Exercise effects on muscle glycogen concentration in beef cattle

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ABSTRACT

Low ultimate-pH of beef is desirable because it increases shelf life and has beneficial effects on colour and tenderness. Industry recommendations are that beef animals are not exercised strenuously prior to trucking, as this may trigger depletion of muscle glycogen and lead to higher beef pH. In 2 experiments, 400-500 kg 18-month-old steers were exercised at a range of intensities up to 5 km distance at 8 km/hr. Biopsy samples from the *longissimus dorsi* muscle were taken and glycogen concentration measured. Although plasma lactate levels were elevated by exercise there was no significant depletion in muscle glycogen concentration (average 17.7 mg/g tissue). Depletion may have occurred had animals been heavier and fatter, or if the exercise regime had been more severe. Alternatively, it may be that at the level of exercise imposed (which was severe by farm-practice standards), animals also needed to be emotionally stressed in order to precipitate a depletion of glycogen, through a combination of muscle contractile and adrenergic reactions.

Keywords: beef; muscle; glycogen; exercise; pH.

INTRODUCTION

Low-ultimate pH of beef is desirable because it increases shelf life and has beneficial effects on colour and tenderness (Purchas & Knight 1994). Living muscle has a pH of about 7.0, and after slaughter of rested, well-fed animals glycogen breakdown to lactic acid results in a fall in pH to about 5.5. In resting cattle the average glycogen concentration is about 14.4 mg/g wet tissue, to achieve a beef ultimate pH of 5.5 the concentration must be greater than 10.3 mg/g at slaughter, and depletion of muscle glycogen can be rapidly triggered by increased circulating adrenaline or strenuous muscular activity (Tarrant 1989). Stressors occurring after the animal leaves the farm will lower muscle glycogen (Purchas 1992), and farmers have little direct control on this. However, they could implement on-farm practices aimed at minimising glycogen depletion, or alternatively at providing a 'glycogen buffer' prior to trucking. New Zealand beef industry recommendations for on-farm management of beef cattle discourage practices which involve animals in strenuous exercise (Meat Research and Development Council 1994).

In this paper we report results of two trials designed to measure the influence of exercise of beef cattle on muscle glycogen concentration.

MATERIALS AND METHODS

Experiment 1

Forty-three 18-month-old beef breed x Friesian steers were weighed and allocated to 3 groups in February 1997, at AgResearch's Flock House Research Station. On the day of the experiment one group (Control) was moved quietly from its adjacent paddock to the yards. A second group (Short) was moved at 4 km/hr over a 2.5 km course along flat, metalled farm tracks which ended at the yards. A third group (Long) was moved twice around the same course, ie., 4 km/hr for 5.0 km. Immediately following their exercise treatment the steers were mildly sedated, a blood sample obtained, and a 300 mg biopsy sample obtained from the *longissimus dorsi* (LD) muscle. Muscle samples were immediately frozen in liquid nitrogen and glycogen concentration subsequently determined using the iodine binding method (Dreiling *et al*., 1987). Blood samples were processed to obtain plasma, and lactate concentration determined.

Experiment 2

Thirty-one 18-month-old beef breed x Friesian steers were weighed and allocated to 2 groups, in a second exercise trial conducted in February 1998. The Control treatment was managed as for experiment 1, but the exercise group (Fast) was subjected to more strenuous exercise than in experiment 1 - these cattle were moved twice around the same course (5 km in total), but at twice the speed i.e., 8 km/hr. In this case use of dogs was necessary to induce the animals to maintain the desired average speed. Blood and muscle sampling occurred as for experiment 1.

Animals used in both experiments were accustomed to human presence and being handled, as they had previously been used in feeding trials.

RESULTS AND DISCUSSION

Exercise did not affect glycogen concentration ($P>0.05$) in the LD muscle in either trial (Table 1). Lactate concentration in the plasma increased with distance walked in experiment 1 ($P<0.05$), and there was a similar tendency in experiment 2 ($P<0.15$).

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TABLE 1: Details of experimental groups, and muscle glycogen and plasma lactate concentrations for experiments 1 and 2.

	Experiment 1			Experiment 2	
	Control	Short	Long	Control	Fast
Number of animals	13	15	15	16	15
Liveweight (kg)	397 ± 42	397 ± 30	394 ± 43	479 ± 13	478 ± 13
Glycogen concentration (mg/g tissue)	16.3 ± 1.2	19.2 ± 1.1	16.2 ± 1.1	19.5 ± 1.0	17.3± 1.0
Lactate concentration (mmol/l)	0.96 ± 0.15	1.19 ± 0.14	1.55 ± 0.14	1.38 ± 0.19	1.79 ± 0.19

In experiment 1 glycogen concentration was not affected by walking the steers at a moderate pace for up to 5 km, although the elevation in plasma lactate was taken to indicate that anaerobic metabolism had occurred (Pethick *et al*., 1991). It was hypothesised that the more vigorous regime of the Fast treatment in experiment 2 would result in an even higher rate of anaerobic metabolism, and this would lead to increased utilisation of muscle glycogen. This did not occur.

Exercising sheep at up to 9 km/hr resulted in incomplete utilisation of liver glycogen (Pethwick *et al*., 1991). Since liver glycogen becomes depleted before that of muscle, these researchers hypothesised that muscle glycogen was not depleted, although they did acknowledge that specific depletion of fast twitch muscle fibres (the LD is normally regarded as fast twitch) may have occurred.

Most of the evidence for physical exercise reducing muscle glycogen concentration in beef cattle involves interactions occurring when unfamiliar bulls are mixed. McVeigh & Tarrant (1982) mixed groups of bulls for 6 hours, leading to a halving of glycogen content in the LD. They concluded that "the unaccustomed and intense physical activity associated with the mixing procedure was undoubtedly a major cause" of the physiological changes observed. However they acknowledged that "physical activity was probably accompanied by emotional arousal in response to a novel and threatening situation." Tarrant (1989), in summarising research on "dark-cutting" (high pH) beef, states that muscle contractile activity (as opposed to adrenaline release) is a major cause of dark-cutting under commercial conditions, and gives several reasons why this should be the case.

It is surprising that glycogen depletion did not occur in the present work. Several possible explanations exist for the lack of an effect: fast-walking of steers does not elicit the same generalised physiological effect as fighting/ mounting activity of bulls; and/or we did not exercise the steers strenuously enough, or for long enough to deplete muscle glycogen; and/or release of adrenaline may be required before the level of exercise we imposed would significantly reduce muscle glycogen.

It is not anticipated that farmers would normally subject steers to more severe pre-trucking exercise conditions than those imposed in this trial. Maybe heavier, fatter animals would be more stressed by such treatment. It is also possible that animals less accustomed to handling would exhibit an adrenergic reaction which exacerbated the effects of exercise.

CONCLUSIONS

Walking mature, well-fed steers of moderate liveweight (400-500 kg) at a moderate speed for 40 minutes is not likely to significantly deplete muscle glycogen content, and hence is unlikely to lead to elevated beef pH post-slaughter.

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