

# Dark cutting beef and strategies to reduce it

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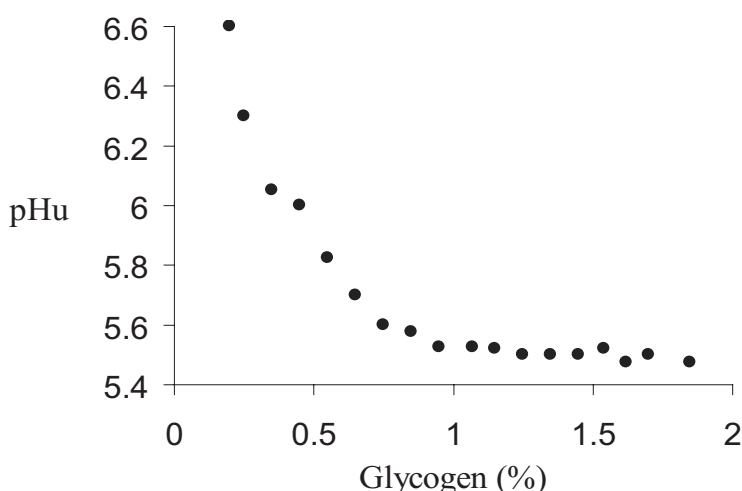
## Session 5d

Glycogen stored in the muscle of animals acts as the energy source for physical activity. After death the glycogen reserves in the muscle are converted to lactic acid in a process called glycolysis. As lactic acid accumulates the pH of the muscle falls from about 7.00 to “normal” values of around 5.40 to 5.60. Glycolysis continues for around 24 hours after slaughter before the ultimate (final) pH level is reached.

Low muscle glycogen levels are found in animals that have been stressed before slaughter or

Traditionally DFD beef has been studied by measuring the pH of meat some 24 hours after slaughter. However the pH of meat has proven to be a relatively insensitive probe for understanding DFD since glycogen levels in skeletal muscle in the live animal must be about 50% depleted before muscle pH shows any change (Figure 5d-1). Therefore ultimate pH is a good indication of glycogen if levels are low, but does not indicate the size of the buffer at the higher glycogen levels.

The measurement of pH is increasingly being demanded by meat retailers for the purpose of quality control and under the new Meat Standards grading scheme a  $\text{pH} \leq 5.7$  is necessary for meat to be eligible for grading.

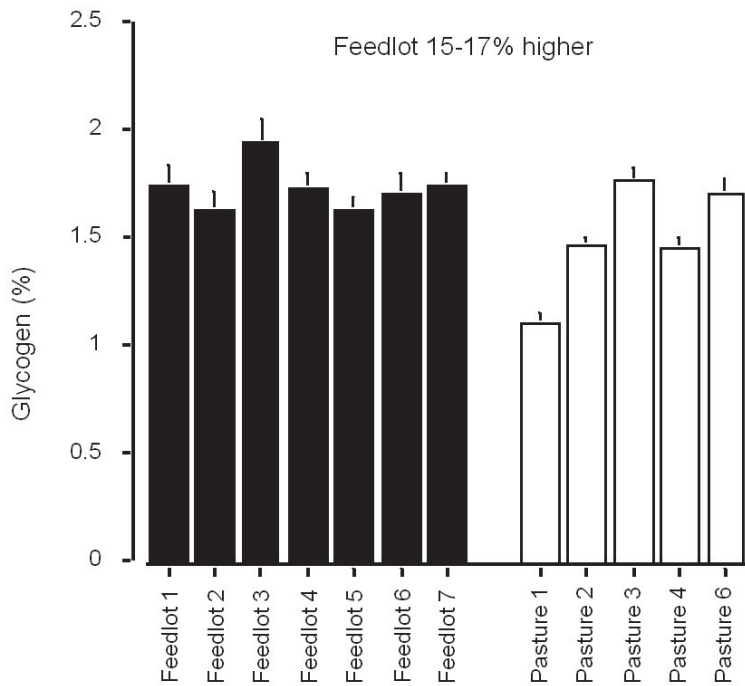


**Figure 5d-1.** The relationship between ultimate pH (pHu) of meat and the concentration of glycogen in muscle (LD) immediately post slaughter (adapted from Warriss 1990).

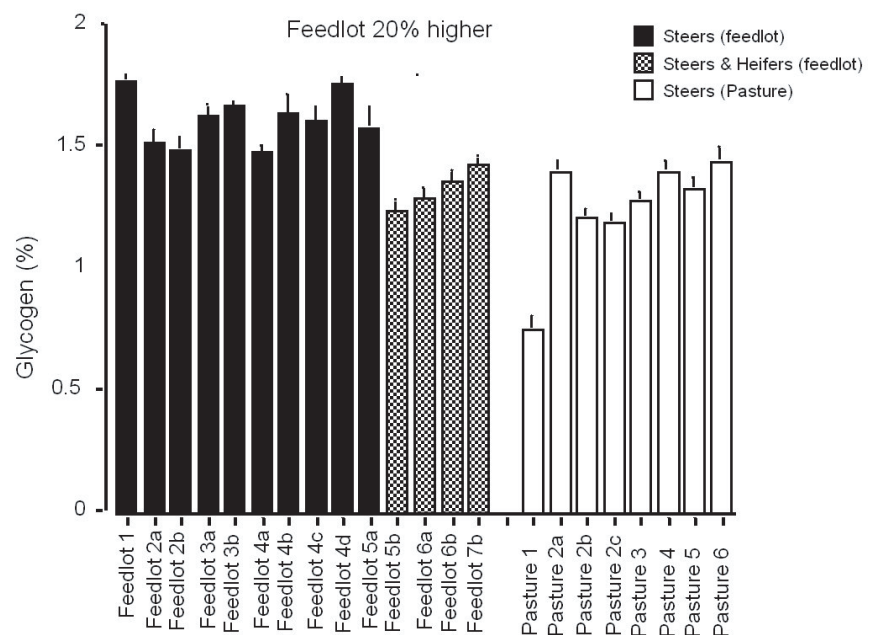
maintained on poor nutrition. As a result of these lower levels of glycogen there is less lactic acid production and meat has a higher ultimate pH. Meat with a high ultimate pH will be dark in colour, often tougher, drier, have a shorter shelf life and is generally undesirable to consumers. In industry terms this is known as dark cutting, or Dark Firm Dry beef (DFD).

## Glycogen and nutrition

Nutrition is an important determinant of muscle glycogen concentration. High energy rations have been shown to promote high muscle glycogen concentrations, an effect highlighted by the comparison between feedlot and pasture fed cattle. Figure 5d-2 demonstrates this effect, as on farm muscle glycogen concentrations for cattle maintained on high energy feedlot rations were 15-17% higher than cattle maintained on lower energy pasture diets. When these same mobs were sent to slaughter, this difference increased to 20%, reflecting the greater adaptation to handling stress in feedlot cattle (Figure 5d-3). From Figure 5d-3 it can also be seen that muscle glycogen concentrations of mixed sex feedlot groups were markedly lower than those consisting of only steers. Heifers tend to be more “flighty” than other cattle, contributing to the greater glycogen loss evidenced in the groups containing heifers.



**Figure 5d-2.** *M. semimembranosus* glycogen concentration “on farm” in pasture fed and feedlot cattle. Values are means of entire mobs.

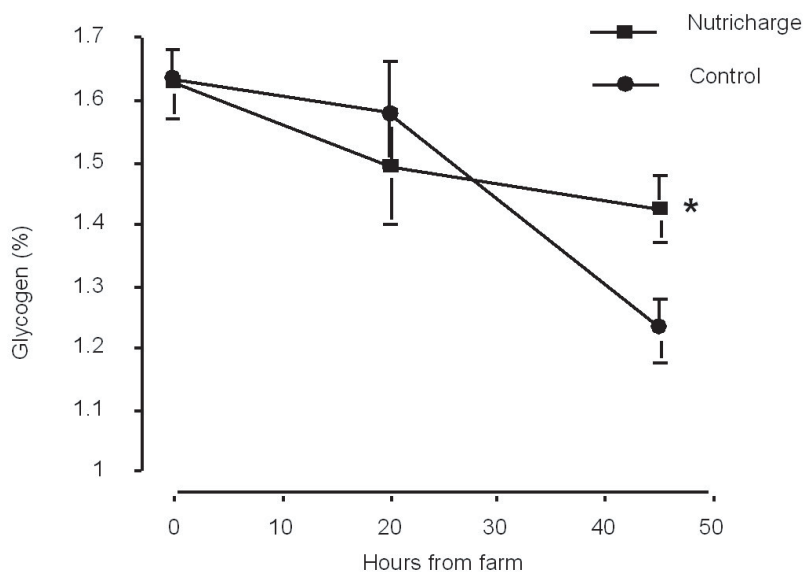


**Figure 5d-3.** *M. longissimus dorsi* glycogen concentration “at abattoir” in pasture fed and feedlot cattle. Values are means of entire mobs.

## Electrolyte supplements

Electrolytes such as calcium, sodium and potassium are essential for an animal’s normal metabolism, and it has been suggested that the levels of these electrolytes may be unbalanced through stress. There are a range of different electrolyte products available commercially and some of them have been tested experimentally within Australia, in most cases marginally reducing glycogen loss prior to slaughter. Figure 5d-3 demonstrates the impact of supplementing cattle with Nutricharge™ in lairage for durations of 18 or 42 hours. Glycogen loss was reduced in the 42 hour lairage scenario. Dressing percentage was also improved in the 42 hour lairage scenario, with the control treatment group having a dressing percent of 53.7% versus 55.2% for the Nutricharge™ treated cattle.

Similar responses have been evidenced in 3 out of 4 experiments with Nutricharge™, however in all cases there were problems with intake of the product. This may be due to the pelleted nature of Nutricharge™ differing from the loose-mix feedlot ration that the animals had previously been maintained on. Thus Nutricharge™ may be an effective option for stress protection in circumstances of extended lairage, so long as intake of the product is adequate.

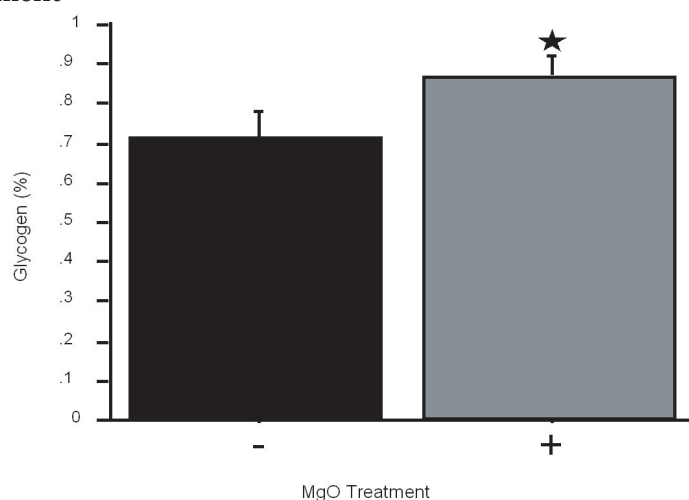


**Figure 5d-4.** Changes in muscle glycogen content of the *m.semimembranosus* with lairage time from feedlot (0 hr sample, muscle biopsy) to slaughter after 16 hrs or 42 hrs in lairage (\* denotes a significant ( $P < 0.05$ ) difference between means at the same time interval).

### Magnesium supplements

The electrolyte magnesium has also been shown to offer some degree of protection from stress in sheep, thus limiting the loss of muscle glycogen prior to slaughter. This electrolyte is supplemented “in feed” in the form of a powder (Magnesium Oxide - MgO) at 1% of the ration for 4 days prior to consignment for slaughter. Figure 5d-4 demonstrates the improvement in muscle glycogen concentration in sheep, a similar response achieved in 3 out of 4 commercial sheep experiments.

MgO has been tested in cattle but has shown little benefit. The supplement demonstrates an effect only when stress is imposed, and in the cattle experiments to date pre-slaughter stress has been minimal, indicating a need for more experimental work in this area. However it may still have scope as a stress protection treatment in cattle.



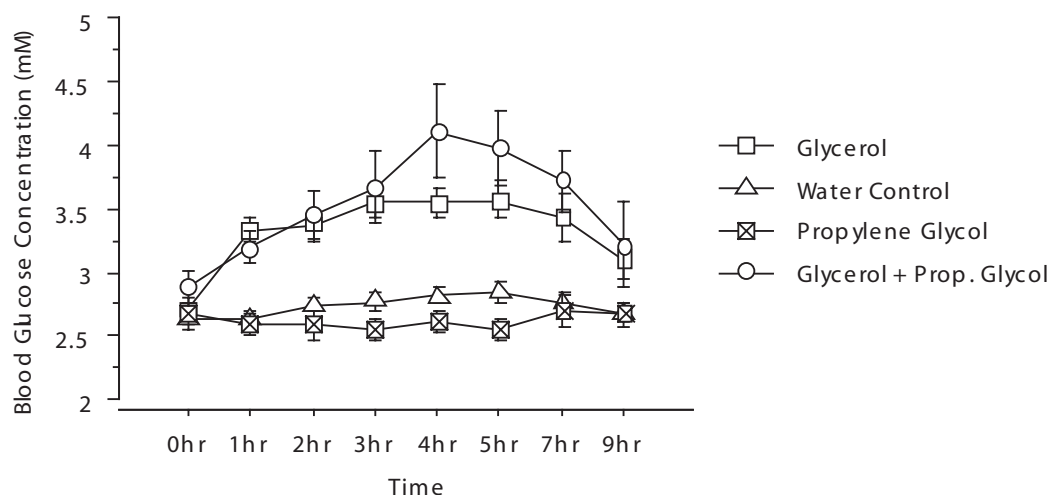
**Figure 5d-5.** Effect of MgO on glycogen concentration at slaughter in the *m.semitendinosus*.

### Water-borne carbohydrate supplements

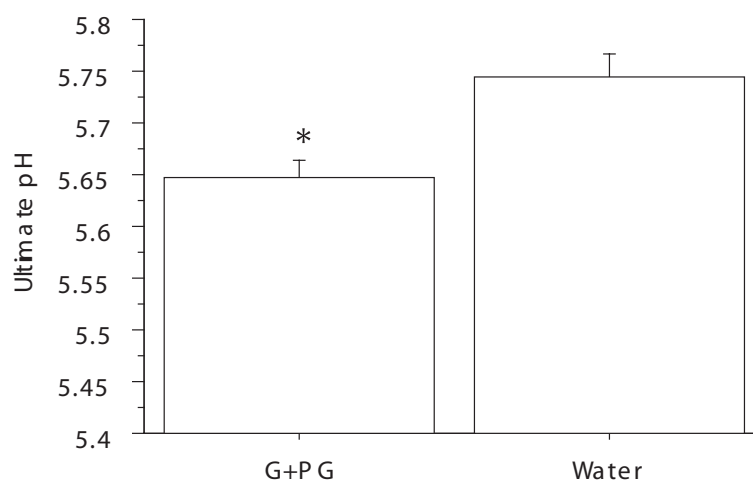
Another option for controlling dark cutting is the use of water-borne carbohydrate supplements. This can include simple sugars such as glucose, or other substrates such as glycerol and propylene glycol. Importantly these substrates have to increase blood glucose concentrations (hyperglycaemia) which in turn promotes muscle glycogen storage. Simple sugars such as glucose have been used with varying degrees of success, however concerns over microbial contamination of water and attraction of insects such as wasps and bees (which deter animals from water troughs) preclude their use.

Alternative hyperglycaemic agents include glycerol and propylene glycol, both commonly used within the dairy industries for treating

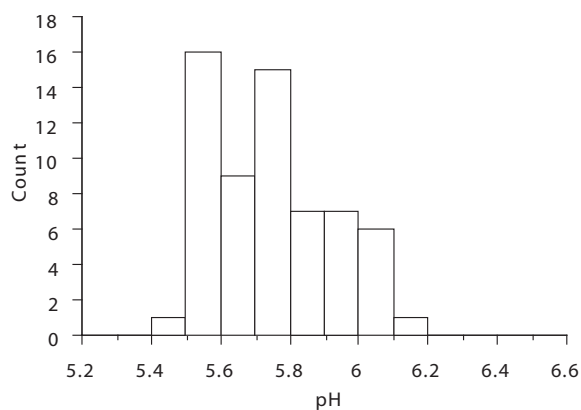
bovine ketosis. Propylene glycol has the added advantage of being an anti-microbial agent commonly used within the pharmaceutical industries. Early phases of this work focused on quantifying the hyperglycaemic effect that glycerol and propylene glycol would have when drenched directly into the rumen of sheep. The dose response curves seen in Figure 5d-5 demonstrate that a combination of glycerol and propylene glycol produces the largest hyperglycaemic response of all substrates. Therefore further work focused on the use of a combination of glycerol and propylene glycol.



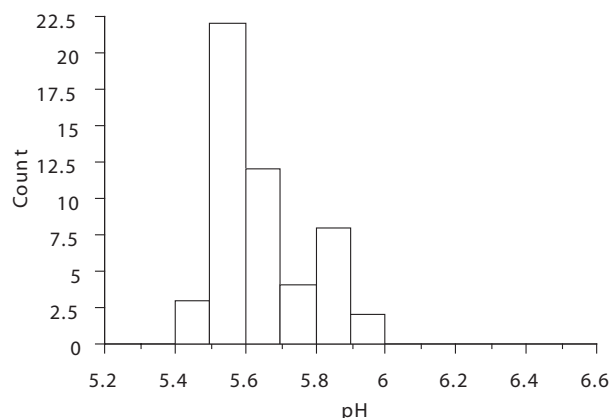
**Figure 5d-6.** The effect of oral glycerol (150g), propylene glycol (150g) and a mixture of glycerol/propylene glycol (105/45g) on blood glucose concentration.



**Figure 5d-7.** The ultimate pH of the *m. longissimus dorsi* in Cows held in lairage for 24 h.



**Figure 5d-8(a)** water only controls 36 Bodies with pH > 5.7



**Figure 5d-8(b)** Glycerol/Propylene treated 14 Bodies with pH > 5.7

**Figure 5d-8.** The Frequency distribution of ultimate pH of the LD in Cows held in lairage for 24 h.

When glycerol and propylene glycol were mixed in drinking water at the rate of 3.5% and 1.5% respectively, it was found that the substrate supplied was insufficient to increase muscle glycogen concentrations in cattle. However, when mixed in the drinking water of animals in lairage, it was shown to reduce the ultimate pH of cattle by about 0.1 of a pH unit irrespective of glycogen concentration. This is demonstrated in Figure 5d-6, where cows were offered either water or water plus the glycerol and propylene glycol supplement for a 24 h lairage period. In practical terms, this meant that from two groups of 62 animals there were 14 bodies with pH >5.7 in the treated group, compared with 36 with pH >5.7 in the water control group (Figure 5d-7).

Furthermore, in all cases for both sheep and cattle, fluid intakes in lairage were shown to *at least* double. For example, a group of 100 heifers were transported for 14 hours from Carnarvon to Harvey in W.A. The control animals (those that didn't receive the water supplement) drank 12 L/head/day, whereas the heifers offered water mixed with 3.5% glycerol and 1.5% propylene glycol drank 23 L/head/day. Thus glycerol and propylene glycol supplements can be an effective agent for reducing ultimate pH, and has the added advantage of increasing fluid intake in lairage, of particular use in plants where water intakes are problematic.

## Conclusion

In conclusion, dark cutting is caused by a shortage of muscle glycogen at slaughter due to stress or poor nutrition. High energy diets such as feedlot rations will increase muscle glycogen concentration at slaughter, and electrolyte supplements such as Nutricharge™ or the use of MgO in feed will protect animals from stress prior to slaughter, limiting the depletion of muscle glycogen. Water borne glycerol and propylene glycol, supplemented at the rate of 3.5% and 1.5% in drinking water, reduces ultimate pH and markedly increases water intake during lairage.

## References

Warriss PD (1990) The handling of cattle pre-slaughter and its effects on carcass and meat quality. *Applied Animal Behaviour Science* **28**, 171-186.



An example of a dark cutter. The eye round sample on the left had a pH of 6.4, compared with the one on the right with a pH of 5.5.