# Controlled atmosphere storage of 'Honey 'n' Pearl' sweet corn

D. W. Brash, V. K. Corrigan and P. L. Hurst

New Zealand Institute for Crop & Food Research Ltd.,
Private Bag 4005, Levin, New Zealand

## Abstract

Honey 'n' Pearl is the most widely grown supersweet sweet corn cultivar in New Zealand for fresh consumption. It is also popular in Asian markets. The main limitation for export is the difficulty of maintaining husk leaf greenness and cob eating quality for the three weeks required for seafreight.

Experiments examined the response of Honey 'n' Pearl sweet corn to controlled atmosphere (C.A.) storage at 0°C followed by shelf-life assessment at 15°C. The experiments measured the effects of CA on appearance, sensory qualities, carbohydrate levels and insect numbers. Low oxygen (2-5%) and moderate $CO_2$ (6-10%) ensured cobs retained sweetness and husk leaves stayed greener for longer during shelf-life compared to air storage. CA storage for three weeks also reduced insect numbers.

***Additioanl key words:*** Zea mays, *supersweet*

## Introduction

Honey 'n' Pearl is the most widely grown supersweet sweet corn cultivar for the fresh market in New Zealand. Supersweet sweet corn incorporates the mutant shrunken-2 (sh2) gene into standard sweet corn. Honey 'n' Pearl is a bi-coloured cultivar, with yellow dominant over white kernels.

The cultivar is popular in Asian markets where sweet corn is a staple vegetable. The main limitations for fresh export are either the high cost of airfreight or the maintenance of quality during the three weeks required for seafreight. Cob eating quality deteriorates in storage at 0°C and during subsequent shelf-life. Husk leaves dehydrate and brown quickly during shelf-life.

Sweet corn responds to controlled atmosphere (CA) storage. CA mixes of 2-4% $O_2$ and 5-10% $CO_2$ are recommended (Saltveit, 1989). Reductions in respiration, sugar conversion, chlorophyll loss and mould development are the expected benefits of CA on sweet corn. No previous research has been carried out on CA storage of supersweet cultivars such as Honey 'n' Pearl. CA may also reduce insect numbers. Sweet corn husk leaves can harbour aphids and other insect pests of quarantine importance.

Our experiments examined the response of Honey 'n' Pearl sweet corn to controlled atmosphere storage at 0°C followed by 3 days shelf-life at 15°C. The experiments measured the effects of CA on appearance, sensory qualities, carbohydrate levels and insect numbers.

## Materials and Methods

Experiments were carried out in 1990 and 1991 with harvests on 6 April and 9 April respectively. Sweet corn was harvested (at 23-24% kernel dry matter content), trimmed and cooled to 1°C within 6 hours of harvest. Cobs had stalk attached and were trimmed to below the bottom node and above the top node (in 1990) or below the bottom node and halfway between nodes (in 1991).

Ten sealed chambers (400 mm x 400 mm x 500 mm) with inlet and outlet ports were assigned randomly to a continuous gas supply (300 mℓ/min) in a coolroom held at 0°C. Table 1 shows the storage treatments. Gas supplies were humidified to maintain relative humidities close to 100%. Twenty-four cobs were placed in each chamber.

**Table 1. Storage treatments in 1990 and 1991.**

| | Storage Atmosphere | |
|---|---|---|
| Year | % $O_2$ | % $CO_2$ |
| **1990** | 2 | 6 |
| (3 & 4 weeks storage; | 2 | 15 |
| 1 replicate) | 5 | 5 |
| | 5 | 15 |
| **1991** | 2 | 6 |
| (3 weeks storage; | 2 | 10 |
| 2 replicates) | 5 | 6 |
| | 5 | 10 |

At the end of storage, cobs were placed in air at 15°C for a three day shelf-life period. A temperature of 15°C was chosen to simulate retail conditions. Moisture loss was minimised by wrapping cobs in polythene and placing them in boxes.

Husk leaf quality was rated visually on 5 cobs per plot on a 4 point scale at the end of storage and after shelf-life in the 1990 experiment and on 5 cobs per plot on a 5 point scale at the end of storage and daily during shelf-life in the 1991 experiment. Table 2 shows the rating scales.

Sensory assessments were made by a team of 9-12 trained panellists after 3 days shelf-life in 1990 and 2 and 3 days shelf-life in 1991. The middle third of five cobs from each storage atmosphere was cooked for four minutes in rapidly boiling unsalted water. Each treatment was cooked in a separate pot. Cobs were drained after cooking and served immediately. Panellists assessed a 40 mm segment of one cob from each storage atmosphere giving a total of 5 segments per sitting. Cobs were rated for sweetness, flavour and off-flavour in both years, and texture and overall acceptability in 1991. Ratings were made on a 150 mm linear scale where the left hand end of the scale represented a low intensity of a characteristic and the right hand end a high intensity. Scores were taken by measuring the distance of the mark from the left hand anchor point of the scale.

Kernel samples for soluble carbohydrate measurement were collected in 1990. A knife was used to slice kernels from one side of 4 cobs per plot. Samples were freeze-dried, ground and frozen. Duplicate 10 mg samples were used for analysis for sucrose, glucose, reducing sugars and total soluble carbohydrate content. Soluble carbohydrates were extracted with 62.5% (v/v) methanol at 55°C (Haslemore and Roughan 1976). Sucrose and glucose were measured using invertase and glucose oxidase (Lloyd and Whelan, 1969). Reducing sugars were measured with p-hydroxybenzoic acid hydrazide (Lever, 1973). Total soluble carbohydrates were measured with phenol-sulphuric acid (Haslemore and Roughan, 1976).

**Table 2. Husk leaf quality rating criteria for sweet corn.**

| Year | Score | Description |
|---|---|---|
| **1990** | 1 | Advanced deterioration and browning |
| | 2 | Very little green colour, widespread browning |
| | 3 | Some loss of green colour |
| | 4 | Fresh green colour |
| **1991** | 1 | Severe wilt, brown dry leaves, mould |
| | 2 | Some wilting, discoloured leaves, slight mould |
| | 3 | Leaves starting to discolour |
| | 4 | Medium green colour |
| | 5 | Fresh, even dark green |

In 1991 insects on the cobs were counted prior to storage (20 cobs) and at the end of storage (10 cobs per plot). Mould on stalk ends was assessed at the end of storage (10 cobs per plot) by rating each stalk end as nil, slight or marked infection.

Results were analysed using PROC GLM in the SAS package. Results of F tests carried out on the main effects are reported, i.e., air vs CA, $O_2$ level, $CO_2$ level, weeks of storage (1990 only). Significance levels up to 10% have been reported because the number of storage chambers limited replication.

## Results

Figure 1 shows 15% $CO_2$ caused injury to husk leaves during storage. Husk leaf quality was lower at the end of storage ($P = 0.009$). Carbon dioxide levels close to 6% were better than 10% at the end of storage ($P = 0.08$) (Fig. 2). CA-stored corn had higher husk quality than air-stored corn after 3 days at 15°C ($P = 0.05$) although all treatments had low ratings. Fresh Honey 'n' Pearl has a husk quality rating close to 3 after 3 days at 15°C (Brash, unpublished).

Taste panels generally preferred the corn stored in the 2% $O_2$/6% $CO_2$ or 5% $O_2$/6% $CO_2$ in both experiments (Figs. 3, 4 and 5), but the results were not consistent. Corn stored in CA was sweeter than corn stored in air in 1990 ($P = 0.06$) and in 1991 ($P = 0.07$) after 3 weeks storage and 3 days shelf-life. CA enhanced acceptability ($P = 0.05$) and texture after 3 days shelf-life ($P = 0.07$) in the 1991 experiment, but there were no significant treatment effects after 2 days shelf-life in this experiment. Sweet corn stored for four weeks in 1990 was unacceptable to the taste panel (results not shown).

Low $CO_2$ (6%) enhanced sweetness over high $CO_2$ (15%) in the 1990 experiment ($P = 0.003$). High $O_2$ (5%) had higher flavour ($P = 0.004$) and lower off-flavour ratings ($P = 0.006$) than low $O_2$ (2%). No responses were obtained within the CA treatments in 1991.

Kernel sucrose concentrations were not influenced by storage atmosphere in the 1990 experiment (Fig. 6).

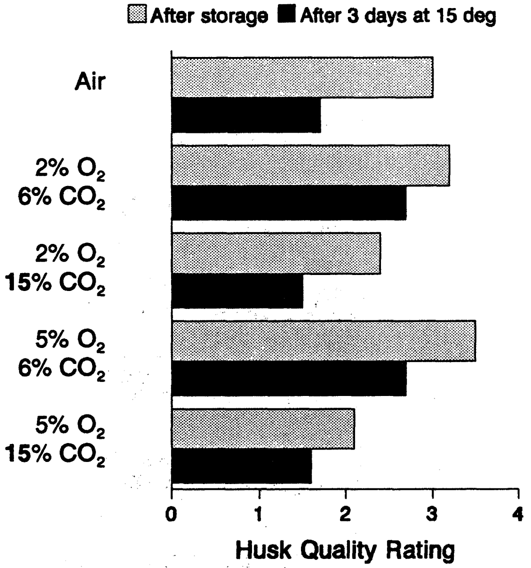


**Figure 1. Effect of storage atmosphere on husk leaf quality (1990 experiment, means of 3 and 4 weeks storage).**

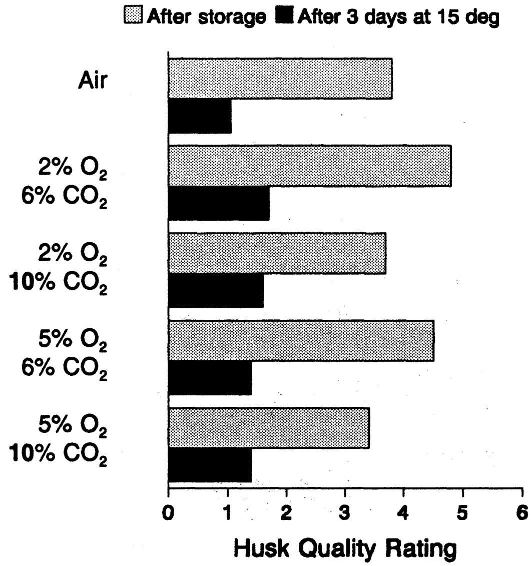


**Figure 2. Effect of storage atmosphere on husk leaf quality after 3 weeks storage (1991).**

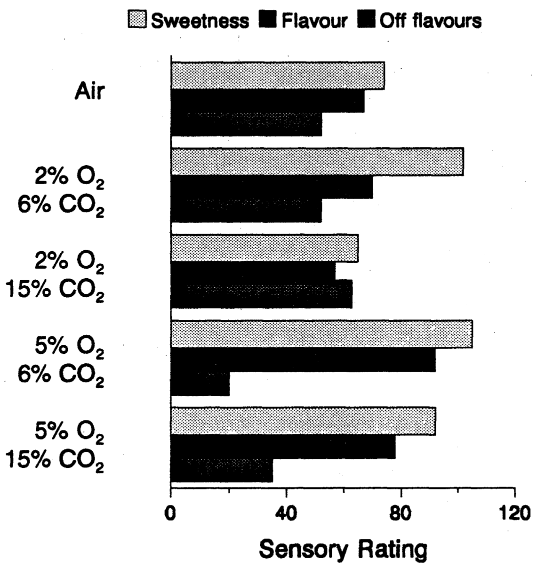


**Figure 3. Effect of storage atmosphere on sensory qualities of cooked sweet corn after 3 weeks storage (1990).**

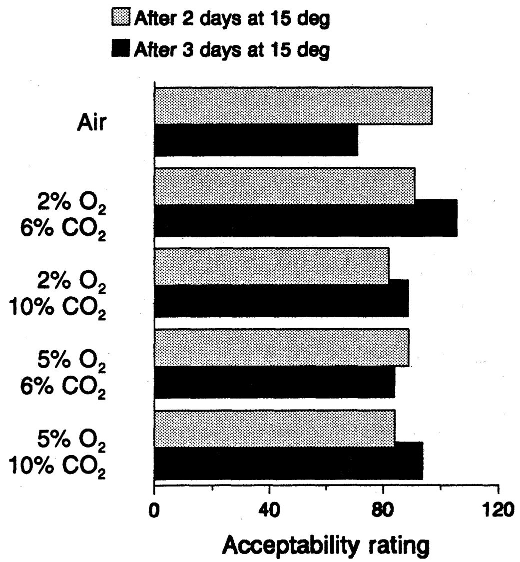


**Figure 4. Effect of storage atmosphere on acceptability rating of cooked sweet corn after 3 weeks storage (1991).**

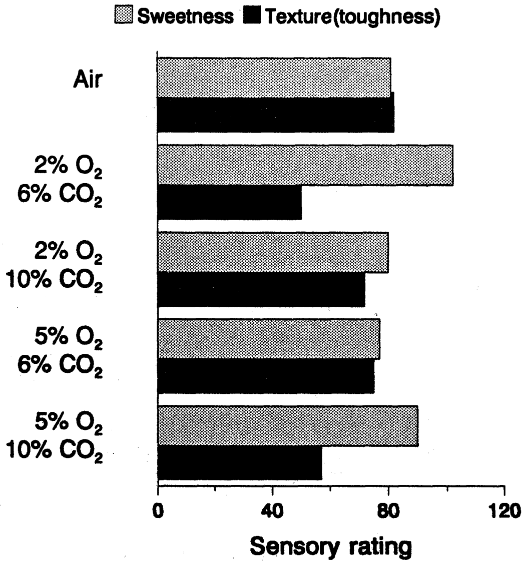


**Figure 5. Effect of storage atmosphere on sweetness and texture of cooked sweet corn after 3 weeks storage (1991).**

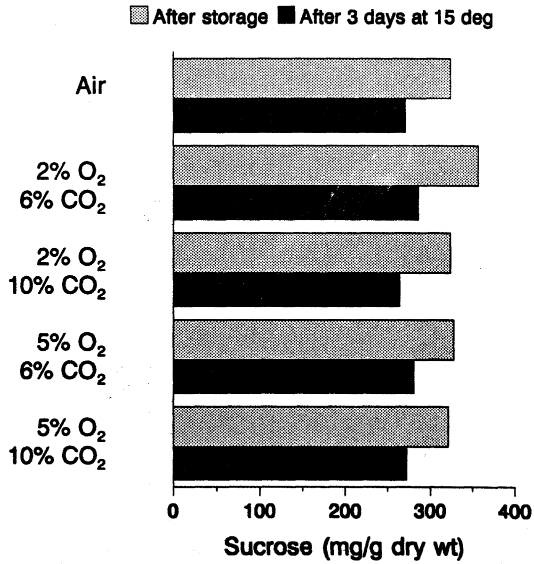


**Figure 6. Effect of storage atmosphere on kernel sucrose after 3 weeks storage (1990).**

Sucrose levels after 3 weeks were significantly higher than after 4 weeks ($P = 0.02$). Storage atmosphere did not affect the other carbohydrates measured. At the end of storage and after 3 days shelf-life glucose concentrations were 15.0 and 16.5 mg/g-dw, respectively. Similarly, reducing sugars were 31.9 and 33.9 mg/g-dw and soluble carbohydrates were 388 and 334 mg/g-dw respectively.

In the 1991 experiment, cobs stored in CA had fewer aphids than air-stored sweet corn ($P = 0.02$) at the end of storage (Fig. 7). Prior to storage 55% of cobs had 0-10 aphids, 30% had 10-100 aphids and 5% had over 100 aphids per cob.

CA also reduced development of mould during storage in the 1991 experiment (Fig. 8). The percentage of stalk ends without mould was higher in CA ($P = 0.0002$) and at the higher level of $CO_2$ ($P = 0.03$).

## Discussion

The storage potential of Honey 'n' Pearl sweet corn was increased by CA but a larger response may be required to make it commercially useful, particularly in reducing the rapid loss of husk leaf quality after cool storage. This loss of quality after storage is likely to be caused by "chilling injury". Leaves of *Zea mays* are chilling sensitive (Miedema, 1982). CA alleviated the symptoms but did not eliminate them. Rapid dehydration of injured outer husk leaves occurs after storage at low temperatures. If the outer leaves are removed at this stage inner leaves are still green.

Our results confirm the recommendations of Saltveit (1989) that 2-4% $O_2$ and 5-10% $CO_2$ is the optimum range for CA storage of sweet corn.

Sucrose was the predominant soluble carbohydrate. Evenson and Boyer (1986) found sweet corn sucrose levels correlated well with hedonic (like/dislike) and sweetness scores given by taste panels. Their experiment covered a wide range of cultivars and sucrose contents. The narrow range of sucrose contents in our experiment make good correlations with storage treatment and taste panel ratings less likely.

Use of CA will help to inhibit storage decay and reduce insect infestation. Additional disinfestation methods may be required as the CA treatments did not give complete insect control.

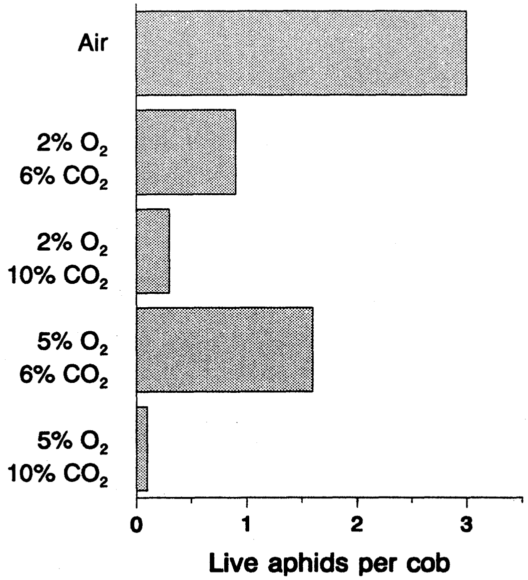


**Figure 7. Effect of storage atmosphere on aphid survival in cold storage (1991).**

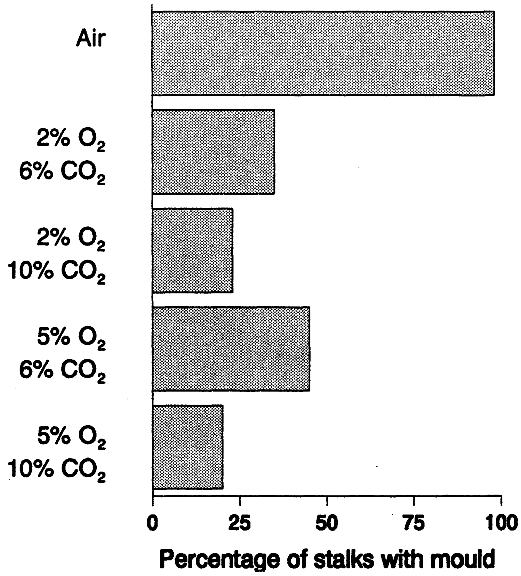


**Figure 8. Effect of storage atmosphere on presence of mould on stalk ends after 3 weeks storage (1991).**

## Acknowledgements

To G. van der Mespel for assistance during storage and to S. Wright for biometric assistance.

## References

Evenson, K.B. and Boyer, C.D. 1986. Carbohydrate composition and sensory quality of fresh and stored sweet corn. *Journal of the American Society of Horticultural Science III (5)*, 734-738.

Haslemore, R.M. and Roughan, P.G. 1976. Rapid chemical analysis of some plant constituents. *Journal of the Science of Food and Agriculture* ***27***, 1171-1178.

Lever, M. 1973. Colorimetric and fluorometric carbohydrate determination with p-hydroxybenzoic acid hydrazide. *Biochemical Medicine* ***7***, 274-281.

Lloyd, J.B. and Whelan, W.J. 1969. An improved method for enzymic determination of glucose in the presence of maltose. *Analytical Biochemistry* ***70***, 467-470.

Miedema, P. 1982. The effects of low temperature on *Zea mays*. *Advances in Agronomy* ***35***, 93-128.

Saltveit, M.E. 1989. A summary of CA requirements and recommendations for vegetables. *In* Proceedings 5th National Controlled Atmosphere Research Conference, (ed. J.K. Fellman), Volume 2, pp. 329-352. University of Idaho, Moscow.