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Retail ready Australian Kobe-style beef for the Japanese market

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Abstract

An oxygen-free saturated carbon dioxide packaging system was developed to supply retailer-ready (1 kg) Australian beef cuts directly to retailers and catering outlets in Japan. Emphasis was placed on attractive in-pack appearance and retail display performance. The retail display life of steaks cut from retailer-ready packs was limited by a grey or green fat discoloration that occurred after 48 to 72 hours display. Clear plastic and metallized film carbon dioxide packs performed comparably but provided no display-life advantage over conventional vacuum packaging. Retailer-ready packaging technology requires further development before a second round of evaluations can be reasonably considered. However, the better control of microbial growth afforded by carbon dioxide packaging will provide commercial advantage where onset of microbial spoilage and not colour stability at retail is likely to be the process-limiting condition.

and sensory attributes of the steaks remained acceptable for up to 48 hours after product was rejected because of grey and green fat discolouration that occurred after 48 to 72 hours display. No significant product-life, or display-life advantage was obtained through the use of the technically difficult CO_2-CAP master pack procedure. Both clear plastic and metallized film packs performed comparably although the former was preferred in Japan because the meat within the pack was visible to the customer. Little commercial interest was found as the system appeared to offer no cost or performance advantages over the importation of conventional vacuum-packed primal cuts.

Recommendation: Basic research needs to be undertaken to understand the mechanism by which the fat component of meat subjected to prolonged chilled storage in vacuum and CO_2-CAP packs discolours during subsequent retail display. Retailer-ready packaging technology should be further developed to rectify the problems identified in the pilot scale trial before a second round of market evaluations can be reasonably considered.

Commercial exploitation: Results of the project, obtained to date, do not lend themselves to immediate commercial application. However, resolution of the technical problems identified in this pilot study, particularly drip control and pack conformation, supported by active market promotion may foster commercial interest in sub-primal packaging of chilled beef for the Japanese market. The better control of microbial growth exhibited by CO_2-CAP packaging would give commercial advantage where spoilage onset is likely to be the process-limiting condition within the export time frame, e.g. for export of chilled pork or lamb rather than Australian feedlot beef.

Research Report

1. Background

The Australian beef feedlot industry produces high quality heavy grade carcasses suitable for the Japanese Kobe-style beef market. To enter this elite trade, beef presented to the consumer must comply with very stringent standards of perfection. In the consumer's eyes the most important are freshness, the marbling of fat within the lean and the colour of both fat and lean. Appropriate conformation and marbling can be assured by a high plane of nutrition and appropriate feedlot husbandry practice. Meat and fat colour as perceived in the market place are in no small part determined by the packaging system and transport regime used to present chilled Australian Kobe-style beef to individual outlets in Japan. Freshness, in the absence of slaughter date or packaging information, is judged subjectively by consumers using product colour and odour as quality indicators.

Preliminary commercial scale trials have indicated the potential for saturated carbon dioxide controlled atmosphere packaging to allow a wide range of customized cuts to be supplied to retail outlets for on-site fabrication in accordance with the wishes of individual customers. Where full service butchery facilities are not available, display of prepacked individual slices of product appears to be becoming increasingly acceptable. However, customers who purchase prepacked product are very conscious of "packed on dates" appearing on retail packaging.

An exploratory literature search suggests that backward and forward vertical integration is being actively pursued by Japanese meat wholesalers. This integration extends to ownership of cattle raising facilities in the US and Canada, as well as in Australia. These wholesalers often make several deliveries per day supply product on a "just in time" basis to retailers . The reasons for frequent delivery are high storage costs, limited display space and above all a demand for freshness in food products. Retailers, therefore, require delivery of small quantities of meat on a regular basis. Furthermore, to satisfy customer demand for freshness an element of on-site fabrication is essential. A packaging system that will satisfy these requirements for the direct supply of small cuts and maximise, within the restraints imposed by the traditional and cultural sensitivities of the Japanese meat trade and its customers, the Australian value-added component will be developed and trialed in the present study.

4. Methodology

4.1 Identification of Retail Requirements

Anticipated problems associated with date labelling of retail packs suggest that Japanese retailers require user friendly packs of relatively small size (single day's supply), that can be fabricated on-site, to provide display product on an as and when required basis. The form of presentation of Australian Kobe-style beef either directly to the consumer or for further processing at retail outlets was determined principally through Japanese supermarket contacts (Tak & Co, Fukuoka, Japan) supported by a review of available literature and a brief visit to Japan by Dr R.G. Bell.

4.2 Development of a Pilot Scale Packaging System

Concept

The Japanese meat trade, insists on seeing what it is buying. Unfortunately, the only gas-impermeable packaging films currently available for CO_2-CAP, aluminium foil laminates and double metallized films, have the silver appearance of aluminium metal, making it impossible to observe product within the sealed packs. Consequently, it was considered essential in a feasibility trial introducing a new marketing/distribution concept that transparent CO_2-CAP packs be used alongside metallized CO_2-CAP packs.

Because attractive presentation is important to the Japanese market a special "eight-pack" display carton was designed for the retailer-ready packs. To meet the need for good visual display of the cartoned product, cuts of meat within individual CO_2-CAP dioxide packs (approx. 1 kg each) were placed into small eight-pack cartons, with equal numbers of metallized and clear plastic packs arranged alternately in two four-pack rows. This arrangement allowed customers to see the product in the clear plastic packs, while ensuring comparable treatment for the two pack types. To further facilitate product inspection, the packaged retailer-ready cuts were placed within the cartons so that a cross-section was visible, i.e. cuts were placed at right angles to the normal packaging presentation of vacuum-packed whole striploins, which is on their sides with the backbone side down. In the CO_2-CAP master pack cartons, the blocks of four clear and four metallized packs were sealed inside a clear plastic barrier bag that allowed visual inspection of the unit packs it contained.

(Ebro TFV 392, Ingolstadt, Germany). The external fat layer was then trimmed from the striploins and cube rolls, as requested by Tak & Co, Fukuoka, Japan. The primal cuts were then cut transversely into portions approximately 10 cm thick each weighing between 750 and 1000 g. Microbiological samples of a representative number of these retailer-ready cuts were taken immediately before packaging using the wet and dry swab technique (Cook, 1991). Aerobic plate counts were performed on these samples by the Food Science Department of the Royal Melbourne Institute of Technology. Three drip saver pads (Dri Loc AC50 Fabri Cell, Auckland, NZ) were wrapped around each retailer-ready portion so as to leave one cross-section surface visible. Each wrapped cut was then slid into a white plastic sleeve (0.5 mm ABS, AHI Plastic Moulding Company, Hamilton, NZ) with the exposed cross-section surface up. The sleeved meat cut was then placed into a primary packaging pouch; either clear plastic or metallized film; and packaged in a 1 L carbon dioxide atmosphere using a Securepack 2, controlled atmosphere packaging machine. Similarly prepared retailer-ready cuts, to serve as controls, were placed into BB4L pouches and vacuum packed.

Groups of eight primary test packs, four clear plastic and four metallized film, or eight vacuum packs were placed into an outer barrier bag liner inside a specially designed "eight-pack" carton and returned to the chiller. The carton liner was made from a nylon barrier film (Trigon Packaging Systems, Hamilton, New Zealand) with a stated oxygen transmission rate of 35 ml/m^2/atm/24 hr at 25°C. A Delphi electronic data logger (Tru-Test, Auckland, NZ) was placed into each of six test pack cartons to monitor temperature during shipment and storage. Cartons containing monitors were clearly identified and excluded from use as master pack treatments. The volume of carbon dioxide introduced (1 L) was calculated to allow almost full absorption of the gas, leaving a relatively tight pack of attractive appearance. After 48 hours absorption at chiller temperature, those cartons designated for master pack treatment were returned to the boning room. Before secondary packaging, six sachets of Z100GA Ageless™ (Mitsubishi Gas Chemical Company, Tokyo, Japan) were placed into each outer barrier bag. Each carton of eight primary packs was placed into the chamber of the Securepack 25 machine and the outer barrier bag liner was evacuated and sealed after the introduction of approximately 2 L of carbon dioxide. Master pack cartons were then returned to the chiller to continue temperature equilibration prior to loadout and shipment to New Zealand and Japan.

- **Colour stability during retail display**

A 10 mm thick steak was sliced from the exposed end of each retailer-ready cut. (One of the three control cuts was sampled from both ends to obtain the required number of samples.) The 20 end steaks were each individually placed cut-side down on drip pads in white polystyrene trays and overwrapped with oxygen permeable cling film. A second steak was then cut and prepared cut-side up for display as described above. Each of the four test treatments and the control were therefore represented by four steaks displaying an "uncut" surface and four displaying a freshly cut surface. From these, ten steaks, one uncut and one cut surface, for each treatment and the control were randomly numbered and placed into a display cabinet operating at 0°C. After two hours the colour of each display steak was measured using a Hunter Lab Mini Scan colour meter (Hunter Associates Laboratory Inc., Reston Virginia, USA). Additional readings were taken after 98 and 170 hours display. The colour measurements taken were CIELAB L* (lightness), a* (redness) and b* (yellowness).

Colour panel assessment was commenced after six hours display and continued on a daily basis, weekends excluded, for a week. At each assessment, up to 20 panellists from an experienced 25-member colour assessment team judged the displayed product under cool white fluorescent lights (Philips TLD 84). Lean colour was assessed on a three-point hedonic scale where 3 = good, 2= acceptable and 1 = marginal to poor; fat colour was also assessed on a three-point scale where 3 = white, 2 = pink and 1 = other (grey or green discoloration).

The 30 steaks not used for colour stability assessment were stored in another part of the display cabinet with one slice of each treatment removed after 6, 98 and 170 hours display for microbiological examination and sensory assessment.

- **Microbiology examination**

Immediately after opening the retailer-ready packs, the wet and dry swab technique (Cook 1991) was used to obtain microbiological samples from the three control packs and three cuts from each of the four test treatments. The swab technique was also used to sample steaks after 6, 98 and 170 hours on display. Initial homogenates of the sample swabs were prepared in sterile dilution fluid (0.1% peptone, 0.85% NaCl) and 0.1 ml volumes of appropriate dilutions thereof were spread onto the surface of Plate Count Agar half plates. The colonies that developed after 72 hours incubation at 25°C were counted. The aerobic plate count per unit surface area was then calculated. For retailer-ready packs opened after 67 and 89 days storage, the

The set of trial packs retained by Prima Meat Packers was returned to the storage chiller for a further 96 hours, after which the packs were removed for visual and sensory assessment.

- **Sunny Supermarket, Hirao, Fukuoka City**

The Supervisor of the meat department, Mr Miyazaki, conducted the assessment. The appearance/visual appeal of the unopened packs was first assessed. The packs were then opened and the meat was exposed to the air for a few minutes before meat odour and colour were assessed. Two steaks were then sliced from each of the retailer-ready cuts. Each pair of steaks was placed onto a drip saver in a polystyrene tray, and overwrapped for retail display. The colour of the steaks was assessed just before they were placed into the display cabinet in the supermarket, and colour was then assessed after 24, 48, 72 and 96 hours display. Although sensory assessment was to have been done at display packaging and after 96 hours display, no cooking facilities were available on the store premises. Consequently, sensory assessment was done only after 96 hours display when Mr Miyazaki could take the test steaks home for cooking.

- **Iwataya Department Store, Tenjin, Fukuoka City**

Mr Yushi Taki the meat department Assistant Manager responsible for the "Aussie Beef" counter, conducted the assessment. The assessment procedure was the same as that used at the Sunny Supermarket. Fortunately, cooking facilities were available as part of an "Aussie Beef" promotion, so limited sensory assessment was undertaken.

- **New Otani Hakata Hotel, Watanabe-Dori, Fukuoka City**

Mr Shikoo Kiruchi, the hotel's occident cuisine Chef conducted the assessment. As with the retail assessments, the visual appeal of the unopened retailer-ready packs was judged. The meat was then removed from the packs and a single steak cut from each and placed onto a plate. The rest of each cut was put into the refrigerator for storage. After five minutes exposure to the air, odour, colour and sensory assessments were made. The next day, the assessment process was repeated using a second steak sliced from each retailer-ready cut. This process was repeated on a daily basis for the next three days.

- **Meat colour measurements**

During the first assessment (meat from packs opened 39 days after packaging) Dr Victor Powell of CSIRO Meat Research Laboratories, Cannon Hill, Queensland, used a Minolta colour meter to objectively measure colour changes occurring during

severely disrupted. (The pack seals, however, were not ruptured.) In the first attempt at master packing, the carton split due to the sudden increase in the volume of its contents. Subsequently, the eight retailer-ready packs and liner bag were removed from the cartons, carbon dioxide packed in the Securepack 25 machine, and then returned to those cartons. The volume of carbon dioxide introduced into the master pack, 2 L, was insufficient. The master pack ended up being partially evacuated, so that it was difficult to reposition the retailer-ready packs after their orderly arrangement had been disrupted during the evacuation cycle.

Cartons were selected so that only striploins were shipped to Japan. The shipment to MIRINZ was made up of a mixture of striploins and cube rolls. Three CO_2-CAP single pack cartons containing temperature monitors were included in each of the shipments, see temperature history results.

5.2 Product Evaluation at MIRINZ

Temperature history

The three temperature histories for product from retailer-ready packaging in Melbourne to preparation for retail display at MIRINZ were very similar. An example is presented in Figure 1.

The chiller at Crown Lamb failed to reduce product temperature much below 4°C. On arrival at MIRINZ, product temperature was reduced to and maintained at approximately -0.25°C for the duration of the trial.

opened after 39, 53, 67 or 89 days chilled storage. With the vacuum packed control, treatment E, confinement odours were evident in packs opened after 67 and 89 days chilled storage.

On exposure to the air, retailer-ready cuts from all packaging treatments bloomed to the attractive red colour of oxygenated fresh meat. Meat colour and colour changes are considered in detail in the next section.

Colour stability during retail display

Colour panel assessment of steaks during retail display at 0°C are presented in Table 1. Assessments were analysed on a majority score basis to exclude bias introduced by ultra-critical or ultra-lenient panellists.

The colour of the outside surface of the retailer-ready pack, "uncut" in Table 1, and that of the freshly cut surface were similar during display and the retail display performances of steaks cut from the five retailer-ready pack treatments were essentially the same. Using the same majority score assessment system, it appears that fat colour, not meat colour, limits retail display life (Table 2). The fat colour was initially pink, rather than white, as a result of drip stain during chilled storage. The steaks became unacceptable to the panellists after 48 hours display through the appearance of grey or greenish patches in the fat. The problem of fat discoloration may have been even more serious if the external fat layer had not been removed from the steaks when they were prepared for packaging.

Table 2

Majority score fat colour assessment of uncut and cut surfaces of steaks cut from meat in retailer-ready packs after 39, 53, 67 and 89 days chilled storage, respectively, using a three-point scale where 3 = white, 2 = pink and 1 = other (grey or green).

Display time (h)	CO_2-CAP Single		CO_2-CAP Master		Control
	Clear (A)	Metallized (B)	Clear (C)	Metallized (D)	Vacuum (E)
Uncut					
6	2, 2, 2, 2	2, 2, 2, 2	2, 2, 2, 2	2, 2, 2, 2	2, 2, 2, 2
24	2, 2, 2, 2	2, 2, 2, 2	2, 2, 2, 2	2, 2, 2, 2	2, 2, 2, 2
48	2, 2, 1, 1	2, 2, 1, 1	1, 2, 2, 1	2, 2, 2, 1	2, 2, 2, 1
72	1, 1, 1, 1	1, 1, 1, 1	2, 2, 1, 1	1, 1, 1, 1	2, 2, 1, 1
96	1, 1, 1, 1*	1, 1, 1, 1*	1, 1, 1, 1*	1, 1, 1, 1*	1, 1, 1, 1*
168	1, 1, 1, 1	1, 1, 1, 1	1, 1, 1, 1	1, 1, 1, 1	1, 1, 1, 1
Cut					
6	2, 2, 2, 2	2, 2, 2, 2	2, 2, 2, 2	2, 2, 2, 2	2, 2, 2, 2
24	2, 2, 2, 2	2, 2, 2, 2	2, 2, 2, 2	2, 2, 2, 2	2, 2, 2, 2
48	2, 1, 1, 2	2, 2, 2, 1	2, 2, 2, 2	2, 2, 2, 1	2, 2, 2, 1
72	1, 1, 1, 1	2, 1, 1, 1	1, 1, 2, 1	2, 1, 1, 1	2, 1, 1, 1
96	1, 1, 1, 1*	2, 1, 1, 1*	1, 1, 1, 1*	2, 1, 1, 1*	2, 1, 1, 1*
168	1, 1, 1, 1	1, 1, 1, 1	1, 1, 1, 1	1, 1, 1, 1	1, 1, 1, 1

* after 150 h.

Hunter CIELAB colour measurements of the uncut and cut lean surfaces of the steaks after 2, 98 and 168 hours display have been reported in full (Bell *et al.*, 1994). The generally high standard deviation about the mean indicates considerable colour variation within the individual steaks. The a* values (redness) decreased with both time displayed and time stored in retailer-ready packs (Table 3), and the uncut and cut surfaces behaved in a similar manner. There does not, however, appear to be a direct correlation between the Hunter CIELAB a* values and panellist assessments (Table 1). Clearly the assessors' perception of acceptability included factors in addition to the "redness" of the meat.

Sensory evaluation

Steaks cut from retailer-ready packs after 53, 67 or 89 days storage were not assessed after 170 display because they had developed spoilage odours.

Mean scores for overall acceptability are given in Table 4. Standard deviations are relatively high, which means that care must be taken when interpreting the results. The overall acceptability of steaks after 2 hours display, particularly the cut surface steaks, did not differ markedly between treatments but improved slightly with storage time. Acceptability usually decreased during display, and that decrease was most marked in steaks cut from the vacuum packed control packs. This observation is compatible with the microbial counts (Table 6), which show that steaks cut from vacuum packs had generally higher counts after 98 hours display than did those from the carbon dioxide packs.

Microbiological examination

The development of the spoilage microflora in retailer-ready packs during chilled storage is summarized in Table 5. All four carbon dioxide packaging treatments, A, B, C and D, effectively retarded microbial proliferation. With vacuum packaging, the high populations after 67 and 89 days storage were associated with the development of confinement odours.

Table 5

Aerobic plate count, $\log_{10}$ CFU/cm^2, of retailer-ready cuts after 0, 39, 53, 67 and 89 days chilled storage.

Time stored (days)	CO_2-CAP Single		CO_2-CAP Master		Control
	Clear (A)	Metallized (B)	Clear (C)	Metallized (D)	Vacuum (E)
0	2.95	2.95	2.95	2.95	2.95
39	2.47	2.02	1.15	4.81	4.43
53	1.58	3.20	1.96	2.27	3.32
67	1.57	3.74	2.21	3.55	5.79
89	1.85	2.20	1.30	4.97	6.50

When the meat is transferred from retailer-ready packs to retail display packaging, the microflora on the meat is subjected to a change in gaseous environment from anaerobic to aerobic. Furthermore, during cutting and packaging, microorganisms present in the processing environment can contaminate the meat. The changes in the microflora on uncut and cut surfaces of steaks from retailer-ready packs during retail display at 0°C are shown in Table 6.

Despite the large difference in the initial microflora found on the uncut and cut surfaces of paired steaks from vacuum packed retailer-ready packs (treatment E), subsequent spoilage development appears similar. The difference in initial microflora on uncut and cut surfaces of paired steaks from carbon dioxide retailer-ready packs was small compared to that observed for vacuum packs. Spoilage microflora development on the paired steaks appears to be similar as does the development on steaks from different retailer-ready packaging treatments. Some doubt must exist concerning the validity of the low counts obtained for some steaks after 170 display, as all these steaks from retailer-ready packs opened after 53, 67 and 89 days storage were excluded from sensory evaluation because of spoilage odours.

The microflora found on the spoiled steaks after 170 hours display were dominated by either lactic acid bacteria or aerobic pseudomonads. The descriptors applied to the "off" odours indicating spoilage onset ranged from dairy, to sour-acid, to stale to sweet putrid. These could describe early lactic souring, advanced lactic souring, early pseudomonad spoilage (aerobic) and advanced pseudomonad spoilage, respectively, which would be entirely consistent with the limited microbiological data available from the present study.

5.3 Production Evaluation in Japan

Product evaluations reported in this section are a combination of personal observations made by Dr R.G. Bell during assessments conducted between 5-9 September 1994, and those performed by the Japanese assessors during this and the two subsequent sessions. During these latter sessions it appears that the retail and hotel assessors did not open the packs on the days they were received. Consequently, the storage time prior to pack opening given in the results differs between assessors.

Temperature history

The traces from the three temperature loggers were similar, and a representative temperature history of product from packaging in Melbourne to distribution from Prima Meat Packers' Yasuyu-gan plant is shown in Figure 2.

The chiller at Crown Lamb failed to reduce product temperature much below 4°C and therefore represents a weak link in the cold chain. However, consolidation of the trial shipment into a sea freight container effectively reduced product temperature to approximately -0.8°C, which approaches the optimum of -1 to -1.5°C. The temperature during the sea voyage was well maintained. As might be

were not visible, these packs were also tight, indicating undergassing. The immediate reaction of the Prima Meat Packers staff was that the metallized film packs were totally unacceptable because their contents could not be seen. The description used was "tight, misshapen mystery packs".

If the CO_2-CAP single pack cartons were less than satisfactory, the CO_2-CAP master pack cartons were little short of disastrous. As discussed previously, the master packing operation had seriously disrupted the tidy arrangement of the retailer-ready packs. On carton opening, the observer was confronted with a confused mess of plastic, foil and oxygen absorber sachets. When the first CO_2-CAP master pack carton was opened for product assessment, two of the clear plastic packs (treatment C) bloomed in the time taken to assemble the four assessment sets, and therefore, were leakers. These leaker packs were included in the assessment sets for evaluation at the two retail outlets.

The three sets of four treatments for evaluation at the retail outlets and the hotel were loaded into a very small refrigerated truck for delivery. The set destined to remain at Prima Meat Packers was returned to the storage chiller along with the remaining three master pack and three single pack cartons. When the four trial packs were removed from the chiller after 96 hours storage, it was evident that the treatment C pack was a leaker, as the meat within this pack was distinctly brown. The meat from the master pack metallized film pack, treatment D, looked "tired" and was disfigured by a brown metmyoglobin spot. Almost reluctantly, Mr Nakayama organized for the product to be prepared for sensory evaluation (the only sensory evaluation actually performed by Prima Meat Packers). The results of this evaluation are shown in Table 7.

Table 7

Assessment of steaks cut from retailer-ready packs removed from cartons at Prima Meat Packers' Kasuya-gun plant after 39 days chilled storage and held for a further 96 hours "holding" at 0°C. Meat scores are reported on a three-point hedonic scale where 3 = good, 2 = acceptable and 1 = marginal to poor.

	Pack type			
	CO_2-CAP Single		CO_2-CAP Master	
Attribute	Clear (A)	Metallized (B)	Clear (C)	Metallized (D)
Appearance of retailer-ready packs	3	2	1	2
Meat colour after 96 hours "holding"	2	2	1	1
Meat odour after 96 hours "holding"	3	2	1	1
Meat flavour after 96 hours "holding"	1	2	1	1

suggests that microbial numbers had not reached spoilage levels, i.e. colour stability and not microbial spoilage onset was the factor determining display life.

Table 8

Assessment of steaks cut from retailer-ready packs at the Sunny Supermarket, Hirao, Fukuoka after 39, 55 and 71 days chilled storage, respectively. Meat scores are reported on a three-point hedonic scale where 3 = good, 2 = acceptable and 1 = marginal to poor.

	Pack type			
	CO_2-CAP Single		CO_2-CAP Master	
Attribute	Clear (A)	Metallised (B)	Clear (C)	Metallized (D)
Appearance of retailer-ready packs	1, 3, 3	2, 3, 3	2, 3, 3	2, 3, 2
Meat colour after				
5 minutes after pack opening	2, 2, 2	2, 2, 2	2, 2, 3	2, 2, 1
0 hours display	2, 2, 2	2, 1, 2	2, 1, 2	2, 2,2
24 hours display	3, 3, 3	3, 3, 3	3, 3, 3	3, 3, 2
48 hours display	2, 2, 2	2, 2, 2	2, 2, 3	2, 2, 1
72 hours display	1, 2, 1	1, 2, 1	1, 2, 2	1, 2, 1
96 hours display	1, 1, 1	1, 1, 1	1, 1, 2	1, 1, 1
Meat odour after				
5 minutes after pack opening	2, 2, 1	2, 2, 1	2, 2, 1	2, 2, 1
Meat flavour after				
96 hours display	2, 2, 2	2, 2, 2	-, 2, 2	-, 2, 2

- not reported

Iwataya Department Store, Tenjin, Fukuoka City

Results of the retail display assessments are presented in Table 9. Compared with steaks at Sunny Supermarket (Table 8), the steaks at Iwataya Department Store had better colour stability. This effect almost certainly resulted from the lower display case temperature, 2 to 3°C in the vicinity of the meat, and the fact that the trial steaks were transferred to a chiller at the close of each day's business. The meat temperature measured when the steaks were returned to the display cabinet each morning averaged 1.5°C. Furthermore, the trial display packs remained in the chiller for the first 36 hours after their preparation because the store does not open on Tuesdays.

Although the colour stability would have allowed the steaks to be displayed for several days, this would not accord with the Department Store's commercial policy. Meat at Iwataya is displayed only on its "pack on" day. In other words, if product

New Otani Hakata Hotel, Watanabe-Dori, Fukuoka City

The hotel/restaurant assessment was conducted by Mr Shiho Kiruchi, the hotel's occident cuisine Chef, who commented that the retailer-ready cuts should have been trimmed to leave a 3 mm layer of subcutaneous fat.

The meat colour became unacceptable before either serious meat odour or flavour deterioration was detectable (Table 10). The large walk-in chiller/refrigerator in the occident cuisine kitchen operated at temperatures as high as 11 °C, despite being set at 0 °C. Temperatures were high because during busy periods, e.g. lunch and dinner, staff were in and out of the chiller frequently. Furthermore, the chiller was a general-purpose piece of equipment used not only for meat storage, but also for cooling desserts, fruit, vegetables and cheese.

Table 10

Assessment of steaks cut from retailer-ready packs at the New Otani Hakata Hotel, Watanabi-Dori, Fukuoka after 39, 54 and 68 days chilled storage, respectively. Meat scores are reported on a three-point hedonic scale where 3 = good, 2 = acceptable and 1 = marginal to poor.

	Pack type			
	CO_2-CAP Single		CO_2-CAP Master	
Attribute	Clear (A)	Metallized (B)	Clear (C)	Metallized (D)
Appearance of retailer-ready packs	2, 2, 2	-, 3, 3	2, 3, 2	3, 2, 3
Meat colour after				
5 minutes after pack opening	2, 3, 1	2, 2, 2	1, 3, 1	2, 2, 2
24 hours holding	3, -, 3	2, 2, 2	3, 3, 3	2, 3, 2
48 hours holding	3, 2, 3	2, 1, 2	3, 3, 3	-, 2, 2
72 hours holding	1, 1, 2	1, 2, 3	1, 2, 2	3, 2, 2
96 hours holding	1, -, -	1, -, -	1, -, -	2, -, -
Meat odour after				
5 minutes after pack opening	2, 2, 2	2, 2, 2	2, 3, 2	2, 2, 2
24 hours holding	2, -, 2	2, 1, 2	3, 3, 3	2, 2, 2
48 hours holding	2, 2, 2	2, 1, 2	2, 2, 2	-, 2, 2
72 hours holding	3, 1, 2	2, 1, 2	2, 2, 2	2, 2, 2
96 hours holding	2, -, -	2, -, -	1, -, -	2, -, -
Meat flavour after				
5 minutes after pack opening	2, 2, 2	3, 1, 2	2, 3, 2	2, 2, 2
24 hours holding	2, -, 2	3, 2, 2	2, 3, 3	2, 2, 2
48 hours holding	2, 2, 2	2, 3, 2	3, 3, 3	-, 2, 2
72 hours holding	2, 1, 2	1, 2, 3	1, 3, 2	2, 2, 2
96 hours holding	2, -, -	1, -, -	1, -, -	2, -, -

- not reported

area and necessitate frequent defrost cycles because of the high humidity experienced in Southern Japan. Effectively, Prima Meat Packers were saying that the product had to perform under existing commercial conditions and that any suggestion that those conditions be modified to accommodate a specific product's display life limitations were commercially naïve.

The pilot scale trial packs were prototypes and not surprisingly proved to be less than perfect. Further development is clearly required to control drip and prevent the muscle collapse that caused the retailer-ready cuts to shrink into the plastic sleeves. It was suggested that the cut orientation adopted to allow visual display of the cross-section within the retailer-ready packs resulted in a low packing density and caused, or exacerbated, muscle collapse. One solution would be to pack the retailer-ready packs in the conventional presentation, i.e. on their sides back-bone side down. This presentation, while reducing the risk of muscle collapse, would also allow drip-absorption capacity to be concentrated at the large end of the cut. Alternatively, the sleeve depth could be reduced so that the retailer-ready cut would initially protrude above the sleeve. With subsequent muscle collapse, the meat would contract to comfortably fill the sleeve.

The necessity for the sleeves was questioned in Japan, as their use in the prototype packs did little to enhance product appearance. Furthermore, the sharp edges of the sleeves almost certainly contributed to the relatively high incidence of leakers. This situation was made worse by the undergassing of the packs. The carbon dioxide was completely absorbed causing the packaging material to be squeezed against the sleeved meat cuts. Display performance differences between CO_2-CAP single and CO_2-CAP master pack presentations were minimal and appear not to warrant further development of the latter system at present.

The results of this pilot scale study must be considered in the context of Japanese market requirements if the commercial potential of the retailer-ready packaging system is to be assessed. Japanese retail outlets selling pre-packed meat are required to label that meat with a "packed on" and "use by" date. Also included on that label is a warning to the customer to keep that meat below 10°C during home storage. Currently, the "use by" date is three days after the "packed on" date, e.g. packed on 94-9-8, use by 94-9-11. In other words, product is expected to remain in an acceptable condition in its display pack for at least 72 hours. Therefore, a 72 hour display life is the minimum performance needed for Australian export beef destined for the Japanese retail market. However, part of that 72 hours is likely to be home storage under marginal refrigeration, so a display life capability of 96 hours

leading to the onset of lactic acid spoilage. This scenario is likely to be limited to the original outside surfaces of retailer-ready cuts. In contrast, on cut steak surfaces where the initial microflora is small, the faster growing pseudomands introduced as contaminants during preparation for retail display would predominate under aerobic display conditions. Under less hygienic conditions of preparation, cut steak surfaces could become heavily contaminated with a lactic microflora, following contact with drip transferred to work surfaces during pack opening, resulting in lactic acid spoilage development.

This pilot scale study has not demonstrated that the use of carbon dioxide packaging of retailer-ready cuts offers any commercial advantage over conventional vacuum packaging. The better control of microbial growth exhibited by carbon dioxide packaging would offer commercial advantage where spoilage onset is likely to be a process-limiting condition within the export time frame, e.g. for export of chilled pork or lamb. In respect of grain-fed beef, the superior microbiological status of steaks from carbon dioxide packs did not compensate for, or influence, the rate of fat colour deterioration. However, it may prolong organoleptic acceptance where the consumer does not see the raw product, i.e. in the hotel-restaurant-institutional (HRI) sector.

The trial sample sent to Japan was too small to allow realistic assessment of the commercial potential for retailer-ready packs. Furthermore, acceptance of the system would have been influenced by the all-too-obvious problems associated with the trial shipment. To allow the commercial potential of retailer-ready packaging to be adequately assessed, a second pilot scale trial appears warranted. That trial would involve only clear plastic CO_2-CAP packs and vacuum packs. The packaging density and meat shrinkage (muscle collapse) problems would be addressed through changed orientation of the retailer-ready packs within a modified carton. Retailer-ready pack appearance would be improved by increasing drip absorption capacity, reducing sleeve depth and increasing the gas volume to meat weight ratio.

The technical problems associated with the first trial shipment indicates quite clearly that commercialization would be premature. Commercial interest assessment indicated that in 1995 there was no place for retailer-ready packs in the Japanese meat marketing system, irrespective of the type of packaging used. It is difficult to discern whether this opinion resulted from, or was prejudiced by, conservatism, prior experience, economic arguments including *ad valorem* tariffs or the mixed results obtained in this trial. It must, however, be concluded, that CO_2-CAP retailer-ready packaging requires further technical development. The potential users

8. Recommendations

1. Basic research needs to be undertaken to understand the mechanism by which fat subjected to prolonged chilled storage discolours during subsequent retail display.
2. Retailer-ready packaging technology should be further developed to address the concerns identified in the pilot scale trial before any further market evaluations are considered.
3. When market research indicates a willingness by Japanese importers to re-consider sub-primal packs a larger evaluation trial should be conducted, using single pack clear plastic carbon dioxide and vacuum retailer-ready units, to determine the commercial viability of the packaging concept. Such a trial should include a well targeted commercial evaluation base and a strong element of product promotion such as in-store tasting.

9. Impact on Meat and Livestock Industry

9.1 Present Time

The concept and technological perfection of retailer-ready packaging for the Japanese market have not progressed to a stage where any significant immediate industry impact could be anticipated. The results obtained do, however, warn industry not to expect fresh meat display performance from long stored chilled product. This information may prove valuable in refining strategies for marketing Australian chilled meats in quality conscious countries such as Japan. From a further research point of view prevention of early discoloration of fat during retail display is of paramount importance to the whole concept of retailer-ready packaging.

9.2 Five Years Time

Unless further work is undertaken to resolve the problem of early fat discoloration and pack presentation, retailer-ready packaging is likely to be consigned to the "good ideas that did not catch on" category. Retailer-ready packaging's future may lie in providing long-life chilled meat packs for direct purchase by consumers rather than serving as a supply vehicle to supply meat for on-site preparation for retail display.