EFFECTS OF SHORT TIME HIGH LEVEL VITAMIN E SUPPLEMENTATION ON MEAT QUALITY ATTRIBUTES OF DISPLAYED LTL STEAKS

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Background

It is well known that high dietary levels of vitamin E for the last 3-4 months before slaughtering may improve colour and lipid stability of beef (Arnold et al., 1993; Liu et al., 1996; Lynch et al., 1999). Although the differences among muscles remain the highest source of variability, it has been suggested that high levels of α-tocopherol may improve water holding capacity, by protecting PUFA phospholipids of the cell membrane from oxidation and myofibrils integrity during refrigeration storage (Cheah et al., 1995; den Hertog-Meischke et al., 1997). Despite of these considerations, the amount of beef supplemented with antioxidant is still very small in Italy. Farmers are not stimulated to use high vit. E supplementations for long periods due to the beef market crisis and the increase in production costs; in addition, only a small number of retailers would compensate producers for the cost of supplementation.

Objectives

In order to obtain beneficial effects with a short time supplementation treatment, a high level vit. E may be necessary to assure a sufficient depot in the cellular membrane of muscle tissue (Mitsumoto et al., 1998). The aim of this experiment was to investigate on the effects of a short time, very high dietary vit. E supplementation in finishing young bulls on main meat quality traits of LTL muscle steaks under retail display conditions.

Methods

18 Charolais young bulls, about 20 months old (fattened to 600-650 kg live weight, with a diet based on corn-silage, cereals, soybean meal and vitamin-mineral supplement), were divided in 3 groups of 6 which received for the last 10 d before slaughter the following levels of vit. E (*all rac*-α-tocopheryl acetate, Rovimix 50, Istituto delle Vitamine-Roche, Milan, I) supplementation: 5,000 IU/head/d (group E1), 10,000 IU/head/d (group E2) and no extra supplementation (group C -control-, animals continued to receive an estimated intake of 250 IU/head/d of α-tocopherol from the usual diet). After slaughtering the carcasses were chilled routinely (4 °C for 30 h) before cutting and vacuum packing of the samples. The content of α-tocopherol was measured (Hoffmann-La Roche, Basel, CH) on blood plasma, liver and LTL muscle of all animals. Post mortem pH fall was measured at 1, 3, 6, 24 h and after 10 days ageing on LTL muscle (pH-meter Testo 230, Testo Gmbh , Lenzkirch, D). Steaks of LTL from the 9th-10th ribs region were obtained from both carcass sides, vacuum packed and aged at 2 °C for 10 d before slicing and displaying -overwrapped with high oxygen permeable PVC film- at 4 °C in a commercial cabinet (1800 lux 24 h/d) for 7 d. Water holding capacity (WHC) of LTL muscle was assessed after 10 d of ageing, by measuring three different traits: vacuum bag drip, drip losses after 72 and 120 h (Barton-Gade et al., 1994) and cooking losses (2.5 cm slice, cooked in water bath at 72.5 °C for 50 min). Shear force of these steaks (mean of 10 core samples, 12.5 mm ∅) was measured by Warner Bratzler device, using Instron equipment. Osmotic pressure on LTL samples at 30 h post mortem (osmolality mOs/kg) was determined on triplicate using an osmometer (Herman Roebling Gmh, Berlin, D) on 100 µl of thaw drip (overnight thawing at 4 °C of frozen samples) and muscle juice (centrifuging 5 g minced muscle at 100,000 g for 20 min). Lipid oxidation expressed as TBARs 2-thiobarbituric acid reactive substances, ng/g of MDA-malondialdeyde (Draper et al. 1993) was determined on LTL sample steaks after 1, 3, 5 and 7 d displaying. Objective colour CIE Lab (Minolta Chroma Meter CR 100, Osaka, J) and freshness index (10 trained panellists) were measured on the steaks at the above mentioned displaying times. All data were analysed using a GLM procedure of the SAS statistical package (SAS, 1998).

Results and discussion

Vit. E supplementation (E1 and E2 *vs* control) improved significantly ($P< 0.05$) the amount of α-tocopherol in the blood plasma as well as in liver and LTL muscle, but the two supplementation levels (E1 *vs* E2) were not significantly different (Table 1); this may suggest that the supplementation with very high levels, above 5,000 IU/head/d, did not achieve any benefit in terms of muscle deposition of α-tocopherol. The concentration of α-tocopherol in the control group (2.9 mg/kg) was higher than that (2.1 µg/g) reported by den Hertog-Meischke et al., (1997) using a similar diet. The concentration of α-tocopherol in LTL muscle obtained with E1 treatment (3.98 mg/kg) was higher than the estimated minimum level of 3.5 mg/kg suggested by Arnold et al., (1993) as that necessary for a beneficial effect on lipid and colour stability of meat during retailing.

Table 1. Mean concentrations of α-tocopherol in tissues after 10 d dietary supplementation

	C	E1	E2	S.E.
Blood plasma (mg/l)	4.91^{a}	9.38^{b}	10.05^{b}	1.84
Liver (mg/kg)	7.21^{a}	21.60^{b}	24.50^{b}	4.51
LTL muscle (mg/kg)	2.91^{a}	3.98^{b}	3.58^{b}	0.48

a, b: means within the same trait-row are statistically different ($P<0.05$)

Table 2 presents the pH values, the osmolality of muscle liquid and some indicators of WHC of the LTL muscle. Post mortem pH decline and final values -pH 24 h- were rather normal and did not show any particular difference between control and treated animals; however the differences between pH 1 values of C and E1-E2 were significant (6.66 *vs* 6.86-6.93, $P <0.05$). As suggested by Cheah et al. (1995), vit. E supplementation could reduce the release of Ca^{2+}, and hence the ions concentration in the sarcoplasm; this reduction may decrease the post mortem glycolytic rate and the pH fall. Nevertheless, the small number of animals in this experiment and the known high variability of pH in early post mortem, do not allow simple conclusion. Osmolality values are expected to be related with final pH and also with the amount of free sarcoplasmic Ca^{2+} ions (Quali et al., 1991; Jeacocke, 1993). No differences were found in ultimate pH values and post rigor osmolality (Table 2) between control and supplemented animals, in both thaw liquid and muscle juice. The measurements of WHC parameters after 10 d of refrigerated storage showed an interesting effect of vit. E supplementation, with the exception of cooking loss that did not vary between treatments (C:30.43; E1:31.91; and E2:29.41;- in Table 2). Supplemented beef LTL samples, E1 and E2, lost significantly ($P <0,05$) less drip when suspended in a bag for 72 and 120 h as compared to the controls; again, the two vit E levels did not differ. Only the highest

supplementation level showed a significant positive effect on reducing the vacuum bag drip. The differences found on WHC in this experiment might be explained by a better integrity of cellular membranes, which could have resulted from the prevention of oxidation and disruption of myofibrils in supplemented animals, as reported by Asghar et al., (1991) and Mitsumoto et al., (1995). Indeed, the initial differences in pH 1 h, if combined with high carcass temperatures, could had an important effect on increasing protein denaturation and reducing WHC. No effect of vit. E supplementation was found on shear force of cooked LTL steaks, after 10 d of ageing.

Table 2. Ph, osmolality, water holding capacity and shear force of LTL muscle

	C	E1	E2	S.E.
pH				
1 h	6.66^{b}	6.93^{a}	6.86^{a}	0.18
3 h	6.55	6.61	6.66	0.18
6 h	6.14	6.36	6.34	0.17
24 h	5.61	5.63	5.63	0.03
10 d	5.55	5.56	5.57	0.02
osmolality (mOs/kg)				
thaw drip	530	533	524	6.74
muscle juice	544	565	547	13.22
WHC (%)				
vacuum bag drip	2.36^{a}	1.91^{a}	1.58^{b}	0.58
drip loss 72 h	3.25^{a}	2.37^{b}	1.92^{b}	0.63
drip loss 120 h	4.00^{a}	2.89^{b}	2.85^{b}	0.61
cooking loss	30.43	31.91	29.41	2.14
shear force (kg)	3.97	3.98	3.87	0.23

a, b: means within the same trait-row are statistically different (P<0.05)

Table 3. Redness -a*- values, panel freshness index and lipid oxidation of LTL muscle during steaks display

	C	E1	E2	S.E.
*redness a**				
d 1	19.11	18.81	19.53	1.21
d 3	18.06	18.34	18.30	1.00
d 5	15.42^{b}	16.73^{ab}	17.53^{a}	1.83
d 7	12.81^{c}	13.84^{b}	15.23^{a}	2.24
freshness index				
d 1	5.27^{b}	5.51^{a}	5.41^{a}	0.23
d 3	4.37^{b}	4.78^{a}	4.68^{a}	0.49
d 5	3.53^{b}	3.95^{b}	4.19^{a}	0.79
d 7	1.96^{b}	2.24^{b}	2.39^{a}	0.35
lipid oxidation TBARs				
d 1	66^{a}	54^{b}	51^{b}	2.53
d 3	79^{a}	70^{b}	73^{b}	5.94
d 5	90^{a}	75^{b}	81^{b}	4.12
d 7	105^{a}	92^{b}	87^{b}	7.93

a, b: means within the same trait-row are statistically different (P<0.05)

Colour stability of steaks during the simulated retail displaying is expressed by the redness a* and panel freshness index values (Table 3). Redness values showed a sufficient colour stability within the first 3 days, without significant differences between control and supplemented steaks; however, after 5 and 7 d, E1 and E2 steaks showed higher a* values, indicating delayed discoloration and metmyoglobin formation. Indeed, a beneficial effect of supplementation on steaks appearance, as expressed by panel freshness index, was found at all assessment times. No clear effects were observed for the two supplementation levels, in terms of colour stability. The small differences between control and supplemented steaks for colour stability found in this experiment might be explained by the relatively high levels of α-tocopherol in control LTL muscles (2.91 mg/kg). In the findings of Yang et al., (2002), supra-nutritional supplementation with vit. E did not evidence beneficial effects on colour stability, during 7 d aerobic storage, when α-tocopherol concentrations of control samples are between 1.8-2.4 mg/kg. In addition, for Liu et al., (1996) with muscle contents of α-tocopherol between 1.4 and 4.5 mg/kg, differences in discoloration rate may be evident after 9 d of aerobic display when a colour stable muscle, such as LTL, is used. However, in this experiment the pro-discoloration factors during display, such as light (time and intensity) and cabinet temperature, might have accelerated discoloration and anticipated the vit. E positive effect at 4-5 d. Similarly to colour stability, lipid oxidation-TBARs showed a small but significant difference (P <0.05) between control and supplemented steaks at all display times. No significant differences were found between the two supplementation levels (E1 *vs* E2).

Conclusions

The results obtained from this preliminary experiment suggest that short time dietary vit. E supplementation, using high level of α-tocopheryl acetate (at list 5,000 IU/head/d), may improve WHC and to a smaller degree, colour and lipid stability of LTL steaks. Very high vit E supplementations for a short time before slaughtering could be considered as an emergency treatment when normal finishing diet supplementation could not achieve a minimum required muscle depot of α-tocopherol in relation with ageing and displaying routine. However, further studies are needed on a larger number of animals and on several muscles with different post mortem glycolytic rate and colour stability.

Pertinent literature

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