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## ABSTRACT

The combined effect of lairage design and lairage time on the incidence of DFD (Dark Firm Dry) on dark-cutting beef in young bulls has been studied in a project comprising about 1800 animals slaughtered at two abattoirs. Three different types of lairage design were tested - individual pens, large free-range pens (6-10 animals per pen), and tethering. For each lairage type, various holding periods were studied. The use of a so-called delivery pen at the producer's was also evaluated. The delivery pen is used for the holding of young bulls destined for slaughter which are gathered the day before delivery in order to assist the transporter and to make loading a one-man job.

The main results can be summarized as follows:

- The use of individual pens instead of large free-range pens resulted in a considerably reduced incidence of DFD meat.
- For the lairage types studied, a holding period of about 3-4 hours was preferable to both shorter and especially to longer holding periods on the day of delivery.
- A long holding period (e.g. overnight), in comparison with a short period in individual pens caused a minor increase in DFD incidence. A corresponding comparison for large pens demonstrated a very substantial increase in DFD.
- When young bulls that had been tethered at the producer's were kept tethered overnight in the lairage prior to slaughter, hardly any DFD meat was found.
- Placing young bulls in a delivery pen at the producer's the day before delivery caused a dramatic increase in DFD incidence.

## INTRODUCTION

In an earlier investigation concerning DFD incidence in Swedish cattle (Fabiansson et al., 1982), we found differences in the frequency of DFD meat both between abattoirs and also between various holding periods for the

animals in the lairages studied. However, we could not explain these differences, due to the design of the experiment. In several investigations (e.g. Duchesne, 1978; Kallweit et al., 1981; Puolanne & Aalto, 1981) it has been concluded that lairage design and length of the holding period are two key factors causing DFD meat.

In the present investigation the combined effect of lairage design and holding period on the DFD incidence in young bulls was studied with the purpose of formulating recommendations to slaughter plants and to producers concerning optimal pre-slaughter handling procedures. Muscles (*M. longissimus dorsi*) with a  $\text{pH}_{24} > 6.20$  were classified as being DFD. Young bulls were used as experimental material, as the DFD incidence for this animal category was found in an earlier investigation to be almost twice as high as in any other category.

## MATERIALS AND METHODS

The investigation was carried out during February-April 1982 and comprised about 1800 young bulls slaughtered at two abattoirs. Three different types of lairage design were used - individual pens, large free-range pens (6-10 animals per pen), and tethering. For each lairage type, various holding periods were studied. The use of a so-called delivery pen at the producer's was also evaluated. Such a pen is used for the holding of young bulls destined for slaughter which are gathered the day before delivery in order to assist the transporter and to make loading a one-man job. About 15% of the animals in the present investigation had been kept in delivery pens. Young bulls tethered at the abattoir had earlier been kept tethered at the producer's and during transport. Animals kept in large pens had also been kept earlier in large free-range pens at the producer's and during transport.

The ultimate pH was measured in *M. longissimus dorsi* between the 10th and 11th rib 20-24 hours post mortem. A Knick Portamess 651 pH-meter with an Ingold meat electrode type Lot 406-M6 was used. The carcasses were electrically stimulated (low voltage 32 sec., 5 V) during the bleeding phase (Rudérus & Fabiansson, 1980).

For each animal the following data were recorded: interval between last feeding time and delivery, housing system at the producer's, producer code, use of delivery pen, age at slaughter, breed, time at delivery, transport distance/time, lairage type, length of holding period, time at slaughter and  $\text{pH}_{24}$ .

The effects of housing system of the producer, abattoir, lairage type and holding period on the ultimate pH, as well as regression of carcass weight and of transport distance/time, were tested statistically using the Statistical Analysis System (Helwig & Council, 1979). Significant interactions between main effects were also included in the statistical models.

## RESULTS AND DISCUSSION

The effect of delivery pen, lairage type and day of slaughter (day of delivery or the day after) on the ultimate pH (least-squares means) is presented in Table 1. DFD frequencies are given within parentheses.



Table 1. Least-squares means for ultimate pH in *M. longissimus dorsi*; effect of delivery pen, lairage type and day of slaughter; DFD frequency in parentheses

Lairage type	Delivery pen <b>not</b> used		Delivery pen used	
	Animals slaughtered		Animals slaughtered	
	day of delivery	day after delivery	day of delivery	day after delivery
Individual pens	5.66 <sup>a</sup> (2.1)	5.69 <sup>ab</sup> (5.6)	5.77 <sup>a</sup> (12.5)	5.86 <sup>b</sup> (14.8)
Large pens	5.75 <sup>b</sup> (12.2)	6.12 <sup>c</sup> (40.9)	6.22 <sup>c</sup> (48.4)	6.21 <sup>c</sup> (48.5)
Tethering	5.73 <sup>b</sup> (14.7)	5.63 <sup>a</sup> (0.7)	-	

Mean values with the same superscript letters do not differ significantly ( $p > 0.01$ ) when tested **within** the two alternatives used for delivery pen.

When the young bulls had not been kept in delivery pens at the producer's it is obvious that the use of individual pens was beneficial for the meat quality. When large pens were used instead, the meat quality was adversely and significantly affected, especially after overnight holding in lairage. The DFD incidence was about 40% for these animals. Our figures are consistent with observations made by Poulanne & Aalto (1981). The beneficial effect found in the present investigation when slaughtering tethered animals the day after delivery has not been discussed in detail in the literature. Kallweit et al. (1981) demonstrated, by keeping young bulls both tethered and in pens free-range for 12-14 hours before slaughter, that tethered animals had a better meat quality due to their restricted physical activity. The relatively high incidence of DFD in tethered animals slaughtered on the day of delivery is not fully understood. In comparison with our results, Poulanne & Aalto (1981) found lower DFD frequencies for the corresponding treatment.

The use of delivery pens caused a dramatic increase, in ultimate pH and DFD frequency. Almost 50% of the young bulls kept in large pens developed DFD meat. The adverse effect of mixing animals at the producer's the day before delivery has not been described earlier. However, Augustini (1981) and Price & Tennessen (1981) pointed to the negative effects on beef quality when mixing strange animals at the abattoir. Mixing of "strangers" evidently exacerbates the problem, irrespective of where the mixing takes place, whether at the producer's or in the lairage. As regards our own findings, it is important to consider the handling routines at the producer's when the problem of dark-cutting is to be dealt with. Our results so far clearly demonstrate that the mixing of young bulls one or two days before slaughter adversely affects beef quality. A study of the effect on DFD incidence of mixing young bulls for longer periods prior to slaughter is under way.

Table 1 shows that the ultimate pH and DFD incidence increased markedly when animals were kept overnight in large pens. When individually penned overnight, a minor increase in DFD meat was found. In Sweden, young bulls

are reared mainly in large free-range pens. Consequently large pens at the abattoir have become the most common lairage type for keeping young bulls. Therefore it was also necessary to examine whether there is any optimal holding period for the different lairage types used - but especially large pens - when the animals are slaughtered on the day of delivery. The effects on the ultimate pH of lairage type, holding period (on the day of delivery) and delivery pen are presented in Table 2. DFD frequencies are given within parentheses.

Table 2. Least-squares means for ultimate pH in *M. longissimus dorsi*; effect of lairage type, holding periods and delivery pen; DFD frequency in parentheses

Lairage type	Holding period (hrs), before slaughter	Ultimate pH	
		Delivery pen not used	Delivery pen used*
Individual pens	0-2.5	5.67 <sup>a</sup> (2.3)	5.76
	2.6-4.5	5.62 <sup>a</sup> (0)	5.76
	4.6-8.0	5.67 <sup>a</sup> (0)	5.81
Large pens	0-2.5	5.77 <sup>b</sup> (14.3)	6.09
	2.6-4.5	5.68 <sup>a</sup> (7.5)	6.46
	4.6-8.0	5.84 <sup>b</sup> (22.2)	6.49
Tethering	0-2.5	5.69 <sup>ab</sup> (11.8)	-
	2.6-4.5	5.62 <sup>a</sup> (0)	-
	4.6-8.0	6.02 <sup>c</sup> (39.1)	-

Mean values with the same superscript letters do not differ significantly ( $p > 0.01$ ) when tested within the same column. \*Not tested statistically due to a limited number of animals.

For all lairage types, a holding period of 2.6-4.5 hours was beneficial, in comparison with the other periods. Puolanne & Aalto (1981) obtained the same result when they related the DFD incidence to holding periods and type of lairage. A holding period of 4.6-8.0 hours for animals kept in large pens and for tethered animals resulted in significantly higher ultimate pH values. The high DFD incidence for tethered animals kept 4.6-8.0 hours caused the negative result presented in Table 1 for tethered young bulls slaughtered on the day of delivery. However, the pH of the individually penned young bulls did not react adversely on an increased holding period. Again, the use of delivery pens caused appreciable dark-cutting problems.

From Table 2 it is obvious that there was an effect of the duration of the holding period *per se* on the ultimate pH. However, we also found that when a holding period of the same duration started at different times during the day, the ultimate pH was affected (see Table 3). Young bulls were kept individually penned for one holding



period, 0-2.5 hours. The period started at different times, thus following the usual routines with breaks for breakfast and luncheon.

Table 3. Least-squares means for ultimate pH in *M. longissimus dorsi*; influence of starting time for a holding period of 0-2.5 hours; young bulls individually penned and slaughtered on day of delivery

Alternatives for starting the holding period	Ultimate pH
Before breakfast (06.00-08.30)	5.65 <sup>a</sup>
Between breakfast and lunch (09.00-12.30)	5.67 <sup>a</sup>
After lunch (13.00-16.00)	5.48 <sup>b</sup>

Mean values with the same superscript letters do not differ significantly ( $p > 0.01$ ).

When young bulls were held in the lairage 0-2.5 hours after lunch it was beneficial for the ultimate pH - in comparison with a holding period of the same length between breakfast and lunch. No comparable data were found in the literature.

We know that the speed of the slaughter line was faster in the morning than in the afternoon. The degree of stress on each animal might therefore be greater between breakfast and lunch, resulting in a greater breakdown of muscle glycogen causing a significant increase in the ultimate pH.

#### CONCLUSIONS

- The use of individual pens vis-à-vis large free-range pens showed a considerably reduced incidence of DFD meat in the former.
- For the lairage types studied, a holding period of about 3-4 hours was preferable to both shorter and especially to longer holding periods on the day of delivery.
- A long holding period (e.g. overnight) in comparison with a short period in individual pens caused a minor increase in DFD incidence. A corresponding comparison for large pens demonstrated a very substantial increase in DFD.
- When the young bulls that had been tethered at the producer's were kept tethered overnight in the lairage prior to slaughter, hardly any DFD meat was found.
- Placing young bulls in a delivery pen at the producer's the day before delivery caused a dramatic increase in DFD incidence.

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