

EFFECTS OF MARKETING PROCEDURE AND LIVELWEIGHT CHANGE PRIOR TO SLAUGHTER ON BEEF CARCASS AND MEAT QUALITY

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SUMMARY

Sixty Hereford-type steers of approximately 400 kg liveweight and 16 to 27 months old were fed on either limited pasture (Low Nutrition; winter pasture typical of SE Australia) or pasture with hay supplement (High Nutrition) for three weeks prior to slaughter. Half the animals from each treatment were taken directly from pasture to slaughter (Direct) while the other half went through a simulated saleyard marketing procedure (Saleyard). The Saleyard cattle had reduced dressing percentage, increased plasma corticosteroid concentrations ($P < 0.01$), reduced muscle glycogen, increased loin muscle ultimate pH, darkened muscle colour and an increased bruise score ($P < 0.05$ for all) compared to Direct cattle. Low Nutrition cattle lost more weight over the three weeks, had a lower final liveweight, a higher carcass dressing % and lower loin muscle glycogen than High Nutrition cattle. Cattle in the Low Nutrition treatment undergoing Saleyard marketing had higher plasma free corticosteroid concentrations and lower muscle glycogen than all other treatments ($P < 0.01$). Cattle slaughtered on a declining plane of nutrition and marketed via a saleyard system are at increased risk of producing carcasses of inferior quality.

Keywords: beef cattle, meat quality, dark-cutting, bruising.

INTRODUCTION

Tenderness, juiciness, flavour, colour and shelf-life of beef meat is detrimentally influenced by a reduced content of muscle glycogen at slaughter, resulting in high pH (pH > 5.8), 'dark-cutting' (DC) meat (Tarrant 1989). Well-fed and rested cattle generally have a muscle glycogen content of 0.8-1.0% wet weight in the *M. longissimus thoracis et lumborum* (LTL). If the muscle glycogen content at slaughter drops below about 0.57%, the ultimate pH of the meat will be > 5.8 (Tarrant, 1989) and will produce inferior meat. Muscle glycogen concentration can be markedly reduced by pre-slaughter stressors such as transport, poor nutrition, cold or changing weather, prolonged exercise, inappropriate pre-slaughter handling or extended time off feed. Cattle encounter new stimuli, strange environments and their social hierarchy is disturbed during the period from paddock/pen to slaughter. The innate, or possibly learned, response of animals to a strange or different environment often determines their stress response, including the release of adrenaline and the subsequent depletion of muscle glycogen.

Stressors associated with seasonal changes such as cold, wet weather and reduced nutritional status of pasture (typical of late autumn and winter in SE Australia) have been reported to contribute to the incidence of dark-cutting beef meat. The inadequacy of summer-autumn pasture has been associated with 'ill-thrift' and decreased blood glucose levels among grazing cattle and sheep (Scott *et al.* 1976), and an increase in the incidence of DC beef carcasses has been reported during autumn-winter for SE Australia (Warner 1989). Little information is available on the effect of liveweight loss before slaughter on subsequent meat quality.

Compared with cattle consigned direct to the abattoir for slaughter, those marketed via a saleyard are generally subjected to more handling, are in transit and without feed and water longer and are exposed to more potential stressors. All of these stressors may cause a reduction in the concentration of muscle glycogen at slaughter (Hails 1978). Saleyard marketing of cattle, transport and associated handling are also believed to be major factors attributed to bruising. In Victoria, 80 per cent of cattle are sold through saleyards.

Cattle are often sold for slaughter during autumn-winter on a reducing plane of nutrition due to limited pasture availability. Given the importance of seasonal effects on nutrition and the influence of transit time on muscle glycogen and carcass bruising, the two major aims of the experiment were to determine the influence of the level of nutrition and marketing procedure (saleyard versus direct consignment) upon carcass and meat quality of beef cattle.

MATERIAL AND METHODS

Sixty Hereford and Hereford-cross steers, 16 to 27 months old, were grazed together for several months in autumn-early winter until three weeks before slaughter. They were then weighed (mean liveweight 402 kg, range 338 to 508 kg) and randomly allocated to one of two nutrition treatments for three weeks: (i) Low Nutrition - grazed on pasture of limited availability; (ii) High Nutrition - grazed on pasture of limited availability but supplemented with one-third bale of pasture hay per head per day.

Non-fasted live weights of the cattle were obtained at weekly intervals. The cattle were classed into strata of live weight change and allocated at random within nutrition treatment and live weight change strata to one of two marketing treatments: (i) Direct - transported direct to the abattoir; (ii) Saleyard - transported to the abattoir through a simulated saleyard procedure.

The Saleyard treatment was applied in the following manner. Two days before slaughter, cattle in the saleyard treatment groups were assembled in familiar yards, transported for 100 km and then placed in unfamiliar yards overnight with access to water. While they were in the unfamiliar yards, the animals were put through pre-determined handling and drafting procedures considered representative of saleyard selling on the basis of liveweight. The next day cattle were transported a further 100 km and returned to the familiar yards. During this time, the Direct cattle remained at pasture.

Subsequent to two hours of simulated saleyard procedure, blood samples were collected from the caudal vein of all animals for measurement of plasma free corticosteroids as an indicator of adrenal response to the treatment. The cattle were transported to the abattoir (30 km) and were fasted from feed and water overnight prior to slaughter.

Within thirty minutes of slaughter, a sample of the LTL was taken over the twelfth rib of each carcass, frozen and stored in liquid nitrogen for measurement of muscle glycogen concentration. Hot carcass weight of an AUSMEAT standard trim carcass and fat depth over the thirteenth rib were recorded. Dressing percentage was calculated as the hot carcass weight expressed as a proportion of the final unfasted liveweight. The bruise score of each carcass was assessed according to the Australian Bruise Scoring system on a scale of 0 to 6 where 0 = no bruising and 6 = large, deep bruising (Anderson and Horder 1979). At 24 hours post-slaughter, the ultimate pH of the LTL was measured and subjectively assessed for muscle colour on a scale of 1 to 10, where 1 = pale red and 10 = very dark purple-red. A ten cm sample of the LTL was removed from the tenth to twelfth ribs, trimmed of fat, frozen at -20°C for three weeks, thawed and measured for Warner-Bratzler peak shear force (Bouton *et al.* 1978).

The effect of nutrition and marketing procedure on animal carcass and meat characteristics was determined by analysis of variance for a split-plot design blocked for effects of stratified live-weight change within each nutritional treatment. Initial live-weight had no effect on any measurements ($P > 0.05$) and is not discussed further.

RESULTS

Nutritional effects

The high nutrition cattle had a positive and higher liveweight change over the three week period ($P < 0.001$) and were 6% heavier in final mean live-weight ($P < 0.01$) than low nutrition cattle, although mean carcass weight was similar ($P > 0.05$). Mean dressing percent was lower ($P < 0.001$) for cattle in the high nutrition treatment and the mean fat depth tended to be higher ($P = 0.08$). (Table 1).

Effect of marketing procedure

Carcasses from cattle in the saleyard treatment had a lower mean carcass weight ($P=0.06$), lower mean dressing percentage ($P<0.001$) and had a higher mean bruise score ($P < 0.01$) compared to the direct consignment treatment. Saleyard cattle had a higher mean level of plasma free corticosteroids ($P < 0.01$) than cattle consigned direct to the abattoir. The LTL muscles of carcasses from saleyard cattle were darker in colour ($P<0.05$), had a higher mean ultimate pH ($P<0.01$) and tended to be tougher ($P=0.09$) than cattle consigned directly to the abattoir.

Interaction between marketing and nutrition

Cattle on a low plane of nutrition that were marketed through a saleyard-type system had a lower mean muscle glycogen level at slaughter ($P<0.01$) than cattle in all other treatment groups. Within the low nutrition group, muscle glycogen was reduced by 43% by saleyard marketing compared to direct consignment. In the high nutrition group, saleyard marketing only reduced muscle glycogen by 13% compared to direct consignment.

Table 1. The effect of level of nutrition (Nutr) and marketing procedure (Mkt) carcass and meat quality attributes and plasma free corticosteroid levels

	High Nutrition		Low Nutrition		s.e.d. ^b		Significance (P)		
	DC ^a	SY ^a	DC	SY	Main effects	Nutr xMkt	Nutr	Mkt	Nutr xMkt
Final liveweight (kg)	422	412	392	393	7.80	10.8	0.009	ns	ns
Liveweight change (kg)	6.5	7.8	-3.7	-4.7	1.26	1.78	<0.001	ns	ns
Hot carcass weight (kg)	217	205	209	203	4.5	6.4	ns	0.06	ns
Dressing percent	51.9	49.8	53.2	51.7	0.36	0.50	<0.001	<0.001	ns
Fat depth (mm)	6.2	5.9	5.5	5.1	0.42	0.60	0.08	ns	ns
Muscle glycogen (% wet weight)	0.72	0.66	0.64	0.36	0.040	0.057	<0.001	<0.001	0.009
Ultimate pH	5.50	5.57	5.52	5.58	0.023	0.032	ns	0.008	ns
Meat colour score ^b	3.2	3.9	3.4	4.2	0.33	0.47	ns	0.02	ns
Peak shear force (kg)	3.49	4.01	3.81	4.04	0.22	0.30	ns	0.09	ns
Bruise score ^c	1.4	4.6	1.3	4.9	1.0	1.5	ns	0.002	ns
Plasma free corticosteroids (ng/mL)	1.44	1.99	1.57	3.42	0.37	0.52	ns	0.002	ns

^a DC = direct consignment, SY=saleyard^b 1 = pale red, 10 = very dark purple-red^c 0 = no bruising, 1 = small, surface bruising, 6 = large, deep bruising.

DISCUSSION

The results suggest that the main effect of nutrition in the three weeks pre-slaughter is on liveweight and fat depth. In addition, cattle on a declining plane of nutrition pre-slaughter are more susceptible to producing a dark-cutting carcass because they are chronically stressed, as indicated by high plasma corticosteroid concentrations and low muscle glycogen concentrations. Saleyard cattle were chronically stressed and produced carcasses with a lower mean dressing percent, higher mean bruise scores, darker meat and higher mean ultimate pH, and a tendency for less tender meat. Low nutrition and saleyard marketing were additive in their effect and together appreciably increased the chronic stress levels in the cattle and significantly reduced muscle glycogen. The method used to consign the cattle for slaughter had a greater effect on meat quality than nutrition, with poor nutrition and saleyard marketing together exacerbating the results.

The treatments imposed had significant effects on carcass and meat quality, but all of the carcasses would have been acceptable to the supermarket trade except for one carcass which exhibited dark-cutting (ultimate pH > 5.8) in the high nutrition, saleyard treatment.

The level of nutrition had a major influence on liveweight change, final liveweight, carcass dressing percentage and fat depth. Surprisingly, hot carcass weight was not influenced by the level of nutrition, but was affected by the method of marketing the cattle; thus the difference in final liveweight between the nutrition treatments was probably caused by differences in gut-fill. Although the cattle marketed through the simulated saleyard system were withdrawn from pasture approximately 24 hours earlier than those consigned direct, this was unlikely to have caused the difference in carcass weight between the marketing treatments as serial slaughter experiments have shown that carcass weight and dressing % are unlikely to be affected until after 3 days of fasting (Kirtan *et al.* 1972). The cattle sold through the saleyard system had a lower mean dressing % and lighter carcasses than cattle sold directly for slaughter. Smith *et al.* (1982) reported that carcass weight decreases linearly with the duration of transport and suggested that stress may reduce the size of some components of carcass weight. Schaefer *et al.* (1996) reported that the stress associated with transport and handling procedures during marketing causes various physiological changes in cattle including dehydration of muscle cells, reducing carcass weight. We have previously found that animals subjected to high levels of stress during transport had lower carcass weights than less stressed animals (Eldridge, unpublished results).

Carcasses of cattle in the simulated saleyard treatment were more bruised than those sent direct to the abattoir for slaughter, probably as a consequence of the extra handling and transport. These carcasses also had a higher mean ultimate pH and darker loin muscles. Shorthose (1980) and Buchter (1975) also found that

cattle consigned direct had lower mean meat pH values than cattle from saleyards, although Warner *et al.* (1988) and Stevenson *et al.* (1996) reported no difference in meat pH between saleyard and direct consigned cattle. Wythes and Shorthose (1984) reported that cattle consigned direct to the abattoir had less bruising than those consigned via a saleyard.

The conditions imposed in this experiment could be considered to be representative of those imposed on cattle during autumn-winter in SE Australia, as at this time of year when pasture availability is often falling. In addition, beef farmers sometimes experience a poor season or time of year and find that they have failed to finish cattle to a desired weight; they realise that the cattle are falling in condition and need to be slaughtered quickly. The increase in the incidence of DC in beef carcasses often seen in SE Australia in autumn-winter may be a consequence of a combination of pre-slaughter stressors. Also, marketing cattle via a saleyard system is likely to produce carcasses with increased bruising. Although the reduction in muscle glycogen concentration found in this study was insufficient to produce DC meat, it demonstrates the importance of considering the effect of multiple stressors on meat quality. These results are consistent with the work of Bray *et al.* (1989) who demonstrated the additive effects of multiple stressors (level of nutrition, shearing, washing) on the ultimate pH of sheep meat.

In conclusion, well-fed cattle marketed for slaughter off a high plane of nutrition were more resistant to the stressors involved in the marketing system than undernourished cattle coming off a declining plane of nutrition. Cattle decreasing in liveweight which are marketed for slaughter via the saleyard system are at a higher risk of producing a carcass of inferior quality.

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