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RESEARCH ARTICLE

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Effects of ascites syndrome in broilers on their growth performances and the availability of energy and nutrients

Abstract An experiment was carried out to investigate the effects of ascites syndrome (AS) on the growth performance and availability of dietary energy and nutrients in broilers. One hundred and twenty one-day-old avian broilers were randomly allotted into two groups (control group and test group) with six replications of ten birds. In the test group, the addition of 3,3,5-triiodothyronine (T_3, 1.5 mg/kg diet) and low ambient temperature (LAT) were used to induce AS. Results showed that T_3 and LAT could successfully induce AS in broilers with an incidence rate of 66.7% and a mortality rate of 23.3%. Compared with the control, the bird growth performance of the test group was decreased ($P < 0.05$) and heart index was increased ($P < 0.05$). For the test group, the availability of dietary energy ($P < 0.01$), crude fat ($P < 0.01$), crude protein ($P < 0.05$), and most amino acids in the second week were lower compared with the control group. Results showed that the low availability of energy and nutrients and the poor growth resulted from the high AS incidence rate.

Keywords broilers, ascites, growth performance, availability

1 Introduction

Ascites Syndrome (AS) or pulmonary hypertension syndrome (PHS) in broilers is one of the major causes for their death, resulting in great economic losses. It has become a major concern of the poultry industry around the world. This disease usually appears in 21-day-old fast growing broilers, with the highest mortality at the age of six to seven weeks (Peacock et al., 1988). The broiler's right ventricle usually becomes enlarged, compensable hypertrophied with plenty of yellow fluids accumulating in the abdominal cavity and liver. The losses from AS around the world are about $ 1 billion per year and the direct losses caused by broiler death are about $ 0.5 billion yearly. In China, the incidence rate of AS is about 3%–5%. There are many factors that induce AS (Julian, 2000). Most researches on the relation between nutrition and AS have mainly focused on the qualitative aspects.

The objective of this trial was to investigate the effects of ascites syndrome induced by 3,3, 5-triiodothyronine (T_3, 1.5 mg/kg diet) and low ambient temperature (LAT) on the performance of broilers, availability of dietary energy and nutrients. The results could provide some basic data for the decrease of AS incidence through nutritional methods.

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2 Materials and methods

2.1 Experiment design

A single-factor design with two groups (control group and test group) was adopted in this experiment. T_3 (1.5 mg/kg diet) and LAT (15°C) were used to induce AS in the test group.

2.2 Experimental diet

Basal diet was formulated to satisfy the nutrient requirements of National Research Council (NRC) (1994). The compositions and nutrient levels of the basal diet are shown in Table 1. T_3 (1.5 mg/kg diet) was added to the basal diet to get the test diet. All diets were in mashed form.

2.3 Experiment birds and management

One hundred and twenty one-day-old avian chickens were randomly divided into two groups with six replicates of ten broilers. Feed and water were accessed freely. The birds in the test group were fed under LAT (15°C room temperature throughout the experiment with 25°C cage temperature in the first week and 20°C after the first week). The birds in the control group were raised according to normal management practices.

Table 1 Compositions and nutrient levels of basal diet

Ingredient	Percentage	Nutrient	Concentration
Corn	56.12	CP/%	20.00
Soybean meal	25.22	ME/KJ·kg^{-1}	12.97
Rapeseed meal	3.00	CF/%	2.80
Fish meal	5.20	EE/%	9.20
Limestone	0.93	Ca/%	0.93
Dicalcium phosphate	1.20	AP/%	0.50
DL-methionine	0.12	Lys/%	1.20
Lysine	0.15	Met/%	0.47
Premix [a)]	1.00	Met + Cys/%	0.80
Salt	0.20		
Choline Chloride	0.26		
Soybean oil	6.60		
Total	100.00		

Note: [a)] Content of vitamins and microelements in the diet per kg: vitamin A, 15 000 IU; cholecalciferol, 3 000 IU; vitamin E, 7.5 IU; menadione, 1.5 mg; niacin, 10.5 mg; d-pantothenic acid, 7.5 mg; riboflavin, 4.8 mg; vitamin B6, 1.8 mg; folic acid, 0.15 mg; thiamine, 0.6 mg; vitamin B_{12}, 0.009 mg; manganese, 100 mg; zinc, 75 mg; iron, 100 mg; copper 8 mg; iodine, 0.45 mg; selenium, 0.15 mg.

2.4 Measurements

2.4.1 Growth performance

Birds were weighed every week (one replicate as a unit) and feed conversion rate was calculated by recording the feed intake per replicate (weekly measurement).

In terms of the incidence of mortality and the heart index of broilers, these were calculated according to the detailed records of the number of dead birds as well as the anatomical measurements of the right ventricle, the left ventricle, and the midriff by weight using the following formulae:

Heart index = (the weight of right ventricle/the weight of left ventricle + the weight of midriff) × 100%

(heart index > 0.25, ascites syndrome; heart index < 0.25, normal).

Incidence = (the birds number with AS/the total birds number of the replicate) × 100%.

2.4.2 Availability of dietary energy and nutrients

Two metabolism trials were conducted from day 11 to day 14 and from day 18 to day 21 with Cr_2O_3 (0.3% of diet) as the marker. Feces were collected with the addition of 5 mL of 10% sulfuric acid (H_2SO_4) per 100 g and a few drops of toluene then stored at −20°C. Samples were then dried at 65°C to analyze the dry matter, crude fat and crude protein, energy and amino acids using the method of Yang (1993). The availability of energy and nutrients were calculated using the following equation

Availability (%) = 100 − [the content of marker in the diet (%)/the content of marker in feces (%)] × [the content of nutrient in feces (%)/the content of nutrient in the diet (%)] × 100.

2.5 Statistical analysis

Growth performance was analyzed with one replicate as a unit. All data were shown as the Mean ± SE and analyzed using the *t*-test. Their differences were expressed as significant ($P < 0.05$) and highly significant ($P < 0.01$).

3 Results and analysis

3.1 Clinical pathology

The broilers suffering from AS showed symptoms of low energy, breathing difficulty and anorexia. There was much yellow fluid in the abdominal cavity in dead birds or birds with AS. The fluid volume varied among different ages from 10 to 100 mL. There was a layer of yellow, colloidal cellulose-like exudation adhering to the liver surface. The liver was intumesced or shrank, the edges round, and the surface rough. Plenty of fluids accumulated in the pericardium of the weak heart, the right ventricle was enlarged, the duodenum hyperemic and eroded, the lungs white, and the kidney hyperemic.

3.2 Heart indexes of broilers

Compared with the control, the heart indexes of broilers in the test group were significantly higher at age of 7 days, 14 days, and 21days (Table 2).

Table 2 Heart indexes of broilers

Age/d	Control group	Test group	*P* value
7	0.16 ± 0.01 (n = 9)	0.23 ± 0.02 (n = 9)	< 0.01
14	0.20 ± 0.01 (n = 8)	0.27 ± 0.03 (n = 9)	< 0.05
21	0.21 ± 0.01 (n = 8)	0.31 ± 0.02 (n = 13)	< 0.01

3.3 Incidence and mortality rate of AS

During the whole experiment period, the AS incidence rate in the test group was 66.7%, but it was only 16% in the control group. The mortality rate of AS in the control group was 1.7% and 23.3% in the test group (Table 3).

Table 3 Incidence and mortality rate of AS induced by T_3 and LAT

Index	Time/d	Control group	Test group
Incidence rate/%	0–7	11.1	55.6
	7–14	12.5	62.5
	14–21	25.0	76.9
	0–21	16.0	66.7
Mortality rate/%	0–21	1.7	23.3

3.4 Growth performance of broilers

Compared with the control, the 21-day-old body weight (BW) and body weight gain (BWG) of the birds in the test group were significantly lower at each weekly measurement ($P < 0.05$, Table 4).

Table 4 Effects of AS induced by T_3 and LAT on performance of broilers

Index	Time/d	Control group	Test group	*P* value
Average body weight/g		38.43 ± 0.43	38.46 ± 0.40	
21-day-old body weight/g		625.68 ± 23.83	415.92 ± 23.21	< 0.01
Average gain/g	0–7	100.70 ± 1.61	76.24 ± 1.47	< 0.01
	7–14	192.07 ± 3.50	142.27 ± 7.44	< 0.01
	14–21	362.91 ± 22.57	201.39 ± 21.25	< 0.01
Feed to gain ratio	0–7	1.21 ± 0.01	1.29 ± 0.01	< 0.01
	7–14	1.43 ± 0.03	1.67 ± 0.06	< 0.01
	14–21	1.71 ± 0.14	2.10 ± 0.18	

3.5 Availability of dietary energy and nutrients

In the second week, the availability of energy, crude protein, and crude fat in the test group decreased significantly than that in the control group. The availability of most amino acids in the test group was significantly lower than that of the control group, except for arginine and proline. The same trend for the availability of energy, crude protein, crude fat and amino acids was seen in the third week but the difference became smaller (Tables 5 and 6).

4 Discussion

4.1 Effects of AS on growth performance of broilers

Decuypere (1994) observed that the addition of T_3 (0.5 mg/kg diet) restrained broilers' growth with a relative increase in liver size and the incidence of hypertrophy of the right ventricle. There were positive T_3 dose-effects in the mortality of broilers (Decuypere et al., 1994). In the present experiment, the performance of broilers in T_3 group decreased significantly with the increase of the incidence of and mortality from AS. T_3 and LAT could accelerate the basal metabolism rate of broilers, and increase the need for oxygen that resulted in high pressure in the pulmonary artery, the compensational hypertrophy of the right ventricle and increase in the heart index (Decuypere et al., 1994).

4.2 Effects of AS on the availability of nutrients and energy

There are few published reports about the effects of AS on the utilization of nutrients and energy. However, there are a lot of reports showing that energy is one of the important factors that induce AS in broilers. Wang et al. (1997) found that the incidence of AS with high dietary metabolizable energy (ME) and protein was 8.7%, but only 3.1% was found with lower

Table 5 Effects of AS induced by T_3 and LAT on the availability of energy and nutrients

Index	The second week			The third week		
	Control group	Test group	*P* value	Control group	Test group	*P* value
Crude protein/%	72.11 ± 0.85	64.90 ± 2.13	< 0.05	70.7 ± 1.07	70.46 ± 0.96	
Energy/%	81.00 ± 0.33	70.34 ± 1.14	< 0.01	80.58 ± 0.31	78.84 ± 0.58	< 0.05
Crude fat/%	97.34 ± 0.54	87.39 ± 1.96	< 0.01	96.40 ± 0.69	89.64 ± 2.07	< 0.05

Table 6 Effects of AS induced by T_3 and LAT on the availability of amino acids

Index	The second week			The third week		
	Control group	Test group	*P* value	Control group	Test group	*P* value
Amino acid/%	82.30 ± 1.10	75.79 ± 1.60	< 0.01	85.55 ± 0.50	82.3 ± 0.53	< 0.01
Met/%	87.11 ± 0.79	78.87 ± 1.84	< 0.01	89.93 ± 0.49	85.71 ± 0.51	< 0.01
Lys/%	87.41 ± 0.48	82.21 ± 1.31	< 0.01	86.96 ± 0.55	85.17 ± 0.77	
Thr/%	82.70 ± 0.65	76.12 ± 1.26	< 0.01	85.45 ± 0.69	83.03 ± 0.49	< 0.05
Arg/%	62.10 ± 1.60	76.15 ± 8.39		63.54 ± 0.72	63.90 ± 1.63	
Glu/%	94.11 ± 0.26	88.16 ± 1.04	< 0.01	94.22 ± 0.19	92.82 ± 0.31	< 0.01
Ser/%	87.40 ± 0.20	81.59 ± 0.82[B]	< 0.01	86.84 ± 0.44	83.90 ± 0.33	< 0.01
His/%	76.53 ± 1.50	58.95 ± 2.92	< 0.01	78.77 ± 1.26	75.52 ± 1.77	
Gly/%	51.51 ± 7.00	45.06 ± 7.37		73.49 ± 2.46	69.47 ± 2.25	
Ala/%	93.86 ± 0.58	89.77 ± 0.61	< 0.01	94.25 ± 0.49	93.26 ± 0.35	
Tyr/%	85.40 ± 0.47	79.39 ± 1.41	< 0.01	86.81 ± 0.29	83.26 ± 0.51	< 0.01
Val/%	86.42 ± 0.91	80.35 ± 1.35	< 0.01	89.05 ± 0.50	84.52 ± 1.08	< 0.01
Phe/%	86.80 ± 0.58	81.66 ± 1.07	< 0.01	88.60 ± 0.23	85.23 ± 0.44	< 0.01
Ile/%	85.12 ± 0.79	79.43 ± 0.90	< 0.01	87.19 ± 0.25	83.73 ± 0.58	< 0.01
Leu/%	89.75 ± 0.28	85.95 ± 0.86	< 0.01	90.71 ± 0.31	88.28 ± 0.28	< 0.01
Pro/%	81.90 ± 5.45	85.07 ± 2.58		88.30 ± 1.04	86.24 ± 0.40	
Asp/%	82.70 ± 0.65	76.12 ± 1.26	< 0.01	83.77 ± 0.41	80.26 ± 0.31	< 0.01

dietary ME and protein. However, Wang et al. (2001) did not find the effect of dietary ME on the incidence of AS.

In this trial, the availability of dietary crude protein, crude fat, energy, and most amino acids in the test group in the second week was decreased compared with the control group. However, the availability of arginine was numerically increased in the test group. L-Arginine is one of the essential amino acids for poultry that can only be accessed by feeding because of the lack of carbamoyl phosphate synthetase, a key enzyme that is necessary for the denovo synthesis of L-Arginine (Chen et al., 2001). L-Arginine is a precursor of nitric oxide, a vasodilator, and can be carried into the cell via Na^{+}-dependent Y^{+}-protein amino acid transporters, then converted into nitric oxide by nitric oxide synthetase in blood platelets. Nitric oxide can activate guanylate cyclase (GC) resulting in the increase of cyclic guanosine monophosphate (cGMP) in blood platelets, which can prohibit blood platetlet adhesion and accumulation, weaken the stimulation of platelet-derived growth factor on pulmonary blood vessel, and decrease the incidence of AS. It seemed that the increase in the availability of arginine in the test group was the result of the increase in the need for arginine to counteract AS. Wideman et al. (1995) reported that each 1% addition of L-Arginine in the diet could decrease the incidence of AS in broilers. More experiments are needed to investigate whether the addition of arginine in the diet would indeed decrease the incidence of AS.

In this study, the availability of crude fat was decreased by AS. Pathological analysis of birds with AS showed that there was less subcutaneous and abdominal fat present compared with normal birds with liver hypertrophy or atrophy. This may be due to the decrease in the transportation of fat from the liver and the de novo synthesis of fatty acid in the liver by AS which results in the fatty liver or hepatocirrhosis.

We also found that the availability of dietary crude fat, energy, and most dietary amino acids in the test group was decreased in the third week but its degree was smaller compared with that in the second week, while there was no difference in the availability of dietary crude protein. It may be the result of the adaptation of broilers to T_3 and LAT, which needs to be confirmed in the future.

In conclusion, the performance of broilers with a high incidence of AS can be induced by T_3 and LAT, resulting in a possible decrease in availability of dietary energy, crude protein, crude fat, and most amino acids.

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