Metabolic Effects of Heat Stress and Restricted Intake on the Lactating Cow

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The main effect of heat stress on the cow is a marked decline in voluntary feed intake (National Research Council 1981). There is increasing evidence, however, that there are physiological effects on the productivity of the lactating cow, beyond that explained by intake alone. Some of these effects may also influence milk composition, in particular casein fractions. As part of a study to identify and quantify these additional effects, blood metabolite concentrations were measured in cows placed under heat stress or with a restricted feed intake.

Twenty-four Holstein-Friesian cows were used in a completely randomised design experiment with 2 runs. Separate groups of 12 cows were used in each run, with the experimental unit being the individual cow. The cows were blocked firstly on β-lactoglobulin genotype (AB or BB) and then on average daily milk yield (high or low), before being randomly allocated to 3 treatments. The cows were tethered in 6 temperature controlled rooms in pairs. In each experimental run, 2 rooms were subjected to each treatment. The 3 treatments were 1) thermoneutral environment (temperature-humidity index (THI) <72), ad libitum intake (C); 2) ad libitum intake and imposed heat stress (increased temperature and humidity to THI ~78) to elicit a decrease in milk yield of 4-5 litres (H); and 3) intake restricted to that observed in H but thermoneutral environment as in C (R). Each experimental run was preceded by a 10-day adjustment period under ad libitum feed on offer and thermoneutral conditions. A 3-day covariate period (Period 1) continued these thermoneutral and ad libitum intake conditions. This was followed by a treatment period of 7 days (Period 2). At the end of each experimental period, all animals had samples of coccygeal arterial blood taken after morning milking and analysed for creatinine, creatinine phosphokinase (CPK), l-lactate, total protein, glucose, urea, β-hydroxybutyrate (B-OHB), NEFA, sodium, potassium, calcium, and chloride concentrations. Measurements were evaluated by analysis of variance, blocked on run/room, and using pairwise tests between means by LSD.

There was a reduction in milk yield of 5.3 L/d with H and 2.3 L/d with R cows. Noteworthy results from blood constituent analysis are presented in Table 1. There was no effect of treatment on plasma concentrations of total protein, glucose, B-OHB, l-lactate, CPK, potassium or sodium. R treatment had no effect on any blood plasma constituent. Heat stress caused a significant increase in plasma urea, plasma creatinine and plasma calcium above plasma concentrations of cows in C. H cows also had significantly higher concentrations of urea and calcium and significantly lower concentrations of serum NEFA than cows in R.

Table 2: Concentration of blood metabolites

Blood metabolite	Treatment group			LSD
	Control	Heat stress	Restricted Intake	
Plasma glucose (mmol/L)	3.28	3.08	3.24	0.27
Plasma urea (mmol/L)	5.35^{A}	6.47^{B}	5.11^{A}	0.68
Plasma creatinine (μmol/L)	82.5^{a}	107.5^{b}	92.8^{ab}	17.1
Plasma calcium (mmol/L)	2.25^{A}	2.38^{B}	2.24^{A}	0.07
Serum NEFA (mmol/L)	0.17^{ab}	0.10^{a}	0.24^{b}	0.10

^{a,b} Differing superscripts within a row indicate significant differences (P<0.05); ^{A,B} Differing superscripts within a row indicate significant differences (P<0.01)

Heat stressed animals have lowered milk production and an increase in gluconeogenesis and metabolic utilisation of amino acids (Bernabucci and Calamari 1998). H and R cows (same ME intake) provide the most interesting comparison and show elevated urea and creatinine and NEFA respectively. Elevated NEFA reflects mobilisation of body fat whereas elevated urea and creatinine reflect catabolism of amino acids and muscle tissue. Thus, for reasons still unknown, H and R cows appear to mobilise different tissues under paired feed restriction. One possibility for this is the need for H cows to produce acute phase proteins under heat stress which are high in aromatic amino acids, the source of which in other studies, with infections and immune responses, has been muscle tissue (Reeds et al 1994).

Bernabucci U, Calamari L (1998) *Zoot. Nut.i Anim.* **24:** 247.
National Research Council (1981) "Effect of environment on nutrient requirements of domestic animals." (National Academy Press: Washington D.C.).
Reeds, PJ, Fjeld, C. and Jahoor, F (1994). *J Nutr.*124, 906-910.

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