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Colour and lipid stability in Australian grass and grain fed cattle

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Background

Meat colour and lipid stability are major factors limiting the quality and acceptability of meat and meat products. Lipid oxidation results in production of free radicals that may lead to the oxidation of meat pigments and the generation of rancid odours and flavours. The oxidative stability of muscle depends on a balance between the amount of anti-oxidants (α–tocopherol) and pro-oxidants (polyunsaturated fatty acids, PUFA) in the muscle. Pasture fed cattle usually has higher concentrations of PUFA and α–tocopherol than meat from grain-fed cattle. These differences may affect the susceptibility of meat towards oxidation. Crouse et al (1984) reported that meat colour from pasture and grain-fed cattle differed significantly. However, colour was determined subjectively and no information about lipid oxidation or antioxidant content in the meat.

Supplementation with supranutritional levels of vitamin E improved the oxidative stability of beef, pork and poultry (Liu et al., 1995). Although most research has been performed with grain-fed cattle the higher content of PUFA in meat from pasture-fed cattle enhance vitamin E requirements and may change the oxidative stability response towards supplementation. To implement vitamin E supplementation at an industrial level, an analysis of the interaction between feed type and vit E supplementation is warranted.

70% of the beef produced in Australia comes from grass-fed cattle therefore, a thorough understanding of the factors that regulate meat colour and lipid stability will improve the quality and acceptability of meat products and increase the profitability of the Australian meat industry.

Objectives

a) To evaluate the effect of the nutritional background (pasture vs grain feeding) on the colour and lipid stability of Australian beef and
b) To investigate the efficacy of supranutritional levels of vitamin E on improving the colour and lipid stability of pasture and grain-fed cattle

Materials and Methods

32 steers were randomly divided in 4 groups of equal number of animals. Each group was assigned to one of the following treatments during the period December to April (summer), for 126 days prior to slaughter:

a) pasture-fed with predominantly Rhodes grass and treated with either 1200 (control) or 3507 (supplemented) IU/head/day of α–tocopheryl acetate (Vitamin E), or
b) fed a sorghum-based feedlot ration, supplemented with either 260 or 2760 IU/head/day of α–tocopheryl acetate.

At 24 h post mortem, the longissimus lumborum (LL) and the gluteus medius (GM) from each carcase were removed. Cores (15 mm thick X 35 mm diam) were cut, wrapped with oxygen permeable fresh meat film and displayed for 7 days at 4°C in the dark.

α–Tocopherol concentration in the muscle was determined at day 1 post-mortem by the method of Liu et al (1996). The same technique was used for measuring α–τocopherol in the basal diet.

Meat colour (CIE L*a*b*) was obtained with a Minolta CR-200 chromameter. Metmyoglobin (MetMb) concentration was measured by reflectance spectrophotometry (Krzywicki, 1979). Development of lipid oxidation, expressed as thiobarbituric acid reactive substances (TBARS), was determined at days 0 and 7 of display by the method of Witte et al. (1970).

Data were analyzed as a split-split plot design. Colour and pigment variations over time were fitted by non-linear regression analysis.

Results and Discussion

Table 1 shows the α–tocopherol content for each muscle and treatment combination. Although supplemented pasture-fed cattle had a higher vitamin E intake than grain-fed animals, no difference ($P > 0.05$) in the α–tocopherol level of muscles was detected between control and supplemented animals. A possible explanation was that the endogenous level of α–tocopherol in the grass was high enough to saturate the muscle. In contrast, muscles from supplemented grain fed animals contained 2.9 times more tocopherol than the control muscles.. For both nutritional backgrounds and in accordance with previous publications (Lanari et al., 1996; Liu et al., 1995), the GM had a higher ($P<0.05$) α–tocopherol level than the LL

Table 1 shows TBARS values (nmol MDA/kg meat) for the different treatment combinations at day 0 and after 7 days display. The effect of vitamin E supplementation, nutritional background or muscle type on lipid stability of meat was not significant ($P>0.05$).

Figs 1 and 2 show the variations of MetMb and a* during display. For all muscle and feed types, supplementation did not improve (($P>0.05$) a* or MetMb stability so data from control and supplemented animals were pooled. The effect of nutritional background was significant ($P<0.001$) for both a* and MetMb. From day 1 to 3, MetMb formation ranked as: GM (pasture) > GM (grain) > LL (pasture) > LL (grain). From day 4 to 7, MetMb concentration in the LL (pasture) was significantly higher ($P<0.0001$) than in the LL (grain). No significant difference ($P>0.05$) was detected between GM (pasture) and GM (grain) for the same time period. From day 0 to day 3 of display, a* values were: * LL (grain) > a* GM (grain) > a* LL (pasture) ~ a* GM (pasture). From day 4 to 7, a* from grain-fed LL was still the highest ($P< 0.0001$) but no difference ($P > 0.05$) was detected between the other muscles.

Assuming that the variations of a* and MetMb concentration vs time followed first order kinetics, the following expression was derived:

$$C = C_0 * \exp(-k * t) + C_1 \quad (1)$$

Where C represent a* or MetMb at time t, C_0 and C_1 are the initial and asymptote values of C respectively, and k (day^{-1}) the rate constant. When the reaction rate was slow enough so that the asymptote levels were not attained, $C_1 = 0$. Under these conditions, the integrated solution is:

$$C = C_0 * \exp(-k * t) \quad (2)$$

Eq. (1) and Eq (2) fitted satisfactorily the a* and MetMb experimental data from grain-fed and pasture-fed cattle respectively.

Sensory determinations indicated that a* = 18 could be considered as a limit of acceptability for colour display life. Using equations (1) and (2) and the corresponding parameters for a*, it was possible to calculate the 95% of the colour display life (Table 2). Changing the feed type from pasture to grain 126 days before slaughter increased display life at least 5 days for the GM and 12 days for the LL. The difference in colour stability across muscle types was more pronounced in meat from grain-fed cattle.

Working with grain-fed LL and GM containing 5.57 and 7.18 mg/kg of α–tocopherol respectively, Liu et al (1996b) reported display lives of 8-9 days for the LL and 2-3 days for GM A comparison between our results and those from Liu et al (1996b) (Table 2). showed that even for the lowest α-tocopherol level, the colour display lives determined in the present study were at least 50% higher.

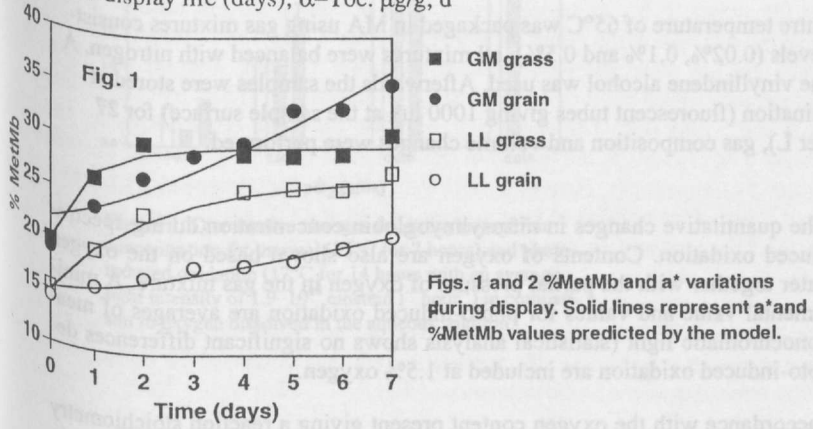
Table 1: TBARS number (nanomol MDA/kg meat and α-tocopherol content (mg/kg meat) in muscle

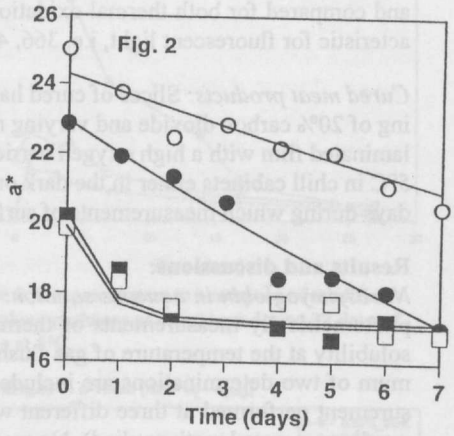
		Pasture-fed		Grain-fed	
	dt days)	TBARS	α–Toc	TBARS	α–Toc
LL control	0	0.57	4.7	0.42	1.8
	7	0.67		0.90	
LL supp	0	0.91	4.6	0.28	4.3
	7	0.67		0.86	
GM control	0	0.95	5.4	0.54	2.4
	7	0.81		1.15	
GM supp	0	0.93	5.7	0.60	6.0
	7	0.94		0.77	

Table 2: Colour display life and α–Tocopherol (mg/kg) of control © and supplemented (S) pasture and grain-fed beef.

	α–Toc (this study)	DL (this study)	α–Toc (Liu et al., 1996a)	DL (Liu et al., 1996a)
LL pasture C	4.7	0.67-0.87		
LL pasture S	4.6			
GM pasture C	5.4	0.78 – 1.35		
GM pasture S	5.7			
LL grain C	1.8	12.62 – 17.7	1.46-2.48	6
LL grain S	4.3		5.57	8-9
GM grain C	2.4	5.47- 6.12	2.08-3.09	2-3
GM grain S	6.0		7.18	2-3

DL = colour display life (days); α–Toc: µg/g; d





Figs. 1 and 2 %MetMb and a* variations during display. Solid lines represent a*and %MetMb values predicted by the model.

Changing the feed from pasture to grain improved the colour display life of beef but did not affect lipid stability.

In our experiment, the benefits in colour stability of grain-fed beef to dietary vitamin E were much higher than in previous reports (Liu et al., 1996b). This has considerable economic importance since we could reduce the cost of the treatment without impairing quality

References

Crouse, J.D., Cross, H.R. and Seideman, J. Anim. Sci. 58: (3) 619-625.

Krzywicki, K. 1979. Meat Sci. 3: 1-10.

Lanari, M.C., Schaefer, D.M., Liu, Q.P. and Cassens, R.G. 1996. J. Food Sci. 61 (5), 884-888.

Liu, Q.P. , Lanari, M.C. and Schaefer, D.M.. 1995. J. Anim. Sci. 73: 3131-3140.

Liu, Q.P., Scheller, K.K. and Schaefer, D.M. 1996a. J. Anim. Sci. 72:2406-2410.

Liu, Q.P. , Scheller, K.K., Arp, S., Schaefer, D.M. and Williams S. 1996b. J. Anim. Sci. 74:106-116

Witte, V.C., Krause, G.F. and Bayley, M.E. 1970. J.Food Sci. 35:585-588.

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