

APRC PROJECT REPORT

Project SP122: Low temperature storage of Gala apples

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Background

Whilst there is general acceptance of the storage recommendations for Gala that were published in APRC News (Issue 21) no consideration was given in previous APRC-funded work to the possibility of storing in CA at temperatures below 1.5°C. This 3-year project to investigate the prospect of reducing the storage temperature for CA-stored Gala apples began in July 2000. This report covers the period from July-December 2000 inclusive.

Year 1

Experimental details

On 20 and 21 September 2000 samples of apples were taken from 6 commercial 'Mondial' Gala orchards in Kent (4) and East Anglia (2) and transported immediately to HRI-East Malling. At this time commercial harvesting was underway or imminent. On arrival at East Malling sub-samples of fruit were taken for maturity assessment and for mineral analysis. The remaining fruit from each orchard was allocated to small-scale (90-kg) CA chambers. There were 4 CA storage treatments (CO₂/ O₂): 5/1, <1/1, <1/2 and 8/13, and 2 storage temperatures: 1.5-2°C and 0-0.5°C. There were 2 replicate chambers for each storage treatment. Samples of fruit were removed from store after 55 days (mid-November). Samples of fruit were assessed for the presence of physiological disorders. Measurements of firmness were carried out using an automated penetrometer fitted with an 11-mm probe. Juice was extracted from each sample for measurement of soluble solids and acid concentration. Assessment for disorders and measurement of firmness were repeated on fruit subjected to a simulated marketing period of 7 days at 20°C.

Results

Harvest maturity

The more practical measures of harvest maturity are firmness, soluble solids (sugar) content and the extent of starch conversion. No precise guidelines have been developed to indicate optimum harvest maturity in relation to storage. Previous work suggested that Gala stored well when picked at above 7 kg (70 N) firmness and over a broad range of starch levels (50-90% black). In comparison with these criteria the apples from the orchards in the study were very firm with high levels of starch (average Ctfl score of 3.8 is equivalent to about 85% starch cover). However, increase in ethylene production is the physiological marker of ripening. Internal ethylene concentration (IEC) in excess of 100 ppb normally indicates that a fruit has commenced its ripening and fruits for storage are usually picked just prior to this

event. The IEC data in table 1 suggests that a high proportion of fruit in all orchards except East Anglia (L) were already ripening when harvested on 20 or 21 September. It will be interesting to relate any differences in storage behaviour to differences in the maturity status of the fruit at harvest. In previous work there was a strong correlation between firmness ex-store and the firmness and starch content of fruit at harvest.

Table 1. Harvest maturity data for 6 commercial 'Mondial' Gala orchards used in the 2000/01 storage experiment. Starch scores relate to the Ctifl starch conversion chart where 1 is almost completely black (100% starch cover) and 10 is almost completely white (0% starch cover). IEC is the concentration of ethylene in the core cavity of the fruit. Firmness and soluble solids were measured with an automated penetrometer and a refractometer respectively, and acidity by titration.

Orchard ref.	Firmness (N)	Sol. Solids (%)	Starch score (Ctifl)	IEC (% fruits >100 ppb)	Acidity (g/kg)
Kent W	84.9	11.1	3.8	40	3.5
Kent C	83.9	11.9	3.5	40	3.3
Kent Pe	81.0	11.8	3.7	80	3.6
Kent Pt	76.4	11.6	4.5	50	2.8
E. Ang. W	79.8	11.7	4.2	90	2.8
E. Ang. L	81.2	10.9	3.0	10	3.2

Fruit mineral composition

Table 2. Mineral compositions of 'Mondial' Gala apples at harvest (20/21 September 2000).

Orchard ref.	N	P	K	Ca	Mg
mg 100g ⁻¹					
Kent W	36.8	8.5	104	9.4	4.7
Kent C	32.7	7.8	102	7.1	4.4
Kent Pe	50.2	9.8	121	7.4	4.6
Kent Pt	31.4	7.6	95	7.0	4.3
E. Ang. W	43.4	8.9	90	7.5	4.1
E. Ang. L	36.4	8.7	104	7.7	4.6

Orchard ref.	Na	Mn	Zn	Cu	B
mg 100g ⁻¹		µg 100g ⁻¹			
Kent W	0.38	60	34	33	218
Kent C	0.48	53	30	32	216
Kent Pe	0.66	61	35	48	213
Kent Pt	0.35	85	35	24	243
E. Ang. W	0.31	52	31	35	398
E. Ang. L	0.74	53	27	27	348

Mineral composition data confirmed previous findings that Gala is a low nutrient apple as regards nitrogen (N), phosphorus (N) and potassium (N) although it has much higher calcium (Ca) levels than many other dessert apple cultivars. No mineral

analysis standards have been established that provide for optimum storage quality. This can only be achieved by larger scale survey experiments conducted over many years. It is therefore difficult to know whether there should be concern over concentrations of N, P and K that in Cox would be considered to be critically low and would be expected to give rise to problems with storage quality. In the event of storage disorders developing in samples of fruit from these orchards it will be interesting to note any association with their mineral composition.

Storage quality

Effects of temperature

At the first examination of the stored fruit in mid-November there was no clear effect of storage temperature on the firmness of the fruit immediately ex-store or after a further 7 days at 20°C. Average firmness ex-store was above 75 N (7.6 kg) in fruit from both temperatures and all CA conditions. However it appeared that soluble solids content was generally slightly lower in fruits stored at the lower temperature. This may have been anticipated since conversion of starch to sugar during storage is likely to be slowed by the lower rate of metabolism associated with the lower temperature. This is likely to be a transient effect. No disorders were evident in the fruit at either temperature.

Effects of CA conditions

The firmness of fruit after 7 days at 20°C was generally in the range 65-70 N (6.6-7.1 kg) with the exception of that of fruit stored under high carbon dioxide (8/13) conditions. As found in previous work fruits stored in 8/13 softened markedly. Fruit from 8/13 at both temperatures softened to 60 N (6.1 kg) after 7 days at 20°C. This confirms the recommended duration (early November) for the storage of Gala under these CA conditions.

Further examinations

Assessments of fruit from all storage treatments are scheduled for early January, late February and mid April, this corresponds with 106, 153 and 178 days from harvest. Samples of juice for acidity measurements taken at the first examination have been frozen and will be analyzed in due course.