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Determination of the Best Level of Dietary Energy with Two Diet Formulation Methods Based on Total and Digestible Amino Acid on Broiler Diet

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Abstract: In order to evaluate the effects of different levels of energy and methods of formulation of Amino Acid (AA) requirements of diets, this experiment was conducted using 392 broiler chicks. The experiment was carried out using a complete randomize block design with 7 levels of energy 3175, 3075, 2975, 2875, 2775, 2675 and 2575 kcal kg^{-1} for grower diet and 3225, 3125, 3025, 2925, 2825, 2725 and 2625 kcal kg^{-1} for finisher diet and two methods of formulation of diets AA requirements (total and digestible) as a factorial arrangement. Results showed that by increasing level of energy feed intake, body weight and FCR were promoted in grower diet ($p<0.05$). Effect of decreasing level of energy up to 2725 and 2825 kcal kg^{-1} was not significant on body weight and FCR in finisher diet, respectively. Formulating of diet based on total or digestible AA affected feed intake and FCR in finisher diet ($p<0.05$). Interaction effect of independent factors affected on body weight in grower diet ($p<0.05$). Decreasing level of energy increased gastrointestinal tract percentage weight ($p<0.05$). Formulation of diet based on digestible AA decreased gastrointestinal tract percentage weight ($p<0.05$). Abdominal fat decreased significantly as ME content of diets decreased. Results showed that it's possible to reduce the level of energy up to 3175 kcal kg^{-1} in grower and 2725 kcal kg^{-1} in finisher diet for giving the best and economical performance response. Formulation of diet based on digestible AA in finisher diet resulted in promotion of performance.

Key words: Total amino acid requirement, digestible amino acid requirement, metabolizable energy, diet, broiler

INTRODUCTION

Energy is not a nutritive substance, rather is a quality or property which exists in nutritive food and is released by oxidation. The first step in diet formulation for chicks is selecting diet energy level which is often considered as the basis for selecting the thickness of the nutritive feed (National Research Council, 1994).

Animals, e.g., birds, consume food to fulfill the internal requirement to energy. Food intake is then terminated when this internal requirement is satisfied.

Therefore, the appropriate proportion between energy requirement level and the nutritive substances of the diet (which is a theory) has a logical explanation and is necessary for attaining the best performance in birds feeding (Leeson and Summers, 2001).

In addition to maintaining the appropriate energy level for attaining the best outcome, there must be an appropriate balance between energy and protein. Proteins are composed of various amino acids. In order to supply amino acids requirements for chicks to reach at maximum grower, formulating diets using various crude proteins is a must. Today, the challenge of using multiple proteins is resolved by formulating diets based on amino acids and then adding synthetic amino acids to the diet (Maiorka *et al*., 2004). On the other hand, amino acids existing in foods are not fully digestible by chicks and the capability of different foods in digesting amino acids varies. Therefore, it is obvious that comparing foods based on digestible amino acids provides a more accurate measure for their relative nutritive value in total required amino acids (Farrell *et al*., 1999; Parsons, 1991).

In many developing countries, formulating diets using foods having high capability of digesting amino acids (corn and soybean meal) and high energy levels results in cost price increaser.

We therefore face this question: By formulating diets based on digestible amino acids, is it possible to employ diluted diets of foods like wheat, barley and bran wheat, while observing no significant effect on broilers performance?

For answering this question, also attention to energy importance and connection of energy with amino acid in diet, this study was conducted to evaluate

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appropriateness of formulation of corn soybean meal based diet on the basis of total and digestible AA requirement when diets had varying levels of metabolic energy.

MATERIALS AND METHODS

All of the experimental procedures were conducted in the Poultry Lab and Nutrition Lab of the Tehran University between 2006 and 2007. A total of 392 as hatched Ross 308 broiler chicks were used in this study. Chicks were reared on floor pens from day old to 10 days of age and received a standard starter diet (3010 kcal kg^{-1} ME and 23% CP), Then after being subjected to an overnight period of feed withdrawal, chicks were weighted individually and transferred to battery cages (40×78×90 cm) and allocated to dietary treatments so that pens had equal initial weight and weight distribution. Four replicate groups of 7 chicks were fed each of dietary treatments. Experimental period began at 10 days of age and lasted in 49 days of age. The experiment was carried out using a complete randomize block design with a 7×2 factorial arrangement. Factors were included different levels of energy (7 energy levels) and methods of formulation of diets AA requirements (total and digestible). Chicks received a grower diet from 10-28 days of age and a finisher diet from 28-49 days of age. Seven levels of ME used for formulation of diets in grower period were 3175, 3075, 2975, 2875, 2675 and 2575 kcal ME per kg of diet. Energy level in finisher period began with 2625 and increased by 100 kcal to achieve 3225 kcal. As diets were diluted, the ratio between ME and other nutrients were kept fix. For each ME level, two method of formulation of AA requirements of diets (total and digestible AA requirement) were employed. All the diets met or exceeded nutrients recommended by Ross management manual (Table 1). Before formulation of diets, feed ingredients were analyzed for CP, total P, Ca and ether extract according to the AOAC procedures (1995), data showed in Table 2. Diets used in this study in finisher period are presented in Table 3. The same ingredients were used for formulation of diets in finisher period.

Body weight and feed consumption were measured at 28 and 49 days of age and then weight gain and feed conversion ratios were calculated. At the termination of experiment, 2 birds from each replicate were selected randomly and were slaughtered and their empty carcass weight in relation to body weight (%), gastrointestinal tract, abdominal fat, liver and heart were expressed as percentage of the carcass weight.

Data were statistically evaluated by the analysis of variance procedure of SAS software (1998), involving a factorial arrangement of main factor (energy level and method of formulation of AA requirements) in a complete randomize block design. Significant differences between

Table 1: Feed specifications for as-hatched Ross 308 broilers

Nutrients	Age: Starter (0-10)		Grower (11-28)		Finisher (29-slaughter)	
Energy (kcal)	3010		3175		3225	
Protein (%)	22-24		20-22		18-20	
Calcium (%)	1		0.90		0.85	
Available phosphorus (%)	0.50		0.45		0.42	
Sodium (%)	0.16		0.16		0.16	
Amino acid (%)	Total	Digestible	Total	Digestible	Total	Digestible
Arginine (%)	1.53	1.29	1.41	1.19	1.21	1.01
Iso-Leucine (%)	0.90	0.79	0.82	0.72	0.70	0.62
Lysine (%)	1.38	1.16	1.25	1.05	1.05	0.88
Methionine (%)	0.48	0.44	0.46	0.42	0.40	0.37
Methionine+Cystine (%)	0.92	0.81	0.80	0.78	0.78	0.69
Threonine (%)	0.85	0.73	0.79	0.68	0.69	0.59
Tryptophan (%)	0.24	0.21	0.21	0.18	0.18	0.16

Table 2: Chemical analysis of feed ingredients (As fed basis)

	Dry mater	Ash	Crud protein	Ether extract	Crud fibre	Calcium	Total phosphor
	(%)						
Coru	91.24	1.97	8.27	4.28	0.58	0.20	0.50
Soybean meal 44	92.89	6.18	46.55	1.80	3.25	0.27	0.93
Wheat bran	92.08	5.20	15.89	3.96	10.55	0.20	0.73
Canola	92.34	7.14	38.80	1.44	13.04	0.65	1.17
Barley	91.00	2.70	10.00	2.20	6.30	0.04	0.35
Oyster shell	100.00	92.53	-	-	-	26.99	0.05
DCP	96.78	78.42	-	-	-	18.89	18.15

Table 3: Composition and nutrient content (g kg^{-1}) of experimental diets in finisher (28-49 days) period

	3225		3125		3025		2925		2825		2725		2625	
Energy	T	D	T	D	T	D	T	T	D	T	D	T	D	T
Corn	50.26	50.16	54.76	54.78	59.50	59.40	64.21	50.26	50.16	54.76	54.78	59.50	59.40	64.21
Soybean meal 44	29.63	29.31	27.76	27.50	25.89	25.68	24.04	29.63	29.31	27.76	27.50	25.89	25.68	24.04
Wheat bran	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barley	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canola	7.89	8.25	7.49	7.78	7.03	7.30	6.51	7.89	8.25	7.49	7.78	7.03	7.30	6.51
Fatty acid	8.59	8.62	6.41	6.44	4.23	4.26	2.02	8.59	8.62	6.41	6.44	4.23	4.26	2.02
Oyster shell	1.40	1.39	1.35	1.34	1.30	1.29	1.25	1.40	1.39	1.35	1.34	1.30	1.29	1.25
DCP	1.25	1.25	1.17	1.17	1.10	1.10	1.03	1.25	1.25	1.17	1.17	1.10	1.10	1.03
Salt	0.34	0.34	0.33	0.33	0.31	0.31	0.30	0.34	0.34	0.33	0.33	0.31	0.31	0.30
Mineral mix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin mix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DL-Methionine	0.10	0.13	0.09	0.12	0.08	0.11	0.07	0.10	0.13	0.09	0.12	0.08	0.11	0.07
L-Lysine	-	-	-	-	0.01	-	0.03	-	-	-	-	0.01	-	0.03
	Calculated nutrients													
	3225		3125		3025		2925		2825		2725		2625	
Metabolizable energy	T	D	T	D	T	D	T	D	T	D	T	D	T	D
Protein	21.08	21.08	20.42	20.42	19.77	20.42	19.12	20.42	18.46	18.46	17.81	17.81	17.16	17.16
D-protein	17.03	17.04	16.35	16.45	16.03	16.54	15.54	16.54	15.03	15.03	14.43	14.39	13.87	13.84
Calcium	0.85	0.85	0.82	0.82	0.80	0.82	0.77	0.82	0.74	0.74	0.72	0.72	0.69	0.69
Avail. Phos	0.42	0.42	0.41	0.41	0.39	0.41	0.38	0.41	0.37	0.37	0.35	0.35	0.34	0.34
Chlorine	0.23	0.23	0.23	0.23	0.22	0.23	0.22	0.23	0.22	0.21	0.25	0.24	0.26	0.23
Potassium	0.84	0.84	0.81	0.81	0.78	0.81	0.75	0.81	0.73	0.73	0.77	0.78	0.79	0.79
Sodium	0.16	0.16	0.16	0.16	0.15	0.16	0.15	0.16	0.14	0.14	0.14	0.14	0.13	0.13
CF	2.28	2.32	2.20	2.23	2.10	2.23	2.00	2.23	2.00	1.99	3.06	3.00	3.69	2.41
Lysine	1.12	1.12	1.07	1.07	1.03	1.07	1.00	1.07	0.96	0.92	0.93	0.89	0.90	0.86
D-Lys	0.99	0.99	0.95	0.94	0.91	0.94	0.88	0.94	0.85	0.81	0.82	0.78	0.79	0.75
Methionine	0.44	0.48	0.43	0.46	0.41	0.46	0.39	0.46	0.38	0.40	0.37	0.40	0.36	0.39
D-Met	0.41	0.45	0.40	0.43	0.38	0.43	0.37	0.43	0.35	0.38	0.35	0.37	0.33	0.36
Met+Cys	0.82	0.86	0.79	0.83	0.77	0.83	0.74	0.83	0.72	0.75	0.69	0.72	0.67	0.69
D-Met+Cys	0.68	0.72	0.66	0.70	0.64	0.70	0.62	0.70	0.60	0.63	0.58	0.61	0.56	0.59
Threonine	0.72	0.72	0.70	0.69	0.68	0.69	0.65	0.69	0.63	0.63	0.61	0.62	0.59	0.60
D-Thr	0.62	0.62	0.60	0.60	0.58	0.60	0.56	0.60	0.54	0.54	0.51	0.52	0.49	0.50
Isoleucine	0.99	0.99	0.95	0.95	0.92	0.95	0.88	0.95	0.84	0.84	0.81	0.82	0.77	0.78
D-Ile	0.90	0.90	0.87	0.87	0.83	0.87	0.80	0.87	0.76	0.76	0.74	0.75	0.70	0.71
Arginine	1.39	1.39	1.33	1.33	1.28	1.33	1.22	1.33	1.16	1.16	1.08	1.09	1.03	1.06
D-Arg	1.27	1.27	1.22	1.21	1.16	1.21	1.11	1.21	1.06	1.06	0.98	0.99	0.93	0.95
Tryptophan	0.35	0.36	0.34	0.34	0.32	0.34	0.30	0.34	0.28	0.29	0.25	0.24	0.23	0.22
D-Trp	0.31	0.31	0.30	0.30	0.28	0.30	0.27	0.30	0.25	0.25	0.22	0.21	0.21	0.21

D: Diet formulation based on digestible amino acid, T: Diet formulation based on total amino acid, D (AA): Digestible amino acid

means were separated by the GLM procedure of SAS software (1998). Means were compared using Duncan's multiple-range test and significance was determined at $p \le 0.05$ (Duncan, 1955).

RESULTS AND DISCUSSION

Feed intake was not significantly influenced by the way amino acid requirements were expressed in grower period (11-28 days) (Table 4), which is consistent with previously published results from experiments comparing diets based on alternative ingredients with low amino acid digestibility to diets based on ingredients with high amino acid digestibility (corn and soybean meal) and to diets with low digestibility ingredients supplemented with synthetic amino acids (Rostagno *et al*., 1995; Dari and Penz, 1996).

Formulation of finisher diet based on total or digestible AA had significant effect on feed intake ($p<0.05$). Diet formulation based on digestible AA resulted on decreasing feed intake in finisher period (Table 4). It seems that, reduced food intake observed in formulated rations based on digestible AA, is due to ability of this formulation method to balance rations close to broilers requirements, because amino acids existing in foods are not fully digestible by chicks and the capability of different foods in digesting amino acids varies. As reported by other researches Parsons (1991) and Fernandez *et al*. (1995), by increasing the amount of food intake in the finisher period, the superiority of diets formulated based on digestible amino acids in formulating more balanced diets was observed. The diet energy level had significant effect on the amount of food intake in grower period ($p<0.05$). By decreasing the diet energy

Table 4: Performance of broiler fed diets formulated based on total and digestible amino acid

Composition		Main effects					
ME level		Feed intake (g)		Body weight gain (g)		Feed conversion (g g^{-1})	
Grower	Finisher	Grower	Finisher	Grower	Finisher	Grower	Finisher
3175	3225	1491^{a}	3084	1065^{a}	1511^{a}	1.40^{d}	2.10^{b}
3075	3125	1462^{ab}	3106	975^{b}	1448^{a}	1.51^{c}	2.15^{b}
2975	3025	1414^{abc}	3195	886^{c}	1445^{a}	1.56^{c}	2.21^{b}
2875	2925	1378^{bc}	3195	793^{d}	1495^{a}	1.80^{b}	2.17^{b}
2775	2825	1332^{c}	3192	755^{d}	1450^{a}	1.76^{b}	2.19^{b}
2675	2725	1323^{c}	3194	679^{e}	1422^{ab}	1.95^{a}	2.28^{ab}
2575	2625	1328^{c}	3168	673^{e}	1250^{b}	1.96^{a}	2.56^{a}
Amino acid		Main effects					
Total		1393	3331^{a}	845	1431	1.69	2.36^{a}
Digestible		1386	2975^{b}	821	1435	1.72	2.11^{b}

	Probability											
	F											
AA	0.78	0.07	0.0001	17.79	0.19	1.78	0.94	0.01	0.36	0.85	0.01	4.80
E	0.01	3.26	0.98	0.17	0.0001	39.37	0.01	15.40	0.0001	19.07	0.01	5.58
AA*E	0.99	0.14	0.23	1.14	0.02	2.73	0.99	0.03	0.10	1.88	0.77	0.53

^{abc}: Means in the same column with a different superscript are significantly different ($p<0.05$)

level, the amount of food intake decreased also (Table 4). This decrease was due to the required increment in the amount of food intake which encountered the barrier of low capacity of chicks GIT, while the latter was the consequence of insufficient grower of chicks in the ages of 11 to 28 days, which is in accordance with results obtained by National Research Council (1994).

The amount of food intake in the finisher period was not influenced by the diet energy level (Table 4). Sunder *et al.* (1988) proved that there is a reverse relationship between capacity of GI tract and diet energy level. Therefore, consuming dilute energy in the starter period allowed chicks to meet their total energy requirements by having more food intake in the finisher period and showed that, by taking low-calorie diets, chicks consume energy more efficiently. Thus an increase of 100 kcal kg^{-1} of energy in the finisher period diets along with more efficient energy consumption resulted in no significant influence on the amount of food intake in the finisher period.

Diet formulation based on amino acids had no significant effect on the weight gain of chicks in the grower and the finisher periods (Table 4). This is in accordance with results obtained by other researchers (Maiorka *et al.*, 2004; Farrell *et al.*, 1999; Dari and Penz, 1996).

The diets energy level had significant effect on chicks weight gain in the grower period ($p<0.05$). By decreasing the diet energy level, the rate of weight gain of chicks was reduced (Table 4). The results showed that the best energy level in the grower period is 3175 kcal kg^{-1}. Researchers have reported that, especially in grower period, broilers weight gain is influenced by diet energy level and therefore, high energy-level diets in comparison with low energy-level ones result in significant increment in the rate of grower (Donaldson, 1985; Hussein *et al.*, 1996; Leeson *et al.*, 1996).

By increasing the diet energy level in the finisher period, weight gain was improved but this was not statistically significant (Table 4). Hence, the diet can be diluted up to 2725 kcal kg^{-1} in the finisher period.

Increment food intake in finisher period (28-49 days) along with more efficient energy consumption resulted to same weight gain in all levels of energy diet (Olumu and Offiong, 1980). Method of diet formulation based on AA had no significant effect on feed conversion ratios in grower and finisher periods (Table 4). These results obtained in previous researches (Farrell *et al.*, 1999; Fernandez *et al.*, 1995; Maiorka *et al.*, 2004).

Feed conversion ratios had better with diet formulation based on digestible AA in finisher period ($p<0.05$) (Table 4). These result showed when diet formulation based on digestible AA was balanced, provided chicken requirements and reduced food in take. Results showed that by increasing levels of energy in diet feed conversion ratios was decreased in grower period ($p<0.05$). Because decreasing level of energy diet had significant effected on broiler efficiency on grower period (Sizemore and Siegel, 1993; Pirgozlieve and Rose, 1999). Feed conversion ratios had no influence significant decreasing level of ME diet until 2725 kcal kg^{-1} in finisher period (Table 4). These result was agreement whit those obtained by Leeson *et al.* (1996).

Interaction effect of independent factors affected just on weight gain in grower period ($p<0.05$). The evaluation of the contrasts showed that the formulation of diet based on digestible AA was best when diets contained the low energy level. For rations with low energy level, we usually

Table 5: Carcass yields of broiler fed diets formulated based on total and digestible AA with different levels of ME

ME level		Main effects				
Grower	Finisher	Carcass	Digestion system	Abdominal fat	Liver	Heart
		(%)				
3175	3225	73.80	9.79^{b}	2.44^{a}	2.05	0.47^{a}
3075	3125	72.79	9.89^{b}	2.33^{ab}	2.12	0.46^{a}
2975	3025	74.27	10.01^{b}	2.25^{abc}	2.07	0.46^{a}
2875	2925	73.98	10.28^{b}	2.02^{abc}	2.09	0.43^{b}
2775	2825	73.55	10.44^{b}	1.85^{bc}	2.05	0.43^{b}
2675	2725	73.07	11.46^{a}	1.69^{c}	2.12	0.42^{b}
2575	2625	72.30	11.84^{a}	1.71^{c}	2.18	0.42^{b}
Amino acid		Main effects				
Total		73.26	10.74^{a}	1.90	2.11	0.64
Digestible		73.53	10.23^{b}	2.07	2.11	0.43
		Probability				
AA		0.21	0.01	0.69	0.45	0.34
E		0.10	0.001	0.001	0.26	0.01
AA*E		0.073	0.08	0.11	0.16	0.81

^{abc}: Means in the same column with a different superscript are significantly different (p<0.05)

use low digestible food stuff. So, formulation according to digestible AA is close to chickens requirements and chickens that feed with these rations (low energy levels), have suitable performance.

Carcass yield of broiler received dietary treatment are shown in Table 5. Results showed that formulation based on AA did not influence carcass yield, independent of the dietary energy level (Table 5). Also interaction effect of energy and method of diet formulation had no significant on carcass yield (Maiorka *et al*., 2004, 2005). Level of ME diet had significant effect on GIT ($p<0.05$), diet contained low energy levels eventuate increasing GIT weight (Table 5). Results Diet formulation method (digestible or total amino acids based) had significant effect on the weight share of digestive system from total body mass ($p<0.05$) and this ratio was lower in chicks fed by the diet formulated based on digestible amino acids. This is in accordance with the results of previous studies (Sunder *et al*., 1988; Waldroup *et al*., 1990). As diets energy level increased, abdominal fat pad increased significantly ($p<0.05$). Diet formulation based on amino acids had no significant effect on abdominal fat pad (Table 5). As many previous experiments have reported, abdominal fat pad increases as diet energy level goes up (Maiorka *et al*., 2004; Farrell *et al*., 1999; Rostagno *et al*., 1995).

Liver weight share from total body mass was not affected by formulation method or diet energy level (Table 5). In high energy-level diets, formulation based on amino acids had no negative effect on liver, which is in accordance with Mairoka *et al*. (2004) findings. Heart weight share from total body mass was affected by diet energy level ($p<0.05$).These result may be related to higher metabolism in chicks fed high density diets (Table 5). The results of this study demonstrate that employing thick diets in grower period (ages of 11 to 28 days) and using diets diluted up to 2725 kcal kg^{-1} and formulated based on digestible amino acids in finisher period results in performance improvement and by reducing cost price leads to significant economical benefits.

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