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Season variation in pasture quality affects the incidence of dark cutting in southern Australian beef production systems

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Short Title: Seasonal pasture quality impacts on rate of dark cutting

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Summary text

Dark cutting reduces beef quality significantly and is a financial burden on the beef industry. The incidence of dark cutting is affected by pasture quality. This study has shown that in the Mediterranean climates of southern Australia, the risk of dark cutting is highest in late summer through to early winter.

Abstract

Dark cutting is detrimental to meat quality and is the major cause of carcass downgrades under the Meat Standards Australia grading system. This study quantified the variation in the incidence of dark cutting in the southern states of Australia due to seasonal changes in animal nutrition. Four years of Meat Standards Australia grading data from 9 beef processors in Western Australia (WA), South Australia (SA), Victoria (VIC) and Tasmania (TAS) was utilised for the analysis. The data set contained 42,162 slaughter groups of 10 head or more and the percentage of dark cutters per slaughter group was analysed. The interaction between month, year and state was significant ($P<0.001$). The lowest risk of dark cutting was in October for SA and WA (1.53% ±0.75 and 6.96% ± 0.76) and November for TAS and VIC (7.34% ±0.9 and 5.27% ± 0.81) potentially when feed availability and quality is highest. The risk of dark cutting was highest for all states during the period from February to June. This period correlates with lower pasture availability, lower quality and higher levels of stress due to lower temperatures. The findings of this study can be utilised by cattle buyers and processors to evaluate their risk of dark cutting carcasses due to annual changes in animal nutrition, allowing for procurement and management decisions to be made which help mitigate the risk and reduce financial losses.

Key words

Cattle; Dark, firm and dry beef; glycogen; Meat Standards Australia; carcass grading; ultimate pH

Introduction

Dark cutting or dark, firm and dry beef is one of the largest issues affecting beef quality world-wide. In Australia alone, 4.8% of over 2.4 million carcasses graded by Meat Standards Australia (MSA) in the 2012/13 financial year were deemed to be dark cutters and non-compliant for MSA grading (MLA 2013) causing significant financial losses. Carcasses are classified as a dark cutter by MSA graders if the pH of the *M. longissimus thoracis* at the quartering site of the carcass is higher than 5.70 or if the meat colour is greater than AUSmeat colour 3. High pH and high meat colour scores are the two major contributors for non-compliance of MSA graded carcasses (MLA 2013). Beef from dark cutting carcasses is discriminated against by MSA as it tends to be dryer in texture, prone to bacterial spoilage, requires longer cooking times to achieve a specified degree of doneness, has variable tenderness and is dark in colour causing it to be rejected by consumers (Ferguson *et al.* 2001; Thompson 2002).

Dark cutting is predominately caused by low levels of muscle glycogen at slaughter (Tarrant 1989). The concentration of muscle glycogen at slaughter is a function of the concentration of glycogen on-farm prior to mustering minus the quantity used during the pre-slaughter period. The effect of stress and muscle contraction during the pre-slaughter period on glycogenolysis is well quantified (Ferguson and Warner 2008), however the variability in the incidence of dark cutting due to seasonal nutritional variation in Australian production systems is not. Knee *et al.* (2004) showed that seasonal variation in feed quality influenced muscle glycogen concentration in the *M. semimembranosus* and *M. semitendinosus* which is the predicted cause for variation in the incidence of dark cutting. The winter dominant rainfall patterns of southern Australia ultimately impact the quantity and quality of pastures grown in, which may imapct the incidence of dark cutting.

Historic MSA carcass grading data is a valuable and underutilised source of information which can be used to quantify the impact of seasonal variation in pasture quality on the incidence of dark cutting but this has not been documented to date. This study quantified the effect of seasonal variation in animal nutrition on the incidence of dark cutting in southern Australian states with the hypothesis that the incidence would be highest in each state when pasture availability and quality is lowest.

Materials and Methods

Meat Standards Australia data

Producers who supply cattle to a processor to be slaughtered and graded under the MSA beef grading system submit a National Vendor Declaration (NVD) to the processor. The declaration identifies the property and a description of the cattle breed, sex and hormonal growth promotant status. The processor must also be licensed by MSA and undergo regular audits to ensure compliance with minimum standards set by MSA in lairage, processing and chilling. Data is collected during the slaughter process. At grading, carcass pH and loin temperature is recorded along with marbling score, ossification scores, rib fat depth, meat colour score, hump height and sex. The AUSMeat standards for ossification, marbling and meat colour are used to assist the MSA graders. Although not part of the MSA grading system, eye muscle area is also measured using the AUSMeat grid. Further detail on measurements of MSA graded carcasses can be found in McGilchrist *et al.* (2012). Data from the NVD is merged with slaughter and carcass grading data prior to uploading to the MSA data base, where the data for this study was extracted from.

Individual carcass measurements of 1,901,682 carcasses routinely graded at 9 processing plants based in Western Australia (WA), South Australia (SA), Victoria (VIC) and Tasmania (TAS) between 2010 and 2013 inclusive were extracted from the MSA database for this analysis. Data from producers in Queensland, New South Wales and the Northern territory were deleted as these numbers were unbalanced across years and months of the study.

Feed type and seasonal effects

Feed type is crudely identified in the MSA data base as 'grass fed' or 'grain fed'. In addition to this feed type information, cattle were also nominated as grain fed if they had come from a feedlot accredited under the National Feedlot Accredited Scheme. Cattle that did not have a feed type recorded in the database and had not come from a feedlot, were assumed to have been finished on grass and were classified as 'grass fed'. For this analysis, all data deemed to be from 'grain fed' cattle were deleted from the data set.

Producer information

Information about the producer (street, town, state and postcode) is supplied with the NVD for a slaughter group. The producer and processor must guarantee that the cattle were transported directly from the property to slaughter, not mixed for 14 days prior to being transported for slaughter or during lairage. Slaughter needs to occur within 48 hours of dispatch from the property of origin (Anon 2011).

Slaughter groups information

A slaughter group is defined as cattle that were delivered as one group to the processor and slaughtered in that group. Based on MSA specifications, carcasses were classified as a dark cutter if they had a meat colour score greater than 3, or a ultimate pH greater than 5.70. The percentage of DFD carcasses were calculated for each slaughter group.

The sex for each lot was determined based on the percentage of castrates or females present within the slaughter group. If greater than 95% of the lot were castrates then the slaughter group was deemed to be a castrate slaughter group and likewise for females. All other lots with less the 95% of a single sex were classified as being of mixed sex. There were

406 slaughter groups that came from saleyards. As these were not distributed evenly across states, years and months, they were excluded from the data set. Slaughter groups with less than 10 cattle were also excluded. After all these before mentioned filters were applied, a total of 469,897 carcasses were excluded from the data base leaving a total of 1,431,785 carcass records. When this data was compiled into slaughter groups, there were 42,162 slaughter groups of 10 head or more. The numbers of carcasses and slaughter groups graded by MSA from each state over the 4 year period of interest is given in Table 1.

Insert Table 1 here

Statistical analysis

The analysis used a linear mixed model (SAS 2001) to determine the effect of input variables on the percentage of dark cutters per slaughter group. The model included fixed effects for processing plant (1 to 9), sex (male, female or mixed), HGP status (yes or no), slaughter month, slaughter year (2010 to 2013), state (WA, SA, VIC, TAS) plus their interactions. Producer and grader were the random terms used in the model. The number of cattle per slaughter group was also put in the model as a covariate but was not significant so the models were not weighted based on the number of head per slaughter group.

Results

Month and year has a significant impact on the incidence of dark cutting in each state ($P<0.001$, Table 2). Processor and sex also had a significant effect on the incidence of dark cutting ($P<0.001$, Table 2) but these results will not be discussed further due to the length of this paper. The impact of producer and grader were also significant as random terms ($P<0.01$).

Insert Table 2 Here

South Australia

SA had the most dramatic effect of month of all 4 states analysed (Figure 1) at 10.91% ± 0.61 between the highest and lowest months of March and October. March had a significantly higher incidence of dark cutting than all other months at 12.44% ±0.86 and October had the lowest incidence at 1.53% ±0.75 which was significantly lower than all other months except September. In SA, the months of February, April, May and June had the next highest incidences of dark cutting at 10.3% ±0.8, 9.05% ± 0.92, 9.22% ± 0.94 and 10.98% ±0.87. June had a significantly higher incidence of dark cutting ($P<0.05$) than April and May. The incidences of dark cutting in January and July were not significantly different to each other ($P>0.05$) but were different to all other months. August, November and December were also not significantly different from each other in SA.

Tasmania

The impact of month in TAS was greatest between June and November with the incidence of dark cutting 1.55% ±0.49 higher in June (10.73% ± 0.93) than November (7.34% ±0.9) ($P<0.01$, Figure1). The incidence of dark cutting in TAS was lower during the period from July through to January. Dark cutting was significantly higher in March, April and June than all other months ($P<0.05$). February, May and July to August were also not significantly different to each other ($P>0.05$).

Insert Figure 1 Here

Victoria

The greatest difference in the incidence of dark cutting in VIC was 5.89% ±0.88 between March (11.16% ± 0.98) and November (5.27% ± 0.81) ($P<0.01$, Figure1). March and May (11.07% ± 1.6) had the highest incidences of dark cutting (Figure 1). May also had the highest standard error of any month. The incidence of dark cutting in January is higher than from July to December ($P<0.05$) but not different to the incidence in February, April or June. In autumn, the rate of dark cutting is lowest in April and this rate of dark cutting is not different from any month from June to December ($P>0.05$, Figure1).

Western Australia

The incidence of dark cutting in the south west of WA was highest in February at 9.56% ± 0.79, which was 2.6% ± 0.46 higher than the lowest incidence record in the month of October at 6.96% ± 0.76. February has a significantly higher incidence of dark cutting than all months ($P<0.05$, Figure 1) other than December. October has a significantly lower incidence of dark cutting than all other months ($P<0.05$) other than July and September. In WA, March through to September and November to January all had similar rates of dark cutting ($P>0.05$).

Discussion

This study demonstrated that in grass fed cattle, the incidence of dark cutting carcasses varied across months and years in all southern states of Australia. This indicates that pasture availability and quality potentially impact on muscle glycogen concentrations and the rates of dark cutting, supporting our initial hypothesis. The variation across months in the incidence of dark cutting indicates a seasonal occurrence. The seasonal effect is more pronounced in SA and VIC compared to that observed in WA and TAS. In SA and VIC, the difference between the worst and best months for dark cutting were 10.91% and 5.91% compared to 2.6% and 1.55% seen in WA and TAS. Knee *et al.* (2004) demonstrated that muscle glycogen concentrations fluctuate throughout the year. Dark cutting is most commonly influenced by glycogen concentrations in muscle, with the seasonal variation in dark cutting observed in this case likely contributed by corresponding variations in muscle glycogen. Therefore it is clear that changes in the rate of dark cutting in MSA carcasses across the year are partially due to the nutritional quality of pasture.

The highest incidence of dark cutting across all 4 states occurred between February and June. This corresponds with a period of low pasture growth, low digestibility and availability due to their Mediterranean climate. Pastures at this time of year have lower crude protein and metabolisable energy which has been shown to impact on muscle glycogen concentrations of cattle (Pethick *et al.* 1999) and therefore will likely impact on the incidence of dark cutting.

In both TAS and SA, June had an increased rate of dark cutting compared to the previous and following months. Warner *et al.* (1986) stated that the additional stress of cold weather at this time could contribute to this rise in dark cutting. However this increased incidence also coincides with a time when cattle in these states have access to a low herbage mass or short green feed which characteristically has a low dry matter percentage, lower soluble carbohydrates and higher crude protein than spring pastures (Walsh and Birrell 1987). Therefore at the start of winter, cattle may have higher rates of dark cutting due to higher maintenance energy requirements, incapacity to eat enough pasture for growth due to the low dry matter percentage which would lower metabolisable energy intake, reducing glycogenesis.

The risk of dark cutting in is lowest in spring which may be attributed to the increase in soluble carbohydrate in pastures at this time (Walsh and Birrell 1987). Pethick *et al.* (1999) demonstrates that glycogen concentration in the muscle can be influenced by metabolisable energy content of the feed consumed, further supporting this argument.

Large variability within each month from February to June indicates that the timing of the break of the season (from dry to wet) has a large impact on the incidence of dark cutting. The variability seen in these months validates that cattle buyers purchasing MSA eligible cattle for direct consignment to processors should take more care in selecting animals that are growing at more than 800g per day during these months to ensure sufficient muscle glycogen concentrations.

In conclusion, the incidence of dark cutting varies significantly between states and years and also across months or seasons. This may reflect variations in pasture quality and availability. Producers and processors of beef cattle in the southern states of Australia need to alter their finishing and procurement strategies during the period from February to June to reduce the risk of dark cutting and minimise financial losses.

Acknowledgements

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Table 1: The number of slaughter groups and carcasses per month graded by MSA at 9 processing plants. The cattle originated from South Australia (SA), Tasmania (TAS), Victoria (VIC) and Western Australia (WA) between 1 January 2010 and 31 December 2013.

	No. Slaughter Groups				No. Carcasses Graded			
Month	SA	TAS	VIC	WA	SA	TAS	VIC	WA
January	1377	921	567	1170	49605	26665	22002	37707
February	899	922	550	982	33411	26373	19311	38393
March	538	873	433	1049	20079	23655	17664	43459
April	416	866	356	913	16013	23319	14905	40483
May	413	1031	386	994	15514	28070	17437	44171
June	434	914	401	832	19253	24617	16612	36992
July	304	996	331	811	12779	25158	14764	34350
August	450	881	404	981	16951	21987	17731	40919
September	724	656	456	1226	25164	16040	17826	41566
October	1432	1008	752	1690	52328	25516	24510	46499
November	1858	1151	871	1885	66597	29571	31053	49906
December	1541	1080	804	1632	60889	28403	29091	46477
Total	10,386	11,299	6,311	14,165	388,583	299,374	242,906	500,922

Table 2: F values, P values, numerator (NDF) and denominator (DDF) degrees of freedom for the effects of processing plant, sex, year, month, state and their interactions.

Effect	NDF, DDF	F-Value	P-Value
Processor	8, >37000	155.82	<0.001
Sex	2, >37000	59.14	<0.001
Month	11, >37000	43.18	<0.001
Year	3, >37000	380.16	<0.001
State	3, >37000	1.64	0.1775
Month*State	33, >37000	12.21	<0.001
Month*Year	33, >37000	28.27	<0.001
Year*State	9, >37000	220.66	<0.001
Month*Year*State	99, >37000	16.86	<0.001

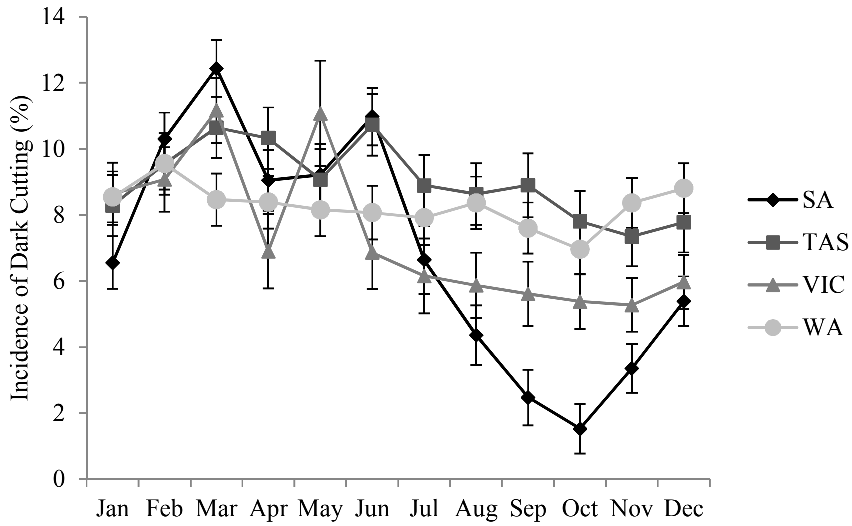

Figure 1: The predicted means for the effect of month on the incidence of dark cutting per slaughter group in South Australia (SA), Tasmania (TAS), Victoria (VIC) and Western Australia (WA) based on MSA carcass grading data from 2010 to 2013