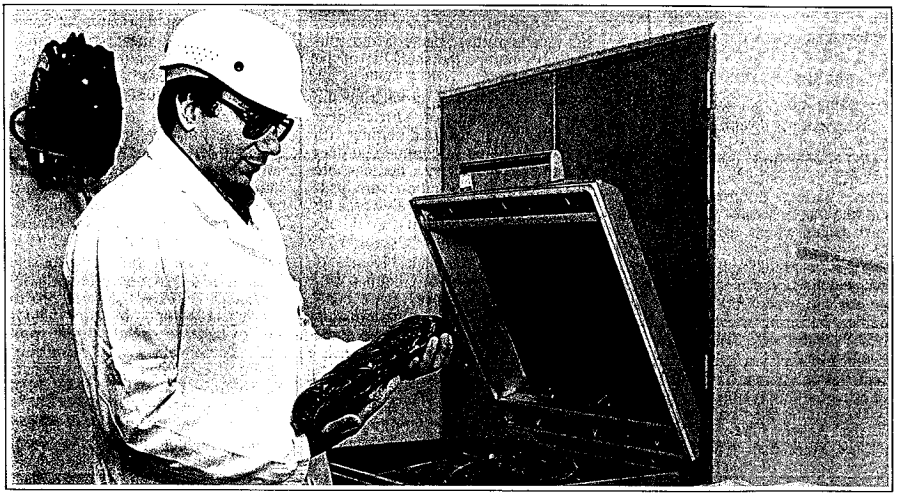
The three Cs; it's back to the basics

Trials reveal no added shelf life through alternative venison packaging

'Modified atmosphere' packaging using 100 per cent carbon dioxide has been found to extend the shelf life of chilled lamb. But with venison, it seems to be a different story. Dennis L. Seman of MAFTech's Invermay Agricultural Centre reports on recent studies . . .



Dennis Seman inspects vacuum-packed venison at Invermay

Twelve weeks' shelf life is possible with chilled venison, so long as it is properly prepared

THE PRESERVATION of meat for local consumption and export can be reduced to following the three Cs: Keep it cold, clean and covered. Out of these three basic principles has evolved the use of vacuum-shrink packaging systems which have been quite successful with the chilled boxed beef trade in the US.

Simply stated, the process includes the placing of either bone-in or boneless cuts into plastic bags of low oxygen and water permeability, extraction of air from the bag and the shrinking of the plastic film around the cut using hot water dip tanks or spray tunnels.

Meat stored in air at refrigerator temperatures usually has a shelf life of only five to six days because of rapid spoilage by cold-tolerant bacteria, especially Pseudomonas species, which produce slime, off odours and off colours in meat.

But because air (oxygen) is eliminated from the meat, vacuum packaging increases the shelf life of meat up to 10-12 weeks, if it's stored at -1 degree C. In addition, residual muscle tissue respiration scavenges any oxygen left in the package and raises the level of carbon dioxide.

These changes in the environment within the pack create conditions hostile to Pseudomonas organisms but suitable for the growth of lactic acid-forming bacteria. These bacteria have a much lower spoilage potential and are necessary for maximising shelf life.

The effects of vacuum packaging on the shelf life and quality of chilled venison have not been studied extensively even though up to 20 per cent — a figure which could rapidly rise to 50 per cent — of export venison is leaving New Zealand chilled.

Consequently, several studies have been conducted at the Invermay Agricultural Centre to evaluate vacuum packaged venison and to compare this with modified atmosphere systems using 100 per cent carbon dioxide.

Meat already packaged in carbon dioxide permeable films is placed in a second package which is flushed ▶

with air and filled with 100 per cent carbon dioxide at a rate of one litre per kilogram of meat. This process further preferentially selects for the growth of lactic acid bacteria while quickly eliminating organisms of high spoilage potential.

Two joint studies with Transpak Industries (Auckland), funded by the Game Industry Board, were designed to compare the effects of containment bags made of different materials (nylon; ultra-high barrier plastic, UHB; and an aluminium foil laminant) on the shelf life of chilled venison. High concentrations of carbon dioxide have already been used successfully for the maintenance of shelf life of beef and lamb where high and variable pH preclude vacuum packaging.

Pre-packaging factors

The initial microbial load of carcases is assessed by swabbing a known surface area of the carcase with a cotton swab and transferring the bacteria to a bottle of diluent solution. Various dilutions are made and the bacteria are plated out in petri dishes which are incubated at 35 degrees C on a non-specific medium (to provide all the nutrients for growth) stored in the air (called an aerobic microbial count). All viable bacteria incubated under these conditions will grow and create colonies.

Bacterial numbers are estimated and reported as colony-forming units or CFU per unit of surface area since all of the bacteria in that particular colony originated from a single bacterial cell or small clump of cells. It is generally thought that carcases with less than 1000 CFU per square centimetre are of excellent microbial quality, but aerobic microbial counts over 1,000,000 CFU per square centimetre indicate poorly handled carcases.

Although cold-loving spoilage bacteria such as Pseudomonas make up a small proportion of the total bacterial contamination of carcases (10-15 per cent), high levels of carcase contamination may result in high loads of these bacteria and considerably reduce the shelf life of the chilled meat.

Table 1

Average aerobic microbial counts of shoulder, mid-loin and leg regions of Red deer stag carcases slaughtered at three locations. Counts are reported in colony forming units per square centimetre (CFU/square centimetre) with the range of values in parentheses.

Location	Carcase Site		
	Shoulder	Mid-loin	Leg
Invermay	1 (0-11)	1 (0-24)	1 (0-16)
Plant B	33 (0-53,000)	30 (0-2000)	nd
Plant C	10 (0-10,000)	21 (0-158,000)	7 (0-2000)

nd = not determined

Studies at Invermay comparing the surface contamination of Red deer carcases, using inverted pelting with deer slaughtered in commercial deer slaughter premises, demonstrate that adequate precautions are usually taken in commercial works to ensure carcases of low bacterial contamination (Table 1).

Both commercial plants B and C (Table 1) have average counts well below 1000 CFU per square centimetre, although contamination levels ranged much higher on some carcases. Inverted pelting consistently gave very low microbial counts with small ranges.

Boneless loins removed from these carcases were sampled for aerobic microbial counts before vacuum packaging (Table 2).

Handling of meat during boning and transportation tends to increase bacterial counts by about 10 times, depending upon the manufacturing practices at the particular plant.

Plant B mechanically stripped the outer connective tissue sheath from each loin muscle, but while this resulted in visually attractive vacuum packaged venison it tended to increase the microbial load on the meat. This illustrates that all machinery used in the fabrication of bone-in or boneless meat for vacuum packaging may actually inoculate meat with bacteria — unless good sanitation practices are followed each day.

Since meat of high pH (6.0 or more) typically has reduced shelf life and is not suitable for extended chilled storage in vacuum packages, staff have been monitoring pH values of deer slaughtered in the Invermay abattoir for the past two years.

The pH values of the saddle muscle of all animals have been remarkably consistent and average from 5.6 to 5.7 depending upon location (values tend to increase slightly in the front end). These values have been consistent even when a few animals were exposed to unintentional high stress.

Hence the effects of high pH caused by pre-slaughter stress do not seem to be a major problem in Red deer. The pH from Fallow deer meat frequently reaches 6.0 or higher and, while this should theoretically reduce its shelf life when stored chilled, in practice it does not seem to.

Table 2

Average aerobic microbial count, reported as colony forming units per gram (CFU/g), boneless saddles taken from Red deer slaughtered in different plants. The range is indicated in parentheses.

Slaughter	Aerobic microbial count (CFU/g)
Invermay	22 (0-2000)
Plant B	355 (0-407,000)
Plant C	17 (0-7000)

Changes during chilled storage

Packaging meat in modified atmospheres containing 100 per cent carbon dioxide lowers the pH of the meat by about 0.1 to 0.2 pH units — apparently through the absorption of carbon dioxide into the meat fluids with the formation of carbonic acid.

This change probably has little effect on the microbial growth within the range of pH found in this study — but it may affect the colour stability of the chilled meat.

The types and numbers of bacteria change when meat is vacuum pack-

aged or packaged under modified atmospheres containing carbon dioxide (Table 3).

Lactic acid-forming bacteria dominated the microflora of both vacuum packaged and modified atmosphere packaged venison making up about 0, 75, 99 and 98 per cent after one, six, 12, and 18 weeks' storage respectively, regardless of packaging method.

These trends are typical of meat packaged by these methods and underscore the changes in the microbial populations from those initially dominated by cold-loving Pseudomonas spoilage organisms to populations dominated by rather innocuous lactic acid bacteria. Lactic acid bacteria eventually spoil meat, but they grow so slowly at -1 degree C that it takes many weeks for them to reach maximum numbers and cause 'off' odours.

Cooked samples of loin muscles were evaluated by 40 panellists at the Meat Industry Research Institute to determine palatability changes caused by the packaging method and chilled storage for 18 weeks.

Results indicated no significant differences in cooked meat aroma, flavour, juiciness or overall acceptability from varied packaging. But panelists consistently rated meat stored for 18 weeks as less desirable in aroma, flavour and overall acceptability than samples evaluated after six or 12 weeks. Maximum acceptable shelf life of chilled venison, expressed in terms of palatability seems to be between 12 and 18 weeks.

The decrease in palatability noted in meat stored for 18 weeks does not seem to be caused by changes in micro-organisms and may be an inherent quality of the meat.

The tenderness of venison loins did not differ through packaging method or length of chilled storage when measured objectively using the institute's Tenderometer. Previous studies indicated measurable tenderisation may take place as the meat is held chilled from one to six weeks, but that there's little improvement thereafter.

Table 3

Average lactic acid bacteria count, reported in colony forming units/gram (CFU/g), of venison saddle portions packaged in four treatments and stored from 1 to 18 weeks at -1 degree C.

Week	Type of Packaging			
	Vacuum	Carbon dioxide -Nylon (CFU/g)	Carbon dioxide -UHB	Carbon dioxide -Foil
1	0	0	0	0
6	31	26,000	65 33	
12	9 million	5 million	10 million	1 million
18	16 million	34 million	2 million	78 million

Although colour is not a particularly good indicator of meat quality, it is the primary criterion used by consumers when buying meat. They expect freshly cut meat to be bright red, and reject it if it's an unappetising brown.

The surface colour of packaged chilled venison loins opened and left for 30 minutes after 12 to 18 weeks' storage was drastically affected by the packaging method.

Meat packaged in vacuum packages and carbon dioxide-foil was redder than loins packaged in carbon dioxide-UHB. This is because the UHB material allowed more oxygen to permieate the gas pack and oxidise the pigment at the surface of the meat.

The brown colour, which did not significantly affect palatability, may be a problem only where the venison's consumer acceptability is based on visual perception. In a restaurant setting, colour means little to the consumer.

Although the UHB material allowed some surface discoloration, it has several advantages which commend it to gas flush packaging; it is cheaper than foil laminated films, it is not liable to pin holes and creasing, and it allows visual appraisal of the product.

Table 4

Days of display to reach a colour acceptability of 2 (purchase with reservation).

Treatment	Weeks of storage			
	1	6	12	18
Vacuum	5	4	3	2
Carbon dioxide -Nylon	4	3	1	1
Carbon dioxide -UHB	5	3	2	1
Carbon dioxide -Foil	3	3	2	2

In the studies, steaks were cut from venison loins and displayed for five days under fluorescent lights — simulated retail conditions — for colour evaluation by a trained panel of 15 people.

In the first study, vacuum packaged venison usually had the redder, more acceptable meat colour after each six week storage than meat packaged by any of the modified atmosphere methods.

But that trend did not follow consistently in the second trial. More differences were noted in the length of time the steaks exhibited acceptable colour during simulated retail display after being stored chilled for up to 18 weeks (Table 4).

Venison stored for one week before slicing and display could usually be expected to last four to five days before the colour became unacceptably brown. Approximately one full day of acceptable display was lost for each six weeks of chilled storage ending with less than one day of display life after 18 weeks. This indicates that chilled venison held more than six weeks may require special presentation if it is to be displayed as a retail item.

ALTHOUGH modified atmosphere packaging using 100 per cent carbon dioxide extends the shelf life of chilled lamb, it does not seem to confer any additional shelf life to chilled venison loins (saddles).

This may be due to the lower, less variable pH found in Red deer stag carcases, to the high microbial quality of the deer used in these studies, and to low storage temperature.

Any departure from good manufacturing practices that will increase microbial loads on meat cuts and not allow proper and adequate chilling and holding will decrease the shelf life of vacuum-packaged venison. □