Effect of Choice Feeding on Performance, Gastrointestinal Development and Feed Utilization of Broilers

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ABSTRACT : The experiment was conducted to study the effect of choice feeding on growth performance, carcass quality, gastrointestinal development and feed utilization of 22-49 days old broilers. One hundred and forty four 22-day-old broilers were randomly allocated to 3 treatments with 4 replicates per treatment and 12 birds per replicate. Three feeding regimes are complete diet (control), ground corn and protein concentrate (treatment I), and soybean meal and balancer (treatment II). Protein concentrate is the residue part of complete diet without corn, and balancer is the residue part of complete diet without soybean meal. Treatment I and II are designed for the broilers to freely choose the two parts of diet. The results showed that: (1) broilers under choice feeding (treatment I and II) had lower performances compared with the control; (2) gastrointestinal development and the efficiency ratios that broilers converted dietary crude protein and lysine to body weight gain were improved in treatment I ($p<0.05$); (3) there were no significant differences in the apparent metabolizabilities of dietary dry matter, crude protein and gross energy, and deposition ratios of dietary nitrogen and energy, and carcass quality among three feeding regimes ($p>0.05$). ***(Asian-Aust. J. Anim. Sci. 2006. Vol 19, No. 1 : 91-96)***

Key Words : Choice Feeding, Broiler, Performance, Nutrient Utilization, Gastrointestinal Development

INTRODUCTION

When two or more types of diets which have different palatability, color, smell, form and nutritional characters are available at the same time, poultry can select what they need to meet their requirements. This ability, named nutritional wisdom, is much stronger than domestic fowls (Shariatmadari and Forbes, 1993; Yao and Wang, 1998). Choice feeding, which based on nutritional wisdom, has both positive and negative effects on poultry performance (Forbes and Corasa, 1995). In most cases, choice feeding can increase the economic performance of poultry production, improve health status and gastrointestinal tract development (Mastika and Shariatmadari, 1985; Forbes and Shariatmadari, 1994), decrease the incidence of ascites and coccidiosis, and improve the immunity (Jones and Taylor, 2001). Most researches demonstrated mainly the effect of choice feeding on layer performance. In the present experiment, our objective was to evaluate the influence of choice feeding on growth performance, carcass quality, gastrointestinal development and feed utilization of broilers.

MATERIALS AND METHODS

Animals and diet

144 Avian broilers of 22 days old which had the similar weight and were in health status were randomly allocated to 3 treatments with 4 replicates per treatment and 12 birds per replicate. All broilers were put into two-layer cages. Each treatment had two feed troughs and one water trough. The broilers were fed freely and house temperature kept at 16-21°C during the experiment with 24 h lighting. Three dietary regimes were offered: complete diet (control), ground corn+protein concentrate (G+P, treatment I), soybean meal+balancer (S+B, treatment II). Based on the same nutrition level, protein concentrate is the complete diet without corn (66.85% corn+33.15% protein concentrate makes complete diet), and balancer is the complete diet without soybean meal (27.70% soybean meal +72.30% balancer makes complete diet). The complete diet was put into 2 troughs in each replicate. For other two choice feeding regimes, the two parts of the diet were put into two different troughs, respectively. The experimental diets were shown in Table 1.

Sample collection

Broilers were weighed on 22 and 49 days old and fasted for 12 h before weighing. The average daily feed intake (ADFI), average daily gain (ADG) and feed conversion ratio (FCR) were calculated. All the excreta of broilers were collected daily on 39-41 day, and then 3% H_2SO_4 (10% w/v) and 0.5% formaldehyde of excreta was added immediately. The excreta was dried at 65°C until their weights were consistent, then the samples were sealed and stored in a refrigerator for further analyses.

After fasting for 12 h, eight broilers of 22 days old and twenty-four of 49 days old were killed (two broilers per replicate). Live weight, dressed weight and percentage, carcass weight and percentage, breast muscle weight and percentage, thigh muscle weight and percentage, abdominal

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Table 1. Compositions and nutrition levels of the experiment diets (%, MJ/kg, 90% dry matter basis)

Item	Complete diet	Corn	Protein concentrate	Soybean meal	Balancer
Ingredient					
Corn	66.85	100	-	-	92.46
Soybean meal	27.70	-	83.56	100	-
Soybean oil	0.90	-	2.71	-	1.24
Dicalcium phosphate	2.10	-	6.33	-	2.90
Limestone	0.81	-	2.44	-	1.12
Sawdust	0.39	-	1.18	-	0.54
Lysine-HCl	0.17	-	0.51	-	0.24
Methionine	0.08	-	0.24	-	0.11
Compound premix[a]	1.00	-	3.02	-	1.38
Composition					
Crude protein[b]	18.50	8.73	38.20	45.12	8.30
Calcium[b]	0.90	0.10	2.52	0.51	1.05
Total phosphorus[b]	0.65	0.25	1.46	0.60	0.67
Available phosphorus[c]	0.50	0.12	1.27	0.32	0.57
Lysine[b]	1.00	0.24	2.53	2.53	0.41
Methionine[b]	0.39	0.19	0.80	0.68	0.28
Methionine+cystine [c]	0.71	0.41	1.39	1.36	0.46
Threonine[b]	0.76	0.31	1.65	1.99	0.29
Tryptophan[b]	0.24	0.06	0.61	0.71	0.06
Isoleucine[b]	0.68	0.25	1.55	1.85	0.23
Aapparent metabolizable energy[c]	12.26	13.59	9.57	10.04	13.11
Linoleic acid (C18:2)[c]	2.05	2.00	2.16	0.77	2.54
Crude fiber[b]	2.90	1.66	5.40	5.25	2.00

[a] Compound premix: 20% NaCl, 20% $NaHCO_3$, 15% compound minerals for broilers, 10% choline chloride (50%), 15% compound enzyme preparation, 3% compound vitamins, 3% zinc bacitracin (10% content), 5% antioxidant, 2% diclazurill (10% content), 7% diluter. Compound premix provide per kg of complete diet: 10,500 IU of vitamin A, 2,500 IU of vitamin D_3 , 15 IU of vitamin E, 8 mg of vitamin K_3, 1 mg of vitamin B_1, 5 mg of vitamin B_2, 10 mg of niacin, 10 μg of vitamin B_{12}, 10 mg of niacin, 8 mg of pantothenic acid, 0.2 mg of folic acid , 0.18 mg of biotin, 3 mg of vitamin B6, 40 mg of Fe, 8 mg of Cu, 60 mg of Mn, 40 mg of Zn, 0.4 mg of I, and 0.2 mg of Se.
[b] Analyzed. [c] Calculated.

fat percentage, relative weight of gizzard and small intestines and the length of small intestines were measured.

Laboratory analysis

Based on slaughter traits, birds were killed without loosing blood, wiping off the craws and digesta. The feather and the broiler body were weighted separately.

- Dressed weight: weight without blood and feather
- Carcass weight: slaughter weight without viscera (kidney, lung, head and claws reserved)
- Breast muscle weight: the weight of pectoralis major, pectoralis minor and the third breast muscle on the left and right
- Thigh muscle weight: the weight of big and small thigh
- Abdominal fat weight: the fat in abdomen and around gizzard
- Small intestine length: the length from duodenum to the junction of ileum and cecum

Dressing percentage = dressed weight/live weight
Carcass percentage = carcass weight/live weight
Breast muscle percentage
= breast muscle weight/carcass weight
Thigh muscle percentage
= thigh muscle weight/carcass weight
Abdominal fat percentage
= abdominal fat weight/live weight
Relative small intestine weight
= small intestine weight/dressed weight
Relative gizzard weight
= gizzard weight/ dressed weight

The nitrogen, amino acid, calcium, phosphorus and crude fiber of diet, feed ingredients and broiler body were determined (AOAC, 1984).

$$\text{CP or energy deposition ratio (\%)} = \frac{\text{Increment of body CP or energy during experiment}}{\text{Intake of CP or energy during experiment}} \times 100$$

Statistical analysis

Differences between treatments and control were analyzed as a one-way factorial design by repeated measures analyses of variance using General Linear Model procedures of the SPSS program (SPSS 11.0).

Table 2. Effect of different feeding regimes on performance of broilers*

Items	Control	Treatment I	Treatment II
ADG (g/d)	57.2±0.5[c]	54.0±0.8[b]	49.6±0.4[a]
ADFI (g/d)	122.3±2.1	124.6±1.9[1]	120.9±3.3[2]
ADFI/weight gain	2.14±0.05[a]	2.31±0.03[ab]	2.44±0.08[b]
Protein intake/weight gain	0.396±0.010[b]	0.355±0.004[a]	0.395±0.012[b]
Lysine intake/weight gain	0.021±0.001[b]	0.019±0.001[a]	0.022±0.001[b]

* Values in the same row with different letters mean p<0.05 and the following tables are the same.

[1] Intake of ground corn and protein concentrate is 97.1 g/d and 27.5 g/d.

[2] Intake of soybean meal and balancer is 25.6 g/d and 95.3 g/d.

Table 3. Effect of different feeding regimes on carcass parameters

Items	Control	Treatment I	Treatment II
Dressing percentage (%)	92.6±0.6	93.3±0.5	92.8±0.7
Carcass percentage (%)	77.3±0.6	76.4±0.4	76.6±0.4
Abdominal fat percentage (%)	1.7±0.2	2.3±0.2	1.8±0.2
Breast muscle percentage (%)	20.7±0.8	19.2±0.6	19.4±0.4
Thigh muscle percentage (%)	22.5±1.0	23.8±0.7	23.8±0.6
CP in living weight (%)	21.6±0.3[b]	19.9±0.7[a]	20.8±0.5[ab]
Energy in living weight (MJ/kg)	9.3±0.4	10.8±0.6	9.1±0.6

Table 4. Effect of different feeding regimes on gastrointestinal development

Items	Control	Treatment I	Treatment II
Gizzard weight (g)	34.22±1.95[a]	41.29±1.50[b]	36.46±0.95[a]
Relative gizzard weight (%)	1.67±0.05[a]	1.92±0.08[b]	1.82±0.06 b
Proventricular weight (g)	7.61±0.67	8.93±0.46	8.18±0.43
Relative proventricular weight (%)	0.38±0.04	0.42±0.02	0.40±0.01
Small intestinal weight (g)	46.48±3.70[a]	58.19±2.42[b]	52.38±3.23[ab]
Relative small intestinal weight (%)	2.28±0.15[a]	2.70±0.08[b]	2.59±0.12[ab]
Length of small intestinal (cm)	164.9±3.1	174.1±3.7	168.3±5.0

RESULTS

Effects of choice feeding on broiler performance (Table 2)

ADG of the birds in treatment I, II was significantly (p<0.05) lower than that of the control, with 5.53% and 13.40% lower, respectively. Treatment II was 8.18% lower than that of treatment I (p<0.05). No differences were found in feed intakes among the treatments.

The FCR (feed to gain) between treatment I and the control, treatment I and treatment II were similar, however, treatment II was 13.91% higher than that of control (p<0.05). Treatment I had a lower ratios of feed CP to gain, feed lysine to gain than treatment II and the control (p<0.05). There were no differences between treatment II and the control.

Effect of choice feeding on carcass quality

As shown in Table 3, compared with the control, treatment I tended to increase the abdominal fat rate (p>0.05). It was mainly because treatment I had a higher energy-to-protein ratio. The thigh muscle percentage in treatment I and II was a little higher than that in the control, which indicated that choice feeding may benefit legs development. CP in living weight of broilers in control was significantly higher than that of treatment I (p<0.05), and there was no difference between treatment II and the control. No differences in other parameters were found among the treatments (p>0.05).

Effect of choice feeding on gastrointestinal development

The result (Table 4) showed that broiler relative gizzard weight of treatment I and II were 14.97% and 8.98% higher than that of the control (p<0.05). Relative small intestinal weight of treatment I was 18.42% higher than that of the control (p<0.05), and treatment II was 13.60% higher than that of the control (p>0.05). No significant differences were found in relative proventricular weight and length of small intestinal among the treatments (p>0.05).

Effect of choice feeding on nutrients metabolizabitity and deposition ratio

There were no significant differences in metabolizability of DM, CP and GE between treatments I, II and the control (p>0.05), however, metabolizability of DM and GE of treatment I, were 4.99% and 4.11% higher than that of treatment II (p<0.05). No differences were found in deposition ratio of CP and GE among all treatments (Table 5).

Table 5. Effects of different feeding regimes on the nutrient apparent metabolizability and deposition ratio (%)

Treatment	Control	Treatment I	Treatment II
DM metabolizability	72.7±0.4[ab]	74.3±0.4[b]	70.7±1.7[a]
CP metabolizability	56.4±0.3	56.6±0.6	50.5±3.9
GE* metabolizability	76.7±0.3[ab]	79.0±0.2[b]	75.8±1.3[a]
Protein deposition ratio	49.2±1.4	47.4±2.1	45.7±3.9
Energy deposition ratio	27.7±2.1	29.9±2.6	23.2±2.3

* Gross energy.

DISCUSSION

Effect of choice feeding on utilization ratios of nutrients

Kasi and Melcoin (1992) have shown that choice feeding whole cereals decreased the passage rate of feed, and increased absorption time and utilization ratio of nutrients. In the present research, choice feeding had no significant effect on metabolizability of DM, CP and GE, while the metabolizabitity of DM and GE in treatment I had an increasing tendency which showed that choice feeding corn could increase broiler metabolizability of matter and energy to some extent.

Leeson (1996) considered that broilers had the ability to choose the diet of the appropriate content of CP and energy. Broilers could adjust feed intake to avoid taking too much CP (Emmans, 1977). Receiving the diets of different energy content, broilers could control energy intake. When offered the low energy content diet, broilers up-regulate the feed intake, and intake and deposition ratio of CP increasing (Newcombe and Summers, 1984). As being shown in this study, the deposition ratios of DM, CP and GE among three treatments had no significant differences (Table 5). Compared with the control, the CP deposition ratio of treatment I, II had a decreasing tendency, yet the energy deposition ratio had an increasing tendency in treatment I, and decreasing tendency in treatment II.

Through calculation, the content of apparent metabolizable energy and CP in the control were lower than NRC (1994) nutrition requirement, other nutrients and the ratio of energy and CP were close to the nutrition requirement or a little higher. The content of available phosphorus and tryptophan in treatment I, II could meet the need of broilers, but CP, calcium, lysine, methionine, isoleucine, threonine, arginine, and apparent metabolizable energy could not meet the need, the ratio of energy and CP was over the nutrition requirement. The amino acid model of treatment I was similar to that of ideal amino acid model of NRC (1994). As calculated, though the contents of CP, calcium, available phosphorus, lysine, methionine of the practical diet in treatment I were 16.76%, 37.78%, 30.00%, 21.00%, 25.64% lower than those in the control, ADG decreased only 5.59%, and the conversion ratio of CP and Lysine to ADG of treatment I was significantly higher than that of the other two treatments (Table 2), which showed that the main factors of broilers growth were the feeding regimes and contents of energy.

Effect of choice feeding on performance

In most cases, economic performance of broilers with choice feeding on whole cereals was no less than that of those with complete diets (Forbes and Corassa, 1995). Ramlah and Halim (1994) indicated that live weight had no significant difference between choice feeding and complete diet of broilers, while choice feeding corn had a better feed efficiency with total feed intake decreasing. Shariatmadari and Forbes (1993) reported, when offered two diets of high and low protein, broilers could make a proper diet through adjusting the intake percentage of the diets, and performance could achieve the optimal level comparing to feeding complete diet. In some conditions, broilers could make a proper diet with high CP diet and high-energy diet, and had the same growth performance with those fed on a complete diet (Shariatmadari and Forbes, 1993). Cowan and Mitchie (1978) and Sinurat and Balnave (1986) reported, broilers had better growth performance with choice feeding than those with complete diet. Yo et al. (1998) considered that broilers fed on complete diet had better growth performance and feed efficiency than those on choice feeding. Siegel et al. (1998) reported, in the first five weeks, broilers were fed on complete diet, and then altered to choice feeding, total feed intake had no significant difference with the control in the sixth week, but broilers live weight of choice feeding low protein diet was lower than that of the control.

But in present trial, broiler ADG on choice feeding were significantly lower ($p<0.05$) than that of the control. Layers were better than broilers on choice feeding because broilers had little time to learn how to make the appropriate choice (Forbes and Corasa, 1995). The lower performance in choice feeding treatments lied in the fact that broilers had not adapted choice feeding because of short life time. In most trials, corn was whole while it was ground in this trial, and whether this had effect on trial result needs further research. Treatment I had a better conversion ratio from CP and lysine to weight gain, which was another question worth further study.

Effect of choice feeding on carcass ratio

Nutrition factors affect broiler body composition significantly, and CP and energy level of diet influence mainly the deposition of abdominal fat. Abdominal fat increased with the metabolizable energy increasing, and decreased with the CP level increasing (Summers and Spratt, 1992). Leeson and Caston (1993) found that broilers had the ability to control feed intake accurately and maintain energy intake constantly. When they took low energy feed, fat deposition of carcass decreased. Siegel et al. (1997) reported that broilers on choice feeding had higher

abdominal fat ratio and lower breast muscle ratio than those fed on complete diet. Jackson et al. (1982) considered, when broilers were offered low energy diet, feed and CP intakes increased, which resulted in carcass fat decreased. Munt et al. (1995) found, when offered broilers pelleted diet, ground diet or separate feed ingredients for choice, broiler carcass had lower CP content on choice feeding than those on pelleted diet or ground diet.

The result of this trial showed, there were no differences in carcass quality among treatments ($p>0.05$), but the broiler abdominal fat rate of treatment I had an increasing tendency ($p>0.05$), this was because broilers liked corn and took too much energy. Thigh muscle rate of treatments had an increasing tendency ($p>0.05$), the reason may be that choice feeding increased broilers activity and improved legs development (Balog et al., 1997). Breast muscle rate of treatment I and II had a decreasing tendency compared with that of the control ($p>0.05$), which was in agreement with the reports of other researchers.

Effect of choice feeding on gastrointestinal development

Choice feeding improved poultry digestive tract development (Cumming, 1994). Mastika and Cumming (1985) found, broilers on choice feeding of whole cereal and the balance diet had bigger gizzard and smaller proventriculus than those on complete feed. When broilers offering hard feed, gizzard could adapt quickly. Kiiskinen (1996) and Cumming (1992) discovered that the increase of gizzard could improve feed efficiency and lower the incidence coccidiosis. Jones and Taylor (2001) found that broilers on choice feeding of whole cereals and high fiber content feed could increase the length and weight of small intestine, improve intestinal development, prevent proventriculus inflation and ascites, and decrease the mortality.

As shown in this study, choice feeding improved gastrointestinal development (Table 3). Relative gizzard weight of treatment I and II was significantly higher than that of the control ($p<0.05$). Relative small intestinal weight of treatment I was obviously higher than that of the control ($p<0.05$), and there was no significant difference between treatment II and the control, however, treatment II had an increasing tendency. No difference of small intestine length was found between treatments and the control, however, an increasing tendency of intestinal weight and length might mean an increase in the inner space and surface area of the intestine, therefore, an increased digestion and absorption to some extent.

CONCLUSION

Choice feeding decreased daily weight gain and feed efficiency of 22-49 day old broilers ($p<0.05$), however choice feeding on corn and protein concentrate (treatment I) improved the conversion ratios of dietary CP and Lysine to weight gain significantly ($p<0.05$). Choice feeding did not affect apparent metabolizability of DM, CP and energy and deposition ratio of CP and energy ($p>0.05$). There were no differences in carcass quality among treatments ($p>0.05$), but broilers fed on corn and protein concentrate may increase abdominal fat rate. Broilers on choice feeding of corn and protein concentrate increased the development of gizzard and small intestine significantly ($p<0.05$), which had no obviously influence on proventriculus.

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