INCIDENCE OF DFD IN BEEF AS INFLUENCED BY TRANSPORT CONDITIONS IN THE NETHERLANDS

RIËTTE L.J.M. VAN LAACK, FRANS J.M. SMULDERS and JAN G. VAN LOGTESTIJN

Department of the Science of Food of Animal Origin, Faculty of Veterinary Medicine, University of Utrecht, P.O.-Box 80175, 3508 TD Utrecht, The Netherlands

SUMMARY

The incidence of beef with a dark-firm-dry condition (DFD; pH_{24} >6.2) in The Netherlands was monitored. In addition it was investigated how transport and delivery conditions affected the incidence. Through measuring pH_{24} values in the M. longissimus dorsi of 800 bulls delivered at the abattoir after a total of 10 h of transport (including stops at the cattle market) the DFD incidence was calculated to be 27.3%. This percentage is much higher than the estimated 0.4% based on the records of insurance companies. The fact that in a second experiment 3.4% of a total of 263 bulls, directly transported from farm to abattoir, exhibited DFD suggests that transport and delivery conditions were the major determinants for the difference in DFD incidence. However, these do not fully explain the contrasts in actual and estimated incidence. It is suggested that the origin of insured vs non-insured slaughter bulls, carcass inspection 1 day post mortem and/or use of electrical stimulation are possible causes of underreporting.

INTRODUCTION

Dark cutting, or DFD meat is found on carcasses of healthy animals and is induced by certain stressful pre-slaughter conditions. It is characterized by a high pH, a purplish-black colour, a firm texture and a 'dry' sticky surface. It occurs in both beef and pork. In contrast with DFD in pig carcasses, dark cutting is the most frequently occurring quality deviation in beef and is of great concern to the meat industry. Although still fit for consumption the meat is generally discounted upon discovery because of its unattractive colour and texture and its reduced shelf-life. On the other hand, it is recognized that DFD meat has superior waterbinding properties which makes it particularly fit for the production of certain sausages.

The DFD condition occurs in carcasses of slaughter animals with low stores of muscle glycogen and it appears to be a particular problem in bulls (Augustini & Fischer, 1979; Buchter, 1981; Fabiansson et al., 1984).

It has repeatedly been shown that activities associated with regrouping, leading to physical exhaustion and thus to glycogen depletion, are the primary cause for dark cutting beef (Bartoš et al., 1988). Two or more days spent in optimal rest conditions are necessary for the glycogen level to be restored (Warris et al., 1984). Recovery from glycogen depletion is thus practically impossible under commercial abattoir conditions. A better alternative is to prevent glycogen exhaustion. It is generally agreed that, at least fot bulls, time in transport to the slaughterhouse should be as short as possible (Hood, 1981). However, precise limits on transport distance have not been reported.

Exact figures on the impact of DFD in The Netherlands are not available. DFD meat is not a condition that has to be registered as such. Estimates based on the records of insurance companies indicate a financial loss of at least 0.83 dollarcents per slaughtered bull. With 309.000 bulls having been slaughtered in 1988 (Netherlands' Commodity Board for Livestock and Meat, 1989) this means an annual loss of approximately \$ 256,000. The actual losses are likely to be much bigger, as the latter figures are based on registered animals with a carcass pH of 6.2 or higher.

The present experiment included a total of 1063 animals and the influence of transport conditions in The Netherlands upon the incidence of DFD was assessed.

MATERIALS AND METHODS

A total of 1063 bulls with a carcass weight of 300-400 kg were investigated. In experiment I 800 animals were transported over a distance of 100 kilometers from the farm via the cattle market to slaughterhouse. Time from

transport to slaughter, including stops at the cattle-market, was estimated to be at least 10 hours.
In experiment II the remaining 263 bulls were delivered directly from the farm to the abattoir. The average time from transport to slaughter was 70 min. Attempts were made to separate bulls originating from different farms. Carcasses were not stimulated electrically.
In both experiments the pH values of the M. longissimus dorsi, M. adductor and M. triceps brachii were measured at 24 h after slaughter (pH_{24}). A portable pH meter, type Polymetron PM55, was used.
Muscles were considered DFD at pH values >6.2.

RESULTS AND DISCUSSION
Figure 1 includes the frequency distribution of pH_{24} values of the adductor, longissimus and triceps brachii muscles in experiment I. The incidence of pH_{24} values >6.2 was the highest in the longissimus muscle and the lowest in the M. triceps brachii. This confirms earlier reports that the M. longissimus dorsi is one of the most sensitive muscles with regard to dark cutting (Augustini & Fischer, 1979; Buchter, 1981; Tarrant & Sherington, 1980-1981). Tarrant and Sherington (1980-1981) suggested that the pH-value of longissimus dorsi muscle might be used to evaluate the occurrence of DFD because only a small proportion of carcasses containing some other muscles with abnormally high pH_{24} values may escape detection. The observed variation amongst muscles is not unexpected for some muscles will require less glycogen than others.
The first experiment was conducted to collect more reliable data on the incidence of DFD. We were rather surprised, however, to find the incidence to be as high as 27.3%, i.e., 90 times higher than the estimated incidence. Upon evaluation of the experiment, transport was likely to be a possible explanation for the results. In The Netherlands transport distance and -time are relatively short and thus one might anticipate that transport is not a significant factor under Dutch circumstances. Yet, in The Netherlands two delivery systems exist, one implying direct transport from farm to abattoir, the other transport from farm to cattle market and subsequently to the abattoir. The observed high incidence in experiment I might have partly resulted from the transport and delivery conditions. Therefore we conducted experiment II in which we attempted to achieve short transport distance and delivery.
In Figure 2 results of both experiment I and II are integrated. As Mm triceps brachii turned out to be relatively insensitive to the treatments, the pH values of this muscle are not included. Figure 2 indicates that the transport procedure greatly influenced the ultimate pH values. Direct transport (experiment II) resulted in the lowest incidence of DFD: based upon pH_{24} of the M. longissimus dorsi the incidence was reduced 9 times as compared with indirect transport (experiment I).
However, the DFD incidence after direct transport was still considerably higher (3.1%) than the estimated incidence (0.4%) based on the estimation of the insurance companies. Several explanations are possible for this discrepancy. In The Netherlands only 50% of the slaughter bulls were insured in 1988. Especially large slaughterhouses do not systematically insure their animals before slaughter and it are mainly these larger firms who buy their animals on the market. Thus the difference between insured and not-insured cattle population may have affected the outcome of our experiments. Furthermore, not every animal with a high ultimate pH is noticed after slaughter. Moreover, DFD meat is not considered 'unfit for consumption' and inspection at 24 hours after slaughter to discover DFD is not common practice at every slaughtering operation. Especially when carcasses are not insured the incentive check for aberrant carcass quality might be lacking. For practical reasons we measured the pH at 24 h post mortem, of animals which were not electrically stimulated. As the ultimate pH value is not always reached in this period (Bodwell et al., 1965) we may have slightly over-estimated the DFD incidence.
The use of electrical stimulation is

increasing in The Netherlands and will be common practice in most beef slaughterhouses within a few years. Dutson et al. (1981) reported that although electrical stimulation can, not prevent DFD meat, it slightly lowered the muscle pH by 0.1 pH unit. Electrical stimulation has been shown to improve and brighten muscle colour (Savell, 1982) and result in higher grading scores provided grading is conducted within 24 h post mortem (Calkins et al., 1980). This implies that the use of electrical stimulation might interfere with subjective selection for DFD carcasses when less severe cases are overlooked. Although Dutson et al. (1981) did not find a significant effect of electrical stimulation on ultimate pH, others report that electrical stimulation might slightly lower the ultimate pH (Shaw & Walker, 1977). It is not clear which mechanism is responsible for this phenomenon but it might be similar to the unknown mechanism causing a lower ultimate pH in PSE meat (Bendall & Swatland, 1988). If indeed electrical stimulation does have a slight effect on pH_{24} some "real" DFD meat (pH >6.2) may be converted into "medium" DFD (5.8 <pH <6.2). This may have positive financial consequences as in the latter pH range meat is not registered as DFD. On the other hand Fjelkner-Mödig and Rudérus (1983) demonstrated that "medium" DFD meat is tougher than 'real' DFD or normal meat. Thus the use of electrical stimulation of DFD-prone carcasses may negatively affect sensory quality of some muscles.

CONCLUSION

The actual incidence of DFD meat in The Netherlands is somewhere between 3.5% and 27.3%, heavily depending on transport and delivery conditions. Direct transport from farm to abattoir is to be preferred. However, even when bulls are directly transported to the slaughterhouse the incidence of DFD is much higher than one might anticipate based on the estimation of insurance companies.

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Fig. 1 Frequency distribution of pH-values of M. longissimus dorsi, M. adductor and M. triceps brachii as assessed in 800 bulls (experiment I)

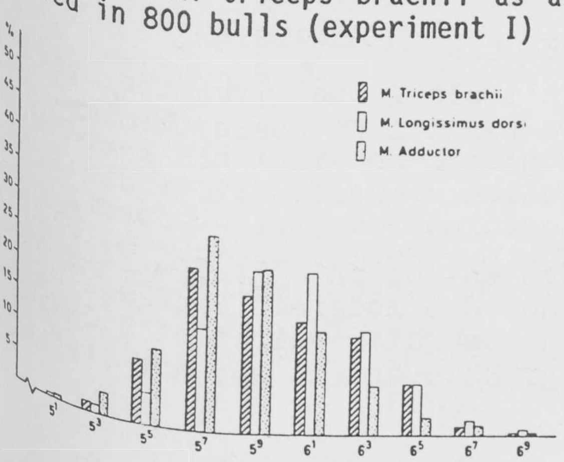

Fig. 2 Influence of transport and delivery system on distribution of pH_{24}-values in M. longissimus dorsi and M. adductor (closed symbols short transport, open symbols long transport)