INFLUENCE OF VACUUM AND MODIFIED ATMOSPHERE PACKAGING ON QUALITY OF VENISON LOINS

D.L. Seman, T.R. Manley and K.R. Drew, MAFTech, Invermay Agricultural Centre, Private Bag, Mosgiel, New Zealand.

SUMMARY

A study were conducted at the Invermay Agricultural Centre to evaluate the use of vacuum and modified atmosphere packaging using 100% carbon dioxide on the quality of venison loins. Loins were packaged in either vacuum packages (VP) or modified atmosphere packaging (100% CO_2) using containment films of ultra-high barrier plastic (CO_2-UHB) or a aluminium foil laminant (CO_2-Foil). Surface colour of loins exposed to the modified atmosphere discoloured as the oxygen content of the headspace increased especially in the CO_2-UHB treatments. pH values were higher ($P < 0.05$) in VP loins than in those packaged in CO_2. Sensory traits of loins were unaffected by packaging but decreased as meat was stored from 12 to 18 weeks. Total anaerobic and lactic acid forming bacteria counts increased as meat was stored up to 18 weeks. Packaging venison loins in CO_2 had no apparent advantage over vacuum packaging.

INTRODUCTION

World wide preference seems to regard chilled meats as being superior to frozen. This has forced meat processors in exporting countries to utilize innovative methods capable of preserving meat quality to allow for the assembly, transport and distribution of the products. Oxygen-impermeable, heat shrinkable films have been successfully used for several years for vacuum packaging beef and lamb for up to 8-12 weeks (Gill 1987), but have several limitations including the fact that high pH meat cannot be vacuum packaged. Recent advances in packaging systems utilizing low storage temperatures (-1°C) and high concentrations (100%) of CO_2 has resulted in the extension of shelf life of chilled lamb beyond 18 and up to 23 weeks (Gill 1986). Although high concentrations of CO_2 have been found to result in the discoloration of fresh meat (Brooks 1933), discoloration using 100% CO_2 modified atmospheres can be reduced or eliminated by first packaging the meat in permeable films before exposure to the gas. The objectives of this study were to measure changes in chilled venison quality (changes in pH, surface discoloration, microbial quality, and sensory characteristics) when stored for extended periods of time (up to 18 weeks) when the meat is either vacuum packaged of stored in a modified atmosphere (100% CO_2) within bags made of an ultra-high barrier film (CO_2-UHB) or aluminium foil laminated film (CO_2-Foil).

EXPERIMENTAL METHODS

Slaughter and packaging.

Thirty red deer stags carcasses were electrically stimulated (45 v, 1.2 amps, 90 sec) and stored at 4°C overnight. Boneless loins were removed 24 hr postmortem, vacuum packaged and sent to Invermay Agricultural Centre. Pairs of loin muscles were cut into six, 18 cm portions and allotted to 3 packaging treatments according to a predetermined scheme to assess variability among animals; vacuum packaged (VP); packaged in 100% CO_2 using the UHB outer film (CO_2-UHB); packaged in 100% CO_2 using CO_2-Foil. A pair of loin portions were packaged individually in Cryovac (W.R. Grace, Porirua, New Zealand) barrier bags (ethylene/vinyl acetate copolymer-polyvinylidene chloride laminate; OTR = 30-40 ml m^{-2} 24 hr^{-1} atm^{-1} at 25°C and 75% RH) to 722 mm Hg and heat shrunk by dipping in a 90°C water bath for 2-3 seconds. Paired loin portions (one from each side) were kept together as a unit and will be denoted as such throughout this paper. Modified atmosphere packages were prepared by first packaging two loin portions in Cryovac E-bags (OTR = 517 ml m^{-2} 24 hr^{-1} atm^{-1} at 0°C and 75% RH, CO_2TR = 7223 ml m^{-2} 24 hr^{-1} atm^{-1} at 27°C and 75% RH) to 722 mm Hg. Paired loin portions were placed inside either the specified outer bag and evacuating the bag twice before filling with 1 L CO_2/kg and heat sealing. Meat was stored at -1°C and sampled after 6, 12 and 18 weeks.

Quality assessment.

The pH of each loin was determined by taking duplicate readings using an Orion spear-tip combination electrode (91-63) and a portable pH meter 24 hr postmortem prior and also from each loin portion (in duplicate) after each designated storage period. Residual oxygen content (expressed as percent) was determined in the modified atmosphere packages by using a Servomex oxygen meter. A composite sample of venison (10 g total) was taken from the two loin portions in each package unit after storage to enumerate lactic acid bacteria (Rogosa media), total aerobes (Plate Count Agar) and total anaerobes (Plate Count Agar) were used (Messer et al. 1984). All enumerations were performed in duplicate. Microbiological counts were reported as $\log_{10}$ CFU/gram. Surface discoloration of loins upon opening was determined by a 3 member evaluation panel using a 5 point colour scale (5 = bright fresh red venison colour, 4 = bright red venison colour, 3 = slightly dark or brown, 2 = moderately dark or brown, 1 = extremely dark or brown) and a 3 point colour acceptability scale (3 = purchase with no reservation, 2 = purchase with reservation, 1 = would not purchase).

Statistical methods.

Experimental units in this study consisted of 2 paired loin portions from each animal which were either packaged individually (VP) or in pairs within a modified gas package (CO_2-UHB or CO_2-Foil). Data were analyzed by analysis of variance. Statistical significance was assessed at the 5% level throughout.

RESULTS AND DISCUSSION

Surface discoloration.

Loins packaged in either VP or CO_2-Foil exhibited higher ($P < 0.05$) surface discoloration scores than those packaged in CO_2-UHB (Table 1). Surface discoloration scores did not change markedly when loins were stored from 12 to 18 weeks. In addition, higher oxygen concentrations were present in CO_2-UHB packages than in CO_2-Foil after 12 and 18 weeks storage resulting in 1.0% and 0.62% oxygen for CO_2-UHB and CO_2-Foil, respectively after 18 weeks. Oxygen concentrations as low as 4 mm Hg (0.5% at atmospheric pressure) have

Table 1. Surface colour and residual oxygen content as affected by packaging method and storage time

	Packaging method			
	Vacuum	CO_2-UHB	CO_2-Foil	SED
DISCOLOURATION[1]				
Week 12	4.3	2.8	4.0	0.13*
Week 18	4.0	2.1	4.3	
RESIDUAL OXYGEN				
Week 6	—	0.3	0.2	0.13*
Week 12	—	0.5	0.2	
Week 18	—	1.0	0.6	

*(P<0.05)

[1]Scored using a 5 point scale (5 = bright fresh red venison colour, 4 = bright red venison colour, 3 = slightly dark or brown, 2 = moderately dark or brown, 1 = extremely dark or brown)

Table 2. Effect of method of packaging and length of storage on the number of bacteria recovered from venison loins (values in brackets are the ranges for each treatment).

Bacteria	Method of packaging		
	Vacuum	CO_2-UHB	CO_2-Foil
		(Log_{10} CFU/g)	
ANAEROBES			
Week			
6	2.45 (1.23-3.76)	1.15 (0-2.08)	1.33 (0-3.23)
12	3.89 (1.66-6.00)	3.62 (2.46-6.00)	3.04 (1.15-5.43)
18	5.22 (3.82-6.59)	4.12 (2.18-591)	2.45 (0-4.70)
SED	0.529*		
LACTIC ACID BACTERIA			
Week			
6	0.45 (0-2.20)	0 (0)	0.47 (0-2.98)
12	2.65 (0-5.86)	2.10 (0-6.00)	1.65 (0-3.18)
18	4.06 (0-6.51)	3.04 (0-4.91)	1.34 (0-4.04)
SED	0.742*		

Table 3. Means of sensory traits of venison loins affected by storage time.

Trait	Week of storage			
	6	12	18	SED
Aroma	5.36	5.29	4.82	0.11*
Texture	5.86	5.64	5.39	0.16*[a]
Flavour	5.29	4.99	4.31	0.15*
Juciness	4.67	4.44	4.62	0.32
Acceptability	5.01	4.77	4.30	0.17*

* Significant (P<0.05)
[a] Significant packaging method X storage time interaction

been found to accelerate the discoloration of meat by increasing the oxidation of myoglobin to form metmyoglobin (Giddings 1977). Although residual oxygen was scavenged to immeasurably low levels three days after packaging (data not presented), residual oxygen levels increased in the CO_2-UHB packs due to ingress through the outer UHB film to levels which were able to accelerate discoloration on the loin surfaces.

pH.

Loins packaged in modified atmosphere packages exhibited lower pH values ($P < 0.05$) than loins which were vacuum packaged except after 18 weeks storage (Fig.1). The same trends have been found in other studies and has been attributed to the absorption of dissolved CO_2 into the meat fluids and the subsequent formation of carbonic acid (Huffman 1974). Lower pH values can result in increased meat discoloration, but in this study, surface discoloration seems more a consequence of oxygen ingress than changes in pH since only venison packaged in the UHB films was discoloured significantly.

Colour stability.

Discoloration scores of loin steaks decreased after 6 weeks of storage from average scores of approximately 4.7 (bright, fresh red) to scores as low as 1.8 after 5 days of display in air under simulated retail conditions (Fig. 2). Trends were similar for each packaging

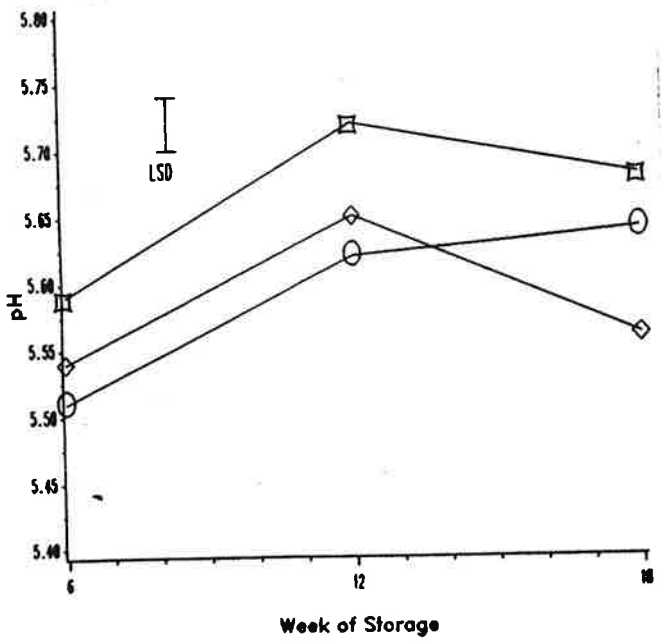

Fig 1. Effect of storage time on pH of venison loins packaged by various methods: Vacuum, ¤; CO_2-UHB, o; CO_2-Foil, ◇.

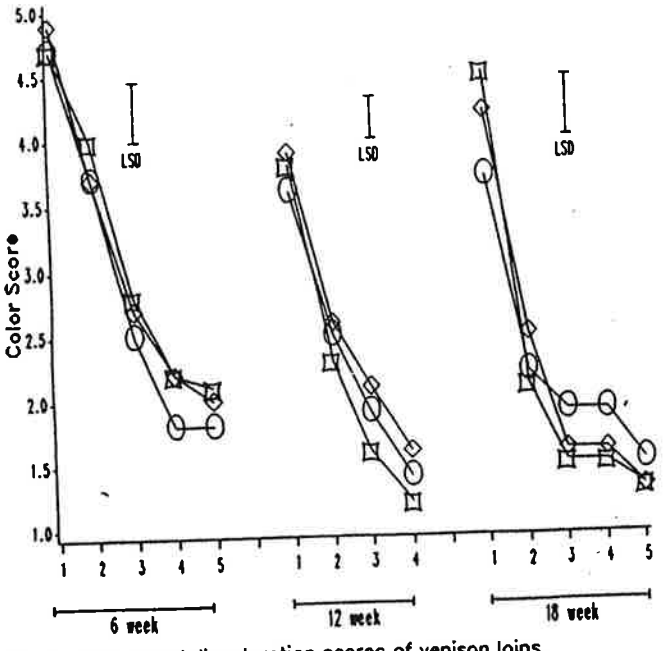

Fig 2. Mean panel discoloration scores of venison loins. Vacuum, ¤; CO_2-UHB, o; CO_2-Foil, ◇. 5=Bright-red venison color; 1=Extremely dark or brown

treatment except CO_2-UHB exhibited lower scores from the third day of display onwards. Trends for steaks stored for 12 weeks were similar except that steaks from VP loins had lower scores after 2 or more days of display than either modified atmosphere treatments. After 18 weeks storage, steaks from CO_2-UHB had lower initial colour scores, but deteriorated less in colour than those from VP or CO_2-Foil. Loin steaks stored for 6 weeks reached the acceptable discoloration limit after 3 days of display, but the time of acceptable display was reduced to 2 days after 12 weeks storage and to 1.5 days after 18 weeks. Decreasing periods of acceptable display has been attributed to decreased effectiveness of intracellular reducing systems as the meat is held for extended periods (Bevilacqua and Zaritzky 1986).

Microbial evaluation.

Recoverable anaerobic bacteria increased up to 2.5 times during the storage period of 6 to 18 weeks after packaging (Table 2). Increases in recoverable lactic acid forming bacteria followed the same trends. Significant effects of packaging method were not found until 18 weeks of storage where meat packed in CO_2-Foil had lower counts ($P < 0.05$). Reasons for the lower levels of lactic acid bacteria recovered after 18 weeks from the CO_2-Foil are not readily apparent. Both the low storage temperatures and high concentrations of CO_2 presented conditions suitable for the proliferation of lactic acid forming bacteria which have been shown to dominate the flora of meat packaged in modified atmospheres with high CO_2 concentrations. The growth of these types of bacteria can be tolerated and contribute little to spoilage in meat destined for extended storage (Gill 1986).

Sensory traits.

Scores for sensory traits were not affected by packaging method but were affected ($P < 0.05$) by storage time (Table 3). Sensory traits of loins (aroma, texture, flavour, and overall acceptability) were similar after 6 and 12 weeks, but were lower when loins were stored to 18 weeks. Juiciness scores did not differ. This indicates the maximum shelf life of chilled venison lies somewhere between 12 and 18 weeks since scores below 5 indicate panelists began to dislike the product.

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