

## New Zealand Society of Animal Production online archive

This paper is from the New Zealand Society for Animal Production online archive. NZSAP holds a regular annual conference in June or July each year for the presentation of technical and applied topics in animal production. NZSAP plays an important role as a forum fostering research in all areas of animal production including production systems, nutrition, meat science, animal welfare, wool science, animal breeding and genetics.

An invitation is extended to all those involved in the field of animal production to apply for membership of the New Zealand Society of Animal Production at our website [www.nzsap.org.nz](http://www.nzsap.org.nz)

[View All Proceedings](#)

[Next Conference](#)

[Join NZSAP](#)

The New Zealand Society of Animal Production in publishing the conference proceedings is engaged in disseminating information, not rendering professional advice or services. The views expressed herein do not necessarily represent the views of the New Zealand Society of Animal Production and the New Zealand Society of Animal Production expressly disclaims any form of liability with respect to anything done or omitted to be done in reliance upon the contents of these proceedings.

This work is licensed under a [Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License](https://creativecommons.org/licenses/by-nc-nd/4.0/).



You are free to:

**Share**— copy and redistribute the material in any medium or format

Under the following terms:

**Attribution** — You must give [appropriate credit](#), provide a link to the license, and [indicate if changes were made](#). You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.

**NonCommercial** — You may not use the material for [commercial purposes](#).

**NoDerivatives** — If you [remix, transform, or build upon](#) the material, you may not distribute the modified material.

<http://creativecommons.org.nz/licences/licences-explained/>

## BRIEF COMMUNICATION: Impacts of different forages and packaging conditions on colour and lipid oxidation stability of lamb loins

YHB Kim<sup>a\*</sup>, AD Stuart<sup>a</sup>, K Rosenvold<sup>a</sup> and G Maclennan<sup>b</sup>

<sup>a</sup>AgResearch Ruakura, Private Bag 3123, Hamilton 3240, New Zealand; <sup>b</sup>Alliance Group Limited, PO Box 845, Invercargill 9840, New Zealand

\*Correspondence author. Email: brad.kim@agresearch.co.nz

**Keywords:** lamb meat colour; forage types; modified atmosphere packaging

### Introduction

Fresh meat colour is one of the most important quality attributes that affects the consumer's meat purchasing decisions (Renner & Labas 1987). A number of factors such as feed type, animal breed, age, sex, display and packaging conditions influence the rate of metmyoglobin formation. Metmyoglobin is the pigment responsible for brown colour on meat surface during retail display (Kim & Hunt 2011).

A pasture-based diet system is central to the economic sustainability of the New Zealand sheep industry. New Zealand sheep farmers are increasingly interested in using alternative forages to improve lamb performance. Diet type can greatly influence meat quality attributes by affecting antioxidant properties, fatty acid profiles and/or the rate of protein synthesis/degradation, which subsequently impact on meat colour, flavour and tenderness (Koochmaraie et al. 2002; Wood et al. 2004). However, there is limited information available regarding the effects of forage types on meat quality and chemical characteristics of long-term chilled lamb meat. The effects of different pasture forages on myoglobin and lipid oxidation stabilities of long term chilled meat under different retail packaging systems have yet to be evaluated. The objective of this study was to determine effects of different forages and two modified atmosphere packaging (MAP) systems (HiOx-MAP: 80%O<sub>2</sub>/20%CO<sub>2</sub> and CO<sub>2</sub>-MAP: 20%CO<sub>2</sub>/80%N<sub>2</sub>) on colour and lipid oxidation stabilities of long-term chilled lamb loins during retail display.

### Materials and methods

A group of 124, 14-week-old lambs were randomly assigned to seven different pasture-feeding regimes for 12 weeks prior to slaughter. These were Ryegrass 'Commando' (*Lolium perenne*, cv Commando) (n = 18), Lucerne (*Medicago sativa* L.) (n = 18), Chicory (*Cichorium intubus*, cv Puna) (n = 19), Plantain 'Tonic' (*Plantago lanceolata*, cv Tonic) (n = 16) and Red clover 'Colenso' (*Trifolium pratense*, cv Colenso). There were three red clover grazing treatments; grazed on red clover up to slaughter (Clover 12) (n = 18); grazed on red clover for 11 weeks and then on pasture for one week before slaughter (Clover 11 + P) (n = 17) and grazed on red clover for nine weeks and then on pasture for three

weeks before slaughter (Clover 9 + 3P) (n = 18). Lambs were rotationally grazed within their allocated forage regimes across four breaks and spending seven days in each break with a 21 day return period. Stocking rates were set to achieve an intake of 2.1 kg DM/lamb/day. The day after slaughter both loins (*M. longissimus dorsi*) were excised from each carcass, vacuum-packed and stored at -1.5°C for nine weeks. After storage, four chops were cut from the loins of each side, randomly allocated either to HiOx-MAP or CO<sub>2</sub>-MAP, and displayed for seven days at 4°C under continuous fluorescent light.

After nine weeks of storage, the pH was measured in duplicate by inserting a calibrated pH probe (Testo 205 pH meter, Lenzkirch, Germany) directly into the meat. The gas composition was monitored by using a headspace oxygen/carbon dioxide analyzer (PBI Dansensor, Glen Rock, NJ, USA) confirming that a high-oxygen level (>70% O<sub>2</sub>) for HiOx-MAP and a low-oxygen level (0.04% O<sub>2</sub>) for CO<sub>2</sub>-MAP were maintained during the display period.

Instrumental colour (CIE L\*a\*b\*) was measured using a Minolta Chromameter (CR-300) and sensory colour evaluations (AMSA 1991) were undertaken by a trained panel (n = 12). After the initial (Day 1; HiOx-MAP only) and end of the display period (Day 7; both HiOx-MAP and CO<sub>2</sub>-MAP), the extent of lipid oxidation was determined according to the method of Kim et al. (2009).

The experimental design was a split plot where the whole plot was the animals used to determine the feeding regimes, and the sub-plots were the loins for the packaging systems (HiOx-MAP/CO<sub>2</sub>-MAP) and the display days with a random assignment. The data were analysed using the ANOVA directive of GenStat (Payne et al. 2009). The lipid oxidation data were log transformed for analysis.

### Results and discussion

Although there were significant differences in pH of the loin samples among forage treatments after 9 weeks of storage (Table 1), the differences were less than (or equal to) 0.1 pH unit. This was not considered likely to be a major factor influencing physical and/or chemical attributes of lamb meat.

The a\* values (redness) were significantly influenced by different forage types and retail packaging systems during display. At Day 1, the

**Table 1** Effects of feeding forages for 12 weeks pre slaughter and retail packaging systems on pH, colour stability and lipid oxidation of chilled loins stored for nine weeks at -1.5°C and displayed for seven days at 4°C. The packaging systems were a high-oxygen modified atmosphere package (80% O<sub>2</sub>, 20% CO<sub>2</sub>) (HiOx-MAP), and a predominant-carbon dioxide modified atmosphere package (20% CO<sub>2</sub>, 80% N<sub>2</sub>) (CO<sub>2</sub>-MAP). Traits for loins packaged under CO<sub>2</sub>-MAP were only determined at Day 7. Discolouration was measured on a seven point scale where 1 = No discolouration, 4 = Modest discolouration and 7 = Total discolouration (American Meat Science Association 1991). Lipid oxidation was measured as a thiobarbituric acid reactive substance, namely mg malondialdehyde (MDA)/kg meat. Red clover 12 = Grazed on red clover up to slaughter; Red clover 11 + P = Grazed on red clover for 11 weeks and then on pasture for one week before slaughter; Red clover 9 + 3P = Grazed on red clover for nine weeks and then on pasture for three weeks on pasture before slaughter.

Trait	Package	Day	Forage						P value (Package x Forage)	Standard error of difference	
			Ryegrass	Lucerne	Chicory	Plantain	Red clover				
							12	11 + P			9 + 3P
Number of lambs			18	18	19	16	18	17	18		
pH			5.80 <sup>b</sup>	5.73 <sup>a</sup>	5.68 <sup>a</sup>	5.71 <sup>a</sup>	5.74 <sup>ab</sup>	5.79 <sup>b</sup>	5.80 <sup>b</sup>	<0.001	0.03
a* (Redness)	HiOx-MAP	1	25.7 <sup>b</sup>	24.8 <sup>a</sup>	25.4 <sup>a</sup>	25.5 <sup>b</sup>	27.0 <sup>c</sup>	27.1 <sup>c</sup>	27.5 <sup>c</sup>	<0.001	0.35
		4	17.1 <sup>e</sup>	10.9 <sup>a</sup>	12.8 <sup>b</sup>	17.5 <sup>e</sup>	14.0 <sup>c</sup>	14.4 <sup>c</sup>	15.3 <sup>d</sup>		
		7	9.5 <sup>d</sup>	6.3 <sup>a</sup>	6.5 <sup>a</sup>	8.6 <sup>c</sup>	7.4 <sup>b</sup>	7.3 <sup>b</sup>	7.5 <sup>b</sup>		
	CO <sub>2</sub> -MAP	7	22.0 <sup>b</sup>	23.2 <sup>bc</sup>	25.7 <sup>c</sup>	24.4 <sup>c</sup>	18.7 <sup>a</sup>	21.4 <sup>b</sup>	23.0 <sup>bc</sup>		
Hue angle (arc tan(b*/a*))	HiOx-MAP	1	24.5 <sup>a</sup>	25.1 <sup>a</sup>	24.9 <sup>a</sup>	25.1 <sup>a</sup>	25.4 <sup>a</sup>	24.8 <sup>a</sup>	25.0 <sup>a</sup>	<0.001	1.81
		4	28.2 <sup>a</sup>	41.9 <sup>c</sup>	36.9 <sup>b</sup>	30.3 <sup>a</sup>	35.8 <sup>b</sup>	33.1 <sup>ab</sup>	33.2 <sup>ab</sup>		
		7	43.0 <sup>a</sup>	59.0 <sup>c</sup>	59.4 <sup>c</sup>	52.0 <sup>b</sup>	55.3 <sup>b</sup>	52.8 <sup>b</sup>	53.5 <sup>b</sup>		
	CO <sub>2</sub> -MAP	7	23.3 <sup>a</sup>	23.7 <sup>a</sup>	23.9 <sup>a</sup>	23.4 <sup>a</sup>	31.8 <sup>b</sup>	26.6 <sup>a</sup>	22.5 <sup>a</sup>		
Discolouration	HiOx-MAP	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	<0.001	0.52
		4	3.2 <sup>ab</sup>	5.7 <sup>c</sup>	5.2 <sup>c</sup>	3.0 <sup>a</sup>	4.6 <sup>bc</sup>	4.4 <sup>bc</sup>	4.1 <sup>b</sup>		
		7	6.3	6.9	6.9	6.4	6.8	6.7	6.7		
	CO <sub>2</sub> -MAP	7	2.7 <sup>c</sup>	1.6 <sup>b</sup>	1.1 <sup>a</sup>	1.1 <sup>a</sup>	4.2 <sup>e</sup>	3.2 <sup>cd</sup>	2.9 <sup>e</sup>		
Lipid oxidation (mg MDA/kg meat)	HiOx-MAP	1	0.3 <sup>a</sup>	0.6 <sup>b</sup>	0.4 <sup>ab</sup>	0.3 <sup>a</sup>	0.6 <sup>b</sup>	0.5 <sup>ab</sup>	0.4 <sup>ab</sup>	<0.001	2.2 <sup>†</sup>
		7	0.8 <sup>c</sup>	2.3 <sup>b</sup>	2.0 <sup>b</sup>	1.8 <sup>ab</sup>	2.1 <sup>b</sup>	2.0 <sup>b</sup>	1.3 <sup>a</sup>		
	CO <sub>2</sub> -MAP	7	0.3 <sup>bc</sup>	0.5 <sup>a</sup>	0.4 <sup>ab</sup>	0.1 <sup>de</sup>	0.4 <sup>ab</sup>	0.2 <sup>c</sup>	0.05 <sup>e</sup>		

Different superscripts within a row indicates values that differ significantly (P < 0.05).

†Standard error of ratio.

loins in HiOx-MAP from lambs finished on all three Clover treatments had higher a\* values than those of the loins from lambs finished on Chicory, Plantain and Ryegrass, with Lucerne the lowest (Table 1). As display time increased, the redness of all the loins decreased with Ryegrass and Plantain appearing to have a superior colour stability followed by Clover 9 + 3P, Clover 11 + P, Clover 12, Chicory and Lucerne the least. Hue angle values and discolouration scores showed that the loins from lambs finished on Lucerne had the most discolouration closely followed by Chicory (Table 1). In contrast, the loins from lambs finished on Ryegrass appeared to have the lowest hue angle value indicating the least discolouration and thus superior colour stability.

At Day 7 the loins packaged in CO<sub>2</sub>-MAP maintained significantly higher a\* values compared with the loins in HiOx-MAP (Table 1). After opening the packages and allowing the loins to bloom for an hour, the initial purplish-red colour of the meat surface was converted to relatively bright red colour (YHB Kim, Unpublished data), which indicates that

myoglobin was capable of oxygenating after 7 days of display in CO<sub>2</sub>-MAP.

There was a significant increase in lipid oxidation of the loins under HiOx-MAP after 7 days of display (Table 1). However, the loins from lambs finished on Ryegrass had the smallest accumulation of lipid oxidation at Day 7 followed by Clover 9 + 3P, while the loins from lambs finished on Lucerne had the highest lipid oxidation accumulation at over 2 mg malondialdehyde (MDA)/kg meat. Levels of ≤ 1 mg malondialdehyde (MDA)/kg meat are considered the threshold for consumers to detect off-flavours (Jayasingh et al. 2002). These findings correspond well with the colour data in that the loins from lambs finished on Ryegrass had the least surface discolouration and the loins from lambs finished on Lucerne developed most rapid discolouration throughout the display period. This can be explained from the coupling reactions of lipid and myoglobin oxidation where free radicals generated from lipid oxidation can directly induce myoglobin oxidation forming metmyoglobin for brown discolouration (O'Grady et al. 2001; Kim et

al. 2010). Further, loins from Ryegrass grazed lambs had superior lipid and colour stabilities, in agreement with the findings by Fraser et al. (2004). They found that meat from lambs finished on Lucerne was oxidatively less stable than that from lambs finished on perennial Ryegrass. The packaging system significantly affected the lipid oxidation values of the loins at Day 7. The loins in CO<sub>2</sub>-MAP had significantly lower lipid oxidation than the ones in HiOx-MAP confirming that the ultra-low level of oxygen in the CO<sub>2</sub>-MAP maintained the least oxidative condition during display of the long-term chilled lamb loins.

## Conclusion

These results suggest that different pasture forages and retail packaging systems can result in profound impacts on lamb meat quality attributes by affecting oxidation stability (myoglobin and lipid oxidation) during retail display. Therefore, developing new packaging strategies while taking into account forage type effects on colour stability is suggested to maximize the colour shelf-life of long-term chill-stored lamb muscles.

## Acknowledgements

This project was supported by Lamb Colour Ltd. through the Meat Research Fund program. Authors wish to thank Meat Science and Technology staff at AgResearch for the sensory colour evaluation and John Waller for the statistical analysis. The appreciation is extended to the staff of Agricom for running the forage treatments.

## References

American Meat Science Association 1991. Guidelines for meat color evaluation. Proceedings of the 44th Annual Reciprocal Meat Conference. National Live Stock and Meat Board & American Meat Science Association, Manhattan, USA. Pp. 232–249.

- Fraser MD, Speijers MHM, Theobald VJ, Fychan R, Jones R 2004. Production performance and meat quality of grazing lambs finished on red clover, lucerne or perennial ryegrass swards. *Grass and Forage Science* 59: 345–356.
- Jayasingh P, Cornforth DP, Brennand CP, Carpenter CE, Whittier DR 2002. Sensory evaluation of ground beef stored in high-oxygen modified atmosphere packaging. *Journal of Food Science* 67: 3493–3496.
- Kim YH, Keeton JT, Smith SB, Maxim JE, Yang HS, Savell JW 2009. Evaluation of antioxidant capacity and colour stability of calcium lactate enhancement on fresh beef under highly oxidizing condition. *Food Chemistry* 115: 272–278.
- Kim YH, Huff-Lonergan E, Sebranek JG, Lonergan SM 2010. Effects of lactate/phosphate injection enhancement on oxidation stability and protein degradation in early postmortem beef cuts packaged in high oxygen modified atmosphere. *Meat Science* 86: 852–858.
- Kim YHB, Hunt MC 2011. Advance technology to improve meat color. In: Joo ST ed. Control of meat quality. Kerala, India, Research Signpost. Pp. 31–60.
- Koohmaraie M, Kent MP, Shackelford SD, Veiseth E, Wheeler TL 2002. Meat tenderness and muscle growth: is there any relationship? *Meat Science* 62: 345–352.
- O'Grady MN, Monahan FJ, Brunton NP 2001. Oxymyoglobin oxidation and lipid oxidation in bovine muscle - Mechanistic studies. *Journal of Food Science* 66: 386–392.
- Payne RW, Murray DA, Harding SA, Baird DB, Soutar DM 2009. GenStat for Windows, 12th Edition. Introduction. Hemel Hempstead, VSN International.
- Renerre M, Labas R 1987. Biochemical factors influencing metmyoglobin formation in beef muscles. *Meat Science* 19: 151–165.
- Wood JD, Richardson RI, Nute GR, Fisher AV, Campo MM, Kasapidou E, Sheard PR, Enser M 2004. Effects of fatty acids on meat quality: a review. *Meat Science* 66: 21–32.