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Effect of Dietary Protein and Lysine on Performance and Carcass Yield of Turkeys

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Abstract: Problem statement: There is a concern related to loss of nitrogen to the environment from animal manure and the high cost of the protein supplement. Thus, the current study was undertaken to determine the effect of reduction of CP and increased of lysine on growth and carcass yield in turkeys. **Approach:** A factorial experiment was carried out with commercial turkeys to evaluate the effect of two dietary levels of CP (90 and 100% of the NRC recommendations) and three dietary lysine levels (90, 110 and 130% of the NRC recommendations) on performance and carcass yield of male turkeys evaluated from 8-16 week of age. **Results:** The CP × lysine interaction was significant ($p<0.05$) for daily gain and Food Conversion Ratio (FCR). 100% CP level increased daily gain (0.13, 0.15 and 0.15 kg day^{-1}) and improved FCR (3.43, 3.12 and 3.01) as dietary levels of lysine in the diet increased ($p<0.05$), but the opposite was true for the birds fed 90% CP. The CP × lysine interaction ($p<0.05$) observed at 16 week of age showed that carcass weigh, breast weight, leg weight and thigh weight increased as the lysine level increased in the diet with 100% CP and the contrary occurred in the 90% CP treatment. **Conclusion:** The results of this experiment suggest a positive relationship between amino acids and CP; however, the increment of amino acids in the diets with low CP should be made keeping a proportional relationship among the dietary amino acids.

Key words: Lysine, protein, turkey performance, carcass yield

INTRODUCTION

Protein and amino acids are the nutrients of most economic value in the diet of turkeys and should be provided in appropriate amounts to minimize feeding costs. More recently, concerns about environmental pollution has encouraged nutritionist to decrease Crude Protein (CP) levels in the diet of turkeys whilst sustaining performance. Diverse studies postulate that it is possible to reduce the level of CP in the diet without any disturbance on performance, whereas an appropriate level of the essential Amino Acids (AA) is provided (Kidd *et al*., 1997; Lemme *et al*., 2004; Waldroup *et al*., 1997; Waibel *et al*., 2000a). Also, it has been proposed an ideal protein ratio for turkeys (Firman and Boling, 1998; Boling and Firman, 1997). The ideal protein indicates the exact balance of AA's needed for growth and maintenance without excesses or deficiencies. This supposed reduces of feed costs and excess levels of nitrogen losses into the manure. Ideal protein has been well-defined in broilers (Baker, 2003), but little data exists on an ideal protein for turkeys. Lysine has been chosen as the reference AA because it is the second limiting in poultry rations, there is a relatively large amount of data available and lysine is primarily used for protein accretion (Firman, 2004). The information available showed that lysine level recommended by National Research Council (1994) for turkeys do not sustain satisfactorily growth rate (Lemme *et al*., 2002). The estimations of lysine requirements in turkeys could vary due to inherent factors on growth rate and food consumption, as well as to environmental factors (Boling and Firman, 1998; Waldroup *et al*., 1997). Therefore, the objective of this study was to evaluate the effect of dietary lysine and protein levels on the productive performance and carcass yield in modern genetic strains of commercial turkeys.

MATERIALS AND METHODS

A two-period experiment was carried out at the Faculty of Veterinary Medicine and Animal Science (University of Yucatan). The average maximum temperatures during the first and second periods were 27.6±3.70 and 26.4±3.00°C and the minimum 21.1±3.73 and 20.3±2.52°C, respectively. Eight week old male turkeys (Nicholas-700) with average BW of 3.37±0.27 and 4.20±0.36 kg were used in the first and second period. Thirty six turkeys were used in each period.

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Six diets consisting of combinations of two CP levels (90 and 100% of the National Research Council (1994) recommendations) and three lysine levels (90, 110 and 130% of the National Research Council (1994) recommendations) were used (Table 1). Lysine levels were reached by the addition of L-lysine HCL and formulated to meet the requirement of the other AA according to the National Research Council (1994). The calculated nutrient values of the diets are shown in Table 2.

Table 1: Diet formulation for male turkeys diets from 8-16 weeks of age, with different levels of Crude Protein (CP) and Lysine (LYS)

	90% CP			100% CP		
Ingredient (%)	90% LYS	110% LYS	130% LYS	90% LYS	110% LYS	130% LYS
Sorghum	53.80	54.15	54.80	51.03	50.68	50.35
Soybean meal	23.99	23.32	22.32	28.82	28.84	28.84
Canola meal	9.99	10.00	9.99	10.00	10.00	10.00
Soybean oil	6.15	6.15	6.15	4.49	4.49	4.49
Wheat bran	2.00	2.00	2.00	2.00	2.00	2.00
Dicalcium phosphate	1.83	1.80	1.80	1.70	1.70	1.70
CaCO 38%	0.83	0.84	0.84	0.84	0.84	0.84
Sodium chloride	0.30	0.30	0.30	0.30	0.30	0.30
Lysine HCL	0.27	0.61	0.97	0.10	0.43	0.77
Flavomicine 4%	0.25	0.25	0.25	0.25	0.25	0.25
Methionine 99%	0.15	0.15	0.15	0.09	0.09	0.09
Vitamin premix[a]	0.10	0.10	0.10	0.10	0.10	0.10
L-threonine ADM	0.07	0.07	0.07	0.00	0.00	0.00
Mycosorb[b]	0.05	0.05	0.05	0.05	0.05	0.05
Lasalocid sodium	0.05	0.05	0.05	0.05	0.05	0.05
Mineral premix[c]	0.05	0.05	0.05	0.05	0.05	0.05
Choline chloride[d]	0.05	0.05	0.05	0.05	0.05	0.05
Funginat 42	0.05	0.05	0.05	0.05	0.05	0.05
Oxidox beta	0.01	0.01	0.01	0.01	0.01	0.01
Manganese	0.01	0.01	0.01	0.01	0.01	0.01

[a]: Content kg^{-1}: vitamin A, 8000 UI; vitamin D, 2500 UI; vitamin E, 8 UI; vitamin K, 2 mg; vitamin B12, 0.002 mg; riboflavin, 5.5 mg; pantothenate of calcium, 13 mg; niacine, 36 mg; choline, 500 mg; folic acid, 0.5 mg; thiamine, 1 mg; pyridoxine, 2.2 mg; biotin, 0.05 mg; [b]: Micotoxin sequestering; [c]: Content kg^{-1} of diet: Manganese, 65 mg; iodine, 1 mg; iron, 55 mg, copper, 6 mg; zinc, 55 mg; selenium, 0.3 mg; [d]: 700 g kg^{-1} of choline chloride

Table 2: Nutrient composition and AA: Lisine ratio of the experimental diets with different levels of Crude Protein (CP) and Lysine (LYS) for male turkeys from 8-16 weeks of age

	90% CP			100% CP		
Nutrient composition (%)	90% LYS	110% LYS	130% LYS	90% LYS	130% LYS	110% LYS
ME, Mcal kg^{-1}	3.00	3.00	3.00	3.00	3.00	3.00
Crude protein	19.80	19.90	19.80	21.50	21.80	22.10
Crude fiber	3.20	3.20	3.20	3.20	3.20	3.20
Non-phytate phosphorus	0.40	0.40	0.40	0.40	0.40	0.40
Calcium	0.90	0.90	0.90	0.90	0.90	0.90
Amino acids (%)						
Lysine	1.20	1.40	1.70	1.20	1.40	1.70
Arginine	1.20	1.20	1.10	1.30	1.30	1.30
Met + Cystine	0.80	0.80	0.80	0.80	0.80	0.80
Threonine	0.80	0.80	0.80	0.80	0.80	0.80
Isoleucine	0.80	0.80	0.80	0.90	0.90	0.90
Phenylalanine	0.90	0.90	0.90	1.00	1.00	1.00
Valine	0.90	0.90	0.90	1.00	1.00	1.00
Tryptophan	0.30	0.30	0.30	0.30	0.30	0.30
Histidine	0.50	0.50	0.50	0.60	0.60	0.60
Leucine	1.70	1.70	1.70	1.80	1.80	1.80
Glys + serine	1.80	1.70	1.70	1.90	1.90	1.90
AA: Lysine ratio						
Arginine: Lysine	1.00	0.85	0.65	1.08	0.93	0.76
Met + Cystine: Lysine	0.67	0.57	0.47	0.67	0.57	0.47
Threonine: Lysine	0.67	0.57	0.47	0.67	0.57	0.47
Tryptophan: Lysine	0.25	0.21	0.18	0.25	0.21	0.18
Valine: Lysine	0.75	0.64	0.53	0.83	0.71	0.59
Isoleucine: Lysine	0.67	0.57	0.47	0.75	0.64	0.53
Leucine: Lysine	1.42	1.21	1.00	1.50	1.29	1.06

Experimental diets were provided *ad libitum*, in pellet form. One week before the beginning of the experiment turkeys were kept in floor pens. During adaptation time, birds consumed the same food used in their former farm (22% CP, 2.8% EE, 12% humidity, 4.5% CF and 10% ash). The turkeys were distributed at random in 18 floor pens (2 birds per pen) and assigned to one of the six experimental diets. Each pen had 1 m^2 concrete floor, covered with wood shavings as bed and equipped with a hanging feeder and an automatic drinker. During the study the birds underwent a regime of natural light. Turkeys were fed the diets from 8-16 week of age and at 16 week of age they were fasted for 12 h, weighted and food consumption calculated. A bird from each pen was randomly selected, killed and carcass measurements recorded.

Slaughter consisted on stunning the turkeys with an electric discharge and then cutting off the jugular vein for bleeding. Later on, they were scalded at 60°C for 1 min and plucked. Finally birds were eviscerated manually, eliminating the neck, head, paws and guts. The hot carcass, the breast from the right half of each carcass (without skin and bones), the thigh, the leg and the wing (with the skin and bone) were weighed. The weights of half of the carcass components were multiplied by 2 to obtain the total yield of the carcass components.

Average weight/bird/pen was calculated. Daily food consumption was considered, as the average food consumption/bird/pen. The average feed conversion ratio/bird/pen was calculated dividing the average daily food consumption/bird/pen by the average body weight/bird/pen. Carcass yield was calculated as a proportion of body weight. Breast, leg, wing and thigh yields were calculated as proportions of the carcass weight.

Data of each period and both combined were analyzed as a factorial experiment. The factors considered in the analysis of each period were protein levels (90 and 100% of NRC recommendations), lysine levels (90, 110 and 130% of NRC recommendations) and CP × lysine interaction. The statistical model for the combined data also included the effect of period. Polynomial orthogonal analyses were further carried out to evaluate the linear and quadratic effects of the lysine levels for each level of CP. Pen was considered the experimental unit and there were 6 replicates per treatment. The ANOVA of the data was carried out using the STATGRAPHICS statistical program (Statgraphics Plus 5.1 for Windows, 2001).

RESULTS

Nutrient compositions of experimental diets are shown in Table 2. The relation of AA: Lysine of diets were as expected reduces conforming Lysine increasing in both low and high protein diets. The results of Daily Weight Gain (DWG), Daily Feed Consumption (DFC) and Feed Conversion Ratio (FCR) are presented in Table 3. There were not significant effect of CP and lysine level in the diets on growth performance ($p>0.05$), however, CP × lysine interaction ($p<0.05$) was observed for DWG. The DWG of birds fed diets with 90% of CP, tend to decrease as lysine level increased from 90-110 and 130% (0.151, 0.132 and 0.135 kg day^{-1}, respectively). On the other hand, the DWG of birds fed diets with 100% of CP increased as the lysine level increased from 90 to 110 and 130 (0.132, 0.149 and 0.147 kg day^{-1}, respectively). Similarly, a significant interaction CP × lysine was observed ($p<0.05$) for FCR. In birds consuming the diets with 90% of CP the FCR increased quadratically as the dietary lysine increased (2.89, 3.28 and 3.08). However, FCR of birds fed diets with 100% CP showed a linear decreased ($p<0.05$) as the lysine level increased (3.43, 3.12 and 3.01).

Table 4 shows the carcass weight and relative organ weights as affected by dietary concentration of CP and Lysine. The thigh yield was significantly ($p<0.05$) reduced with decreasing CP and lysine in the diet. Nevertheless, a significant interaction ($p<0.05$) was observed in this study between the levels of CP and lysine for the carcass, breast, leg and thigh weights.

Table 3: Mean performance of male turkeys fed with different dietary lysine (LYS) and crude protein (CP) levels

Factor		Daily gain	Food consumption	Feed
CP (%)	LYS (%)	(Kg)	(Kg)	conversion
90	90	0.1510	0.4320	2.9000
90	110	0.1320	0.4310	3.3000
90	130	0.1350	0.4160	3.1000
100	90	0.1320	0.4480	3.4000
100	110	0.1490	0.4630	3.1000
100	130	0.1470	0.4420	3.0000
SE		0.0023	0.0069	0.0400
Mean		0.1410	0.4390	3.1000
p-values				
B		0.8861	0.0089	0.0016
CP		0.4757	0.0845	0.2580
LYS		0.9845	0.5838	0.3316
CP × LYS		0.0076	0.8963	0.0052
Contrast for lysine level				
90% CP				
Linear		0.0596	0.5113	0.2273
Quadratic		0.1228	0.7579	0.0335
100% CP				
Linear		0.0767	0.7921	0.0090
Quadratic		0.1803	0.4074	0.4451

LYS: Lysine; CP: Crude Protein; B: Block; P: Probability value; SE: Standard Error

Table 4: Carcass yield in turkeys fed on different dietary Lysine (LYS) and Crude Protein (CP) levels at 16 week-old

Factor		Live	Carcass		Breast		Leg		Thigh		Wing	
		weight	weight	Yield								
CP	LYS	(kg)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)	(kg)	(%)
90	90	12.6000	8.9000	71.2000	2.6000	28.8000	1.3000	14.7000	1.5000	17.0000	1.1000	12.5000
90	110	11.5000	8.5000	73.8000	2.5000	29.0000	1.3000	14.7000	1.4000	16.0000	1.0000	12.1000
90	130	11.1000	8.0000	71.8000	2.1000	26.7000	1.2000	14.8000	1.3000	16.3000	1.0000	13.0000
100	90	10.9000	8.1000	73.7000	2.3000	28.7000	1.1000	14.0000	1.3000	15.9000	1.0000	12.1000
100	110	12.1000	8.8000	72.8000	2.6000	29.8000	1.3000	14.3000	1.4000	16.1000	1.0000	11.8000
100	130	11.9000	8.7000	73.7000	2.6000	30.1000	1.3000	14.4000	1.3000	15.1000	1.0000	11.9000
SE		0.1400	0.1100	0.3700	0.0500	0.3400	0.0200	0.1700	0.0200	0.1100	0.0200	0.1600
N		36.0000	36.0000	36.0000	36.0000	36.0000	36.0000	36.0000	36.0000	36.0000	36.0000	36.0000
MEAN		11.7000	8.5000	72.8000	2.5000	28.9000	1.2000	14.5000	1.4000	16.1000	1.0000	12.2000
p-values												
B		0.0657	0.0419	0.4580	0.0848	0.6169	0.0399	0.5636	0.0094	0.1329	0.6731	0.1716
CP		0.6080	0.8314	0.1296	0.1968	0.0573	0.3846	0.1330	0.1314	0.0025	0.2769	0.0703
LYS		0.6192	0.5715	0.6714	0.3796	0.4834	0.7404	0.8885	0.1020	0.0315	0.9832	0.4410
CP × LYS		0.0031	0.0149	0.1381	0.0089	0.1021	0.0343	0.9241	0.0058	0.0460	0.2339	0.5675
Contrast for lysine level												
90% CP												
Linear		0.0058	0.0167	0.6645	0.0102	0.0811	0.0542	0.9254	0.0017	0.0624	0.2472	0.3216
Quadratic		0.4878	0.8838	0.0510	0.4305	0.2356	0.9564	0.9245	0.4524	0.0830	0.5007	0.2239
100% CP												
Linear		0.0731	0.0887	0.9848	0.0588	0.2270	0.0876	0.5626	0.5474	0.0527	0.3331	0.7813
Quadratic		0.1339	0.2608	0.4096	0.3056	0.6791	0.3158	0.8634	0.0437	0.0667	0.6129	0.6614

LYS: Lysine; CP: Crude Protein; B: Block; P: Probability value; SE: Standard Error

The carcass, breast, leg and thigh weights reduces as lysine increases in 90% CP diets and contrary increases as lysine increases in 100% CP diets.

DISCUSSION

The significant positive linear relationship between the increase in dietary lysine and the daily gain and food consumption found in the current study in turkeys fed 100% CP diets, is in good agreement with the linear response reported by Veldkamp *et al*. (2000). Inversely, the negative response observed in 90% CP diets conforming increased lysine can be related to the reduction of lysine: Other AA ratio, particularly with arginine (Table 2) that is an antagonistic AA of the lysine (Brake *et al*., 1998) and valine, leucine and isoleucine that are important for optimum growth (Lemme *et al*., 2004). These results are also associated to the hypothesis suggesting that an adequate balance among the dietary AA it is necessary in order to meet the requirements of the birds (Applegate *et al*., 2008; Baker *et al*., 2003; Boling and Firman, 1998; Firman and Boling, 1998). According to Lemme *et al*. (2002) the dietary AA imbalances result in a reduction of BWG, increases in the FCR and reduction of carcass yield. The results obtained in this experiment indicate that diets containing 90% CP and 90% lysine supported the growing performance of the turkeys, while, in diets having 100% CP, the 90% of lysine was not sufficient. The lysine content in diets with 100% of CP had to be higher to sustain the growing performance of the turkeys. The increased of CP in the diets, increased also content of other AA such as arginine and valine, so, the increased of lysine to keep an appropriate relationship among AA could be required (Table 2). The imbalance in the essential amino acids could be caused by the increasing level of the CP or the AA, without consideration of the relation between both (Corzo *et al*., 2002).

The carcass, breast, leg and thigh weights reduction as lysine increases in 90% CP are also associated with the imbalance of amino acids observed in the diet containing 90% CP. In Table 2 it is demonstrated that as the lysine level in the diet increased, they became more limiting to other amino acids, e.g., arginine, valine, isoleucine and leucine, that are important for optimum growth (Lemme *et al*., 2004). On the other hand, in diets with 100% CP the dietary levels of those AA were higher and they probably kept better relationship with lysine. These results agreed with that reported by Waldroup *et al*. (2003) who confirmed that as an amino acid becomes more limiting in the diet the protein content in the carcass decreases. Similarly to the results obtained in the current research, Corzo *et al*. (2002) found that increasing the lysine level in the diet of finishing male chickens (42-56 day of age) decreased the breast yield and incremented the FCR. These authors explained their results as a function of the imbalance in the essential amino acids caused by the increasing level of the dietary lysine. In this respect, several reports mention the importance of considering other essential amino acids besides the lysine in order

to improve the breast yield when diets with low CP content are used (Kidd and Kerr, 1996; Kidd and Kerr, 1998; Veldkamp *et al*., 2003; Veldkamp *et al*., 2005; Waibel *et al*., 2000b). Waibel *et al*. (2000b) mentioned that the supplementation with threonine, isoleucine, valine, arginine and tryptophan improved the breast yield in turkeys. Kidd *et al*. (1997) reported that the proportional increment of the sulfur amino acids, lysine, threonine and triptophan in low protein diets (92% of the NRC recommendations) improved the yield of the breast in male turkeys. In contrast, Applegate *et al*. (2008) demonstrates that diets containing AA formulations above NRC recommendations do not provide any additional performance or breast yield benefits in turkeys. Other reports, found that improving the relationship among AA (e.g., arginine: Lysine) increased both the breast yield and the DWG and decreased the FCR in turkeys (Firman and Boling, 1998).

CONCLUSION

The results obtained suggested that a CP reduction of 10% in turkey diets could be possible, as long as a corresponding relationship exist among the amino acids. Increases of lysine in low protein diets could allow an unbalance among the essential aminoacids, so a reduction in productive performance can be observed in the turkeys. On the other hand, increase lysine in diets with protein according requirements allowed an increase in the productive performance until a point where no longer there was improvement in the productive performance of the turkeys. These assertions emphasize to lysine like an amino acid from which an ideal protein model for turkeys can be designed. Also, more information on the ideal relationship among amino acids in diets for turkeys is necessary due to the continuous genetic improvement in that specie.

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