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Study on Mechanism of Ascites Syndrome of Broilers

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Abstract: Two hundred and forty male Cobb broilers were used to study the reasons of causing ascites. The results showed that cold ambient temperature could induce ascites (33.89 vs. 2.50%) and significantly increase Triiodothyronine (T_3), but reduce Thyroxine (T_4) concentrations in plasma ($p<0.05$). The ascitic broilers had high concentrations of aldosterone and K^{Ex}, but low concentrations of T_3 and T_4 in the plasma ($p<0.05$). The lower body weight and higher relative heart, lung and liver weight of the ascitic broilers demonstrated the metabolic disarrangement. When ascites occurred, hematocrit in blood increased significantly ($p<0.05$) although there were no significant changes in total protein and albumin concentrations in plasma except for week 5. The mash feed could reduce body weight and the onset of ascites and lower the concentrations of Ca, Na and P ions in plasma in week 7, compared with the pellet feed ($p<0.05$).

Key words: Broilers, ascites, plasma, biochemical indexes, body weight, relative organ weight

INTRODUCTION

The ascites syndrome, a metabolic disorder that accounts for over 25% of overall mortality, has become the most noticeable, non-infectious cause of loss in the broiler industry worldwide (De Smit *et al*., 2005). There are many factors that cause ascites, for example, high altitude, rapid growth rate, limiting lung volume, the provision of high energy rations and pelleted diets, cold, poor ventilation, the presence of respiratory disease, high sodium and low dietary phosphorus levels, hepatotoxins, mycotoxins and furazolidone in the feed, vitamin E and Se deficiencies and stress (Vanhooser *et al*., 1995; Diaz-Cruz *et al*., 1996; Gordon, 1997). Among so many causes, which one is the main trigger is still questionable. It was reported that low temperature was an easy and economical method to trigger ascites (Scheele *et al*., 2003). One report has indicated that high nutrient metabolic rate could cause ascites (Olkowski and Classen, 1998) however, high levels of the hormones (T_3 and T_4) in the plasma are related to nutrient metabolism. The aim of this research is to use low temperature to trigger ascites in order to investigate the relationship between some physiological parameters and ascites and to seek the optimum methods of predicting and preventing this disease.

MATERIALS AND METHODS

Broilers and treatments: The experiment was conducted in chicken farm, Henan Agricultural University, from March to June in 2005. Two hundred and forty male Cobb broilers were divided equally into 24 groups and allocated to one of four treatments. The birds in treatment 1 (16 groups) were fed with pelleted feeds in a relatively cold environment to induce ascites from 3 weeks of age; the birds in treatment 2 (4 groups) were fed with pelleted feeds under common condition as control and the birds allocated to treatment 3 (4 groups) were fed with mash feeds under common condition as control too. The allocation of birds to the conditions described for treatment 1 was such that there would be sufficient birds showing ascites.

The ambient temperatures for both the control and cold environments were similar for the first 2 weeks of the experiment. At week 3, the cold environment was 2% cooler (23 vs. 25%) and from week 4 was further reduced (13 vs. 25%). Fine control of temperature was needed during this time to achieve sensible results in any experiment.

Diets and managements: The broilers were fed with commercial corn-soybean diets formulated according to NRC (1994) standards. The crude protein and energy levels for the broilers at the age of 0-3 and 4-7 weeks were 23.1% and 13.44 MJ ME kg^{-1}, 19.8% and 13.42 MJ ME kg^{-1}, respectively. Feed and water were provided *ad libitum* and the birds were grown under continuous lighting.

Sample analyses and statistical analyses: The birds were weighed weekly and blood was taken and analyzed at three weeks of age and weekly intervals thereafter from a

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sample of chickens in each treatment. The hormones, mineral and protein concentrations in plasma were measured using a gamma counter (Diagnostic Products Corporation, Los Angeles, CA., USA), atomic absorption spectrometer (GBC Scientific Equipment Pty Ltd., Dandenong, VIC, Australia) and colorimetric methods (Elisa, 520 nm; Helena Laboratories, Beaumont, Texas, USA), respectively. The data were analyzed using SAS software (SAS Institute Inc., 1996).

RESULTS

Ambient temperature and T_3 and T_4 concentrations in plasma: Cold ambient temperature tended to increase T_3 concentration but decrease T_4 concentration, compared to the other treatments ($p<0.05$). The broilers showing obvious signs of ascites had generally lower T_3 concentrations than those without sign (Table 1).

Body weight and relative organ weight: The ascetic broilers had the lowest body weight ($p<0.05$) and the highest organ ratio (heart, lung, liver, right ventricular weights/body weight) at 7 weeks of age ($p<0.05$) (Table 2).

Mineral, protein and albumin concentrations in plasma: Table 3 showed that the ascetic broilers had higher concentrations of $K^{£r}$ in plasma at the age of 6 weeks, compared with the healthy broilers. The mash feed reduced Ca, Na, P concentrations in plasma (only at 7 weeks old), compared with the pellet feed ($p<0.05$).

Table 4 indicated the changes of total protein and albumin concentrations in plasma. At the age of 5 weeks, the lower temperature increased total protein and albumin concentrations ($p<0.05$) and the ascetic birds had lower total protein content. At the age of 7 weeks, the pellet diet made the total protein content higher, compared with the mash diet.

Table 1: The relationship between ascites and plasma hormone contents (ng mL^{-1}) (means±SE)

T_3	Week 4	n	Week 5	n	Week 6	n	Week 7	n
Ascites^{+}	3.28±0.11^{a}	16	2.71±0.17^{b}	17	2.11±0.24^{b}	11	1.08±0.26^{bc}	6
Ascites^{-}	2.94±0.16^{a}	10	3.28±0.23^{a}	10	2.79±0.54^{a}	10	1.94±0.23^{a}	8
Pellet	1.64±0.15^{b}	10	2.18±0.22^{b}	10	1.42±0.24^{c}	10	1.48±0.19^{ac}	10
Mash	1.38±0.15^{b}	9	2.31±0.22^{b}	10	1.35±0.31^{c}	10	0.49±0.25^{c}	6
T_4								
Ascites^{+}	3.05±0.39^{d}	16	3.09±0.49^{b}	17	1.21±0.35^{b}	10	1.75±0.84^{c}	6
Ascites^{-}	4.29±0.49^{c}	10	3.69±1.49^{b}	10	2.19±1.10^{b}	10	4.38±0.73^{b}	8
Pellet	6.76±1.39^{b}	10	4.66±0.64^{ab}	10	6.39±0.39^{a}	9	7.23±0.68^{a}	10
Mash	10.38±0.53^{a}	9	6.04±0.67^{ba}	10	7.38±1.35^{a}	10	8.46±0.68^{a}	9

Note: Birds from treatments denoted with 'ascites^{+}' and 'ascites^{-}' were sourced from treatment 1, "Pellet" from treatment 2 and "Mash" from treatment 3. Means lacking a common superscript letter in each line differ ($p<0.05$)

Table 2: Body weights and relative organ weights (at 7 Weeks old) (means±SE)

	Ascites^{+}	Ascites^{-}	Pellet	Mash
Number of broilers	19	15	10	10
Body weight (kg)	2.13±0.09^{a}	2.89±0.10^{b}	3.32±0.05^{c}	2.89±0.06^{b}
Organ weight/body weight (%)				
Heart	0.72±0.04^{a}	0.59±0.03^{b}	0.45±0.02^{c}	0.44±0.01^{c}
Lung	0.59±0.03^{a}	0.42±0.02^{b}	0.38±0.01^{b}	0.42±0.02^{b}
Liver	2.66±0.13^{a}	1.98±0.05^{bc}	1.81±0.12^{c}	2.18±0.11^{b}
Right ventricular	0.18±0.02^{a}	0.13±0.02^{b}	0.11±0.01^{b}	0.09±0.01^{b}
Right ventricular to total ventricular (%)	25.85±1.24^{a}	21.27±0.69^{b}	22.16±0.54^{b}	22.31±1.27^{b}
Rate of ascites (%)	---	33.89	2.50	0.00

Note: Means lacking a common superscript letter in each column differ ($p<0.05$)

Table 3: Mineral concentrations in plasma (mg L^{-1}) (means±SE)

Week 5	Ascites^{+}	Ascites^{-}	Pellet	Mash
Number of broilers	17	9	10	10
Ca	98.42±3.15^{a}	110.18±2.72^{b}	99.44±1.72^{a}	99.03±1.01^{a}
Mg	19.68±0.97^{a}	19.34±0.67^{a}	18.97±0.38^{a}	19.81±0.51^{a}
Na	3522.83±66.34^{a}	3398.84±85.51^{a}	3318.89±26.44^{a}	3353.77±27.05^{a}
K	237.60±5.51^{a}	237.69±9.02^{a}	232.58±3.76^{a}	252.11±6.75^{a}
P	163.86±5.97^{a}	168.83±3.67^{a}	179.91±4.37^{a}	174.26±3.71^{a}
Week 7				
Number of broilers	8	15	10	11
Ca	134.78±2.88^{a}	132.68±4.23^{ab}	121.75±4.42^{b}	104.73±1.44^{c}
Mg	27.09±0.64^{a}	24.03±0.73^{ab}	25.64±2.46^{ab}	21.41±0.31^{b}
Na	3582.39±69.59^{a}	3491.35±40.63^{ab}	3372.30±60.46^{b}	2898.55±61.09^{c}
K	292.40±22.17^{a}	219.02±5.75^{b}	231.70±17.00^{b}	206.88±5.29^{b}
P	186.52±31.87^{ab}	180.00±3.74^{ab}	190.58±14.48^{a}	145.26±3.04^{b}

Note: Means lacking a common superscript letter in each column differ ($p<0.05$)

Table 4: Total protein and albumin content in plasma (g L^{-1}, means±SE)

Total protein	Ascites$^+$	n	Ascites$^-$	n	Pellet	n	Mash	n
Week 3	31.3 ± 0.5^a	16	30.5 ± 0.7^a	10	31.6 ± 0.8^a	10	31.1 ± 0.9^a	10
Week 5	34.8 ± 0.9^a	16	38.1 ± 1.1^b	10	33.7 ± 0.7^{ac}	10	31.2 ± 0.6^c	10
Week 7	31.3 ± 2.1^{ab}	8	34.1 ± 0.9^a	15	34.0 ± 1.4^a	10	27.0 ± 0.8^b	11
Albumin								
Week 3	12.1 ± 0.1^a	16	11.9 ± 0.3^a	10	12.2 ± 0.2^a	10	12.1 ± 0.3^a	10
Week 5	14.1 ± 0.4^a	16	14.4 ± 0.3^a	10	13.1 ± 0.2^b	10	12.8 ± 0.2^b	10
Week 7	12.3 ± 0.8^a	8	12.2 ± 0.2^a	15	11.6 ± 0.3^{ab}	10	10.5 ± 0.2^b	11

Note: Means lacking a common superscript letter in each column differ ($p<0.05$)

Table 5: Aldosterone and renin contents in plasma and hematocrit in blood (means±SE)

	Ascites$^+$		Ascites$^-$		Pellet		Mash	
Week 6								
Aldosterone (pg mL^{-1})	37.43 ± 6.18^a	8	12.10 ± 6.18^b	8	5.82 ± 7.81^b	5	15.42 ± 8.74^{ab}	4
Renin (ng mL^{-1})	0.62 ± 0.07^a	17	0.67 ± 0.09^a	10	0.68 ± 0.09^a	10	0.43 ± 0.09^a	9
Hematocrit (%)								
Week 3	26.29 ± 0.53^a	19	26.27 ± 0.44^a	15	26.17 ± 0.43^a	10	25.16 ± 0.33^a	10
Week 4	31.44 ± 0.55^a	18	30.51 ± 0.48^{ab}	15	28.88 ± 0.32^{bc}	10	28.67 ± 0.58^c	10
Week 5	35.58 ± 1.25^a	18	33.48 ± 0.69^a	15	29.19 ± 0.69^b	10	28.36 ± 0.88^b	10
Week 6	39.79 ± 2.59^a	13	33.17 ± 0.67^b	15	28.88 ± 0.54^{bc}	7	27.60 ± 0.73^c	10
Week 7	39.85 ± 3.89^a	8	34.50 ± 0.78^b	15	28.60 ± 0.73^{bc}	10	29.10 ± 0.78^c	10

Note: Means lacking a common superscript letter in each column differ ($p<0.05$)

Aldosterone and renin contents in plasma and hematocrit changes in blood: Table 5 indicated that there was a tendency towards a greater haematocrit value of the birds in the ascites$^+$ treatment from week 5 and which thereafter was significantly greater than the other three treatments ($p<0.05$). The ascetic birds could make the concentration of aldosterone in plasma higher (37.43 vs. 12.10 pg mL^{-1}).

DISCUSSION

The results showing that low environmental temperature increased plasma T_3 concentration agree with Scheele *et al.* (1992). This increase may be due to the need for additional metabolic heat to maintain body temperature in the cooler environment. The subsequent increase in metabolic rate results in an increase in blood pressure as the heart attempts to maintain oxygen supply to the organs and muscles thus leading to pulmonary hypertension and right ventricular failure. Interestingly, even though high T_3 concentration could induce ascites (Chineme *et al.*, 1995) the ascetic broilers had lower plasma T_3 than the healthy ones in the "cold" control group (Scheele *et al.*, 2003) especially after 5 weeks old. The reason may be that metabolic disarrangement could have taken place as soon as ascites occurred and this could influence T_3 excretion. T_4 had the opposite response, i.e. low temperature reduced T_4. It has been assumed that low temperatures improve the excretion of Thyroid-Stimulating Hormone (TSH) (Hendrich and Turner, 1964) and the excretion speed of thyroid (Mueller and Amezcua, 1959) to cause the thyroid to produce more T_4 and less T_3, or make T_4 be transferred to T_3 because T_3 is more effect than T_4 to increase metabolic rate for the birds to adapt to the cold stress condition.

The result also showed that the ascetic broilers had higher K^+ concentration in plasma, which corresponds with the higher aldosterone concentration in plasma because the function of aldosterone is to discharge high concentration of K^+ from animal body. The higher K^+ concentration in plasma may have been due to leakage of plasma from the circulatory system caused by right ventricular failure.

The ascetic broilers had the highest hematocrits values (Scheele *et al.*, 2003) which indicated a (subjective) rapid compensatory erythropoiesis had been triggered in response to the hypoxaemia, but Luger *et al.* (2001) report showed that hematocrits was low before the ascetic broiler died, which was different from this result. The higher percentage of heart, lung and liver weight with respect to body weight and the higher (RV/TV) in the ascetic broilers were also part of the syndrome of hypoxaemia (Julian *et al.*, 1987; Scheele *et al.*, 2003). The concentration of total and albumin in plasma was not significantly different between ascitic broilers and non-ascitic broilers, which supports the theory that the ascitic fluid is plasma from the circulatory system, except for the birds at the age of 5 weeks.

The provision of a pellet feed increased body weight gain, Ca, Na, P and total protein concentration in the plasma, when compared with the mash feed. The reason was that pellets improved feed conversion. Because the birds had a lower body weight when fed the mash form of the diet, the feed and oxygen demanded by the body would be less than the pellet fed birds and hence the tendency to develop ascites would be less.

CONCLUSION

It may be concluded that the increase of T_3 concentration in plasma and hematocrits in blood and decrease of T_4 concentration in plasma are the signals to predict that the ascites will take place; The decrease of T_3 and T_4 concentrations in plasma and increase of hematocrits in blood are the signals to predict that the ascites has taken place; The practical suggestions for preventing ascites in broilers are to maintain heat stable throughout the growing period (Sato *et al.*, 2002), decrease heat slowly and feed balanced mash diets as the final rations.

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