ISSN 1682-8356
ansinet.org/ijps

INTERNATIONAL JOURNAL OF POULTRY SCIENCE

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

International Journal of Poultry Science 8 (5): 508-511, 2009
ISSN 1682-8356

Effects of Dietary Energy and Protein on Growth Performance and Carcass Quality of Broilers during Starter Phase

Zhuye Niu, Jingsong Shi, Fuzhu Liu, Xianhui Wang, Chunqi Gao and Likai Yao
College of Animal Science and Technology, Northwest A and F University,
Yangling, 712100 Shaanxi, P.R. China

Abstract: A 3x4 factorial arrangement with three Metabolizable Energy (ME) levels (12.13, 12.55, 12.97 MJ/kg) and four Crude Protein (CP) levels (20.0, 21.0, 22.0 and 23.0%), respectively, was undertaken to investigate the influence of varying levels of dietary energy and protein on broiler performance and carcass quality from 1-21 d aysof age. Six hundred 1 day old broiler chicks were randomly divided into 12 treatments, each of which had five replicates of 10 birds. BW of 21 days of age was significantly increased with an increase in dietary ME ($p<0.05$), while not influenced by dietary CP ($p>0.05$). Both ME and CP significantly improved feed efficiency ($P<0.05$). ME significantly affected on feed intake, while CP not affected. However, there were no significant interaction in BW, average daily gain, feed intake and feed efficiency between dietary ME and CP. Higher level of dietary ME (12.97 MJ/kg) significantly increased abdominal fat percentage when compared with lower ME (12.13MJ/kg or 12.55 MJ/kg). L* of leg meat was decreased by dietary ME, while *L** of breast meat was not affected. *a** of both breast meat and leg meat was increased with increasing dietary ME and CP. *b** of leg meat was decreased by ME while b* of breast meat was not affected. Water-holding capacity (WHC) of breast meat was decreased by dietary ME, while increased by dietary CP. The results of present research indicated that the optimal dietary ME requirement of broilers from 1-21 days of age is 12.97 MJ/kg and the CP requirement is 21-22%.

Key words: Broiler, energy, protein, growth performance, carcass quality

INTRODUCTION

Foods derived from animal products are an important source of nutrients in human diet and play an increasing role in the human nutrition in future (Givens, 2005). In all aspects of animal products, growth of poultry meat production, in particular chicken meat, has been very speedy over the last decades and up to now occupies second place in volume in the world just following pork, becoming a type of the cheapest food derived from animals worldwide. However, more and more concerns have being focused on poultry meat quality and its food safety (Le Behan-Dval, 2004). The quality of the meat is mainly influenced by genotype of animals and its environment, especially either nutrients or stress undergone during growing period or before slaughter. With the rapid expansion of the fast-food trade and increased public awareness of excess fat as a possible health hazard, the large amount of carcass fat in the modern broiler chicken is being questioned and criticized more and more by processors and consumers. Energy and protein are important nutrients, representing majority of total cost of the diets for animals. All activities of animals, including breathe, palpitation, blood cycle, muscle movement, growth and producing products etc., need energy mainly derived from feeds. Protein is the key component of cell, playing an important role in the process of life. Growth rate and feed efficiency of broilers were improved with increase in dietary protein or energy. However, a significant interaction between protein and energy indicated the importance of a balanced energy: protein ratio to achieve optimum performance (Jackson *et al.*, 1982b; Wang and Liu, 2002). The research showed that broiler carcass composition could be altered through manipulation of dietary protein or energy (Fraps, 1943; Marion and Woodroof, 1966; Velu and Baker, 1974; Twining *et al.*, 1978; Jackson *et al.*, 1982a; Chen *et al.*, 1998). Seaton *et al.* (1978) observed an increase in carcass fat and a decrease in moisture with an increase in the dietary energy level while, carcass protein unaffected. This is in contrast to the reports of Summers *et al.* (1965) and Velu and Baker (1974). The present study was undertaken to investigate the influence of varying levels of dietary energy and protein on broiler performance and carcass quality from 1-21 days of age.

MATERIALS AND METHODS

Experimental design and birds: This experiment was conducted according to protocols approved by the Northwest A and F University Animal Care and Use Committee. A total of 600 1 day old Avian broiler chicks were obtained from a local hatchery and randomly divided into 12 groups, each group had five replicates and each replicate contained 10 birds. These birds were randomly assigned to 12 dietary treatments (Table 1) in a 3x4 factorial arrangement with three Metabolizable

Table 1: Ingredients and nutrient level of experimental diets

Ingredients (%)	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7	Diet 8	Diet 9	Diet 10	Diet 11	Diet 12
Corn	64.20	61.50	58.40	55.60	62.00	58.80	56.00	53.30	59.70	56.60	53.60	51.00
Soybean meal	29.20	31.30	33.10	34.80	29.50	31.80	33.60	34.60	29.90	32.20	34.20	35.30
Corn-gluten meal	1.20	1.68	2.56	3.30	1.20	1.70	2.50	3.70	1.30	1.70	2.30	3.50
$CaHPO_4$	1.55	1.50	1.50	1.50	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
Limestone	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fish meal	1.68	1.80	1.80	2.00	1.78	1.80	1.85	2.10	1.70	1.80	1.90	2.10
Corn oil	0.32	0.37	0.79	0.95	2.12	2.50	2.65	2.90	4.00	4.30	4.60	4.70
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Premix[1]	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Calculated analysis[2]												
CP (%)	20.00	21.00	22.00	23.00	20.00	21.00	22.00	23.00	20.00	21.00	22.00	23.00
ME (MJ/kg)	12.13	12.13	12.13	12.13	12.55	12.55	12.55	12.55	12.97	12.97	12.97	12.97
Ca (%)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
AP (%)	0.43	0.42	0.42	0.43	0.43	0.43	0.43	0.44	0.42	0.43	0.43	0.44
Lysine (%)	1.10	1.16	1.21	1.26	1.11	1.16	1.21	1.25	1.11	1.17	1.22	1.26
Methionine (%)	0.31	0.33	0.34	0.36	0.31	0.32	0.34	0.36	0.31	0.32	0.34	0.36
Met+Cys (%)	0.63	0.66	0.69	0.72	0.63	0.66	0.69	0.72	0.63	0.66	0.69	0.72

[1]Provided/kilogram of diet: Vitamin A, 12,000 IU; Vitamin E, 10 mg; Vitamin D_3, 2,200 IU; niacin, 35.0 mg; D-pantothenic acid, 12 mg; riboflavin 3.6 mg; pyridoxine, 3.5 mg; thiamine, 2.4 mg; menadione,1.3 mg; folic acid, 1.4 mg; biotin,0.15 mg; Vitamin B_{12}, 0.03 mg; Mn, 60 mg; Zn, 40 mg; Fe, 80 mg; Cu, 8 mg; I, 0.3 mg; Se, 0.2 mg, [2]ME value is calculated, the other nutrition levels are analysized

Energy (ME) levels (12.13, 12.55, 12.97 MJ/kg) and four Crude Protein (CP) levels (20.0, 21.0, 22.0 and 23.0%), respectively, from 1-21 days of age. The diets were fed in mash form. The birds were provided feed and water *ad libitum* throughout the experimental period and feed intake and BW were recorded weekly. The photoperiod was set at 22L: 2D throughout the whole experimental period. Room temperature was at 35°C at the first day and gradually reduced 2-3°C weekly.

Processing procedure: At 21 days of age, two birds from each replicate were slaughtered after a 12 h fast and access to water *ad libitum* to measure eviscerated carcass percentage, breast meat percentage, leg meat percentage, abdominal fat percentage.

Muscle pH: At 30 min post-mortem, the breast and leg muscle pH was, respectively determined at a depth of 2.5 cm below the surface by using a Model PH-211 Meter equipped with a spear electrode.

Color measurement: The surface color of chicken rolls was measured in package using a Hunter Lab Scan colorimeter and expressed as color *L**- (lightness), *a**- (redness) and *b**- (yellowness) values. A color reading was taken from both sides of rolls. The same packaging materials were used to cover a white standard plate in order to eliminate the influence of packaging material on meat color.

Water-holding capacity: Water-Holding Capacity (WHC) was estimated by determining expressible juice using a modification of the filter paper press method described by Wierbicki and Deatherage (1958). Briefly, a raw meat sample weighing about 1,000 mg was placed between 18 pieces of 11 cm-diameter filter paper and pressed at 35 kg for 5 min. Expressed juice was defined as the loss in weight after pressing and presented as a percentage of the initial weight of the original sample (Bouton *et al*., 1971).

Shear force: The muscles were refrigerated overnight at 4°C and then brought to room temperature before cooking. The breast muscle from each bird was cooked to an internal temperature of 70°C on a digital thermostat water bath (HH-4, Jiangbo instrument, Jiangsu, China). End point internal temperature was monitored with a thermometer. Cooked muscle was cooled to room temperature. Slices of 1x1 cm were cut perpendicular to the fiber orientation of the muscle. Ten 1x1x1x1 cm cores about 3 cm thick were removed parallel to the fiber orientation through the thickest portion of the cooked muscle. Warner-Bratzler shear force was determined by using an Instron Universal Mechanical Machine (Instron model 4411, Instron Corp., Canton, MA). A Warner-Bratzler apparatus was attached to a 50 kg load cell and tests were performed at a cross head speed of 127 mm min^{-1}. Signals were processed with the Instron Series ninth software package.

Statistical analysis: All the date were analyzed statistically using the general linear model procedure (SAS Institute, 1996) and the treatment means were separated by Duncan's multiple range test.

RESULTS AND DISCUSSION

The effect of dietary ME or CP on broiler growth performance from hatch to 21 days of age was placed in Table 2. BW of 21 days of age was significantly increased with an increase in dietary ME ($p<0.05$), while not influenced by dietary CP ($p>0.05$). Average daily gain was significantly influenced by dietary ME ($p<0.05$).

Although, there was a tendency to increase in average daily gain with increase in dietary CP, no significant

Table 2: Effects of energy and protein on broiler growth performance from 1-21 days of age

ME (MJ/kg)	CP (%)	Feed intake (g/d/bird)	Daily gain (g/d/bird)	Feed: gain	21 days BW (g)	ME consumed per gain (KJ/g)	CP consumed per gain (g)
12.13		31.66^{a}	23.55^{a}	1.35^{a}	0.54^{a}	16.32	0.29^{a}
12.55		32.24^{b}	24.72^{b}	1.31^{b}	0.57^{b}	16.38	0.28^{b}
12.97		31.88^{ab}	25.31^{c}	1.27^{c}	0.58^{c}	16.42	0.27^{c}
	20.0	32.10	24.19	1.33a	0.55	16.67^{a}	0.27^{a}
	21.0	32.03	24.50	1.31b	0.56	16.43^{b}	0.28^{b}
	22.0	31.91	24.70	1.29bc	0.56	16.21^{bc}	0.28^{b}
	23.0	31.68	24.72	1.29c	0.57	16.18^{c}	0.27^{a}
SEM		0.65	0.76	0.25	0.02	0.31	0.01
Probability							
ME		0.0234	<0.0001	<0.0001	<0.0001	NS	<0.0001
CP		NS	NS	0.0002	NS	0.0002	<0.0001
MExCP		NS	NS	NS	NS	NS	NS

Table 3: Effects of energy and protein on carcass yield of broilers at 21 days of age (%)

ME (MJ/kg)	CP (%)	Dressing Percentage	Eviscerated Percentage	Semi-eviscerated Percentage	Breast meat Percentage	Leg meat Percentage	Abdominal fat
12.13		94.03	64.18	81.15^{a}	11.68	12.93^{a}	1.19^{a}
12.55		93.77	65.13	82.77^{b}	11.65	13.19^{ab}	1.34^{a}
12.97		93.68	65.58	83.29^{b}	11.16	13.59^{b}	1.56^{b}
	20.0	93.92	64.95	82.42	11.51	13.29	1.41
	21.0	93.74	65.43	82.78	11.54	13.58	1.31
	22.0	93.84	65.30	82.59	11.67	12.98	1.44
	23.0	93.81	64.16	81.81	11.73	13.09	1.29
SEM		0.01377	0.0189	0.0165	0.0046	0.0036	0.00254
Probability							
ME		NS	NS	0.0004	NS	0.0197	0.0002
CP		NS	NS	NS	NS	NS	NS
MExCP		NS	0.0411	NS	NS	NS	NS

effect of CP on average daily gain was observed ($p>0.05$). Both ME and CP significantly improved feed efficiency ($p<0.05$). ME significantly affected on feed intake, while CP not affected. These results were agreed with previous reports by Jackson *et al.* (1982b) and Wang and Liu (2002). However, there were no significant interaction in BW, average daily gain, feed intake and feed efficiency between dietary ME and CP. This result was disagreed with the report of Jackson *et al.* (1982b). ME consumed per gain was significantly affected by dietary CP ($p<0.05$) while not influenced by dietary ME ($p>0.05$). CP consumed per gain linearly decreased with increasing dietary ME, which indicated the efficiency of protein utilization was increased as dietary ME was increased, this result was in agreement with the result reported by Velu and Baker (1974).

The effect of dietary ME or CP on broiler carcass yield was showed in Table 3. Dietary ME significantly influenced semi-eviscerated carcass percentage leg meat percentage and abdominal fat percentage. Although, semi-eviscerated carcass (with giblet) percentage was increased ($p<0.05$) with increasing dietary ME from 12.55-12.97 MJ/kg, differences in semi-eviscerated carcass percentage of birds fed 12.55 and 12.97 MJ/kg were not significant. Higher level of dietary ME (12.97 MJ/kg) significantly increased abdominal fat percentage when compared with lower ME (12.13 and 12.55 MJ/kg). No significant influence of dietary CP on broiler carcass yield was observed in this experiment.

The index of animal growth performance is often considered as a classical indicator on the requirements of animal dietary CP and ME. But it is not always able to reflect the requirements of the best carcass components of animals, therefore, it is necessary to further consider the carcass traits of animal. Based on this study, we considered abdominal fat percentage as a sensitive carcass characteristic index on the research of dietary CP and ME requirements.

The effect of ME or CP on meat quality of broilers at 21 days of age was presented in Table 4 and 5. The results indicated that there was significant influence of dietary ME or CP on broiler meat quality at 21 days of age.

L^* of leg meat was decreased by dietary ME, while, L^* of breast meat was not affected. a^* of both breast meat and leg meat was increased with increasing dietary ME and CP. b^* of leg meat was decreased by ME while, b^* of breast meat was not affected.

WHC of breast meat was decreased by dietary ME, while increased by dietary CP. Although, pH in both breast meat and leg meat was decreased by increasing dietary ME from 12.55-12.97 MJ/kg, differences in pH between 12.55 and 12.97 MJ/kg of ME were not significant. Shear force of breast meat was decreased by dietary ME while, shear force of leg meat was not affected. There were no effect of dietary CP on pH and shear force both in breast meat and leg meat.

In general, based on the data of growth performance, carcass yield and meat quality, it was indicated that

Table 4: Effects of energy and protein on meat color of broilers

ME MJ/kg	CP (%)	Breast meat *L**	Breast meat *a**	Breast meat *b**	Leg meat *L**	Leg meat *a**	Leg meat *b**
12.13		31.22	12.22^{a}	17.41	36.44^{a}	12.99^{a}	18.77^{a}
12.55		30.26	15.24^{ab}	16.91	32.12^{b}	16.29^{b}	17.34^{ab}
12.97		29.31	16.24^{b}	16.28	34.26^{ab}	17.25^{b}	16.10^{b}
	20.00	29.85	14.36^{a}	17.32^{ab}	34.33	15.18^{a}	18.75^{a}
	21.00	31.12	13.28^{a}	16.51^{bc}	35.84	13.54^{b}	16.43^{b}
	22.00	30.90	14.66^{ab}	15.38^{c}	34.99	16.29^{ac}	16.25^{b}
	23.00	29.18	15.96^{b}	18.25^{a}	31.94	17.03^{c}	18.19^{ab}
SEM	2.76	1.88	1.86		3.93	2.05	2.71
Probability							
ME		NS	<0.0001	NS	0.0047	<0.0001	0.0112
CP		NS	0.0036	0.001	NS	0.0002	0.0312
MExCP		0.0003	0.0011	0.0265	0.0043	0.0014	0.0339

Table 5: Effects of energy and protein on meat quality of broilers at 21 days of age

ME MJ/kg	CP (%)	Shear force (N) Breast muscle	Shear force (N) Leg muscle	PH Breast muscle	PH Leg muscle	WHC (%) Breast muscle	WHC (%) Leg muscle
12.13		16.43^{a}	26.47	6.37^{a}	6.38^{a}	18.14^{a}	20.82^{a}
12.55		10.82^{b}	28.49	6.00^{b}	6.16^{b}	15.38^{b}	14.77^{b}
12.97		10.68^{b}	30.40	6.01^{b}	6.13^{b}	13.45^{b}	18.74^{a}
	20.0	15.27	28.88	6.30	6.36	13.24^{a}	18.10
	21.0	13.65	27.33	6.31	6.29	15.65^{ab}	18.39
	22.0	11.35	28.26	6.01	6.16	17.04^{b}	18.49
	23.0	10.30	29.34	6.01	6.36	16.69^{b}	17.45
SEM	5.88	5.62	0.38	0.26	0.04	0.05	
Probability							
ME		0.004	NS	0.0029	0.0068	0.0011	0.0008
CP		NS	NS	NS	NS	0.03	NS
Me x CP		NS	NS	NS	NS	NS	NS

the optimal dietary ME requirement of broilers from 1-21 days of age is 12.97 MJ/kg and the CP requirement is 21-22%.

ACKNOWLEDGMENT

Financial support provided by the National Basic Research Program of China (Project 2006BAD12B02-07) is gratefully acknowledged.

REFERENCES

Bouton, P.E., P.V. Harris and W.R. Shorthose, 1971. Effect of ultimate pH upon the water-holding capacity and tenderness of mutton. J. Food Sci., 36: 435-439.

Chen, J.W., S. Yang and K.H. Mo, 1998. Effect of dietary protein and energy on abdominal fat and blood lipids of broilers. Chinese J. Anim. Nutr., 1: 22-28.

Fraps, G.S., 1943. Relation of The protein, fat and energy of the ration to the composition of chickens. Poult. Sci., 22: 421-424.

Givens, D.I., 2005. The role of animal nutrition in improving the nutritive value of animal-derived foods in relation to chronic disease. Proc. Nutr. Soc., 64: 395-402.

Jackson, S., J.D. Summers and S. Leeson, 1982a. Effect of dietary protein and energy on carcass composition and efficiency of nutrient utilization. Poult. Sci., 61: 2224-2231.

Jackson, S., J.D. Summers and S. Leeson, 1982b. Effect of dietary protein and energy on broiler performance and production cost. Poult. Sci., 61: 2232-2240.

Le Behan-Dval, E., 2004. Genetic variability within and between breeds of poultry technological meat quality. World's Poult. Sci. J., 60: 331-340.

Marion, J. E. and J.G. Woodroof, 1966. Composition and stability of broiler carcass as affected by dietary protein and fat. Poult., Sci., 45: 241-247.

SAS, 1996. SAS? User's Guide: Statistics. SAS Institute Inc., Cary, NC.

Seaton, K.W., O.P. Thomas, R.M. Gous and E.H. Bossard, 1978. The effect of diet on liver glycogen and body composition in the chick. Poult. Sci., 57: 692-698.

Summers, J.D., S.J. Slinger and G.C. Ashton, 1965. The effect of dietary energy and protein on carcass composition with a note for estimating carcass composition. Poult. Sci., 44: 501-509.

Twining, P.V., O.P. Thomas and E.H. Bossard, 1978. Effect of diet and type of birds on the carcass composition of broilers at 28, 49 and 59 days of age. Poult. Sci., 57: 492-497.

Velu, J.G. and D.H. Baker, 1974. Body composition and protein utilization of chicks fed graded levels of fat. Poult. Sci., 53: 1831-1838.

Wang, S.Y. and H.Y. Liu, 2002. Effect of different energy and protein on production performance of broilers. Shandong Agric. Sci., 4: 43-44.

Wierbicki, E. and F.E. Deatherage, 1958. Determination of water-holding capacity of fresh meats. Agric. Food Chem., 6: 387-392.