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Effects of excess dietary lysine and methionine on performance and economical efficiency of broiler chicks

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ABSTRACT

An experiment was conducted to determine the effects of excess levels of dietary lysine (Lys) and methionine (Met) on some performance traits and economical efficiency of the broiler chicks. 300 one-day-old broiler chicks (Ross 308) were used in a completely randomized design. The birds were allotted to five groups, each of which included four replicates (15 birds per replicate). The groups received the same basal diet supplemented with Lys and Met (as TSAA) in 0, 10, 20, 30 or 40% more than NRC (1994) recommendation. The collected data were analyzed by SPSS software and Duncan's test was used to compare the means on a value of P< 0.05. The results indicated that the two highest levels of Lys and Met treatments (30 and 40% more than NRC recommendation) led to significant increase in carcass efficiency, breast muscle yield, heart and liver weight and also economical efficiency of carcass yield (P< 0.05), whereas feed conversion ratio (FCR) and abdominal fat pad which were the least in these two treatment groups (P< 0.05). Addition Lys and Met 40% more than NRC tend to significant decrease in body weight gain and economical efficiency of live weight yield but there was no significant effect of the treatments on thigh and leg yield. The finding of this experiment showed that increasing Lys and Met to diets of today's broiler in excess of NRC recommendations can improve FCR, abdominal fat deposition, carcass efficiency, breast meat yield, and also profitability of production. Results reported here support the hypothesis that it is possible to produce poultry meat with lower fat content and more economical by supplementation excess Lys and Met to broiler foods.

Key words: Lysine, Methionine, Performance, Economical efficiency, Broilers

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INTRODUCTION

The requirements of methionine and lysine as the first two limiting amino acids in practical corn-soybean based foods for broiler chicks was evaluated by some researchers. Recent researches have suggested that levels of lysine and methionine in excess of NRC (1994) recommendations may result in enhanced performance, especially in regard with breast meat yield [14,18,23,25], weight gain and feed conversion ratio]11,25]. Some studies else that have been conducted to evaluate the effects of these amino acids in excess of NRC recommendations on laying hens performance, confirmed it effect on egg production, feed conversion ratio, egg weight, egg mass and livability specially in low protein diets [4]. Murray et al [19] found that addition of synthetic amino acids like lysine and methionine at high levels to the diet can stimulate insulin secretion from pancreas by aggregating in plasma which in turn releases amino acids and fatty acids [27] from the bodily saved sources and leads to protein synthesis, moreover, some reports have shown the positive effect of adding more lysine to the diet than required on the chickens suffering different stresses (1,17] or improve in immune system [3].

Also, lysine and methionine as two essential precursors of L-carnitine [2] can play important roles in lipid and energy metabolism in poultry. L-carnitine is a natural, vitamin-like substance that acts in the cells as a receptor molecule for activated fatty acids. The major metabolic role of it appears to be the transport of long-chain fatty acids into the mitochondria for B-oxidation [7]. A shortage of this substance results mainly in impaired energy metabolism and membrane function [13]. In this regard, some researches indicated that carnitine supplementation of diets can be used to augment carnitine supply for use in metabolism, thereby facilitating fatty acid oxidation and reducing the amount of long-chain fatty acids available for storage in adipose tissue [10]. Some evidence shows that excess lysine and methionine may improve economical efficiency of the broiler products.

The aim of the present work was to investigate the influences of dietary lysine and methionine in excess of NRC recommendation levels on some carcass traits and economical profit of broiler chicks in a commercial strain (Ross 308).

MATERIALS AND METHODS

This experiment was conducted at the broiler farm belonged to Islamic Azad univesity, Rasht branch, using three hundred one-day-old male broiler chickens (Ross 308) that were selected very carefully in aspects of uniformity in body weight, appearance, motility, etc, so that the body weight deviation of mean (46gr) was only 0.5gr. The chicks allotted to five treatment groups, each of which included four replicates of 15 birds, performed in a completely randomized design. Same basal diet was supplemented with 5 levels of synthetic lysine (as Lys-HCl) and methionine (D-L-methionine) in amount of 0 (control), 10, 20, 30 or 40% higher than NRC (1994) recommendation, regarding with lysine and total sulfur amino acids (TSAA) for broilers. Diets were fed from 1 to 42 d and included starter (1 to 21 d) and grower (21 to 42 d). Nutrient levels of the basal diets were based on the NRC (1994) recommendations. In order to buffer the excess chloride provided by L-Lys HCl, there was added 0.1% $NaHCo_3$ to both basal diets including starter and grower that were supplied in mash physical form (Table 1).

The broiler chickens were maintained in 2 x 1 m pens, equipped with bell drinkers and hanging tube feeders, feed and water were available ad libitum, light schedule, temperature and general management were performed according to Ross broiler manual [21]. During 42 d experimental period, body weight gain, feed consumption, mortality and feed conversion ratio were recorded weekly, birds were checked twice a day for mortality; dead birds were weighed and the weight was used to adjust feed conversion ratio (FCR: total feed consumed divided by weight of live birds plus dead birds). At days 21 and 42, three birds from each pen that were within one-half standard deviation of the overall pen mean and free from visible defects were randomly chosen for blood sampling which collected into a syringe from wing vein (1 ml from each bird) and placed in heparinized tubes. These blood samples were urgently sent to laboratory to determine triglyceride, cholesterol, low density lipoprotein (LDL), high density lipoprotein (HDL), uric acid and glucose.

At day 42, after blood sampling, feed but not water was withheld 6 hr prior to slaughter and then, that three birds of each replicate were processed for carcass characteristics. For evaluation the performance of the weight of breast and thigh (with leg) muscles, calculated in gram and also as carcass weight percentage. In order to evaluate economical efficiency, the total income earned from the sale of meat produced by each experimental group was calculated; the total cost (feed, day old chick, vaccine, labor, sanitary affairs, fuel, etc) which were spent for each experimental group was also calculated.

The net revenues (NR) of different experimental groups were calculated according to following formula: Net revenue = Total income –Total cost

To calculating the marketable carcass, it need to divide the cost of each kg live weight to carcass efficiency coefficients belong to each group and also costs of processing should be considered.

Table 1. Composition (g/kg) of basal diets

Ingredient	Starter (0-21 d)	Grower (21-42 d)
Yellow corn	550	620
Dehulled soybean meal	380	320
Corn oil	21.5	14
Dicalcium phosphate	22	18
Oyster shell	14	15.8
Sodium chloride	2	2
Vitamin premix [1]	3	3
Trace mineral mix [2]	3	3
L-Lysine-HCl	1.2	1.1
DL-methionine (98%)	2.3	2.1
Sodium bicarbonate	1	1
Total	1000	1000
Nutrient:		
ME (kcal/kg)	3000	3000
CP (%)	21.90	19.8
Lysine (%)	1.10	1.00
Methionine (%)	0.50	0.40
TSAA (%)	0.90	0.75

[1] *Provides per kg of diets: vit A 17500 IU, cholecalciferol 5000 IU, vit E 25 IU, B_{12} 0.03 mg, Riboflavin 15 mg, Niacin 75 mg, choline 700 mg, Folic acid 1.5 mg, Pyridoxine 6.25 mg, Biotin 0.127 mg, Thiamine 3.05 mg.*

[2] *Provides per kg of diet: zinc 100 mg, manganese 120 mg, copper 10 mg, iron 75 mg, iodine 2.5mg, selenium 0.15 mg, calcium 130 mg*

The collected data were analyzed by variance analysis method and Duncan's test was used to comparison the means based on a value of P< 0.05 by SPSS software [26].

RESULTS AND DISCUSSION

Table 2 shows the effect of excess lysine and methionine on some performance traits at the end of experiment (42 d). No significant effect of trial diets was observed in term of thigh and leg percentage of carcass weight, but significant effect relate to body gain, breast meat yield (P < 0.05) and feed conversion ratio, carcass efficiency, abdominal fat pad, liver and heart weight (P< 0.01) was observed. Comparison between the treatment means showed that, based on a value of P < 0.05, in regard with body gain and abdominal fat, the least value belonged to the highest treatment (1.4 NRC). Carcass efficiency increased from control to 4th level of the treatments but not in the highest level although there was not a significant difference between 1.3 and 1.4 NRC groups; also there was a linear reduction of abdominal fat parallel with increase dietary lysine and methionine, whereas, means of carcass efficiency, breast muscle and heart weight of this group and lower level (1.3NRC) was significantly higher than others. The weight of liver and heart (as percentage of carcass weight) was linearly increased in response to addition of dietary lysine and methionine to the basal diet. Feed conversion ratio in 1.3 and 1.4 NRC treatments was significantly (P < 0.05) lower than the treatment groups with lower levels of lysine and methionine.

In this study, food cost per each kg live weight gain was the lowest in treatment 1.3 NRC (Table 2) and table 3, shows the highest carcass efficiency in this group.

Table 3 shows the weight of some parts of the broilers carcass in gram with plus and menus of standard deviations in each treatment group. As it is seen, the fourth level of treatments (1.3 NRC) had the highest numerical amount of live body, carcass, breast muscle, liver and heart weight. On the contrary, the weight of abdominal fat pad in this group was the lowest between all groups.

Mortality was very low (only 4 birds) that belonged to 4 different groups and so its data was not enough to analysis.

Results of economical efficiency calculation based on each kg live body or carcass weights are summarized in tables 4 and 5 respectively. The economical calculations are performed based on the prices in Iran market at the end of experimental period as follow:

Each Kg basal diet = 0.96 USD
Each Kg Lysine = 5.2 USD
Each Kg Methionine = 6.7 USD

Each kg broiler live weight = 2.75 USD
Each kg marketable broiler carcass: 3.90 USD

As it is shown in table 4, the net revenue of live body weight in T3 group (1.2 NRC) was the least and treatment 4 (1.3 NRC) was the highest among all of the treatment groups, The comparison the mean of net revenue in different treatment groups shows that 1.3 NRC significantly made more money than other treatments ($p<0.05$).

Table 2. Effect of lysine and methionine on performance and carcass processing parameters of broilers at 42 day of age (Means ± SD)

Variable	Amount of dietary lysine and methionine (based on TSAA) relative to NRC recommendation					SEM	P
	NRC - (control)	1.1 NRC	1.2 NRC	1.3 NRC	1.4 NRC		
Body weight gain (g)	2960^{a}±65.15	2920^{a}±69.95	2850^{ab}±66.12	2970^{a}±62.25	2730^{b}±56.50	28.59	*
Absolute gain of live weight, gr[1]	2913±65.12	2873±69.90	2803±66.12	2923±62.25	2683±56.50	-	-
Mean daily gain of live weight, gr	69.4±1.55	68.4±1.48	66.7±1.41	69.6±1.54	63.9±1.39	-	-
Feed conversion ratio	1.83^{a}±0.05	1.82^{a}±0.05	1.89^{a}±0.06	1.62^{b}±0.05	1.69^{b}±0.05	0.025	**
Food costs for 1 kg live weight gain (dollar)	1.76±0.02	1.77±0.01	1.85 ±0.02	1.62 ±0.03	1.70 ±0.02	-	-
Carcass efficiency (%)	71.5^{c}±1.95	73^{b}±1.86	74^{b}±1.48	78^{a}±1.56	77.3^{a}±1.65	0.598	**
Breast muscle yield (%)	34.67^{b}±0.11	36.65^{b}±0.12	35.60^{b}±0.23	38.12^{a}±0.16	39.10^{a}±0.15	0.454	*
Thigh and leg muscle (%)	37.22±3.25	40.82±2.95	36.95±3.25	37.65±3.87	33.67±3.13	0.944	NS
Abdominal fat pad (%)	0.91^{a}±0.01	0.85^{ab}±0.01	0.84^{b}±0.01	0.67^{c}±0.01	0.44^{d}±0.01	0.041	**
Liver weight (%)	2.17^{c}±0.01	2.21^{c}±0.02	2.67^{b}±0.02	2.75^{ab}±0.02	2.94^{a}±0.02	0.74	**
Heart weight (%)	0.605^{c}±0.003	0.617^{c}±0.004	0.710^{b}±0.03	0.810^{a}±0.04	0.827^{a}±0.03	0.023	**

1 Live weight menus primary chick weight.
In each row means do not have the same letters; their differences are significant ($P < 0.05$) *,** and ^{NS} are significant at 0.05 level, 0.01 and non-significant, respectively.

In this study, abdominal fat pad and feed conversion ratio were affected by supplemented lysine and methionine in excess of NRC (1994) recommendation, so that reducing about 50% in abdominal fat in the highest level of lysine and methionine group (1.4 NRC) in comparison with control group (NRC) was observed (Table 2).

Table 3. Some parts of carcass (weights in gram ± SD)

Variable	NRC - (control)	1.1 NRC	1.2 NRC	1.3 NRC	1.4 NRC
Body weight (g)	2960±65.15	2920±69.95	2850±66.12	2970±62.25	2730±56.5
Carcass weight	2116.5±47.32	2131.5±45.35	2109±47.32	2316.5±49.78	2110±41.65
Breast muscle	733.6±32.48	781.2±34.21	750.8±35.65	883±38.98	825±37.45
Thigh and leg muscle	787.6±40.05	870±38.87	779.3±32.15	872.1±31.25	710.4±29.95
Abdominal fat pad	19.2±1.05	18.1±1.55	17.7±1.25	15.5±0.98	9.3±1.02
Liver weight	45.9±1.85	47.1±2.01	56.3±1.35	63.7±2.11	62±1.41
Heart weight	12.7±0.14	13.1±0.21	15±0.22	18.7±0.32	17.4±0.38

Table 4. Influence of lysine and methionine on Net Revenue per each kg live weight produced by the broilers.

Treatment groups	Income (USD/Kg live weight)	Costs (USD/Kg live weight)					Revenue (USD/Kg live weight
	Live weight price	Basal diet	Excess lysine and methionine added	Chick cost	Other costs	Total Costs	Net Revenue
NRC(control)	2.75	1.76	0.00	0.50	0.25	2.51	0.24^{b}
1.1 NRC	2.75	1.75	0.02	0.51	0.25	2.53	0.22^{b}
1.2 NRC	2.75	1.81	0.04	0.52	0.25	2.61	0.14^{c}
1.3 NRC	2.75	1.56	0.06	0.50	0.25	2.37	0.38^{a}
1.4 NRC	2.75	1.62	0.08	0.55	0.25	2.50	0.25^{b}

In the last column, means do not have the same letters, their differences are significant ($P < 0.05$)

Comparison between the means of net revenue per kg carcass production is shown in table 5. As it is seen, there are some changes in situation of some treatment groups when calculating was performed on carcass weight revenue so that the highest profit here belongs to the both highest levels of lysine and methionine (1.3 and 1.4 NRC).

Table 5. Influence of lysine and methionine on Net Revenue per each kg carcass produced by the broilers.

Treatment groups	Income (USD/Kg)	Live weight cost	Carcass Efficiency (%)	Costs (USD/Kg)			Revenue (USD/Kg)
	Carcass price			Carcass cost	Process cost	Total costs	Net Revenue
NRC(Control)	3.90	2.51	71.5	3.51	0.10	3.61	0.29[b]
1.1 NRC	3.90	2.52	73	3.45	0.10	3.55	0.35[b]
1.2 NRC	3.90	2.60	74	3.51	0.10	3.61	0.29[b]
1.3 NRC	3.90	2.37	78	3.04	0.10	3.14	0.76[a]
1.4 NRC	3.90	2.45	77.3	3.17	0.10	3.27	0.63[a]

In the last column, means do not have the same letters; their differences are significant ($P < 0.05$)

This result can be caused by two separate effects of lysine and methionine in high level: 1) as two amino acids tend to stimulate pancreas for further secretion insulin into blood. Insulin in poultry versus mammals is not an anti-lipolytic hormone, on the contrary, it can exert glucagon effect on release fatty acids and amino acids from the bodily saved sources and lead to protein synthesis [27] moreover, there is no question that breast meat yield, as a major portion of the protein synthesis in the body, is very sensitive to essential amino acids of the diets specially in today's broiler strains which are genetically emphasized on processing parameters and breast meat yield, and so, it is suggested that significant increasing breast muscle percentage and carcass efficiency in treatments with higher dietary levels of lysine and methionine (1.3 and 1.4 NRC) which are shown in Tables 2 and 3 can be occurred from this aspects. This findings are in agree with that of Si et al [25], Schutte and Pack [23] and Hicking et al [14]. In contrast, some researchers such as Han and Baker [12] failed to observe any favorable response to supplemented excess dietary lysine and methionine.

2), supplementation of these two amino acids to diets as precursors of L-carnitine, could be used to augment carnitine supply for use in metabolism, thereby facilitating fatty acid oxidation and so reducing the amount of long-chain fatty acids available for storage fat especially as abdominal fat pad. An increase in carnitine synthesis causes the increase of carnitine concentration in muscle and liver which leads to the increase activity of carnitine acetyltransferase and accelerate the transportation of acetyl-CoA from mitochondria to cytosol. A part of excess Acetyl-CoA present in cytosol can go to providing enough carbon chain to synthesis none essential amino acids and finally tissues protein.

Improvement in feed conversion ratio in the two highest levels of lysine and methionine treatments (Table 2) represents a more feed efficiency due to enhanced performance in metabolism of energy and protein which is in agree with some studies (Xu, et al [28]., Si et al [25]., Gorman and Belnave [11].

Increase of liver weight (as percentage of carcass weight and absolute weight which are shown in tables 2 and 3) in a linear manner as lysine and methionine increased may be due to a positive response to faster rate of metabolism for synthesis L-carnitine, glucose, cholesterol, protein and even degrade the excess lysine and methionine. In regard with heart weight percentage, a linear increase similar to liver weight was observed. Corresponding to some finding, L-carnitine is necessary for correct activity of heart muscle which itself made from lysine and methionine [13]. This increase was related to improvement in heart efficiency and didn't cause by hypertrophy of right ventricle. The present result from an aspect is in agree with Buyse et al [5] who found that addition L-carnitine to the broilers' diet caused increase in heart weight.

In regard with economical efficiency, the highest revenue obtained by the higher levels of lysine and methionine may be due to better performance in feed conversion ratio, carcass efficiency and lower fat deposition in these groups.

CONCLUSION

The results obtained from this study implicate that excess lysine and methionine could decrease abdominal fat content, feed conversion ratio, and increase breast muscle yield, carcass efficiency and also economical efficiency of the broilers. So, it is suggested that excess levels of lysine and methionine may result in enhanced economical performance and processing yield especially in regard with the above-mentioned traits in today's high performance broiler strains like Ross 308. These results emphasize the influence of excess dietary levels of lysine and methionine more than NRC recommendation on economical efficiency of broilers even when the farmers sell the birds as live weight.

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