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Internal Report No. 72

Asparagus: Effect of Changed Atmospheres on Fresh Asparagus Quality

A report prepared for the New Zealand Asparagus Council

Winna Harvey

June 1992

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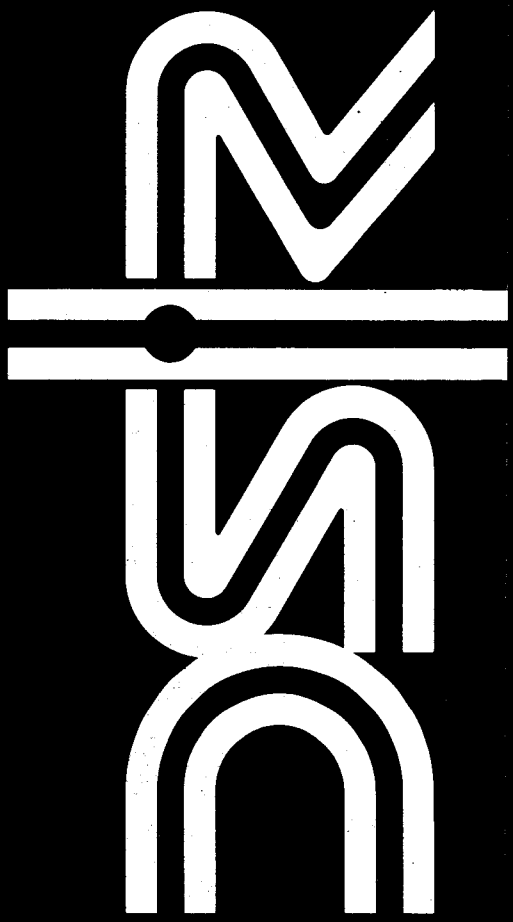

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Making Science Work For New Zealand

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1 EXECUTIVE SUMMARY

Modified atmosphere packaging was seen as a possible technique to be used to counteract the effects of warm temperatures which occur during export of fresh asparagus.

Five commercially available films were used to package 1 kg lots of asparagus which were then subjected to a time/temperature regime simulating air freighting to, and marketing of asparagus in Japan.

The non-perforated film used resulted in over-modification with pack atmospheres in which CO_2 increased and O_2 decreased to unacceptable levels. Consequently there was damage to spears. However, these films may have been more useful for smaller packs where the ratio of film to asparagus would be higher.

The micro-perforated films prevented the spears drying out, resulting in fresher looking spears. The gas modification in these films was in the range 6-9% CO_2 and 9-13% O_2. High humidity in packs was a problem with the development of mould very soon after the packs were opened.

2 INTRODUCTION

The cool chain for exporting fresh asparagus to Japan is not ideal. The temperature should be kept as low as possible (0-4°C) without freezing, but it tends to rise to 15°C or higher during various stages, particularly:

during the air flight,
while awaiting fumigation and during fumigation,
and during re-packing into smaller sized portions.

Because of the variable temperature regime of the distribution system, another means of reducing the respiration rate was required.

When respiring vegetables are packaged in an appropriate permeable film, an equilibrated atmosphere suitably depleted in O_2 and enriched in CO_2 develops. This can retard product respiration and the associated biochemical processes involved in ripening and senescence. This packaging technology is referred to as Modified Atmosphere Packaging (MAP) and differs from controlled atmospheres (CA) where the gases are constantly monitored and controlled at precisely the desired proportions throughout the period of storage.

The difficulty with MAP is coming up with the right film to allow the gases to travel back and forth.

Studies have been made ("The asparagus cool chain from harvest to export Market" Report to the NZ Asparagus Council, Don Brash, 1990) to determine the temperatures that can be expected in consignments of fresh export asparagus spears. This research proposed to use these times and temperatures in conjunction with appropriate films to assess the effect on quality.

The aim was to find a technique which would reduce the risk of high respiration and consequent deterioration of spears in cases where the cool chain was non-ideal.

3 METHOD

Asparagus (a mixture of varieties grown at one site) was harvested at Lincoln on 13 and 20 November 1991. It was cooled in iced water, cut to 21 cm and sealed in 1 kg amounts in bags (22 x 35 cm) made from a variety of films. (see Table 1 for film types).

Spears were stored upright for 9 days under temperatures simulating temperatures experienced by asparagus being exported to Japan, (see Table 2 for times and temperatures used).

During this period, gas samples were taken from bags and CO_2 and O_2 percentages analyzed.

At the end of the storage period, spears were assessed visually for quality and also assessed by a trained taste panel. The opened packs were then kept at 15-20°C for a further "shelf" period and examined every day.

4 RESULTS

1. Atmosphere modification occurred rapidly, especially in the non-perforated packs. Oxygen levels dropped rapidly (and CO_2 levels rose) during the first day in storage as the spears were still respiring rapidly. After 5 days at cool temperatures, respiration had slowed down and these levels did not drop any further. However, once the temperature rose again (to 15°C), the asparagus increased its respiration rate (in the packs where there was still enough O_2 for respiration to be uninhibited) and O_2 levels dropped further (with CO_2 levels rising). Oxygen levels reached their lowest after one day at 18°C.

Figures 1 and 2 show the mean CO_2 and O_2 levels in the modified atmosphere packs at five assessment points during the simulated transportation period.

2. The major effect of the Modified Atmosphere Packs on spear quality was caused by over-modification (too much change to the original gas percentages), especially in the MR15 packs and to a lesser extent in the RD106 packs. Spears showed symptoms of physiological injury, (similar to those described by other researchers) for spears exposed to injurious levels of CO_2. When packs containing severely injured spears were opened, a strong alcoholic odour was detected. This suggested that the spears had shifted to anaerobic respiration. Packs in which the O_2 level dropped to below 10%, and where the CO_2 was over 12%, showed injury to spears. Taste panels detected this injury as off-flavour in those spears which were not too injured to be tasted. The highest CO_2 levels occurred during the period at 15°C (simulating air transport) and did not increase further. However, packs opened before the last three days at 18°C, showed less injury than those kept closed. This indicates that length of time at these high CO_2 levels also contributes to the injury effect.

Spears packed in the highly perforated packs and control spears, lost colour and were dry, brownish and shrivelled looking.

Spears packed in the micro-perforated packs were of the best quality.

High humidity in packs meant that during "shelf" trials (with opened packs at 18-20°C), rotting was quite rapid as indicated from mould lesions seen first as brown marks on spears. These moulds were diagnosed as *Fusarium* and *Stemphylium* species which under storage conditions are known to cause decays where tissues are damaged or bruised, and storage temperatures are moderately high.

Figure 3 shows % marketable spears in each type of pack. The control and SM250 spears, although showing a high % marketable spears, were dry looking but did not have rots because of the lower humidity.

3. Taste panels showed that stored spears were less sweet than fresh, and spears from the MR15 film pack, and to a lesser extent from the RD106 pack, developed off-flavours. The highly perforated SM250 pack produced the least sweet spears.

Crispness increased with storage compared to fresh spears. Table 3 gives mean scores for each flavour attribute for each pack.

5 CONCLUSIONS

The difficulty with using gas permeable films to produce modified atmospheres is in identifying the most appropriate film. This research tested five films under conditions simulating air transport to Japan. The effects produced would be different if the ratio of film to asparagus were changed. This experiment used 1 kg of asparagus to approximately 1500 cm^2 of film. If a 5 kg box liner was used, the ratio would be 1kg of asparagus to 650cm^2 of film. This reduction means that there would be less film to handle the respiration gases. Over-wrapping of whole pallets would place an even greater demand on the permeability of the film used. Conversely, a small consumer sized pack would have a higher ratio of film to asparagus and so there would be less O_2 depletion and less CO_2 build-up.

While the micro-perforated films were able to produce the desired levels of CO_2 (around 5-7%), they were less successful at lowering the O_2 levels to around 10%. The ideal gas mixture is as yet unidentified, but it appears that a CO_2 level above 10% or an O_2 level below 10% causes damage. Using MAP with stable temperature conditions, the O_2 and CO_2 levels usually add up to 20-21%, so possibly a ratio of 7% CO_2: 14% O_2 or similar should be aimed for. These levels were achieved in the micro-perforated packs. Films are normally three times as permeable to CO_2 as they are to O_2 but when the plant material is respiring rapidly, the O_2 is being depleted and the CO_2 produced too rapidly for the film to handle.

The ideal packaging situation would be to pack consumer sized packs in New Zealand which stayed on the asparagus all the way through to the consumer. According to some Japanese importers, the asparagus often experiences very warm temperatures in Japan at the re-packaging stage when it is made into small bundles for retail sale. The factories where this is done are seldom air-conditioned and air temperatures in Japan in October/November can be very warm. The problem here is overcoming the quarantine requirements regarding insects which require fumigation to be performed on entry into Japan. This would not allow the use of this type of pack as it would have to be removed for fumigation (unless the film used allowed the fumigating gas to permeate into the packs or unless some other means of destroying insects in asparagus were devised.)

6 ACKNOWLEDGEMENTS

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The technical assistance of Peter Lammerink, field assistance from the asparagus breeder Helen Fraser-Kevern, advice and help with gas measurement from MAF Technology Levin, statistical assistance from David Saville of MAF Technology Lincoln, and packaging advice and provision of suitable films from Trigon Packaging and W.R. Grace is acknowledged with thanks.

TABLE 1: Specifications of Films Used to Package Asparagus

FILM	Permeability to:			Perforated area (%)	Thickness
	O_2 *	CO_2 *	H_20 vapour #		
MR15	9500	26500	23	Nil	15µ
RD106	11,226	33000	25.1	Nil	15µ
MP13.5	high	high	low	0.001	30µ
MP19	high	high	low	0.0002	30µ
SM250	very high	very high	very high	0.5	15µ

* : $cc/m^2/24$ h, bar

: $g/m^2/24$ h, 38°C and 100% Delta R.H.

- RD 106 film is an anti-fog, extremely tough, multi-layered, cross-linked poly-olefin, with a wide range of shrink properties.
- MR15 is a multi-layer, co-extruded poly-olefin shrink film.
- MP13.5 and MP19 are micro-perforated poly-ethylene films. The MP13.5 film had perforations which were 0.1 mm in diameter 13.5 mm apart, in rows which were 60 mm apart. The MP19 film had the perforations 19 mm apart in rows 60 mm apart.
- SM250 is a highly perforated film (perforations 0.5mm in diameter, 7 mm apart in rows 6 mm apart) of the type often used to wrap French bread.

TABLE 2: Simulated Transportation and Marketing Conditions

1.	Held 5 days at 4-6°C - simulates time in N.Z.
2.	Held 1 day at 15°C - simulates air transport
3.	Held 3 days at 18°C - simulates time to retail sale in Japan a) bags opened - fumigation * b)bags closed #

* If asparagus arrived in Japan and had to be fumigated then the bags would have to be opened for this.

\# Ideally the modified atmosphere should be maintained until the asparagus reaches the consumer or at least until it reaches the supermarket shelf.

The above temperature regime was used to simulate the sort of temperatures experienced by asparagus during export to Japan. (see "The asparagus cool chain from harvest to export Market" Report to the NZ Asparagus Council, Don Brash, 1990).

TABLE 3: Taste Panel Results

Packaging	Sweet	Bitter	Flavour	Off-flavour	Crisp-ness	Fibrous-ness
MR15	666	498	537	753	740	718
RD106	567	616	648	535	793	613
13.5MP	633	433	650	207	840	458
19MP	671	400	607	161	979	571
SM250	342	591	507	160	990	680
Control*	569	490	514	53	1075	412
Fresh	851	314	633	60.5	823	717
$LSD_{.05}$	226	389	298	370.4	172	263

* Control asparagus was stored without packaging.

All attributes were scored by panellists using a rating line (150 mm long). Panellists make a mark on the line to rate each characteristic and the distance from the zero point at the left end of the scale to the mark is measured. Scores for each attribute range from 0 for absence of the characteristic, to 1500 for extreme strength in that characteristic. Asparagus is expected to be around 750 for sweetness, flavour, crispness and fibrousness, 400 for bitterness, and 0 for off-flavour.

The following differences are shown in the above table:

Sweetness:	The control, SM250 and RD106 are significantly less sweet than fresh asparagus. (Sweetness is expected to decrease with storage.)
Bitterness:	Large LSD gives no significant differences.
Flavour:	No sign. diff.
Off-flavour:	MR15 and RD106 had significantly more off-flavour than most other treatments.
Crispness:	Control spears were more crisp.
Fibrousness:	MR15 and fresh spears were more fibrous than the control.

FIGURE 1

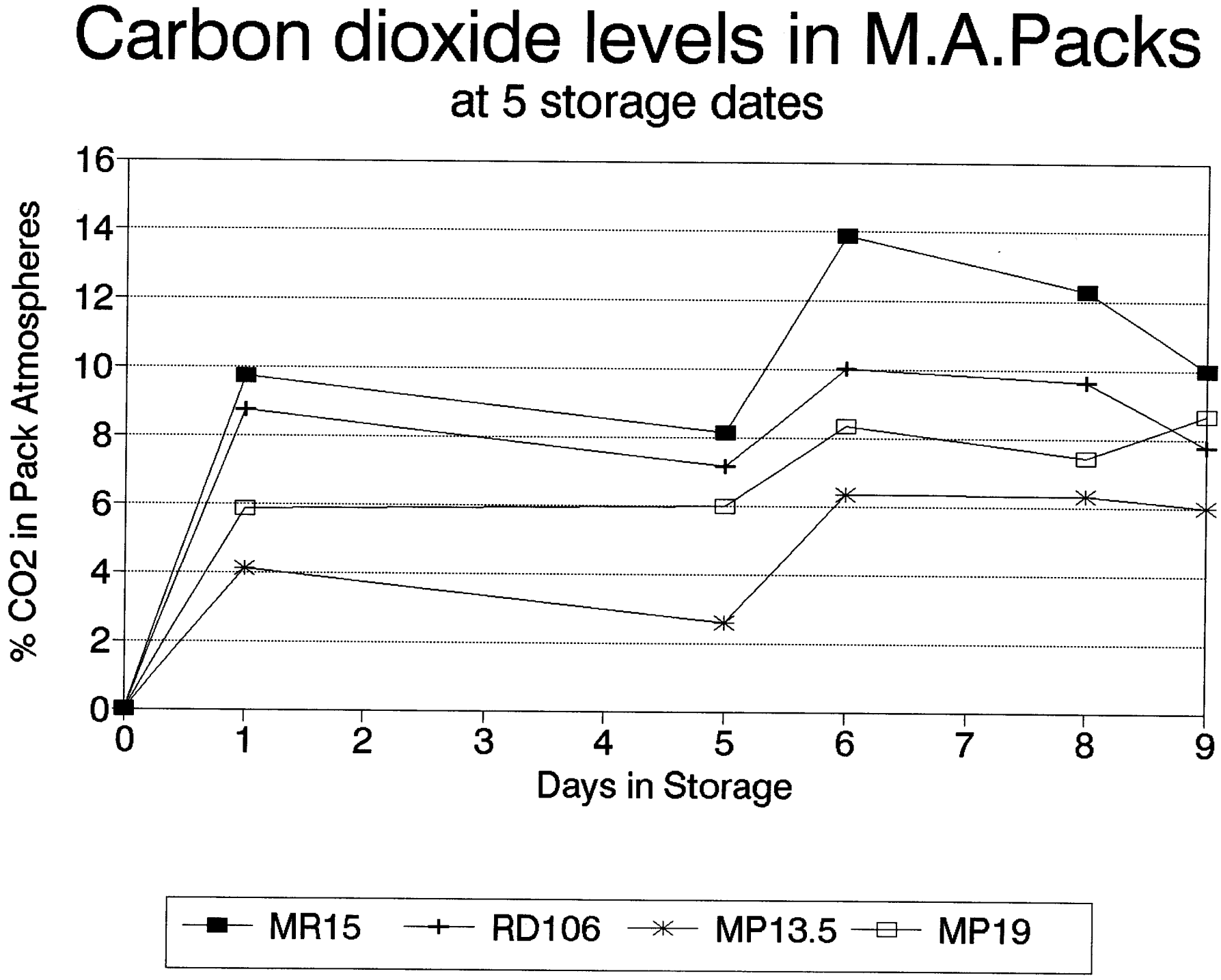

FIGURE 2

Oxygen Levels in M.A.Packs

at 5 storage dates

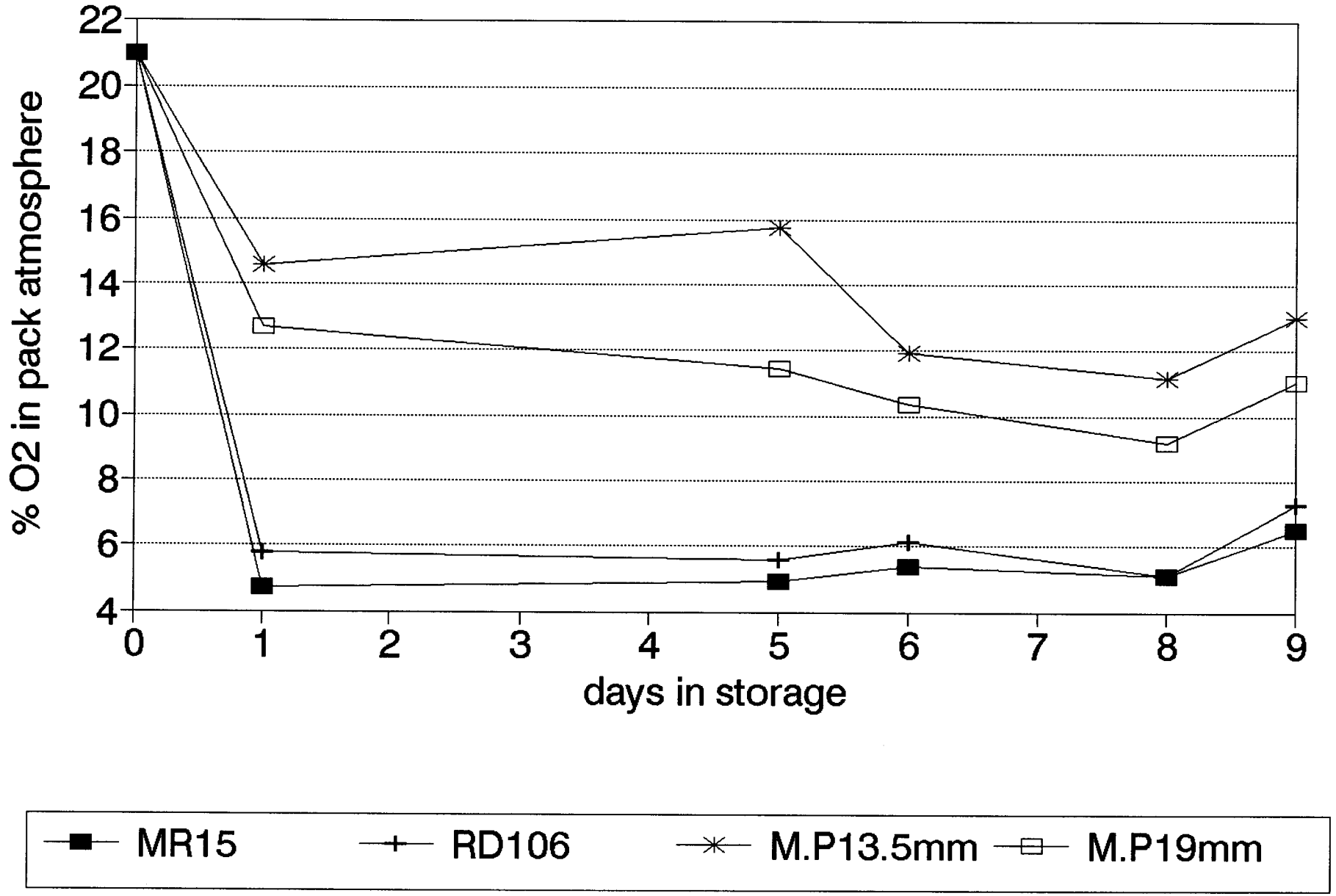

FIGURE 3

% Marketable Spears at End of Storage

and after 48 hours at shelf temp.