Behaviour and meat quality at an Otago deer slaughter plant

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Abstract

The first five days' data from an on-going study at a deer slaughter premises (DSP) were analysed. The study aims to describe behavioural and meat quality variables and relationships between these variables and pre-slaughter factors such as farm of origin and conditions during transport. Over the five days 590 deer, primarily red x wapiti hybrid yearling males, from 16 farms (mean distance from the DSP = 182 km) were observed. During overnight lairage a mean of 4 fights/hr (range 0-26/hr), primarily involving biting, were observed. In the lead-in race immediately prior to stunning, rearing, climbing the walls, jumping and lying down were observed in 21, 8, 7 and 7 % of deer respectively, and a difference in behaviour between farms was found ($P<0.001$). Bruising was found on the hocks, hindquarters, forequarters and loins in 59.3, 38.7, 7.5 and 2.0 % of carcasses respectively. The frequency of bruising differed between farms and days ($P<0.001$), and was related to the size of the load sent by the farmer ($P<0.05$). The overall mean pH was 5.64. The percentage of carcasses with moderately high pH (>5.8) in all three locations measured (leg, loin and shoulder) was 3.5 and the percentage of carcasses with very high pH (>6.2) in all locations was 0.4. Differences in pH values were observed between farms and days ($P<0.001$), and pH was positively related to bruising ($P<0.05$). Overall the study has begun to define behavioural and meat quality variables and reveal factors affecting these variables.

Introduction

In October 1997 a study was initiated at Invermay, in co-operation with an Otago deer slaughter plant, to provide information on the welfare and meat quality of slaughtered deer. Existing data indicated that there was potential to improve both of these variables. For example, a survey carried out in 1988-1989 established that wounds, bruises and related lesions were a major cause of downgrading and represented a significant economic loss (Selwyn & Hathaway, 1990). A different study showed that the incidence of bruising varied with season, carrier company, distance travelled and lairage duration as well as physical condition of the animals (Jago, 1993). Further investigation of 153 deer revealed relationships between pre-slaughter conditions (lairage duration and time in a lead-in race to the stunning box) and post-slaughter indices of stress (pH and plasma creatine kinase levels) (Jago, 1993). High pH meat occurs when an animal's muscle glycogen stores are depleted prior to slaughter, and has deleterious effects on meat colour, water-holding capacity, shelf life and tenderness (Shorthose, 1996).

The aim of the Invermay study is to describe existing behavioural and meat quality variables at an Otago Deer Slaughter Plant and to more clearly define relationships between pre-slaughter factors, bruising and pH. For one kill day each week, measurements are being made of behaviour during overnight lairage and prior to stunning, pH in three muscles (leg, loin and shoulder; effects

of pre-slaughter stress on muscle pH may vary between muscles within the same animal (Kay *et al.*, 1981; Monin, 1981; Wiklund *et al.*, 1996)), and bruising. These variables are being compared with a range of background factors (such as farm of origin, prior handling experience of the deer, and duration of transport). The following report results from the first five kill days.

Methods

Behaviour recording

Behaviour was recorded during 2000hr-400hr in one 4m x 4m pen (containing 9 to 15 deer), using an infrared camera and light source. The deer were in lairage prior to slaughter the next day. For 30 minutes at 90-minute intervals the number of fights, and activities (biting, kicking or butting) and number of animals (2, 3 or more) involved in each fight were recorded from the videotapes. At the end of each 30-minute period an agitation score, based on the number of animals in the pen stepping during five minutes (none, some animals some of the time, all animals within five minutes, or all animals throughout five minutes) was assigned.

Activities in the 4m raceway leading into the stunning box were recorded on videotape for all animals slaughtered that day. Variables measured from the tape were as follows: whether or not the deer reared, jumped, climbed the walls, lay down, burrowed under others, bit, kicked or butted other deer, took more than 30s to enter the stunning box, or butted the board used to shift the deer, and the approximate time the deer was in the race

pH recording

At approximately 24 hours post-mortem pH was measured in triplicate using an Orion model 265 meter and a Mettler Toledo 'Ingold' spear tip electrode at three locations in the carcass: the leg (*M. Biceps femoris*), striploin (*M Longissimus dorsi*) and shoulder (*M. Triceps brachii*).

Bruise recording

At approximately 20 minutes post-mortem the MAF meat inspector recorded the number of bruises in the hindquarter, ribs, loin and forequarter regions of the carcass, assigning each bruise to one of five size categories: < 100 mm diameter and < 5 mm deep, < 100 mm diameter and > 5 mm deep, > 100 mm diameter and < 5 mm deep, > 100 mm diameter and > 5 mm deep, or < 100 mm diameter and > 50 mm deep. In the case of the ribs the last category was omitted and instead broken ribs were recorded with particular note of whether they were an acute or chronic situation. Bruising on the hocks was also recorded as either present or absent.

Farm details

Farmers were sent a questionnaire prior to sending stock to the plant, then telephoned after their stock had been killed. Questions asked included the species, sex and number of deer sent, the number of times the deer had been yarded previously, the time yarded prior to transportation, availability of water in the yard pen, and any notable animals (for instance extremely tame or aggressive, or injured). Other background data obtained for the kill day were the weather conditions and carriers used.

Statistical methods

Difficulties with data recording errors have precluded comparisons between data sets on a per animal basis; this has been carried out on a per farm basis instead. Differences between farms in means and percentages of variables were analysed by least squares and a binomial generalized linear model, respectively. Means by day were averaged over the farms for that day. Relationships between farms means of variables were analysed by linear regression, with weighting for the number of deer per farm in some cases.

Results

General

Over the five kill days 590 deer were observed, with "loads" from 16 farms transported by 7 carriers. Percentages of the different deer species killed constituted 15 % and 7 % from elk and red deer loads respectively, with the remainder red x wapiti hybrids and mixed loads of different species. Nearly all loads were spikers, and 72 % of deer came in mixed sex loads while the rest were stags. The average distance travelled was 182 km, range 20-270 km.

Overnight lairage pen

The mean number of fights observed per hour was 4 (s.d. 2.6), with a range of 0-13 per 30 minute observation period. Most (89 %) fights involved biting, while boxing was seen in 40 % of fights and butting in only 4 % of fights. Approximately equal percentages of fights fell into the categories of involving 2, 3 or more deer (35, 36 and 28 %, respectively). The mean agitation score was 1 (equivalent to some deer moving throughout the five minute observation period). There was no suggestion of any difference in behaviour between nights, or between different periods during the night.

Lead-in race

The most commonly observed behaviour in the lead-in race was rearing, seen in 21 (S.E. 2.1) % of deer, followed by climbing, jumping, and lying down (respective percentages were 8 (S.E. 1.4), 7 (S.E. 1.3), and 7 (S.E. 1.3)). Other activities were observed in 2 % of deer or less. A significant difference between farms in behaviour in the race was observed ($P< 0.001$); for example of 20 deer on one farm 45 % were observed rearing and 25 % lay down, whereas of 21 deer from another farm no deer were observed rearing and only 6 % lay down. However there was no obvious factor associated with this difference. Deer which showed climbing, jumping or rearing were more likely to have been held in the race for a long time rather than held briefly ($P <0.05$). There was no suggestion of any consistent effect of the number of times (range 1-40) the deer had been handled over the previous year on behaviour in the lead-in race.

Bruising

Bruising occurred most frequently on the hocks, with 59.3 % of carcasses having bruises in this area, followed by the hindquarters (38.7 % of carcasses), forequarters (7.5 %) and loins (2.0 %). The most common bruises (excluding those on hocks) were small and less than 5 mm deep (19.2 % of carcasses, Table 1). Two deer had broken ribs.

Table 1. Percentage of carcasses with bruises of different sizes and depths

Percentage of carcasses with bruising (excluding hocks)				
< 100 mm diameter		> 100 mm diameter		
< 5 mm deep	> 5 mm deep	< 5 mm deep	> 5 - 50 mm deep	> 50 mm deep or broken nb
19 2	7 3	8 7	9 1	2 6

The frequency of bruising observed differed significantly between farms ($P<0.001$), ranging from 23 % to 95 % of carcasses being bruised to some degree. One of the five days in the study stood out as having a particularly low percentage (55) of bruised carcasses ($P<0.001$). Bruising was related to the size of the load sent by the farmer ($P<0.05$), with the proportion of bruised carcasses tending to increase with load size, although a high frequency of bruising was still observed in some small mobs (Figure 1).

pH

The overall mean pH was 5.64 (s.d. 0.006), with means for the leg, loin and shoulder being 5.59 (s.d. 0.006), 5.61 (s.d. 0.006) and 5.72 (s.d. 0.007) respectively. There was a significant difference between farms ($P < 0.001$), with mean values ranging from 5.51-5.70, and a significant difference between days ($P < 0.001$). Bruising was related to pH ($P < 0.05$, Figure 2). The frequency of moderately high pH (> 5.8) was 5.7% for the leg, 8.4% for the loin, and 19.6% for the shoulder. The frequency of very high pH (> 6.2) was 1.0% for the leg, 0.8% for the loin, and 2.2% for the shoulder. When the percentage of carcasses with high pH all three locations was examined it was found that only 3.5% of carcasses were above pH 5.8 and only 0.4% of carcasses were above pH 6.2. There was considerable variation between days with no carcasses with pH above 5.8 on some days and up to 8.7% of carcasses with pH above 5.8 on other days.

Discussion

The first five days of the study have yielded a preliminary description of behavioural and meat quality variables and revealed some interesting relationships. However some useful comparisons have been precluded due to difficulties with data recording (which are being addressed). Unfortunately one of these comparisons was the relationship between fighting in overnight lairage and bruising. In some groups a considerable amount of fighting was observed, which might have been expected to result in high levels of bruising in the carcasses. Jago *et al.* (1993) found that in three of the 12 months of her study, bruising levels were higher in deer held in overnight lairage compared with those slaughtered on the day of arrival, suggesting that holding deer overnight was undesirable.

In spite of the relationship between bruising and overnight lairage, for deer which were not held overnight in the study by Jago *et al.* (1993), there was a negative relationship between pH and the amount of time spent in lairage (mean = 16 minutes, SEM = 1.9 minutes), indicating that this was a time of recovery. Grigor *et al.* (1997) found mixed effects of lairage time (0, 3, 6 or 18 hours, with hay, straw bedding and water available); agonistic behaviour increased and liveweight decreased over 18 hours, no treatment effects were seen for carcass weight, bruising or muscle glycogen, but an increase in liver glycogen and a decrease in plasma creatine kinase activity suggested the deer were beginning to recover from handling/transport. The lowest 24 hour pH levels were seen in the deer held for 6 hours (Grigor *et al.*, 1997). Overall it was concluded that

because behaviour was disturbed, the deer should be slaughtered as soon as possible after arrival at the plant (Grigor *et al.*, 1997). It seems that lairage can affect both welfare and meat quality and it would be worthwhile increasing the amount of information being generated in the present study, by increasing the number of pens under overnight observation (at present only one of 16, holding up to 15 deer, is being observed).

Approximately one fifth of the deer were observed rearing in the lead-in race immediately prior to stunning, eight percent attempted to climb up the walls and seven percent lay down. These observations suggest that some of the deer were very disturbed immediately prior to slaughter and the reasons for this should be examined. The wide range in behaviour between farms (for example 45 % rearing and 25 % lying down compared with no rearing and 6 % lying down) suggests that the previous handling experience of the deer may influence their behaviour during pre-slaughter handling. There was no indication of a relationship between the number of times deer were handled on the farm on their behaviour in the lead-in race, therefore perhaps the way in which the deer were handled and/or the facilities used may have a bearing on this. Details from the farmers regarding their handling techniques would be useful. Over the five kill days studied there was no replication of farms (i.e. no farmer had sent stock in on more than one occasion) but as the study progresses more data on the same farms will be obtained to allow further investigation of farm effects.

As with behaviour in the lead-in race, the frequency of bruising differed between farms. Jago *et al.* (1993) observed differences in bruising frequencies between carrier companies, which were confounded with farms as the same carriers generally transported animals from the same farms. However in the present study 8 carriers were used, transporting deer from 16 farms, and no effect of carrier was seen, indicating that the differences observed by Jago *et al.* (1993) may have been due to the farms rather than transporters.

The hindquarters were the most common site of bruising (aside from the hocks which were bruised in more than half of the deer), and this was also observed by Jago *et al.* (1993). The association found between farm load size and bruising could be attributable to deer in larger loads being more crowded in pens and possibly climbing on top of each other. Bruising differed between days, with one day having a particularly low frequency of bruised carcasses. At present we can only speculate as to the reasons for this and the causes of bruising; as the study progresses associations between variables will become clearer, as will areas where focal observations are required. Fighting during overnight lairage may be an important source of bruising.

The overall mean pH value was 5.64, comparable to Jago *et al. 's* (1993) figure of 5.65. Again there were differences between farms, and also a difference between days. A positive relationship between bruising and pH was observed. It has been well established that physical stress results in glycogen depletion which will result in high ultimate pH meat if it occurs prior to slaughter (ultimate pH is the measurement of pH when the conversion from muscle to meat is complete) (Ashmore *et al.*, 1973; McVeigh & Tarrant, 1981). Apart from affecting meat colour, texture and water-holding properties, this quality defect reduces shelf-life, especially for vacuum packaged meat (McVeigh & Tarrant, 1981). Most studies on beef and lamb examined only the striploin and have reported levels of 8-15% for lamb and mutton (Graafhuis & Devine, 1994), and up to 70% for bull beef (Purchas, 1990) so the level reported here (8.4%) is comparable to other meat animals and on the low side. However, a high pH value in only one or two muscles indicates a localised effect (e.g. a bruise), and these are trimmed out by the boning staff. If the stress is severe the whole carcass will be affected and this is of greater economic significance. When the number

of carcasses with high pH in all three locations was considered in the present study, the percentage affected was very low (only 3.5% > pH 5.8 and only 0.4% > pH 6.2). This was encouraging from both a meat quality and animal welfare point of view, though there is still room for improvement.

In conclusion, from the first five days of the study we have started to clarify some of the factors affecting behaviour and meat quality. For future observations we need to minimise errors in data recording, and preferably extend the study to provide more information, particularly regarding on-farm handling practices and behaviour during overnight lairage.

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Figure 1. Relationship between bruising and farm group size (P<0.05)

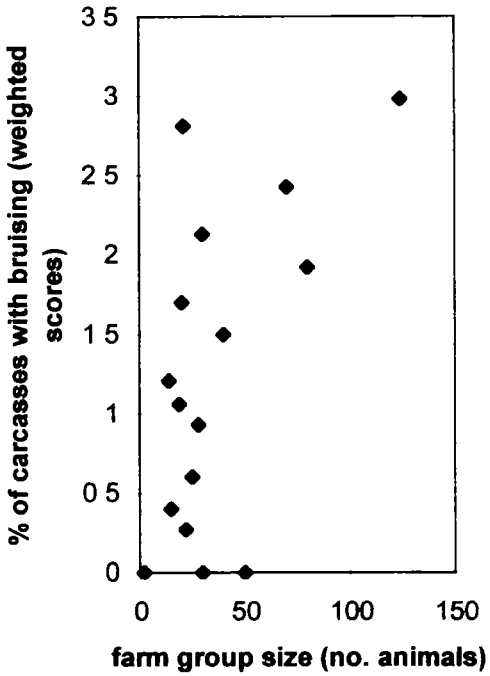

Figure 2. Relationship between pH and bruising (P<0.05)