APRC Project Report

Project SP112: Strategies to improve the textural quality of CA-stored Cox apples

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This 3-year project began in June 1997 and is directed towards an improvement in the textural quality of Cox apples stored under controlled atmosphere conditions. Three approaches are being taken to achieve the overall objective and progress within each is described separately.

1. Investigation of the effect of ReTain™ on fruit quality

Details of a trial carried out in 1997 were given in the previous 6-monthly report. These are summarized as follows:

A single spray of ReTain™ (50g a.i. per acre) was applied to Queen Cox (M9) trees on 14 August 1997 (4 weeks before anticipated harvest date) using a knapsack sprayer. A surfactant (0.1% v/v ABG-7011) was added to the spray solution. Apples from treated and untreated trees were harvested on 8, 15, 22 and 29 September. On each occasion measurements were made to assess fruit maturity and samples of fruit were placed into CA storage (1.2% O_2, <1% CO_2) at 3.5ºC. Separate storage containers were used for treated and untreated fruit and for fruit from each pick.

As noted in the previous report there were marked effects of ReTain™ in retarding fruit maturation on the tree. This was evidenced by a delayed increase in the concentration of ethylene and soluble solids in the fruit, and delayed decline in starch (iodine test) content. The ethylene concentration in storage containers of untreated fruit was about 10-fold higher than in those containing fruit treated with ReTain™. The ethylene concentration in containers of fruit from the final harvest were higher that in those with fruit picked earlier; this applied to both treated and untreated fruit.

In January the firmness of untreated fruit declined progressively with delayed harvest and only those from the first pick (8 September) met the ex-store firmness target of 64 Newtons (N) or 6.5 kg. Fruit from trees treated with ReTain™ did not show a progressive decline in firmness with delay in harvesting, and the firmness of fruit from all picks was 64 N (6.5 kg) or above. Treated fruit were also greener in background colour than the untreated.

A similar pattern of treatment effects occurred on fruit removed from CA storage in March. Average firmness increase from ReTain™ application was 8 N (0.8 kg) and the firmness of treated fruit from all picks was 60 N (6.1 kg) or above. However, none of the picks of untreated fruit achieved the 60 N firmness required at the point of sale.

In January the overall quality (red and background colour, soluble solids concentration and firmness) of treated fruit picked on 22 September was similar to that of untreated fruit picked on 8 September. A similar comparison could be made between treated fruit picked on 29 September and untreated fruit picked on 15 September. However the firmness of fruit treated with ReTain™ was higher despite the 2 week difference in harvest date and this effect was also apparent after a further 7 days at 18ºC (simulated marketing). By March the firmness of untreated fruit picked on the first occasion was below that of treated fruit picked on the final harvest date. Therefore, in fruit stored until March, it was not possible to identify harvest dates for treated and untreated fruit which provided comparable quality.

On the basis of the results obtained in this trial on Cox it is clear that ReTain™ is a potent inhibitor of ethylene production and causes a marked delay in fruit maturation. Harvesting of fruit from Cox trees treated with ReTain™ needs to be delayed in order to achieve sufficient sugar content. Although, in this trial, there were no significant effects of ReTain™ on red colour and mean fruit weight, US results suggest that a delay in harvesting of treated fruit is required to achieve sufficient size and colour. Further trials, with a higher degree of replication than was possible in 1997, are required to quantify effects of ReTain™ on fruit size, yield and red colour development.

Despite a harvest delay of two weeks the firmness of fruit treated with ReTain™ was superior to that of the untreated. The use of this product offers the exciting prospect of rectifying the major weakness in Cox, i.e. inconsistent textural quality. Further work is required to confirm and extend the results obtained in 1997. It will be important to determine whether beneficial effects of ReTain™ can be achieved where treated and untreated fruit are stored in the same CA containers. There is the exciting prospect that ethylene removal in combination with ReTain™ application could have a major effect in retarding softening of CA-stored Cox apples.

2. Effect of temperature on loss of firmness in fruit removed from CA storage

On 13 February 1998 samples of Cox apples were taken from bulk storage bins from a commercial CA store which had been unsealed 2 days earlier. Samples from 6 different orchards were transported immediately to HRI-East Malling in a non-refrigerated vehicle. Fruit from each orchard was randomized into 18 kg plastic containers and loaded into polypropylene cabinets (nominal 80 kg capacity) situated in controlled temperature rooms within the Jim Mount Building. Fruit temperature was maintained at -0.5, 1.5, 3.5, 10 and 18º C. Additionally at 3.5º C fruit was held in an atmosphere of 5% CO_2 + 16% O_2 (5/16). Samples of fruit were removed after 4, 10, 14 and 21 days. After 21 days all remaining fruit was transferred to 18º C for a further 7 days. At each removal fruit samples were weighed and background colour compared with a chart used commercially. Samples were subjected to firmness testing using a motorized penetrometer fitted with an 11 mm probe. Finally, apples were cut and examined for the presence of disorders. At the same time an appraisal of eating quality was made by David Johnson. Apples were scored for firmness and taste (maximum 3 points for each) with an additional point for juiciness and aroma. Thus the maximum score for sensory quality was 8.

Over a period of 3 weeks, weight loss (% / day) at -0.5, 1.5, 3.5, 10 and 18^{o} C was 0.05, 0.02, 0.02, 0.13 and 0.31 respectively. Fruit quality was compromised by holding fruit above 3.5^{o} C, particularly at 18^{o} C where shrivel was evident after 14 days. Weight loss in fruit held at 3.5^{o} C was similar in air and 5/16 storage.

Firmness of fruit immediately ex-store ranged from 47-62N (4.8-6.3 kg) and was therefore already below the level of 64N (6.5 kg) suggested for dispatch to market. Average firmness for the 6 consignments was 55N (5.6 kg). Rate of softening was related to holding temperature but was not a linear effect over the entire 3-week period. However, calculating loss of firmness per day is a convenient way to indicate the marked effect of holding temperature on firmness loss. Over a period of 3 weeks firmness loss (N / day) at -0.5, 1.5, 3.5, 10 and 18^{o} C was 0.1, 0.2, 0.3, 0.4 and 0.7 respectively. These data indicate the importance of post-storage temperature in maintaining quality through to the retail shelf. A firmness of 59N (6 kg) is considered necessary to provide consumers with acceptable eating quality. Based on these rates of firmness loss, at 18^{o} C there would be a maximum of 7 days from removal from store to purchase (assuming 64 N ex-store firmness). Clearly there are major advantages in maintaining cool temperatures throughout distribution and some justification for providing chilled display at the retail level. Holding fruit at 3.5^{o} C in a 5/16 atmosphere slightly reduced loss of firmness compared with normal air at 3.5^{o} C. However, reduced softening was achieved more easily by reducing the air store temperature to 1.5^{o} C.

The average background colour score ex-store was 1.6. Fruit maintained at 10 and 18^{o} C reached the maximum degree of yellow (colour score above 2) after 10 and 4 days respectively. Those that were held at 3.5^{o} C or below remain acceptably green through to the final inspection (3 weeks). For these particular consignments of fruit the maximum period from removal to purchase was 4, 9 and 21 days at 18, 10 and 3.5^{o} C respectively. Holding fruit at 3.5^{o} C in a 5/16 atmosphere resulted in fruit with similar background colour to those kept in normal air at 3.5^{o} C.

Average scores for quality remained high (6 or higher) for 14 days in fruit stored at or below 3.5^{o} C. However, at 10 and 18^{o} C, sensory scores were 4.7 and 3.8 respectively 10 days after removal from store.

The incidences of physiological disorders were generally low and not sufficient to assess the effects of post-storage treatments. However it was interesting to note that virtually all occurrences of corking disorders were restricted to apples from an orchard where the level of potassium in the fruit was 21 mg $100g^{-1}$ higher than recommended for long-term storage. Corking disorders were more frequent in fruit held in a 5/16 atmosphere at 3.5^{o} C and in those kept at 18^{o} C. Breakdown occurred to a slight extent in fruit from all post-storage treatments except 3.5^{o} C.

It is clear that maintenance of the quality of Cox apples during distribution requires control of product temperature and the duration from unloading the store to the point of sale. Removing fruit from store when firmness is in excess of 64 N will provide more time for grading and distribution but the use of refrigerated conditions is likely to provide the greatest benefit in maintenance of quality. Holding fruit at temperatures below 3.5^{o} C slowed further deterioration in quality but cannot be advised on late-stored fruit until it has been established that risk of breakdown is not aggravated.

3. Influence of water loss on textural properties of fruit in CA storage

The work programme has proceeded as planned. However, due to the recent absence, through illness, of the project leader responsible for this component of the work it is not possible to provide a report on progress. It is anticipated that this will be forthcoming in the next 6-monthly report which will become due after December 1998.