# The Effect of Pre-transport Cattle Management on Stress, Metabolism and Carcass Weight of Bulls

L. H. Jacobson and C. J. Cook
Meat Industry Research Institute of New Zealand, PO Box 617, Hamilton, New Zealand. e-mail: l.jacobson@mirinz.org.nz

## Introduction

In addition to stressors such as muster, transport, and unfamiliar surroundings at an abattoir, cattle may be fasted during the pre-slaughter period. Fasting can cause increases in plasma metabolites, consistent with mobilisation of energy reserves (Rule *et al.*, 1985; Ward *et al.*, 1992). In conjunction with transport and lairage, fasting may also cause significant reductions in liveweight and carcass yield (Jones *et al.*, 1988). Pre-slaughter fasting is often investigated in the period from start of transport to slaughter, probably due to the common abattoir practice of overnight lairage without feed. However, extensive grassland cattle systems may include a significant period of fasting between mustering and loading for transport. The aim of the present study was therefore to investigate what effect feeding regime during the holding period on-farm had on stress responses to subsequent transport and lairage, and on the final meat product.

## Materials and Methods

Two year old Friesian bulls (n=40) were assigned to 3 on-farm pre-transport holding treatments: 20, 8 or 3 hours (h). Groups were sub-divided within holding treatment, 20 to receive silage (at about 2.3 times maintenance energy requirements) during holding in yards, the remaining 20 fasted. Bulls were then transported for 2 hours to a commercial abattoir and slaughtered. Water was available *ad libitum* during holding and lairage.

Blood samples, heart rate (MIRINZ remote telemetric electrocardiogram collection system, Hamilton), rectal temperature (flexible digital thermometer, Becton Dickinson and Company, Canada), and live weight (True Test Scales, Auckland, New Zealand) were taken before and after holding. With the exception of live weight , these measures were taken again after transport. Blood plasma was separated and frozen immediately after collection, and later analysed for concentrations of urea nitrogen (PUN, urease kinetic UV method), non-esterified fatty acids (NEFA, ASC-ACOD calorimetric method, Wako Pure Chemical Industries Limited (1990), Osaka, Japan) and total cortisol ($^{125}$I radio-immunoassay). Warm carcass weights were recorded about 20 minutes after slaughter.

## Results and Discussion

After the holding period, bulls fasted during 20 h holding had a lower mean live weight than those fed silage, and those held for shorter periods ($p<0.05$, Table 1). For these 20 h fasted bulls, the mean live weight was 31 kg lighter after holding than before (overall mean pre-holding live weight was 546 kg). This live weight loss of about 1.6 kg h$^{-1}$ is higher than the live weight loss of 1.2 kg h$^{-1}$ reported for cattle fasted for 24 h after 3 h of transport (Jones *et al.*, 1988). However, estimates of cattle live weight losses with fasting vary. Mean live weight loss with fasting over about 24 h in other studies include 7.6% (Wythes *et al.*, 1980) and 10.7% (Bass and Duganzich, 1980) of initial live weight, compared with 5.7% in the present study. Live weight loss with fasting, particularly in the first 24 h, is thought to be mainly a function of gut emptying (Bass and Duganzich, 1980; Wythes *et al.*, 1980; Jones *et al.*, 1988). Variations in initial gut fill may also account for some differences in the literature.
NEFA concentrations were also affected by holding period, with highest levels of NEFA shown by animals fasted for 20 h ($p<0.05$, Table 1). Presence of high levels of fatty acids in blood suggests fat mobilisation from adipose tissue (Rule *et al.*, 1985). In the present study, mean NEFA concentration of bulls fasted for 20 h was almost twice that of bulls fed silage over 20 h holding. It was also much greater than the NEFA concentration of 0.35 mmol/L determined in bulls and steers fasted for 30 h in the study of Ward *et al.* (1988). This indicated a high level of lipolysis in bulls fasted for 20 h in the present trial, and may have contributed to the total live weight loss in these animals.

Mean PUN was higher in bulls held for 3 h than 8 and 20 h, and in bulls fed silage in comparison with those fasted during holding (Table 1). This initially appears counter-intuitive, as conditions giving rise to lipolysis, such as feed deprivation, may also be expected to increase the concentration of PUN as a by-product of catabolism of labile protein reserves for glycolytic precursors (Rule *et al.*, 1985). PUN concentrations have been shown to increase in cattle fasted for 30 h (1.8 - 2.3 mmol/L, Ward *et al.*, 1988) and 48 h (2.4-2.7 mmol/L, Rule *et al.*, 1985). Comparable differences in PUN were shown between bulls fed (4.2 mmol/L) and fasted (4.8 mmol/L) over a 20 h period in the present study. Bulls held for 3 and 8 h, however, had greater PUN concentrations than those held for 20 h, and also had higher mean PUN in fed groups than fasted. It is possible that the elevated PUN the fed bulls held for 3 and 8 h may have had a dietary contribution from silage, and perhaps pasture consumed before muster. Alternatively, or additionally, mustering, yarding and sampling may have promoted stress-induced proteolysis.

Stress tends to give rise to an increase in sympathetic and HPA axis indicators, such as cortisol and heart rate (Dantzer and Morméde, 1985; Cook and Jacobson, 1996). The mean cortisol concentrations of bulls held for 3 hours (46.5 and 60.7 nmol/L) was greater than bulls held 8 and 20 h (about 31 nmol/L, $p<0.05$, Table 1), and basal mean cortisol concentrations measured in adult Holstein-Friesian cows (33±2 nmol/L, Verkerk *et al.*, 1994). Bulls in the 3 and 8 h holding group also tended to have higher heart rates (77-90 bpm) than those in the 20 h group (71-72 bpm, $p<0.05$, Table 1). Basal heart rate for adult cattle range between 48-80 bpm (Clabough and Swanson, 1992), and have been estimated as 58-65 bpm in New Zealand 2-year old Friesian bulls (Cook and Jacobson, 1996). Comparing these ranges with mean heart rates of bulls in the present study suggests possibly some tachycardia (heart rate above basal) in all groups, but more so in the 3 and 8 h held groups. This elevated cortisol and heart rate of bulls held for shorter periods in the present trial, despite a lack of effect of treatments on rectal temperature ($p>0.05$), indicates a stress response. As increases in cortisol within physiologic ranges can induce proteolysis (Simmons *et al.*, 1984), it is possible that elevated cortisol in bulls held for 3 h may have induced tissue protein catabolism, with resultant deamination products contributing to the elevated PUN in these groups.

Transportation after holding appeared to intensify the effect of holding time on the mean plasma cortisol concentration of bulls held pre-transport for 3 h, with increases in mean cortisol from about 54 nmol/L after holding, to 100 nmol/L after transport (Table 1). Heart rate after transport, however, was not significantly affected by pre-transport holding periods. This appears to be due mainly to an increase in mean heart rate of bulls held for 20 h, rather than a decrease in mean heart rates of other groups. In addition, heart rate after transport was weakly correlated with cortisol concentration ($r = 0.32$, $p<0.05$). This indicates all groups experienced at least some stress responses to transport.

Additional transport-related stress appeared to have a greater effect on metabolism of bulls held pre-transport for 3 and 8 h than the provision of feed during holding. Before transport, feeding condition during holding had a significant effect on NEFA ($p<0.05$) and PUN ($p<0.001$). After

transport, however, feeding conditions were less significant in analysis (Table 1). In addition, after transport cortisol was correlated with PUN ($r = 0.51$, $p<0.001$), and although cortisol was not correlated with NEFA, PUN was ($r = 0.44$, $p<0.001$). Thus, stress responses to transport appeared to over-ride the effect of fasting during pre-transport holding periods of 3 and 8 h. However, feeding conditions during 20 h holding still affect post-transport NEFA and PUN, suggesting fasting-induced lipolyisis and proteolysis.

If fasting promoted significant lipolysis and proteolysis, carcass weights would be expected to be lower in fasted bulls than those fed silage during holding. This was the case with bulls held for 20 h, where the mean carcass weight was 26 kg greater than fasted bulls. Feeding conditions and holding time did not affect carcass weights of bulls held for 3 and 8 h, perhaps due to the time required for digestion and metabolism of silage nutrients. Interestingly, the mean carcass weights of the 3 and 8 h held groups were lower than that of bulls fed silage over 20 h pre-transport holding. This suggests that even short holding times (3 to 8 h) with subsequent transportation could have a detrimental effect on carcass weights.

In summary, the holding period before transport, and conditions during that period, can affect stress responses to transport and final meat yield. Mustering and yarding animals can increase levels of stress indicators, and holding in yards for less than 8 h appears to be inadequate time for recovery. Transporting bulls before recovery of stress indicators may result in increased stress responses and some loss in carcass weights. Holding socially familiar bulls pre-transport for 20 h may allow a decline in stress response indicators in comparison to shorter holding periods, and reduce responses to subsequent transport. Further research may confirm the rate of incidence of stressor application to the magnitude of stress response. Fasting bulls before transport for 20 h, although not increasing stress responses to transport, was detrimental to carcass weight production. Greater mean carcass weight, lower NEFA and PUN of silage-fed bulls during 20 h holding suggested a sparing effect on body reserves. Overall, of the pre-transport conditions investigated, stress response to transport and carcass yield were optimised with holding on farm for 20 h before transport with provision of a familiar feed source.

## References


Bass, J.J. and Duganzich, D.M. 1980. Anim. Prod., 31: 111-113.
Clabough, D.L. and Swanson, C.R., 1989. Am. J. Physiol., 257: R1303-R1306.
Cook, C.J. and Jacobson, L. H. 1996. Aust. Vet. J., 74: 28-29.
Dantzer, R. and Mormède, P. 1985. In: G.P. Moberg (Ed.), Animal Stress, American Physiological Society, Maryland, U.S.A, pp. 81-95.
Jones, J.M.D., Schaeffer, A.L., Tong, A.K.W. and Vincent, B.C. 1988. Livest. Prod. Sci., 20: 25-35.
Rule, D.C., Beitz, D.C., de Boer, G., Lyle, R.R., Trenkle, A.H. and Young, J.W. 1985. J. Anim. Sci., 61: 868-875.
Simmons, P.S., Miles, J.M., Gerich, J.E. and Haymond, M.W. 1984. J. Clin. Invest. 73: 412-420.
Verkerk, G.A., Macmillan, K.L. and McLeay, L.M. 1994. Dom. Anim. Endocr., 11: 115-123.
Ward, J.R., Henricks, D.M., Jenkins, T.C. and Bridges, W.C. 1992. Dom. Anim. Endocr., 9: 97-103.
Wythes, J.R., McLennan, S.R. and Toleman, M.A. 1980. Aust. J. Exp. Agric. Anim. Husb., 20: 517-521.


TABLE 1.
Physiological parameters of 2 year old bulls (n=40) after holding in yards for 20, 8 or 3 h, and after subsequent transport, with bulls either provided silage (+) or fasted (-) during holding. Data were tested by analysis of variance.

| Holding treatment | [1]Liveweight (kg) after holding | [2]Heart Rate (bpm) | | [2,3]Non-esterified Fatty Acid (mmol/L) | | [2]Plasma Urea Nitrogen (mmol/L) | | [2,3]Cortisol (nmol/L) | | [1]Carcass weight (kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | holding | transport | holding | transport | holding | transport | holding | transport | |
| 3 (-) | $541^{a}$ | $82^{a,b}$ | $86^{a}$ | $0.30^{a,b}$ | $0.46^{a}$ | $6.86^{a}$ | $6.59^{a}$ | $60.7^{a}$ | $92.1^{a}$ | $287^{a}$ |
| 3 (+) | $543^{a}$ | $77^{a,b}$ | $83^{a}$ | $0.27^{a}$ | $0.45^{a}$ | $7.40^{b}$ | $6.85^{a}$ | $46.5^{a,b}$ | $108.8^{a}$ | $281^{a,b}$ |
| 8 (-) | $537^{a}$ | $90^{a}$ | $86^{a}$ | $0.45^{b,c}$ | $0.32^{a}$ | $5.10^{c}$ | $4.57^{b}$ | $28.9^{b}$ | $30.8^{b}$ | $289^{a,c}$ |
| 8 (+) | $541^{a}$ | $76^{a,b}$ | $77^{a}$ | $0.45^{b,c}$ | $0.39^{a}$ | $7.10^{a,b}$ | $5.86^{c}$ | $30.9^{b}$ | $31.5^{b}$ | $284^{a,b}$ |
| 20 (-) | $515^{b}$ | $71^{b}$ | $82^{a}$ | $0.56^{c}$ | $0.38^{a}$ | $4.81^{c}$ | $4.76^{b}$ | $31.0^{b}$ | $27.5^{b}$ | $274^{b}$ |
| 20 (+) | $555^{c}$ | $72^{b}$ | $80^{a}$ | $0.29^{a}$ | $0.12^{b}$ | 4.24 | 3.26 | $34.3^{b}$ | $21.5^{b}$ | $300^{c}$ |
| LSD[4] | 8 | 14 | 14 | [5]1.54 | [5]1.96 | 0.38 | 0.37 | [5]1.68 | [5]1.93 | 12 |
| Interaction | *** | ns | ns | * | ** | *** | *** | ns | ns | *** |
| Holding time | ** | * | ns | ns | ** | *** | *** | * | *** | ns |
| Feed conditions | *** | ns | ns | * | ns | *** | ns | ns | ns | ns |

[1] Liveweight and carcass weight means are adjusted for the covariate pre-holding liveweight.
[2] Heart rate, non-esterified fatty acid, plasma urea nitrogen and cortisol means are adjusted for the covariate pre-holding residuals.
[3] Means presented are transformed back from analysis on $\log_e$ data.
[4] LSD = least significant difference between means for significance at 5%.
[5] Least significant ratio quoted instead of LSD due to analysis on transformed data.
ns = not significant ($p>0.05$), * = $p<0.05$, ** = $p<0.01$, *** = $p<0.001$.
[a,b,c] Means with the same superscript within column are not significantly different ($p>0.05$).