BETAINE AMELIORATES THE IMPACT OF HEAT STRESS IN BROILERS, IMPROVING BREAST MUSCLE GROWTH AND REDUCING DRIP LOSS.

Shakeri M[1], Cottrell J.J[1], Warner R.D.[1] and Dunshea F.R.[1*]

[1]The University of Melbourne, Parkville, VIC 3010, Australia;

*Corresponding author email: fdunshea@unimelb.edu.au

I. INTRODUCTION

Seasonal heat waves pose a challenge to animal production industries due to reduced productivity, increased morbidity and mortality. Furthermore, with increases in the frequency intensity and duration of heat waves forecast, heat stress (HS) is both a current and emerging problem. Reduced productivity is in part due to lower feed intake during heat events. However, thermoregulatory process during heat stress also comes at a metabolic cost and can include oxidative stress. As pre-slaughter stress can impair meat quality [1,2], the aims of this experiment were to investigate the effects of rearing broiler chickens under a hot, or “heat stress” environment on growth rates and meat quality. Additionally, this experiment also investigated if nutritional amelioration strategies could improve growth performance and meat quality. This was done by supplementing the organic osmolyte betaine alone, or in combination with the anti-oxidants selenium and vitamin E.

II. MATERIALS AND METHODS

72 one day-old-Male Ross 308 were reared in pens under normal conditions (TN, 33^{0}C at 1d and gradually reduced to 25^{0}C at 21d and was kept at 25^{0}C from 21-42d) vs diurnal heat stress (HS, 33^{0}C from 8:00AM-16:00PM from 1-42d). Rectal temperature (RT) and respiratory rate (RR) in breaths per minute (BPM) was measured at the end of the experiment. Chickens were fed with basal diet (CON, 0.3mg/kg selenium and 50 IU/kg vitamin E), betaine (BET, 1g/kg) or the combination of betaine, selenium (0.3mg/kg) and vitamin E (200 IU/kg) (BAX), and feed intake was calculated weekly on a per pen basis. On d41, blood samples were collected from wing vein for blood gas and metabolic analysis, then the chickens were stunned and bled on d42. After slaughter the carcasses were dressed and chilled in iced water (~ 4-6 ^{0}C) for 40min, then air chilled at 4^{0}C for until 24h. Breast meat quality was assessed by pH fall (<10min, 1h and after 24h), drip loss (10g suspended for 48h), Warner-Bratzler Shear Force (WBSF, 1x1x3cm) and color at 24h and day4. All data was analysed with Genstat V18 using an unbalanced ANOVA for the main effects of temperature (TN vs HS), diet (CON, BET, BAX) and their interactions. Significant differences between treatment groups were determined using a post-hoc Fishers least significant difference test and signified by differing alphabetical superscripts.

III. RESULTS AND DISCUSSION

The RR of broilers reared under HS conditions doubled (64.9 vs 143 BPM, for TN vs HS, P<0.001, Figure 1), however, the RT remained significantly higher than TN broilers (42.0 vs 42.8°C, P<0.001). The

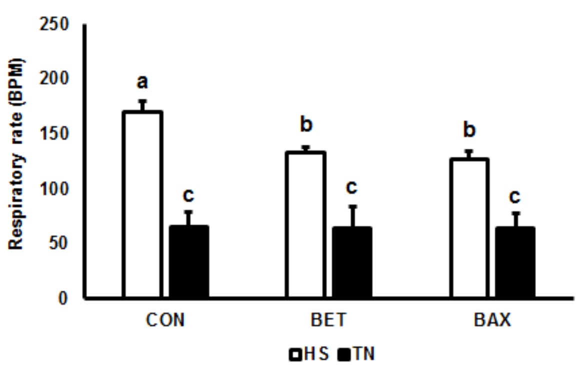

Figure 1. Respiratory rate changes by temperature and diet

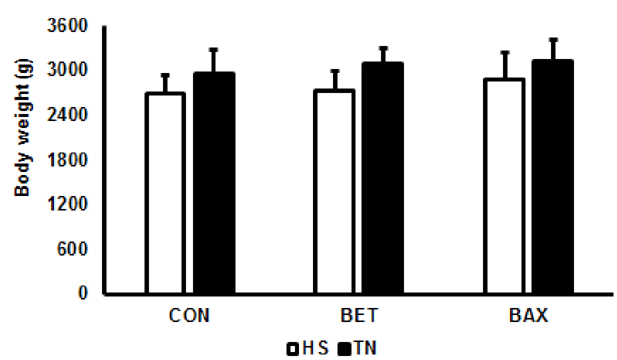

Figure 2. Body weight of broilers on CON, BET and BAX diets housed in TN vs HS

excess body heat was not dissipated, despite that increased “thermal panting” (as indicated by elevated RR) confirms that the broilers were in a heat stressed state. Both BET and BAX ameliorated the elevated RR under HS conditions (Figure 1, P<0.001) and RT was lower overall (42.6^{a}, 42.2^{b} and 42.4^{ab} ^{o}C, for CON, BET and BAX, P=0.018). The increased RR in HS broilers corresponded with lower pCO_2 (TN vs HS, 53.4 vs 41.5 mmHg, P=0.002). Reduced blood bicarbonate (HCO_3^-) was observed in HS broilers (28.1 vs 25.8 mmol/L, P=0.024), indicating buffering against increased CO_2 exhalation. Thermal panting forms an essential component of thermoregulation, however, the sustained and elevated RR can lead to hyperventilation and is not without consequences. This was evident by a significant increase in blood pH (7.31 v 7.39, P=0.021) and haematocrit was reduced by 13% (21.8 v 18.8 %, P=0.003), confirming that the HS chickens were experiencing pertubations in acid base balance due to respiratory alkalosis. BAX tended to increase HCO_3^- (26.0, 26.2 and 29.6 mmol/L, P=0.064) and reduce lactate production overall (7.4, 6.5 and 4.5 mmol/L, P=0.003), however no interactive effects with HS were observed. Rearing broilers under HS conditions reduced feed intake and final body weight (3111 vs 2742g, P<0.001). The use of nutritional supplements increased body weight, particularly in the BAX group (2809^{a}, 2951^{ab} and 3048^{b} g, P=0.024, Figure 2), however no interactive effects with HS were observed. Broilers reared under HS conditions had ~14% less breast meat than those reared under TN conditions (741 vs 635g, P<0.001, Figure 3). Conversely the BET and BAX diets increased breast meat by 10 and 14 % respectively (639^{a}, 702^{b} and 732^{b} g, P=0.011). However, no interaction between the diets and HS were observed. Neither HS, nor the experimental diets influenced meat pH, WBSF or colour. The meat total water content was not influenced by HS or diet. However, the BET diet reduced drip loss overall (2.70^{a}, 1.48^{b} and 1.98^{ab} %, P=0.012), however there was a trend for the greatest improvement to be against CON HS broilers (P=0.067, Figure 4).

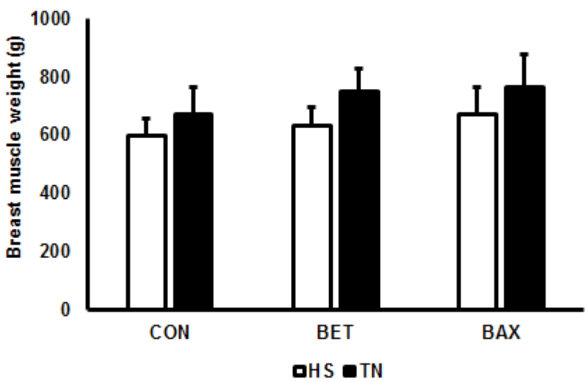

Figure 3. Breast muscle weight of broiler on CON, BET and BAX diets housed in TN vs HS

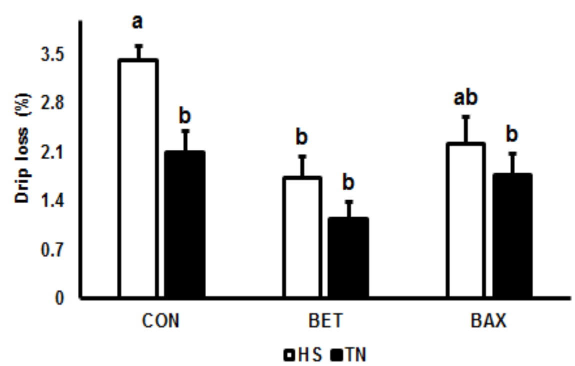

Figure 4. Drip loss changes by temperatue and diet. *Denotes P=0.067 for the interaction diet×temperature

IV. CONCLUSION

Supplementing betaine alone or in combination with anti-oxidants improved tolerance to HS, as indicated by reductions in RR and RT. Furthermore BET and BAX had overall improvements in growth rates and breast muscle growth and drip loss under both TN and HS conditions.

ACKNOWLEDGEMENTS

The authors would like to thank the Faculty of Veterinary and Agricultural Science, The University of Melbourne for the farm and laboratory facilities.

REFERENCES

1. Dai, S. F., Gao, F., Xu, X. L., Zhang, W. H., Song, S. X., & Zhou, G. H. (2012). Effects of dietary glutamine and gamma-aminobutyric acid on meat colour, pH, composition, and water-holding characteristic in broilers under cyclic heat stress. British Poultry Science 53: 471-481.
2. O’Shea, Y. A. C., Moore, D., & Hutchison, C. (2017). The response of growth performance and meat quality of broiler chickens to an experimental model of cyclical heat stress. In 28th Annual Australian Poultry Science Symposium (p. 237), 13-15 February 2017, Sydney, Australia.