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Effects of Dietary Lysine on Broiler Performance and Carcass Yield – Meta-Analysis

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ABSTRACT

There has been a great evolution and improvement in the nutrition of poultry and lysine has been used the reference amino acid to increase animal protein deposition. Therefore, a meta-analysis was performed with the objective of studying the effect of different dietary lysine levels on the performance and carcass yield of broiler chickens. In total, 21 studies published in Brazil since 1999 were included. Bird performance considered daily weight gain (178 observations) and feed conversion ratio (188 observations) results. Carcass quality was evaluated relative to carcass yield (24 observations), abdominal fat (24 observations) and breast meat yield (30 observations). Data were checked for normality and were submitted to analysis of variance. Weight gain and carcass yield increased with the addition of 1.05% of lysine to the diet, whereas feed conversion ratio and abdominal fat were reduced as dietary lysine concentration increased. The results, therefore, indicate that lysine is essential in bird nutrition and significantly affects bird performance and carcass yield.

INTRODUCTION

The development of production practices that increase productivity within a short period of time has been is essential to supply the increasing demand for animal protein by the growing global population. The poultry industry is one of the most efficient sectros of the meat industry in terms of converting plants into protein products for human consumption (Moro *et al.*, 2005).

The nutritional requirements of meat-producing animals needs to be reguarly updated to allow for better production performance of modern broilers as they ardue to their continuous genetic improvement. Changes in broiler growth rate and carcass yield have been associated with the supply of amino acids, such as lysine, which is a reference amino acid to increase animal protein deposition (Trindade Neto *et al.*, 2010).

Broilers require more dietary lysine during early growth stages, lysine dietary level depends on the parameters measured, such as weight gain, abdominal fat, and feed conversion ratio (Campestrini *et al.*, 2010). The balance of dietary amino acids is also important, because inadequate ratios among amino acids may negatively affect bird performance, and cause locomotion, feathering, and immunity problems (Kidd & Fancher, 2001).

There is a substantial amount of information in the literature on the effects of dietary lysine levels on the development and performance of broiler chickens (Rama *et al.*, 2011; Salehifar *et al.*, 2012; Mateos *et al.*, 2013). Therefore, meta-analysis may provide useful and thorough information on how different dietary lysine levels of lysine may impact poultry production (Bucher *et al.*, 2012; Kerr *et al.*, 2013).

Meta-analysis was originally introduced in psychology and medicine and has become increasingly popular in animal science, and applied to different species such as poultry, sheep, cattle, and pigs (Sauer *et al.*, 2008). Meta-analysis is a statistical technique that consists of combining the results of several studies in one single analysis to obtain broadly valid inferences (Van Houwelingen *et al.*, 2002). This study, therefore, aimed at performing a meta-analysis to evaluate the effects of dietary lysine levels on the performance and carcass yield of broiler chickens.

MATERIAL AND METHODS

This study was conducted at the Federal Technological University of Paraná, Dois Vizinhos campus, Brazil (UTFPR-DV). A total of 47 scientific papers on the effects of dietary lysine levels on poultry performance were found and a total of 21 papers were selected to perform the meta-analysis. The scientific papers used are listed in Table 1.

The effects of dietary lysine levels on performance parameters evaluated, including weight gain (178 observations) and feed conversion ratio (188 observations), and on carcass quality, including carcass yield (24 observations), abdominal fat (24 observations) and breast meat yield (30 observations), were evaluated.

Data obtained from the selected studies (Table 1) were first organized in Microsoft Excel® spreadsheets. Bird age was designated within ranges, as illustrated in Table 1. The dietary lysine levels evaluated among the selected studies were further divided into five categories within the ranges of 0.8 - 0.9; 0.91 - 1.0; 1.01 - 1.1; 1.11 - 1.2; 1.21 - 1.3%.

The following tests of normality were applied: Kolmogorov-Smirnov, Cramer-von Mises, Anderson-Darling, Kuiper, Watson, Lilliefors and Shapiro-Wilk test, using the software Assistat (Silva & Azevedo, 2002). The data were submitted to analysis of variance and estimates of regression equations to the third grade were obtained using the statistical software SAS (2001). Lysine concentration was regressed as linear functions of weight gain, carcass yield, breast meat yield, abdominal fat and feed conversion ratio. The addition of quadratic and cubic terms was also tested in the regressions.

RESULTS AND DISCUSSION

Table 2 presents the statistical results of the analysis of variance of the regression equations, including the degrees of freedom (DF), sum of squares (SS), mean square (MS), p-value (p) for the overall quadratic model and coefficient of variation (CV) for each of the dependent variables, including weight gain (WG), feed conversion ratio (FC), breast meat yield (BM), carcass yield (CY) and abdominal fat (AF).

Table 1 – Scientific papers used in the meta-analysis of dietary lysine levels and their effects in poultry performance.

Author	Number of Birds Studied	Bird Age [days]	Dietary Lysine Levels Studied [%]
Conhalato *et al.* (1999)	450	22 - 42	0.88;0.94;1.00;1.06;1.12
Barbosa *et al.* (2000) A	1920	22 - 40	0.8;0.86;0.92;0.98;1.04;1.10
Barbosa *et al.* (2000) B	1920	15 - 40	0.83;0.89;0.95;1.01;1.07.1.13
Barbosa *et al.* (2000) C	1920	01 - 21	1.00;1.06;1.12;1.18;1.24;1.30
Bellaver *et al.* (2002)	2808	01 - 21	0.92;1.02;1.12;1.22
Costa *et al.* (2001) A	1440	01 - 21	1.03;1.09;1.15;1.21;1.27;1.33
Costa *et al.* (2001) B	1440	22 - 40	0.92;0.98;1.04;1.10;1.16;1.22
Barbosa *et al.* (2001)	972	42 - 56	0.94;1.04;1.14
Borges *et al.* (2002)	400	01 - 21	1.04;1.10;1.16;1.22;1.28
Lana *et al.* (2005)	378	22 - 42	0.78;0.84;0.89;0.96;1.02
Amarante Jr. *et al.* (2005)	1800	22 - 42	0.94;1.02;1.09;1.18;1.26;1.34
Costa *et al.* (2005)	900	22 - 42	0.94;1.02;1.09;1.18;1.26;1.34
Costa *et al.* (2006) A	900	22 - 42	0.94;1.02;1.10;1.18;1.26;1.34
Costa *et al.* (2006) B	900	43 - 49	0.85;0.93;1.01;1.09;1.17;1.25
Toledo *et al.* (2007)	1050	1 - 11	1.12;1.17;1.221.27;1.35
Rodrigues *et al.* (2008)	1200	22 - 42	1.00; 1.09; 1.17; 1.26; 1.34
Goulart *et al.* (2008)	780	01 - 42	1.10;1.16;1.22;1.28;1.34;1.40
Trindade Neto *et al.* (2009)	203	37 - 49	0.90; 0.95; 1.00; 1.05; 1.10
Trindade Neto *et al.* (2010)	180	22 - 42	0.84; 0.87; 0.99; 1.02; 1.03
Siqueira *et al.* (2011)	600	22 - 35	0.79; 0.88; 0.96; 1.04; 1.13
Trindade Neto *et al.* (2011)	210	23 - 36	0.95; 1.00; 1.05; 1.10; 1.15

Table 2 – Analysis of Variance Results.

	DF	SS	MS	p	CV
WG	2	1,348.65	674.32	0.0216	15.90
FC	2	337.86	168.931	0.4808	15.18
BM	2	8,104.32	4,052.16	0.0006	0.55
CY	2	1,375.22	687.61	0.0060	0.18
AF	2	0.15	0.08	0.1684	3.42

The coefficient of variation results presented in Table 2 were consistent with literature: Silva *et al.* (2008), de 6.63%; Marcondes *et al.* (2008), 11.63% and Canesin *et al.* (2006), 7.96%. The addition of the quadratic term was significant for weight gain (WG) as a function of lysine concentration, as illustrated in Figure 1. The highest weight gain values were obtained with lysine concentration of 1.05% and the second order relationship between weight gain (g) and lysine concentration (%) is given by the following equation ($R^2 = 0.05$):

$$GP = -3248.39 + 8276.57 * \text{Lysine Level} - 3981.09 * \text{Lysine Level}^2 \quad \text{Eq. (1)}$$

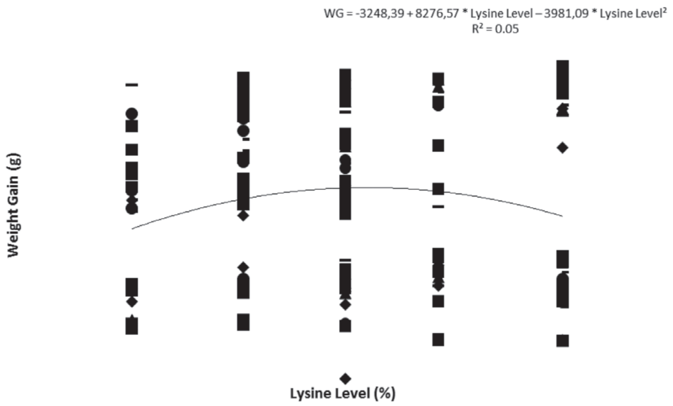

Figure 1 – Broiler weigh gain (g) as a second order function of lysine level (%).

Goulart *et al.* (2008) evaluated lysine requirements of broiler chickens during three rearing phases (pre-starter, 1-7, starter, 8-21 and grower, 22-42 days of age). The authors also found a second order relationship between weight gain and lysine concentration, as well as between feed conversion ratio and lysine concentration ($p<0.01$). The highest weight gain (117.6 g/bird) and the best feed conversion ratio (1.09 kg/kg) in the pre-starter phase were obtained at lysine concentrations of 1.286% and 1.239%, respectively. The authors found that, before reaching the best performance at the reported lysine levels, the diet was either deficient in lysine or unbalanced relative to the other dietary amino acids. Above the optimal lysine levels, however, bird performance did not improve with increasing lysine levels, and lysine was excreted.

Amino acids in excess are catabolized and excreted as uric acid (Leclercq, 1998). The metabolic cost to incorporate an amino acid to a protein chain is of approximately ATP molecules, whereas the cost to excrete an amino acid is 6 to 18 ATP molecules, depending on the amount of nitrogen present in the amino acid. Moreover, the excretion of excessive dietary amino acids will expends energy that could instead be utilized for tissue deposition, and therefore it is very costly for the birds (Costa *et al.*, 2001).

High dietary lysine levels may change the function and the requirements of other amino acids, such as arginine, which in turn changes the requirements of methionine, affecting bird development and performance (Chamruspollert *et al.*, 2002).

Namazu *et al.* (2008) also found a quadratic relationship between weight gain and dietary lysine levels. However, it was found that feed intake has a first order relationship with lysine levels. Sklan & Noy (2004) evaluated starter male and female broiler chickens and found that that weight gain improved with 1.05% of dietary lysine, as determined in the present study, whereas the best feed conversion ratio was obtained with 1.03% of lysine. Trindade Neto *et al.* (2010) recommended a minimum of 1.002% of digestible lysine for high-yield cuts of male broilers.

Toledo *et al.* (2007) reported that dietary lysine level should not be lower than 1.20% for male Ross broilers between 1 and 11 days of age reared under low immune challenge conditions. Kidd & Fancher (2001) proposed an optimal lysine level of 1.22% for starter broilers to obtain high weight gain and carcass yield. Barboza *et al.* (2000) found a quadratic relationship between both weight gain and feed conversion ratio and dietary lysine levels. The authors reported 1,265.4 g weight gain in male Ross chickens and 1,269.2 in Hubbard male chickens with lysine concentrations of 0.98% and 0.92%, respectively. Ross and Hubbard female chickens presented weight gains of 1,047.0 g and 1,017.4 g, respectively, for the same lysine levels. Rostagno *et al.* (2005) found a second order relationship ($p<0.05$) between weight gain and lysine. The authors suggested a requirement of 1.044% of dietary lysine for broiler chickens. Their recommendation is higher than the level suggested by Barboza *et al.* (2000) of 0.90%.

Feed conversion ratio presented a second order relationship with lysine levels, as illustrated in Figure 2. Feed conversion ratio decreased as lysine levels increased and this relationship is shown by the following equation:

$FCR = 4.10 - 2.77 * \text{Lysine Level} + 0.78 * \text{Lysine Level}^2$ ($R^2 = 0.23$) Eq. (2)

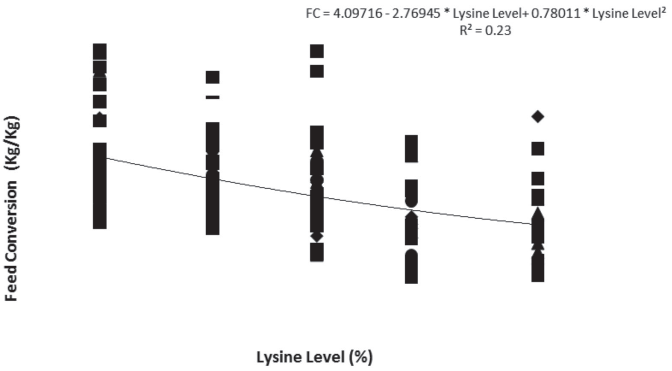

Figure 2 – Broiler feed conversion ratio as a second order function of lysine levels.

Siqueira *et al.* (2011) found an exponential relationship between feed conversion ratio and dietary lysine levels for broiler chickens during the grower and finisher phases, as described by the following equation:

$FCR = 1.84 - 0.22 * (e^{-6.44*(\text{lysine level} - 0.75)})$. eq. (3)

Trindade Neto *et al.* (2009), however, found a first order relationship between feed conversion ratio and lysine levels, as described by the equation:

$FCR = 3.16 - 0.87 * \text{lysine levels}$ eq. (4)

Those authors stressed that lysine levels should not be lower than 1.10% or a total of 29.6 grams during the finisher phase (35 to 47 days).

Costa *et al.* (2006) also reported that feed conversion ratio improved with increasing lysine levels, as described by the first order ($p<0.01$) equation:

$FC = 1.57+ 0.29 \text{ lysine levels}$ ($R^2 = 0.75$) eq. (5)

Nascimento (2003) found that increasing dietary lysine levels promoted higher muscle deposition and weight gain, and reduced abdominal fat, leading to better feed conversion ratio.

Siqueira *et al.* (2007) reported 1.64 kg/kg feed conversion ratio in broiler chickens fed 1.085% lysine, which is close to the results of the present study and to the recommendation of Rostagno *et al.* (2005) of 1.045% lysine for broiler chickens. Accordingly, Lana *et al.* (2005) reported optimal feed conversion ratio with 1.075% dietary lysine level fed 22- to 42-day-old broiler chickens reared in zone of least thermoregulatory effort (23.8°C).

Carcass yield has been shown to increase with increasing dietary lysine levels (Almeida *et al.*, 2002). Accordingly, carcass yield and breast meat yield increased with lysine levels at a second order relationship, as shown in Figures 3 and 4 and described by the following equations:

$CY = 27.87 + 76.45 * \text{lysine level} - 37.30 * \text{lysine level}^2$ ($R^2 = 0.97$) Eq. (6)

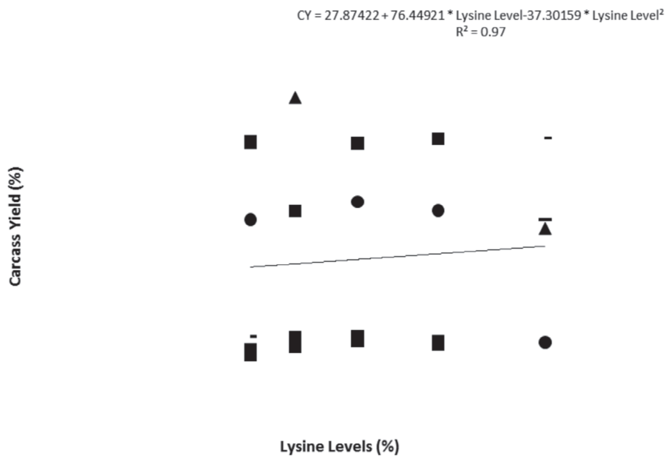

Figure 3 – Broiler carcass yield as a second order function of lysine level.

$BMY = - 63.76 + 165.36 * \text{lysine level} -79.81 * \text{lysine level}^2$ ($R^2 = 0.99$) Eq. (7)

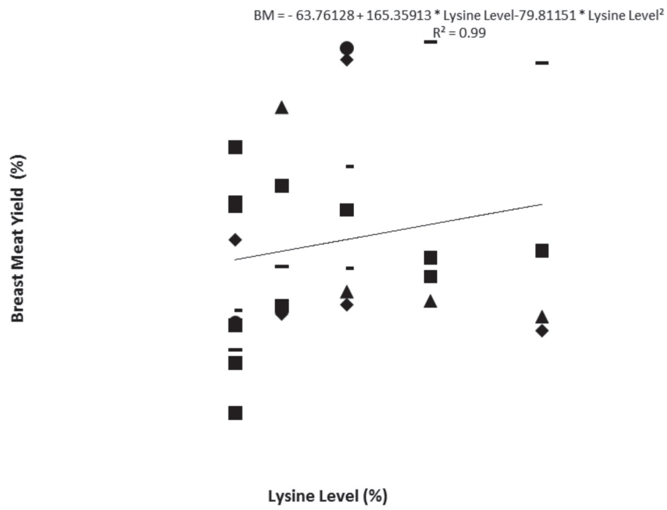

Figure 4 – Broiler breast meat yield as a second order function of lysine level.

Valério *et al.* (2003) and Siqueira *et al.* (2007) did not find any significant ($p\geq0.05$) effect of dietary lysine levels on carcass yield. Pavan *et al.* (2003) studied broiler feeds based on corn and soybean meal containing lysine levels of 1.18, 1.24, and 1.30% in pre-starter diets; 1.10, 1.16, and 1.22% in starter diets; 1.0, 1.06, and 1.12% in grower diets; and 0.85, 0.91, and 0.97% in finisher diets, and did not find any relationship between lysine levels and breast meat yield.

Almeida *et al.* (2002) found that increasing dietary lysine levels promoted higher breast meat yield ($p\leq0.05$), especially in 49-day-old female broilers. Goulart *et al.* (2008) obtained a quadratic relationship between dietary lysine levels and breast meat weight

($p \leq 0.05$), suggesting a dietary level of 1.008% lysine to achieve maximum breast meat weight. Ojano-Dirain & Waldroup (2002) verified that increasing dietary lysine levels from 1.03% to 1.12% increased breast meat yield and reduced abdominal fat yield.

Lysine level had a quadratic relationship with abdominal fat ($p \leq 0.01$), as described by the equation:

AF=10.46 – 15.04 * lysine level + 6.94 * lysine level² (R^2 = 0.88) Eq. (8)

The lowest abdominal fat levels were obtained with 1.28% dietary lysine (Figure 5).

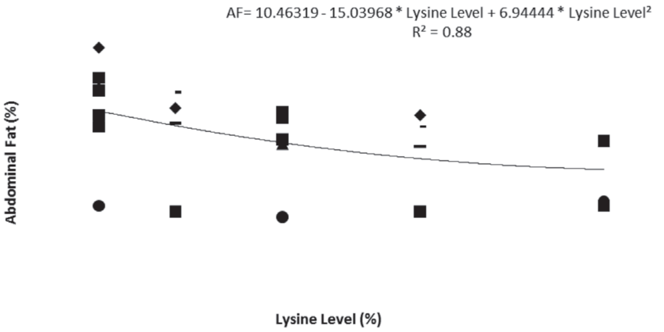

Figure 5 – Relationship between abdominal fat (%) and dietary lysine levels (%) in broiler chickens.

The obtained abdominal fat results are consistent with the findings of Barboza *et al.* (2000) and Costa *et al.* (2006). Almeida *et al.* (2002) found that increasing dietary lysine levels up to 1.00% allow for the reduction of abdominal fat in broilers. Accordingly, Borges *et al.* (2002) reported a quadratic reduction in abdominal fat as lysine levels were increased up to 1.11%, as described by the equation:

AF = 1.92*lysine level² + 4.27*lysine level + 1.01 (R^2 = 0.91) Eq. (9)

Costa *et al.* (2001), on the other hand, that the relationship between lysine levels and abdominal fat was linear.

CONCLUSIONS

Dietary lysine levels of approximately 1.05% resulted in higher weight gain in broilers. High dietary lysine levels promoted better feed conversion ratio, greater breast meat yield, and reduced abdominal fat yield. Therefore, bird performance and carcass yield are strongly affected by dietary lysine concentration.

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