals, one of which is to decrease nitrogen pollution and safe the environment (Relandeau andLe Bellego, 2004). The other one is to diminish the cost of broiler meat production(Kidd and Kerr, 1996). Availability of synthetic amino acids such as lysine, methionine and threonine made that possible, and now they are being used in broilers diet to meet their amino acids requirements to achieve better performance(Araújo et al., 2004). National Research Council recommended levels of essential amino acids (NRC, 1994) that should be supplied to the broilers diet so as to obtain better performance, but these levels were mainly examined in thermoneutral environment. Therefore in tropical environment the effect of higher temperature should be considered when formulated diet containing recommended levels of amino acids for broilers, because some researches noticed that higher temperature produces an effect on amino acids functions either by affect their digestibility (Larbier et al., 1993) or by reducing feed consumption (Akyuz, 2009). Another point should also be considered when formulated broilers diet which is the amino acids balance because it has been reported that essential amino acids imbalance will lower the level of the most limiting amino acid in plasma and reduce feed consumption and growth rate and finally death may occur(Park,2006). Interaction of threonine with lysine is an example of limiting amino acids interaction

(Kidd et al., 1997$_a$). Gong et al.,(2005) noticed that lysine level in broiler diet affect threonine need for optimum performance.

The objective of this review is to discuss threonine-lysine ratio and its effect on broiler performance and carcass characteristics.

Amino acids requirements of broilers

Amino acids are the backbone of proteins. Their requirements affected by different factors such as dietary factors like metabolizable energy concentration and amino acids imbalance. Other factors include environmental temperature, immunological stress, sex, age and species (D'Mello, 2003). As cited by Oviedo-Rondón and Waldroup,(2002) till now, the accurate ratio of dietary amino acids that lead to optimum performance cannot be specified, although digestibility of each amino acid was determined. This attributed to some factors, firstly it has been reported that growth doesn't respond linearly to various levels of dietary amino acids (Phillips,1981). Secondly, it attributed to amino acids imbalance (D'Mello, 2003). Finally, it may be due to the presence of antinutritional factors which may adversely affect amino acids digestibility (Gilani et al., 2005).There are different ways to express amino acids requirements, either as a proportion of diet (g/ kg diet) or as a rate to crude protein in the diet (D'Mello, 2003).

Amino acids imbalance

Essential amino acids imbalance is the consequence of limiting amino acids interaction when supplied broilers with diet deficient in one or more limiting amino acid and excess in other limiting amino acid (Harper,1956). Amino acids imbalance should be differentiated from amino acids deficiency. In the former case either the decrease in supplemented amino acid or the addition of limiting one will cure the condition, whereas, only the addition of limiting amino acid will overcome the latter case (Gietzen,1993). As reported by (Park,2006) amino acids imbalance will lower the level of the most limiting amino acids in plasma. This occurs as a result of increase in protein synthesis in the liver (Benevenga et al., 1968;Ip and Harper,1974). Esteve-Garcia (1984) disagreed with this pretention. The author reported unchanged in net liver protein concentration in spite of acceleration of liver protein synthesis according to isoleucine imbalance. Decrease in feed intake when imbalance amino acid diet was offered interpreted to lower level of limiting amino acid in the brain. This happens due to contention between imbalanced amino acid and unbalancing amino acid for transferring from blood to brain leading to behavioral reaction (Gietzen,1993).

Threonine requirements for broilers

Threonine importance for broilers performance, intestinal health and immunity

Recently, threonine is considered as the third or fourth limiting amino acid in most feedstuffs of plant sources for poultry. It is also considered as one of the important factors that affect poultry performance due to increase in the use of lysine and methionine in broilers diet (Gong et al.,2005). Direct influence of threonine on feeding strategies of young chicks was reported (Wils-Plotz and Dilger,2013). The authors found that threonine and fiber concentration produce obvious effect on growth performance, intestinal health and mucin discharge. Rezeipour et al., (2012) exhibited that supplementation of threonine to broiler diets improve feed efficiency, weight gain and intestinal morphology by increasing crypt depth and villi height and width of ileum and jejunum. Authors also, observed that addition of threonine to broiler diets increases antibody titer against Newcastle disease at 42 day of age. Findings of Maroufyan et al.,(2010) are in line with those mentioned above. Researchers noticed that use of methionine and threonine in broiler diets above NRC recommendations considered as a better nutritional strategy to overcome unfavorable stress conditions by improving immune cells in tropical area. In addition, Moghaddam and Emadi,(2014) assured these findings, authors concluded that dietary threonine and vitamin A improve broilers immune response. Corzo et al.,(2007) attributed increase in threonine requirements for broilers raised in built-up litter environments to microbial challenges, because threonine involved in mucin formation and mucin control microbial communities and nutrient availability in the gut. Kidd et al.,(1997$_a$) disagrees with these findings. Authors failed to observe immunity improvement as a result of application of lysine and threonine.

Factors affect threonine requirements for broilers

As mentioned in amino acids, several factors affect threonine requirements for broilers such as age, crude

protein and main ingredients of the diet (Barkley and Wallis, 2001_a;Barkley and Wallis, 2001_b) featheringrate(Dozier et al., 2000)environmental condition (dirty or clean) (Kidd et al.,2003;Corzo et al., 2007) gut health (Zaghari et al.,2011) genetic differences (Rosa et al.,2001) sex(Dozier et al.,2001_a; Dozier et al.,2001_b).

Barkley and Wallis,(2001_a)derived a model by analyzing data of threonine requirements for broilers published between 1985 and 1998 to detect the factors affecting them. The model exhibited that age of broilers and crude protein content of the diet are the main factors affecting threonine needs for broilers. Barkley and Wallis,(2001_b)tested the above model by determining threonine requirements of male broilers at different ages (7-21 day and 21-42 day) offered diets with different levels of threonine (0.0, 0.56, 1.0, 1.55 and 2.0 g/kg) and crude protein (207 and 196 g/kg). Authors found that the experiment confirmed results obtained by the model that derived from the analysis of published data. Effect of feathering rate has been declared by Dozier et al.,(2000) by comparing response of fast-feathered male broilers against slow-feathered male broilers to threonine supplementation. Authors found threonine supplementation enhanced growth rate of fast-feathered broilers rather than slow-feathered broilers. Influence of broilers genotype on threonine requirements assured by Rosa et al.,(2001). Authors studied effects of different levels of threonine of three commercial strains (Hy-Line W-36, High Yield Arbor Acres and Classic Yield Arbor Acres). Results obtained were that for Classic and High Yield Arbor Acres threonine needs are very similar but for Hy-Line W-36 threonine needs are very low. Dozier et al.,(2001_a)observed the impact of sex on threonine requirements when studied responses of male and female broilers to graded concentrations of threonine from 42 to 56 days of age. Authors noticed that 0.74% of threonine is suitable for male broilers to get better growth rate and feed efficiency and 0.63% is proper for females. This effect of sex on threonine requirements was assured by Dozier et al.,(2001_b)when examined reaction of male and female broilers to adequate and deficient dietary threonine on nitrogen and energy recovery. Authors stated that males fed on adequate dietary threonine performed well in retention of nitrogen and recovery of energy when compare to those fed on deficient dietary threonine while females showed similar response to deficient and adequate threonine on nitrogen utilization. Effect of environmental temperature on threonine requirements was searched by Shan et al., (2003). Authors carried out experiment in which broilers raised at two different environmental temperatures (25° C and 35° C) and fed different levels of threonine. Authors reported that threonine needs for broiler chicks (7-21 day) at 25° C and 35° C are similar.

Threonine requirements for male broilers and female broilers have been reported to lie within range from 0.68 to 0.79% and 0.58 to 0.75% of the diet, respectively. Its requirement increased when crude protein in the diet increases to remove addition nitrogen (Kidd and Kerr, 1996). Zaghari et al.,(2011) declared that, during starter period (0-21 day) threonine requirements for broilers body weight gain at high crude protein diets are higher than its requirement at low crude protein diets. Opposite to this finding Çiftci and Ceylan,(2004) found at low crude protein diets threonine requirements are higher. It was observed that, supplementation of threonine to diet with lower protein content resulted in growth performance equal to that obtained by diet with recommended crude protein (Kidd et al., 1997_b). The author examined the effect of addition of 0.1% L-threonine to the diet containing 84% of NRC crude protein on growth performance of large white toms against diet containing 100% NRC crude protein. On the other hand, Ospina-Rojas et al.,(2014_b) found feeding broiler chickens vegetable-based diets with a 3% decrease in crude protein during starter period required supplying the diets with valine and glycine in addition to methionine, lysine and threonine to overcome negative effects on the performance and serum parameters. During grower period supplying with valine, isoleucine, arginine and glycine needed in addition to methionine, lysine and threonine to restore adverse effects on the performance of broiler chickens.Furthermore, Kidd,(2000) reported that, supplementation of lower level of digestible threonine negatively affected performance, efficiency of sulfur containing amino acids and utilization of digestible lysine.

Threonine-lysine ratio and Interaction

Recently, all essential amino acids are introduced into broilers diet as a ratio to lysine, according to this strategy diet costs and nitrogen release are reduced (Emmert and Baker,1997). Some researches stated the

adequate digestible threonine to lysine ratio for better performance. Baker et al.,(2002) stated that digestible Threonine to digestible lysine (dThr:dLys) ratio of 0.56 is suitable to maximize body weight of chick broilers from 8 to 21 day of age. Recently, it has been reported that from 3 to 16 day of age of male broiler optimum dThr:dLys ratio for better body weight gain and feed conversion ratio are 0.70 and 0.66 respectively (Mehri et al.,2012). Authors attributed different results to different methods of statistical analysis. In recent research response surface design was used while in the other research linear broken-line regression was used. In addition, different basal diets, experimental conditions or genetics suggested as the cause of different findings. Kidd et al., (2004) found 0.68 dThr:dLys ratio is adequate for better weight gain and breast meat weight of broilers from 21 to 42 day of age. These findings are greater than findings obtained by Mack et al.,(1999) who found that better body weight gain of male broilers achieved at 0.63 dThr:dLys ratio during growing period (20-40 day). In addition, Corzo et al.,(2009) recommended 0.69 as digestible threonine to lysine ratio for better body weight gain and 0.70 for improved feed conversion ratio of female broilers from 14 to 28 day of age. Mejia et al.,(2012) aimed to determine simultaneously dietary requirements of lysine and threonine for male broilers from 35 to 49 day of age. The authors found for maximizing body weight true digestible threonine to lysine ratio of 0.66 is suitable, and for feed consumption, feed conversion and breast meat weight true digestible threonine of 0.67, 0.72 and 0.74, respectively are optimum. Furthermore, Ospina-Rojas et al.,(2014_a) recommended that, at low protein diets, digestible lysine of 1.005% and Thr:Lys ratio of 0.57 are adequate for maximum performance and carcass production of broilers during growth period (22-42 day). These findings are in line with findings ofCorzo et al.,(2009) who noticed that threonine requirements for better weight gain increase with increased crude protein and decrease with its reduction. On the other hand current results disagree with Çiftci and Ceylan,(2004) who mentioned in low crude protein diets higher threonine level required for optimum body weight gain. During subclinical intestinal clostridium infection (*C. perfringens*) Star et al.,(2012) observed that higher levels of dThr:dLys (0.67-0.70) increase body weight gain and feed intake.

Lysine-threonine interaction has been reported by Kidd et al.,(1997_b) from 18 to 54 day of age of broilers fed 100% lysine and 83% threonine of NRC or 105% lysine and 100% threonine of NRC leading to enhance weight gain and breast yield.

Conclusion

Although It was observed that, optimum ratio of threonine to lysine for better performance is differ according to statistical analysis method, breed, age, sex of birds, basal diets and to environmental conditions, we can concluded:

- From 3 to 16 day of age of male broiler optimum dThr:dLys ratio for better body weight gain and feed conversion ratio are 0.70 and 0.66 respectively.
- dThr:dLys ratio of 0.68 is adequate for better performance and carcass yields of broilers from 21 to 42 day of age.
- At low protein diets, digestible lysine of 1.005% and Thr:Lys ratio of 0.57 are adequate for maximum performance and carcass production of broilers during growth period (22-42 day).
- From 14 to 28 day of age of female broiler 0.69 dThr:dLys is optimum for better body weight gain and 0.70 for improved feed conversion ratio.
- During subclinical intestinal clostridium infection (*C. perfringens*) higher levels of dThr:dLys (0.67-0.70) improve growth performance.

References

Akyuz A. 2009. Effects of some climates parameters of environmentally uncontrollable broiler houses on broiler performance. J. Anim. Vet. Adv. 8: 2608-2612.

Araújo, L. F., O. M. Junqueira, C. S. S. Araújo, D. E. Faria and Andreotti, M. O. 2004. Different criteria of feed formulation for broilers aged 43 to 49 days. Braz. J. Poult. Sci. 6: 61-64.

Baker, D. H., A. B. Batal, T. M. Parr, N. R. Augspurger and Parsons, C. M. 2002. Ideal ratio (relative to lysine) of tryptophan, threonine, isoleucine, and valine for chicks during the second and third weeks posthatch. Poult. Sci. 81: 485-494.

Barkley, G. R. and Wallis, I. R. 2001_a. Threonine requirements of broiler chickens: why do published values differ? Br. Poult. Sci. 42: 610-615.

Barkley, G. R. and Wallis, I. R. 2001_b. Threonine requirements of broiler chickens: an experimental validation of a model using growth responses and carcass analysis. Br. Poult. Sci. 42: 616-624.

Benevenga, N. J., A. E. Harper and Rogers, Q. R. 1968. Effect of an amino acid imbalance on the metabolism of the most-limiting amino acid in the rat. J. Nutr. 95: 434-444.

Çiftci,İ. and Ceylan, N. 2004. Effects of dietary threonine and crude protein on growth performance, carcass and meat composition of broiler chickens. Br. Poult. Sci. 45: 280-289.

Corzo, A., M. T. Kidd, W. A. Dozier III, G. T. Pharr and Koutsos, E. A. 2007. Dietary threonine needs for growth and immunity of broilers raised under different litter conditions. J. Appl. Poult. Res. 16: 574-582.

Corzo, A., W. A. Dozier III, R. E. Loar II, M. T. Kidd and Tillman, P. B. 2009. Assessing the threonine-to-lysine ratio of female broilers from 14 to 28 days of age. J. Appl. Poult. Res. 18: 237-243.

D'Mello, J. P. F.2003. Amino Acids in Animal Nutrition. 2nd ed. Wallingford, Oxon, UK:CAB International. Pp. 237-257.

Dozier III, W. A., E. T. Moran Jr and Kidd, M. T. 2000. Responses of fast- and slow-feathering male broilers to dietary threonine during 42 to 56 days of age. J. Appl. Poult. Res. 9: 460-467.

Dozier III, W. A., E. T. Moran Jr and Kidd, M. T. 2001_a. Comparisons of male and female broilers responses to dietary threonine from 42 to 56 days of age. J. Appl. Poult. Res. 10: 53-59.

Dozier III, W. A., E. T. Moran Jr and Kidd, M. T. 2001_b. Male and female broiler responses to low and adequate dietary threonine on nitrogen and energy balance. Poult. Sci. 80: 926-930.

Emmert, J. L. and Baker, D. H. 1997. Use of the ideal protein concept for precision formulation of amino acid levels in broiler diets. J. Appl. Poult. Res. 6: 462-470.

Esteve-Garcia,E. 1984. Protein and amino acid metabolism in an isoleucine imbalance. Master Thesis. Cornell University, Ithaca, NY.

Gietzen, D. W. 1993. Neural mechanisms in the responses to amino acid deficiency. J. Nutr. 123: 610-625.

Gilani, G. S., K. A. Cockell and Sepehr, E. 2005. Effects of antinutritional factors on protein digestibility and amino acid availability in foods. J. AOAC Inter. 88: 967-987.

Gong, L. M., C. H. Lai,S. Y. Qiao,D. Li,Y. X. Ma and Liu, Y. L. 2005. Growth performance, carcass characteristics, nutrient digestibility and serum biochemical parameters of broilers fed low-protein diets supplemented with various ratios of threonine to lysine. Asia-Aust. J. Anim. Sci. 18: 1164-1170.

Harper, A. E. 1956. Amino acid imbalances, toxicities and antagonisms. Nutr. Rev. 14: 225-227. Cited in: Park, B. C. 2006. Amino acid imbalance-biochemical mechanism and nutritional aspects. Asia-Aust. J. Anim. Sci.19: 1361-1368.

Ip, C. C. Y. and Harper, A. E. 1974. Liver polysome profiles and protein synthesis in rats fedα threonine-imbalanced diet. J. Nutr. 104: 252-263.

Kidd, M. T. 2000. Nutritional considerations concerning threonine in broilers. World Poult. Sci. J. 56: 139-151(Abstract).

Kidd, M.T. and Kerr, B. J. 1996. L-Threonine for poultry: A review. J. Appl. Poult. Res. 5: 358-367.

Kidd, M. T., B. J. Kerr and Anthony, N. B. 1997_a. Dietary interactions between lysine and threonine in broilers. Poult. Sci. 76: 608-614.

Kidd, M. T., B. J. Kerr,J. A. England and Waldroup, P. W. 1997_b. Performance and carcass composition of large white toms as affected by dietary crude protein and threonine supplements. Poult. Sci. 76: 1392-1397.

Kidd, M. T., A. Corzo, D. Hoehler, B. J. Kerr, S. J. Barber and Branton, S. L. 2004. Threonine needs of broiler chickens with different growth rates. Poult. Sci. 83: 1368-1375.

Kidd, M. T., S. J. Barber, W. S. Virden, W. A. Dozier III, D. W. Chamblee and Wiernusz, C. 2003. Threonine responses of Cobb male finishing broilers in differing environmental conditions. J. Appl. Poult. Res. 12: 115-123.

Larbier, Z. M., A. M. Chaqneau and Geraert, P. A. 1993. Influence of ambient temperature on true digestibility of protein and amino acids of rapeseed and soybean meals in broilers. Poult. Sci. 72: 289-295.

Mack, S., D. Bercovici, G. De Groote, B. Leclercq, M. Lippens, M. Pack, J. B. Schutte and van Cauwenberghe, S. 1999. Ideal amino acid profile and dietary lysine specification for broiler chickens of 20 to 40 days of age. Br. Poult. Sci. 40: 257-265.

Maroufyan, E., A. Kasim, S. R. Hashemi, T. C. Loh and Bejo, M. H. 2010. Responses of performance and differential leukocyte count to methionine and

threonine supplementations on broiler chickens challenged with infectious bursal disease in tropical condition. Asian J. Biol. Sci. 3: 68-76.

Mehri, M., A. A. Davarpanah and Mirzaei, H. R. 2012. Estimation of ideal ratios of methionine and threonine to lysine in starting broiler chicks using response surface methodology. Poult. Sci. 91: 771-777.

Mejia, L., P. B. Tillman, C. D. Zumwalt and Corzo, A. 2012. Assessment of the threonine-to-lysine ratio of male broilers from 35 to 49 days of age. J. Appl. Poult. Res. 21: 235-242.

Moghaddam, H. S. and Emadi, M. 2014. The Effect of threonine and vitamin A on immune system in broiler chickens. Inter. J. Adv. Biol. Biom. Res. 2: 756-763.

National Research Council. 1994. Nutrient Requirements for Poultry. 9th ed., Washington DC: National Academic Press. Pp. 27-29.

Ospina-Rojas, I. C., A. E. Murakami, C. Eyng, K. P. Picoli, C. Scapinello and Do Amaral Duarte, C. R. 2014_a. Threonine-lysine ratio on the requirements of digestible lysine in diets for broilers. Acta. Sci. Anim. Sci. 36: 157-162.

Ospina-Rojas, I. C.,A. E. Murakami, C. R. Do Amaral Duarte, C. Eyng, C. A. Lopes De Oliveira and Janeiro, V.2014_b. Valine, isoleucine, arginine and glycine supplementation of low-protein diets for broiler chickens during the starter and grower phases. Br. Poult. Sci. (to be published).

Oviedo-Rondón, E. O. and Waldroup, P. W. 2002. Models to estimate amino acids requirements for broiler chickens: A review. Inter. J. Poult. Sci. 1: 106-113.

Park, B. C. 2006. Amino acid imbalance-biochemical mechanism and nutritional aspects. Asia-Aust. J. Anim. Sci.19: 1361-1368.

Phillips, R. D. 1981. Linear and nonlinear models for measuring protein nutritional quality. J. Nutr. 111: 1058-1066.

Relandeau, C. and Le Bellego, L. 2004. Amino acid nutrition of the broiler chicken update on lysine, threonine and other amino acids. Ajinomoto Anim. Nutr. Bulletin 27.

Rezeipour, V.,H. Fononi and Irani, M. 2012. Effects of dietary L-threonine *Saccharomyces cerevisiae* on performance, intestinal morphology and immune response of broiler chickens. SA J. Anim. Sci. 42: 266-273.

Rosa, A. P., G. M. Pesti, H. M. Edwards Jr and Bakalli, R. I. 2001. Threonine requirements of different broiler genotypes. Poult. Sci. 80: 1710-1717.

Shan, A. S., K. G. Sterling, G. M. Pesti, R. I. Bakalli, J. P. Driver and Tejedor, A. A. 2003. The influence of temperature on the threonine and tryptophan requirements of young broiler chicks. Poult. Sci. 82: 1154-1162.

Star, L., M. Rovers, E. Corrent and van der Klis, J. D. 2012. Threonine requirement of broiler chickens during subclinical intestinal clostridium infection. Poult. Sci. 91: 643-652.

Wils-Plotz, E. L. and Dilger, R. N. 2013. Combined dietary effects of supplemental threonine and purified fiber on growth performance and intestinal health of young chicks. Poult. Sci. 92: 726-734.

Zaghari, M., F. Zaefarian and Shivazad, M. 2011. Standardized ileal digestible threonine requirements and its effects on performance and gut morphology of broiler chicks fed two levels of protein. J. Agr. Sci. Tech. 13: 541-552.