Short communication

Effects of dietary vitamin E supplementation on performance and meat characteristics in fattening bulls from the Belgian Blue breed

I. Dufrasne, C. Marche, A. Clinquart, J.L. Hornick, C. Van Eenaeme, L. Istasse

*Experimental Research Station B39, Veterinary Faculty University, B39, 4000 Liege, Belgium
†Haute Ecole de la Communauté Française ISI, 4500 Huy, Belgium
‡Department of Food Science (Technology), Veterinary Faculty University B43, Liege, Belgium
§Department of Nutrition, Veterinary Faculty University B43, Liege, Belgium

Received 20 August 1998; received in revised form 5 May 1999; accepted 25 October 1999

Abstract

An experiment was conducted to study effects of dietary vitamin E supplementation on animal performance, slaughter characteristics and meat quality traits in Belgian Blue double-muscled bulls. Two groups of six bulls each were offered (close to ad libitum) a fattening diet based on sugar beet pulp for 154 days, at which time they were slaughtered. The diet given to the control group (CG) contained 12.5 mg vitamin E / kg concentrate. The vitamin E-treated group (VG) received the same concentrate plus a supplement of 1000 mg vitamin E per bull daily. Steaks from m. longissimus thoracis were used to determine meat quality characteristics, alpha tocopherol concentration and thiobarbituric acid reactive substances content (TBARS), an indicator of oxidation rancidity. Supplementation had no influence on animal performance or carcass characteristics. The main findings were that vitamin E doubled the muscle alpha tocopherol level (1.9 vs. 0.9 mg / kg; \( P < 0.001 \)), lipid oxidation was suppressed as indicated by TBARS values \( (P < 0.01 \) at days 7, 9, 11 and 14 after slaughter), but muscle colour was not significantly affected although \( a^* \) (redness) tended to be higher for VG.

Keywords: Belgian Blue bulls; Colour; Meat; Oxidation; Vitamin E

1. Introduction

Discolouration of the surface can be interpreted by consumers as a condition of un wholesomeness (Faustman et al., 1989). Discolouration in retail meats during display is due to muscle pigment and lipid oxidation in intramuscular fat and membrane phospholipids (Sherbeck et al., 1995). Changes in flavour are related to oxidative rancidity mainly when the unsaturated fatty acids content of the meat is high (Lin et al., 1989; Shahidi, 1992).
Vitamin E is recognized for its role in lipid oxidation by preventing formation of free radicals (Bjorneboe et al., 1989), and dietary vitamin E is known to improve colour stability (Faustman et al., 1989).

The objectives of the present experiment were to assess the effects of dietary vitamin E supplementation on animal performance, slaughter characteristics and meat quality traits in Belgian Blue double-muscled bulls, animals with very low fat content and with rather pale meat (Clinquart et al., 1994).

2. Materials and methods

2.1. Animals and management

Twelve double-muscled Belgian Blue bulls of mean live weight 404 kg were allocated to two groups of six each. One group (control group, CG) was offered a fattening diet based on sugar beet pulp to which vitamin E (Produits Roche S.A., 1060 Bruxelles, Belgium; 500 mg vitamin E/g) was added at a rate of 12.5 mg/kg concentrate. Food intakes were maintained close to ad libitum by weekly adjustments of the amount offered. The bulls in the second group (vitamin E group, VG) received the same concentrate as CG but, in addition, they were offered 1000 mg vitamin E per head daily. Barley straw was offered ad libitum in a hay rack. The length of the fattening period was 153.0 and 154.5 days in CG and VG groups, respectively. At the end of the experiment, the bulls were slaughtered in a commercial abattoir. Selection for slaughter was based on degree of fatness, estimated by palpation of the tail head, loin and rib area.

2.2. Measurements

Feed intake of both groups was recorded daily and live weight was recorded once a month. At slaughter, the carcass weight was recorded, and pH was measured in the m. longissimus thoracis. Two days after slaughter, ribs 7, 8 and 9 were removed from the carcass and dissected to estimate the carcass composition (Martin and Toreele, 1962). Meat quality was determined on 2.5-cm thick steak cuts from m. longissimus thoracis. Vitamin E and cholesterol concentrations were measured in these samples. The pH was measured on freshly cut surfaces. The HunterLab labscan II device (Hunter Associate Laboratory Inc., Reston, Virginia, USA) was used to objectively measure CIE Lab brightness (L*) and colour (a* and b*). A steak was divided into six slices which were stored individually in polystyrene trays covered by a polyethylene film. They were held at 4±1°C under 2000–2600 lux lighting for periods of 2, 4, 7, 9, 11 and 14 days after slaughter and then assessed for colour and for oxidative rancidity by the thiobarbituric acid-reacting substances (TBARS) procedure. Another steak was used for cooking loss and Warner Bratzler shear force determinations 9 days after slaughter.

2.3. Chemical analysis

The chemical composition of the diets and m. longissimus thoracis were determined according to official procedures (Horwitz, 1975). Alpha-tocopherol was determined in meat samples by the method described by Bourgeois and Ciba (1988). The TBARS concentrations were measured by the method of Tarladgis et al. (1960) and expressed as μg malonaldehyde equivalents per g of fresh meat.

2.4. Statistical analysis

One-way and two-way analyses of variance were carried out as appropriate according to the methods described by Dagnelie (1975).

3. Results

Animal performance, slaughter and carcass characteristics did not differ between CG and VG. The total live weight gain was 228 and 220 kg in the CG and VG groups, respectively. The average daily gain across both groups was 1.46 kg. The average total feed intake was 1605 kg per animal and the conversion ratio of concentrate to live weight gain was 7.18 kg/kg. Slaughter weight was 614 kg and killing-out percentage 63.4%; the proportions of muscle, adipose tissue and bone estimated in the
Table 1: Meat quality characteristics (mean±S.E.) of control (CG) and vitamin E-supplemented (VG) Belgian Blue bulls

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>CG</th>
<th>VG</th>
<th>Level of significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH after</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 h</td>
<td></td>
<td>6.7±0.09</td>
<td>6.6±0.02</td>
<td></td>
</tr>
<tr>
<td>2 h</td>
<td></td>
<td>6.4±0.06</td>
<td>6.4±0.06</td>
<td></td>
</tr>
<tr>
<td>4 h</td>
<td></td>
<td>5.8±0.09</td>
<td>5.8±0.07</td>
<td></td>
</tr>
<tr>
<td>48 h</td>
<td></td>
<td>5.5±0.03</td>
<td>5.5±0.03</td>
<td></td>
</tr>
<tr>
<td>9 days</td>
<td></td>
<td>5.6±0.02</td>
<td>5.6±0.02</td>
<td></td>
</tr>
<tr>
<td>Drip loss (%)</td>
<td></td>
<td>5.1±0.46</td>
<td>4.8±0.25</td>
<td></td>
</tr>
<tr>
<td>Cooking loss (%)</td>
<td></td>
<td>27.8±0.53</td>
<td>28.3±0.82</td>
<td></td>
</tr>
<tr>
<td>Peak shear force (N)</td>
<td></td>
<td>37.4±7.18</td>
<td>46.8±4.98</td>
<td></td>
</tr>
<tr>
<td>Colour (48 h)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L*</td>
<td></td>
<td>43.6±0.92</td>
<td>43.1±0.39</td>
<td></td>
</tr>
<tr>
<td>a*</td>
<td></td>
<td>23.0±0.72</td>
<td>23.1±0.36</td>
<td></td>
</tr>
<tr>
<td>b*</td>
<td></td>
<td>21.5±0.54</td>
<td>21.2±0.18</td>
<td></td>
</tr>
<tr>
<td>a*/b*</td>
<td></td>
<td>1.1±0.02</td>
<td>1.1±0.02</td>
<td></td>
</tr>
</tbody>
</table>

*There was no difference (P > 0.10) between treatments.

carcass from the rib section were 72.3, 15.0 and 12.7%, respectively.

Table 1 summarizes the meat characteristics. pH,

cooking loss, drip loss and peak shear force were not significantly different between the two groups. There were no differences in the colour parameters 48 h after slaughter. The changes in redness (a*) over the 14-day period of storage after slaughter are shown in Fig. 1. Although the differences were not significant, the meat of the VG bulls tended to be redder (a* value of 23.9 vs. 22.7; P < 0.10 on day 9). The L* value tended to be lower in the VG group on day 2 (P < 0.10).

Chemical composition of m. longissimus thoracis is given in Table 2. There were no significant effects of vitamin E on dry matter (DM; 245 g/kg), ash (45 g/kg DM), crude protein (915 g/kg DM), ether extract (35 g/kg DM) and cholesterol concentrations (1.94 g/kg DM). Supplementation with vitamin E doubled the alpha-tocopherol concentration in meat in the VG group (1.9 vs. 0.9 mg/kg fresh meat; P < 0.001).

Fig. 2 shows the evolution of TBARS content in m. longissimus thoracis over the 14-day maturation period.
period. There were no significant differences between the CG and VG groups on days 2 and 4, but TBARS content was higher \( (P < 0.01) \) in the CG than in the VG group on days 7, 9, 11 and 14 of storage.

4. Discussion

In conventional diet formulation, vitamin E is commonly used as an antioxidant to protect cell membranes. In the present trial, vitamin E was added at a rate of 12.5 mg/kg concentrate diet in the CG group. Such concentration is considered as adequate with traditional feedstuffs, even with fast growing animals. Institut National de Recherche Agricole (INRA) (Jarrige, 1988) recommended 5–10 mg vitamin E per kg dry feed for ruminants. According to the Nutrition Research Council (NRC, 1984), the vitamin E requirement of cattle was estimated at between 15 and 60 mg/kg dry diet. The Agricultural Research Council (ARC, 1980) suggested a minimal requirement lying between 10 and 15 mg/kg dietary DM but, in order to prevent clinical or subclinical myopathy, higher concentrations ranging between 15 and 28 mg/kg DM were proposed. The 1000 mg/day vitamin E supplementation was in the range of supplementation used by others in fattening diets for other breeds with a view to enhancing meat colour (500 mg, Shorland et al. (1981); 300 mg, Arnold et al. (1992); 500–2000 mg, Arnold et al. (1993), Garber et al. (1996), Liu et al. (1996)). Supplementation with vitamin E resulted in a significant increase in muscle alpha-tocopherol concentration (1.9 mg/kg fresh weight). The extent of the present response was similar to that reported by Mitsumoto et al. (1993) (6.00 vs. 1.33 mg/kg fresh weight in m. longissimus lumborum) but close to the result of Garber et al. (1996) (6.07 vs. 2.73 mg/kg fresh weight in m. gluteus medius). According to Liu et al. (1995), a concentration of 3.5 mg/kg fresh weight was sufficient for near maximal suppression of lipid oxidation and metmyoglobin formation in fresh meat. The result from the present study indicated a suppression of lipid oxidation for up to 14 days of storage and a tendency for a redder meat due to vitamin E. It was thus possible that effects on lipid oxidation were obtained at a lower alpha-tocopherol concentration than effects on colouration. It was also possible that the 12.5 mg vitamin E supplementation level used to meet nutritional requirements in the CG also had some protective effects against lipid oxidation and muscle discoulouration.

In conclusion, vitamin E supplementation of Belgian Blue bulls at an inclusion rate greatly in excess of nutritional recommendations, significantly reduced lipid oxidation and tended to maintain meat redness at a high value. It was thus advantageous for shelf-life of the meat from a breed having low fat content and pale meat.

Acknowledgements

The authors wish to acknowledge the financial support of Ministère de la Région Wallonne, Direction Générale de l’Agriculture, Belgium.

References

Garber, M.J., Roeder, R.A., Davidson, P.M., Pumfrey, W.M.,