The Effect of Chick Methionine Status on Broiler Performance and Physiological Response to Acute and Chronic Heat Stress

A.S. Leaflet R2806

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Summary and Implications

An experiment was conducted to test methionine source and concentration on the growth performance and physiological responses of heat-stressed broiler chickens. Birds were fed either DL methionine or 2-hydroxy-4-methylthiobutanoic acid (HMB) at two concentrations (adequate: starter 0.94%, grower 0.84% or superadequate: adequate concentrations +20% methionine) over a six day period at normal or elevated environmental temperatures. Heat treatment was initiated at 21 days of age within controlled environmental chambers. Blood samples were taken 6 hours and 6 days post treatment to determine the effects of acute and chronic heat stress on various blood parameters. Heat treatment significantly impaired growth performance over the 6 day period. There were no effects of methionine source or concentration on the growth performance of broilers within any of the environmental treatments. Blood parameters changed during acute heat stress, but normalized over chronic heat exposure. Birds were apparently able to adapt blood chemistry to heat exposure subsequent to chronic heat stress, but were still negatively affected from a performance standpoint.

Introduction

Heat stress from increased environmental temperature has a significant impact on broiler productivity and welfare and can result in reduced feed intake, body weight gain and may increase the feed:gain ratio. Heat stress can also produce what are known as reactive oxygen species (ROS) within the body. These molecules are highly reactive and can cause damage to various tissues, impairing broiler performance. As a nutritional intervention, synthetic methionine added to the diet has been explored as method of ameliorating the effects of ROS associated with high environmental temperature. This may be due to the fact that methionine can be converted to cysteine, a critical component of the body's antioxidant defense system which is critical in the detoxification of ROS. The purpose of this experiment was to determine if varying sources and concentrations of methionine impact broiler performance and physiological response during periods of acute or chronic heat stress. Concurrently, an attempt was made to determine the effect of heat treatment on body weight gain (BWG) by accounting for differential feed intake associated with heat exposure using pair-fed birds exposed to a standard environmental temperature. Various blood parameters were also measured to further characterize the physiological response to both acute and chronic heat stress.

Materials and Methods

This experiment was performed over two separate time periods due to space limitations within the environmental chambers, with each of the runs utilizing 400 Ross 308 male broiler chicks. Chicks were placed in floor pens, and fed diets containing either DL methionine (DLM) or 2-hydroxy-4-methylthiobutanoic acid (HMB) at adequate (starter 0.94%, grower 0.84%) or superadequate (starter 1.13%, grower 1.00%) concentrations. At three weeks of age, birds were wing-banded and placed in the environmental chambers which were kept at an elevated (95° F) or normal temperature (75° F) or normal temperature coupled with pair-feeding. Blood samples were collected via heart-puncture 6 hours into the heat treatment to determine acute heat stress effects on various blood gas parameters. Samples were also taken at 6 days into the heat treatment to determine the effects of chronic heat stress on these same parameters. Data were analyzed using a 3-way ANOVA in JMP (SAS Institute, Cary, NC).

Results and Discussion

Elevated environmental temperature was found to significantly reduce BWG and feed intake while increasing the feed:gain ratio (Table 1). Utilizing the pair-fed treatment, it was determined that approximately 54% of the reduced BWG was due to the effects of elevated environmental temperature and that the remaining BWG reduction was associated with reduced feed intake. During the acute phase, heat treatment decreased blood pCO_2, hematocrit, and hemoglobin levels while increasing blood pH in comparison to other environmental treatments (Table 2). These results are characteristic of broilers that are heat stressed and emphasize the fact that heat stress was indeed occurring. These same blood parameters were not significantly affected during chronic heat stress, suggesting the chickens were able to adapt to these environmental temperatures and return blood chemistry to thermoneutral levels within 6 days. (Table 3). Neither source nor concentration of methionine exerted a significant effect on broiler performance at elevated environmental temperatures. Although their patterns of absorption and utilization differ, these data suggest that both HMB and DLM are similarly effective methionine sources as bird performance was similar with either compound. The data suggest that feeding superadequate concentrations of methionine beyond bird requirements has little protective value during bouts of sustained heat stress.

Acknowledgments

We would like to acknowledge Adisseo France SAS for kindly providing Rhodimet® NP 99 and Rhodimet® AT 88. We recognize the care for the birds provided by W. Larson, J. Tjelta, W. Rogers, and R. Holbrooke of Iowa State University poultry farm, and also like to thank A. Gabler, R. Murugesan, K. Nesheim, and C. McDonald for assistance in conducting this experiment.

Table 1. Main treatment effects on broiler performance (day 21-27) during heat stress exposure.

Met Source	Met Concentration	Heat Treatment	Body Weight Gain (g/bird)	Feed Intake (kg/pen)	FCR (g/g)
DLM			395	4.77	1.781
HMB			372	4.76	1.861
SEM			9.21	0.1	0.04
	A		388	4.88	1.839
	+20		379	4.65	1.803
	SEM		11.28	0.1	2.24
		NT	435[a]	5.31[a]	1.765[b]
		NT-PF	383[b]	4.65[b]	1.736[b]
		ET	323[c]	4.34[c]	1.961[a]
		SEM	11.27	0.16	0.06
ANOVA			**<0.01**	**<0.01**	**<0.01**
Heat Trt			**<0.01**	**<0.01**	**<0.01**

DLM: DL methionine, HMB: 2-hydroxy-4-methylthiobutanoic acid, A: Adequate methionine, +20%: Adequate methionine +20%, NT: normal temperature, NT-PF: normal temperature-pair fed, ET: elevated temperature.

Table 2. Main treatment effects on blood parameters 6 hours into heat exposure.

Met Source	Met Concentration	Environmental Treatment	pH	pCO_2	Hct (%)	Hb (g/dL)
DLM			7.15	59.6	19.30	6.57
HMB			7.18	54.8	18.47	6.27
SEM			0.01	1.76	0.35	0.12
	A		7.15	59.8[a]	19.21	6.53
	+20		7.18	54.5[b]	18.56	6.31
	SEM		0.02	1.75	0.35	0.12
		NT	7.12[b]	61.1[a]	19.51[a]	6.63[a]
		NT-PF	7.15[b]	58.4[a]	19.47[a]	6.62[a]
		ET	7.23[a]	51.0[b]	17.67[b]	6.01[b]
		SEM	0.02	2.13	0.43	0.15
ANOVA			**<0.01**	**0.01**	**0.02**	**0.02**
Met source			0.19	0.055	0.10	0.09
Met conc.				**0.04**	0.20	0.20
			0.11			
Environment			**<0.01**	**<0.01**	**<0.01**	**<0.01**

DLM: DL methionine, HMB: 2-hydroxy-4-methylthiobutanoic acid, A: Adequate methionine, +20%: Adequate methionine +20%, NT: normal temperature, NT-PF: normal temperature-pair fed, ET: elevated temperature.

Table 3. Main treatment effects on blood parameters 6 days into heat exposure.

Met Source	Met Concentration	Environmental Treatment	pH	pCO_2	Hct (%)	Hb(g/dL)
DLM			7.16	59.46	20.24	6.88
HMB			7.15	61.87	21.21	7.21
SEM			0.01	1.86	0.45	0.15
	A		7.16	59.74	20.96	7.12
	+20		7.15	61.59	20.50	6.97
	SEM		0.01	1.86	0.45	0.15
		NT	7.18	61.12	21.37	7.26
		NT-PF	7.12	63.39	20.08	6.83
		ET	7.16	57.49	20.73	7.05
		SEM	0.01	2.28	0.54	0.18
ANOVA			0.06	0.44	0.30	0.31
Met source			0.35	0.36	0.13	0.13
Met conc.			0.52	0.48	0.46	0.46
Environment			0.02	0.20	0.26	0.27

DLM: DL methionine, HMB: 2-hydroxy-4-methylthiobutanoic acid, A: Adequate methionine, +20%: Adequate methionine +20%, NT: normal temperature, NT-PF: normal temperature-pair fed, ET: elevated temperature.