EFFECT OF DIETARY VITAMIN E AND/OR ORGANIC SELENIUM SUPPLEMENTATION ON THE OXIDATIVE STABILITY OF BEEF

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BACKGROUND

Oxidation reactions are a major cause of deterioration in meat quality and adversely affect attributes such as colour, flavour and nutritive value (Pearson et al., 1983). The oxidation reactions that occur in muscle post slaughter can be accelerated by processing factors such as mincing, freeze-thawing and exposure to high oxygen atmospheres or ultra-violet light. Dietary components are known to affect the susceptibility of muscle components to oxidise and can thereby influence meat quality (Monahan, 1995). Dietary lipids, for example, can influence the fatty acid profiles of muscle lipids and the susceptibility of these lipids to oxidise (Larick and Turner, 1989). Pro-oxidant components in the diet can increase susceptibility of muscle to oxidation (Kanner et al., 1990). On the other hand, antioxidants of dietary origin can increase the oxidative stability of muscle with beneficial effects on flavour and colour and the effect of dietary vitamin E on the oxidative stability of muscle is well established across a variety of species (Buckley et al., 1989; Faustman et al., 1989). Muscle Se levels have been shown to respond to dietary Se (DeVore et al., 1983; Ekholm et al., 1990) and the Se-dependent enzyme glutathione peroxidase (Se-GSH-Px) functions as an antioxidant, converting lipid peroxides into less reactive products.

OBJECTIVE

The objective of the present study was to investigate the effects of vitamin E and Se in beef animal diets on muscle vitamin E and glutathione peroxidase activity and on the oxidative stability of beef.

METHODS

Animals and diets. 28 beef animals were randomly divided into 4 groups of 7 and assigned to one of 4 diets for 55 days before slaughter. The dietary treatments were as follows: group A received a control diet consisting of a barley-based concentrate ration with 20 I.U. vitamin E (dl-α-tocopheryl acetate)/kg and 0.1 mg/kg inorganic Se; group B received the group A diet with a vitamin E supplement of 300 I.U./kg; group C received the group A diet with a supplement of 0.3 mg/kg organic Se/kg; group D received the group A diet with a vitamin E supplement of 300 I.U. E/kg diet and 0.3 mg/kg organic Se/kg diet. At 24 h postmortem the *M. longissimus dorsi* samples were taken from each carcass. Samples for Se-GSH-Px activity measurement were frozen by immersion in liquid N_2 and stored at -20°C prior to analysis. Muscle samples were also vacuum packaged and stored at -20°C for α-tocopherol analysis and oxidation studies.

Muscle vitamin E (α-tocopherol). Muscle vitamin E levels were determined by the method of Buttriss and Diplock (1984).

Se-glutathione peroxidase activity. Se-GSH-Px activity in muscle extracts was measured according to the method of DeVore and Greene (1982) and expressed as nmoles NADPH oxidised/min/mg protein.

Lipid and oxymyoglobin oxidation in beef stored in high oxygen packs. Muscle samples were thawed at 4°C, minced, placed in gas impermeable polyvinylchloride bags, evacuated and flushed with 80 % O_2:20 % CO_2. All samples were stored for up to 14 days at 4°C. Lipid oxidation was determined following the method of Siu and Draper (1978) and expressed as 2-thiobarbituric acid reactive substances (TBARS) in mg malonaldehyde/kg muscle. Oxymyoglobin oxidation was monitored according to the method of Krzywicki (1982) and expressed % of total myoglobin.

Statistical analysis. The data was analysed by ANOVA using the General Linear Model procedure of SAS®. Differences between treatment means at the 5% level were determined using the LSD test.

RESULTS AND DISCUSSION

Dietary vitamin E supplementation led to a 3-fold increase in muscle α-tocopherol levels ($P<0.05$) (Figure 1). The results are in agreement with other studies (Faustman et al., 1989; Arnold et al., 1993; Lanari et al., 1995). Previous studies in our laboratory, involving supplementation of silage-fed animals, did not produce clear-cut effects on muscle vitamin E levels and it was proposed that variation in the intake of α-tocopherol from silage may have been responsible for the lack of a vitamin E supplementation effect (O'Grady et al., 1998). In the present study, the basal vitamin E level in all diets was controlled and, probably because of the lower level of intake of the high energy concentrate relative to silage, the effect of supplementation was more pronounced.

The levels of Se-GSH-Px activity fell within the range previously reported by DeVore and Greene (1982). However, no significant difference in Se-GSH-Px activity was observed between animals fed control (0.1 mg/kg) and supplemental (0.3 mg/kg) levels of Se (Figure 2). It has been reported that in chickens fed levels of selenium similar to those used in the present study (0.09 mg/kg and 0.31 mg/kg Se) Se-GSH-Px activity was significantly higher in the supplemented group (DeVore et al. 1983). Ekholm et al (1991) reported a significant effect of dietary Se on muscle Se but the basal diet contained a level lower (0.03 mg/kg) than the basal diet in the present study.

Muscle vitamin E of animals receiving the basal dietary vitamin E level was below that shown to be necessary for acceptable colour stability (Faustman et al., 1989; O'Grady et al., 1998). Oxymyoglobin and lipid oxidation in muscle from animals fed the basal vitamin E level was higher ($P < 0.05$) than in muscle from the vitamin E-supplemented group (Figures 3 and 4). The effect of vitamin E on lipid oxidation in animal tissues is well established and the effectiveness of vitamin E in inhibiting oxymyoglobin oxidation may be attributed to its role in protecting myoglobin from the effects of oxidising lipids (O'Grady et al., 1996).

Susceptibility of minced beef stored in high oxygen packs to oxymyoglobin and lipid oxidation was unaffected by dietary Se level (Figures 3 and 4). These results were not unexpected since muscle Se-GSH-Px activity did not respond to the dietary Se level.

CONCLUSIONS

In beef animals fed concentrate-based diets muscle vitamin E levels respond to dietary vitamin E when dietary levels increase from 20 to 320 I.U./kg. Muscle glutathione peroxidase activity is unaffected by increasing dietary Se intake from 0.1 – 0.3 mg/kg or by dietary vitamin E, at the levels studied. The oxidative stability of muscle (oxymyoglobin and lipid stability) increases with increased vitamin E demonstrating that the sensory quality of beef may be influenced by muscle vitamin E level. Elevating dietary Se, while adhering to regulations relating to dietary Se, does not affect the oxidative stability of muscle tissue. The results suggest that adjusting dietary Se has limited potential for enhancing the quality of beef or accentuating the effect of vitamin E.

LITERATURE

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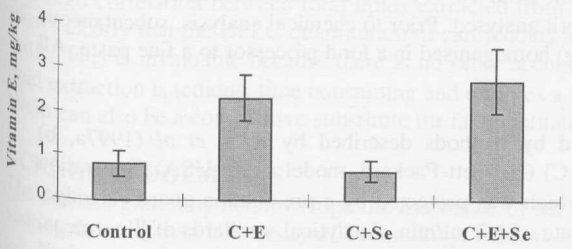

Fig 1. Vitamin E levels in muscle from animals fed control and supplemented (C+E, C+Se and C+E+Se) diets.

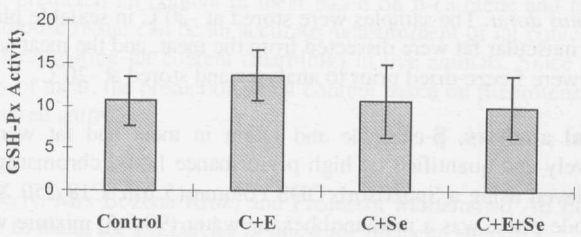

Fig 2. GSH-Px activity in muscle from animals fed control and supplemented (C+E, C+Se and C+E+Se) diets.

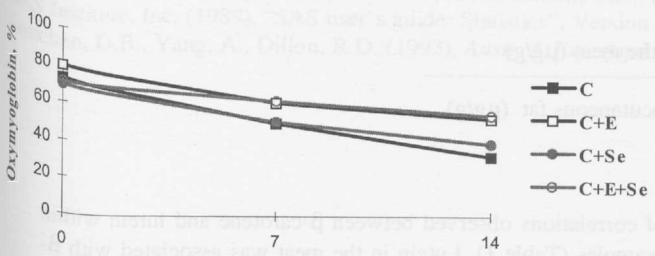

Fig 3. Oxymyoglobin oxidation in muscle from animals fed control and supplemented (C+E, C+Se and C+E+Se) diets.

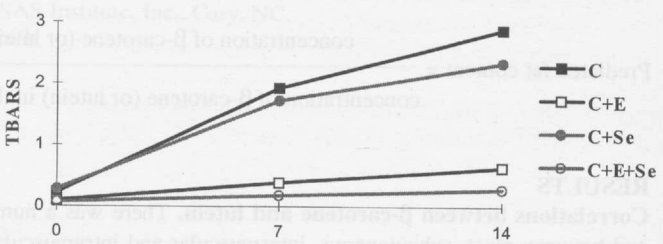

Fig 4. Lipid oxidation in muscle from animals fed control and supplemented (C+E, C+Se and C+E+Se) diets.