EXTENDING COLOUR LIFE OF MA PACKED BEEF BY SUPPLEMENTING FEED WITH VITAMIN E.

TAYLOR A.A.*, VEGA L.*, WOOD J.D.* and ANGOLD M.**

* Division of Food Animal Science, School of Veterinary Science, University of Bristol, Langford, Bristol, UK.
** Roche Products Ltd., Heanor Gate, Heanor, Derbyshire, UK.

S-IVA.44

SUMMARY

Supplementing feed with vitamin E has been shown to extend useful display life of overwrapped beef cuts by delaying pigment oxidation. This study examined the effect of such treatment on the colour stability of beef packed in modified atmospheres (MA). The animals used were eight barley-fed bulls, 12-13 months old and 440-480 kg live weight. Initially, four were used as controls and the other four had their concentrate diet supplemented with 2, 500 IU/animal-day of vitamin E for 40 days. At 48h after slaughter, the longissimus dorsi (LD) muscles were removed from each carcass side and individually vacuum packed. Muscles from the left sides were aged at 1°C for 7 days (LD7) and from the right sides for 21 days (LD21). At the end of these storage periods, slices from each muscle were sealed in MA packs with 70% O_2 + 30% CO_2 and stored at 4°C to simulate retail display. Every two days for up to 21 days display, packs were opened and the meat colour assessed. Using an X-Rite spectral instrument, CIE values L*, a*, b* were obtained and percentage metmyoglobin on the surface was calculated. Photographs were taken of top surfaces and sections cut through each slice to show colour and depth of oxygen penetration.

Time before metmyoglobin concentration exceeded 20% in LD7 was increased from 11 days (control) to 21 days (vit E). For LD21, the extension was from 11 days (control) to 19 days (vit E). Samples from treated animals maintained higher a* and saturation values, with lower hue values and therefore were redder for longer than controls. Vit E supplementation also reduced drip loss at the end of 7d and 21d storage and delayed fat rancidity.

Introduction

The colour life of fresh meat is of great importance in marketing, and techniques such as modified atmosphere (MA) packing are used to extend the period during which meat can be displayed attractively. Even so, the saleable life of MA packed fresh meat is limited by oxidation of the muscle pigment, myoglobin, to the unacceptable brown-grey metmyoglobin. There is therefore considerable interest in procedures which might further delay oxidation of both the muscle pigments and muscle lipids. Recent work has shown that supplementing the diet of cattle with vitamin E can extend the colour life of overwrapped fresh beef (Faustman *et al*, 1989; Mitsuru *et al*, 1991; Arnold *et al*, 1992, 1993). The rate of discolouration of beef due to oxidation can vary between breeds and between different muscles (Faustman & Cassens, 1991). Meat which is aged for longer periods, and therefore has accumulated more metmyoglobin, discolours faster than meat aged for shorter periods.

Vitamin E is absorbed and incorporated into the cellular membranes of muscle where it acts as a lipid soluble antioxidant, limiting pigment oxidation and therefore improving colour stability. The most effective form of Vitamin E for this purpose is a-tocopheryl acetate which is converted to a-tocopherol during digestion (Hidiroglow *et al.*, 1988). The present study was designed to evaluate pigment oxidation, colour characteristics and extension of colour life of MA packed beef from cattle fed on a diet supplemented with Vitamin E.

Materials and Methods

Animals - The animals used were 8 barley-fed bulls, 4 of which were Charolais cross, two Simmental cross and two Limousin cross, 12-13 months old and 440-480 kg live weight. They were divided into experimental and control groups, balanced for breed, age and weight.

Feeding - The animals were fed for 40 days before slaughter with the same pre-mixed diet, except that the diet of the experimental group was supplemented with 0.0835% a-tocopheryl acetate. Both groups were fed 3kg pre-mixed diet twice daily. The experimental animals, therefore, received 2,500 IU of vitamin E/head/day; control animals had a base level of 150 IU/head/day, due to natural level of vitamin E in the diet.

Slaughter and chilling - All the animals were slaughtered at the same time and carcasses were chilled for 48h at 1°C, after which *M. longissimus dorsi* (LD) was removed, vacuum packed and aged at 1°C. Left sides were aged for 7d and right sides for 21d.

pH - pH was measured in the LD of each carcass at 45 min, 3h and 48h post-mortem, by homogenising 1g tissue in 10ml. 5mM sodium iodoacetate solution, and measuring with a glass electrode and Radiometer pH meter.

Drip loss - A 25 mm thick slice from the middle of the LD was used for drip measurement, by suspending in a net in a polythene bag at 1°C, and weighing the exudate that accumulated in the bag after 2d and 7d.

Retail display - From each LD, 12 slices each 25 mm thick, were cut and packed in individual MA trays with 70% O_2 + 30% CO_2. Packs were stored for up to 21d at 3-5°C to simulate retail display, and one pack from each side was removed every 2 days for assessment.

Assessment of LD slices - At each assessment time, slices were removed from the MA packs and photographed under standard illumination to show changes in colour during simulated display. Slices were also sectioned and photographed to show the depth of oxygen penetration, i.e. down to the myoglobin layer.

Colour measurement - The colour of each slice was measured with an X-Rite spectral measurement instrument, determining the CIELAB coordinates L*, a*, b*. The a* and b* values were used to calculate saturation and hue. Percentage metmyoglobin on the meat surface was also measured by the reflectance spectrophotometric method (Krzywicki, 1979), based on the relation between reflectance readings at 700, 630, 572, 525 and 473 nm. A linear relationship between percent metmyoglobin and consumer perception of meat discolouration has been demonstrated by Hood & Riordan (1973) and in this experiment, accumulation of 20% metmyoglobin at the surface was considered to signify the end of colour life.

Lipid oxidation - Lipid oxidation of fresh and cooked LD was evaluated using the thiobarbituric acid tests (Tarladgis *et al.*, 1960) after 21d vacuum packed storage at 1°C. Fresh meat was measured after a further 2 and 7d storage. Cooked meat was measured after cooking to 80°C in a dry air oven and storing at 4°C for up to 7d.

Statistical analysis - Differences between control and vitamin E treated samples were analysed by a paired Student t-test, and by analysis of variance of repeated measurements using the statistical package Stats View II (1988).

Results and Discussion

Carcass characteristics of control and vitamin E treated animals were similar. Mean live weights were 491 kg (control) and 486 kg (treated); carcass weights were 292 kg and 290 kg respectively. Ultimate pH values at 48h post-slaughter were also similar at 5.77.

Table 1 shows that drip loss, measured from 48h post-slaughter, was significantly lower (< 0.05) in the vitamin E treated meat after both 2 and 7d. There was no difference in drip loss between control and treated meat after it had been aged for 7 or 21d.

Figure 1 shows the changes in colour saturation (redness) during simulated retail display of (a) 7d aged LD (LD7) and (b) 21d aged LD (LD21). With LD7, saturation of control and vitamin E treated samples did not differ significantly until 7 days, after which vitamin E meat had higher values i.e. were redder. Vitamin E samples maintained high saturation until the end of storage at 23 days, whereas controls were approaching S=20 by 13 days. With LD 21, vitamin E samples had significantly higher saturation from 3 days, and values remained high until about 13 days, after which they began to fall. Even so, they did not approach S=20 until about 19 days. By contrast, control samples deteriorated steadily and were approaching S=20 by 13 days.

Figure 2 shows the changes in colour hue (yellowness) during simulated retail display of (a) 7 day aged LD (LD7) and (b) 21 day aged LD (LD21). With LD7, vitamin E samples had significantly lower hue values than control from 11 days onwards. They remained low until the end of storage at 23 days, whereas hue values of control samples increased (became more yellow) rapidly from 11 days. With LD21, the pattern was similar, with a significant difference from 7 days. Hue values of vitamin E samples remained low until about 15 days after which they began to increase. Hue of control samples increased rapidly from 11 days.

Figure 3 shows changes in percentage of metmyoglobin on the exposed meat surfaces. Increasing levels of metmyoglobin cause loss of redness in meat and, in this study, the attractive colour life of the meat was judged to have ended when metmyoglobin reached 20% (Hood & Riordan, 1973). Metmyoglobin concentration began to differ ($P < 0.05$) between vitamin E and control samples by 7 days, always being less in the vitamin E treated meat. With LD7, controls had more than 20% metmyoglobin by 11 days and the concentration increased steadily from then. Vitamin E samples remained well below 20% throughout storage and were still less than 15% by 23 days. LD21 controls did not exceed 20% metmyoglobin until 11 days, after which the concentration increased rapidly. Vitamin E treated samples did not exceed 20% until 19 days.

All the measured colour parameters were in agreement, showing that vitamin E treatment extended the red colour life of LD by up to 10 days (7d aged) and 8 days (21d aged). Sections cut through the LD slices showed that formation of the brown metmyoglobin layer at the boundary of oxygen penetration into the meat was greatly delayed by vitamin E treatment, and oxidation of the oxymyoglobin layer responsible for the attractive red surface of meat was similarly delayed.

Table 2 shows rancidity development, indicated by TBA values, in the LD21 samples, raw and cooked. TBA values were significantly lower in the vitamin E treated raw meat after 2 days and 7 days storage at 4°C. There was however, no difference between controls and treated samples after cooking, where TBA values were generally higher and increased during storage at 4°C.

Discussion

The principal effect of vitamin E supplementation is to delay both oxidation of lean tissue colour and the fatty acids in lean and fat tissues. A secondary effect, reduction of drip loss, has been reported before (Asghar *et al.*, 1991). During a 7 day storage period, beef LD from vitamin E treated cattle, lost 42% less drip than untreated controls. The advantage was not carried through however, to 21 day aged meat.

The dramatic effects on tissue oxidation seen here were achieved after only 40 days of feeding a diet providing 2500 IU vitamin E/day. The critical factor at the tissue level is presumably the concentration of a-tocopherol. Mitsuru *et al.* (1991) suggest that this is
3.5 mg/kg muscle tissue.

All colour measurements made showed that the supplemented cattle produced beef which was redder during storage than beef from untreated controls and maintained superior redness for longer. The improvement in colour stability apparently arose in two ways. Firstly, treatment with vitamin E delayed, for many days, the formation of the metmyoglobin layer which forms at the limit of oxygen penetration into meat. This meant that there was no danger of this discoloured layer breaking through to the surface. Secondly, the thick oxymyoglobin surface layer which gives MA packed meat its long colour life, did not gradually oxidise as it does in untreated meat. The combination of these two effects meant that the two reactions which limit colour life of meat in modified atmospheres were effectively blocked for a prolonged period. As colour life is extended, it is no longer the limiting factor to useful display life, and the development of off-odours and flavours from lipid oxidation becomes more important. By retarding this oxidation vitamin E treatment makes an important contribution in prolonging the saleable life of MA packed beef.

Conclusions

Feeding beef animals with 2,500 IU of a-tocopheryl acetate for 40 days prolonged the colour life of MA packed fresh and aged beef. Vitamin E treated, 7 day aged LD slices retained their attractive red colour for 21 days compared with 11 days for untreated controls; for 21 day aged LD the improvement was from 11 days to 19 days. This was due to the antioxidant effect of vitamin E retained in the muscle, delaying oxidation of oxymyoglobin to metmyoglobin. Vitamin E supplementation also retarded lipid oxidation in raw beef, an additional factor in prolonging useful display life. The treatment also considerably reduced drip loss from fresh meat. The longer life which MA packing gives to fresh meat can therefore be extended even further by vitamin supplementation.

References

Arnold, R.N., Arp, S.C., Scheller, K.K., Williams, S.N. and Schaefer, D.M. (1993). Dietary a-tocopheryl acetate enhances beef quality in Holstein and beef steers J. Food Sci., 58, (1) 28-33.

Arnold, R.N., Arp, S.C., Scheller, K.K., Williams, S.N., Schaefer, D.M., and Buege, D.R. (1992). Effect of long- or short-term feeding of a-tocopheryl acetate to Holstein and crossbreed beef steers on performance, carcass characteristics and beef color stability. J. Anim. Sci., 70, 3055-3065.

Faustman, C. and Cassens, R.G. (1991). The effect of cattle breed and muscle type on discoloration and various biochemical parameters in fresh beef. J. Anim Sci., 69, 184-193.

Faustman, C., Cassens, R.G., Schaefer, D.M., Buege, D.R., Scheller, K.K. and Williams, S.N. (1989). Improvement of pigment and lipid stability in Holstein steer beef by dietary supplementation with vitamin E. J. Food Sci., 54 (4) 858-862.

Hidiroglou, N. Lafflame, L.F. and McDowell, L.R. (1988). Blood plasma and tissue concentrations of vitamin E in beef cattle as influenced by supplementation of various tocopherol compounds. J. Amer. Oil Chem. Soc., 37, 44-48.

Hood, D.E. & Riordan, E.B. (1973). Discoloration in pre-packed beef measured by reflectance spectrophotometry and shopper discrimination. J. Fd. Technol., 8, 333-343.

Kryzywicki, K. (1979). Assessment of relative content of myoglobin, oxymyoglobin and metmyoglobin at the surface of beef. Meat Sci., 3, 1-10.

Mitsuru, M., Cassens, R.G., Schaefer, D.M., Arnold, R.N. and Scheller, K.K. (1991). Improvement of color and lipid stability in beef longissimus with dietary vitamin E and vitamin C dip treatment. J. Food Sci., 6, 1489-1492.

Tarladgis, B.G., Watts, B.M., Younathan, M.T. and Dugan, L.R., (196). A distillation method for the quantitative determination of malonaldehyde in rancid foods. J. Amer. Oil Chem. Soc. 37, 44-48.