PE7.40 Effects of Diet and Packaging on Fatty Acid Composition, Shelf-life and Sensory Attributes of Venison Finished from Grass or Concentrates 370.00

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***Abstract*—Venison has a reputation for being a healthier meat in terms of its fatty acid composition than beef or lamb, and is a growing market in the UK. In order to lengthen the supply period of venison, some farmers are feeding concentrates to finish animals earlier, but these are known to increase the less desirable n-6 fatty acids in the meat. Since venison does not have a very good colour stability in aerobic conditions., this work was designed to establish the difference in meat from animals fed a grass or a concentrate diet and whether supplementation of the diet with Vitamin E could be effective in increasing colour shelf life. Four groups of 10, 22-month old red deer hinds were allocated to a 2x2 factorial design with grass or concentrate as the diet, with or without supplementation with vitamin E. After slaughter, samples of m. *longissimus lumborum* were taken for analysis of fatty acid composition, vitamin E content and 5 day aged meat was used for sensory analysis and tested for colour and lipid stability after simulated retail display in either high oxygen modified atmosphere or in vacuum packs. Fatty acid composition was not affected by vitamin E addition but those animals fed grass had more n-3 fatty acids in their meat and those fed concentrates had more n-6 fatty acids. The fat content of the meat was low at around 1.3% and the P:S ratio was of the order of 0.6, better than the desired value of 0.4 and much better than the value of 0.1-0.2 often found in beef and lamb meat., the higher proportion of PUFA in the meat being responsible. This, and possibly a higher content of iron, led to the meat being much less stable than beef. Vitamin E was not as able to extend the shelf life as it can for beef. Consequently it is recommended that venison should be distributed in vacuum packs and not in high oxygen modified atmospheres. A trained sensory panel found the meat to be very tender and juicy, much more so when fed grass than concentrates.**

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I. INTRODUCTION

The UK consumes, per year, 550 tonnes of home-produced farmed venison [2], a similar amount of imported farmed venison, mainly from New Zealand, and wild venison of around 2500 tonnes [4]. Venison production is a 'natural', extensive system, mainly from grass, and the meat is leaner, yields a greater proportion of 'first class meat', but is darker in colour than beef or lamb [3,11]. The fatty acid composition of venison [9, 12], when compared with beef and lamb [e.g. 8] has a lower concentration of intramuscular fatty acids, at around 1.6% of muscle fresh weight, compared with typical values of 3.8% for beef and 4.9% for lamb, [10]. The concentrations of saturated (SAT) and monounsaturated (MUFA) fatty acids are lower, and the polyunsaturated fatty acid (PUFA) content are higher, in venison. As a result, the P:S ratio for venison loin muscle is highest at 0.41 compared with 0.11 and 0.15 for beef and lamb respectively. The n-3 fatty acid concentrations are similar in venison and lamb, but higher than in beef, giving lower n-6:n-3 ratios, but for all three species are well within the acceptable limit of 4.0 [7]. As with beef, grass-fed deer have more n-3 fatty acids in their lipid, whereas concentrate fed deer have more n-6 fatty acids [20].

In fresh venison, colour deterioration and off-flavours can occur after 3-4 days when stored at 3^0C in aerobic conditions [19] but this might be improved by supplementing diets with vitamin E, as has been successful for beef [1].

Further research on venison was needed to explore the effects of various feeding regimes on parameters associated with meat lipids, including antioxidants and oxidation products, in relation to meat quality attributes; such as shelf life and colour stability.

II. MATERIALS AND METHODS

A feeding trial, lasting on average 109 days, used four groups of ten, 22-month old red deer (*Cervus elaphus*) hinds randomly allocated, according to live weight, in a 2 x 2 factorial design, involving two feed treatments, with and without vitamin E (fed as 4 g/head/day ROVIMIX E-50 adsorbate to

provide 2g vitamin E). The feed treatments were grazed ryegrass/clover swards and indoor–fed baled silage plus 1.0 kg/head/day of concentrates (whole barley:soya, 90:10). The latter was designed to produce a growth rate of the concentrate-fed animals similar to that expected in grass-grazed animals.

The deer were slaughtered in two batches in a commercial deer abattoir, chilled and loin muscle (*longissimus lumborum*) extracted. A sample of loin was frozen for subsequent analysis of vitamin E and fatty acid composition. The rest was vacuum packed and aged to 5 days post slaughter when it was cut into steaks. Three steaks were packed in a modified atmosphere (MA: O_2:CO_2, 80:20), and three in vacuum packs (VAC) and subjected to simulated retail display (16h light, 8h dark, 3°C, 700lux). Colour (L* a* b*) coordinates [5], were measured on the surface of a steak through the pack film with a Minolta-Chromameter CR400 (Minolta Camera Company, Milton Keynes), daily for MA packs and every 3rd and 7th day for VAC packs. Chroma was calculated as $[(a^*)^2 + (b^*)^2]^{0.5}$ Thiobarbituric acid reacting substances (TBARS) as a measure of lipid oxidation were measured on days 4 and 7 of display (MAP) or days 14 and 35 (VAC) [16]. Further samples were frozen for sensory analysis. Vitamin E was analysed in the muscle tissue using 5,7-Dimethyl-tocol as internal standard [1].

Sensory samples were thawed overnight at 1°C and cooked to 74°C internal temperature before assessment as described by Warren et al. [18] using 8-point category scales for texture, juiciness, venison flavour intensity and other flavour intensity, and hedonic scales for flavour liking and overall liking.

Fatty acids analysis was carried out by direct saponification as described in detail in [6]. Samples were hydrolysed with 2M KOH in water:methanol (1:1) with heneicosanoic acid (C21:0) methyl ester as internal standard and the FAs extracted into petroleum spirit, methylated using diazomethane and analysed by gas liquid chromatography. Samples were injected in the split mode, 70:1, onto a CP Sil 88, 50m x 0.25mm fatty acid methyl esters (FAME) column (Chrompack UK Ltd, London) with helium as the carrier gas.

An ANOVA with diet and days as factors was used and means compared post hoc by the Tukey-Kramer test. For chroma and TBARS, day was nested within animal.

III. RESULTS AND DISCUSSION

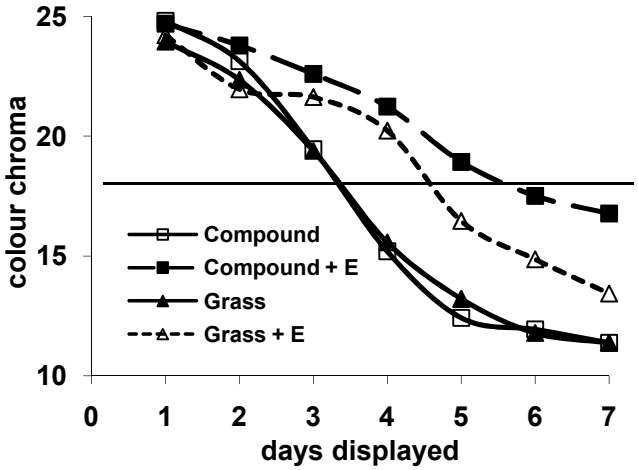
There was no effect of vitamin E addition on fatty acid composition so results are presented for grass-grazed vs. concentrate supplemented (Table 1). Diet had no effect on total fatty acids or content of total SFA, MUFA or PUFA. But it is very noticeable that the amount of fat in venison is less than that found in beef or lamb and that the proportions of SAT and MUFA, at approximately 30 and 20% respectively, are much less than the approximate 47% found in beef, resulting in a concomitant increase in PUFA from around 7% in beef to the 33-34% found here. This resulted in a much more favourable P:S ratio greater than 0.4 for both diets. As with beef and lamb, changing from a concentrate to a grass-grazed diet increased the concentration of n-3 fatty acids and reduced that of n-6, as seen by [20]. However, compared to beef [see for instance Warren *et al.,* 17], the concentration of C18:3*n*-3 was double and C18:2*n*-6 was 3-4 fold higher than in beef, even for grass-grazed animals.

Table 1. Selected fatty acids (mg /kg meat) and nutritional indices

mg/100g meat	Concentrates	Grass	significance
Total FA	1343	1254	ns
SFA	408	393	ns
MUFA	253	256	ns
PUFA	455	407	ns
C14:0	37.0	35.5	ns
C16:0	225.5	209.8	ns
C18:0	128.8	161.2	***
C18:1*cis*-9	127.5	139.3	***
C18:2*n*-6	222.7	190.9	***
C20:4*n-6*	89.4	76.5	***
C18:3*n*-3	17.7	76.6	***
C20:5*n*-3	24.2	40.2	***
C22:6*n*-3	8.5	12.1	***
P:S	0.67	0.69	ns
18:2 : 18:3	13.1	2.5	***

ns not significant, *** $p<0.001$

Figure 1. The effect of diet and vitamin E on colour shelf life of venison steaks displayed in high oxygen modified atmosphere



Feeding both concentrates and grazing grass produced meat that only had a 3 day colour shelf life in MA packs, which was increased by 2 days, for grass-grazed animals, and 3 days for concentrate fed animals, when supplemented with vitamin E. Chroma values for vacuum packed samples (not shown) were low due to the lack of oxygen and were unaffected by diet or vitamin E supplementation and values did not begin to decline until after day 17.

Similarly, TBARS were high after 4 days in MAP unless supplemented with vitamin E. Vitamin E was also successful in reducing the TBARS value in concentrate-fed animals subject to 7 d display, but was less so when animals grazed grass (Figure 1).

Table 2. TBARS and vitamin E concentrations (mg/kg lean meat)

	TBARS MA		VAC		Vit E
	4d	7d	14d	35d	
Conc	9.7 [a]	16.2 [c]	0.2 [b]	0.2 [b]	2.1 [a]
Conc +E	1.2 [b]	3.1 [b]	0.2 [b]	0.2 [b]	5.6 [c]
Grass	8.1 [a]	17.2 [c]	0.2 [b]	0.2 [b]	4.6 [b]
Grass+E	2.5 [b]	9.4 [a]	0.2 [b]	0.2 [b]	5.9 [c]

[abc], values in a column with different superscripts are significantly different p,0.05

The TBARS values in vacuum packs were low and remained unchanged during storage. Whilst the concentration of vitamin E in concentrate-fed animals was low (Table 2) it was higher in grass-grazed animals but insufficient to maintain meat colour and lipid stability. Supplementing animals produced higher concentrations of vitamin E in both grass-grazed and concentrate-fed animals. This result is unlike that for beef, where the vitamin E concentration in grass-fed animals is usually sufficient to maintain colour and lipid stability and supplementation has less of an effect [18, 21] Stevenson *et al.* [15] found that venison had similar vitamin E levels as grass-fed or vitamin E supplemented grain-fed beef, but had faster oxidation rates, possibly due to higher copper and iron levels. Okabe *et al.* [14] found that the effective level of vitamin E for stabilizing lipid in venison was 7-9 mg/kg tissue, which is much higher than the 3.5 mg/kg tissue reported for beef [13], and postulated that this was due to the higher phospholipid unsaturated fatty acid and myoglobin (iron) contents of venison. In this work grass-grazed and vitamin E supplemented animals had vitamin E concentrations between these two values, but the concentration of long chain PUFA with a greater number of double bonds, and hence more susceptible to oxidation, was greater in the grass-grazed animals than those fed concentrates.

The sensory panel found that feeding vitamin E had no effect on flavour profile of the meat, but that the grass-grazed animals produced meat that was more tender and more juicy than those fed concentrates. Again this is not usually seen for beef. Diet did not affect venison flavour but grass-grazed animals had higher 'other flavours' one of which was seen to be 'bloody' in the flavour profile, 'livery' was also higher in grass-grazed animals but not significantly so. Similar trends were seen by [20], but none of their results were statistically significantly different.

Table 3. Sensory panel results

Descriptor	Concentrate	Grass	significance
Tenderness	4.38	5.16	***
Juiciness	4.86	5.19	*
Venison	4.34	4.34	ns
Other flavours	2.58	2.97	*
Hedonic			
Flavour liking	4.61	4.56	ns
Overall liking	4.41	4.48	ns
100mm line scales used			
Bloody	13.26	17.26	*
Livery	8.82	10.30	ns

ns: not significantly different, * $p<0.05$, *** $p<0.001$

IV. CONCLUSION

Venison is low in fat and saturated fat and higher in PUFA than other red meats and has good P:S and n-

6 to n-3 ratios that are in line with the recommendations for healthy eating. Meat from grass-fed deer has more n-3 PUFA than concentrate-fed deer but is less stable than beef. It would appear that vitamin E supplementation may need to be higher than that used for beef, and hence be economically less viable, if it is to maintain colour shelf-life in high oxygen MAP comparable to that of beef. For this reason venison should not be displayed in high oxygen atmospheres.

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