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Quality meat from Merinos

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Abstract

Consistent high-quality lamb products are required to maintain consumer confidence and consumption. We conducted studies to compare the meat quality traits of Merinos with those of first- and second-cross lambs. There is great diversity within the Merino genotype, particularly with regard to wool fibre diameter, which complicates generalisations. However, studies of the quality of meat from Merinos were unanimous in that Merinos produce meat that rates highly in terms of flavour, tenderness and overall acceptability. In one study, the retail display-life of loin meat from Merinos was inferior; high pH has been a consistent problem with Merino meat for a number of years. The prevalence of high-pH meat can be minimised by on-farm concentrate feeding, increasing the plane of nutrition of pasture-fed lambs prior to consignment, using sires with a high estimated breeding value for muscling, minimising stress factors between farm and slaughter and using sires with low agitation scores. The retail display-life of meat from Merinos can be improved by reducing the prevalence of high pH meat and using sires with a high estimated breeding value for muscling.

Introduction

Consistent high-quality lamb products are required to maintain consumer confidence and consumption. The appearance and colour of the product in a retail display determines economic returns to supermarkets: a one-day reduction in the shelf-life of a meat product can cost millions per year. The eating quality of meat is predominantly derived from the tenderness, flavour, odour and juiciness; for lamb, flavour and tenderness are equally important. Dark-cutting meat results from muscle that lacks sufficient glycogen at slaughter to decrease the pH below 5.7. High-pH meat is inferior in colour, flavour and retail display-life and varies in tenderness, which is unacceptable for sale as high-quality meat. In this report, a comparison is made between Merinos and other genotypes in regard to these quality traits.

Dark-cutting meat in Merinos

Dark-cutting or high-pH meat is a persistent quality defect found in all meat species (Tarrant, 1989). Caused by a lack of normal acidification of meat during rigor development, dark-cutting is a direct consequence of low muscle glycogen at slaughter (Tarrant, 1989). Dark-cutting meat is less desirable to consumers because it is darker in colour, less tender in the pH range of 5.8–6.2, tends to have off-flavours, spoils more rapidly and requires a longer cooking time (Jacob et al., 2005). There is little data on the prevalence of dark-cutting sheep meat. Safari et al. (2002) reported that, of lamb

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loins purchased at the retail counter in four Australian cities, 10% had a pH above 5.8. Multiple stressors such as transport, time off feed, mustering, saleyards, mixing and unfamiliar environments can additively affect the ultimate pH of sheep meat (Devine and Chrystall, 1989). Merino lambs appear to be more susceptible to the effects of stress on muscle glycogen concentration than cross-bred lambs (Hopkins et al., 1996; Gardner et al., 1999) but other studies observed that Merino meat has a pHu similar to that of meat from other breeds (Hopkins and Fogarty, 1998; Hopkins et al., 2005). However, recent Sheep CRC data obtained from a resource flock showed that the loins of Merinos have a pH of 5.73 at 24 h post-mortem, which is greater than those of lambs sired by Border Leicester rams (pH 5.69) or Poll Dorset rams (pH 5.64) (David Hopkins, unpublished data). In the more stress-sensitive *semitendinosus* muscle, a pH of 6.00 was observed for lambs from Merino dams and a pH of 5.93 for lambs from Border Leicester × Merino dams (David Hopkins, unpublished data). In a study of 13 consignments of lamb in Western Australia, the muscle glycogen content of leg muscle (*semimembranosus*) at slaughter was reduced relative to that on-farm for four groups, three of which were Merinos (Jacob et al., 2005). Commercial slaughter of Merino lambs sometimes results in a greater loss of muscle glycogen relative to that of first-cross and second-cross lambs (Fig. 1; Gardner et al., 1999). This resulted in a higher pHu in the leg muscles (*semimembranosus* and *semitendinosus)* and the loin (*longissimus thoracis*) of Merino lambs. Under a low-stress system (slaughter within 10 min of removal from the pen), there were no differences in muscle glycogen between breeds (Gardner et al., 1999).

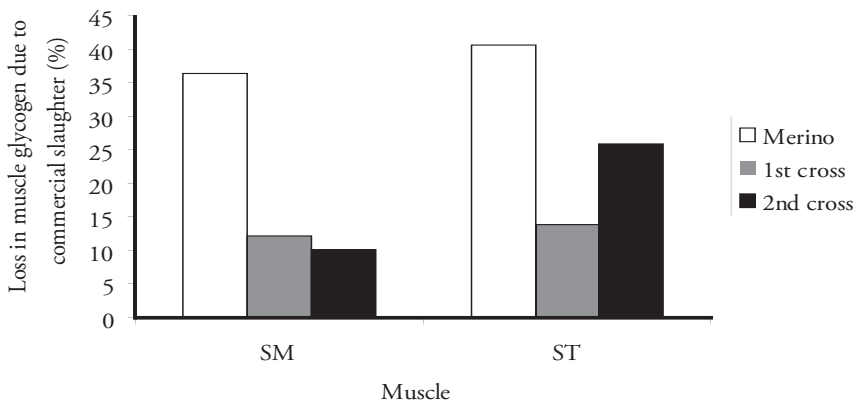

Fig. 1. Percentage loss of muscle glycogen from the *semitendinosus* (ST) and *semimembranosus* (SM) muscles in a commercial slaughter system relative to that in a low-stress slaughter system for Merinos, first-cross and second-cross 6-month-old wether lambs (adapted from Gardner et al., 1999).

Hopkins et al. (2005) compared 342 Merino wether hoggets and observed that two superfine wool strains had the highest pH in the loin and leg (*semitendinosus*) and that the coarse wool and medium wool strains had the lowest pH. The superfine wool strains had lower activities of aerobic enzymes in the loin muscles than the medium strains, suggesting that the difference between the strains may be caused by metabolic differences in the muscles. In a comparison of five genotypes, the loin muscles of Merinos were similar between genotypes and Merinos had the highest ultimate pH of the leg muscle (*rectus femoris*) (Fig. 2; Warner et al., unpublished data).

It would appear that Merinos do not have inherently low levels of muscle glycogen but deplete more muscle glycogen between farm and slaughter, particularly that of muscles such as the *rectus femoris* that express dark-cutting more readily. On-farm factors appear to be more important than transport and lairage in determining the effect of breed and consignment on the incidence of dark-cutting (Jacob et al., 2005).

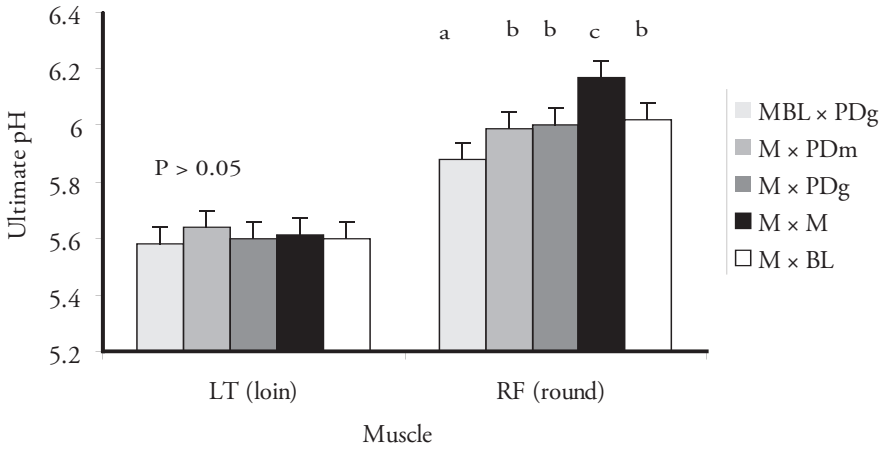

Fig. 2. Effect of genotype on the ultimate pH of the *longissimus thoracis* (LT) and *rectus femoris* (RF) (least-squares means; error bars, standard error of the difference; different superscripts within a muscle indicate differences between genotypes [P < 0.05]; Warner et al., unpublished data).

Intermediary metabolism and meat quality

Work conducted by the Sheep CRC showed that muscle glycogen content is higher in animals with a high estimated breeding value (EBV) for muscling, but only if lambs are well fed (Martin et al., 2004;Gardner et al., 2006). Furthermore, if the muscle glycogen of high EBV lambs is depleted, they replete their glycogen to a greater extent if provided with adequate energy. If adequate nutrition is not provided, their rate of glycogen repletion is lower than that of low EBV lambs. The data suggests that these effects are independent of breed, occurring in both Merinos and crossbreds. Therefore, sires with high muscle EBVs will improve muscle glycogen content of Merino lambs if adequate nutrition is provided. If the glycogen stores of high-EBV Merino lambs are depleted by stress, they will respond to subsequent high energy feeding.

Several studies have been conducted to elucidate the effects of breed and breeding value on responses to hormones involved in glycogen and the storage and mobilisation of fat. Although there are differences in glucose metabolism between breeds, interactions with muscling EBV are evident. Consequently, muscling EBV may be as important as breed in determining glycogen synthesis and mobilisation. Within the Merino breed, there is great variation in EBV. Selection for high muscling EBV coupled with adequate nutrition will ensure high glycogen levels at slaughter. There is some evidence from Sheep CRC research that Merinos are more sensitive to the stress hormone, cortisol, than crossbreds. The data suggest that there are breed differences in fat mobilisation responses to stressors such as adrenaline, but these may be affected by nutrition and EBVs for muscling or feed efficiency.

Variation within Merinos in heritability of pHu and temperament

Within the Merino breed, there is variation in temperament and muscle pH. Fogarty et al. (2003) studied muscle pH of 1045 nineteen-month-old Merino rams and found that coarse-wool strains had a higher pH of the loin muscle than that of medium- and fine-wool strains. They estimated that the mean heritability of pH within the flock was 0.3 and concluded that there was scope to improve meat quality through selection.

Some sheep have a calm temperament and are more at ease with isolation, novelty and close

contact with humans whereas others display a nervous disposition and have difficulty coping with these situations. This trait was found to be moderately heritable (h^2 = 0.35 ± 0.04) by Blache and Ferguson (2005), who measured temperament of 4849 progeny from 25 flocks of four sheep breeds (Merino, Poll Dorset, White Suffolk and Border Leicester) using an isolation box. They suggested that it is possible to select for temperament on-farm using a simplified version of the isolation-box test. Use of the isolation-box test on 8-month-old lambs (n = 450) at Cowra showed that the Merinos and second-cross lambs had the lowest agitation score and the Poll Dorset × Merino had the highest agitation score (Fig. 3; Ferguson, unpublished data). The test was repeated six months later using 14-month-old animals (n = 295), and the results were similar (Ferguson, unpublished data). It is interesting that the Merinos had the lowest agitation score, considering that they had the highest pHu for the leg muscle (Fig. 2). This suggests that although Merinos may be more sensitive to pre-slaughter stress, their behavioural responses (agitation scores) to one minute of isolation are not as high as that of other genotypes. The complex array of behavioural, physiological and emotional changes that occur in response to stress varies according to the type, duration and intensity of the stressor.

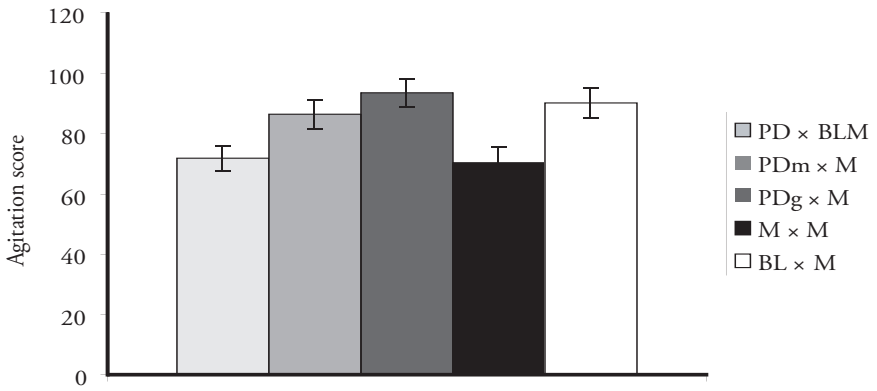

Fig. 3. Effect of genotype on agitation score of seven-month-old lambs ([abc]Genotypes with a different superscript differ in agitation score (P < 0.05); Ferguson, unpublished data).

Colour and shelf-life of meat from Merinos

Consumers can be deterred from buying dark-cutting meat because it is perceived as not being as fresh as lighter coloured meat (Issanchou, 1996). There is potential for different breeds of sheep to exhibit differences in colour due to variations in the haem content of muscles (Dransfield et al., 1979). There is a strong industry perception in Western Australia that Merino lambs have a greater incidence of dark meat (Gardner et al., 1999). This perception is most likely because of the higher occurrence of dark-cutting meat. Under a low stress system, the colour of the loin muscle from Merinos is similar to that of first- and second-cross lambs (Gardner et al., 1999). This occurs even though the myoglobin content of the leg muscles (*semimembranosus* and *semitendinosus*) of Merino lambs is lower than that of first- and second-cross lambs (Gardner et al., 1999). In contrast, under a commercial slaughter system, Merino lambs produced meat with less redness and yellowness, presumably due to the higher pHu of the meat (Gardner et al., 1999).

The accumulation of the brown pigment, myoglobin, at the expense of the bright-red pigment, oxymyoglobin, in the meat surface limits the shelf-life of meat. The formation of metmyoglobin in meat is predominantly determined by the rate of oxidation. Thus, factors that promote oxidation will reduce the shelf-life. These factors include high temperature, low pH, light and the presence

of metal ions. In muscles with more aerobic fibres and a low ultimate pH, higher levels of oxygen consumption promote oxidation. In a recent sheep CRC study, loin muscle from Merinos was found to be less red when initially displayed and was browner after five days of display (Fig. 4; Warner et al., unpublished data).

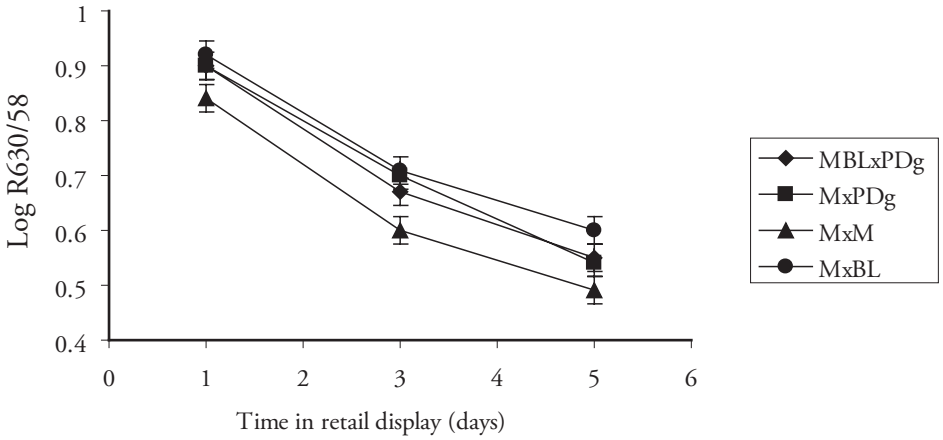

Fig. 4. Effect of genotype on browning of the loin muscle (*longissimus thoracis*) during simulated retail display at 4 °C (measured as log reflectance at 630/580 nm, which indicates the ratio of oxymyoglobin to metmyoglobin; genotype effect was significant at $P < 0.05$ at all time-points; Warner et al., unpublished data).

Flavour

The characteristic mutton flavour/odour results in low consumer acceptance of sheep meat. Mutton flavour has been described as sweaty, sour, urinary, faecal, barnyard, oily, sharp and acrid (Wong et al., 1975). The compounds associated with these aromas and flavours have been identified as branched-chain and unsaturated fatty acids (Wong et al., 1975). The presence of these compounds results in low consumer acceptance of sheep meat in many countries (Wong et al., 1975). There are indications that puberty or age causes an increase in the odourous 4-methyl nonanoic acid (MNA) and 4-methyl ontanoic acid (MOA). These two compounds have been implicated in the unacceptable flavours and odours in lamb and sheep meat.

In a comparison of five different genotypes, eight-month-old Merino lambs were found to have acceptably low levels of MNA and MOA. Merinos had levels similar to those of Border Leicester × Merino and Poll Dorset × Border Leicester–Merino lambs but lower levels than those of Poll Dorset × Merino lambs (Salvatore and Dunshea, unpublished data). Thus, Merino meat can be considered to be highly acceptable to the consumer in terms of odour and flavour.

Merinos produce tender meat

Tenderness is a key attribute that determines the acceptability of meat to the consumer. Tenderness is determined by on-farm factors (genetics, growth-path, pre-slaughter nutrition) and processing factors (pre-slaughter stressors, post-slaughter pH and temperature decrease, chilling rate and ageing). Merino lambs have tenderness similar to that of first- and second-crosses when assessed using objective measurements (Hopkins and Fogarty, 1998; Hopkins et al., 2005) and a consumer panel (Safari at al., 2001), and this was confirmed by CRC research (David Hopkins, unpublished data).

Conclusion

The retail display-life of meat from Merinos can be improved by feeding of concentrates prior to consignment, increasing the nutrition of pasture-fed lambs prior to consignment, using sires with high yearling EBVs for muscling, minimising stress between farm and slaughter and using sires with low agitation scores.

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