BRIEF COMMUNICATION: Carcass characteristics and meat quality of early, mid- and late-season commercial lambs

Y Ye[ab], NM Schreurs[b], PL Johnson[c], RA Corner-Thomas[b], MP Agnew[a], P Silcock[d], GT Eyres[d], G Maclennan[e] and CE Realini[a]*

[a]*AgResearch Grasslands, Tennent Drive, Palmerston North, New Zealand,* [b]Animal Science, School of Agriculture and Environment, Massey University, Private Bag 11222, Palmerston North 4442, New Zealand; [c]AgResearch Invermay, Puddle Alley, Mosgiel, New Zealand, [d]Department of Food Science, University of Otago, Dunedin, New Zealand. [e]*Alliance Group Ltd, 51 Don Street, PO Box 845, Invercargill, New Zealand*

**Corresponding author.* E-mail: carolina.realini@agresearch.co.nz

Abstract

Comparisons were made of carcass and meat quality characteristics of three groups of wether lambs (n=15/group): a composite breed slaughtered at weaning (EARLY), and at 6-8 months of age (MID) and Merino lambs slaughtered at 12 months of age (LATE). Carcass weight and eye muscle area were measured and meat quality was measured on the *Longissimus thoracis* (loin). All lambs had similar carcass weights (18.7-19.0 kg; P>0.05). Meat from LATE lambs had higher ultimate pH and intramuscular fat % (P<0.001) than EARLY and MID lambs. Loins from EARLY lambs had lower Chroma (P<0.01), higher eye muscle area (P<0.001) and shear force (P<0.05) and greater percentage of polyunsaturated fatty acids (P<0.001) than loins from MID and LATE lambs. Although statistical differences were observed in meat quality measurements, differences in absolute values suggest that the three production systems resulted in minor variation in meat quality.

Keywords: lamb; season; carcass; diet; meat quality

Introduction

In New Zealand, the majority of lambs are born between early July and late October. Lambs grow at different rates depending on the amount of milk they obtain from their mother plus other management factors such as pasture quality and quantity. A liveweight gain of 300g/day or more in lambs can be achieved if ewes are provided with a high allowance of a good quality pasture resulting in maximum milk production (Peterson et al. 2006). Target carcass weights for lambs in New Zealand are 17-21 kg to maximise value per kilogram. A faster growth rate results in lambs achieving target slaughter weight sooner however, the merino is late maturing breed and normally achieve their target slaughter weight at an older age (Wynn & Thwaites 1981).

The New Zealand sheep industry has selected for fast growing lambs for on-farm efficiency (Craigie et al. 2017). High growth rates, have been reported to have a negative effect on meat quality in pigs, beef cattle and poultry, due to changes in muscle structure and metabolism (Dransfield & Sosnicki 1998). A younger slaughter age has been associated with positive effects on meat eating quality such as tenderness (Mashele et al. 2017). New Zealand research has indicated a seasonal effect on lamb meat quality with lambs slaughtered after the winter having tougher meat (Purchas et al. 2002). A recent review of sheep meat quality concluded that a younger slaughter age has benefits on meat eating quality (Hopkins & Mortimer 2014), but few studies have been conducted using commercial lambs to validate this conclusion.

The objective of this study was to investigate the effect of New Zealand commercial production systems which, have combined effects of breed and slaughter age, on carcass and meat quality of lambs.

Material and methods

Animals

The *Longissimus thoracis* (loin) was collected from 45 commercial wether lambs from three stage-of-season groups (n=15). Stage of season was considered as EARLY, MID or LATE to reflect lambs finished at weaning, or after a short or long finishing period (for description of groups refer to Table 1).

Slaughter and sampling

Lambs were transported from three farms in Central Otago to the abattoir (Alliance Group Ltd, Lorneville, Invercargill) and were stunned, exsanguinated, electrically stimulated and dressed according to commercial procedures. EARLY and LATE lambs were slaughtered on 7th December 2017 and MID lambs were slaughtered on 1st March 2018. Half-carcasses were chilled at 4°C for 24 h before being boned out. The loin was removed with the fat-cap from the left carcass side (~40cm length). All samples were vacuum packed and chilled at -1.5°C for 21 days followed by storage at -20°C until analysis.

Carcass, meat quality and fatty acids

Hot carcass weight was recorded by the processing plant. The GR (soft-tissue depth on 12th rib at point 11cm from middle line) was estimated using the Alliance Group VIAscan® system. Lean meat colour (CIELAB Colour Minolta CR-400 D65 Illuminant, USA) and pH (Eutech Instruments, Singapore) were measured at the meat plant on the loin immediately after boning-out. Chroma and hue angle were calculated using the equations of Zhang et al. (2018).

Eye muscle area (EMA) was measured on a transverse cut of the loin at Massey University by tracing the area and subsequently measured using a planimeter (Placom

Table 1 Description of pre-slaughter factors of EARLY, MID and LATE lambs evaluated in the study.

Group	Age at slaughter (months)	Finishing diet	Breed	Farm	Distance from farm to meat plant (km)
EARLY	4	Pre-weaning[1]	Perendale × Texel, Finn, Romney	A	100
MID	6-8	Mixed Pasture[2]	Perendale × LambSupreme	B	80
LATE	12	Mixed Pasture[3]	Merino	C	250

[1] Pre-weaning: suckled and grazing diet of the mother (chicory and red clover mix).

[2] Mixed Pasture: Perennial ryegrass, red and white clover mix.

[3]Mixed Pasture: Perennial ryegrass-white clover followed by fescue, red and white clover, plantain mix during the last 2 weeks.

Table 2 Carcass, IMF (as % of total raw meat) and meat quality characteristics (mean±standard error of mean) of composite lambs slaughtered at 4 months (EARLY) or, 6-8 months (MID) and Merino lambs slaughtered at 12 months (LATE).

Characteristic	Early	Mid	Late	P
Hot carcass weight (kg)	18.8±0.15	18.7±0.10	19.0±0.23	0.465
GR (mm)	9.8±0.32^{a}	9.2±0.43^{a}	2.9±0.52^{b}	**< 0.001**
Fat depth over loin (mm)	5.4±0.51	4.8±0.55	4.4±0.64	0.558
Eye muscle area (cm^2)	13.2±0.95^{a}	9.9±0.55^{b}	10.2±0.29^{b}	**<0.001**
IMF of loin (%)	2.92±0.15^{b}	2.89±0.16^{b}	3.52±0.18^{a}	**< 0.05**
pH	5.59±0.02^{b}	5.58±0.01^{b}	5.87±0.05^{a}	**< 0.001**
Sarcomere length (μm)	1.61±0.02^{b}	1.68±0.02^{a}	1.57±0.02^{b}	**< 0.01**
Shear force (kgF)	3.56±0.41^{a}	2.53±0.12^{b}	2.72±0.18^{b}	**< 0.05**
*L**	38.72±0.75	38.04±0.39	37.04±0.87	0.244
*a**	17.56±0.35^{b}	20.28±0.41^{a}	18.54±0.45^{b}	**< 0.001**
*b**	8.06±0.26^{b}	8.14±0.27^{b}	9.19±0.44^{a}	**< 0.05**
Hue (°)	24.63±0.66^{a}	21.86±0.58^{b}	26.25±0.85^{a}	**< 0.001**
Chroma	19.34±0.37^{b}	21.86±0.45^{a}	20.72±0.55^{a}	**< 0.01**

Values within rows with different superscripts are significantly different according to Tukey posthoc test ($P < 0.05$).

KP-90N, Japan). Fat depth over the loin was measured at a point where the muscle was deepest. Sarcomere length was measured by laser diffraction (Purchas & Barton et al. 1976). Tenderness was assessed by measuring the peak force required to shear 13×13 mm cores (Schreurs et al. 2013) from the loin steak cooked in a water bath at 70°C for 90 min (Warner-Bratzler V-blade, TMS-Pilot Texture Analyzer, USA). Fatty acid concentration and intramuscular fat (IMF) were measured using a trans-methylation gas chromatography (Craigie et al. 2017). The meat quality measurements were analysed using general linear models (PROC GLM, SAS) with stage of season as the fixed effect.

Results and discussion

Carcass characteristics

Hot carcass weight and fat depth were the same ($P>0.05$) among groups (Table 2). This reflects a similar level of finishing for the lambs in the different groups, although GR was greater for the EARLY and MID lambs than for the LATE lambs ($P<0.001$). The low GR in LATE lambs indicates that these animals were lean before slaughter, which might be a reflect confounding breed and management effects.

The greater EMA for EARLY ($P<0.001$, Table 2) than LATE lambs, suggests that muscle growth was greater for the lambs slaughtered directly after weaning. It is noted that the EARLY lambs had a Texel component in their breeding and this breed is attributed with greater muscle deposition, especially in the loin area (Johnson et al. 2005). The LATE lambs had a greater IMF% than MID and EARLY lambs ($P<0.05$; Table2) which is similar to Mashele et al. (2017) who found greater IMF% in the loin of older animals. The IMF is noted to be a later developing component of the carcass (Hopkins et al. 2006) so the greater fat in older lambs confirms this physiological effect.

Meat quality

The chroma of the meat from EARLY lambs was lower than those of MID and LATE lambs ($P<0.05$, Table 2), indicating that there was less colour saturation and redness associated with the younger animals. Red meat colour intensifies as the animals get older as a consequence of increasing concentration of myoglobin (Hopkins et al. 2007). A lower redness colour value and saturation values associated with EARLY lambs in the current study is therefore, expected.

Loins from EARLY lambs had a greater shear force ($P<0.001$, Table 2) than MID and LATE lambs suggesting that the meat was tougher. Greater and faster muscle development in EARLY lambs may result in larger muscle fibres (Dransfield & Sosnicki 1998), which can be associated with tougher meat (Maltin et al. 2003). Regardless, all shear force values were below 4 kgF, indicating that, the meat was generally tender (Hopkins et al. 2006) and it is likely these low shear force results were enabled by the aging process (Mccormick et al. 1994).

The meat from LATE lambs had a higher pH than that

Table 3 Fatty acid composition (as % of total FA) in the loin of composite lambs slaughtered at 4 months (EARLY) or, 6-8 months (MID) and Merino lambs slaughtered at 12 months (LATE).

	Early	Mid	Late	P
Total SFA[1] %	47.02±0.39 [a]	44.53±0.52 [b]	47.01±0.46 [a]	**< 0.001**
Total MUFA[2] %	37.94±0.51 [c]	43.52±0.74 [b]	45.03±0.53 [a]	**< 0.001**
Total PUFA[3] %	15.05±0.40 [a]	11.95±0.74 [b]	7.95±0.32 [c]	**< 0.001**

[1] SFA = ∑ 10:0, 12:0, 14:0, 15:0, 16:0, 17:0, 18:0, 20:0, 22:0, 24:0, i-14:0, i-15:0, ai-15:0, i-16:0, i-17:0, ai-17:0.
[2] MUFA = ∑ 14:1, 16:1, 17:1, t9-18:1, t11-18:1, c9-18:1, c11-18:1, 20:1, 22:1, 24:1.
[3] PUFA = ∑ 18:2n-6, 20:4n-6, 22:2n6, 18:3n-3, 20:5n3, 22:5n3, 22:6n-3, CLAc9t11.
Values within rows with different superscripts are significantly different according to Tukey posthoc test (P < 0.05).

from MID and EARLY lambs (P<0.05, Table 2), which may have been caused by glycogen loss in the muscle due to the longer travel distance or the propensity of the Merino to loose greater amounts of muscle glycogen under pre-slaughter conditions (Hopkins & Mortimer 2014). This aspect warrants further investigation to understand if it is a breed effect rather than an age or stage of season effect. A shorter sarcomere length (P<0.01) in meat from LATE compared to MID lambs was observed, however, the sarcomere lengths were within the expected range associated with meat from electrically stimulated carcasses that are not exhibiting cold shortening.

Fatty acids

The EARLY lambs had a greater proportion of polyunsaturated fatty acid (PUFA) and lower proportion of monounsaturated fatty acid (MUFA) compared to MID and LATE lambs (P<0.001, Table 3). The PUFA percentage was lower with an older slaughter age, consistent with observation by Gabriella et al. (2015). The meat of LATE lambs had a higher proportion of MUFA and lower proportion of PUFA compared to MID lambs (P<0.001). Finishing lambs earlier at 4 months of age is associated with lower IMF% and a higher proportion of PUFAs than finishing lambs at 12 months.

Loins from EARLY lambs with similar carcass weight to those from MID and LATE production systems, may result in larger eye muscle area and higher shear force, however, the values indicate tender meat resulting in minor variation in meat quality.

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