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BRIEF COMMUNICATION: The effects of different forage types on lamb performance and meat quality

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INTRODUCTION

Meat quality is made up of a number of traits, with colour at the point of purchase, being perceived as the main indicator of freshness. The traits of aroma, flavour, succulence, and texture influence the eating experience and the probability of repurchase. A number of factors influence meat quality traits, including environmental factors such as stressors, feed type and quality and animal factors such as age, genetics and sex.

In New Zealand it is becoming more common to use a variety of forage types to finish lambs. A number of studies have investigated the impact of different forages on the quality of meat, with some studies reporting stronger flavours in lambs fed on white clover than lambs fed on ryegrass (Schreurs *et al.,* 2008) and stronger flavour of lambs fed on brassica than those fed on pasture (Hopkins *et al.,* 1995). Other studies however, have shown no differences in the flavour of lamb fed on different pasture types (Bailey *et al.,* 1994).

The aim of this study was to assess the impact of different feed treatments on lamb meat quality, given the number of different finishing options available to New Zealand farmers.

MATERIALS AND METHODS

Livestock measurements

Lambs (n=155) born in September to October 2008 were obtained at weaning from three different sources; Ceres Research Centre, Prebbleton, Canterbury (Line 1; n = 30), a commercial farm on Banks Peninsula, Canterbury (Line 2; n = 109) and the Canterbury Park Saleyards, Christchurch (Line 3; n = 16).

On 14 January 2009, all lambs were randomly allocated to one of seven pure forage treatments (Brassica ‘Goliath’ (*Brassica napus, cv* Goliath; n = 30), Brassica ‘Winfred’ (*Brassica napus, cv* Winfred; n = 29), Leaf turnip ‘Hunter’ (*Brassica rapa*, *cv* Hunter; n = 15), Radish ‘Graza’ (*Raphanus sativa, cv* Graza; n = 10), Pasture ‘commando’ (*Lolium perenne*, *cv* Commando; n = 26), Plantain ‘Tonic’ (*Plantago lanceolata*, *cv* Tonic; n = 14) and Red clover ‘Colenso’ (*Trifolium pratense, cv* Colenso; n = 31). Stocking rates for lambs pre- and/or post-weaning were reviewed weekly and additional area opened up, or removed, to ensure feed cover was maintained between 1000-1200 kg DM/ha. Feed mass and forage growth rates were determined by pasture cuts in caged areas. Lambs were slaughtered at Alliance Group Smithfield plant on the 25 February 2009.

Meat quality measurements

Carcass weight, GR depth at a point 11 cm from the midline in the region of the 12th rib and meat yield traits were measured using the Alliance Group VIAScan® system.

Two short loins (fat cap on) were collected from each animal, 24 hours after slaughter. The loins were cut in two and labelled with lamb tag and treatment. Each half loin was vacuum packed and treated one of two ways. Two half loins were chilled at -1°C for eight weeks and two other half loins being frozen at -20°C. The chilled loins were used for colour stability and pH assessments and frozen loins were used for tenderness and eating quality assessments.

To measure pH, three measurements were taken from each chilled loin using a meat probe and WTW pH330i Metre pH machine.

To measure colour stability three slices (2 cm thick) were cut from the middle of the chilled loin and were modified atmosphere packed (MAP) in trays at an oxygen to carbon dioxide ratio of 80:20. The MAP packed loins were maintained at 4°C with L*, a*, and b* colour measurements (Minolta Chromameter (CR-400)) taken from each of the slices at one, two, four and seven days. Colour deterioration was calculated by the time in days for a* to deteriorate to an unacceptable level of 16, by regressing the colour readings against time.

To measure tenderness, half of the frozen loin sample was thawed at 4°C, cooked in a 100°C water bath to an internal temperature of 75°C and allowed to cool to 2°C (Graafhius *et al.*, 1991). Peak shear force measurements (10 per sample) were taken using a MIRINZ pneumatic tenderometer.

TABLE 1: Least square means ±standard errors of liveweight gain from weaning to slaughter, hot carcass weight, VIAScan® yield data, pH and tenderness at slaughter for lambs fed seven pure forage diets prior to slaughter.

Forage diet	Sex	Liveweight gain (kg/day)	Hot carcass weight (kg)	Loin yield (kg)	Shoulder yield (kg)	Total yield (kg)	pH	Tenderness (kgF)
Brassica	Ewe	0.31 ± 0.02^{a}	17.6 ± 0.4^{a}	2.46 ± 0.04^{ab}	2.88 ± 0.03^{ac}	8.96 ± 0.11^{ac}	5.58 ± 0.01^{a}	7.9 ± 0.5^{abc}
(Goliath)	Ram	0.32 ± 0.02^{a}	17.3 ± 0.6^{ac}	2.41 ± 0.05^{a}	2.89 ± 0.04^{abc}	8.85 ± 0.14^{a}	5.61 ± 0.02^{ab}	7.1 ± 0.6^{ab}
Brassica	Ewe	0.26 ± 0.02^{g}	17.0 ± 0.5^{ace}	2.42 ± 0.04^{ad}	2.92 ± 0.04^{abc}	8.93 ± 0.12^{ad}	5.59 ± 0.01^{abd}	7.7 ± 0.5^{ab}
(Winfred)	Ram	0.28 ± 0.02^{ag}	17.7 ± 0.5^{af}	2.53 ± 0.04^{abc}	3.00 ± 0.04^{e}	9.19 ± 0.13^{ad}	9.19 ± 0.13^{ab}	6.9 ± 0.6^{ab}
Turnip	Ewe	0.06 ± 0.03^{bf}	15.8 ± 0.9^{bc}	2.49 ± 0.03^{abc}	3.03 ± 0.07^{bde}	9.24 ± 0.21^{acd}	5.64 ± 0.03^{bc}	6.7 ± 1.0^{ab}
	Ram	0.20 ± 0.02^{c}	17.8 ± 0.6^{a}	2.49 ± 0.05^{abc}	2.90 ± 0.05^{abc}	8.98 ± 0.14^{ac}	5.64 ± 0.02^{bc}	8.2 ± 0.7^{c}
Radish	Ewe	0.06 ± 0.03^{bef}	17.1 ± 0.8^{cd}	2.49 ± 0.06^{abc}	2.86 ± 0.06^{ac}	8.93 ± 0.19^{ab}	5.64 ± 0.02^{bc}	7.3 ± 1.0^{abc}
	Ram	-0.01 ± 0.03^{f}	13.9 ± 0.8^{b}	2.20 ± 0.07^{e}	2.65 ± 0.06^{d}	8.05 ± 0.20^{e}	5.68 ± 0.02^{cd}	7.3 ± 1.1^{abc}
Pasture*	Ewe	0.14 ± 0.04^{bcd}	15.4 ± 0.6^{be}	2.54 ± 0.05^{abc}	2.90 ± 0.04^{abce}	9.21 ± 0.14^{acd}	5.62 ± 0.02^{abc}	5.8 ± 1.0^{b}
	Ram	0.16 ± 0.03^{cd}	15.8 ± 0.5^{b}	2.57 ± 0.04^{bc}	2.93 ± 0.04^{abe}	9.24 ± 0.12^{bcd}	5.61 ± 0.02^{ab}	9.5 ± 0.8^{c}
Plantain	Ewe	0.13 ± 0.02^{de}	15.3 ± 0.9^{bd}	2.59 ± 0.05^{c}	2.85 ± 0.04^{ac}	9.10 ± 0.14^{acd}	5.61 ± 0.02^{ab}	7.4 ± 0.7^{ab}
	Ram	0.09 ± 0.05^{bdf}	15.1 ± 0.9^{be}	2.39 ± 0.07^{a}	2.78 ± 0.07^{cd}	8.63 ± 0.21^{d}	5.57 ± 0.03^{a}	8.1 ± 1.4^{abc}
Red clover	Ewe	0.11 ± 0.02^{bd}	15.3 ± 0.6^{b}	2.42 ± 0.05^{ad}	2.89 ± 0.04^{ac}	8.98 ± 0.14^{ad}	5.58 ± 0.02^{a}	6.8 ± 0.7^{ab}
	Ram	0.15 ± 0.02^{d}	16.8 ± 0.4^{ace}	2.47 ± 0.04^{ab}	2.87 ± 0.03^{ac}	9.01 ± 0.11^{ad}	5.66 ± 0.01^{c}	8.0 ± 0.6^{abc}

Values within columns with different superscripts are significantly different ($P < 0.05$).

TABLE 2: Least square means ±standard errors of brightness and redness colour measurements of meat following slaughter from lambs fed seven pure forage diets prior to slaughter.

Forage diet	Brightness (L*)	Redness (a*)				Deterioration (days)
	After 1 day	After 1 day	After 2 days	After 4 days	After 7 days	
Brassica (Goliath)	41.0 ± 0.3	20.9 ± 0.3^{ab}	20.3 ± 0.2	19.1 ± 0.2^{ab}	16.0 ± 0.4^{b}	7.2 ± 0.4^{bc}
Brassica (Winfred)	41.1 ± 0.3	21.1 ± 0.3^{ab}	20.2 ± 0.2	18.8 ± 0.2^{b}	15.5 ± 0.4^{b}	6.5 ± 0.4^{c}
Turnip	40.8 ± 0.4	21.2 ± 0.4^{ab}	20.5 ± 0.3	19.1 ± 0.3^{ab}	15.9 ± 0.6^{b}	6.4 ± 0.5^{abc}
Radish	41.5 ± 0.6	20.7 ± 0.5^{a}	20.7 ± 0.4	19.3 ± 0.4^{ab}	15.8 ± 0.7^{b}	7.1 ± 0.6^{bc}
Pasture	41.4 ± 0.5	21.1 ± 0.3^{ab}	20.2 ± 0.2	19.0 ± 0.2^{b}	15.3 ± 0.4^{b}	7.0 ± 0.4^{bc}
Plantain	41.6 ± 0.5	22.2 ± 0.4^{b}	21.3 ± 0.3	19.7 ± 0.4^{a}	16.4 ± 0.6^{b}	7.6 ± 0.6^{b}
Red clover	40.8 ± 0.4	21.3 ± 0.3^{ab}	20.5 ± 0.2	19.0 ± 0.2^{b}	13.2 ± 0.4^{a}	5.4 ± 0.4^{a}

Values within columns with different superscripts are significantly different ($P < 0.05$).

To measure eating quality, half of the frozen loin was thawed over night and cooked on a hot plate; the meat side was cooked for six minutes, then the fat side for six minutes. The loin was cut into 2 cm^2 cubes and delivered to a trained taste panel of New Zealanders to quantitatively assess aroma, flavour, texture, succulence and overall liking. Panellists assessed each sample using a scale from one (poor) to nine (excellent).

Statistical analysis

Liveweight gain, hot carcass weight, GRdepth, leg, loin, shoulder and total yield, pH and tenderness were analysed using general linear model (PROC GLM; SAS). Colour measurements taken over time were analysed using a repeated measure analysis (PROC GLM; SAS). Taste panel traits were analysed using general linear models (PROC GLM, SAS). Individual panellist scores for each individual trait were averaged for analysis.

For all analyses, fixed effects of forage treatment, lamb sex and line were included. The forage treatments were not balanced for line, therefore only interactions between forage treatment and sex were tested for significance. Non-significant interactions were removed from the final analysis of each trait. Linear effects of hot carcass weight were fitted as a covariate in yield traits and pH models, and linear effects of hot carcass weight, GR and linear and quadratic effects of pH were fitted as covariates in the tenderness model.

RESULTS AND DISCUSSION

Forage treatment and lamb sex had a significant effect on the lamb performance traits mentioned in Table 1 ($P < 0.05$). Overall, lambs grazed on Brassica had greater liveweight gains than lambs grazed on other forage treatments ($P < 0.05$). Ram lambs fed on the Radish treatment only maintained their weight, whereas lambs fed on Turnip, Pasture, Plantain and Red clover were intermediate between the lambs fed Brassica and Radish treatment diets. Forage treatment had an effect on leg yield (Goliath, 3.6 ± 0.05 kg; Winfred, 3.6 ± 0.05 kg; Turnip, 3.6 ± 0.06 kg; Radish, 3.6 ± 0.05 kg; Pasture, 3.8 ± 0.05 kg; Plantain, 3.6 ± 0.06 kg; Red clover, 3.7 ± 0.05 kg;) and no effect on GR.

All loins were within a desirable pH range of 5.4-5.8, with only eight lambs having a pH ≥ 5.8. There was a significant interaction between forage treatment and sex ($P < 0.05$). Ram lambs grazed on Radish had lower pH than ewe lambs grazed on the same treatment, where ewe lambs grazed on Red clover had a lower pH than ram lambs grazed on the same treatment. The lambs fed on Radish in this study had lower carcass weights and the ram lambs on the Radish treatment lost live-weight over the course of the experiment, therefore they were probably more stressed than lambs fed on other treatments. Under-nutrition and stress are known to be causes of high pH in meat.

Lambs fed on Red clover had browner meat on Day 4 and Day 7, and deteriorated faster than lambs fed on the other treatments ($P < 0.05$; Table 2). The faster deterioration of meat colour of lambs fed on Red clover was also seen in a further trial (A.W. Campbell, Unpublished data) and in beef (Richardson *et al.,* 2005). Lambs fed on forage legumes, such as red clover, have been previously reported to have a higher proportion of unsaturated to saturated fatty acids (Fraser *et al*., 2004) which may contribute to oxidative instability and consequently, faster colour degradation.

Forage treatment had no effect on the whiteness/brightness (L*) of the loin. Generally, differences in L* caused through diet are between pasture-fed and grain-fed lambs, with grain-fed lambs having whiter/brighter meat (Priolo *et al*., 2001).

There were no significant differences in meat tenderness of lambs fed any of the different forages as measured by the tenderometer. There were significant effects of liveweight gain ($P < 0.01$) and VIAScan GR ($P < 0.01$) on tenderness. For every 50 grams/day improvement in live weight gain for a lamb ($P < 0.01$), there was a 0.44 kgF increase in shear force and for every millimetre increase in VIAScan GR there was a 0.30 kgF decrease in shear force ($P < 0.001$). Relationships between meat quality and growth rate and meat yield are of interest to explore further as ram breeders place significant selection emphases on these traits.

There were no significant effects of forage treatment on any of the eating quality measurements, aroma, flavour, texture, succulence or overall acceptability. This is a positive result for encouraging the use of alternate forage crops and pasture by New Zealand farmers.

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