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Review

Animal welfare at markets and during transport and slaughter

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ABSTRACT

This review highlights some recent developments in our understanding of stress and physical injuries that occur before and during transport to slaughter, during handling at livestock markets, and at the time animals are put-up for slaughter within abattoirs. Stress in pigs during transfer to the stunning point within the abattoir has important effects on meat quality, and there is growing evidence that strenuous exercise or CO_2 stunning can contribute to oxidative rancidity in pigs, poultry and fish. In the EU, putting cattle through a crush in order to check that their eartag numbers correspond to their passport numbers is imposing additional stress, and there are reports that it is leading to greater hide contamination with *Escherichia coli* O157. Recent developments in stunning and slaughter include a better understanding of the causes of variation in captive bolt gun performance, the effectiveness of poll instead of frontal shooting in water buffalo, the prevalence of false aneurysms in carotid arteries during shechita and halal slaughter, and the stress effects of CO_2 stunning in fish. Stunning pigs with 90% CO_2 leads to less PSE meat than 80% CO_2. There have been concerns about the physical activity that cattle show following electrical stunning with an electrically induced cardiac arrest, and with electrical stunning using DC waveforms in broiler chickens. There is also growing concern about the hygiene problems that exist in wet markets, where animals are slaughtered alongside meat that is on display to customers.

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1. Introduction

This paper summarises some key findings from recent research into animal welfare during the preslaughter and slaughter periods. It focuses on injuries and ease of handling, stress effects on subsequent meat quality, and contemporary problems in stunning and slaughter.

2. Recent trends in preslaughter management

Certain breeds, such as Limousin, Red Bororo cattle and Texel sheep, are difficult to handle (Minka & Ayo, 2007; Tompsett &

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Gregory, 2008). It is often recommended that such animals should be familiarised with handling procedures, as this makes them easier to manage during the preslaughter period. There is no doubt that familiarisation helps, but in the case of pigs, a potential disadvantage is that familiarised animals have higher counts of enteric bacteria per gram of faeces in their excreta during the presalughter period (Dowd, Callaway, & Morrow-Tesch, 2007). The mechanisms that explain these and other stress-related effects on enteric bacteria and virus populations are not understood, and they need investigating.

It is also widely recognised that preslaughter stress starts as animals are being loaded onto the vehicles that take them to abattoirs. However, there are two recent studies showing that it can start earlier than this. Under Australian conditions, pre-transport stress or underfeeding were present in five out of 13 lamb consignments as determined from depletion of muscle glycogen in biopsies taken before loading (Jacob, Pethick, & Chapman, 2005). Previous work by the same group showed there was a linear correlation between muscle glycogen concentration and ME intake, and so it was suggested that improvement in nutritional management should solve a good part of this problem. However, there were four lamb consignments with lower muscle glycogen concentrations on arrival at the abattoir compared with levels before leaving the farm, and three of those had been fed grain before embarkation.

The second study was in New Zealand. When New Zealand lambs are prepared for slaughter they are usually graded and crutched shortly before leaving the farms. When this was done, along with weighing, it was found that it took the lambs more than 3 days to recover a normal pH_{ult} in the *longissimus dorsi* (Devine et al., 2006). The intermediate pH_{ult} meat (5.75–6.00) in lambs given insufficient time to recover resulted in tougher meat, but the toughness disappeared if the meat was allowed to age.

There are mixed reports about whether handling stress in the abattoir before slaughter is being adequately controlled. In the EU the situation started to deteriorate with the introduction of cattle passports ten years ago. Introducing cattle passports increased the amount of preslaughter handling. Cattle must have their ear tag numbers checked against the number in the passport each time they are sold at markets and when they are presented for slaughter at an abattoir. This involves holding them in a crush, and as with any crush-work, some animals get bruised and others react badly to being confined. In addition, in a study on cattle sent from 30 farms to 10 abattoirs in Scotland, putting cattle through a crush in the lairage was found to increase hide contamination with *E. coli* O157 (Mather et al., 2007). By contrast, the situation in the USA where passports are not used is improving, in terms of the prevalence of vocalising, thanks to closer attention to welfare auditing (Grandin, 2006; Table 1).

When animals are forced to take strenuous exercise, muscle is prone to forming lipid peroxidation metabolites. The mechanisms that explain this are understood, but there have been few situations where it has been found to affect meat quality (Gregory, 1998, 2007). Ten minutes preslaughter exercise on a treadmill (3.8 km/h) resulted in slightly higher TBARS development in heated pork meatballs, compared to product from unexercised controls, but this must have been quite a severe stress compared with usual practice (Young et al., 2003). Preslaughter heat stress and CO_2 stunning could be more common factors leading to oxidative rancidity (Mujahid, Akiba, Warden, & Toyomizu, 2007). TBARS concentration in broiler breast meat was higher in CO_2 stunned than electrically stunned birds (Alvarado, Richards, O'Keefe, & Wang, 2007). TBARS formation was particularly pronounced in poorly bled birds (Table 2). CO_2 stunning in trout also leads to greater TBARS formation compared to killing by holding in ice (Giuffrida et al., 2007). Whether this was due to their greater exercise or to the potency of carbonate radicals as membrane lipid oxidising agents is not clear.

The way in which pigs are reared can affect ease of handling during the preslaughter period and the extent to which they have to be encouraged to get them to move. Pigs reared on slatted floors were more difficult to load onto vehicles, showing more balking, compared with pigs reared on solid floors. This could have been due to the novelty of the floor type, and because they seem to be more reluctant to move generally (Nanni Costa, Tassone, Righetti, Melotti, & Comellini, 2007). They were, however, less likely to slip during loading.

Hambrecht et al. (2005) compared the relative effects of transport stress, lairage duration and rough handling during transfer in the lairage to the stunning point on subsequent meat quality in stress resistant pigs under European conditions. Stressful handling during transfer to the stunner had the biggest effect on pH_{ult} and on muscle lactate concentration at 2–3 h post-mortem. This was not surprising in the case of muscle lactate, but the 0.13 unit increase in pH_{ult} from mishandling immediately before slaughter was unexpected. The general conclusion was that the greatest benefits in terms of meat quality are likely to come from reducing stress in the lairage during the final stages before slaughter.

The importance of exercise and handling stress immediately before stunning could be even greater in hotter climates. The remedy, however, is not always straight-forward. It is recognised that under subtropical conditions, antemortem showering helps to relieve heat stress in pigs, and this should help alleviate the immediate preslaughter acidosis that contributes to PSE meat. In broilers, however, there is a risk that showering birds can lead to a higher proportion of high pH_{ult} meat, especially when it is applied too enthusiastically (Guarnieri et al., 2004).

One of the ugliest aspects of preslaughter handling is the way downer animals are managed at abattoirs. These are animals that are either injured, or are too weak, or too sick to stand and walk. In the US, in 1994 and 1999, 1.15% and 0.8% of cattle waiting in pens at abattoirs were culled because they were in this condition. This amounted to 71,117 and 49,520 cattle, of which 1.1% and 1.5% were dairy cows and 0.7% and 1.1% were beef cattle (Stull, Payne, Berry, & Reynolds, 2007).

Table 1
Change in prevalence of repeat shooting and vocalising in cattle in US abattoirs in recent years

	1996	1999	2003
Number of abattoirs	6	41	50
Cattle vocalising during handling + stunning (%)	8	2.4	2.0
Range	1–32	0–17	0–6
Number of abattoirs	10	41	50
Cattle stunned with first shot (%)	89.5	96.2	98.6
Range	80–95	84–100	92–100

Table 2
Effect of different stunning methods on muscle haem pigment concentration and TBARS formation in breast meat cooked 4 d after slaughter

Stunning and slaughter method	Meat TBARS	Muscle haem
	mg/kg	μmol/g ± SE
CO_2 stunning – not bled	11.13[a]	10.04 ± 1.70[a]
No stunning – bled	10.72[a]	8.37 ± 1.80[b]
CO_2 stunning – bled	10.56[a]	8.53 ± 1.38[b]
Electrical stunning – decapitated	9.63[b]	8.40 ± 1.72[b]
Electrical stunning – unilateral cut	8.75[c]	8.72 ± 1.66[b]

Means in a column with a different superscript letter were significantly different at least at $p = 0.05$.