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Review

Factors affecting lamb eating quality and the potential for their integration into an MSA sheepmeat grading model

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ABSTRACT

Major efforts in the sheep industry to control eating quality have resulted in reduced product variability. Yet inconsistent eating quality for consumers remains, due to a degree of inaccurate representation of cut quality. Eating quality defined through a complex interplay of different factors can be predicted for individual cuts, and Meat Standards Australia (MSA) grading schemes have been developed to achieve these defined quality outcomes. This review outlines the justifications to refine the current sheepmeat MSA pathways system to transition into a cuts-based prediction model and details some of the factors affecting sheepmeat eating quality as key factors under consideration into the new model. The development of the new sheepmeat MSA prediction model will allow for more efficient carcass sorting to underpin a value based payment system throughout the supply chain. However it requires the inclusion of individual carcass yield and eating quality measurements (i.e. IMF). Furthermore, the adoption challenges internationally of an MSA like model are discussed.

1. Introduction

With the global population on the rise, currently estimated at 7.5 billion (The World Bank, 2017), sustainable food security systems have been a major topic of interest. This, in line with specific market and consumer demands creates a challenge for the agricultural sector as a whole, and has put pressure on the red meat industry to maintain productivity gains and stay competitive against other protein sources. The Australian sheep and beef sectors are highly export driven with 57% and 68% of total lamb (worth AUD$1.9 billion) and beef (worth AUD$7.1 billion) production being exported worldwide in 2016–17 (Meat and Livestock Australia, 2017a,b). Thus given its value and volume, it is inevitable that international market requirements and consumer expectations will need to be met to maintain product confidence and to ensure continued demand.

Reasons for global decline in red meat consumption are multifactorial, and vary between countries and different consumer groups. The increase worldwide in obesity and associated diseases has no doubt resulted in dietary changes and new food trends (Binnie, Barlow, Johnson, & Harrison, 2014). Consumers are seeking healthier food options, aiming to eat more natural, fresh and unprocessed foods (Food Chats, 2016). In some cases, these changes in food consumption patterns have also been influenced by perhaps different restrictive dietary advice to reduce red meat consumption despite red meat intake levels being within dietary recommendations (Binnie et al., 2014). Furthermore, the environmental impact of food production has no doubt stimulated different consumer choices (Westhoek et al., 2011, 2014). Additionally, the price per kg for beef and lamb is much higher than other protein sources thus affecting demand and placing pressure on industry to deliver not just consumer value but also consistent and predictable quality to maintain consumer trust. Collectively, these factors along with inconsistency in eating quality, are regarded as major issues contributing to the global beef and sheepmeat consumption decline (Henchion, McCarthy, Resconi, & Troy, 2014; Miller, Carr, Ramsey, Crockett, & Hoover, 2001; Russell, McAlister, Ross, & Pethick, 2005). Irrespective of these consumption levels, it is well established that consumers demand good nutritional attributes, high animal welfare standards, value for money and consistent eating quality (Henchion et al., 2014; Pethick, Ball, Banks, & Hocquette, 2011; Pethick, Banks, Hales, & Ross, 2006). Hence consumer focused research is highly important to underpin future demand for red meat, particularly for beef, and sheepmeat.

Eating quality in terms of sensory perception is one of the key factors influencing red meat demand, determining and reinforcing the consumer's food choice and repeat purchase behaviour (Grunert, Bredahl, & Brunsø, 2004; Henchion et al., 2014; Pethick et al., 2006). Providing acceptable eating quality is essential to underpin consumer demand and willingness to pay, which are key profitability drivers of

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the industry moving forward (Pethick et al., 2006). However, because eating quality is not apparent to the consumer at time of purchase, predicting eating quality before consumption is essential. Furthermore, reduced variation through improved product description according to eating quality would maintain and strengthen consumer confidence. This has been successfully demonstrated by the Meat Standards Australia (MSA) prediction model (Polkinghorne, Thompson, Watson, Gee, & Porter, 2008) particularly for beef which is aimed at delivering an eating quality guarantee to consumers at a cooked portion level. Additionally, the sheepmeat MSA pathways model aims to improve the overall eating quality of sheepmeat.

Therefore, to maintain a strong global demand for beef and lamb, the product must be tailored to meet consumer demands of good value for money, nutrition, sustainably and ethically sourced, yet maintain consistent eating quality. This review aims to provide an overview of the factors affecting consumer eating quality of lamb ranging from paddock to plate, and the need for a new sheepmeat MSA grading system. Although focussed on sheepmeat, this paper illustrates some concepts in beef where research is more extensive as a point of comparison. In particular, the review highlights the evolving development of the sheepmeat MSA system in comparison with the well-developed and published beef MSA model. Furthermore, the paper explores the possibilities to apply the MSA system internationally.

2. Factors affecting eating quality

Tenderness, juiciness, liking of flavour and overall liking are all important quality determinants of sensory perception of meat. Several studies in both lamb and beef have described the influence of genetic and production factors on sensory attributes. The complex interplay between these production, genotypic and environmental factors contribute to the phenotypic variation in meat eating quality. Many of the findings from these studies have been incorporated into the beef MSA system to predict eating quality for individual cuts under different cooking methods. In future, a similar approach is intended for sheepmeat, with the key factors under consideration discussed below.

2.1. Genotype

There are numerous studies presenting conflicting evidence regarding the impact of genotype on sensory scores. However it should be noted that many studies used small datasets contributing to the inconsistency in results and therefore should be interpreted with care. In addition, differences between the studies, such as trained or untrained consumer panels and a combination of production factors, make comparison difficult. For example, Safari, Fogarty, Ferrier, Hopkins and Gilmour (2001) found no sensory differences between progeny from three sire type groups (Maternal, Merino, and Terminal genotypes) although the study used trained panelists and cryptorchid lambs. Similarly, several other studies found no or small significant differences in eating quality between genotypes (Arsenos et al., 2002; Ellis, Webster, Merrell, & Brown, 2010; Esenbuga, Yanar, & Dayioglu, 2001). An earlier study in New Zealand, indicated more distinct flavour intensities (referred to as “foreign flavours”) and higher sensory tenderness in meat from Merino lambs compared to meat from crossbred lambs (Young, Reid, & Scales, 1993), however there was no difference in juiciness, flavour and overall acceptability of the *longissimus* muscle. Meat from UK Scottish Blackface lambs versus meat from Texel lambs had higher tenderness, stronger flavour and higher overall liking scores (Navajas et al., 2008). Furthermore, certain high muscling genotypes such as the Callipyge and Carwell mutations have shown to impact on meat quality through reductions in tenderness and intramuscular fat % (IMF) content (Duckett, Snowder, & Cockett, 2000; Jopson et al., 2001; Koohmaraie, Shackelford, Wheeler, Lonergan, & Doumit, 1995). Though it has been suggested that meat from sheep carrying the *Callipyge* mutation, can have improved eating quality, particular for the loin and leg muscle, when post-mortem tenderisation treatments such as electrical stimulation, prolonged aging and freezing prior to aging are used (Carpenter & Solomon, 1995; Duckett, Klein, Dodson, & Snowder, 1998).

Untrained consumer data within Australia has showed genotypic differences in Merino lambs having lower sensory scores (juiciness, flavour liking, and overall liking) compared to Border Leicester × Merino lambs, and Terminal first cross lambs (Hopkins, Walker, Thompson, & Pethick, 2005). Yet in contrast, a much larger study (n = 1434) by Pannier et al. (2014) found Merino sired progeny to have higher sensory scores than Terminal sired lambs (Poll Dorset, Suffolk, Texel, White Suffolk, mated with Merino or Border Leicester–Merino ewes). This was irrespective of the difference in IMF between sire types (Pannier et al., 2014; Pannier, Gardner, et al., 2014), and possibly reflected the higher selection pressure for leaner animals within the Terminal sire line resulting in unfavorable sensory effects (lowest scores) compared to Merino and Maternal sired lambs. In addition, individual sire (n = 175) variation across the three sire types (Merino, Maternal, Terminal) accounted for 10 eating quality score differences (in tenderness and overall liking on a 0-100 scale) for both the *longissimus lumborum* and *semimembranosus* muscle (Pannier, unpublished results), indicating a strong influence of sire genetics on eating quality in this large dataset. Genotypic differences are unlikely to be driven by just breed, as typically variation of traits within a breed is quite large, therefore studies that conduct sensory analysis on large numbers of progeny from many sires within and across breeds are needed to determine the genetic parameters for eating quality (Mortimer et al., 2015).

2.2. Gender

In lamb, studies across several countries have shown gender to have a small and weak influence on sensory attributes, sensory scores are generally higher for meat from female animals compared to males (Arsenos et al., 2002; Navajas et al., 2008; Pannier, Pethick, et al., 2014). Pannier, Gardner, et al. (2014) showed female lambs to have 1.8, 1.6, 0.9, 0.9 and 1.5 higher sensory scores for tenderness, juiciness, flavour, odour and overall liking respectively, in the *longissimus lumborum* muscle when compared to wether lambs. Often these sensory differences are thought to be due to IMF differences between females and males (females having more IMF) (Craigie et al., 2012; Pannier, Pethick, et al., 2014) however this was not the case in the latter study (Pannier, Gardner, et al., 2014). Similarly Navajas et al. (2008) reported a small difference between ewe and rams lambs for the *longissimus lumborum*, with ewe lambs having higher flavour and overall liking scores, although IMF was not tested. There are also a number of studies which have shown no gender difference in terms of impact on sensory attributes (Teixeira, Batista, Delfa, & Cadavez, 2005; Tejeda, Peña, & Andrés, 2008). However the datasets used were significantly smaller (e.g. n = 48 Tejeda et al. (2008); n = 72 Teixeira et al. (2005) compared to Pannier, Gardner, et al. (2014) (n = 1434) and were unlikely to be able to prove any difference because of the low power of the study due to the low animal numbers. In addition, uncastrated lambs were used in the smaller studies, likely contributing to the discrepancy in the results. Largely these results are in agreement with the view that differences between the genders on eating quality traits are less important (Dransfield, Nute, Hogg, & Walters, 1990) compared to other factors affecting eating quality (e.g. IMF) as discussed in this review. This implies that production systems producing ewe, uncastrated, and wether lambs will provide very similar products on the market in terms of eating quality.

2.3. Animal age

Eating quality is also influenced by animal age. In Australia, sheep age classification is based on teeth eruption with lambs being classified