ANTIOXIDANT STATUS AND BEEF TENDERNESS AS INFLUENCED BY HIGH LEVELS OF VITAMIN E AND D_3 IN DIET

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Background

Beef consumers are demanding more in terms of beef quality than ever in the past. Quality equation now contains additive factors such as safety, nutrition and convenience. To find new and innovative ways to produce high-quality beef products research has also focused on the use of vitamins to improve beef quality. Studies have shown the efficacy of supplementing vitamin E in extending the retail shelf-life of beef (Liu et al., 1995). Vitamin E primarily functions as an antioxidant protecting poliunsaturated fatty acids in vivo and post slaughter animal tissues and muscle foods (Morrissey et al., 1994) from free-radical attack. Dietary supplementation of vitamin E increases the concentration of α-tocopherol in muscle and reduces the susceptibility of the muscle to lipid oxidation (Buckley et al., 1995, Lahucky et al., 2001). As was shown by estimation α-tocopherol concentration in beef muscles and its general distribution around the carcass, a high degree of meat quality prediction may be established (Lynch et al., 2000, Lahucky et al., 2002). During post-slaughter metabolism of muscles the process of lipid oxidation need no longer be tightly controlled due to weakness of the antioxidative defence systems, and this may affect meat quality traits (Lauridsen et al., 1999, Lahucky et al., 2001, 2002). Regarding meat quality traits there were reported contradictory results on the shear force value (tenderness of meat) after application of vitamin E (Mitsumoto et al., 1995, Lahucky et al., 2001). Recently Montgomery et al. (2000) reported that dietary vitamin D_3 (5 or 7.5 x 10^6 IU D_3/day) given daily from 7 to 10 days before slaughter improved tenderness (lower W-B shear force values) of 14-days post mortem aged beef. Later Scanga et al. (2001) were not able to find significant improvement cooked longissimus tenderness after oral supplementation with higher level of vitamin D_3 of heifers.

Objectives

The purpose of the present study was to investigate and to compare the effects of high dietary supplement of vitamin E and D_3 on the antioxidant status and tenderness of beef.

Methods

Slovak Pied bulls (n=18) were assigned to one of three groups (each n=6). Control group fed standard diets containing 20 mg α-tocopherylacetate/kg feed (C group). Dietary treatment groups received 1000 α-tocopherylacetate/head/day for 100 days (E group) and 7.5 x 10^6 IU of vitamin D_3 (7-dehydrocholesterol) for 7 days before slaughter (D group). Each group was held separate and each animal was fed individually. Animals were slaughtered at an average live weight of 540 ± 45 kg under condition of Institute (RIAP Nitra) facilities. Just before slaughter a biopsy muscle sample of *M. semitendinosus* (ST), (approx. 1 g) was taken by quick and efficient spring loaded biopsy instrument (Biotech, Slovakia) and stored (liqiud nitrogen) until analysed. After 48 h of chilling (3 – 4° C) carcasses were cut and *M. longissimus thoracis* (LT) and *M. psoas major* (PM) were collected and portioned for 48 h (2 days) and 7 days analyses. The pH and chemical measurements (total protein, intramuscular fat and water) were made from LT and PM samples 2 days post mortem. The contents of α-tocopherol in ST, LT and PM muscle samples of control and with vitamin E supplemented groups were assessed by HPLC as described by Lahucky et al. (2001). For evaluating the antiperoxidative status of LT and PM homogenates the determination TBARS (2-thibarbituric acid reactive substances) was used. TBARS were expressed in terms of malondialdehyde, a breakdown product formed during peroxidation stimulated by Fe^{2+}/ascorbate as described by Lahucky et al. (2001). Warner-Bratzler shear force was estimated from 2 and 7 days of LT and PM muscle samples of all groups. Steaks (2.5 cm thick) were randomly assigned end point-cooking temperature (85°C) and allowed to cool to room temperature (25°C). When steaks had cooled to room temperature, a minimum of three, 1.2-cm diameter cores were removed from each steak parallel to the muscle fiber orientation and shear force was determined for each cores using a Warner-Bratzler shear (WBS) machine then averaged to determine mean steak shear force (kg).
Statistical analyses were calculated as mean values and standard error and differences were evaluated by t-test.

Results and discussion

The biophysical (pH) and chemical traits (protein, intramuscular fat, water) were not significantly different between control and treatment groups (result not shown). However, level of intramuscular fat were generally higher ($P<0.05$) in PM muscle (mean 3.02, SE 0.64) when compared to LT muscle (mean 2.15, SE 0.36).
Higher levels α-tocopherol were found in all muscles from animals fed with higher level of vitamin E (Table 1). Differences between control and vitamin E groups were significant ($P<0.05$) and similar findings were reported by Lynch et al. (2000). Level of α-tocopherol decreased in the order PM > ST > LT what agreed as reported Chan et al. (1996). From findings given in Table 1 it seems using biopsy samples of ST muscle to control of α-tocopherol content ante-mortem (biopsy samples) may be possible.
From Figure 1 follows the rate of iron-induced muscle homogenate was strongly influenced by dietary vitamin E ($P<0.05$) and antioxidative status increased in the order PM > LT. Several studies have shown that dietary supplementation with vitamin E reduces the susceptibility of muscle membranes toward Fe^{2+} - induced lipid oxidation (Lauridsen et al. 1999, Lahucky et al. 2001). The results from group D (Figure 1) are also lower if compared to control group but differences are not significant ($P>0.05$).
As follows from Figure 2 vitamin E supplementation does not improve tenderness of beef and tendency of higher shear force values were found after 2 days (LT and PM) and 7 days (LT) aging of muscle samples and similarities were found also in pigs (Lahucky et al., 2001). It seems mechanism of influence on aging of meat is not clear (Mitsumoto et al., 1995). Higher level of shear force values in vitamine E and control groups could be influenced also by interaction of tenderness with temperature end point Wheeler et al. (1999). Oral treatment with vitamin D_3 (group D, figure 2) positively influenced shear force value (mainly at 2 days aging of LT, $P<0.05$) when compared to group E and control. But lower W-B values were only on tendency ($P>0.05$) at 7 days aging of LT and PM muscles. Contradictory results on positively effect of oral supplementaion with vitamin D_3 were received (Montgomery et al., 2000, Scanga et al., 2001) and it is apparent that more work is necessary and increased dosage or improved delivery of the vitamin D_3 may be required in future studies. Our preliminary results demonstrate that to combine supplementing vitamin E and vitamin D_3 are promising for further experimental approach.

Conclusion

Supplementation of vitamin E to feed for bulls improves level of α-tocopherol and the antioxidant potential in muscles. Improvment of shear force by oral supplementation with vitamin D_3 seems to be promising for further experimental works.

Pertinent literature
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Table 1. Effect of vitamin E suppplementation on the concentration α - tocopherol of post mortem bovine *m. longissimus thoracis* (LT), *psoas major* (PM) and ante mortem *m. semitendinosus* (ST) samples

Trait		Group C		Group E	
	n	mean	SE	mean	SE
POST MORTEM					
Longissimus thoracis	6	2.87	0.21	4.32[c]	0.17
Psoas major	6	4.24	0.24	6.77[b]	0.37
ANTE MORTEM					
Semitendinosus	5	3.56	0.64	6.55[a]	0.94

a - P< 0.05; b - P< 0.01; c - P< 0.001
Group C = control group (vitamin E 20mg/kg diet)
Group E = group with vitamin E (supplementation vitamin E 1000mg/animal/day)

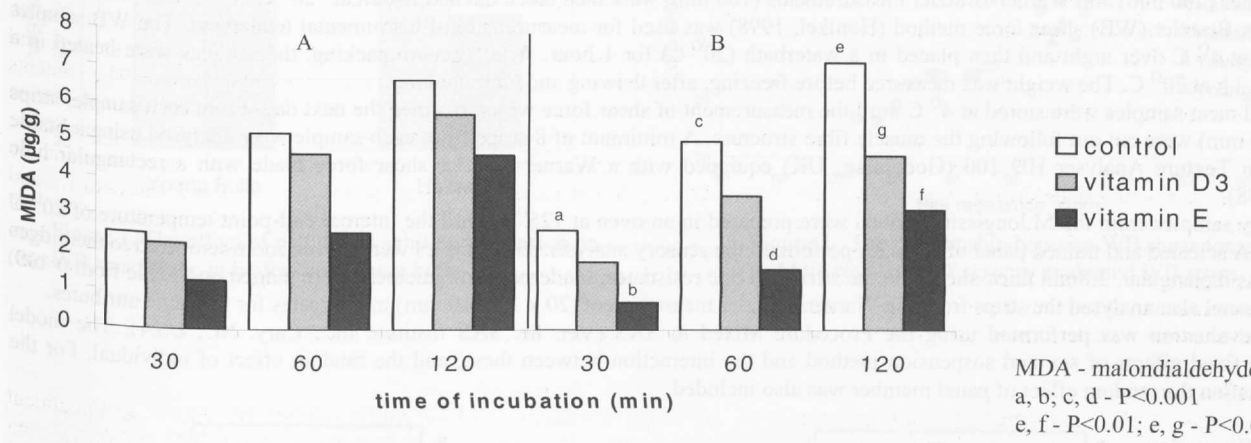

Fig. 1: Antioxidant status (MDA) of *longissimus thoracis* (A) and *psoas major* (B) beef muscles after stimulation with with Fe^{2+}/askorbate

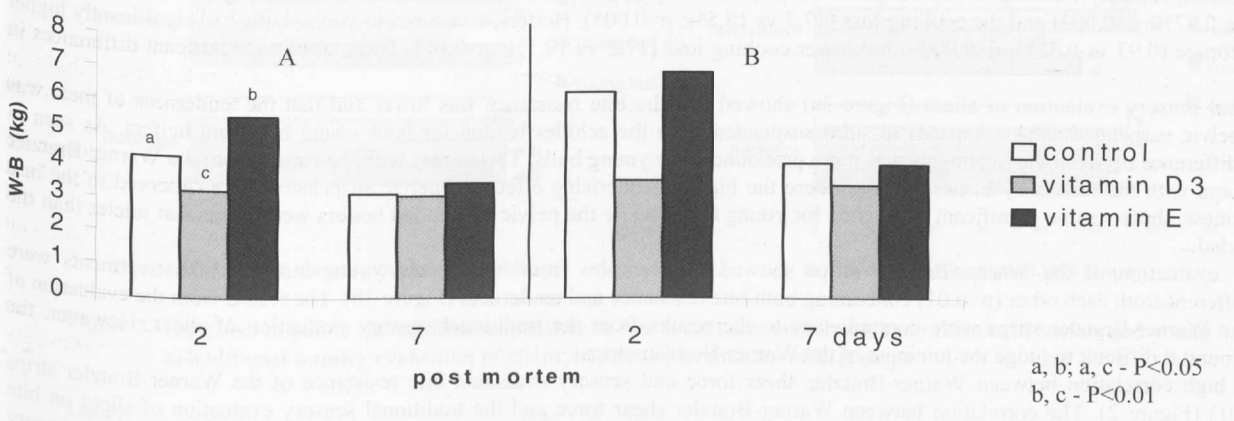

Fig. 2: Shear force (W-B) of *longissimus thoracis* (A) and *psoas major* (B) beef muscles