PASTURE MAGNESIUM AND CHLORIDE IMPACT DARK CUTTING

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Abstract - King Island pasture raised cattle (n=3,185) sent for slaughter on mainland Tasmania were evaluated to determine which on farm factors increased the incidence of dark cutting. Cattle were sent in groups (n=61) to slaughter from March - June 2015. Animal and management factors were recorded and pasture quantity and quality was measured. The incidence of dark cutting in groups of cattle accessing dam water decreased by 23.2% from 25% ± 3.2 to 1.8% ± 3.2 as pasture magnesium concentration increased from 0.18% to 0.28% DM (P<0.01). As chlorine increased from 1% to 2.5%, the incidence of dark cutting in cattle drinking dam water dropped by 21.3% from 23.3% ± 3.2 to 2.0% ± 4.0 (P<0.05). Groups of cattle with a dam water source had 5.9% higher dark cutting than groups with access to trough water (8.5% ± 1.8, P<0.01). Groups of cattle which received supplementary feed (hay/silage) had a 6.1% lower incidence of dark cutting compared to groups on pasture alone (8.4% ± 1.7, P<0.01).

Key Words – Beef, Meat Quality

I. INTRODUCTION

Dark cutting or dark, firm and dry beef costs the Australian beef industry up to $55m per annum due to not meeting Meat Standards Australia grading requirements for pH and/or meat colour [1]. The annual dark cutting rates in Australia are approximately 5.9%, however geographical locations and seasons can increase average rates up to 35% (unpublished data). Dark cutting is caused by low muscle glycogen concentration at slaughter. Considerable research over the past few decades has identified major factors impacting muscle glycogen storage and breakdown however variability in incidence between beef producers at certain times of the year is currently unexplained. One such instance is the prevalence of southern Australian cattle coming off pasture during autumn and early winter [2]. During this period the pastures are grass dominant, young, short and rapidly growing. Typically high in protein, potassium (K) but low in calcium (Ca) and magnesium (Mg) concentrations, these pastures can impede magnesium absorption in beef cattle and result in a sub-clinical metabolic disease known as hypomagnesaemia (HypoMg) or grass tetany [3]. Magnesium is an essential dietary mineral and cofactor for numerous physiological and biochemical functions including nerve conduction, muscle contraction and catecholamine release. HypoMg may cause dark Cutting by reducing feed intake [4] thus reducing muscle glycogenesis. Furthermore it is likely to increase glycogenolysis due to neuromuscular hyperexcitability and increased adrenaline responsiveness to stress [3,4]. Risk of HypoMg due to pasture mineral concentration can be calculated using the grass tetany index K/(Mg+Ca). Thus we hypothesise that cattle grazing pastures with a higher grass tetany index will have an increased incidence of dark cutting.

II. MATERIALS AND METHODS

Groups (n=61) of cattle (n=3,185) of varying sexes, ages and breeds, were pasture raised on King Island, Tasmania before transport to mainland Tasmania on a ship between March and June for slaughter, all at the same processing plant. Animal and management factors for each group of cattle were recorded including water source (dam or trough), pasture type, supplementary feed (yes or no), lifetime yardings, lifetime truckings, average age, weaning age, weaning method, days since last draft, trace element supplementation in the last 6wks (yes or no), hours of curfew off feed prior to shipping and trucking distance from farm gate to King Island port. Environmental factors for each shipment date were recorded including weather forecast, maximum and minimum temperature, wind speed and direction, sea state, swell, wave direction and wave period.

Pasture availability in kg Dry Matter per hectare was calculated using the average of fifteen $0.1m^2$ quadrant cuts oven dried. Swards of pasture and supplementary feed (hay/silage) consumed by each group were freeze dried and mycotoxin content and forage quality was analysed. Mycotoxins families tested were Ochratoxin-A, Zearalenone, Fumonisins, Aflatoxins, Ergot Alkaloids, β-trichothecenes and α-trichothecenes (Biomin Singapore Pte Ltd, Singapore). Forage quality included metabolisable energy, crude protein, dry matter, metabolisable energy, acid detergent fibre, effective neutral detergent fibre, in vitro true digestibility, trace element and mineral concentrations (Mg, K, Ca, Sodium, Chloride (Cl), Copper, Molybdenum) using Near Infra-Red and Wet Chemistry (Dairy One, Ithaca, New York, USA). The grass tetany index was calculated using the equation (K/(Ca+Mg)) in milliequivalents (MEq), where indices greater than 2.2 suggest an increased risk of HypoMg [3].

All carcasses were graded by qualified Meat Standards Australia graders where the *longissimus thoracis* must be pH ≤5.7 and/or meat colour ≤3 to be eligible for grading.

The combined total of carcasses ineligible for grading (pHu>5.7 and meat colour >3) were used to give a percentage of dark cutting per group. A univariate analysis for each management and environmental factor along with the curve linear term for covariates was conducted initially to inform the base model of the general linear model. The percentage of dark cutting per group was analysed using a general linear model in SAS. Fixed effects included animal factors (sex and consignment date) and management factors previously listed. Continuous terms included in the model were other management factors (lifetime yarding's, days since last draft, weaning age, trucking distance on King Island and paddock size), pasture quantity (available pasture), quality (metabolisable energy, crude protein, effective neutral detergent fiber and acid detergent fiber) and the grass tetany index. The grass tetany index was not significant thus the individual minerals K, Mg, Ca were put into the model along with Sodium, Molybdenum and Cl). Curvilinear terms for each continuous variable were also tested. Terms which were not significant (P>0.05) were removed from the model.

III. RESULTS AND DISCUSSION

Magnesium

The incidence of dark cutting per group was not associated with the grass tetany index (P>0.05) however low pasture Mg independent of K and Ca did increase the incidence of dark cutting (P<0.01). In groups of cattle sourcing water from dams, there was a 23.2% reduction in the incidence of dark cutting from 25.0% ± 3.2 to 1.8% ±3.2 as pasture Mg increased from 0.18% to 0.28% Dry Matter (DM) (Figure 1). Pasture Mg concentration had no impact on the incidence of dark cutting in cattle with access to trough water (P>0.05, Figure 1).

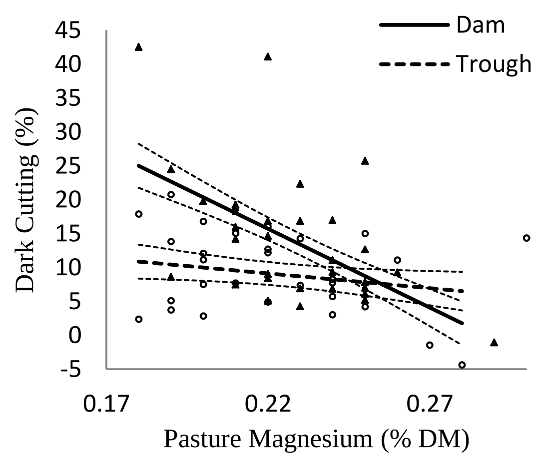

Figure 1. The effect of water source and pasture magnesium concentration on the incidence of dark cutting per group. Bold lines represent the least squared means, small dashed lines represent the standard error. ▲ Denotes residuals from the response line for Dam water source. ○ denotes residuals from the response line for Trough water source.

Chloride

Pasture Cl had a significant impact on the incidence of dark cutting of cattle sourcing water from dams (P<0.05). As Cl increased from 1% to 2.5% DM, the incidence of dark cutting in cattle decreased by 21.3% from 23.3 ± 3.2 to 2.0% ± 4.0. Pasture Cl concentration had no impact on the incidence of dark cutting in cattle with access to trough water (P>0.05).

Water

Water source had a significant impact on the incidence of dark cutting per group (P<0.01). Cattle with a dam water source had an average dark cutting rate of 14.4% ± 1.6 dark cutting per group. This was 5.9% ± 2.1 higher than cattle with trough water access whose average incidence was 8.5% ± 1.8 (P<0.01). All trough water was from dams which were spring fed or runoff water. No troughs were filled with bore water.

Supplementary feed

Supplementation improved the rate of dark cutting from 14.5% ±1.6 in the pasture only group to 8.4% ± 1.7 in the supplemented groups (P<0.01). However the supplement metabolisable energy, water soluable carbohydrates and crude protein were significantly lower (P<0.05) than the pastures and supplement Neutral Detergent Fiber and Acid Detergent Fiber were significantly higher than the pastures (P<0.01).

Contrary to our hypothesis, the grass tetany index did not impact the incidence of dark cutting beef, however increasing pasture Mg did reduce dark cutting in groups of cattle sourcing water from dams. The interaction between pasture Mg and water source has not been previously described. The effect of low pasture Mg increasing dark cutting with a dam water source suggests that water palatability reduced forage consumption and in turn reduced overall Mg intake [6,7]. These results suggest that water quality is impacting Mg and Cl intake as there is a positive interaction between clean water source and forage intake [6,7]. Water is critical in forage digestion as rumen microbial attachment to feed particles is largely facilitated by the rumen fluid matrix [8]. Willms *et al* [7] reported grazing cattle with a dam water source had a 23% reduction in weight gain compared to those with clean trough water access which may also be decreasing glycogen deposition. Water intake directly affects grazing habits [7]. Cattle with clean water trough access have been shown to spend longer time grazing compared to those with a faecal contaminated water sources such as a dam [7]. Hence water source may impact dark cutting due to the water palatability impacting overall forage intake, weight gain and glycogen storage [7].

The significant increase in dark cutting rate with low pasture Mg suggests that HypoMg may have been occurring in these cattle. HypoMg results from low reticulo-rumen availability of Mg or poor absorption. Dietary Mg on offer is low in grass dominant, short (<1,000kg DM/ha), rapidly growing pastures [3,4]. Solubility of Mg in Rumen rapidly declines as rumen fluid pH >6.5 [5]. Rumen pH tends to be higher in grazing animals due to high K of pasture, increased saliva production and high digestible protein diets [5]. The ammonia and ammonium ion end-products of excessive rumen degradable protein can increase the rumen fluid pH >6.5 [3,5]. Absorption of Mg across the rumen wall is impaired by high dietary K (>3.0%) [3]. High ruminal K depolarizes the apical membrane of the rumen epithelium and reduces the potential of the Na-linked active transport to drive Mg across the rumen wall [3,4]. Pastures sampled were at mineral levels and grass tetany index consistent with high risk for HypoMg however did not have a significant effect. In contrast to our hypothesis the fact that low pasture Mg increased dark cutting independent of K suggests that reduced Mg intake underpins this finding rather than K-induced malabsorption of Mg.

The effect of pasture Cl on dark cutting rate is a finding previously unreported in beef cattle. Cl is vital for acid-base balance, digestion of protein and the absorption of amino acids and minerals [9]. The proposed mechanism of action Cl on dark cutting is via acidification of the rumen and improved Mg absorption [5].

The association between supplementary feeding and dark cutting in this study was not due to increased quality of feed on offer. The quality of the supplementary feed, evaluated by crude protein, water soluble carbohydrates, metabolisable energy, neutral detergent fiber and acid detergent fiber were lower than pasture on offer. The suggested mechanism of action of supplementary feed reducing dark cutting is reduction in stress response from improved human habituation. Another mechanism may have been from increased fibre content of feed on offer improving gut fill during transport, reducing stress on the animal however this requires further investigation.

IV. CONCLUSION

This study suggests that producers should monitor pasture Mg and Cl levels when dam water is used and potentially supplement to reduce dark cutting. Confirmation of the mechanism by which low pasture Mg and Cl increases dark cutting in cattle with dam water access requires further research. Providing good quality clean water, free from faecal contamination is important in maximising feed intake and glycogen storage thus reducing the incidence of dark cutting. Further investigation of the mechanism why supplementary feed of inferior quality to available pasture reduces incidence of dark cutting is required. Habituation to humans is important to reduce stress with transport and lairage handling however the optimum preparation type and level is still unknown. Improving water palatability, human habituation and monitoring pasture magnesium can help reduce dark cutting and thereby minimise its large economic impact on the beef industry.

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