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Australian prime lamb—a vision for 2020

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Abstract

This article describes the evolution of the prime lamb industry from the 1980s to the present and proposes a path for the future until 2020. In terms of income generated, the industry was floundering in the 1980s, but income increased rapidly after the late 1990s. The increase in the value of the industry was underpinned by a shift to a focus on the consumer demand and implemented by improvements in genetics, farm management and marketing. Current genetic improvement is mainly driven by improvement of carcass weight; future improvements will be derived from a reduction in fatness and an increase in muscle. The influence of genetic selection for leanness and muscle on muscle structure is discussed. It is concluded that selection and management strategies should focus on maintaining muscle with an aerobic metabolism, as this will optimise the organoleptic qualities and nutrient content of meat, which have significant implications for human health. Fat metabolism is discussed in relation to opportunities for maintaining intramuscular fat levels, reducing saturated fat content of lamb and increasing the long-chain omega-3 content of lamb. Future research should focus on improvements in supply-chain efficiency, eating quality, visual appeal, odour and the health attributes of lamb meat.

Introduction

A long-term research and development effort undertaken by Meat and Livestock Australia (MLA) and, more recently, by MLA in collaboration with the Australian Sheep Industry CRC resulted in a rapidly growing and profitable Australian lamb industry. MLA, supported by a market-receptive terminal sire sector, has implemented a strong genetic improvement platform, originally as Lambplan™ and now as Sheep Genetics Australia. These genetic platforms have resulted in improvements in the weight and leanness of carcasses and in the financial worth of the industry.

The sheep-meat eating-quality program has shown that lamb is an attractive product—it is tender, juicy and has good flavour. Furthermore, the use of selected muscles or cuts presents opportunities for development of products from meat from older sheep. Knowledge of improved husbandry, processing and retail options are necessary to achieve a high level of consumer satisfaction and positive outcomes for the sheep-meat sector (Pethick et al., 2005a). It is important that a supply-chain approach is adopted in which all sectors adopt best-practice procedures. MLA-funded medical and human nutrition research and development has provided considerable information on the health-promoting and nutraceutical aspects of lamb, sheep meat and beef, and has benchmarked these products against many other foods and protein sources.

This paper discusses this research and proposes a framework for developing lamb production and lamb products on a broad front to address supply-chain efficiency, integrity and consumer requirements. Key elements are improving supply-chain efficiency by maintaining genetic selection pressure to increase early expression of growth and muscle traits while simultaneously improve eating quality, other meat characteristics and the nutritional value of the product.

Modern meat products

Marketing research undertaken by MLA has indicated that the future of red meat products should be based on the following fundamental aspects of consumer demand:

- Products should have high organoleptic appeal, viz., they should be juicy, tender and have good flavour.
- Products should be good sources of lean, high-quality protein and nutrients (fatty acid species, minerals and vitamins) that are consistent with a healthy diet.
- Production systems should comply with ethical standards for animal welfare and environmental protection.
- Products should be safe and the integrity of supply chains should be such that claims relating to quality and health-promoting features can be justified.
- Production systems throughout the supply chain should be cost-efficient to the extent that consumers perceive the product as good value for money, i.e., that quality and price are matched.

Genetic improvement

Genetic improvement is traditionally seen as a long-term investment to improve the efficiency of animal growth and the value of the product to the supply chain. However, there is clear evidence that genetic gains can also be realised within short time-frames, providing the objectives are clear and are valued by the supply chains. Banks (2003) discussed the evolution of the Australian prime lamb industry from the 1980s until the present. The industry was floundering during the 80s and early 90s and began a slow recovery in the late 90s. However, from 2000, the industry has experienced exceptional growth (Fig. 1).

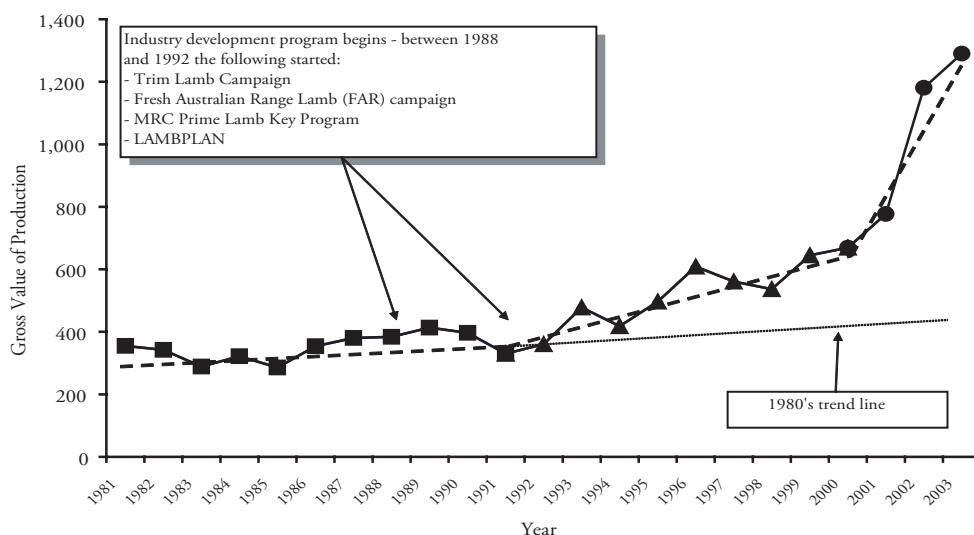


Fig. 1. Gross value of lamb production, CPI corrected (million dollars).

Banks (2003) showed that genetic improvement of carcase weight and leanness of terminal sires was closely associated with the 2000 boom in the value of the lamb industry (Fig. 2). Genetic improvement is only one component of the success of the prime lamb industry, but it is a very significant one:

genetic improvement of productivity and product quality increased at 4% p.a. from the late 1990s. Genetic improvement has been important in facilitating the production of the larger, leaner lambs that customers demand, which was not possible before 1990. Conversion of genetic improvement into improved returns requires a whole-of-industry approach, which includes improvements in farm management, genetics, marketing and a consumer-focused industry.

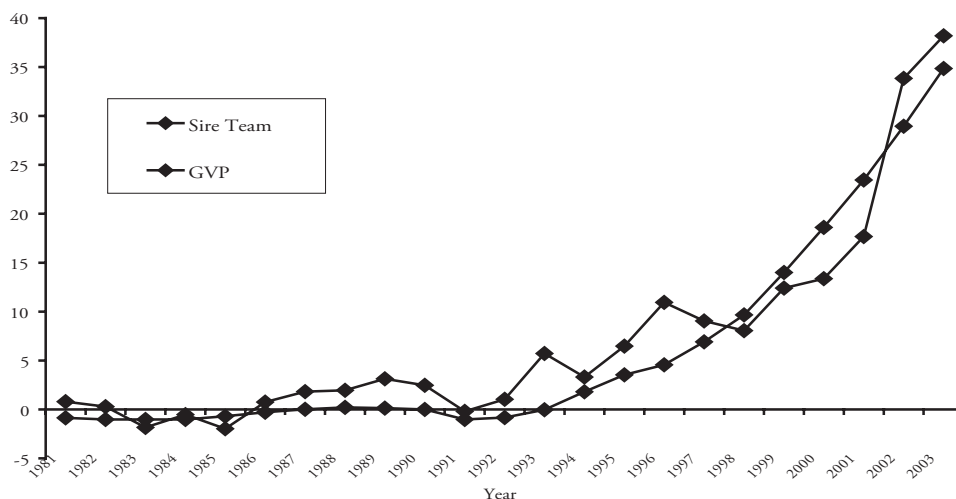


Fig. 2. The relationship between gross value of production (GVP) and terminal-sire genetic merit (Sire Team). Gross value of production is expressed as a deviation from the long-term pre-1990 average (\$335 million on-farm) and divided by 25 to scale with the genetic merit index. The sire team is the average genetic merit using the carcass plus Lambplan index of the sire team for each year and assuming that sires of lambs born in a particular year were born 1, 2 and 3 years previously.

The power of a whole-of-industry approach is illustrated by MLA's sheep-meat eating-quality program. The adoption of practices such as ageing of lamb meat for five days and processing to comply with a defined pH $\times$ temperature window (pH 6 at 18–25 °C; Thompson et al., 2005) resulted in a substantial improvement in tenderness (Fig. 3). All industry sectors are important for improvement of tenderness: to meet the pH $\times$ temperature window, producers should ensure that lambs are on a rising plane of nutrition before slaughter, processors should use electrical stimulation to manage the pH decline of meat and retailers should ensure that the product is aged. Implementation of this practice has been rapid in the past 3–5 years (Hopkins et al., 2006), which is partly due to the best-practice requirements of major Australian supermarkets.

Despite these improvements, there is a concern that the true genetic potential of carcass attributes has not been exploited because much of the increase in productivity was due to an increase in carcass weight. Continued improvement of carcass qualities can be achieved by improvements in leanness and increased muscling (Banks and Ross, 2003). Such improvements will result in more efficient on-farm production and greater meat yield for processors and retailers. We have no doubt that the lamb industry can implement further improvements, as the required genetic selection indices are available (Gardner et al., 2006). In addition, there is evidence that extra muscling also benefits meat quality and resilience of Merinos (Warner et al., 2006), indicating that there is scope for this maternal sheep breed to contribute to genetic gain for lean meat yield. This raises two issues: where will lamb, as a product, position itself in the next 10–20 years and what are the consequences of extreme selection for leanness and increased muscling?

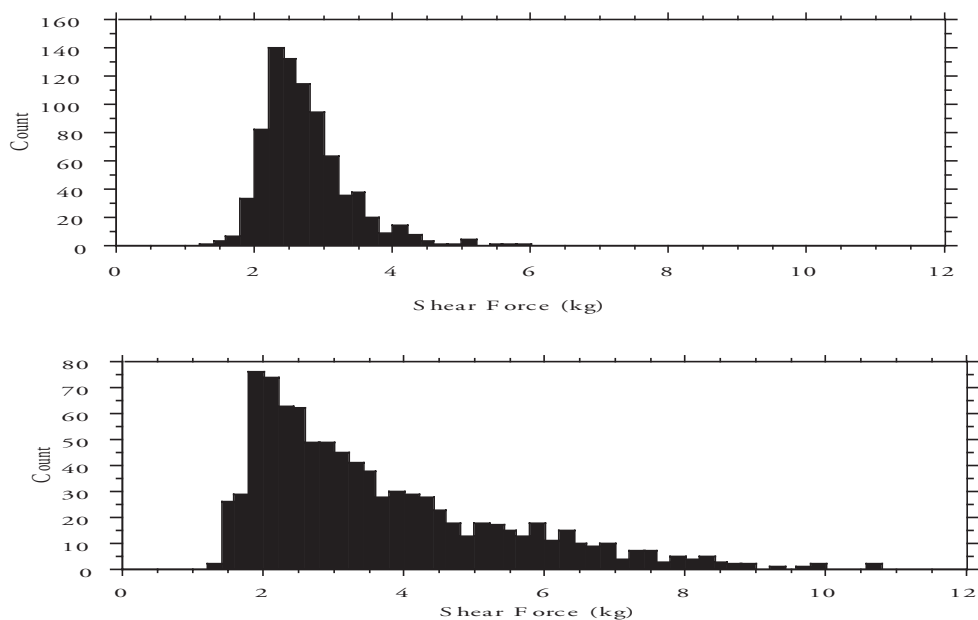


Fig. 3. Frequency distribution of lamb loin shear force that can be delivered by best practice supply chains (left, $n = 806$) compared with the same data collected for a retail audit in 1997/98 (right; from Safari et al., 2002; $n = 907$).

Muscle structure

Current research with prime lambs (Gardner et al., 2006) and other species (Pethick et al., 2005b) shows that selection for muscling can result in structural and biochemical changes to muscle. These changes result in a less aerobic muscle, less intramuscular fat and, sometimes, a reduction in tenderness (Gardner et al., 2006), all of which could affect the consumer appeal of lamb meat.

Savell and Cross (1986) concluded that the minimum ether-extractable fat content of grilling cuts for acceptable consumer satisfaction is 3% on a fresh, uncooked basis. The lamb loin currently contains about 4–5% intramuscular fat (Pethick et al., 2005a) and it is suggested that this value should be maintained in the future. To make a ‘low in fat’ claim, meat has to contain less than 3% fat (Food Standards Australia and New Zealand, 2004), but selection for less fat would have a negative effect on flavour, juiciness and cooking properties of lamb meat. However, to obtain a National Heart Foundation recommendation, a product must contain less than 10% fat, for which lamb could easily qualify. Research on intramuscular fat in beef (Pethick et al., 2005b; Pugh et al., 2005) suggests that a level of 4–5% fat could be achieved for lamb meat either by maintaining a minimum carcass fatness specification (e.g., GR tissue depth > 5 mm) or selecting for sires that show increased intramuscular fat at the expense of total carcass fatness. Pressure to reduce subcutaneous and intermuscular fat for fabrication of commercial cuts that consist of a combination of several muscles exists within the industry. Given this pressure, genetic selection for redistribution of fat towards intramuscular fat sites would be advisable.

The consequences of the association between less aerobic muscle and increased muscle yield are not entirely clear. One consequence would be a decrease in heme-iron content. Considering current health and marketing trends, this would have a negative effect in the long-term (Macrae, 2004). A recent analysis of Australian lamb cuts (Williams et al., 2002) showed that the average iron content of lamb muscle across the carcass is 2.2 mg per 100 g (range: 1.5–3.1 mg per 100 g). The current requirement for a claim that lamb is a ‘good source of iron’ (i.e., 25% of the recommended daily

intake of iron, averaged over both sexes, from one 135 g serving of lean lamb) is equivalent to an iron content of 2.2 mg per 100 g (Food Standards Australia and New Zealand, 2004). Given that the recommended daily intake of iron is even higher for premenopausal women, we suggest that the lamb industry should adopt selection programs that increase the iron content of meat and avoid those that decrease it.

Relationships between other nutrients and the aerobic capacity of muscle that contribute to the difference in the nutrient profile of red meats compared to pork or chicken (Cobiac and Syrette, 2000) are likely to apply to lamb. Data collected for MLA (Williams et al., 2002) were used to correlate the muscle contents of iron and zinc with that of other nutrients (Table 1). Interestingly, there was no correlation between iron and zinc, and the correlations between iron and other nutrients varied considerably. These data are based on a small subset of lamb cuts from animals of undefined genetics, age and nutritional background. Further work is needed on the impact of selection and management for increasing iron content of meat on concentrations of other nutrients. There is some evidence that the iron content of meat is linked to eating quality, as assessed by taste panels (Maltin et al., 2000) and that oxidative fibre type in muscle is correlated with tenderness.

Table 1. Correlation (r^2) between iron and zinc content and other nutrients in lean lamb meat (ns: non-significant). Calculated using data from Williams et al. (2002).

	Selenium	Thiamine	Riboflavin	Pyridoxine	Alpha-tocopherol	Vitamin B ₁₂	Niacin
Iron	0.56 ($P < 0.001$)	0.35 ($P = 0.015$)	0.18 ($P = 0.1$)	-0.38 ($P = 0.11$)	-0.54 ($P = 0.002$)	ns	ns
Zinc	ns	ns	ns	ns	ns	0.25 ($P = 0.06$)	-0.56 ($P < 0.001$)

Not all aspects of meat colour are associated with positive attributes of meat quality. Metmyoglobin is associated with browning of meat and represents a large financial loss for the retail sector as brown meat is heavily discounted because of consumer resistance. One factor that determines the rate of metmyoglobin formation is post-mortem oxygen consumption of meat, which is greater in aerobic muscle (Trout, 2002). Thus, studies on changes in the aerobic capacity of muscle should take metmyoglobin formation into account. A positive outcome of this interaction is that management and genetic factors that reduce metmyoglobin formation are likely to increase the antioxidant status of lamb (e.g., selenium, glutathione and vitamin E content) and hence contribute to human health claims.

Adipose tissue and fat

Fat composition has been a topical issue for some time. Most research has focused on the deleterious consequences of diets high in saturated fatty acids (Enser et al., 1998; Dewhurst et al., 2003), a feature of ruminant depot fats (Cobiac and Serette, 2000). Data collected for MLA (Williams et al., 2002) show that the saturated fat content of lean lamb meat across the carcass is 2.4 g per 100 g (range: 1.5–4.4 g per 100 g). The 'low in saturated fat' claim is associated with a saturated fat content of 1.5 g per 100 g (Food Standards Australia and New Zealand, 2004). The lamb meat industry may consider aiming for this level.

The other major fatty acids of consumer interest are the long-chain omega-3 fatty acids, eicosapentaenoic acid (EPA) and docosahexanoic acid (DHA). These fatty acids occur in high concentrations in fish and have been associated with many health claims (Macrae, 2004). The

threshold values for making claims of 'a source of omega-3 fatty acids' and of a 'good source of omega-3 fatty acids' are 30 mg per 100 g and 45 mg per 100 g, respectively (Food Standards Australia and New Zealand, 2004). MLA data on lamb meat composition (Williams et al., 2002) show that the content of EPA plus DHA in Australian lamb meat is 35 mg per 100 g (range: 21–60 mg per 100 g). The majority of cuts contain more than 30 mg per 100 g, which indicates that lamb may be 'a source' of EPA and DHA as defined by Food Standards Australia and New Zealand (2004). Lamb also has high levels of docosapentaenoic acid (34–68 mg per 100 g), an omega-3 fatty acid that is not currently included in the definition of an omega-3 claim. However, further research may change this definition.

Manipulation of the fatty acid profiles of lamb and beef meat has been reviewed elsewhere (Dewhurst et al., 2003; Durand et al., 2005). Dietary strategies are effective but typically involve feeding expensive ingredients (fish oil, various oil-seed products and formaldehyde-protected oils) and are not economic. However, the role of forage as a source of the long-chain omega-3 precursor, linolenic acid, offers an exciting opportunity for lamb (Dewhurst et al., 2003). Lamb meat is derived from animals that are typically less than 12 months old; under dry conditions, even prime lambs spend much of their life grazing. More research is needed to understand the role of forage as actively growing pasture or as conserved hay or silage in the long-chain omega-3 fatty acid content of lamb meat.

The contribution of genetic improvement to changing the fat composition of lamb has been underestimated. Research with Japanese Black cattle identified an association between a polymorphism in the gene coding for delta 9 desaturase (also called stearoyl-CoA desaturase) and the monounsaturated fatty acid content of beef fat (Taniguchi et al., 2004). Selection at this axis would offer a cost-effective solution for lowering the saturated fat content of Australian lamb. The potential of genetic selection to increase the content of long-chain omega-3 fatty acids has not been explored. Pathways for fatty acid elongation and higher-level desaturation (delta 6, 5 and 4 desaturases) represent key rate-limiting steps for the conversion of linolenic acid into EPA and DHA. Future quantitative genetic and genomic selection studies will shed light on the potential for selection at this axis.

A feature of the fat in lamb and mutton that deserves further attention concerns factors that determine the accumulation of branched-chain methyl fatty acids, which are associated with an unpleasant cooking odour (Prescott et al., 2001). Australian researchers have developed an assay for these fatty acids, which should be included as key elements in future lamb meat research (Warner et al., 2006).

Conclusions

We suggest that the path forward for the lamb industry is to develop a whole-of-industry niche-product based on consumer organoleptic qualities, nutrition and health. Production traits such as genetic potential for growth, reduced fat content and increased muscle content are important for on-farm and post-farm efficiency. Can the Australian lamb industry underpin an efficient research and development program to this end? We believe that the answer is 'yes', given the strong genetic base of Sheep Genetics Australia and the continuing commitment of lamb producers and processors to support and invest in research and development.

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