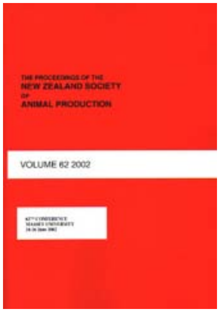
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A new generation meat program in Australia within the Co-operative Research Centre for Sheep Industry Innovation

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ABSTRACT

The Information Nucleus flock (INF) is the central focus of the Co-operative Research Centre (CRC) for Sheep Industry Innovation. It is made up of eight sheep flocks across Australia that are genetically linked by the use of common sires. The objective of the INF is to measure a range of biological and production parameters and to produce heritability estimates and genetic correlations for a range of new traits. Approximately 100 sires are mated annually by artificial insemination to 5,000 ewes across the sites. Sires from various breeds are joined to Merino and crossbred ewes. Each year 2,000 progeny are evaluated for a wide range of meat production and consumer-relevant traits. Some of these traits are new and novel, such as the content of iron, zinc and omega-3 fatty acids. Their measurement is designed to ensure lamb maintains its marketing edge as a healthy, nutritious meat so that it is the consumer's preferred choice of meat. This paper will provide an overview of the program and highlight specific areas that are novel with respect to sheep meat.

Keywords: lamb; meat; quality.

INTRODUCTION

The Australian Co-operative Research Centre (CRC) for Sheep Industry Innovation consists of five programs of which Program 3 is the Next Generation Meat Quality program. The Information Nucleus Flock (INF) (Program 4) is a central resource providing lambs and genetic analyses for Program 3. Within Program 3 there are four projects:

- Project 3.1.1. Measurement of new phenotypes to provide phenotypic data for new meat quality phenotypes; then estimation of genetic parameters and molecular breeding values by Program 4.
- Project 3.2. Biology and production pathways for desired phenotypes to increase understanding of the biology of phenotypes that contribute to desired industry outcomes such as increased lean meat yield, improved eating and meat quality.
- Project 3.3.1. Lean meat yield and supply chains to develop new approaches for measuring lean meat yield that will facilitate the adoption of trading on a lean meat yield basis.
- Project 3.4.1. Application of meat processing technologies to investigate technologies for improving processing efficiency and meat quality.

Collection of meat quality and yield phenotypic data from INF lambs will be achieved through Project 3.1.1. To ensure consistent results across different sites, standardised protocols have been developed for the range of field and laboratory procedures used in Project 3.1.1 (K. Pearce, Unpublished data). Furthermore calibration procedures have been used to harmonise the results from different laboratories. Slaughter data will be obtained from crossbred progeny with a target carcass weight of 21.5 kg from the following breed crosses: Terminal x Merino ewes and wethers, Border Leicester x Merino wethers and Terminal x (Border Leicester x Merino) ewes and wethers. Additionally, half of the Merino wethers are shorn at 10 to 11 months of age and then slaughtered as lambs at a target average carcass weight of 21.5 kg. The list of traits being measured and the importance and application of these traits is given in Table 1. These traits will be measured for 2,000 progeny per year.

MEASUREMENT OF LEAN MEAT YIELD

Lean meat yield (LMY) is an important economic trait for processors because fat and bone are of little value with more fat and bone resulting in a lower lean meat yield. For example, using data from Hopkins *et al.* (1995), if two carcasss each weigh 21.5 kg but one has a GR fat measurement

TABLE 1: Carcass and meat traits being measured on Information Nucleus flock (INF) slaughter progeny. GR = A fat content assessment based on measurement of total tissue depth over the12th rib at a point 110 mm from the midline of the carcass; Fat C = Depth of subcutaneous fat above the M. *Longissimus* over the 12th rib at a point 45 mm from the midline of the carcass.

Trait	Application and importance
Skin assessment	Consumer acceptability
Hot carcass weight	Lean meat yield prediction
GR, Fat C and Fat 5th rib depths	Lean meat yield prediction/consumer acceptability
Eye muscle area	Lean meat yield prediction
Weight of shortloin subcutaneous fat	Lean meat yield prediction
Weight of boneless short loin muscle	Lean meat yield prediction
Weight of topside muscle	Lean meat yield prediction
Weight of round muscle	Lean meat yield prediction
Weight of hind leg bone	Lean meat yield prediction
Rate of pH decline	Eating quality acceptability
Isocitrate dehydrogenase (ICDH) enzyme activity	Biochemistry
Fresh 24 hour meat colour	Consumer acceptability
Ultimate pH	Consumer/eating quality acceptability
Shear force of the loin muscle (1 and 5 day aged)	Eating quality acceptability
Compression of the topside muscle	Eating quality acceptability
Connective tissue content of the topside muscle	Eating quality acceptability
Intramuscular fat of the loin muscle	Eating quality acceptability
Myoglobin content of the loin muscle	Biochemistry
Iron and zinc content of the loin muscle	Nutritional value
Long chain fatty acids (Omega-3s) of the loin muscle	Nutritional value
Retail colour stability of the loin muscle	Consumer acceptability

(A fat content assessment based on measurement of total tissue depth over the12th rib at a point 110 mm from the midline of the carcass) of 10 mm and the other 20 mm, then there is a 5.6% decrease in lean meat yield for the fatter carcass. In the case of a 21.5 kg carcass this equates to 1.2 kg of lean meat. At a price of AUS$10/kg this is a $12 per head difference. New systems of predicting LMY are being investigated in Project 3.3.1, because the sheep meat industry has not fully adopted existing yield prediction systems such as VIASCAN®. For all INF progeny an estimate of LMY is being achieved using a partial bone out procedure to avoid the cost, of a full bone out. In this system a subset of components are weighed and the values used in predictive models to estimate LMY. Samples for eating quality acceptability and nutritional value will be taken from the short loin and hindleg. Components of these two primal cuts are being weighed for the purpose of estimating LMY, using a similar approach to Hopkins (2008). The predictive models for LMY are being derived by computerized tomography (CT)-scanning using a subset of INF carcasss. Models are being developed to predict the lean content using the relevant traits listed in Table 1 These models will in turn be used to provide LMY estimates for all INF slaughtered lambs.

DETERMINING THE RATE OF RIGOR ONSET

Results from the Sheep Meat Eating Quality program suggested that there is an 'ideal' rate of pH fall. A target of 18 to 25°C at pH 6.0 would give superior eating quality for the short-aged domestic market compared to slower or faster rates of pH fall (Thompson *et al.,* 2005). This outcome was generally consistent with the early studies of Locker and Hagyard (1963) that showed minimal shortening at close to 15°C, and with a suite of much later experiments, such as Devine *et al.* (2002), that showed maximum tenderness when excised muscle entered rigor at these temperatures. To adjust for variation in onset of rigor between sites and the potential for this to confound eating quality, all carcasses are being electrically stimulated with new post dressing electrical stimulation technology (Hopkins *et al.,* 2008). Furthermore the rate of pH decline in the loin is being measured for all carcasses and used as a covariate in the analysis of shear force.

AN IMPORTANT CONSUMER TRAIT

Some consumers use meat colour as a visual cue for freshness (Issanchou, 1996) and this impacts on purchasing decisions. Further, consumers find the browning of meat caused by metmyoglobin unappealing. The formation of metmyoglobin during display can be studied by measuring the reflectance of light from the surface of meat and deriving the wavelength ratio at 630/580 nm to estimate a oxymyoglobin/metmyoglobin (oxy/met) ratio. Some workers have suggested that consumers of lamb discriminate against the meat when the oxy/met value falls below 3.5 (Morrissey *et al.,* 2008) and so the change in oxy/met during shelf display is being measured on a subset of carcasses using a Hunter Lab Mini Scan (Model No. 45/0-L, aperture size of 25 mm).

CONSIDERATION OF EATING QUALITY

The three factors that determine meat tenderness are 'background toughness', the toughening phase and the tenderisation phase. While the toughening and tenderisation phases take place during the post-mortem storage period, background toughness exists at the time of slaughter and does not change during the storage period. This toughness is linked to connective tissue content and previous research has shown that in a cut like the topside selection for muscling can lead to an increase in toughness (Hopkins *et al.,* 2007a). Additionally, this cut has low eating quality (Pethick *et al.,* 2006b). For this reason the compression and connective tissue of the topside is being examined. Data analysis will reveal the genetic relationship between muscling and toughness attributes. Another important trait that impacts on eating quality is intramuscular fat (IMF) (Hopkins *et al.,* 2007b). There is some evidence that selection for muscling reduces this trait (Hopkins *et al.,* 2005). Establishing the genetic relationships between these traits is important to ensure breeding objectives do not compromise the market acceptance of lamb.

Aside from developing genetic parameters for toughness, the meat program is working at the processing level through Project 3.4.1 to develop other approaches for improving eating quality. Chilling conditions that minimise weight loss without negatively impacting on tenderness present a significant saving to industry. Very fast chilling has been proposed as a method to optimise processing efficiency by reducing processing time and chilling inventories. This approach is being studied. Initial results suggest that if hot-boned lamb loin is chilled rapidly before rigor, the meat can be tender two days post-slaughter (R.H. Jacob, Unpublished data). Further work on this approach is under way. Development work, funded by Meat and Livestock Australia (MLA), is under way on a machine to stretch meat. This offers scope for integration with the removal of the forequarter (FQ) pre-rigor so as to prevent shortening and potentially reduce toughness. The stretching will also change the shape of the FQ and could predispose the FQ to portion cutting as shown below (Figure 1). Such an approach will only be applicable to lean lambs to avoid excessive seam fat and the scope for this approach is being examined in this project.

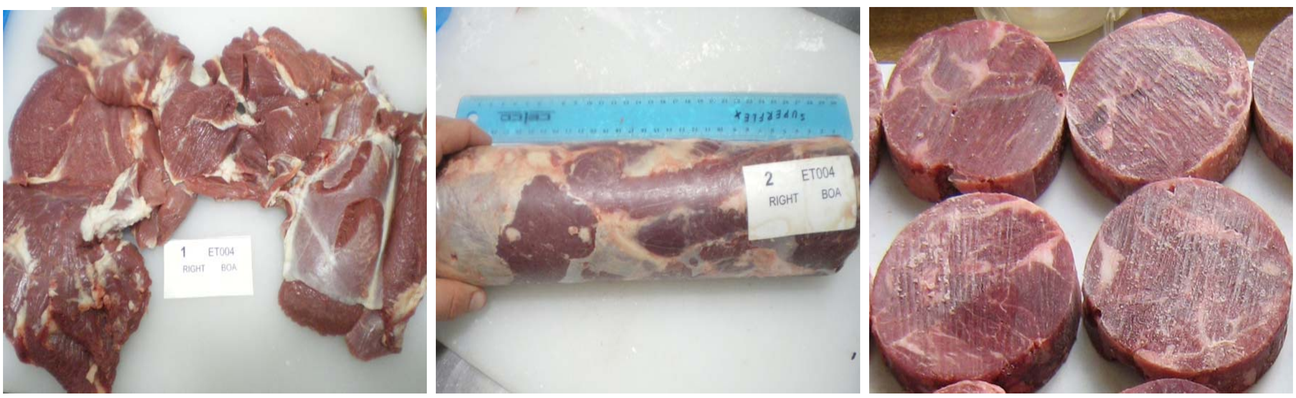
NUTRITIVE VALUE OF LAMB

Achieving levels of iron (Fe), zinc (Zn) and omega-3 fatty acids that reach recommended dietary guidelines has been proposed as a key marketing tool for red meat in the future (Pethick *et al.,* 2006a). Data reported by the Human Health and Marketing Division of MLA (Meat and Livestock Australia, 2007), suggests that lamb contains adequate levels for Zn, but that Fe and omega-3 need improvement. For example, the current data suggests that a 135 g serving of lean lamb contains 2.7 mg of Fe with the recommended dietary intake (RDI) being 8 mg/d for all men and for women over 50 years of age. However for younger women the RDI is 18 mg/d (National Health and Medical Research Council, 2006). Since a ‘good source’ is considered to provide 25% of the RDI (Williams, 2007) there is room to improve Fe levels for younger women. Further to this, previous data on Fe levels (D. Pethick *unpublished data*) indicate lamb could be vulnerable to lower than the expected Fe levels published by Williams (2007) and given a general decrease in aerobicity (due to an increase in muscling) would lead to a decline in Fe levels. This is not a desirable outcome for lamb and we must prevent any decline in Fe levels. By contrast the RDI for Zn is 14 mg for men and 8 mg for women (National Health and Medical Research Council, 2006) and given a 135 g serve of lean lamb contains 6 mg of Zn (Williams, 2007) then this is a good source of Zn.

Newly introduced nutrient reference values indicate that most Australians need to increase their intake of the long-chain n-3 polyunsaturated omega-3 fatty acids so as to reduce the risk of chronic disease (Howe *et al.,* 2007). These fatty acids

FIGURE 1: (a) Hot-boned lamb forequarter; (b) the same meat after stretching and reforming into a roll; (c) portion-sized slices of frozen meat cut from the roll.

(a) (b) (c)



include eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA) and docosapentaenoic acid (DPA). Unfortunately DPA cannot currently be included in the nutrient content claim for omega-3 under the Food Standards Code (Howe *et al.,* 2007). Current Food Standards in fact favour fish over red meat because red meat contains relatively high levels of DPA compared to fish (Howe *et al.*, 2007). Based on current data, it appears that the level of all three fatty acids in 135 g of lean lamb is approximately 97 mg (Williams, 2007) with the RDI ranging from 90 to 160 mg/d for women and men respectively (National Health and Medical Research Council, 2006). Recent data for the loin from 14 month-old sheep had the level at 95 mg (E.N. Ponnampalam, Unpublished data) in close agreement with the data of Williams (2007). The level of the omega-3 does appear to vary across cuts (Williams, 2007). Even if only EPA and DHA can be claimed, lamb can still be considered a source of omega-3 on average. In Project 3.2.1 several experiments will be conducted to investigate whether the maternal diet and the finishing diet can be manipulated to increase omega-3 levels in muscle. Some work will also be undertaken to explore genomic regions relating to the action of critical fatty acid enzymes that are important in the production of these fatty acids. Given the importance of Fe, Zn and the omega-3s they are being measured on all slaughtered progeny. The scale of the program is a world first with the intention of better understanding the levels of these key nutrients and how management and genetics of the animal supplying the meat impact on the levels.

In sheep, a preliminary Australian value for heritability of EPA content of muscle is 0.17 (Greeff *et al.,* 2006) while a value of 0.21 has been reported (Karamichou *et al.,* 2006) from United Kingdom research. This heritability value is moderate, but nevertheless indicates that selection for increased EPA concentration is feasible. No genetic parameters determined under Australian conditions exist for docosahexaenoic acid, which is another important omega-3 fatty acid, although a heritability of 0.13 was reported by Karamichou *et al.* (2006). Genetic parameters for these traits will be derived in the program based on data from INF animals.

INTERRELATIONSHIPS BETWEEN MEAT TRAITS

An important advantage of the research described will be the ability to relate different traits at the phenotypic and genotypic levels. For example, fresh meat colour and colour stability can be influenced by a number of animal factors such as myoglobin concentration, and long chain fatty acid concentration. Myoglobin concentration increases with age of animal (Gardner *et al.,* 2007) and can decrease with selection for muscling, due to a decrease in aerobicity (Gardner *et al.,* 2007). Isocitrate dehydrogenase is an enzyme associated with oxidative (aerobic) muscle metabolism. Along with myoglobin it is being measured to provide the genetic parameters needed to ensure any selection is not antagonistic towards fresh colour or display colour.

SUMMARY

The meat program will develop improved models to examine the relationships between carcass and meat traits and contribute to the development of genetic parameters for new and novel meat traits. This will ensure that selection for production traits does not lead to deleterious effects on the quality traits for which lamb has a marketing edge. Targeted research will also examine the potential to manipulate important nutritive value and eating quality traits, while at the same time investigating ways to improve and measure meat quality at the processing level.

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