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The effect of forage type on lamb carcass traits, meat quality and sensory traits

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ABSTRACT

The aim of this study was to evaluate the effect of different forage-types on lamb carcass, meat quality and sensory attributes. Sixty-two, White Dorper lambs finished on bladder clover, brassica, chicory + arrowleaf clover, lucerne + phalaris or lucerne, were slaughtered at a commercial abattoir. At 24 h *post-mortem*, the *m. longissimus thoracis et lumborum* (LL) was removed from the left side and sliced into three equal sub-samples, vacuum packaged and randomly assigned to ageing periods (5, 12 or 40 days) and the right side was aged for 5 days. The *m. semimembranosus* and *m. adductor femoris* were removed and, the former was then aged for 40 days. Lambs fed chicory + arrowleaf clover or lucerne had a higher dressing percentage and fat depth. Bladder clover gave the highest level of glycogen in the LL. No sensory or other meat quality trait differences were found between the treatments. In general, no treatments showed any unfavourable effect on the traits examined.

1. Introduction

Red meat in general is considered a contributor of important nutrients in the diet of humans and a valuable source of dietary protein and iron (Ponnampalam et al., 2010). Lamb diet is one of the main environmental factors which affect carcass and meat quality (Fraser & Rowarth, 1996). Diet has been shown to influence the fatty acid profiles, antioxidant properties, rate of protein synthesis, colour, flavour, tenderness and others properties of meat quality (Young, Cruickshank, MacLean, & Muir, 1994; Wood et al., 2004; Kim, Stuart, Rosenvold, & Maclennan, 2013). These effects are important as the central objective of animal industries is to produce high quality meat that meets consumer demands and expectations (Jiang et al., 2015).

Australian lamb producers often use extensive forage-based finishing systems that include irrigated, dryland, green and senesced pasture, as well as feed supplements (Ponnampalam et al., 2014). When compared with concentrate-based systems the forage-based systems are better suited to finishing lambs because of: a lower fat content (Blackburn, Snowder, & Glimp, 1991); reduced production costs (Woodward & Fernández, 1999); better use of natural resources; and provision of meat quality that better represents consumer requirements (Grunert, Bredahl, & Brunsø, 2004). However, seasonal oscillations and climatic variability can affect forage quantity, nutritional quality and availability and as consequence, affect lambs capacity to achieve their productivity potential (Nardone, Ronchi, Lacetera, Ranieri, & Bernabucci, 2010) by exhibiting slower growth rates, lower carcass weights and potentially meat with a lower nutritional value (Winichayakul et al., 2008) compared to concentrate finished animals.

Efficient forage-types must have high protein and low cellulose and hemicellulose content (Fraser & Rowarth, 1996). Novel forage types offer a way to fulfil this prerequisite (Brown, 1990; Howes, Bekhit, Burritt, & Campbell, 2015), but some forage-types may alter carcass and meat quality. Thus, identifying novel forage-types that improve lamb production and meat quality simultaneously is advantageous (Aurousseau et al., 2007). A number of previous studies which have evaluated different forage-types have attempted to address these requirements, but their value has been limited by the forage-types studied and fundamental experimental design flaws, for instance failing to sufficiently replicate treatments (e.g. Hopkins, Beattie, & Pirlot, 1995a; Hopkins, Holst, Hall, & Atkinson, 1995b). Despite these limitations there are indications that if for example lambs are finished on brasscias that this can lower sensory quality (Hopkins et al., 1995a) and there

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reports of off-flavours developing Park, Spurway, Wheeler (1972). The contention was that some novel forage types may have a detrimental effect on various meat quality traits including sensory traits. Therefore the aim of this study was, to evaluate the effect of three novel forage types (Bladder clover, Brassica, Chicory + Arrowleaf clover) in comparison to more common forages (Lucerne + Phalaris and Lucerne) on the lamb carcass, meat and eating quality traits.

2. Material and methods

2.1. Experimental design

All animal procedures were approved by the Charles Sturt University Animal Care and Ethics Committee (Protocol No. 12/101). Experimental design and treatments were described by McGrath, Sandral, Friend (2015). Briefly, weaned, mixed-sex (wether and ewe) lambs grazed replicated (3 plots per forage-type) pastures sown to bladder clover (*Trifolium spumosum* cv. Bartolo) (n = 12), hybrid forage brassica (*Brassica napus* cv. Stego) (n = 12), lucerne (*Medicago sativa* cv. SARDI 10) (n = 12), chicory (*Cichorium intybus* cv. Choice) + arrowleaf clover (*Trifolium vesiculosum* cv. Arrowtas) (n = 15) and lucerne + phalaris (*Phalaris aquatica* cv. Advanced AT) (n = 11) for 49 days from 15 of October to 2 of December 2014. The lambs were weighed initially (34.4 ± 5.6 kg) and then thereafter weekly throughout the field experiment and finally two days prior to slaughter following an overnight curfew (44.1 ± 6.4 kg) before then being returned to their assigned plots. Pluck samples were collected from pastures to reflect likely diet composition (Cook, 1964), dried at 70 °C for 48 h and tested for metabolisable energy (ME) and crude protein (CP) using NIR spectroscopy (Table 1) (CSIRO, 2007).

2.2. Slaughter

Only the lambs that had reached to the minimum live weight of 36 kg were slaughtered and they were then transported to a commercial abattoir (400 km away), where they were held in lairage overnight and slaughtered as a single group the following day. Head only stunning was used prior to slaughter and after slaughter all carcasses were exposed to a number of electrical inputs routinely used by the cooperating abattoir. These included application from a high frequency immobilisation unit, applied for 25–35 s (2000 Hz, 400 V, and a maximum current of 9 A over 7 animals, pulse width of 150 μs) and moderate frequency immobilisation (800 Hz, 300 peak volts, a constant current of 1.7 A, pulse width 150 μs) applied for 5–7 s. This was followed by low voltage electronic bleed (15 Hz, 550 peak volts, constant current of 0.8 A, pulse width 500 μs) applied for 20 s and post dressing medium voltage electrical stimulation (MVS) with a constant current 1.0 A and pulse width of 2500 μs, but variable frequency across the 6 electrodes (the frequency for electrodes 1 & 2 was set at 25 Hz, 3 & 4 at 15 Hz and 5 & 6 at 10 Hz, with 300 peak volts) applied for 30–35 s as described by Toohey, van de Ven, Thompson, Geesink, Hopkins (2013).

Table 1
Metabolisable energy (ME, MJ/kg), crude protein (CP, g/kg DM) and neutral detergent fibre (NDF, g/kg DM) of five forage types used to graze lambs. Adapted from McGrath et al. (2015).

Date	Bladder	Brassica	Chicory/arrowleaf	Lucerne/phalaris	Lucerne
ME					
October	11.2	11.0	12.5	9.6	12.8
November	9.2	8.4	11.5	8.0	11.7
December	8.4	5.6	10.4	7.7	10.8
CP					
October	19.1	22.5	30.5	19.0	29.0
November	14.4	16.3	20.2	11.9	23.8
December	16.0	10.9	16.4	18.1	22.5
NDF					
October	37.1	17.6	34.8	48.7	33.5
November	47.8	35.6	38.4	56.4	40.8
December	60.3	51.1	41.7	58.2	43.4

ME = 0.203 × DOMD − 3.001 (Packer, Clayton, & Cusack, 2011).

2.3. Carcass preparation and measurements

All carcasses were trimmed according to AUS-MEAT specifications (Anonymous, 2005). Hot carcass weight (HCW) was recorded and the depth of tissue at the GR site (the depth of muscle and fat tissue from the surface of the carcass to the lateral surface of the twelfth rib (110-mm from the midline) was measured using a GR knife. The dressing process included the removal of the pelt; evisceration; removal of the skull at the junction of the cervical vertebrae; and removal of the hooves at the carpus/metacarpus and tarsus/metatarsus joints, allowing the carcass to be hung from the Achilles tendon.

2.4. Sampling

Sample cores from the right side of the *m. longissimus thoracis et lumborum* (LL) (0.5 cm diameter) were removed from each carcass between the 12th/13th rib upon entry into the chiller (approximately 30 min *post-mortem*). These were then immediately frozen and transported in liquid nitrogen, then stored in a −80 °C freezer prior to analysis for glycogen content. The carcasses remained in the chillers (3–4 °C) for 24 h after which the topside (*m. semimembranosus*) (Product identification number HAM 5073, Anonymous, 2005) was removed from the right side and the LL was removed from the both sides (Product identification number HAM 4910, Anonymous, 2005). Measures of subcutaneous fat depth (Fat C) and muscle depth and width (EMD and EMW; LL) were taken at the 12th rib by experienced personnel using a metal ruler and these values were multiplied and the product then multiplied by 0.008 as a three component vector to give a cross sectional area estimate (EMA) (Hopkins, Gilbert, Pirlot, & Roberts, 1992). The fresh colour was measured on the LL at the 12th rib.

The boned LL and topside were transported (at 4 °C) in a portable chiller to the Centre for Red Meat and Sheep Development (NSW Department of Primary Industries, Cowra, New South Wales, Australia). All LL removed from the left side were sliced into three equal samples and vacuum packaged in gas impermeable plastic bags and then randomly assigned to ageing periods of 5, 12 or 40 days, so that each LL was represented in each period and used for measurement of water activity and colour under simulated retail display. The other side of LL was aged for 5 days and used to measurement of intramuscular fat, pH 24 h, moisture content and sarcomere length and was also used for sensory assessment. Ageing occurred under refrigeration (1.6 °C average). The topside had the *m. semimembranosus* (SM) and *m. adductor femoris* (AF) removed, the cap muscle (*m. gracillis*) was then removed from the SM. The AF muscle was used to measure moisture content and sample was stored in tubes and freeze-dried for measurement of intramuscular fat (IMF). The SM was vacuum packed, and aged (1.6 °C average) for 40 days and then frozen at −20 °C for subsequent measurement of ultimate pH, shear force, cooking loss and purge loss.

2.5. pH post-mortem and ultimate pH

The LL pH was measured at 24 h *post-mortem* (pH_{24}LL) at the 12th/13th rib site using a pH metre with temperature compensation (WP-80, TPS Pty Ltd., Brisbane, Australia) and a polypropylene spear-type gel electrode (Ionode IJ 44) calibrated using two pH buffers (pH 4.01 and pH 6.86), (Fowler, Schmidt, van de Ven, Wynn, & Hopkins, 2015).

The ultimate pH of the *m. semimembranosus* (pHuSM) was measured after 40 days of ageing. Approximately 1 g of tissue was removed from each still frozen sample, and then homogenised at 19,000 rpm for 2 bursts of 15 s (Ystral homogeniser: Series X10/25, Ystral, Germany) in 50 mL Falcon tubes containing 6 mL of buffer solution (Dransfield,