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# Genetic parameters for meat quality traits of Australian lamb meat

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ABSTRACT

Genetic parameters were estimated for a range of meat quality traits recorded on Australian lamb meat. Data were collected from Merino and crossbred progeny of Merino, terminal and maternal meat breed sires of the Information Nucleus programme. Lambs born between 2007 and 2010 (n = 8968) were slaughtered, these being the progeny of 372 sires and 5309 dams. Meat quality traits were found generally to be of moderate heritability (estimates between 0.15 and 0.30 for measures of meat tenderness, meat colour, polyunsaturated fat content, mineral content and muscle oxidative capacity), with notable exceptions of intramuscular fat (0.48), ultimate pH (0.08) and fresh meat colour $a^*$ (0.08) and $b^*$ (0.10) values. Genetic correlations between hot carcass weight and the meat quality traits were low. The genetic correlation between intramuscular fat and shear force was high (−0.62). Several measures of meat quality (fresh meat redness, retail meat redness, retail oxy/met value and iron content) appear to have potential for inclusion in meat sheep breeding objectives.


## 1. Introduction

Improvement of the quality of Australian lamb meat, particularly eating quality and nutritional value, will enhance the industry's capacity to meet increasing consumer expectations for lamb products (Pethick, Ball, Banks, & Hocquette, 2011). Over the last two decades, the Australian sheep meat industry has delivered large increases in lamb production and profitability, with genetic improvement in growth, leanness and muscling making a substantial contribution to these gains (Fogarty, 2009). There is evidence that continued selection for leanness (higher lean meat yield) may adversely affect aspects of eating quality and intramuscular fat content (Hopkins, Hegarty, & Farrell, 2005; Karamichou, Richardson, Nute, McLean, & Bishop, 2006). Hence, Pethick et al. (2011) asserted that genetic improvement programmes will have an important role in contributing to the enhancement of meat quality of lamb, although it will be a complex task to determine the important component traits for eating quality and nutritional value that should be measured on an on-going and cost-effective basis.

Genetic variation exists for some meat quality traits, as reviewed by Hopkins, Fogarty, and Mortimer (2011). While estimates of heritability for some traits have been reported, there are few published estimates of genetic and phenotypic correlations among meat quality traits or with other production traits. Information on heritabilities and genetic correlations among meat quality traits is needed to identify their importance in breeding programmes that efficiently improve lamb meat quality and productivity. Using data from progeny of the Information Nucleus Flock programme of the Co-operative Research Centre for Sheep Industry Innovation (Fogarty, Banks, van der Werf, Ball, & Gibson, 2007; van der Werf, Kinghorn, & Banks, 2010), this study aims to estimate heritability for a range of meat quality traits as well as the genetic and phenotypic correlations among the traits. The traits include those relevant to eating quality and tenderness, fresh and retail meat colour, nutritional value

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and hot carcass weight. The environmental effects influencing these meat quality traits have been identified and were reported recently by Jacob, D'Antuono, Gilmour, and Warner (2014), Kelman, Pannier, Pethick, and Gardner (2014), Pannier, Pethick, Boyce, et al. (2014-a), Pannier, Pethick, Geesink, et al. (2014-b) and Ponnampalam, Butler, Jacob, Pethick, et al. (2014). Using a sub-set of the data, an earlier study by Mortimer et al. (2010) reported preliminary genetic parameter estimates for some meat quality traits, as well as live animal and carcass traits, and identified intramuscular fat and shear force as potential traits for inclusion in sheep breeding objectives. The present paper provides a more extensive report on the genetic parameters for a wider selection of meat quality traits than previous reports.

## 2. Materials and methods

### 2.1. Animals

Data were collected over a 5 year period (2007 to 2012) from the crossbred and Merino progeny of the Information Nucleus breeding programme at eight research sites and a commercial farm around Australia. The design of the Information Nucleus has been described fully by van der Werf et al. (2010), including the procedure used to select the sires for AI mating with the flocks' base ewes. Sires were selected from a range of breeds used in the Australian sheep industry (Merino, maternal and terminal meat breeds). The base ewes, depending on the research farm location, were drawn from pedigreed and/or commercial flock sources and usually consisted of approximately 80% Merino ewes and 20% Border Leicester × Merino ewes. The results presented herein were generated from records from 8968 slaughtered lambs, born between 2007 and 2010. These lambs were the progeny of 372 sires and 5309 dams and were born in 6915 litters. The average number of lambs slaughtered was 1.7 per dam. Data for intramuscular fat, shear force (after 5 days of ageing), mineral traits, fatty acids and myoglobin content were available on lambs born 2007–2009 and on isocitrate dehydrogenase activity for lambs born 2007–2008. The retail colour traits were recorded only on progeny born 2007–2010 at the Cowra, Trangie, Hamilton, Rutherglen and Katanning sites.

Once weaned, the lambs at each site were managed to achieve target carcass weights of 21–22 kg, with target growth rates of 200 g/day for crossbred lambs and 150 g/day for Merino lambs prior to slaughter. The nutritional history of the lambs at each site is given by Ponnampalam, Butler, Jacob, Pethick, et al. (2014). The lambs usually grazed the extensive pastures available at the sites, but were supplemented with grain, hay or feedlot pellets when the pasture supply was restricted. Each year, a fasted weight (2 h off feed and water) recorded one week prior to slaughter was used to allocate the lambs to a slaughter group, balanced for weight within sex, sire and production types used in the Australian sheep industry (Merino, Border Leicester × Merino, terminal meat breed × Merino and terminal meat breed × Border Leicester–Merino). All lambs were slaughtered at commercial abattoirs. The average age at slaughter in days (standard deviation) was: 258 (64.3) for 2007-born lambs across 30 slaughter groups; 281 (86.6) for 2008-born lambs across 29 groups; 256 (59.5) for 2009-born lambs across 28 slaughter groups; and 260 (65.0) for 2010-born lambs across 30 slaughter groups.

### 2.2. Lamb slaughter and measures

The post-slaughter sampling protocol for the carcass and meat quality traits is described by Pearce (2009). Briefly, all carcasses were subjected to medium voltage electrical stimulation and trimmed according to AUS-MEAT specifications (Anonymous, 1992). At slaughter, hot carcass weight (HCWT) was recorded. A sample (1 g) taken from the *M. longissimus thoracis et lumborum* (LL), was frozen in liquid nitrogen within 2 h of death and subsequently assayed for isocitrate dehydrogenase (ICDH; EC 1.1.1.42) according to a procedure described by Gardner, Pethick, Greenwood, and Hegarty (2006). Carcasses were chilled overnight (3–4 °C) and then were cut between the 12th and 13th ribs to expose the surface of the LL. At 24 h post-mortem, the lumbar portion of the LL muscle was excised from the carcass.

### 2.3. Meat quality measurements

The cut surface of the LL at the 12th rib was exposed to the air at ambient temperature for 30–40 min and the meat colour measured as described by Warner et al. (2010), using Minolta Chroma metres (Models CR-300 and CR-400) set on the $L^*$, $a^*$, $b^*$ system (where $L^*$ (cf$L^*$) measures relative lightness, $a^*$ (cf$a^*$) relative redness and $b^*$ (cf$b^*$) relative yellowness). Three replicate measurements were taken at different positions and an average value was used for analysis. The pH of the LL was measured at approximately 24 h ($pH_{24}$LL) after slaughter using a number of different pH metres linked to pH electrodes calibrated at chiller temperatures (3–4 °C) (Pearce et al., 2010). After removal of subcutaneous fat and epimysium from the excised LL muscle, two 40 g samples of diced muscle were collected, frozen and stored as described by Pannier et al. (2010). Iron and zinc contents were measured on one sample as described by Pannier et al. (2010), while a range of fatty acids was measured on the other sample, including the long chain omega-3 fatty acids eicosapentaenoic acid (EPA, 20:5n − 3), docosapentaenoic acid (DPA, 22:5n − 3) and docosahexaenoic acid (DHA, 22:6n − 3) and omega-6 fatty acids linoleic acid (LA, 18:2n − 6) and arachidonic acid (ARA, 20:4n − 6) as described by Ponnampalam et al. (2010). Totals for the fatty acids were calculated for each sample of: EPA and DHA (EPA + DHA); EPA, DPA and DHA (EPA + DPA + DHA); and LA and ARA (LA + ARA).

Myoglobin content (Myo) was measured on a sample (1 g) taken from the loin using methods described by Trout (1991). A sample (50 g) was also taken for analysis of intramuscular fat (IMF) and then frozen before storage (Pannier, Pethick, Geesink, et al., 2014-b). Percentage of IMF was determined using a near infrared procedure (NIR) in a Technicon Infralyser 450, as described by Perry, Shorthose, Ferguson, and Thompson (2001). Meat colour stability under simulated retail display was measured on a 3 cm slice from the cranial end of the LL which had been vacuum packed and aged for 5 days. Further details are provided by Jacob et al. (2014). Data analysed herein (prefixed ret) were recorded after 2 days of simulated retail display. These data included $L^*$ (ret$L^*$), $a^*$ (ret$a^*$), $b^*$ (ret$b^*$) and oxymyoglobin/metmyoglobin value (retOxy/Met or oxy/met value). Psychometric hue angle (reth) and psychometric chroma (retC*) were calculated as psychometric hue $= \tan^{-1}$ ($b^* / a^*$) and psychometric chroma $= (a^{*2} + b^{*2})^{0.5}$ (Hunt et al., 1991). A section of the LL (65 g) was aged for 5 days at 3–4 °C, and stored frozen. For shear force testing (SF5), these samples then were cooked from frozen for 35 min in plastic bags at 71 °C in a water bath and tested using a Lloyd texture analyser (Model LRX, Lloyd Instruments, Hampshire, UK) with a Warner–Bratzler type shear blade fitted as described by Hopkins, Toohey, Warner, Kerr, and van de Ven (2010).

### 2.4. Statistical analyses

All analyses of the data were conducted using the software ASReml (Gilmour, Gogel, Cullis, Welham, & Thompson, 2009) and restricted maximum likelihood procedures. Initially, a mixed linear model was used to identify those fixed effects influencing the traits, which included the fixed effects of site, year of birth (4, 3 or 2 levels), slaughter group, sire breed (19 levels: Border Leicester, Bond, Booroola Merino, Corriedale, Coopworth, Dohne Merino, East Friesian, Hampshire Down, Ile de France, Merino (ultrafine/superfine wool type), Merino (fine/medium wool type), Merino (medium/strong wool type), Poll Dorset, Southdown, Prime South African Meat Merino, Suffolk, Texel, White Suffolk or Dorper), dam breed (2 levels: Merino or Merino x Border Leicester), sex (2 levels: male castrate or female), type of birth and rearing (6 levels:11, 21, 22, 31, 32 or 33 for lambs born and reared respectively)